Listing of the Plenary, Oral and Poster Presentations of the Abstracts of the 2017 American Brachytherapy Society Annual Meeting

Scientific Session: GYN Proffered Papers I
Thursday, April 20, 2017
8:00 AM - 9:00 AM

PP01
Presentation Time: 8:00 AM
Image Based Brachytherapy with MRI-Based Planning in the Treatment of Cervical Cancer: A Single Institution Outcome Analysis of 220 Patients
Scott Glaser, University of Pittsburgh Cancer Institute

PP02
Presentation Time: 8:09 AM
Is There a Role of Neoadjuvant Radiotherapy Including High Dose Rate Image-Based Brachytherapy in Locally Advanced Type II Endometrial Cancer Clinically Extending to Cervix ± Parametria?
Uzoma Iheagwara, UPMC CancerCenter

PP03
Presentation Time: 8:18 AM
Clinical Outcomes Using Image Guided Interstitial Brachytherapy for Definitive Cervical Cancer Patients with High Risk Clinical Target Volumes Greater Than 30 cc
Chenyang Wang, UCLA

PP04
Presentation Time: 8:27 AM
Increasing Age Predicts Poor Cervical Cancer Prognosis with Subsequent Effect on Treatment and Overall Survival
Bridget Quinn, VCU School of Medicine

PP05
Presentation Time: 8:36 AM
Management of Elderly Patients with Early Stage Medically Inoperable Endometrial Cancer: Systematic Review and National Cancer Database Analysis
Sunil Dutta, University of Virginia

PP06
Presentation Time: 8:45 AM
Brachytherapy Should Not Be Omitted from the Adjuvant Management of Uterine Carcinosarcoma
William Stokes, University of Colorado School of Medicine

Scientific Session: Prostate Proffered Papers I
Thursday, April 20, 2017
9:00 AM - 10:00 AM

PP07
Presentation Time: 9:00 AM
Real-Time Transrectal Ultrasound-Based Planning for High Dose-Rate Brachytherapy Boost in Intermediate and High Risk Prostate Cancer
Julia Pearse, Ryerson University

PP08
Presentation Time: 9:09 AM
Predictive Factors of Long-Term Rectal Toxicity Following I-125 Prostate Brachytherapy with or without External Beam Radiotherapy
Atsunori Yorozu, Tokyo Medical Center, NHO

PP09 Presentation Time: 9:18 AM
Lack of Benefit Associated with External Beam Radiotherapy in Addition to Brachytherapy for Intermediate- to High-Risk Prostate Cancer
Vinayak Muralidhar, Harvard Radiation Oncology Program

PP10 Presentation Time: 9:27 AM
Pre-Treatment MRI Staging Predicts for Biochemical Failure in High-Risk Prostate Cancer Treated with Combination High-Dose-Rate Brachytherapy and External Beam Radiotherapy
John Hegde, University of California, Los Angeles

PP11 Presentation Time: 9:36 AM
Using a Surgical PSA-Threshold (> 0.2 ng/mL) to Define Biochemical Failure in the ASCENDE-RT Phase 3 Trial
Mira Keyes, Vancouver Cancer Centre

PP12 Presentation Time: 9:45 AM
Prostate HDR Monotherapy: Initial Efficacy Results from a Randomized Trial of One versus Two Fractions
Gerard Morton, Sunnybrook Odette Cancer Centre

Scientific Session: Physics Proffered Papers
Thursday, April 20, 2017
2:30 PM - 3:30 PM

PP14 Presentation Time: 2:30 PM
Commissioning and Clinical Use of the CivaSheet, a Novel Shielded Pd103 Array
Antonio Damato, Memorial Sloan Kettering Cancer Center

PP15 Presentation Time: 2:39 PM
Commissioning of Post-Treatment PET-Based Dosimetry Software for Hepatic Radioembolization with Yttrium-90 Microspheres
Jose Garcia-Ramirez, Washington University School of Medicine

PP16 Presentation Time: 2:48 PM
Retrospective Evaluation of Prostate Cancer Treatment Plan Quality Obtained from Intermediate Energy Sources for High Dose Rate Brachytherapy
Gabriel Famulari, McGill University

PP17 Presentation Time: 2:57 PM
Treatment Planning Using the TG-43 Hybrid Technique for HDR Non-Invasive Breast Brachytherapy Applicators
Adam Bastien, Advanced Radiation Therapy, LLC

PP18 Presentation Time: 3:06 PM
A Novel Delivery System for High Dose Rate Intensity Modulated Brachytherapy with Intermediate Energy Brachytherapy Radiation Sources Such as 169Yb
Gabriel Famulari, McGill University
Scientific Session: Miscellaneous Proffered Papers  
Thursday, April 20, 2017  
4:00 PM - 5:00 PM

**PP19**  
Patterns of Care and Impact of Brachytherapy Boost Utilization for Squamous Cell Carcinoma of the Base of Tongue in a Large, National Cohort  
*Anna Lee, SUNY Downstate Medical Center*

**PP20**  
Preliminary Clinical Study in Open MRI-Guided $^{125}$I Seed Implantation for Treatment of Brain Tumor  
*Chengli Li, Shandong Provincial Medical Imaging Research Institute*

**PP21**  
CT-Guided $^{125}$I Brachytherapy for Locally Recurrent Nasopharyngeal Carcinoma  
*Huizheng Yan, Sun Yat-sen University Cancer Center*

**PP22**  
Differential Uptake Volume Histograms as a Predictor of Response in Rectal Adenocarcinoma Patients Treated with Preoperative Endorectal Brachytherapy  
*Slobodan Devic, McGill University*

**PP23**  
Bachytherapy Skin Practice in Spain: A Survey Study  
*Silvia Rodriguez Villalba, Hospital Clinica Benidorm*

**PP24**  
Retrospective Analysis of Surface Brachytherapy for Non-melanoma Skin Cancer of the Extremities  
*David Olek, Scott and White*

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**Scientific Session: Physics Snap Orals (E-Poster)**  
Thursday, April 20, 2017  
5:00 PM - 6:00 PM

**PHSOR1**  
Windowless Extrapolation Chamber and Radiochromic Film Measurements of a Flat $^{106}$Ru Eye Plaque  
*Jon Hansen, University of Wisconsin-Madison*

**PHSOR2**  
Significant Dose Reduction to Heart with Innovative Design of a Prone Breast Board During HDR Partial Breast Irradiation Brachytherapy  
*Jiaju Zhang, Staten Island University Hospital, Northwell Health*

**PHSOR3**  
Failure Mode and Effects Analysis in Multimodal Low Dose-Rate Prostate Brachytherapy  
*Ivan Buzurovic, Dana-Farber/ Brigham Women's Cancer Center, Harvard Medical School*

**PHSOR4**  
Dosimetric Characteristics for an LDR Brachytherapy Stent for Esophageal Cancer  
*Presentation Time: 5:15 PM*
Mark Rivard, Tufts University School of Medicine

PHSOR5  Presentation Time: 5:20 PM
Experimental Research on a Novel Robotic System for Lung Cancer Brachytherapy
Shan Jiang, School of Mechanical Engineering, Tianjin University

PHSOR6  Presentation Time: 5:25 PM
Dosimetry Verification for Radioactive Seed Implantation in Malignant Tumor Under CT and 3D Printing Template Guidance
Zhe Ji, Peking University Third Hospital

PHSOR7  Presentation Time: 5:30 PM
Changes in Seed Configuration Within Prostate with Implantation of a Hydrogel Rectal Spacer and Its Impact on Urethral Dose
Amandeep Taggar, MSKCC

PHSOR8  Presentation Time: 5:35 PM
Influence of Bone Tissue on the Depth-Dose Characteristics for the CivaSheet
Mark Rivard, Tufts University School of Medicine

PHSOR9  Presentation Time: 5:40 PM
HDR Monotherapy in Prostate Cancer: Radiobiological Considerations When Determining Biologically Effective Dose in Clinical Trials
Christopher Tien, Yale University School of Medicine

PHSOR10  Presentation Time: 5:45 PM
Hsiang-Chi Kuo, Montefiore Medical Center

PHSOR11  Presentation Time: 5:50 PM
Monte Carlo Calculations of TG-43 Dosimetry Parameters of Low-Energy Brachytherapy Seeds for Gold Nanoparticle-Aided Radiotherapy
Bo Liu, University of Massachusetts Lowell

PHSOR12  Presentation Time: 5:55 PM
Dose Specification and Source Ordering Nomogram for CivaSheet Pd-103 Sources
Gilad Cohen, MSKCC

Scientific Session: GYN Proffered Papers II
Friday, April 21, 2017
9:00 AM - 10:00 AM

PP25  Presentation Time: 9:00 AM
Exploring Deep Convolution Neural Networks with Transfer Learning for Rectum Toxicity Prediction in Cervical Cancer Radiotherapy
Xin Zhen, The University of Texas, Southwestern Medical Center

PP26  Presentation Time: 9:09 AM
Primary Tumor-Directed Brachytherapy Is Associated with Improved Survival for Patients with Metastatic Cervical or Uterine Carcinoma
Yuan Rao, Washington University in St. Louis
Distant Metastasis Is the Primary Site of Failure Following Image Guided Interstitial Brachytherapy in Management of Primary Vaginal Cancers
Jagdeep Raince, UCLA

Trends in Cervical Cancer Brachytherapy Volume Suggest Case Volume Is Not the Primary Driver of Poor Compliance Rates with Brachytherapy Delivery for Locally Advanced Cervical Cancer
Daniel Trifiletti, University of Virginia Health System

External Pelvic and Vaginal Irradiation versus Vaginal Irradiation Alone as Postoperative Therapy in Women with Early Stage Uterine Serous Carcinoma: Results of a National Cancer Database Analysis
Ankit Modh, Henry Ford Health System

Image-Guided Brachytherapy for Definitive Treatment of Inoperable Endometrial Carcinoma
Brian Gebhardt, UPMC

Plenary Session
Friday, April 21, 2017
1:45 PM - 3:00 PM

Long Term Outcomes of I\textsuperscript{125} Eye Plaque Brachytherapy in Patients with Choroidal Melanoma
Irina Sparks, MCW

Evaluation of a Machine-Learning Algorithm for Treatment Planning in Prostate Low-Dose-Rate Brachytherapy
Alexandru Nicolae, Sunnybrook Health Sciences Centre

A Prospective Phase II Trial of Trans-Perineal Ultra-Sound-Guided Brachytherapy for Locally Recurrent Prostate Cancer After External Beam Radiotherapy (NRG/RTOG 0526)
Juanita Crook, BC Cancer Agency

The Use of Functional MRI in Cervical Cancer Patients with Incomplete Response on PET/CT Following MRI Guided High-Dose Rate Brachytherapy
Ronny Kalash, University of Pittsburgh Medical Center

Factors Associated with Willingness to Invest in a New HDR Isotope
Raymond Mailhor Vega, NYU Cancer Center

PP27
PP28
PP29
PP30

Scientific Session: Socioeconomic Proffered Papers
Friday, April 21, 2017
3:30 PM - 4:30 PM

Factors Associated with Willingness to Invest in a New HDR Isotope
Raymond Mailhor Vega, NYU Cancer Center

PP31
PP32
Quality of Life After I-125 Seeds Implantation in Patients with Advanced Malignant Tumor
Panfeng Wang, Department of Radiotherapy in Peking University Third Hospital

PP33
Social and Racial Divides in the Utilization of Brachytherapy for Common Malignancies
Zachary Horne, University of Pittsburgh Cancer Institute

PP34
The Successful Implementation of High Dose Rate 192-Ir Brachytherapy for Cervix Cancer in a Low-Middle Income Country
Sommer Nurkic, University of Florida College of Medicine

PP35
Starting a Prostate HDR Program in a Young Cancer Center - 1st Year Experience
Aimee Lauzon, CISSS Laval

PP36
Reducing Prostate High Dose Rate Brachytherapy Treatment Planning Duration Through Targeted Interventions
Abhishek Solanki, Loyola University Chicago

Scientific Session: Breast Snap Orals (E-Poster)
Friday, April 21, 2017
5:45 PM - 6:45 PM

BSOR1
Use of Phantoms to Simulate Breast Brachytherapy Insertion
Harry Brastianos, Queen's University

BSOR2
Impact of the Dosimetric Consequences from Minimal Displacements Throughout the Treatment Time in APBI with SAVI Applicators
Shereen Chandrasekara, Florida Atlantic University

BSOR3
Skin Dose Estimation for Contura Multi-Lumen Balloon Breast Brachytherapy
Y. Jessica Huang, University of Utah

BSOR4
The Consistency Dosimetric Analysis of the Accelerated Breast Brachytherapy
Janeil Pinder, Florida Atlantic University

BSOR5
Local Failure by Biological Subtype After Accelerated Partial Breast Irradiation Using Single-Entry Catheters
Aman Saini, Midwestern University

BSOR6
Accelerated Partial Breast Irradiation in the Era of Large Gene Array Genetic Testing
Linda Smith, Comprehensive Breast Care

BSOR7

Clinical and Toxicity Outcomes in Asian Women with Limited Breast Volume Using Multicatheter Accelerated Partial Breast Irradiation
Johann Tang, National Cancer Institute Singapore

BSOR8 Presentation Time: 6:20 PM
Disparities and Trends in Brachytherapy Utilization by Race for Patients with Breast and Prostate Cancer
Ozer Algan, University of Oklahoma

BSOR9 Presentation Time: 6:25 PM
Intraoperative Radiation (IORT) as Adjuvant Radiation Monotherapy for Early-Stage Breast Cancer Patients Treated with Breast Conserving Surgery
Gary Proulx, Massachusetts General Hospital

BSOR10 Presentation Time: 6:30 PM
Initial Evaluation of Multicatheter Brachytherapy Technique for Lumpectomy Cavity Boost
Steven Skolnik, Arizona Center for Cancer Care

BSOR11 Presentation Time: 6:35 PM
Clinical Experience Using Accelerated Partial Breast Irradiation: First 101 Patients Treated at Gamma West Cancer Services
Brandon Fisher, Gamma West Cancer Services

BSOR12 Presentation Time: 6:40 PM
Ten Year Results of Accelerated Partial Breast Irradiation (APBI) Using Interstitial Multicatheter High Dose Rate Brachytherapy (HDR BT) After Breast Conserving Surgery for Low Risk Invasive In Situ Breast Cancer
Sylwia Kellas-Sleczka, Maria Sklodowska-Curie Memorial Cancer Center and Institute of Oncology Gliwice Branch

Scientific Session: Miscellaneous Snap Orals (E-Poster)
Friday, April 21, 2017
5:45 PM - 6:45 PM

MSOR1 Presentation Time: 5:45 PM
Radiation-Emitting Expandable Stents for Portal Vein Tumor Thrombosis
Jin-He Guo, Zhong-Do Hospital

MSOR2 Presentation Time: 5:50 PM
Analysis of Related Factors the Incidence of Postoperative Pneumothorax After CT-Guided Iodine-125 Implantation in the Treatment for Patients with Lung Cancer
Xiaodong Huo, The Second Hospital of Tianjin Medical University

MSOR3 Presentation Time: 5:55 PM
Efficacy and Safety of Stents Loaded with I-125 Seeds Versus Conventional Stents Treatment for Patients with Medium Terminal Cancer of Esophagus: Meta-Analysis and Systematic Review
Dingkun Hou, The Second Hospital of Tianjin Medical University

MSOR4 Presentation Time: 6:00 PM
Unresectable Hepatocellular Carcinoma with Tumor Thrombus in the First Order Portal Vein Branch Treated by Linear Iodine125 Seeds Strand Implantation Combined with Transarterial Chemoembolization: A Propensity Sore Analysis
Zi-Han Zhang, Zhongshan Hospital, Fudan University
MSOR5  Presentation Time: 6:05 PM
CT-Guided Iodine-125 Seeds Implantation Combined with Chemotherapy for Locally Advanced Pancreatic Carcinoma
Wujie Wang, The Second Hospital of Shandong University

MSOR6  Presentation Time: 6:10 PM
Preliminary Clinical Experience from a Phase I Feasibility Study of a Novel Permanent Unidirectional Intraoperative Brachytherapy Device
Neil Taunk, Memorial Sloan Kettering Cancer Center

MSOR7  Presentation Time: 6:15 PM
Histopathological Analysis of Naïve Swine Esophagus Irradiated with a Brachytherapy Stent Demonstrated Favorable Tissue Tolerance of High Mucosal Tissue Doses
Arnold Herskovic, Rush University Medical Center

MSOR8  Presentation Time: 6:20 PM
A Novel Irradiation Stent for the Treatment of Malignant Hilar Biliary Obstruction: A Case Series
Jian Lu, Zhongda Hospital, Southeast University

MSOR9  Presentation Time: 6:25 PM
Custom Mold Technique with 3D Printed Applicator “Shell” in Penile HDR Brachytherapy
Laszlo Voros, Memorial Sloan Kettering Cancer Center

MSOR10  Presentation Time: 6:30 PM
Clinical Investigation of Iodine125 Radioactive Particles Treatment in Single Brain Metastasis of Non-Small Cell Lung Cancer
Xiaokun Hu, Affiliate Hospital of Qingdao University

MSOR11  Presentation Time: 6:35 PM
Prescription Depth in Surface Skin Brachytherapy
Domingo Granero, ERESA-Hospital General Universitario

MSOR12  Presentation Time: 6:40 PM
High Dose-Rate Brachytherapy Treatment of Psoriasis of the Nail Bed Using Custom Made Micro Applicators
Ivan Buzurovic, Dana-Farber/ Brigham Women’s Cancer Center, Harvard Medical School

Scientific Session: Breast Proffered Papers
Saturday, April 22, 2017
9:00 AM - 10:00 AM

PP37  Presentation Time: 9:00 AM
Long-Term Outcomes of Women with Invasive Non-Ductal Breast Cancers Treated with Multicatheter Interstitial Accelerated Partial Breast Irradiation
Bethany Anderson, University of Wisconsin

PP38  Presentation Time: 9:09 AM
Long-Term Outcomes of Accelerated Partial Breast Irradiation via Multi-Catheter Interstitial HDR Brachytherapy
Prashant Gabani, Washington University School of Medicine

PP39  Presentation Time: 9:18 AM
Fractionation Trends in Breast Cancer and Implications in Partial Breast Irradiation
Daniel Trifiletti, University of Virginia Health System

PP40 Presentation Time: 9:27 AM
A Quantitative Evaluation of Pd-103 Permanent Breast Seed Implant Mark-Up Procedure
Danielle Anderson, BCCA - SAH Centre for the Southern Interior

PP41 Presentation Time: 9:36 AM
Seed Distribution Stability in Permanent Breast Seed Implant Brachytherapy
Michelle Hilts, BC Cancer Agency - Southern Interior

PP42 Presentation Time: 9:45 AM
Feasibility and Clinical Value of CT-Guided 125I Brachytherapy in Pain Palliation of Bone Metastases from Breast Cancer
Zhiqiang Mo, Sun Yat-sen University Cancer Center

Scientific Session: Prostate Proffered Papers II
Saturday, April 22, 2017
10:30 AM - 11:30 AM

PP43 Presentation Time: 10:30 AM
Effect of Different Hypofractionated Regimens Combination on Clinical Outcomes in Prostate Cancer Patients Treated with High Dose-Rate Brachytherapy Boost
Eric Vigneault, CHUQ L'Hôtel Dieu de Québec, Centre de Recherche sur le Cancer-Université Laval

PP44 Presentation Time: 10:39 AM
Long-Term Outcome of Low-Dose Rate Brachytherapy with I-125 Seeds as a Monotherapy for High-Risk Prostate Cancer Patients
Takashi Kawanaka, Tokushima University

PP45 Presentation Time: 10:48 AM
Feasibility and Dosimetric Outcomes of MRI-Based Planning for Delivery of High-Dose-Rate Brachytherapy for Prostate Cancer
Sean All, University of Central Florida College of Medicine

PP46 Presentation Time: 10:57 AM
MRI-Based Prostate Brachytherapy - Imaging with and without an Endorectal Coil for Post-Implant Quality Assurance
Jeremiah Sanders, MD Anderson Cancer Center

PP47 Presentation Time: 11:06 AM
Validation of MRI to US Registration for Focal HDR Prostate Brachytherapy
Eric Poulin, CHU de Québec

PP48 Presentation Time: 11:15 AM
Automated Prostate Brachytherapy Seed Detection on Post-Implant MRI Using Novel Martin Algorithm
Geoffrey Martin, University of Texas MD Anderson Cancer Center
GSOR1 | Presentation Time: 11:30 AM
Understanding Outcome Beyond EQD2 in Tandem and Ovoid Cervical Cancer Brachytherapy Treatments
Emma Fields, Virginia Commonwealth University

GSOR3 | Presentation Time: 11:40 AM
Sustainable Gynecological Brachytherapy in an Increasingly Cost-Aware Healthcare System: Conversion of Labor-Intense Interstitial Brachytherapy to Hybrid Intracavitary Brachytherapy for Locally Advanced Cervical Cancer
Brandon Dyer, University of California Davis Comprehensive Cancer Center

GSOR4 | Presentation Time: 11:45 AM
Survival Outcomes in Women with Early Stage Uterine Non-Endometrioid Carcinoma with Adjuvant Chemotherapy and Vaginal Brachytherapy Alone
Joon Lee, Henry Ford Hospital

GSOR5 | Presentation Time: 11:50 AM
Detecting Applicator Displacement During HDR Interstitial Brachytherapy for Gynecologic Malignancies
William Taylor, The Ohio State University

GSOR6 | Presentation Time: 11:55 AM
Impact of Adaptive Planning on Image-Guided Perineal Brachytherapy for Gynecologic Malignancies
Adam Gladwish, Sunnybrook Health Sciences Centre

GSOR7 | Presentation Time: 12:00 PM
Outcomes of Locally Advanced Cervical Cancer Patients Following the Use of the Hybrid Intracavitary and Interstitial Utrecht Tandem and Ovoids Applicator in an Outpatient Setting
Amanda Rivera, Montefiore Medical Center

GSOR8 | Presentation Time: 12:05 PM
Deformable Registration for MRI Based Brachytherapy - Ready to Replace MRI with Applicator in Place?
Junzo Chino, Duke Cancer Institute

GSOR9 | Presentation Time: 12:10 PM
Early Outcomes and Impact of a Hybrid IC/IS Applicator for a New MRI-Based Cervical Brachytherapy Program
Matthew Harkenrider, Loyola University Chicago, Stritch School of Medicine

GSOR10 | Presentation Time: 12:15 PM
Intracavitary versus Intracavitary/Interstitial HDR Brachytherapy for Cervical Cancer: Dose Difference to High Risk Clinical Target Volume
Kamal Akbarov, National Center of Oncology

GSOR11 | Presentation Time: 12:20 PM
Competency Evaluation for Gynecologic Brachytherapy for Radiation Oncology Residents
Allison Quick, Ohio State University

GSOR12  Presentation Time: 12:25 PM
The Role of Interstitial Brachytherapy in Gynecologic Malignancies. The Importance of MRI Compatible Applicators in Volume Definition and Treatment Planning
Silvia Rodriguez Villalba, Hospital Clinica Benidorm

Scientific Session: Prostate Snap Orals (E-Poster)
Saturday, April 22, 2017
11:30 AM - 12:30 PM

PSOR1  Presentation Time: 11:30 AM
Three Year Results of a Prospective Study on Focal Salvage HDR Prostate Brachytherapy After Previous Definitive External Beam Radiotherapy (XRT)
Hans Chung, Sunnybrook Odette Cancer Center

PSOR2  Presentation Time: 11:35 AM
Robotically-Assisted 3D Ultrasound-Guided High-Dose-Rate Prostate Brachytherapy
William Hrinivich, Western University

PSOR3  Presentation Time: 11:40 AM
Placement of an Absorbable Rectal Hydrogel Spacer in Patients Undergoing Low-Dose-Rate Brachytherapy with Pd-103 Seeds
Amandeep Taggar, MSKCC

PSOR4  Presentation Time: 11:45 AM
Are Standard Dosimetric Parameters Accurately Representing the Dose to the Bladder Neck in MRI-Guided High Dose-Rate Prostate Brachytherapy?
Joelle Helou, University of Toronto

PSOR5  Presentation Time: 11:50 AM
Gastrointestinal Toxicity and Colorectal Cancer Screening in the Setting of Prostate Brachytherapy
L. Matthew Scala, Kaiser Permanente Santa Clara

PSOR6  Presentation Time: 11:55 AM
Prostate Downsizing with Degarelix Prior to Brachytherapy: Results of a Phase II Trial
Martin Korzeniowski, BC Cancer Agency

PSOR8  Presentation Time: 12:05 PM
Early Toxicity and Health Related Quality of Life Results of HDR Brachytherapy as Monotherapy for Low/Intermediate Risk Prostate Cancer
Marc Gaudet, The Ottawa Hospital

PSOR9  Presentation Time: 12:10 PM
Prostate Brachytherapy Procedural Training: Incorporation of Related Procedures in Resident Training and Competency Assessment
Michael Folkert, UT Southwestern Medical Center

PSOR10  Presentation Time: 12:15 PM
Single Radiation Therapy (EBRT) vs Combined Treatment (EBRT + BT) in Intermediate and High Risk Prostate Cancer. Are We Sure That Exclusive EBRT Is a Valid Approach Treatment Mode?
Silvia Rodriguez Villalba, Hospital Clinica Benidorm
MRI-Guided Transperineal Prostate Biopsy Using Commercially Available Prostate Biopsy Planning Systems
K. Hsi, Peninsula Cancer Center

GYN Posters

PO01
Overall Treatment Days (OTD) Relationships of BRT Boost. The Treatment Timing Effectiveness on Survival
Fabrizio Piro, Radioterapia Oncologica

PO02
Clinical Outcomes and Dosimetric Optimization in CT Based Interstitial Brachytherapy Using MUPIT in Gynecological Malignancy
Vibhay Pareek, Jupiter Hospital

PO03
3D Printing Individual Applicator Used for Interstitial Brachytherapy in Recurrent Cervical Cancer
Ang Qu, Peking University Third Hospital

PO04
To Avoid Dosimetric Uncertainties About a Possible Movement of the Applicator, After Positioning, Centering and Execution HDR Brachytherapy in Cervical Cancer
Francesca Vallerga, S.S. Brachytherapy Ospedale San Paolo

PO05
Patterns of Local Recurrence After Hybrid of Intracavitary and Interstitial Brachytherapy for Locally Advanced Cervical Cancer
Naoya Murakami, National Cancer Center Hospital, Tokyo, Japan

PO06
Cumulative Dosimetric Evaluation of the Organs at Risk in Vaginal Cuff Brachytherapy with Multi-Lumen Cylinder Applicators
Nicolae Dumitru, Florida Atlantic University

PO07
Image Guided High Dose Rate Intracavitary Brachytherapy in the Treatment of Medically Inoperable Early Stage Endometrioid Type Endometrial Adenocarcinoma
Scott Jordan, Temple Health Fox Chase Cancer Center

PO08
¹²⁵I Seed Implantation in the Treatment of 3 Cases of Recurrent Cervical Cancer
Yongbing Xu, Oncology Dep.1 of Hebei General Hospital

PO09
Use of Deformable Registration to Assess Dose to Normal Tissue for HDR Vaginal Implants
Vrinda Narayana, Providence Hospital

PO10
The Consistency of Treatment for GYN Cancer with HDR Using MLC
Marjan Shojaei, Florida Atlantic University
PO11
Dynamics of the Vaginal Wall Dose in HDR Interstitial Brachytherapy for Gynecological Cancer: Phantom vs. Patient Case
Robert Kim, University of Alabama at Birmingham

PO12
Early Institutional Experience with Intracavitary Multichannel Vaginal Cylinder Brachytherapy Boost
Ericka Wiebe, Cross Cancer Institute

PO14
Systematic Checking of the Location of Brachytherapy Applicators in the Treatment of the Vaginal Cuff: Necessity to Guarantee Treatment Success
Silvia Rodriguez Villalba, Hospital Clinica Benidorm

PO15
Implementation and Advantages of a Pre-Planning Technique for Interstitial Gynecological Brachytherapy
Michael Ashenafi, Medical University of South Carolina

PO16
How Often Are Advanced Vaginal Recurrences Amenable to Intracavitary Brachytherapy After External Beam Radiotherapy?
Jagdeep Raince, UCLA

PO17
Feasibility of Pneumo-Occluder Balloon in Place of Vaginal Packing During Ring and Tandem HDR Brachytherapy for Cervical Cancer
Payal Soni, University of Michigan

PO18
Boosting Rectovaginal Disease Using Multi-Channel Capri Balloon Applicator Brachytherapy
Leah Katz, NYU Langone Medical Center

PO19
Acute Catheter Complications from Perineal Interstitial Brachytherapy (ISBT) in Gynecological Cancer Patients: A Prospective Analysis of Organ Injury, Infections and Radiological Needle Intrusions
Eric Leung, Sunnybrook Health Sciences Centre, Odette Cancer Centre

PO20
Feasibility Study of Toxicity Outcomes Using GEC-ESTRO Contouring Guidelines on CT Based Instead of MRI-Based Planning in Locally Advanced Cervical Cancer Patients
Johann Tang, National Cancer Institute Singapore

PO21
Dual-Tandem Brachytherapy for Stage I Endometrial Cancer: An Eight-Year Experience
David Arsanious, University of Vermont Medical Center

PO22
Transition from LDR to HDR Brachytherapy for Cervical Cancer: Evaluation of Tumor Control, Survival, and Toxicity
PO25
Evaluation of Distortions in Electromagnetic Navigation of Catheters for Image-Guided Gynecological Brachytherapy
Mark Semple, Odette Cancer Centre, Sunnybrook Health Science Centre

PO26
Does Variable $^{192}$Ir Dose Rate Affect Vaginal Toxicity in High-Dose-Rate Brachytherapy?
Christopher Tien, Yale University School of Medicine

PO27
Salvage EBRT and HDR Brachytherapy for Isolated Vaginal Recurrence of Endometrial Cancer in Patients with No Prior Adjuvant Therapy
Christopher Chapman, University of California San Francisco

PO28
The Prognostic Value of Lymphovascular Space Invasion in Locoregional Endometrial Cancer by Adjuvant Treatment and Stage
Samual Francis, University of Utah Huntsman Cancer Hospital

PO30
Disparities in Utilization and the Survival Value of Brachytherapy for Cervical Cancer in California
Jyoti Mayadev, UC Davis Medical Center

PO32
Five Years Outcomes of Image Guided Brachytherapy (IGBT) with Inverse Planning for Locally Advanced Cervical Cancer
Samuel Bergeron Gravel, CHU de Québec and Université Laval

PO33
Feasibility of a Biomechanical Model Based Deformable Image Registration for MRI Guided CT-Based Brachytherapy for Locally Advanced Cervical Cancer
Yi Rong, University of California Davis Comprehensive Cancer Center

PO34
High Dose-Rate Tandem and Ovoid Brachytherapy in Cervical Cancer: Dosimetric Predictors of Disease Control and Toxicity
Daniel Trifiletti, University of Virginia Health System

Miscellaneous Posters

PO36
Investigation of a New Device to Improve Dosimetric Outcomes in Intravascular Brachytherapy
Joseph DeCunha, McGill University

PO38
Clinical Study of CT-Guided 3D Print Coplanar Template and Bare Hand in Brachytherapy
Haitao Wang, The Second Hospital of Tianjin Medical University

PO39
The Initial Study on the Dosimetry and Safety of Self-Expandable Esophageal Stent Loaded with $^{125}$I Seeds in Treatment of Esophageal Cancer
Kaixian Zhang, Tengzhou People's Central Hospital

PO41
\(^{125}\text{I} \text{ Brachytherapy Alone for Recurrent or Locally Advanced Salivary Gland Cancers of Maxillary Region}
Ming-wei Huang, Peking University School and Hospital of Stomatology

PO43
The Clinical Use of I-125 Brachytherapy to Treat Malignant Adenogenous Tumors Invaded Cranial Base Area
Ning Xu, Peking University School of Stomatology

PO45
Directional LDR Intraoperative Brachytherapy for Head and Neck Cancer
Sean Cavanaugh, Cancer Treatment Centers of America

PO46
Nuclei Size Distribution as a Predictor for Radiosensitivity with \(^{192}\text{Ir} \text{ Brachytherapy}
Nguyen Traong, McGill University

PO49
Iodine-125 Implantation Combined with Radiofrequency Ablation in the Treatment of Hepatocellular Carcinma: A Meta Analysis
Haitao Wang, The Second Hospital of Tianjin Medical University

PO50
Iodine-125 Seed Implantation in the Treatment of Locally Recurrent Sacrococcygea Chordoma: Report of 3 Cases and Review of Literature
Junjie Yang, Oncology Dep. 1 of Hebei General Hospital

PO51
Iodine-125 Salvage Therapy for Recurrent Gliomas
Xueda Li, Affiliate Hospital of Qingdao University

PO52
The Role of Real-Time Optimization of Radioactive Seed Implantation in Treatment of Gliomas
Shifeng Liu, Affiliate Hospital of Qingdao University

PO53
The Influence of Target Volume by CT-MRI Image Fusion in Brachytherapy for Intracranial Malignant Gliomas
Shifeng Liu, Affiliate Hospital of Qingdao University

PO54
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Jekwon Yeh, Cancer Center of Irvine

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Jekwon Yeh, Cancer Center of Irvine
Purpose: Image Based Brachytherapy (IBBT) is a vital component of the standard care for patients with locally advanced cervical cancer. IBBT allows for more accurate dose delivery to the target, allowing for dose escalation of large targets and sparing of normal organs with small targets. Several institutions and groups have reported early retrospective outcomes of IBBT and a multi-institution prospective evaluation is underway. We sought to evaluate a large cohort of cervical cancer patients treated with MRI-guided IBBT at a single institution with intermediate to long-term follow-up. Materials and Methods: We identified the first 225 cervical cancer patients consecutively treated with MRI-guided IBBT between 2007 and 2016 at our institution. Five patients who had less than 3 months follow-up were excluded. Patients were FIGO stage IB1-IVA and were treated concurrently with EBRT (typically 45 Gy in 25 fractions to the pelvis +/- paraaortic region with a boost to suspicious lymph nodes and the side wall when disease extended laterally) and weekly cisplatin. Brachytherapy was typically interdigitated with EBRT starting during the 4th week and consisted of 5 fractions of IBBT using ring and tandem +/- hybrid interstitial needles at 5-6 Gy per fraction. Pretreatment PET/CT scan results were available for 97% of patients. Radiotherapy dosage is reported as the biologically equivalent dose at 2 Gy per fraction (EQD2) cumulatively from both EBRT and IBBT. The minimum dose received by 90% (D90) of the high risk clinical target volume (HRCTV) and the most heavily irradiated 2 cc (D2cc) of normal tissue is reported. Toxicity grading was per common terminology criteria for adverse events (CTCAE) version 4 with any toxicity (excluding ureteral stenosis) more than 3 months post treatment considered as late toxicity. Results: Of the 220 evaluable patients, baseline characteristics were as follows: 80% squamous cell, 16% adenocarcinoma; stage IB1 9%, IB2 10%, IIA1 3%, IIA2 1%, IIB 56%, IIBB 20%, IVA 1%; 21% grade 1, 30% grade 2, 49% grade 3, median tumor size 5cm (interquartile range [IQR] 4-6 cm), 48% node positive by PET. Treatment characteristics were as follows: 78% IMRT use; 90% ring and tandem (R&T), 10% hybrid R&T plus interstitial; 81% completed treatment within 8 weeks, 93% within 9 weeks; median HRCTV volume 31 cc (IQR 26-39.3), median HRCTV D90 83.7 Gy (IQR 81.8-85.4), median bladder D2cc 75 Gy (IQR 69.6-79.7), median rectum D2cc 54.9 Gy (IQR 52.5-57.7), median sigmoid D2cc 62.8 Gy (IQR 58.7-67). At a median follow-up of 29 months (IQR 13-49), the 3-year local control (LC), locoregional Control (LRC), and distant control (DC) were 89.5%, 87.1%, and 85.9% respectively, this translated into a disease free survival (DFS), overall survival (OS), and cancer specific survival (CSS) of 76%, 76.2%, and 85.5% respectively. Univariate analysis of local recurrence demonstrated adenocarcinoma histology was associated with higher local failure (OR=2.9, p=0.04) as was HRCTV volume (OR=1.058 per cc, p=0.004). A single patient developed acute grade 3 diarrhea and 4 patients developed any grade 3-4 late toxicity (2.2% at 3 years). Late toxicity consisted of three patients with vesicovaginal fistula, and one with rectovesicovaginal fistula. A subset-analysis of 82 patients with at least 3 years (median 4.8 years [range 3-8.9 years]) of follow-up revealed only one local recurrence beyond 3 yrs (56 months at the distal vagina) and 3 distance recurrences (36, 48, and 62 months). No grade 3 or higher toxicity beyond 3 years occurred. Conclusions: Herein we have reported on one of the largest and most mature cohorts of patients who have received MRI-guided IBBT in the management of cervical cancer. Our results suggest that IBBT is associated with
PP02

Presentation Time: 8:09 AM

Is There a Role of Neoadjuvant Radiotherapy Including High Dose Rate Image-Based Brachytherapy in Locally Advanced Type II Endometrial Cancer Clinically Extending to Cervix ± Parametria?

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Purpose: Pre-operative chemoradiation (CRT) including a combination of external beam radiotherapy plus brachytherapy is used as an alternative to upfront surgical staging in patients with locally-advanced endometrial cancer extending to the cervix ± parametria. Performing pre-operative treatment therefore increases likelihood of resection with negative margins and leads to less extensive surgery in a patient population often with significant comorbidity. However, for patients with type II cancers concerns of radiation resistance and aggressive biology has limited the application of pre-operative radiation therapy. We hypothesize that despite aggressive biology pre-operative CRT including image-based brachytherapy remains a viable treatment option for patients with type II cancer with high rates of down-staging and response. Materials and Methods: A retrospective review was performed from 2008-2016. Twenty-four patients with type II endometrial cancer with clinical evidence of cervical ± parametria involvement who were treated using neoadjuvant external beam radiotherapy (45-50.4 Gy in 25-28 fractions) and Ir-192 HDR brachytherapy (5-5.5 Gy in 3-4 fractions) ± concurrent and adjuvant chemotherapy were identified and reviewed. Patients with type I cancer or those treated in the re-irradiation setting were excluded. CT/MRI imaging was performed for each fraction of brachytherapy. HRCTV and organs at risk were identified. Total doses were converted to EQD2 with planned HRCTV doses of 65-70 Gy. Results: The median age of the cohort of was 68 years with median BMI 31. Pathologic characteristics were as follows: 42% were carcinosarcoma, 25% papillary serous, 17% clear cell and the remaining 17% had mixed but majority type II histology. All patients had clinical and radiographic cervix involvement with 63% having parametrial extension. Fifty-four percent of patients had clinical or radiographic nodal involvement (8% pelvic only, 46% pelvic + para-aortic, and 4% non-regional inguinal nodes + pelvic). Concurrent weekly cisplatin (40mg/m2) was administered to 88% of the patients. Surgery was performed at a median of 7 weeks after completion of brachytherapy. After surgery, 79% received adjuvant chemotherapy which was most commonly carboplatin and paclitaxel. The median D90 to HRCTV was 67Gy (range: 62-73); the median D2cc for the bladder, rectum, and sigmoid was 64Gy (58-70), 51Gy (48-59), and 58Gy (45-63) respectively. Twenty-three patients (96%) completed the full planned course of therapy including extra-fascial hysterectomy. The one patient who did not, had disease progression outside of the pelvis on restaging after radiotherapy. Pathological and clinical complete response within the cervix and uterus occurred in 17%, and 35% of the cohort, respectively. The remaining 48% had residual macroscopic disease. At the time of surgery 70% had no pathologic cervical involvement, and 91% had margin negative resection. Median follow-up from the time of surgery was 11 months (range: 0-95). The 1-year local control, regional control, distant control, disease-free survival and overall survival for patients completing the full course of therapy were 88%, 84%, 73%, 48%, and 56%, respectively. There was no acute grade 3+ toxicity specifically attributable to radiation. One patient died within 90 days of surgery due to postoperative cardiopulmonary complications. One patient developed an abdominal incision infection requiring debridement, wound vac, and IV antibiotics. Late grade 3 small bowel obstruction was observed in one patient (4%), which was managed conservatively. Conclusions: This is the largest report of neoadjuvant CRT for type II locally advanced endometrial cancer. Pre-operative treatment effectively increases the likelihood of achieving complete resection with negative margins in the majority of advanced type II endometrial cancer patients and should be considered a viable alternative to upfront surgical staging.

PP03

Presentation Time: 8:18 AM

low rates of severe acute or late toxicity and leads to excellent rates of local control. Long-term follow-up suggests this impressive tolerability and efficacy extends well beyond 3 years.
Clinical Outcomes Using Image Guided Interstitial Brachytherapy for Definitive Cervical Cancer Patients with High Risk Clinical Target Volumes Greater Than 30 cc

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Purpose: Subset analysis from retroEMBRACE shows a 10% improvement in local control outcomes utilizing image-guided adaptive brachytherapy (BT) with hybrid BT (intracavitary+interstitial) for patients with high-risk clinical target volumes (HR-CTV) over 30 cc compared with those treated with intracavitary BT only. There is limited clinical data using image-guided interstitial BT for patients with HR-CTVs greater than 30 cc and so we reviewed our institutional experience with this approach.

Materials and Methods: A retrospective review of cervical cancer patients with HR-CTVs over 30 cc treated with an image-guided interstitial BT boost between 2010-2013 was performed. A total of 38 patients were identified. Distribution by FIGO stage was: 7.9% (3/38) I, 26.3% (10/38) II, 50.0% (19/38) III, and 15.8% (6/38) IVA. 68.4% were node positive. 84.2% had squamous cell cancer. Median age was 51 years (range 23-89). 92.1% received concurrent chemotherapy. All patients were treated with external beam radiation therapy to a median dose of 45 Gy (range, 36 - 50.4 Gy) before receiving BT. High-dose-rate BT was delivered in a single implant to a median dose of 6 Gy × 5 fractions to a CT-defined volume. Median total equivalent 2-Gy dose (EQD2) dose for EBRT+BT was 85 Gy (range 77-85) and D90 to the HR-CTV was 92 Gy (range 72-97). Median HR-CTV volume was 59 cc (range 31-175). Median D2cc for the rectum, sigmoid, and bladder were: 68 (range 60-72), 60 (range 50-72), and 72 Gy (range 63-95). Kaplan-Meier (KM) method was used for actuarial survival analysis, and KM with log-rank test was used for univariate analysis with respect to the following categorical variables: FIGO stage, AJCC stage, nodal status, and chemotherapy. Univariate regression was applied to continuous variables including total EQD2, HR-CTV volume, age and D90. Toxicity was graded using Common Terminology Criteria for Adverse Events, version 4.0.

Results: Median follow-up was 18 months (range 2-55). Three-year actuarial local control and distant control were 78% and 42%, respectively. Seven of the eight local failures were in patients with FIGO IIIB disease and one failure was in a patient with IIB disease. Three year disease-free and overall survival were 36% and 52%. Genitourinary and/or gastrointestinal Grade 3 or higher toxicity was seen in 5 patients (3 FIGO IIIB and 2 IVA disease) for crude rates of 10.5% and 2.6%. Univariate analysis for predictors of local control, distant control, and overall survival showed no significant predictors.

Conclusions: Data from retroEMBRACE reported 3-year local control rates of 93% and 79% for patients with IIB and IIIB disease for all HR-CTVs. In our series of predominantly FIGO stage III/IV patients with a median HR-CTV of about 60 cc our 3-year local control was 78% while achieving a median D90 of 92 Gy. Efforts to improve both local and DM control outcomes in patients with advanced FIGO stage and large HR-CTV volumes are needed.

PP04 Increasing Age Predicts Poor Cervical Cancer Prognosis with Subsequent Effect on Treatment and Overall Survival

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Purpose: Stage and histology are well-established prognostic factors for cervical cancer, but the importance of age has been controversial and a clear role for this factor has not yet been defined. Thus, we aim with this study to evaluate the significance of age as an independent prognostic factor in women with cervical cancer and evaluate the therapeutic consequences and survival outcomes as they relate to this factor.

Materials and Methods: Surveillance, Epidemiology, and End Results (SEER) database was used to retrospectively analyze patients diagnosed with cervical cancer from 1973 to 2013 in the United States. Data collected included demographics, tumor histology and stage, treatment details and survival outcomes. Age was grouped into 20-49, 50-69, ≥70 years. Stage was localized (FIGO IA-IB1), regional (IB2-IVA) and distant (IVB). Treatments were classified as “aggressive” (surgery, external beam (EB) RT + brachytherapy (BT), surgery + BT, surgery + EBRT, or surgery + EBRT + BT) or “non-aggressive” (EBRT alone, BT alone or no treatment). Statistical analysis performed on this data included the use of the Log-Rank test, Chi-squared analysis, and the Cox Proportional Hazards model.

Results: 46,350 women with
cervical cancer were identified using the SEER database. 54% were ages <50 yrs, 33% 50-69, and 13% ≥70 yrs. Older women, particularly those over age 70, show significantly decreased survival trends when stratified by stage and histology (p<0.0001). Furthermore, taking stage, histology, and race into account, increasing age demonstrates negative prognostic significance with a HR of 2.87 for women over age 70 and 1.46 for women ages 50-69. Additionally, women over 70, regardless of stage, are significantly more likely to receive non-aggressive treatment regimens (<0.0001), or no treatment at all (p<0.0001). Finally, older women gain a significant survival advantage from treatment, even with less aggressive regimens, as compared to no treatment at all (p<0.0001), with brachytherapy alone showing the greatest survival benefit (p<0.0001 vs NT; p<0.003 vs EBRT) among less aggressive therapies. When evaluated by stage, brachytherapy continues to hold a significant survival advantage for localized, regional, and distant disease (p<0.0001 vs. NT), with a benefit over EBRT seen as well for women with more advanced disease (p<0.0001). Conclusions: Older women with cervical cancer show a poor overall survival trend that remains consistent among various stages and histologic subtypes. Risk analysis of this study population supports that age is an independent negative prognostic factor, even when accounting for stage, histology, and race. Furthermore, older women less aggressively treated compared to their younger counterparts, with a significant number receiving no treatment at all. Despite this, older women still obtain a survival benefit with less aggressive therapy, particularly with brachytherapy alone. Most interesting is that brachytherapy shows a survival benefit for older women among all cervical cancer stages, supporting the immense potential clinical benefit. In fact, women over 70 with more advanced stage disease showed a significant survival benefit with brachytherapy over external beam radiotherapy as well. Previous studies have created a foundation of literature, which shows that inclusion of brachytherapy in treatment regimens among all age groups improves survival and that older women in general are less likely to be adequately treated for cervical cancer. The novelty of this study lies in the fact that it demonstrates that older women, who we show are at risk for a poorer overall prognosis because of their age, are not only receiving appropriate treatment less often, they are dying more frequently because of it. Our data supports that older women are high-risk group of patients that would benefit significantly from treatment, even if that treatment is brachytherapy alone. Brachytherapy for cervical cancer is a tolerable procedure, even for most elderly women, and should, therefore, remain a standard clinical option for this population, regardless of their stage or histology at diagnosis.

PP05
Management of Elderly Patients with Early Stage Medically Inoperable Endometrial Cancer: Systematic Review and National Cancer Database Analysis
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Purpose: To evaluate the effectiveness of radiation therapy among elderly patients who are deemed medically inoperable. Materials and Methods: We searched PubMed to identify studies from the past 25 years that reported outcomes of medically inoperable endometrial cancer patients treated with radiation alone. The National Cancer Database (NCDB) was queried to identify patients 65 years and older with stage I-II medically inoperable endometrial cancer. Univariable and multivariable models were performed to investigate the impact of prognostic factors on overall survival. Results: Thirteen papers met inclusion criteria for the systematic review. Overall survival for stage I tumors at 5 years was 30-95%. Reported pelvic control for the 1037 patients with early stage tumors was 80-100% for stage I, and 61-89% for Stage II. Late complications for all patients treated ranged from 0-21%. Death from intercurrent disease was as high as 87.5% in one subset of patients. There were 1,261 evaluable uterine cancer patients in the NCDB. EBRT alone was used in 32%, brachytherapy alone in 12%, combination therapy (EBRT + brachytherapy) in 17%, and no radiotherapy used in 39% of patients. The NCDB analysis demonstrated that any radiotherapy was associated with improved survival over no local therapy. Combination therapy (EBRT+brachytherapy) was associated with the most favorable survival with a hazard ratio (HR) of 0.442 (p < 0.001 over no radiotherapy), although benefits were also seen with EBRT alone (HR 0.694, p < 0.001) and with brachytherapy alone (HR 0.499, p < 0.001) compared to no radiotherapy. Conclusions: The available evidence suggests high rates of local control after radiation therapy for elderly women with stage I-II medically inoperable endometrial cancer. Our analysis of the NCDB suggests radiation therapy improves survival, and combination therapy...
therapy provides the most favorable outcomes. Given a relatively favorable toxicity profile, definitive radiation therapy should be considered a preferred approach for patients with medically inoperable endometrial cancer.
We incorporated sociodemographic, facility-specific, and treatment-related covariates including chemotherapy and EBRT. Multivariate Cox regression was used to determine hazard ratios (HR) for mortality with 95% confidence intervals (95%CI) among both the overall cohort and various subgroups of interest. **Results:** 4,272 women were included, with 518 (12.1%) receiving BT without EBRT, and 468 (11.0%) undergoing BT with EBRT. Among the entire analytic cohort, BT was associated with improved OS (HR 0.76, 95%CI 0.68-0.85, p<0.01). This improvement was also noted on subgroup analysis among each age stratum (<60, 60-69, ≥70) and irrespective of margin status or receipt of lymph node dissection, chemotherapy, or EBRT (HR 0.74, 95%CI 0.64-0.87, p<0.01 without EBRT; HR 0.75, 95%CI 0.63-0.89, p<0.01 with EBRT) (Figure). **Conclusions:** Post-hysterectomy BT is associated with improved OS in UCS, irrespective of age or receipt of other adjuvant modalities, and should not be omitted from the management of this aggressive disease. This finding, coupled with the low utilization rates we identify, suggests that BT is likely underutilized in UCS.

Abbreviations in Figure: CD, Charlson-Deyo comorbidity score; FIGO; International Federation of Gynecology and Obstetrics; H, hysterectomy; LNS, lymph node dissection; ChT, chemotherapy
Scientific Session: Prostate Proffered Papers I  
Thursday, April 20, 2017  
9:00 AM - 10:00 AM

PP07  
Presentation Time: 9:00 AM

Real-Time Transrectal Ultrasound-Based Planning for High Dose-Rate Brachytherapy Boost in Intermediate and High Risk Prostate Cancer

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Purpose: To report clinical outcomes following high dose-rate (HDR) brachytherapy boost delivered as a single fraction with real-time transrectal ultrasound (TRUS) guidance. As patients do not need to be moved for CT based planning, it is hypothesized that the outcome will be as good as or better than studies using HDR boost under CT.

Materials and Methods: A retrospective review was undertaken of all patients treated at a single institution with TRUS-guided HDR boost between June 2009 and December 2011, following the transition from CT to TRUS-based technique. Contouring was done using real-time TRUS imaging. Patients’ date of birth, baseline PSA, and biopsy reports were collected, including information on Gleason score, cores taken and positive, overall surface %, % Gleason 4 or 5, clinical stage, and prostate volume. Patient treatments were recorded, including HDR dosimetric data. PSA values were collected every 3-12 months post treatment. Endpoints were defined as patient death, biochemical disease-free survival (bDFS), local recurrence, and distant metastatic recurrence. bDFS was defined using the Phoenix definition of a PSA +2 ng/mL over nadir. Analysis was done using Kaplan-Meier survival curves. Log-rank tests were done to test significance between risk groups. To find significant predictive factors for survival, the univariate and multivariate cox proportional hazard model was used. Values < 0.05 were considered statistically significant.

Results: There were 239 patients total, median age is 65 years (range 44 to 82 years) and median baseline PSA is 7.2 ng/mL (range 1.5 to 84 ng/ml). 18 patients were Gleason 6 (7.5%), 208 patients were Gleason 7 (87.0%), and the remaining 13 patients were Gleason 8-10 (5.4%). There were three risk groups: low risk (5 patients), intermediate risk (206 patients) and high risk (28 patients). Median follow up duration is 60 months (range 0.03-92.5 months). All patients were planned to receive an HDR boost of 15 Gy. Contouring was done using real-time TRUS imaging. Dosimetry for the HDR boost was as follows: median prostate V100 of 96.4%, V150 of 34.8%, V200 of 11.0%, median urethra Dmax of 122.5%, D10 of 116.0%, and median rectal V80 of 0.03 cc. All patients were followed up with external beam radiation therapy (EBRT). 219 patients (91.6%) were treated with 37.5 Gy in 15 fractions, 6 (2.5%) were treated with 45 Gy in 25 fractions, and 14 (5.9%) were treated with 46 Gy in 23 fractions. 41 patients (17.2%) also underwent androgen deprivation therapy (ADT) before or immediately after radiation. Overall survival was 98.5% at five years, bDFS was 92.6% at five years, local recurrence-free survival was 95.0% at six years, and metastases-free survival was 98.2% at six years. We were unable to define any baseline treatment factors associated with patient outcome. EBRT modality and dose, as well as ADT, did not appear to predict patient outcome. PSA nadirs are higher on average in patients that later develop biochemical failure (median 0.93 ng/ml compared to median 0.14 ng/ml).

Conclusions: A 15 Gy HDR boost performed using real-time TRUS guidance is associated with favourable outcomes, with results comparable to our previously reported results using CT based planning for intermediate risk patients.
Predictive Factors of Long-Term Rectal Toxicity Following I-125 Prostate Brachytherapy with or without External Beam Radiotherapy

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Purpose: To analyze factors and dosimetry parameters associated with rectal toxicity in 2,216 permanent prostate brachytherapy (BT) patients with or without supplemental external beam radiotherapy (EBRT). To investigate how to minimize long-term rectal toxicity. Materials and Methods: This retrospective cohort study examined I-125 brachytherapy patients treated with or without EBRT between 2003 and 2013. A total of 1261 patients (57%) were treated with BT, and another 955 men were treated with BT combined with EBRT. The prescription dose was 145 Gy without EBRT or 110 Gy with EBRT, and the dose to 90% of the prostate (D90) was 110-130% of the prescribed dose. Neoadjuvant androgen deprivation (NAD) was given to 39% of patients. The patient, treatment, and implant factors were examined for an association with rectal toxicity. Toxicity was graded according to the National Cancer Institute’s Common Terminology Criteria for Adverse Events version 4.0. Rectal dosimetry was calculated through dose-volume histogram (DVH) of the rectum using day-1 and day-30 CT-based dosimetry, and expressed as volume of rectum in cc receiving 100% and 150% of the prescription BT dose (RV100 and RV150, respectively), and as % of the prescription dose to 5% and 30% of rectum (RD5 and RD30, respectively). In the combination therapy, EBRT started 6 weeks after the implants and 45Gy in 25 fractions was given to the prostate and seminal vesicles. EBRT was delivered initially as 3 dimensional conformal therapy until 2009, and later as intensity modulated radiotherapy (IMRT). In IMRT planning, the rectal volumes receiving doses higher than 30 Gy, 35 Gy,
and 40Gy should be kept under 35%, 25%, and 15%, respectively. Radiation doses were converted to the biological effective dose (BED) using an α/β ratio of 2 and the D90 values of the prostate on a day-30 CT scan. The Kaplan-Meier method and Cox regression model were used for analysis. **Results:** The median follow-up was 7.6 years. Median RV100 was 0.15 cc at day 1, and 0.56 cc at day 30. Proctitis, rectal bleeding, fecal incontinence, diarrhea, and anal pain occurred in 22.8%, 22.7%, 15.1%, 10.5%, and 9.9% of patients, respectively. Actuarial risk of grade 2+ rectal toxicity was 5.6% at 8 years. The majority cases (89%) of grade 2+ toxicities were diagnosed by the third year. Rectal bleeding accounted for 87% of grade 2+ toxicities. Only 5 patients (0.2%) experienced grade 3. Upon univariate analysis, the likelihood of grade 2+ rectal toxicity was significantly associated with EBRT, RV110, RV100, RD30, RD5, BED, anticoagulant, IMRT, and BT planning method (preplan vs. intraoperative plan). Actuarial risk of grade 2+ was 2.0 % for patients treated with BT alone, and 10.5% for patients receiving EBRT (p<0.001). Only EBRT (p<0.001), RV100 at day 1 (p=0.001), RD30 at day 30 (p=0.01), IMRT (p<0.05), and anticoagulant (p=0.05) fit a Cox regression multivariate model. As RV100 at day 1 increased, so did grade 2+ toxicity: 5.0% for ≤0.2cc (n=1674), 6.0% for 0.2-0.5cc (n=386), 9.6% for 0.5-1.0cc (n=126), and 20.0% for >1.0cc (n=30) (p<0.001). RD30 at day 30 ≤40% (n=1362) resulted in 4.3% of grade 2+ vs. 7.9% for RD30 >40% (n=854) (p<0.001). In patients receiving EBRT, grade 2+ toxicity occurred in 12.8% of 3D-conformal therapy patients and 5.6% of IMRT patients (p=0.001). **Conclusions:** I-125 prostate brachytherapy is well tolerated, especially when used as monotherapy. Rectal dosimetry in BT is relevant to long-term rectal toxicity following BT with or without EBRT. With proper and achievable rectal dose constraints, IMRT yielded less toxicity when used in combination with BT.

**PP09**

**Presentation Time: 9:18 AM**

**Lack of Benefit Associated with External Beam Radiotherapy in Addition to Brachytherapy for Intermediate- to High-Risk Prostate Cancer**

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**Introduction:** Recent randomized trial data suggest a lack of benefit in terms of progression-free survival associated with external beam radiation therapy (EBRT) plus brachytherapy (BT) compared to BT alone for intermediate-risk prostate cancer patients with relatively favorable characteristics (clinical T1c-T2b, and either Gleason 2-6/PSA10-20 or G7/PSA<10 disease). We used a national database to evaluate the whether the addition of EBRT to BT alone would improve prostate cancer specific mortality (PCSM) among a more generalized patient cohort with intermediate or high-risk disease. **Materials and Methods:** Within the SEER-Medicare database, we identified 5,820 patients with National Cancer Center Network (NCCN) intermediate (74.5%) or high-risk (25.5%) prostate cancer diagnosed 2004-2009 and treated with BT plus or minus EBRT and with or without androgen deprivation therapy (ADT). We used Fine & Gray competing risks regression to study whether patients treated with BT+EBRT had better 5-year PCSM than those treated with BT alone after adjusting for race, marital status, age, income quartile, education quartile, year of diagnosis, ADT (none, <=6 months, vs >6 months), and comorbidity level as assessed by the Charlson score. We also conducted subgroup analyses based on Gleason score, clinical T stage, ADT use, and NCCN risk stratifications, including the Zumsteg definitions of favorable vs unfavorable intermediate-risk disease. **Results:** Patients treated with EBRT+BT did not have a significantly better 5-year PCSM compared to those treated with BT alone (2.4% vs 1.0%, hazard ratio [HR] 1.61, 95% confidence interval [CI] 0.87-2.98, p = 0.113). There was no benefit among the favorable intermediate-risk (1.2% vs 0.6%, HR 1.90, 95% CI 0.67-5.37, p = 0.227), unfavorable intermediate-risk (1.0% vs 1.2%, HR 0.55, 95% CI 0.15-20.07, p = 0.375), or high-risk (5.2% vs 2.0%, HR 2.15, p = 0.137) subgroups. There was no benefit among patients with Gleason score 6 (2.1% vs 0.6%, HR 3.10, 95% CI 0.68-14.15, p = 0.144), Gleason score 7 (1.1% vs 0.7%, HR 1.06, 95% CI 0.37-3.01, p = 0.920), or Gleason score 8-10 (6.0% vs 3.6%, HR 1.83, 95% CI 0.59-5.72, p = 0.297) disease. There was also no benefit when patients were stratified with respect to T-stage (T1: HR 0.90, p = 0.853; T2: HR 1.98, p = 0.095; T3: insufficient patient numbers for analysis). Similarly, there was no difference when analyzing only patients who received ADT (3.0% vs 1.4%, HR 1.52, 95% CI 0.89-2.62, p = 0.128) or who did not receive ADT (0.9% vs 0.5%, HR 1.44, 95% CI 0.45-4.60, p = 0.543). **Conclusions:** These results suggest that after adjusting for patient-specific factors including ADT use and comorbidity, patients with intermediate-risk or high-risk prostate...
cancer treated with BT may not benefit from the additional use of EBRT. These findings are consistent with the recent randomized trial showing that men with relatively favorable intermediate-risk disease can be treated with brachytherapy alone and provide a rationale for future prospective trials evaluating brachytherapy with ADT for patients with unfavorable intermediate or high-risk disease.

PP10

Pre-Treatment MRI Staging Predicts for Biochemical Failure in High-Risk Prostate Cancer Treated with Combination High-Dose-Rate Brachytherapy and External Beam Radiotherapy
John V. Hegde, MD1, D. Jeffrey Demanes, MD1, Darlene Veruttipong, MPH1, Jagdeep Raince, MD1, Sang-June Park, PhD1, Mitchell Kamrava, MD2.
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Purpose: It is unknown whether pre-treatment MRI staging information appropriately influences risk stratification, or rather leads to unnecessary risk category inflation. We reviewed men with high-risk prostate cancer to evaluate whether MRI staging predicts for biochemical failure following combination high-dose-rate (HDR) brachytherapy and external beam radiation therapy (EBRT). Materials and Methods: Between 2011-2015, 37 men with National Comprehensive Care Network-classified high-risk prostate cancer (based on baseline clinical and biopsy variables) were also staged with a 3-Tesla multiparametric MRI prior to treatment with combination HDR brachytherapy and EBRT. Pre-treatment and treatment variables, including age, PSA, clinical T-category, biopsy Gleason score (GS), percent positive biopsies, MRI prostate volume, MRI T-category, MRI quantitative parameters, total radiation dose and the use/duration of androgen deprivation therapy (ADT), were evaluated for association with biochemical failure (Phoenix definition) using univariate Cox regression analysis. Results: The median age at diagnosis was 68 years (range 51-83). Median PSA at diagnosis was 9 ng/ml (range 2-100). GS was ≤8 in 38% and 9 in 62%. Clinical T-category (by digital rectal examination) was T1/T2 in 89%, T3a in 8%, and T3b in 3%. MRI T-category was T1/T2 in 65%, T3a in 14%, T3b in 19%, and T4 in 3%. Clinical T-category was upstaged by MRI from clinically-localized (≤T2c) to >T3a disease in 24.3%. The median doses for EBRT and HDR brachytherapy were 45 Gy (range 39.6-50.4) in 1.8-2 Gy/fraction and 21.75 Gy (range 15-24) in 3 fractions (range 1-4). The median duration of ADT was 12 months (range 2-27) in the 81% receiving ADT. With a median follow-up of 30.3 months (range 7.2-62.8), actuarial 3-year biochemical relapse-free survival was 75.7% (95% confidence interval (CI) 52.6-88.6). On univariate analysis (Table), only MRI evidence of seminal vesicle invasion (SVI) predicted for biochemical failure (HR 13.98, 95% CI 2.17-90.09, p=0.0055). PSA at diagnosis (HR 1.02, p=0.052) and MRI evidence of >T3 disease (HR 4.27, p=0.0503) also showed trends for predicting biochemical failure. Other pre-treatment and treatment factors, including radiation dose and ADT use/duration, did not predict for biochemical failure. Conclusions: In men with high-risk prostate cancer treated with combination HDR brachytherapy and EBRT, MRI evidence of SVI predicted for biochemical failure, whereas traditional pre-treatment clinical and biopsy variables were not predictive. Therefore, pre-treatment multiparametric MRI appears useful for identifying men with high-risk prostate cancer who are at higher risk for biochemical failure following this treatment.
Using a Surgical PSA-Threshold (> 0.2 ng/mL) to Define Biochemical Failure in the ASCENDE-RT Phase 3 Trial

**Purpose:** ASCENDE-RT is a trial of definitive radiation therapy for high- and intermediate-risk prostate cancer. In this re-analysis of ASCENDE-RT, a surgical PSA-threshold (> 0.2 ng/mL) is compared to the ASTRO consensus (nadir +2 ng/mL) PSA-threshold to explore the impact of failure definition on the rate of biochemical progression free survival (b-PFS). **Materials and Methods:** ASCENDE-RT registered 276 high- and 122 intermediate-risk patients. Treatment combined 12 months of androgen deprivation therapy (ADT) 8 months of which was neoadjuvant, followed by whole pelvis external beam radiation therapy (EBRT) to 46 Gy and one of two prostate boosts which was the randomization variable. Of the 398 subjects, 200 were randomized to a EBRT boost (DE-EBRT arm) and 198 were assigned to a low-dose-rate brachytherapy boost (LDR-PB arm). Excluding 15 subjects who received neither treatment and correcting 14 crossovers leaves the denominators of used in this analysis (195 for DE-EBRT and 188 for LDR-PB). Median follow up is 6.5 years. **Results:** Compared to the ASTRO consensus, using a > 0.2ng/mL PSA-threshold doubled the number of relapse events from 69 to 139. The increase was overwhelmingly confined to the DE-EBRT subjects, where substituting the lower PSA-threshold increased the number of relapses to 112 from just 48 events using ASTRO. The 7-yr K-M b-PFS for the DE-EBRT declined to 37.7% compared to 76.4% using ASTRO (log rank p < 0.001). In contrast, using the > 0.2 ng/mL PSA-threshold did not significantly worsen b-PFS among LDR-PB subset with 7-yr K-M b-PFS of 86.0% using > 0.2 ng/mL versus 88.0% using ASTRO (log rank p = 0.319). **Conclusions:** Using the ASTRO PSA-threshold as comparator, a surgical PSA-threshold of > 0.2 ng/mL greatly increased the number of biochemical relapse events for the subset of ASCENDE-RT trial patients that received the external beam boost, but had little effect on the subset who received a brachytherapy boost.
Presentation Time: 9:45 AM

Prostate HDR Monotherapy: Initial Efficacy Results from a Randomized Trial of One versus Two Fractions

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Purpose: To determine prostate specific antigen (PSA) response and early disease control rates following high dose-rate (HDR) brachytherapy monotherapy as either 19 Gy x 1 or 13.5 Gy x 2 in early stage prostate cancer.

Materials and Methods: 170 patients were randomized to receive either a single 19 Gy HDR or 13.5 Gy as 2 fractions one week apart, in an REB approved clinical trial. Eligible patients had NCCN low or intermediate risk prostate cancer, prostate volume under 60 cc and no use of androgen deprivation. We have previously reported favourable early toxicity data, with less urinary and sexual morbidity in the 19 Gy arm. Prostate specific antigen (PSA) measurement and digital rectal examination was performed every 3 months for the first year and every 6 months thereafter. Persistently rising PSA or abnormal clinical findings were investigated with imaging, which usually included CT scan, bone scan, multiparametric MRI and prostate biopsy. Trends in PSA over time were investigated using a General Linear Mixed Model, and biochemical disease-free survival (bDFS) was defined using the Phoenix definition. Benign bounce was not considered failure. Kaplan-Meier curves were generated of bDFS and local recurrence-free and metastases-free survival, and log-rank test used to explore differences.

Results: Median follow-up is 27 months (range 12 to 43 months). 87 patients were randomized to receive 19 Gy x 1 and 83 to receive 13.5 Gy x 2. Treatment was delivered using real-time trans-perineal ultrasound guidance, and dose prescribed to prostate with a margin of up to 3 mm. Relative dosimetry was similar between arms (median prostate V100 of 97%, V200 of 11% and D90 of 110%). Two-thirds (66.5%) had low-tier intermediate risk disease, 10.5% had high-tier intermediate and 23% had low risk disease, with no significant difference between arms. In the 19 Gy arm, median PSA at baseline, 12, 24 and 36 months was 6.4, 1.6, 1.2 and 1.35 ng/ml, respectively. Respective values in the 2-fraction arm were 6.3, 1.2, 0.61 and 0.48 ng/ml (Figure 1). PSA decline was more rapid in the 2-fraction arm. PSA continues to decrease in the 2-fraction arm whereas an earlier and higher nadir is apparent with the single fraction. Initial risk grouping was not associated with subsequent PSA kinetics or recurrence. In the 19 Gy arm, 7 patients have relapsed biochemically of whom 6 were found to have local recurrence and were offered local salvage. In the 2-fraction arm, 1 patient developed biochemical failure and was found to have distant metastases. No local recurrence has occurred. Biochemical failure (p=.041) and local recurrence (p=.015) were more common in the 19 Gy arm.

Conclusions: With short median follow-up, we have observed higher PSA values and higher local recurrence rate in the single fraction arm. Contrary to linear-quadratic predictions, 19 Gy does not appear to be biologically equivalent to 27 Gy in 2 fractions. Single 19 Gy should be used with caution as monotherapy, and future protocols should explore higher dose, for example by increasing the prescription dose or by focused intraprostatic boosting.
Commissioning and Clinical Use of the CivaSheet, a Novel Shielded Pd103 Array
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Purpose: The CivaDot, a novel source model in which Pd-103 pellets are embedded in absorbable material and are shielded on one side, creating a unidirectional source plane (CivaSheet, CivaTech Oncology Inc, Research Triangle Park, NC) has been used at our hospital on an IRB-approved protocol. This source may offer dose conformity similar to that offered by HDR IORT, as well the ability to reconstruct the implant after the procedure for followup. Here we describe some of the steps taken in preparation for using the CivaSheet clinically.

Materials and Methods: Two Standard imaging HDR 1000 plus Brachytherapy well chambers, Max-4000 electrometers, and a custom CivaTech dot holder were used to establish in-house calibration of the sources using an ADCL calibrated CivaDot. The ADCL protocol was utilized where four readings taken for each dot at four orthogonal orientations of the jig are averaged to establish calibration factors. The calibration factors were used to verify the source strength of 10% assay of vendor provided CivaDots. The TG43 source information entered in Brachyvision was Monte Carlo generated (Rivard, Brachytherapy 2016). Due to TPS data entry limitations, the 2D anisotropy function had to be rounded and clipped and source size had to be defined as a planar pellet with a 0.01cm length. A dummy Civasheet (6 x 6 CivaDot grid) surrounded by superflab was CT scanned (1mm slice thickness) and used for planning tests in Brachyvision version 13.6 TPS (Varian Medial Systems, Palo Alto, CA). Independent TG43 calculations on a set of
representative points were performed. Source strength verification and post-operative dose evaluation in Brachyvision were performed for all patients treated. **Results:** Uncertainties were found with source placement which is dependent upon the gold artifact. Care needs to be taken with the placement of the dots in CT images as the gold shield artifact may appear aligned with axial orientation, while the dots may not be. Clinical photos of the implanted CivaSheet taken in the OR were used to assist with source reconstruction and with the identification of the shielded and non-shielded side in patient studies. Source angulation can be difficult in Brachyvision although a copy and paste option does exist and helps reduce time spent rotating the dots. The dose matrix properties were adjusted so that the plane separation (0.1 cm) and the resolution set to a height and width of 0.1 cm to match the 0.1 cm cuts used in the CT scanning brachy protocol. Agreement between manufacturers stated activity and our calibration results were within 5% in all cases. In spite of anisotropy table rounding, the TG43 hand calculations and Brachyvision results in homogenous water medium were in overall good agreement (<1%) outside the plane of the sources. 4% agreement was observed in the plane of the source and is attributed to high dose gradients and TPS limitations. **Conclusions:** Commissioning and clinical deployment of the CivaSheet was feasible using Brachyvision for post-operative dose evaluation. Brachyvision dose calculations are in good agreement with previously published Monte Carlo data despite TPS data entry limits.

Correct Dot orientation (Left) and incorrect (Right)

**PP15**

**Presentation Time: 2:39 PM**

**Commissioning of Post-Treatment PET-Based Dosimetry Software for Hepatic Radioembolization with Yttrium-90 Microspheres**


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**Purpose:** Radioembolization via yttrium-90 (⁹⁰Y) microspheres enables selective internal radiotherapy (SIRT) for hepatic malignancies. Even though careful planning of the procedure takes place, including pre-treatment angiograms and technetium-99m labeled macroaggregated albumin (⁹⁹mTc-MAA) SPECT, there is no standard for post-delivery imaging and dosimetry of the microsphere distribution for treatment delivery verification. Recent studies have reported utilizing the small positron yield of ⁹⁰Y (32 ppm) to image patients with PET after their treatment to perform dosimetry analysis. In this study, we compared results from a commercial dosimetry software—MIM SurePlan (MIM Software, Cleveland, OH)—to a MATLAB-based program developed in-house for the purpose of commissioning the software for clinical use. **Materials and Methods:** Dose calculations for both algorithms were tested in phantoms and clinical studies using a dose-point kernel (DPK) and dosimetry formalism reported in MIRD Pamphlet 17 for voxel-based dosimetry. PET images (4.17x4.17x2.03 mm³) were resampled to the published kernel voxel size (3x3x3 mm³) and then convolved with the kernel. MIM saves the resulting dose map to RTDose DICOM; MATLAB resamples the dose map back to the original voxel size and then saves it as a DICOM image. A 4mm/5% gamma test was performed on a masked digital phantom image of a large uniform cylinder (13 MBq/mL, 20.4 diameter, 24.2 cm long), as well as images obtained from a physical ACR phantom filled with ⁹⁰Y chloride solution. Average dose and D70 (Gy) were compared between algorithms on the digital phantom, the ACR phantom, and 5 patient cases representing a variety of scenarios: 2 resin microspheres and 3 glass microspheres; 4 lobar and 1 segmental injection; 3 imaged on the day of treatment and 2 imaged on the next day. **Results:** For the digital phantom, the gamma-pass-rate was 97.26% and the differences between average dose and D70 were 0.076% and 0.10%, respectively. For the ACR phantom, the gamma pass rate was 97.66% and differences for average dose and D70 for the whole phantom and the hot cylinders were <2.3% and <5.1%, respectively. For the clinical cases, the maximum difference for average dose was 6.05% and that for D70 was 8.05%. For average dose, 96.3% of the ROIs had an absolute difference <5%; for D70, 88.9% of the ROIs had an absolute difference <5%. There was no dependence on time between injection and imaging for these differences, suggesting a correct application of decay correction to injection time. **Conclusions:** In summary, gamma-pass-rates and absolute differences in dose statistics, i.e., average dose and D70, for digital and physical phantoms and patient imaging studies were in good agreement between the MATLAB program and the MIM software, with discrepancies likely due to differences in resampling techniques. The results from this study validate the clinical use of MIM SurePlan for post-procedural PET-based dosimetry of ⁹⁰Y radioembolization, laying the groundwork for a standardized method of treatment delivery verification.

**PP16**  
**Retrospective Evaluation of Prostate Cancer Treatment Plan Quality Obtained from Intermediate Energy Sources for High Dose Rate Brachytherapy**  
Gabriel Famulari, Msc¹, John J. Munro III, PhD², Shirin Abbasinejad Enger, PhD²³.  
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**Purpose:** Recent studies have identified and proposed gamma emitting radionuclides in the intermediate energy region that can provide optimal depth dose distributions while reducing shielding requirements compared to ¹⁹²Ir. The impact of source energy on the treatment plan quality was studied in a retrospective evaluation for a prostate cancer patient using a range of high- and intermediate-energy brachytherapy sources: ⁶⁰Co, ¹⁹²Ir, ⁷⁵Se, ¹⁶⁹Yb, and ¹⁵³Gd. The impact of tissue composition and density was also assessed. **Materials and Methods:** Post implant treatment plans were simulated with a Geant4-based Monte Carlo (MC) dose calculation engine, BrachySource, coupled to a column-generation based optimizer, for a prostate cancer patient treated with the microSelectron-V2 source. Treatment plans were simulated using ⁶⁰Co, ¹⁹²Ir, ⁷⁵Se, ¹⁶⁹Yb, and ¹⁵³Gd as the active cores of the source. Two MC calculation protocols were performed: (1) dose calculations for which patient anatomy is modelled as unit density water and (2) dose calculations for which patient anatomy is modelled with accurate chemical composition of tissues and densities are obtained using the HU values from CT scan. **Results:** With 90% of the planning target volume (PTV) receiving over 15 Gy, optimized plans can reduce the PTV V₁₅ to 19.8 %, 18.0 %, 18.5 %, 15.7 % and 11.6 % for ⁶⁰Co, ¹⁹²Ir, ⁷⁵Se, ¹⁶⁹Yb, and ¹⁵³Gd, respectively, without sacrificing the urethral D₁₀, the bladder V₇₅ and the rectum V₇₅. In general, dose homogeneity index (HI) within the PTV increased with decreasing average photon energy. The inclusion of tissue composition and density corrections resulted in a reduction of the PTV D₉₀ (urethral D₉₀) by 0.0 % (0.0 %), 0.8 % (0.7 %), 1.8 % (1.6 %), 3.0 % (4.7 %) and 4.5 % (4.1 %) for ⁶⁰Co, ¹⁹²Ir, ⁷⁵Se,
$^{169}$Yb, and $^{153}$Gd, respectively. **Conclusions:** Intermediate-energy sources have the potential to increase dose homogeneity within the PTV while reducing hot spots in the urethra, bladder, and rectum. This work shows the importance of accurate MC-based treatment planning engine, which can account for tissue composition and heterogeneities, for the dosimetry of intermediate-energy sources.

The authors acknowledge partial support by the CREATE Medical Physics Training Network grant of the Natural Sciences and Engineering Research Council (NSERC) (number 432290) and NSERC Discovery grant (number 241018).

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<th>Structure</th>
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<th>$^{75}$Se</th>
<th>$^{169}$Yb</th>
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Table 1: DVH values for Monte Carlo simulated CT postimplant prostate plans. Plans were optimized for each source.

**PP17**  
**Presentation Time: 2:57 PM**  
**Treatment Planning Using the TG-43 Hybrid Technique for HDR Non-Invasive Breast Brachytherapy Applicators**

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**Purpose:** The AccuBoost HDR $^{192}$Ir non-invasive breast brachytherapy (BT) applicators have been in clinical use for almost a decade. The number of dwell positions, dwell times, and overall treatment time are determined from a nomogram based on Monte Carlo (MC) simulations and radiation dose measurements. This approach has attributes like determining absorbed dose to breast tissue (vs. water) and simplifying the treatment planning with a sophisticated lookup table. However, it is not compatible with image-guided BT, which uses 3D datasets for evaluating dose to patient-specific tissues. Given the current absence of these applicators in HDR treatment planning system (TPS) applicator libraries, a method was developed to permit 3D dose calculations.  

**Materials and Methods:** AccuBoost treatment delivery is based on pairs of parallel-opposed beams of applicators collimating HDR $^{192}$Ir. Due to dose superposition, the dose distribution from one beam/applicator was examined. A virtual source was created based on the combination of dose contributions from all dwell positions. The TG-43 hybrid technique permits characterization of complex, multi-source dose distributions within a conventional TPS using the TG-43 dose calculation formalism. Differing from the standard TG-43 formalism, the source coordinate system was placed in contact with the patient skin. The radial dose function (RDF) was defined along the applicator axis of symmetry ($\theta$=0°). Scaled with the dose rate constant, dose distribution normalization was based on the clinical nomograms for each applicator. The 2D anisotropy function $F(r,\theta)$ was used to account for applicator directionality. A non-clinical BT unit was created in BrachyVision (BV) TPS (Varian Medical Systems, Palo Alto, CA) with the tip to source center distance set to zero. A 0.01cm active length source approximating a point was assigned to this new BT unit to model the AccuBoost 6 cm Skin Dose Optimized applicator. The RDF was input into the TPS with the dose matrix set to (512 mm)$^2$ with 1 mm resolution, then extracted via DICOM-RT export using PYDICOM software and imported into MATLAB 2012A to mitigate rounding and interpolation differences between the MC and BV results. The MC-derived dose distribution and the RDF matrix were used to calculate $F(r,\theta)$. A subset of points was selected from $F(r,\theta)$ to represent the data for $r \leq 10$cm. $F(r,\theta>90^\circ)$ was set=0 to void the dose distribution outside the patient. The dose calculations were performed in a water phantom, using an applicator with a single dwell position. The dose matrix parameters and analysis methods were used to extract the BV dose distribution to calculate the percentage difference between the MC and BV results on a millimeter-scale rectilinear grid.  

**Results:** The TG-43 hybrid method
with the BV TPS was able to replicate the original MC-based dose distributions. With an assortment of RDF values, even setting it to a constant value of unity, the highly-anisotropic dose distribution could be obtained with combination of the RDF and $F(r,\theta)$. The accuracy of this approach is depicted in the isodose plot comparison between the dose distributions from the original MC simulations (top left) and the BV results (top right) with agreement within 2% (bottom left) and 5% (bottom right) for $r \leq 10\text{cm}$. Agreement between BV and MC data was within 5% for >98% of the matrix points, which improved with increasing $F(r,\theta)$ sampling and selecting high-gradient points to minimize BV linear interpolation errors. Another beneficial technique was to select RDF values to further minimize $F(r,\theta)$ interpolation.

**Conclusions:** The multi-source, MC-based dose distributions were accurately characterized within the BV TPS. Combinations of each TG-43 hybrid source could replicate the parallel-opposed beams and resultant dose.
distribution. This approach permits image-guided treatment planning within a conventional and widely-used BT TPS.

**PP18**  
**Presentation Time: 3:06 PM**  
**A Novel Delivery System for High Dose Rate Intensity Modulated Brachytherapy with Intermediate Energy Brachytherapy Radiation Sources Such as $^{169}$Yb**  
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$^2$Oncology, McGill University Health Centre, Montreal, QC, Canada.

**Purpose:** Conventional brachytherapy often results in less than ideal tumor dose conformity due to the non-symmetrical shape of the tumors resulting in dose spillage to radiation sensitive healthy tissues. Intensity modulated Brachytherapy (IMBT) gives a possibility to dynamically direct the radiation towards the tumor and away from healthy tissues by incorporation of partially-shielded brachytherapy sources. However, in interstitial brachytherapy radiation sources are inserted into a patient’s tissue, where the space available for applicators is limited. The thickness of the shield must be in the sub-millimeter range to fit inside existing brachytherapy catheters and yet modify the intensity of the source by several half-value layers. Sub millimeter of a dense metal can shield photons from the recently available high dose rate brachytherapy source, $^{169}$Yb (available since 2016 by SPECMed http://spec-med.com), while several millimeters are needed to shield from the conventionally used $^{192}$Ir source, for which the shield would not fit inside brachytherapy catheters.  

**Materials and Methods:** We have developed a new delivery system for IMBT using intermediate energy brachytherapy radiation sources such as $^{169}$Yb. The prototype delivery system controls the rotation of the shielded catheters while the afterloader controls the movement of the source inside the catheter. The delivery system is standalone, can be used with any commercial afterloader and is placed between the afterloader and the patient. The prototype is divided in three main systems: a rotating system, a link assembly and a shield assembly. The rotation of the shield is controlled through a series of moving panels with an interlock system. Each series of panels can be connected to a separate motor handling that specific shielded needle rotation. This gives the user many degrees of freedom. If the user needs one rotating shielded needle, one panel can be used, if the user needs two needle that will rotate independently of each other, two series of moving panels with an interlock system will be used. Each series of panels can be connected to a separate motor handling the rotation. The shielded needles are connected to the rotating mechanism through flexible luers that will give the radiation oncologist opportunity to implant the needles in angle if needed (not just as straight lines). The motors are equipped with sensors (controller sensors) that control the motor position. A second sensor placed directly on the shield, or at the end of the link assembly, reads the real position of the shield and gives the information back to the controller sensor, which will adjust the rotation of the shield.  

**Results:** Validation of the functionality of the delivery system, validation of the assembly and the connection between the afterloader and the platinum shielded plastic needle and validation of the resistance to wear of the plastic needle during use has been completed. Proof of principle phantom measurements and delivering IMBT dose distributions with clinically acceptable measurement-to-calculation agreement of 1 mm are planned with $^{169}$Yb as the radiation source during the spring.  

**Conclusions:** By developing and making IMBT delivery system clinically available, the potential of brachytherapy will be significantly improved with reduced toxicity, improved therapeutic ratio and clinical outcomes as end-goals. The authors acknowledge partial support by the CREATE Medical Physics Training Network Grant of the Natural Sciences and Engineering Research Council (NSERC) (number 432290) and NSERC Discovery Grant (number 241018).
Patterns of Care and Impact of Brachytherapy Boost Utilization for Squamous Cell Carcinoma of the Base of Tongue in a Large, National Cohort

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1Radiation Oncology, SUNY Downstate Medical Center, Brooklyn, NY, USA, 2Veterans Affairs, New York Harbor Healthcare System, Brooklyn, NY, USA, 3Otolaryngology-Head & Neck Surgery, NYU Langone Medical Center, New York, NY, USA, 4Veterans Affairs, New York Harbor Healthcare System, New York, NY, USA.

Purpose: Brachytherapy (BT) boost has been shown to result in good local tumor control with an acceptable toxicity profile in patients who receive organ preservation treatment for base of tongue (BOT) carcinomas. In this study, the National Cancer Data Base (NCDB) was analyzed to evaluate the patterns of care and impact of BT boost on overall survival (OS) for patients with squamous cell carcinoma (SCC) of the BOT.

Materials and Methods: Patients with non-metastatic squamous cell carcinoma of the BOT between 2004-2012 who received concurrent external beam radiation therapy (EBRT) and chemotherapy with or without BT boost were queried. Patients who had any surgery performed on the primary site were excluded. However, those who had two or more neck nodes removed were considered to have had a neck sampling or neck dissection and were included. Those surviving ≤6 months were excluded. Descriptive statistics were used to compare the two groups and OS was analyzed using the
Kaplan-Meier method. Cox regression was used to identify covariates that affected OS. **Results:** A total of 16,343 patients were included in this study, from which 138 (0.8%) received EBRT + BT and the remaining received EBRT only. Median follow up was 40.6 months. The median EBRT dose for those who did and did not received the BT boost was 6300cGy and 7000cGy, respectively. Neck dissection was performed for 38.4% of BT patients and 11.8% of EBRT patients. The utilization of BT boost declined over time from 2.1% in 2004 to 0.2% in 2012 (p<0.0001) while IMRT use increased from 22.4% in 2004 to 69% in 2012 (p<0.0001). Of those who received a BT boost, 17 (12%) received low dose rate, 70 (51%) received high dose rate and the rest were not specified. Treatment location other than the Northeast was significantly associated with a decreased likelihood of BT (OR 0.05-0.38, p<0.001), as well as year of diagnosis 2007-2009 (OR 0.62, 95% CI 0.43-0.91, p=0.01) and year of diagnosis 2010-2012 (OR 0.25, 95% CI 0.16-0.42, p<0.001). The 3- and 5-year OS was 83.2% and 78.3% for EBRT + BT compared to 76.8% and 68.4% for EBRT only (p=0.02). Multivariable analysis revealed that the addition of BT boost (HR 0.69, p=0.035), the presence of a neck dissection (HR 0.59, p<0.001), and treatment at an academic center (HR 0.87, p<0.001) were associated with improved OS. **Conclusions:** Brachytherapy boost is infrequently used in United States hospitals, and has further decreased in its utilization from 2.1% to 0.2%. However, BT boost was associated with favorable survival outcomes.

**PP20**

**Presentation Time:** 4:09 PM

**Preliminary Clinical Study in Open MRI-Guided 125I Seed Implantation for Treatment of Brain Tumor**

Cheng Li, Professor.

*Interventional MRI, Shandong Provincial Medical Imaging Research Institute, Jinan, China.*

**Purpose:** To investigate the feasibility and effectiveness of open magnetic resonance imaging (MRI) guided 125I seed implantation for the treatment of brain gliomas and metastatic tumors. **Materials and Methods:** A retrospective analysis was performed in 34 cases of clinical diagnosed brain glioma and metastatic tumor, including 6 cases of primary brain glioma, 4 cases of recurrent brain glioma after surgical treatment, 10 cases of recurrent brain glioma after radiotherapy, 6 cases of brain metastases of breast cancer, 8 cases of brain metastases of lung cancer. All the patients received MRI-guided 125I seed implantation. Treatment plan system (TPS) was used to determine the number and spatial distribution of 125I seeds before procedure. The procedure was performed under guidance by MR fluoroscopy and Real-time technique in a 1.0T open MR. CT scan and quality verification were performed within 24 hours after procedures. All the patients were followed up after treatment to evaluate the effectiveness and complications. **Results:** According to the response evaluation criteria of WHO, the response rate of the whole group was 47.1%, 70.5%, 80.1% at 1, 3 and 6 months after operation. The 1-year survival rate was 64.7%. There were no severe complications, except one case of minimal hemorrhage from the needle, one case of epilepsy during the procedure, and one case of cognitive dysfunction 3 months after procedure, which returned to normal 8 months later. **Conclusions:** Open MRI guided 125I seed implantation for the treatment of brain gliomas and metastatic tumors is safe, feasible and effective. MR fluoroscopy and Real-time technique are simple and accurate, and could reduce the incidence of complications.

**PP21**

**Presentation Time:** 4:18 PM

**CT-Guided 125I Brachytherapy for Locally Recurrent Nasopharyngeal Carcinoma**

Huzheng Yan, MD, Fujun Zhang, MD, PhD.

*Sun Yat-sen University Cancer Center, Guangzhou, China.*

**Purpose:** The study evaluated the feasibility, clinical effectiveness, and quality of life of computed tomography (CT)-guided 125I brachytherapy for locally recurrent nasopharyngeal carcinoma (NPC). **Materials and Methods:** We recruited 81 patients diagnosed with locally recurrent NPC after previous radiotherapy with or without chemotherapy. Thirty-nine patients received 125I brachytherapy (group A) and 42 received re-irradiation (IMRT, group B). The evaluated outcomes were local control, complications, and quality of life. Cox proportional hazards regression analysis was used to compare local tumor progression-free survival (LTPFS) and overall survival (OS) in the two treatment groups. **Results:** The median follow-up was 30 months (range, 5-68 months), median LTPFS was 21 in group A and 17 months in group B. The 1-, 2-, and 3-year OS in group A were 84.6%, 51.3%, 30.7%, and 85.7%, 50.0%, and 32.6% in group B. In group A, 10/39 patients (25.6%) experienced at least one ≥grade III complication; no grade V complications occurred. In group B, 28/42 (66.7%) experienced at least one ≥grade III
complication and 6/42 (14.3%) died of severe grade V complications. No significant between-group difference existed in the Quality of Life score on the EORTC QLQ-H&N35 questionnaire before treatment. In group A, quality of life was significantly improved after treatment; but did not improve, or even deteriorated in group B. **Conclusions:** $^{125}$I brachytherapy was a feasible, safe, and effective treatment for locally recurrent NPC. $^{125}$I brachytherapy significantly reduced complications caused by re-irradiation and improved patients’ quality of life.

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**PP22**  
Presentation Time: 4:27 PM  
**Differential Uptake Volume Histograms as a Predictor of Response in Rectal Adenocarcinoma Patients Treated with Preoperative Endorectal Brachytherapy**  
Slobodan Devic, PhD, James Schneider, MSc, Te Vuong, MD, Nada Tomic, MSc, Robert Libhona, MD, Marc Hickey, MD, Guillaume Chaussé, MD, Francois DeBlois, PhD, Jan Seuntjens, PhD, Gerald Batist, MD. McGill University, Montreal, QC, Canada.  
**Purpose:** Diagnostic PET/CT is slowly being integrated into treatment planning process of radiation therapy for many cancers. The most commonly used quantitative diagnostic tool, standardized uptake value (SUV), assumes uniform distribution over the whole body and is subject to significant variability from reconstruction algorithms to acquisition method [EJNMMI Res.2015;5:31]. On the other hand, according to Erdi et al. [Cancer 1997;80:S2505-9] signal to background ratio (S/B) reflects activity specific for local tissue and recommended S/B as the quantity of choice for radiotherapy target definitions. In the case of paired organs (lung) Devic et al. [Int J Rad Oncol Biol Phys 2010; 78: 1555-62] demonstrated the feasibility of sampling background uptake in contralateral healthy lung and then scaling it by physical densities to obtain the S/B for NSCLC patients. In this work we describe not only a new method to define background uptake in non-paired organs (applied to rectal cancer patients) to provide localized S/B, but the use of S/B to predict response to preoperative endorectal brachytherapy in T3 rectal cancer patients.  
**Materials and Methods:** Differential uptake volume histogram (dUVH) method [Devic et al. BJR 2016;89:20150388] was applied to a group of 20 rectal adenocarcinoma patients that received preoperative endorectal brachytherapy [Vuong et al., J Cont Brachyther 2015;7:183-8]. All patients had PET/CT scan prior to brachytherapy for staging purposes. Based on post-surgery pathology results, half of the patients had a complete response after brachytherapy (T3->pT0) while the other half had no or minimal response (T3->T3). Uptake values (in Bq/ml) were sampled on PET images, using CT, and co-registered PET/CT images (Fig.1 top) by placing the
sampling region of interest (ROI) over both tumor and healthy rectal tissue, and at the same time by avoiding air (gas) and/or feces. **Results:** Once dUVH was generated in terms of raw uptake values (Fig.1.middle left) the histogram was normalized to the uptake value of the very first peak (median value), assumed to correspond to the normal rectal tissue glucose uptake. Subsequently, maximum S/B ratios ($S/B_{\text{max}}$) were sampled for all patients (Fig.1.middle right). A t-test statistical analysis compared the recorded $S/B_{\text{max}}$ to $SUV_{\text{max}}$ values obtained from clinical reports of the diagnostic/staging PET/CT scans. For the $S/B_{\text{max}}$, the two patient populations showed average values of 10.1±0.8 for good responders vs. 5.6±0.8 for poor responders (p<0.005) respectively. On the other hand, the corresponding values for the $SUV_{\text{max}}$ were 17.7±9.7 and 14.8±4.1 (p=0.403) for good and poor responders, respectively. The results are presented in the form of Gaussian distributions for good (green) and poor (red) responders for the $S/B_{\text{max}}$ (solid) and $SUV_{\text{max}}$ (dashed) parameters in Figure 1 (bottom). While there are some contradictory data in the literature regarding correlation between $SUV_{\text{max}}$ and clinical outcomes (this study demonstrates no correlation as well), our $S/B_{\text{max}}$ results are not only predictive of the patient’s response to brachytherapy but they are also in agreement with the notion that more aggressive tumors (having higher glucose uptake and spending longer periods of time in M phase, known to be more radiosensitive) have a better response to radiotherapy. **Conclusions:** While dUVH method was initially developed to extract different biological sub-volumes (glucose phenotypes) within tumors, the method described here shows an alternative to sampling the background (normal) uptake within the contralateral (healthy) tissue in the case of paired organs. Furthermore, reconstructed $S/B_{\text{max}}$ values may prove to represent a predictive factor of tumor response to radiation and could be useful in creating patient-specific treatment strategies.
Figure 1: Sampling of FDG uptake within rectal tumor and normal rectal tissue (top); differential Uptake Volume Histogram (dUVH) in terms of uptake values (middle-left); dUVH normalized to the uptake value of the first peak assuming to represent normal rectal tissue glucose uptake (middle-right); results of two-sample t-test (bottom) for S/Bmax (solid lines) and SUVmax (dashed lines) for the two patient groups (red: T3->T3; green: T3->pT0).
**Purpose:** The aim of this study was to define current patterns of care among Spanish radiation oncologists of the Spanish Group of Brachytherapy (GEB) within the Spanish Radiation and Oncology Society (SEOR) using brachytherapy (BT) for the treatment of skin tumors. **Materials and Methods:** There are 69 Brachytherapy Units in the official SEOR database. Of these, 25 centers (36%) perform skin BT. An electronic survey was administered to members of the GEB. The respondents were asked to describe the indications, type of applicators, planning dosimetry, number of fractions, size of each fraction, total dose and frequency of the BT sessions. **Results:** A total of 24 surveys were completed (96%). (*): 43% treated squamous cell carcinoma (SCC) and basal cell carcinoma (BCC), 20% metastases, 13% melanoma and 24% other pathological types (lymphoma or kaposi, among others.). 7% used Leipzig applicators. 17% Valencia applicators, 23% Freiburg Flap (Elekta)/ HAM (Varian), 29% custom molds, 22% performed interstitial BT and 2% electronic BT. 19% of respondents routinely estimated lesion depth by ultrasound. CT scan was employed for dosimetry in 83% of the centers and 74% used a thermoplastic mask for repositioning. For 100% of the users of Leipzig or Valencia applicators the dose was prescribed at 3-4 mm with a schedule of 6 fractions of 7Gy or 7 fractions of 6Gy twice a week. When interstitial implants were used, 9-10 fractions ranging from 3-5.5Gy were administered in two daily fractions six hours apart. The prescribed doses for adjuvant treatments (positive margins, risk of recurrence factors or recurrences) ranged from 30 fractions of 2Gy to 8 fractions of 5Gy and for radical treatments 5 fractions of 7Gy to 10 fractions of 5Gy with a trend to increasing the fraction size for larger targets (> 5 cm) and decreasing fractions in older patients or with a bad Karnofsky index. Hypofractionation was the preferred dose schedule, 2 or 3 times a week, although 2 centers used a daily schedule. **Conclusions:** The use of skin BT treatment is increasing in Radiotherapy Departments in Spain. Further prospective studies are needed to unify the criteria related to fraction size and total doses to be used in skin BT. (*): Hospital Universitario Quirón (Madrid), Hospital Universitario San Chinarro (Madrid), Fundación Instituto Valenciano de Oncología (FIVO)(Valencia), Hospital Ramón y Cajal (Madrid), Hospital de Navarra (Pamplona), Hospital Marqués de Valdecilla (Santander), Hospital Infanta Cristina (Badajoz), Fundación Rioja Salud (Logroño), Hospital de Reus (Tarragona), Instituto Oncológico Cataluña (ICO. Barcelona), Hospital La Paz (Madrid), Hospital de Cruces (Bilbao), Hospital Universitario la Fe (Valencia), Hospital Universitario Carlos Haya (Málaga), Hospital Universitario Valladolid (Valladolid), Hospital Virgen de la Victoria (Málaga), Hospital de la Ribera Alzira (Valencia), Hospital Clínica Benidorm (Alicante), Hospital Negrín las Palmas (Gran Canaria), Centro Oncológico (La Coruña), Hospital de la Esperanza (Barcelona), Hospital Mixoeiro (Vigo), Hospital Doce de Octubre (Madrid), Fundación IMOR (Barcelona).

**PP24**

**Presentation Time: 4:45 PM**

**Retrospective Analysis of Surface Brachytherapy for Non-melanoma Skin Cancer of the Extremities**

David Olek, M.D.\(^1\), Mathew Gestaue, M.D.\(^1\), Moataz El-Ghamry, M.D.\(^1\), Niloyjyoti Deb, M.D.\(^1\), Subhakar Mutyala, M.D.\(^2\).

\(^1\)Radiation Oncology, Scott and White, Temple, TX, USA, \(^2\)Radiation Oncology, University of Arizona College of Medicine Phoenix, Phoenix, AZ, USA.

**Purpose:** The gold standard for treatment of early stage non-melanoma skin cancers (NMSC) is surgery. In patients with NMSC of the extremities, complications from definitive surgery, such as non-healing wounds are common due to poor blood flow, age, and comorbidities that delay healing. In situations where NMSC is located on the extremities, radiation therapy may be preferred as it does not involve surgical excision and thus may reduce the rate of non-healing wound formation. We have used a modern version of brachytherapy, the ‘3D topographic applicator brachytherapy’ (3TAB), to treat NMSC since 2010. This study retrospectively analyzes NMSC of the extremities treated with 3TAB in terms of acute toxicity, chronic toxicity, and recurrence rate. **Materials and Methods:** Thirty-seven patients with 59 early stage NMSC lesions of the extremities were treated with 3TAB from 2010-2013. For each lesion, a custom applicator was fashioned using a thermoplastic mold with HAM or Freiburg flap. A 3D optimized plan was created, and the dose was prescribed to a depth of 3mm, with the skin surface dose constrained to 135%. Dose fractionation schemes included 48 Gy in 16 fractions (fx) delivered 4 times weekly or 40 Gy in 8 fx delivered twice weekly. Acute toxicity was graded based on the RTOG grading criteria. Chronic toxicity was graded by the presence or lack of toxicity. **Results:** Median age was 78.2 yrs (mean 77.3 yrs, range: 66-96yrs) (Table).
54.2% of NMSC were located on the legs, 69.5% of all lesions were squamous cell carcinomas, and 71.2% were stage 1. The median tumor diameter was 1.0cm (mean: 1.5cm; range: 0.5-5.0cm). 3TAB was the definitive treatment modality in 89.8%. All completed treatment as prescribed. 59.9% were treated with 40 Gy in 8 fxs. Median follow-up was 20.0 months (mean: 27.7 months; range: 0.9-69.1 months). Maximum acute toxicity of radiation dermatitis was noted to be grade 1 in 22.0%, grade 2 in 22.0%, grade 3 in 32.3%, and grade 4 in 22.0%. Thirteen (22%) treatment sites developed ulceration, one of which was due to disease recurrence. Of the treated ulcers, 6 were treated with hyperbaric oxygen, 5 with wound care, and 1 eventually needed a graft. At last follow-up, 7 ulcers (11.9%) were still being treated and had not healed. Of note, 100% of chronic ulcers occurred in the lower extremities. Recurrence rate was 6.8%, and median time to recurrence was 11.4 months (mean: 18.0 months; range: 6.5-47.6 months). **Conclusions:** Treatment of NMSC of the extremities with 3TAB was able to provide excellent local control (93.2%) at a median follow-up of 20.0 months. Due to the age, comorbidities, and poor lower extremity circulation, chronic ulceration occurred at a rate of 11.9%. Further investigation and analysis is needed in determining the dose and fraction scheme optimal in treating NMSC, while decreasing the risk of ulceration.
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<td>BCC</td>
<td>12 (20.3)</td>
</tr>
<tr>
<td>SCC</td>
<td>41 (69.5)</td>
</tr>
<tr>
<td>BCC + SCC</td>
<td>1 (1.7)</td>
</tr>
<tr>
<td>Bowen's Disease</td>
<td>5 (8.5)</td>
</tr>
<tr>
<td><strong>Stage</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>5 (8.5)</td>
</tr>
<tr>
<td>1</td>
<td>42 (71.2)</td>
</tr>
<tr>
<td>2</td>
<td>10 (16.9)</td>
</tr>
<tr>
<td>UNK</td>
<td>2 (3.4)</td>
</tr>
<tr>
<td><strong>Tumor Diameter</strong></td>
<td>1.5 cm (0.5-5.0 cm)</td>
</tr>
<tr>
<td></td>
<td>Median: 1.0 cm</td>
</tr>
<tr>
<td><strong>Primary Disease</strong></td>
<td>53 (89.8)</td>
</tr>
<tr>
<td><strong>Adjuvant Disease</strong></td>
<td>3 (5.1)</td>
</tr>
<tr>
<td><strong>Recurrent Disease</strong></td>
<td>3 (5.1)</td>
</tr>
<tr>
<td><strong>Prescribed Dose</strong></td>
<td></td>
</tr>
<tr>
<td>40 Gy in 8 frs</td>
<td>33 (59.9)</td>
</tr>
<tr>
<td>48 Gy in 16 frs</td>
<td>26 (44.1)</td>
</tr>
<tr>
<td><strong>Completed TXT:</strong></td>
<td>59 (100.0)</td>
</tr>
<tr>
<td><strong>Follow-up (mo)</strong></td>
<td>27.7 (0.9-69.1)</td>
</tr>
<tr>
<td></td>
<td>Median: 20.0</td>
</tr>
<tr>
<td><strong>Recurrence Rate</strong></td>
<td>4 (6.8)</td>
</tr>
<tr>
<td></td>
<td>50% Leg, 25% Hand, 25% Finger</td>
</tr>
<tr>
<td><strong>Time to Recurrence</strong></td>
<td>18.0 (6.5-47.6)</td>
</tr>
<tr>
<td><strong>Maximum Acute Toxicity</strong></td>
<td></td>
</tr>
<tr>
<td>G0</td>
<td>1 (1.7)</td>
</tr>
<tr>
<td>G1</td>
<td>13 (22.0)</td>
</tr>
<tr>
<td>G2</td>
<td>13 (22.0)</td>
</tr>
<tr>
<td>G3</td>
<td>19 (32.3)</td>
</tr>
<tr>
<td>G4</td>
<td>13 (22.0)</td>
</tr>
<tr>
<td><strong>Time to First Follow-up</strong></td>
<td>19.41 (0-111)</td>
</tr>
<tr>
<td>(days)</td>
<td>Median: 15</td>
</tr>
<tr>
<td><strong>Toxicity at 1st Follow-up</strong></td>
<td></td>
</tr>
<tr>
<td>G0</td>
<td>16 (27.1)</td>
</tr>
<tr>
<td>G1</td>
<td>14 (23.7)</td>
</tr>
<tr>
<td>G2</td>
<td>20 (33.9)</td>
</tr>
<tr>
<td>G3</td>
<td>9 (15.3)</td>
</tr>
<tr>
<td><strong>Chronic Toxicity</strong></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>18 (30.6)</td>
</tr>
<tr>
<td>Non-healing Ulcer</td>
<td>6 (10.2)</td>
</tr>
<tr>
<td>Telangiectasia</td>
<td>1 (1.7)</td>
</tr>
<tr>
<td>Hyper-/Hypopigmentation</td>
<td>2 (3.4)</td>
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<tr>
<td>Chronic Ulcer</td>
<td>8 (13.6)</td>
</tr>
<tr>
<td>Hyperkeratosis</td>
<td>1 (1.7)</td>
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**Scientific Session: Physics Snap Orals (E-Poster)**

**Thursday, April 20, 2017**

5:00 PM - 6:00 PM

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**PHSOR1**

**Presentation Time: 5:00 PM**

**Windowless Extrapolation Chamber and Radiochromic Film Measurements of a Flat $^{106}$Ru Eye Plaque**

Jon Hansen, M.S., Wesley S. Culberson, Ph.D., Larry A. DeWerd, Ph.D.

*Medical Physics, University of Wisconsin-Madison, Madison, WI, USA.*

**Purpose:** The surface dose rate to water from a flat $^{106}$Ru CCB eye plaque was determined using a windowless extrapolation chamber, and results were checked against measurements made with radiochromic film. This work was performed as part of a larger aim to determine surface dose rate from curved $^{106}$Ru plaques using a convex windowless extrapolation chamber. **Materials and Methods:** A novel planar extrapolation chamber without an entrance window was previously constructed at the University of Wisconsin Medical Radiation Research Center. For this work, a special flat $^{106}$Ru CCB eye plaque was acquired from the manufacturer BEBIG in Berlin, Germany prior to being stamped into its standard curved shape. The cylindrical source had a thickness of 1 mm and a diameter of 21.5 mm. Windowless extrapolation chamber measurements were performed using a collecting electrode composed of D400 conductive plastic. During measurements, a voltage bias was placed on the $^{106}$Ru source with the collecting electrode held at ground. Current was measured at varying air gap separations and used to calculate the surface dose rate to water. Correction factors for backscatter and side-scatter losses in the extrapolation chamber were calculated using the EGSnrc cavity Monte Carlo user code. Dose rate results were compared with on-contact film measurements made with HD-V2 and un-laminated EBT3 radiochromic film. Each film type was calibrated according to absorbed dose to water in a $^{60}$Co beam with the film positioned in air with sufficient buildup material. Exposures were performed with the flat $^{106}$Ru CCB plaque in contact with the film on a 4 cm thick Virtual Water slab. HD-V2 film was read using a 670 nm Personal Densitometer SI system, while un-laminated EBT3 film was read using the red color channel from an EPSON Expression 10000XL flatbed scanner. **Results:** Three separate measurements were performed for the flat $^{106}$Ru CCB plaque with the windowless extrapolation chamber. The average surface dose rate to water was determined to be 2.53 mGy/s with a standard deviation of 1.22% ($k=1$). The reported dose rate is decay-corrected to Nov. 7, 2016 and represents an average over a central 4 mm diameter area defined by the dimensions of the chamber’s collecting electrode. For the radiochromic film measurements, dose rate was determined to be $(2.66+0.07)$ mGy/s from HD-V2 film and $(2.38+0.08)$ mGy/s from un-laminated EBT3 film. These dose rate values have been decay-corrected to Nov. 7, 2016, and the reported uncertainties represent propagated standard deviation values at the $k=1$ level from multiple film measurements. **Conclusions:** During this work, the surface dose rate to water from a flat $^{106}$Ru CCB source was measured using a planar windowless extrapolation chamber. The dose rate results of the on-contact radiochromic film agreed with those of the extrapolation chamber to within 6%. Based on the principles shown in this work, a convex windowless extrapolation chamber is proposed to measure surface dose rate from concave $^{106}$Ru eye plaques.

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**PHSOR2**

**Presentation Time: 5:05 PM**

**Significant Dose Reduction to Heart with Innovative Design of a Prone Breast Board During HDR**

Jiaju Zhang, MD¹, Qinghui Zhang, PhD², Yu Chen, PhD².

¹Radiation Oncology, Staten Island University Hospital, Northwell Health, Staten Island, NY, USA, ²Radiation Oncology, Department of Radiation Medicine, Northwell Health, Lake Success, NY, USA.

**Purpose:** The aim of this study is to develop and validate an innovative prone breast board which can significantly reduce dose to heart and other critical organs during high dose rate (HDR) accelerated partial breast irradiation (APBI) brachytherapy for pendulous breast. **Materials and Methods:** The microSelectron Digital HDR brachytherapy afterloader system with a radioactive source of one 10 Ci Ir-192 seed and Oncentra Brachy treatment planning system were used for the study. A medium-sized left breast phantom (~900 cc) was made of play-doh in supine shape and prone pendula shape, which was placed on a sliced female Rando anthropomorphic phantom. A conceptually designed prototype of prone breast shield housing was made in house of Cerobend alloy. This shield housing comprised of a 1.8 cm thick U-shaped part and a 3.3 cm thick top heart-shaped part. This Cerobend shield
was used together with a commercial, available in our clinic, prone breast board. A typical lumpectomy cavity was assumed to be in medial location and in a diameter of 3 cm, corresponding to a planning target volume (PTV) of 51 cc. One channel catheter (such as in a balloon applicator) was used for planning and delivery. Prescription of 340 cGy with 10 fractions was planned for PTV, however, delivered once for a total of 34 Gy in order to measure accumulated doses in a whole course of APBI. Two cavity locations or source positions were planned for the prone breast. Position 1 was medial and away from the chest wall. Position 2 was inner and closer to the chest wall.

Radiation doses were measured by Gafchromic EBT3 films and nanoDot optically stimulated luminescent dosimeters (OSLDs). To measure heart and left lung doses the OSLDs were attached on a 3 mm bolus. The bolus was paired with an EBT3 film and then inserted together between two slices of the Rando phantom directly posterior to the breast. **Results:** The measured planar dose distributions by the EBT3 films are qualitatively consistent with the Oncentra planned dose distributions. Doses to various organs were measured by OSLDs. The mean dose of heart is estimated by averaging 6 nanoDot results around and in heart. Similarly, the Lt Lung dose is an average of anterior and posterior nanoDot results in left lung. Dose reduction to heart is in a range of 30 - 70% when breast in prone position compare to supine position, which can be simply attributed to an increased distance from the cavity to the chest wall. When the shield is used, 90% or more dose reduction to heart is achieved. The use of the shield in prone position 2 can completely spare the heart, resulting in further dose reduction. It is interesting to learn that doses to other organs (e.g., Rt Breast, Lt Lens, Thyroid, and Abdomen) increase in prone positions without the shield. This is mainly due to the less attenuation of gamma rays for pendulous breast than supine breast. However, when the shield is used, doses to those organs are dramatically reduced to ~1 cGy level. **Conclusions:** Dependent on lumpectomy cavity location, at least 90% dose reduction to heart and left lung was observed during a whole course of HDR APBI using our conceptually designed shield housing for pendulous breast. Moreover, doses to other critical organs have also been greatly reduced to a background dose level. A clinically practical, adjustable pendulous breast shield housing together with a new designed prone breast board is under construction. Significantly decrease cardiac risk for HDR APBI patients is expected if this new apparatus is used.
Purpose: Failure mode and effects analysis (FMEA) is proven to be an efficient tool to comprehensively assess the radiation therapy quality management program for various treatment modalities and disease sites. In this study, the FMEA was applied as a functional analysis tool in multimodal low dose-rate (LDR) prostate brachytherapy (PB) in order to identify the failure modes and to minimize their probability of occurrence that can crucially influence the successful treatment delivery. Materials and Methods: A total of 109 patients were treated for prostate cancer with permanent interstitial brachytherapy using I-125 in 2016. Fifty-seven out of the total number of patients received the treatment using the Oncentra® Prostate treatment planning system (TPS) for dose calculation and a robotic device seedSelectron™ for automated seed delivery. The remaining 52 patients received LDR brachytherapy using the same TPS; however, the seed delivery was performed with the QUICKLINK® Delivery System. The workflow for the robotic-based (RB) procedure significantly differs from the manual seed delivery (MSD) technique. The principal steps in the RB procedure are: imaging, contouring, needle insertion and reconstruction, contours/needle evaluation/re-adjustment with dynamic dose calculation, treatment planning (based on the inserted needles), and treatment delivery, as in figure. The MSD technique consists of: imaging, contouring, treatment planning, and treatment delivery (including the insertion and reconstruction of the seed-preloaded needles). In summary, the needles are inserted in the early phase immediately after the contouring in the RB procedure, whereas the preloaded needles are inserted at the last phase, in the MSD procedure. Therefore, a structured robust quality assurance tool with qualitative and quantitative analysis was developed to identify the critical steps and to mitigate the risk. Results: By using the process maps, we identify the potential failure modes (FM) of the individual processes, assigning the potential causes to each of them. The most critical FMs were the connectivity problems, patient positioning and template errors, contouring errors caused by image artifacts, wrong prescription, wrong source activity in the TPS, wrong optimization parameters for inverse planning, robot calibration problems/unobserved shift of the base-plane, non-standard communication between the physician and the physicist, and plan execution failure. The potential effects of the failure were determined in order to define the risk priority number (RPN). The highest RPN (1000) were given to the processes with highest severity and occurrence in which the failure led to critical failures (e.g., a medical event) such as wrong prescription or activity, and incomplete plan execution. During the risk assessment, special attention was focused on processes with lower severity and high occurrences since their combination can potentially lead to the critical failure modes. An example for this was the minor displacement of an individual needle, which occurs frequently during the seed implantation. If a significant number of needles are subject to the small displacement, the overall quality of the treatment plan and dosimetry can be compromised, e.g. when the needles deflect toward the urethra. This approach resulted in changes of the workflow in order to address the initially non-detectable failures, such as the accidental deletion of the seeds when the needle status was converted from 'live' to 'virtual'. The supplemental points, such as independent secondary review and check forms, were added in order to mitigate the risk. Conclusions: The increased complexity in LDR PB resulted in the usage of the FMEA for improved quality management of the program. This analysis was developed to be compliant with the existing quality assurance program.
**Dosimetric Characteristics for an LDR Brachytherapy Stent for Esophageal Cancer**

Mark J. Rivard, Ph.D.\(^1\), Arnold M. Herskovic, M.D.\(^2\), Claude Clerc, Ph.D.\(^3\), John Hingston, Ph.D.\(^3\), John T. Favreau, Ph.D.\(^3\).

\(^1\)Tufts University School of Medicine, Boston, MA, USA, \(^2\)Rush University Medical Center, Chicago, IL, USA, \(^3\)Boston Scientific, Marlborough, MA, USA.

**Purpose:** Worldwide, esophageal cancer afflicts 0.5 M people annually with half of the patients inoperable at detection. Radiation therapy is generally administered via external-beam radiation therapy (EBRT), HDR BT, or a combination of both. While radiation is used to downstage the tumor or relieve dysphagia, this process can take several weeks and irradiates healthy tissues in large treatment margins. Despite dose escalation, 5-year survival rates are <20%. Esophageal stents provide immediate dysphagia relief and can be used alone or with EBRT (mainly for palliative patients). To combine the benefits of stenting with radiation, an LDR BT stent was designed based on Monte Carlo (MC) dosimetry. **Materials and Methods:** Lesions present with a range of locations, lengths, and depths. A standardized geometry was chosen with the target extending 0.5 cm deep into the tissue from the stent periphery and spanning a 5 cm length. The stent was 12 cm long with a 2 cm outer diameter. Plastic tubes were attached inside helically braided stents (plastic or metal) to contain stranded LDR BT seeds. Stents loaded with six strands of 125\(^{I}\) seeds (used in our pilot pig study) were used as a baseline. Given the air-filled stent and stent materials that were not radiologically equivalent to water or tissue at these low energies, a conventional BT treatment planning system would not suffice and MC simulations using the MCNP6 radiation transport code employed to accurately estimate radiation doses. Simulations for a range of photon energies showed 0.05 MeV as optimal with 125\(^{I}\) and 131\(^{Cs}\) seeds producing good results and 103\(^{Pd}\) seeds having high dose gradients. To homogenize surface dose and minimize dose hotspots to the radiation-sensitive mucosa, the seed density in the strands and the source strength uniformity along the strand was varied. The latter was achieved through iterative optimization based on source-distance weighting. The stent was centrally positioned within a 20 cm diameter and 24 cm long...
cylindrical water phantom, which provided full radiation scatter conditions over the regions of interest. Dose was calculated from 0-2.5 cm distant from the stent axis of symmetry and 4.5 cm along the stent length away from the midplane. The sampling resolution was $2^\circ$ azimuthally and 0.01 cm normal to and along the stent axis. Dose was normalized to the 0.5 cm target depth on the stent midplane. Simulations used in excess of $10^{10}$ photon histories to minimize statistical uncertainties. **Results:** Surface dose uniformity improved with increasing tube count, but prevented stent compression as necessary for clinical deployment. The best approach was increasing seed density (114 in total) along the strand length to reduce the maximum surface dose by 20%. In combination with source strength weighting, the maximum surface dose decreased an additional 5% to 2.5 times the prescription dose. In contrast, the LDR BT $^{125}$I stent by Guo et al. (Radiology, 2008) had 27 seeds positioned outside the stent and a maximum surface dose 150 times the average dose 0.5 cm from the stent midplane. All these dose ratios would be diminished in practice due to breathing, peristalsis, etc. The metal stent attenuated slightly more than the plastic stent and produced 10% higher dose hotspots than the plastic stent. $^{131}$Cs seeds produced dose distributions that had better surface and target dose uniformity than the $^{125}$I. However, the radiation was more penetrating and the radiobiological influence of the shorter half-life needs to be evaluated in practice.

**Conclusions:** Given the high mortality rate and large incidence of patients presenting with esophageal cancer, this novel device may have a significant impact on cancer management and patient beneficence. Advantages over
existing radiotherapy technologies include fewer hospital visits, no sophisticated equipment and related expertise, favorable radiobiology, and a more conformal dose distribution.

PHSOR5  
Presentation Time: 5:20 PM  
Experimental Research on a Novel Robotic System for Lung Cancer Brachytherapy  
Huaisu Dou, Master¹, Shan Jiang, Professor¹,², Zhiyong Yang, Professor¹, Luqing Sun, Doctor¹, Xiaodong Ma, Doctor¹, Bin Huo, MD¹, Shude Chai, MD¹, Haitao Wang, MD¹, Qiang Cao, MD¹, Lei Wang, MD¹.  
¹School of Mechanical Engineering, Tianjin University, Tianjin, China, ²Centre for Advanced Mechanisms and Robotics, Tianjin University, Tianjin, China, ³Department of Oncology, The second Hospital of Tianjin Medical University, Tianjin, China.

Purpose: Currently, lung cancer has become the highest morbidity and mortality cancer in the world. As an important form of radiotherapy, image-guided brachytherapy has been successfully applied to the treatment of early stage lung cancer. Clinical lung cancer brachytherapy requires clinicians to have a wealth of experience to insert the needles with simple auxiliary equipment or freehand. It is a complex and time-consuming procedure. In order to improve the accuracy of seeds implantation, reduce the operation time and CT scan times, we designed a 4 DOFs CT-guided robotic system to assist this procedure. The purpose of this research is to validate the clinical practicability of the robotic system.

Materials and Methods: The robotic system we designed is used to assist the positioning of the puncture template (the end effector of the robot) automatically. The lung brachytherapy TPS (treatment planning system) software was designed for the robot, so that the robot can be driven to the target position by the dose planning information directly. This design greatly reduces the operation time and the difficulty for the clinicians to control the robot. The experimental research is divided into two parts. One is the robot mechanical accuracy validation in laboratory by using 3D laser tracker and IMU (inertial measurement unit). From which, the position accuracy has been calculated and error has been compensated. Another is the phantom experiment in a CT environment. To imitate clinical puncture, a high imitation dummy model was used. The thoracic cavity was filled with non-biological materials with a 50 cm³ prosthesis tumor which made of pork. The dose planning was made according to the CT images of the prosthesis tumor and we can get a preoperative DVH (dose volume histogram) curve. We can get the target position through dose planning information, the control commands was transmitted to drive the robot to the target point automatically. After seeds implanted, we can get the postoperative DVH curve to verify the accuracy of seeds implantation.

Results: In the first experiment, the position accuracy was 0.28 mm, which has met the desired accuracy 0.5 mm by the collaboration hospital requirement. The phantom experiment show that the robotic system has good CT compatibility and responds reliably without any malfunctions. Compared to the manual positioning, average 30 minutes were saved by the robot in the process of template positioning and seeds implantation. If the operation by robot is skilled, more time will be saved. The prescription dose was 120Gy. The postoperative DVH curve shows that the accuracy of seeds implantation met the preoperative dose planning.

Conclusions: Compared with current procedure, the robotic system we designed is convenient to control with high accuracy and timesaving. The experiments indicated that the robotic system we designed is reliable and ready to put further studies on animal experiments. All the experimental results show that the robotic system will bring significant improvement in the efficiency and accuracy of clinical lung brachytherapy.
Dosimetry Verification for Radioactive Seed Implantation in Malignant Tumor Under CT and 3D Printing Template Guidance

Zhe Ji, Medical Doctor, Yuliang Jiang, Master of Medicine, Haitao Sun, Master of Science, Fuxin Guo, Medical Doctor, Ran Peng, Medical Doctor, Junjie Wang, Medical Doctor.
Peking University Third Hospital, Beijing, China.

Purpose: Brachytherapy treatment planning system (BTPS) has been widely used in radioactive seed implantations. However, accurately realizing the design of BTPS during an operation is difficult even by image guidance, and the implantation accuracy greatly depends on the personal experience of the doctor. In recent years, our department applied 3D printing individual guide templates (abbreviated as 3D printing templates) to assist the seed implantation in tumor. The purpose of this study is to compare the dose distributions of postoperative plans with preoperative plans for 3D printing templates assist seeds implantations, exploring the effects of the technology for seeds implantations in dosimetry level and provide data support for the optimization and standardization in seeds implantation. We believe that our study is the first one to compare the postoperative plans and preoperative plans for seed implantations (except prostate cancer) and with the largest sample size, especially for 3D printing template.

Materials and Methods: Between December 2015 and December 2016, a total of 138 patients (148 lesions) received 3D printing templates assist radioactive seeds implantations in our department, and included in the study. Many types of tumors were included (such as rectal cancer, cervical cancer, nasopharyngeal carcinoma, lung cancer, etc). The sites of implantations including head and neck, chest, pelvic and paravertebral/retroperitoneal. The prescribed dose was 110-150Gy. All patients carried out preoperative planning design, template design and production, and compared the dose distribution of postoperative plan with preoperative plan. Dose parameters including D90, MPD, V100, V150, V200, CI, EI, HI of target volume and D2cc of spinal cord. Statistical software is SPSS 21. Results: A total of 143 3D printing templates were designed and produced which including 148 treatment areas (47 of head and neck, 33 of chest, 21 of paravertebral/retroperitoneal, 47 of pelvis). The median D90 of postoperative GTV is 142.9Gy (rang 91.3-279 Gy), 71% of the D90 (105/148) is higher than that of the prescription dose. For postoperative plans, the mean D90, MPD, V100, V150, V200 of GTV and D2cc of spinal cord was 139.9Gy, 71.7Gy, 89.6%, 64.7%, 43.7% and 5.6Gy, respectively, which was 141.3Gy, 66.8Gy, 89.4%, 62.2%, 35.7% and 4.7Gy, respectively, in preoperative plans. There was significant difference in P value between the two groups for MPD, V150, V200 and D2cc (p=0.014, 0.043, 0.001, 0.018, respectively). The actual dose conformity of GTV was worse than preplanned (CI was 0.60 and 0.65, respectively), the actual dose of external GTV was higher than preplanned (EI was 57.3% and 45.3%, respectively) and the actual dose homogeneity of GTV was worse than preplanned (HI was 28.8% and 30.2%, respectively). The differences of CI and EI between two groups had
statistically significant (p=0.002, 0.013, respectively). For chest areas, MPD, V200, CI, EI had significant difference (p=0.039, 0.004, 0.024, 0.002, respectively). For pelvic areas, V200, D2cc had significant difference (p=0.002, 0.036, respectively). For paravertebral/retroperitoneal areas, only CI had significant difference (p=0.005). For head and neck areas, all the parameters had no significant difference. D90 had no significant difference between postoperative plans and preoperative plans in whole group and each subgroup. **Conclusions:** Though the actual dose of GTV was lower than preplanned dose, and the high dose area of GTV was larger than preplanned range in most cases, the postoperative D90 closed to the expectation of preoperative plan. Even under the condition of large samples, good consistencies were shown, especially for head and neck areas. The greatest differences were in chest which may because of breathing. 3D printing template improve the accuracy of seed implantation, and has a good application prospect and is worthy of further development and promotion.

**Phsor7**

**Presentation Time: 5:30 PM**

**Changes in Seed Configuration Within Prostate with Implantation of a Hydrogel Rectal Spacer and Its Impact on Urethral Dose**

Amandeep S. Taggar, MD MS, Nitin Mathur, MS, Tomer Charas, MD, Gil’ad N. Cohen, MS, Satish Mangal, RTT, Marisa Kollmeier, MD, Michael J. Zelefsky, MD, Antonio L. Damato, PhD.

**MSKCC, New York, NY, USA.**

**Purpose:** Implantation of rectal spacer, while increases the distance between the prostate and rectum, may theoretically result in changes in seed configuration within the prostate as the gland is deformed and pushed anteriorly and splayed laterally, possibly resulting in smaller distance between urethra and seeds. We evaluated intra-prostatic seed shifts after implantation of a hydrogel spacer between the prostate and rectum and assessed its impact on urethral dose. **Materials and Methods:** Ten patients undergoing low-dose-rate brachytherapy with Pd-103 seeds, and implantation of a rectal hydrogel spacer (SpaceOAR™ Augmenix, Waltham, MA) were evaluated.
Two intraoperative cone beam CT scans, one immediately prior to and one immediately after implantation of spacer were obtained while trans-rectal probe was removed and the patients’ position remained unchanged. One patient was excluded from analysis because of setup variation due to Foley catheter displacement and bladder filling. All of the seeds were identified and urethra was contoured on both CT datasets in VarisSeed™ (Varian Medical System, Palo Alto, Ca). DICOM plans and structure sets were exported to a MatLab™ (The Mathworks Natick, MA) routine to calculate the distance between each seed and the urethra contour (r), and their component in the left-right (x) and anterior-posterior (y) directions. Changes in the average distances between pre- and post-spacer CT scans were calculated. The maximum dose to the urethra (Dmax) was calculated and compared between two datasets. The differences were compared using a 2-tailed paired Students T-test (p < 0.05 for statistical significance). Results: Mean (range, standard deviation(SD)) change in distance between seed and urethra (r) was 0.3 mm (-1.1 to 0.2 cm, 0.4) away from the urethra (p-value 0.08). Mean changes in “x” and “y” directions were 0.2 mm (-0.1 to 0.4 mm, 0.2 mm, p-value 0.005) away from the urethra and 0.5 mm (0.1 to 1.4 mm, 0.4 mm, p-value 0.004) towards the urethra, respectively. On average, Dmax to the urethra only increased by 3.8% (-0.7% - 23.5%, p-value 0.26). In one patient, with a large increase in urethra Dmax, average changes in seed-to-urethra distances (r, x and y) were 0.22 mm, 0.37 mm and -0.08 mm, and the increase was due to the decrease in distance of one seed already unusually proximal to the urethra before the spacer injection. Conclusions: Despite small anterior-posterior and lateral shift in the seed positions due to implantation of rectal spacer, there was no significant increase in dose to the urethra. Cases where seeds are positioned in close proximity to the urethra may experience an increase in urethral dose due to spacer injection.

PHSOR8

Presentation Time: 5:35 PM

Influence of Bone Tissue on the Depth-Dose Characteristics for the CivaSheet

Mark J. Rivard, PhD
Tufts University School of Medicine, Boston, MA, USA.

Purpose: While conventional brachytherapy TPSes calculate the dose to water in water for clinical applications (based on TG-43 reference conditions), sometimes implants are located in the vicinity of high-Z tissues such as bone. For low-energy photon-emitting radionuclides such as $^{103}$Pd, the radiological differences between water and bone are dramatic compared to high-energy radionuclides such as $^{192}$Ir. This study quantitatively evaluated the dosimetric influence of bone in comparison to water for several practical geometries specific to the CivaSheet brachytherapy device. Materials and Methods: The MCNP6 radiation transport code was used in conjunction with the simulated geometry of an individual CivaSheet element (i.e., CivaDot) within a 10-cm diameter spherical phantom composed entirely of liquid water or with one hemisphere being ICRU-44 cortical bone ($\rho=1.92$ g/cm$^3$, 22.5% mass Ca). Based on the ratio of mass-energy absorption coefficients for 0.02 MeV photons, a factor of 6.5 dose increase would be expected. To evaluate the effect of arbitrary implant placement and surrounding tissue, the CivaDot was located at depths of 0≤d≤0.5 cm (0.05 cm increments) from the bone. Based on the cylindrical symmetry of a CivaDot, absorbed doses (to water in water and to bone in bone) were estimated in voxels 0.1 cm high and 0.01 cm wide. Comparisons were made between the geometries with the all-water phantom and with the bone present. Dose ratios revealed the influence of the bone on dose associated with the conventional TG-43 water-based approach. A total of >3x10$^{10}$ photon histories were simulated for each phantom/source geometry. This resulted in statistical uncertainties <2% along the CivaDot axis of symmetry within r≤1 cm, with lower values (<0.1% on average) positioned laterally away from the axis of symmetry. Results: The dose deposition in bone was higher than in water as expected due to the photoelectric effect. This is shown by a logarithmic plot of the dose distribution (top image). Directly along the CivaDot central axis when in contact with bone (bottom left image), dose to bone was 6.3 times higher than to water at the surface, becoming equivalent due to photon attenuation by bone at d=0.3 cm, and 3.5 times lower at d=0.5 cm. Offset laterally by 0.6 cm to approximate the mean distance between 0.8-cm spacing for CivaDots on a CivaSheet (bottom right image), dose to bone was 4.5 times higher than to water at the surface, becoming equivalent due to photon attenuation by bone at d=0.05 cm, and 13 times lower at d=0.5 cm. This change in results from the central axis positioning was deemed more representative of clinical circumstances, and was due to the increased attenuation that occurred due to the tangential path of the $^{103}$Pd photons. If the CivaDot was at d=0.5 cm (and with the aforementioned 0.6 cm lateral offset), dose to bone was 3.3 times higher than to water at the surface, becoming equivalent due to photon attenuation by bone at d=0.12 cm, and 15 times lower at d=0.5 cm. This trend was similar to when no bolus material was present and for 0≤d≤0.5 cm. When
correcting the central axis results to locate the CivaDot in the homogeneous water phantom as for the circumstances when the CivaDot was located at various distances away from the water:bone interface, the results became equivalent (within the simulation uncertainties, 2% within 0.5 cm of the source) for all bolus material thicknesses. The same behavior was observed for correcting the dose distribution results when the CivaDots were positioned laterally by 0.6 cm. Consequently a distance-dependent correction to the water dose distribution could accurately replicate the bone dose distribution.
**Conclusions:** Monte Carlo simulations of a low-energy photon-emitting brachytherapy source located in the vicinity of a high-Z tissue interface revealed factors of +6 changes in the dose distribution in comparison to water. Using this technique for correcting water dose in a conventional brachytherapy TPS may permit depiction of dose distributions from low-energy photon-emitting sources in the vicinity of high-Z tissues such as bone.

**PHSOR9**

**Presentation Time: 5:40 PM**

**HDR Monotherapy in Prostate Cancer: Radiobiological Considerations When Determining Biologically Effective Dose in Clinical Trials**

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**Purpose:** To determine whether simplified calculations of biologically effective dose (BED) are appropriate, particularly when trying to establish a general consensus on an emerging modality, namely prostate cancer treated using monotherapy brachytherapy. The impact of varying source strength due to natural source decay was also investigated. **Materials and Methods:** The simplified version of BED was compared against the full-form expression for BED for thirty-five HDR monotherapy prostate cancer dose fractionation schemes currently in clinical use. The majority of schema are based on the simplified form BED = nd [1+d/ (α/β)], calculated for α/β=1.5. This form of the expression does not account for intrafraction repair, interfraction repair, or repopulation. The interfraction repair and repopulation are affected by the varying implant schedule of the schema. The intrafraction repair further complicates the BED by variations in dwell times due to the source’s decaying source strength. Thus, for any given patient, we calculated a range of values of dwell times, which represent values from a new full-strength to a source which would be ready for source exchange. Dwell times were normalized to a 15 minute delivery time for a prescription dose of 20 Gy for a nominal 10 Ci source. Other parameters such as T_k, T_p, and α were taken from the recommendations of the American Association of Physicists in Medicine Task Group 137. Calculations were repeated for α/β values of 1.5 and 3. **Results:** The simplified BED assigns the dose protraction factor, G, as unity. This assumption indicates that all dose is delivered instantaneously with no intrafraction repair. Our calculations show the value of G to be, in reality, much smaller, between 0.65 and 0.82 in a 19 Gy delivery. Dose protraction effects were milder for smaller fraction sizes, but even for a 6 Gy delivery, the value of G was between 0.87 and 0.94. Even for schemes which involved multiple implants, calculations showed interfraction repopulation was not significant due to the large value of α relative to doubling time. Together, repair mechanisms resulted in the simplified form of BED calculations overestimating, on average, by 10.0% to 23.2% (α/β=1.5) and by 9.0% to 20.3% (α/β=3) depending on source strength. **Conclusions:** Repair and repopulation can be significant in monotherapy HDR for prostate cancer. The simplified BED calculation may not be appropriate, particularly for clinical trials which are designed to determine the efficacy of fractionation schema. Investigators should consider evaluating BED as a range rather than a discrete value when presenting results unless source activity is explicitly incorporated as well.

Hsiang-Chi Kuo, PhD1, Keyur J Mehta, MD1, Ravindra Yaparpalvi, MS1, Dinesh Mynampati, MS1, William Bodner, MD1, Madhur Garg, MD1, Dinesh Mynampati, MS1, William Bodner, MD1, Madhur Garg, MD1, David Huang, PhD2, Wolfgang A. Tomé, PhD1, Shalom Kalnicki, MD1.

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Purpose: To investigate the feasibility of replacing subjective evaluation of brachytherapy plan quality by a geometric driven dose estimation model derived from statistical learning in the treatment of advanced cervical cancer patients. Materials and Methods: A total of 96 CT scans from 20 locally advanced cervix cancer patients imaged with the hybrid intracavitary-interstitial Utrecht applicator were planned. Plans were recreated with and without the interstitial needles, referred to hereafter as IS/IC technique, respectively. Planning criteria in 2 Gy fraction equivalents (EQD2, α/β=3) were as follows 2 cm³ bladder < 90 Gy, 2 cm³ rectum < 70 Gy, 2 cm³ sigmoid bowel < 75 Gy, while optimizing dose coverage to 90% of the high risk target volume (HR-CTV) to a combined external beam plus brachytherapy dose of EQD2 = 85 Gy (α/β=10). After grouping D90 of the HR-CTV into 6 classes (“A” (D90≥110% of the prescription dose), “B” (110%>D90≥100%), “C” (100%>D90≥90%), “D” (90%>D90≥80%), “E” (80%>D90≥70%), and “F” (D90<70%), 14 features extracted from the geometrical shape of HR-CTV and were used as input variables into an Ordinal Logistic Regression (OLR) to learn their association with D90. 70% of the plans were randomly selected to train the models, the remaining 30% of plans were used as test set for the models. Model performance was evaluated using the successful classification rate of both IS and IC techniques for both training and test sets. The same OLR algorithm was also used to predict the improvement in target coverage (“e”: ∆D90<0%; “d”: 0 ≤ ∆D90<10%; “c”: 10% ≤ ∆D90 <20%; “b”: 20% ≤ ∆D90 <30%; “a”: ∆D90 ≥ 30%) that could be achieved by combining an intracavitary cervical implant with an interstitial insert. Results: The successful classification rate in the training set of the IS technique and IC technique were 62.3% and 93.3%, respectively. The successful classification rate in the test set of the IS technique and IC technique were 50% and 47.2%, respectively. The proposed model was able to predict the range of D90 increase in 71% of the training cases. The prediction rate decrease to 37% in the test cases. Figure 1 compares model performance of “True” vs. “Predict” for IS and IC techniques in the train cases and test cases, and compares the ∆D90 prediction after IC replaced with IS. Conclusions: OLR models built from features extracted from the target geometry can be used to predict the plan
quality of a cervical brachytherapy implant. They can also be used to predict the dose coverage advantage by replacing an IC implant with an IS implant. Overall, prediction was better for IC implants in the training set.
Monte Carlo Calculations of TG-43 Dosimetry Parameters of Low-Energy Brachytherapy Seeds for Gold Nanoparticle-Aided Radiotherapy

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Purpose: Radiation dose enhancement to the tumor using gold nano-particles (GNP) as radiation sensitizer takes advantage of the strong absorption by gold of ionizing radiation. It has been demonstrated that GNP-aided radiotherapy is most effective in the presence of low-energy (tens of keV) photons [1] [2]. Two sources with effective energies within this domain, 125I and 103Pd are used as permanent seed implants for tumor treatments in Low Dose Rate (LDR) brachytherapy. The purpose of the present study is to understand the effect on TG-43 dosimetry parameters of these two sources in the presence of GNP.

Materials and Methods: Monte Carlo code Geant4 was used to calculate a complete dosimetry data set in TG-43 formalism of two interstitial brachytherapy seeds: Amersham OncoSeed 6711 125I and BEBIG GmbH IsoSeed 103Pd. Dosimetry parameters in pure water were compared to published data as check on the model for seed geometry. The impact of gold concentration (0.1-15 mg/g) on the dosimetry parameters was investigated. A non-linear function was established to model the dose enhancement (DE) at the transversal plane (r = 0.25-5 cm, θ = 90°) as a function of gold concentration. Here, DE is calculated as the ratio of the dose with the presence of gold to that in pure water at the same point. Results: The presence of gold shows a significant impact on the radial dose function as seen in figs (1a) and (1b). DE values of 2.89 and 2.34 are observed for the 125I seed and 103Pd seeds respectively at r = 0.25 cm. However, DE is not always higher than unit. For instance, at r = 2 cm, DE of the 103Pd seed is 0.34 because gold increases the photon attenuation significantly. As illustrated in figs (1c) and (1d), there is little difference in the anisotropy function for pure water and water/GNP. Therefore, DE remains approximately constant for a fixed r and can be calculated at the point on the transverse plane (r, θ = 90°). A non-linear model for DE as a function of gold concentration (C), with an exponential component representing the increase of photon attenuation and a linear component representing the increase of mass absorption coefficient of the medium provides an excellent parameterization of the Monte Carlo results as seen in figs (1e) and (1f). The average discrepancies between fit and data are better than 0.5% over the full range of fit and maximum discrepancies are less than 2.0%. Conclusions: The low-energy seeds, 6711 125I and IsoSeed 103Pd, were modeled successfully within Geant4. Excellent fits to dose values in water with varying gold concentrations are achieved using a non-linear function. This function is a good candidate for dosimetry calculations in GNP-aided brachytherapy when used in association with the TG-43 data in pure water.
Figures (1a) and (1b) show radial dose functions for $^{125}$I and $^{103}$Pd respectively. Figures (1c) and (1d) show anisotropy functions at $r = 1$ cm for $^{125}$I and $^{103}$Pd respectively. Figures (1e) and (1f) illustrate model fits versus data points of $DE$ as a function of gold concentration at the transversal plane for $^{125}$I and $^{103}$Pd respectively. 

**Reference:**
[1] E. Lechtman et al., Implications on clinical scenario of gold nanoparticle radiosensitization in regards to photon energy, nanoparticle size, concentration and location, Phys Med Biol 56, 4631-4647 (2011)

**PHSOR12**

**Presentation Time: 5:55 PM**

**Dose Specification and Source Ordering Nomogram for CivaSheet Pd-103 Sources**

Gilad N. Cohen, MS$^1$, Abraham Wu, MD$^2$, Karen Episcopia, MS$^1$, Neil Taunk, MD$^2$, Amandeep S. Taggar, MD$^2$, Antonio L. Damato, PhD$^1$.

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**Purpose:** We present a nomogram for dose specification, source ordering and plan checking for brachytherapy procedures using the CivaSheet source array. **Materials and Methods:** Dose distributions at 5 mm from the CivaSheet were calculated for rectangular 1U/Dot arrays ranging from 2x2 to 20x20 Dots (0.8x0.8 to 15.2x15.2 cm) using Matlab. Ideal flat geometry was assumed. The average dose along the line through centers of the peripheral dots at a depth of 5 mm from the sheet was defined as 90% of the reference dose, and was used to generate the nomogram tables. This normalization factor was chosen to minimize the area receiving more than 120% while maximizing coverage by at least 80% of the prescription dose. Dose uniformity was evaluated in terms of A80%, A100%, and A120%, where A is the percent of the treatment area that receives at least the specified dose. **Results:** The required source strength was found to depend on the elongation of the treatment area, with smaller treatment areas requiring higher source strength. The median source strength of 2.38 U/Dot was found to deliver 100 Gy at 5 mm (range: 2.32-3.30 U/Dot; standard deviation: 0.14 U/Dot). Low dose (<90%) was restricted to the corners of the
treatment area, and was considered acceptable in most clinical scenarios. Median A80% is 100% with a minimum of 96%, and the median A100% is 76% (range 0-88%). The low coverage was observed in source arrays with a shortest dimension of 2 and 3 dots. As expected, dose uniformity improved with increasing treatment area, with a median A120% of 8% (range 0-21%). In all cases, the mean dose to the treatment area exceeded 90%. **Conclusions:** Lookup tables values for each array were calculated in U/Dot/100Gy for source ordering, and in Gy/U/Dot for intraoperative prediction of the expected dose given available source strength and treatment area, and for assistance with checking post implant evaluations. The nomogram is in clinical use at our center for patients treated on an IRB-approved protocol. Post-implant CT evaluation for those cases confirmed the desired dose specification.

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**Scientific Session: GYN Proffered Papers II**
*Friday, April 21, 2017*
*9:00 AM - 10:00 AM*

**PP25**
*Exploring Deep Convolution Neural Networks with Transfer Learning for Rectum Toxicity Prediction in Cervical Cancer Radiotherapy*

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1The University of Texas, Southwestern Medical Center, Dallas, TX, USA, 2Southern Medical University, Guang Zhou, China, 3Wayne State University, Detroit, OH, USA.

**Purpose:** Despite benefits of chemoradiation for cervical cancer, the local control of advanced stage bulky cervical tumors(LACC) is determined by delivering adequate Brachytherapy dose. This is essentially limited by the toxicity of surrounding organ at risk (OARs) especially the rectum. Better understanding of the OARs dose distribution-
toxicity relationship is critical for safe dose escalation to improve tumor local control and treatment outcome. We sought to clarify the rectal dose spatial distribution-brachy toxicity relationship by employing 1) an accurate deformable registration to obtain precise accumulated dose map and 2) a deep convolutional neural network (CNN) with transfer learning to establish a dose distribution-toxicity prediction model. **Materials and Methods:** To estimate cumulative rectum dose received over an entire treatment course, a previously developed topography-preserved point-matching DIR (TOP-DIR) algorithm was adopted. The rectum surface mesh was generated via an efficient particle-based surface meshing approach and fractional dose including EBRT is deformed and summed after rectum surface matching. A VGG-16 CNN network pre-trained on a large scale natural image database, ImageNet, was built as our rectum toxicity prediction model. The cumulative EBRT-BT doses on the rectum surface (Fig. 1a) are unfolded to obtain the rectum surface dose maps (RSDMs, Fig. 1b) which are then used to fine-tune the pre-trained VGG-16 network. To mitigate an imbalance in the training cohort [12 rectal complication patients (toxicity data) and 30 non-complication ones (non-toxicity data)], we employed the adaptive synthetic sampling approach (ADASYN) to create additional toxicity data. To identify and locate the learned features that distinguish toxicity from non-toxicity in the CNN network, the gradient-weighted class activation mapping (Grad-CAM) was used to highlight the discriminative regions on the RSDM. We comprehensively evaluated our VGG-16 network fine-tuned on all layers and compared with an “off-the-self” approach and “shallow tuning” approach. The “off-the-shelf” approach adopted all the weights from the pre-trained VGG-16 network and trained only the final classifier layer, while the “shallow tuning” approach fine-tuned the last few fully connected layers only. **Results:** The proposed prediction model was validated by a leave-one-out method on 42 cervical cancer patients. Inferior performance was observed when the VGG-16 CNN was trained by the “off-the-shelf” or “shallow tuning” approach; however, incremental performances were observed when more convolution layers were included in the fine-tuning. With all layers fine-tuned in VGG-16, a satisfactory prediction performance was achieved with accuracy of 88.1%, sensitivity of 75%, specificity of 93.3% and AUC (the area under an ROC curve) of 0.96. The salient region of the Grad-CAMs that was learned by the prediction model was found to be consistent with the statistical results analyzed from the RSDMs (Fig. 1c, 1d): the salient regions of the Grad-CAMs of the toxicity groups (Fig. 1f) were located on the upper region which corresponded to the regions with small p-values in the RSDM p-value map (Fig. 1e). **Conclusions:** The extensive evaluation results conducted in this study have demonstrated the feasibility of building a CNN-based rectum toxicity prediction model with transfer learning. The proposed prediction model can serve as a practical tool for rectum dose and induced toxicity analysis for cervical cancer radiotherapy.
Primary Tumor-Directed Brachytherapy Is Associated with Improved Survival for Patients with Metastatic Cervical or Uterine Carcinoma
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Purpose: Brachytherapy may reduce bleeding, palliate symptoms, or provide local control for patients with metastatic cervical or uterine carcinoma, but it is unknown if treatment influences survival in this population of patients. Materials and Methods: Data from 2004-2013 from the National Cancer Institute’s Surveillance, Epidemiology, and End Results (SEER) database were analyzed. Patients with FIGO stage IVB cervical or endometrial carcinoma, corresponding to distant metastatic disease, were included. Survival was evaluated using the Kaplan-Meier method and Cox proportional hazard models. Results: A total of 8,106 patients were analyzed, of which 3,067 (38%) had cervical carcinoma and 5,039 (62%) had uterine carcinoma. The pathology was squamous cell carcinoma in 1,986 (25%) patients, adenocarcinoma in 5,029 (62%), and other histology in 1,091 (13%).

Fig 1. (a) 3D rectum surface dose; (b) 2D rectum RSDM; (c) Mean rectum RSDM of the toxicity group; (d) Mean rectum RSDM of the non-toxicity group; (e) p-value map of the RSDM between the toxicity and non-toxicity group; (f) Mean Grad-CAM map of the toxicity group. The abbreviations indicate the directions of ‘S: Superior’, ‘I: Inferior’, ‘P: Posterior’, ‘A: Anterior’, ‘R: Right’ and ‘L: Left’.
Primary tumor-directed brachytherapy was delivered to 814 (10%) patients. The median follow-up was 10 months (range, 1-119). The median survival (MS) was 13 months (95% Confidence Interval [CI], 12.5-13.5) in the overall cohort, 27 months (95% CI 23.9-30.1) in patients who received brachytherapy, and 11 months (95% CI 10.6-11.4) in patients who did not receive brachytherapy (p<0.01). Use of brachytherapy was independently associated with prolonged survival on multivariate analysis (MVA) (Hazard Ratio 0.55, 95% CI 0.50-0.62, p<0.01), when adjusted for age, primary tumor location and extent, histology, external beam radiation (EBRT), cytoreductive surgery, and location of metastatic disease. EBRT was also associated with survival on MVA but with a smaller effect (Hazard Ratio 0.82, 95% CI 0.77-0.87, p<0.01). Palliative brachytherapy was associated with prolonged survival in patients with distant lymph node (MS 33 vs 14 months, p<0.01) or visceral/peritoneal metastasis (MS 23 vs 11 months, p<0.01). In the subset of patients with detailed information on location of metastases, brachytherapy was associated with prolonged survival in patients with lung (MS 17 vs 7 months, p<0.01) or liver (MS 11 vs 7 months, p=0.02); but not brain (p=0.16) or bone metastasis (p=0.26). These associations were validated using matched-pair analysis, sequential landmark adjustment, and decision-tree modeling of risk groups. Conclusions: The use of primary tumor-directed brachytherapy is independently associated with improved survival in patients with metastatic cervical or uterine carcinoma. Its utilization should be considered in patients with symptomatic primary tumors, even in the setting of advanced metastatic disease. Prospective trials evaluating brachytherapy in this population of patients should be supported based off the hypothesis-generating results of our study.

PP27 Presentation Time: 9:18 AM
Distant Metastasis Is the Primary Site of Failure Following Image Guided Interstitial Brachytherapy in Management of Primary Vaginal Cancers
Jagdeep Raince, MD1, Sang June Park, PhD2, Lalaine Zaide, PA-C1, D. Jeffrey Demanes, MD1, Mitchell Kamrava, MD2.
1UCLA, Los Angeles, CA, USA, 2Samuel Oschin Cancer Center, Cedars Sinai Medical Center, Los Angeles, CA, USA.
Purpose: We performed a retrospective analysis of our institutional experience using image guided interstitial brachytherapy (IGBT) for women with primary vaginal cancers given limited data utilizing this approach. Materials and Methods: Between 2010-2015, 18 primary vaginal cancer patients were treated with interstitial IGBT. Median age was 67 years old. Distribution by FIGO stage was: 6% I, 22% II, 39% III, 17% IVA, 17% IVB (2 patients with PA nodal disease and 1 with perirectal deposit). 50% of the cohort was node positive. 83% had squamous cell cancer. 67% received concurrent chemotherapy. 78% of patients had tumors > 4 cm at diagnosis. The median EBRT dose was 45 Gy. High-dose-rate BT was delivered in a single implant to a median dose of 25 Gy in 5 fractions to a CT-defined volume. Median EBRT+BT EQD2 dose was 75.5 Gy and median BT EQD2 dose was 31.3 Gy. Median CTV volume treated was 81 cc. The CTV volume encompassed the whole vagina in 56% of patients, just gross disease in 28% and a combination of both in 17% (initial volume whole vagina and then cone down to gross disease). The median D90 for the CTV was 83 Gy. The median cumulative EQD2 D2cc dose for the rectum, sigmoid, and bladder, were 63 Gy, 50 Gy, and 64 Gy. The urethra D1cc median cumulative EQD2 dose was 64 Gy. Kaplan-Meier method was used for actuarial survival analysis. Toxicity was graded using Common Terminology Criteria for Adverse Events, version 4.0. Results: Median follow-up time was 27 months. Three-year actuarial local control (LC) was 88%. Three-year actuarial rate of developing distant metastasis (DM) was 46%. 78% of distant metastasis developed in the lungs. Three-year actuarial cause specific and overall survival (OS) were 83% and 62%, respectively. There were no Grade 3 or higher GU/GI toxicities. Conclusions: Utilization of IGBT for primary vaginal cancers results in high local control rates with low significant gastrointestinal and genitourinary toxicities. Distant metastasis is the predominant site of failure. Investigation into identifying patients at highest risk of developing distant metastasis and considering adjuvant chemotherapy is warranted to help improve outcomes for these women.

PP28 Presentation Time: 9:27 AM
Trends in Cervical Cancer Brachytherapy Volume Suggest Case Volume Is Not the Primary Driver of Poor Compliance Rates with Brachytherapy Delivery for Locally Advanced Cervical Cancer
Daniel M. Trifiletti, MD1, Surbhi Grover, MD, MPH2, Bruce Libby, PhD4, Timothy N. Showalter, MD, MPH1.
1CA, USA.
Purpose: In the treatment of cervical cancer, brachytherapy utilization is decreasing and it is thought to be related to trainee exposure. Our purpose was to evaluate temporal trends in the volume of cervical cancer brachytherapy cases available to radiation oncology trainees as a potential contributing factor to recognized national trends toward decreased utilization of brachytherapy for locally advanced cervical cancer. Materials and Methods: The National Cancer Database (NCDB) was queried to identify a cohort of women diagnosed with locally advanced cervical cancer during 2004-2013 who were treated with primary radiation therapy. We identified academic facilities that reported radiation therapy and brachytherapy delivery for the cohort during the study period and categorized facilities based on number of cases per calendar year. We then evaluated temporal trends in proportion of facilities. Results: A total of 6,290 patients treated at 220 facilities were included in the analysis. Overall, the proportion of academic facilities with 6+ or 4-5 annual patients appears relatively stable during the study period without a clear downward trend over time. The proportion of facilities with 6+ annual patients treated with brachytherapy was consistently low (near 20%), and the proportion of facilities with 0 annual patients was consistently high (near 20%), throughout the study period (Figure). Conclusions: Our analysis of the NCDB suggests that cervical cancer case volume at academic institutions, available for radiation oncology resident training, was relatively stable throughout the study period. These findings suggest that targeting resident educational programs should not be the highest priority for interventions to improve rates of appropriate utilization of brachytherapy for cervical cancer patients, and that effective efforts will instead focus on other issues such as reimbursement reform, encouraging referral to specialized brachytherapy centers, and educating practicing clinicians.
External Pelvic and Vaginal Irradiation versus Vaginal Irradiation Alone as Postoperative Therapy in Women with Early Stage Uterine Serous Carcinoma: Results of a National Cancer Database Analysis

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1Radiation Oncology, Henry Ford Health System, Detroit, MI, USA, 2Public Health Science, Henry Ford Health System, Detroit, MI, USA, 3Gynecologic Oncology, Henry Ford Health System, Detroit, MI, USA.

Purpose: Adjuvant treatment in women with early stage uterine serous carcinoma (USC) consists of chemotherapy with either vaginal brachytherapy (VB), pelvic external beam radiation therapy (EBRT), or a combination of VB and pelvic EBRT. We sought to compare survival outcomes across these various radiation treatment modalities using the National Cancer Database (NCDB). Materials and Methods: The NCDB was queried for adult females with histologically confirmed International Federation of Gynecology and Obstetrics (FIGO) 1988 stage I-II USC diagnosed from 2003-2013 treated definitively with hysterectomy, adjuvant chemotherapy and radiation therapy. Chi-square tests were used to assess differences by radiation type (VB, pelvic EBRT, and EBRT+VB) and various clinical variables. The Kaplan-Meier and the log-rank test methods were used to evaluate survival outcomes. Risk factors related to overall survival (OS) were identified by univariate and multivariate analysis. Results: We identified 1,336 patients with USC who met our inclusion criteria. The majority of patients were treated with VB
(66%) compared with EBRT (21%) or combination EBRT+VB (13%). The proportion of patients who received EBRT+VB was higher for those who did not have a lymph node dissection or with fewer dissected lymph nodes. Patients treated with VB alone had longer 5-year survival (84% [95% CI 80-90%]) than those treated with EBRT (75% [69-80%]) (p < 0.001). On multivariate analysis, the presence of lymphovascular space invasion (HR 2.48, p < 0.001) and the absence of a lymph node dissection (HR 2.24, p=0.047) were independent predictors of OS.

**Conclusions:** In this large population based study, there is a suggestion that VB alone may be sufficient adjuvant radiation in patients with USC treated with chemotherapy and who underwent an adequate surgical staging. There is a clear benefit to complete nodal analysis and should be performed in all patients with this high-risk histology.

**PP30**  
**Presentation Time:** 9:45 AM  
**Image-Guided Brachytherapy for Definitive Treatment of Inoperable Endometrial Carcinoma**  
Brian J. Gebhardt, MD¹, Beant S. Gill, MD¹, Hayeon Kim, PhD, DABR², Christopher Houser, MS¹, Scott M. Glaser, MD, Joseph Kelley, MD², Paniti Sukumvanich, MD², Robert Edwards, MD², John Comerci, MD², Alexander Olawaiye, MD², Madeleine Courtney-Brooks, MD, MPH², Michelle Boisen, MD², Jessica Berger, MD², Sushil Beriwal, MD².

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**Purpose:** Standard management of endometrial cancer consists of upfront surgical staging +/- adjuvant therapy depending upon pathologic risk factors. A significant proportion of patients (pts), however, are unable to undergo surgery due to medical comorbidities, and in this setting definitive BT +/- external beam radiotherapy (EBRT) can be used for definitive management of early stage disease. We present our experience with image-guided definitive BT alone for treatment of clinical Stage I medically inoperable endometrial cancer. **Materials and Methods:** Pts with medically inoperable, clinical Stage I endometrial adenocarcinoma treated with definitive BT alone were retrospectively reviewed. Pts were required to have Grade 1-2 histology and low-volume disease defined as less than 50% myometrial invasion and tumor size ≤4 cm on MRI. Treatment consisted of 5-6 fractions of image-guided high-dose-rate (HDR) BT utilizing a tandem and cylinder applicator with either CT- or MRI-based planning for each fraction. For pts who underwent MRI-based planning, the gross tumor volume (GTV) was contoured. The dose, typically 7-7.5 Gy/fx, was prescribed to the high-risk clinical target volume (HR-CTV), which consisted of the entire uterus, cervix, and upper 1-2 cm of the vagina. Doses were calculated and normalized to the equivalent 2 Gy dose (EQD2). Local-regional control (LRC) was defined as complete imaging response or cessation of vaginal bleeding if MRI was unavailable. **Results:** From 2007-2016 45 pts underwent definitive BT alone to a median dose of 37.5 Gy (range, 35-45 Gy) in 5-6 fractions. Nineteen pts (42%) were treated with MRI-based plans with MRI obtained with applicator in place, 19 (42%) with CT-based plans with MRI obtained prior to BT, and 7 (16%) with CT-based plans alone. The median GTV and HR-CTV volumes were 5.9 cc (range, 0.7-18.7 cc) and 80.9 cc (range, 17.2-159.0 cc), respectively. The median cumulative dose to 90% (D90) of the GTV was 132.8 Gy (range, 76.5-295.6 Gy) EQD2, and the median HR-CTV D90 was 49.7 Gy (range, 34.5-57.2 Gy). The median follow-up among living pts was 18.6 months (range, 3.0-64.3 months). Cessation of vaginal bleeding occurred in 98%. Post-treatment MRI was performed in 29 pts (64.4%), of which complete response (CR) was demonstrated in 26 (90%), and 3 (10%) had residual nonspecific signal abnormality. Of these 3 pts, 2 had resolution of vaginal bleeding and no further evidence of disease on follow-up, and the 3rd had residual endometrial thickening and a suspicious iliac node on follow-up MRI and subsequently developed peritoneal carcinomatosis 9 months after BT. Among pts with imaging CR, there were 2 local failures consisting of nodularity within the endometrium managed with D&C and levonorgestrel IUD in 1 pt and a vaginal recurrence salvaged with vaginal BT in another. The GTV D90 were 104.3 Gy and 126.1 Gy in these 2 pts, compared with a median of 138.4 Gy in other patients. The 2-year LRC and overall survival rates were 90% and 86%, respectively. Among a subset of 20 pts with at least 2 years follow-up (median 37.6 months), no additional local failures were seen beyond 2 years. The median rectum, sigmoid, and bladder dose to 2 cc (D2cc) EQD2 values were 19.8 Gy (range, 8.3-46.3 Gy), 40.4 Gy (range, 17.5-60.7 Gy), and 45.8 Gy (22.1-66.1 Gy), respectively. No grade 3 or greater acute or late toxicity was observed. **Conclusions:** Image-guided HDR BT alone for treatment of early-stage, medically inoperable endometrial cancer is feasible with excellent response rates and early clinical results. While dose to the HR-CTV was relatively low, the high LRC rates may be related to the high dose delivered to the GTV with 3D planning. This image-guided approach also allows better sparing of adjacent critical organs and ensures coverage of the target, which likely contributed to the low toxicity rate and high rate of local control in comparison with prior series utilizing 2D point-based planning. These data suggest that in
select pts with grade 1-2, low-volume disease, EBRT may be omitted without compromising disease control and thus sparing the potential morbidity of pelvic radiation in a medically frail population.

Plenary Session
Friday, April 21, 2017
1:45 PM - 3:00 PM

PL01 Presentation Time: 1:45 PM
Long Term Outcomes of I\textsuperscript{125} Eye Plaque Brachytherapy in Patients with Choroidal Melanoma
Irina Sparks, MD\textsuperscript{1}, William Wiroshtko, MD\textsuperscript{2}, Jason Rownd, MS\textsuperscript{3}, Natalya Morrow, PhD\textsuperscript{4}, Beth Erickson, MD\textsuperscript{4}.
\textsuperscript{1}Radiation Oncology, MCW, Milwaukee, WI, USA, \textsuperscript{2}Eye PLAce Cancer Center, Milwaukee, WI, USA, \textsuperscript{3}Ophthalmology, MD, USA, \textsuperscript{4}Ophthalmology, MCW, Milwaukee, WI, USA.

Purpose: To determine the relationship between MCW prescription parameters and outcomes in patients with choroidal melanoma treated with I\textsuperscript{125} eye plaque radiotherapy. Background: Choroidal melanoma is a rare condition that impacts vision and survival. Eye plaque therapy is a vision-preserving treatment that has been utilized for many decades; however, further optimization of the treatment parameters is needed to reduce toxicities and improve outcomes. Variations in treatment approaches exist among different institutions. At MCW the prescription dose is typically specified at the tumor apex and the prescription dose and dose rate are slightly lower than used in COMS studies. This retrospective review investigated the relationship between MCW treatment parameters and outcomes.

Materials and Methods: From 2000-2015, 134 consecutive patients underwent I\textsuperscript{125} eye plaque (COMS design) brachytherapy for treatment of choroidal melanoma. 3 patients were excluded due to follow up <1 year. With IRB approval, data was collected via retrospective review, including demographic, clinical and dosimetric parameters (total dose, dose rate, dose gradient across the lesion). Dose and dose rate to macula and optic disk were calculated accounting for uncertainty of the rotational position of the plaque. Simple statistical analysis was performed to assess outcomes including decrease in visual acuity by >2 lines on a Snellen chart, retinopathy, functional vision preservation at 2 and 5 years, local and distal disease control, and survival (i.e., disease-free survival and overall survival).

Results: Population consisted of 98% Caucasian with median age of 62 (26-88). 53% were women. Median tumor height was 3.4 mm (1.5-10.47) with median basal diameter of 10.7 mm (3.2-18.6). COMS stage was 18% small and 76% medium. Average plaque size was 16 (12-20). Median dose(TG43) received at the apex was 68.7 (51.8-77.7) Gy and dose rate 58.35 (46.8-70.4) cGy/hr. Median dose received at the base was 129 (79.8-350) Gy and dose rate 110.7 (61.1-299) cGy/hr with the gradient across the tumor 62.3 (11.9-280) Gy. With median follow up of 47 months local recurrence was observed in 13% and metastatic disease in 17% of patients. Median dose and dose rate received at the tumor apex in patients with local recurrence was not statistically different than in patients without local recurrence, 68.8 Gy (58.6 cGy/hr) vs. 68.7 Gy (58.3 cGy/hr) respectively. Metastases to liver was the most common site with median time to diagnosis from brachytherapy procedure of 22 months. Median distance to fovea was 6 mm and to optic nerve was 6.5 mm. Median dose received by fovea was 33.95±13 (3.55-307) Gy and dose rate 28.6±10.2 (3.15-259) cGy/hr. Median dose received by optic disk was 29.5±10.8 (3.55-307) Gy and dose rate 24.6±9 (3.15-251) cGy/hr. 27% of patients had 20/20 vision and 12% had significant visual impairment pretreatment. 105 and 48 patients had vision assessed post treatment at 2 and 5 years respectively with >2 lines drop on Snellen chart seen in 43% at 2 years and 46% at 5 years. Severe visual loss (>20/200) was seen in 33%. Vision loss potentially induced primarily by radiation was seen in 29%. 2 patients have undergoneenucleation due to eye pain and 9% for local recurrence.

Conclusions: Patients with choroidal melanoma treated with I\textsuperscript{125} eye plaque brachytherapy at our institution experienced comparable local control and rate of metastases, and had better visual preservation in comparison to reported by COMS studies. Dose specification at the apex does not result in an increased risk of recurrence in patients with apical heights <5mm. The total dose and dose rate used may improve long term visual outcome as compared to the COMS study.

PL02 Presentation Time: 2:00 PM
Evaluation of a Machine-Learning Algorithm for Treatment Planning in Prostate Low-Dose-Rate Brachytherapy
Alexandru M. Nicolae, MSc\textsuperscript{1}, Gerard Morton, MD\textsuperscript{2}, Hans Chung, MD\textsuperscript{2}, Andrew Loblaw, MD, MSc\textsuperscript{2}, Suneil Jain, MB BCh Phd\textsuperscript{2}, Darren Mitchell, MBBS\textsuperscript{3}, Lin Lu, BSc\textsuperscript{4}, Joelle Helou, MD\textsuperscript{2}, Motasem Al-Hanaqa, MD\textsuperscript{2}, Emily Heath, PhD\textsuperscript{2}, Ananth Ravi, PhD\textsuperscript{1}.
Purpose: This retrospective study presents the results of a machine-learning (ML) algorithm used to automatically generate high-quality, prostate low-dose-rate (LDR) brachytherapy treatment plans. The algorithm can replicate several characteristics of expert created pre-operative LDR treatment plans. The planning efficiency, dosimetry, and quality (as assessed by experts) of pre-operative plans generated with an ML model was evaluated. Materials and Methods: A training database of 100 prostate LDR treatment plans - filtered for high-quality post-operative dosimetry - was used to train an ML model to predict source patterns that approximate successful plan dosimetry. The algorithm was trained on cases with similar anatomic features to obtain a starting treatment plan. A stochastic, iterative decision process was then used to examine different plan states to find an optimal state for the current anatomy; planning strategies were then stored to predict future planning cases. This study compared pre-operative treatment plans generated by the ML algorithm against brachytherapist (BT) treatment plans in terms of planning time, and dosimetry. Qualitative pre-operative plan quality was evaluated by expert BTs using a Likert scale questionnaire in a blinded comparison study. Results: The average planning time for the ML algorithm to produce a plan from an optimal policy was 0.84 ± 0.57 min., compared with 17.88 ± 8.76 minutes for the expert planner (p = 0.020). Pre-operative plans were highly comparable dosimetrically to the BT plans with only the prostate V150% being 4% lower for ML plans (p = 0.002). Figure 1 demonstrates axial isodose distributions for a single patient showing a) the ML plan, b) the expert BT plan and c) a generic optimization algorithm plan. The responses to the Likert questionnaire demonstrated that rankings of the ML-generated plans were comparable to expert BT treatment plans in terms of target coverage, normal tissue avoidance, implant confidence, and the need for significant plan modifications. Respondents had difficulty differentiating between plans generated by a human planner or those generated by the ML algorithm. Conclusions: The prototype ML algorithm is capable of rapidly generating prostate LDR pre-operative treatment plans that have comparable quality to plans created by BT-experts. The adoption of automated planning models for brachytherapy is expected to improve the uniformity of plan quality, while reducing planning time, frequency of planning errors, and use of clinical staff resources.
Purpose: Prior studies of low dose rate (LDR) prostate brachytherapy (BT) for salvage of local recurrence (LR) after external beam radiotherapy (EBRT) are limited by retrospective reporting. The primary objective of this prospective Phase II trial (NCT00450411) was to evaluate late gastrointestinal (GI) and genitourinary (GU) adverse events (AEs) after salvage LDR BT. Materials and Methods: Eligible patients had low or intermediate risk prostate cancer prior to EBRT and biopsy-proven LR at an interval > 30 mos after EBRT, with PSA < 10 ng/mL and no regional or distant disease at study entry. Prescribed minimum target dose was 140 Gy with I-125, or 120 Gy with Pd-103. The primary endpoint was late GI/GU AEs occurring 9-24 mos after BT, Grade 3 or higher, and possibly, probably or definitely attributed to BT. These were projected to be ≤ 10%, with ≥ 20% considered unacceptable. With a one-sided significance level of 0.05 and an 85% power, 87 evaluable patients were required under Fleming’s multiple testing procedure. Analyzable patients had a minimum 23 months follow-up. All events were graded with CTCAE V3.0. Multivariate analyses investigated associations of pre-treatment or treatment variables with AEs.

Time to first occurrence of an AE was modeled by the Fine-Gray method. Results: From 05/11/2007 - 01/21/2014, 100 patients were registered from 20 centers, of which 92 were analyzable. Median follow up was 54 mos (range 4-97); median age was 70 (IQR: 65-74). Initial Gleason score was 7 in 48%, and PSA >10 ng/ml in 16%. Median dose of EBRT was 74 Gy (IQR: 70-76). Androgen deprivation was combined with salvage BT in 16%. Median interval from prior EBRT was 85 months (IQR: 60-119). The primary endpoint was evaluable in 87(95%) of the 92 patients. Twelve (14%) experienced late grade 3 GI/GU AEs (1 proctitis; 1 urethral fistula; the remainder being urinary frequency, incontinence, and retention). There were no treatment-related grade 4 or 5 AEs. No pre-treatment variable predicted late AEs, including prior EBRT dose and elapsed interval. Higher BT dose (D90: isodose covering 90% of the target volume) predicted both occurrence of late AE (OR 1.24; 95% CI 1.01-1.52; p=0.04) and time to occurrence (HR 1.19: 95% CI 1.02-1.38; p=0.03). Although the prescribed dose was constant, the delivered dose varied considerably. The median D90 was 150 Gy (IQR: 140-159 Gy) but with a maximum of 209 Gy. Although median V150 (% ETV receiving ≥150% of prescribed dose) was 50%, the range was 18-90%.

Conclusions: This is the first prospective multicenter trial to report outcomes of salvage LDR BT for post EBRT LR. The rate of late grade 3 AEs (14%) was not unacceptable by the predetermined protocol specification, without any grade 4-5 events, comparable to a study of primary EBRT + LDR (WR Lee 2007; RTOG 0019). The only factor predictive of late AEs was implant dose, underlining the need for meticulous planning and technique to limit the final delivered dose. Clinical outcomes for efficacy will be reported when minimum 5-yr follow-up is met. Support: This project was supported by grants U10CA180868 and U10CA180822 from the NCI.

PL04  Presentation Time: 2:30 PM

The Use of Functional MRI in Cervical Cancer Patients with Incomplete Response on PET/CT Following MRI Guided High-Dose Rate Brachytherapy

Ronny Kalash, D.O.1, Balasubramanya Rangaswamy, M.D.3, Scott Glaser, M.D.1, Hayeon Kim, PhD1, Christopher Houser, PhD1, Sushil Beriwal, M.D.1.

1Radiation Oncology, University of Pittsburgh Medical Center, Pittsburgh, PA, USA, 2Radiology, University of Pittsburgh Medical Center, Pittsburgh, PA, USA.

Purpose: Multiple series have reported a 30% incomplete metabolic response rate on PET/CT following definitive chemoradiation for cervical cancer. Post-treatment metabolic response has significantly predicted progression free survival (PFS), with incomplete responders having a reported 3 year PFS of 25-35%. Herein we investigated the correlation between PET/CT response and outcome in the era of MRI based planning, and assess whether the addition of DW-MRI could more accurately classify treatment response and prognosis in patients with an incomplete response on PET/CT (PET-1R). Materials and Methods: A single-institution retrospective chart review identified consecutive patients with FIGO stage IB1-IVA cervical cancer treated with concurrent chemoradiation including cisplatin and high-dose rate brachytherapy via ring and tandem, with or without interstitial needles.

Results: From 05/11/2007 - 01/21/2014, 103 patients were registered from 20 centers, of which 92 were analyzable. Median follow up was 54 mos (range 4-24 mos after BT, Grade 3 or higher, and possibly, probably or definitely attributed to BT. These were projected to be ≤ 10%, with ≥ 20% considered unacceptable. With a one-sided significance level of 0.05 and an 85% power, 87 evaluable patients were required under Fleming’s multiple testing procedure. Analyzable patients had a minimum 23 months follow-up. All events were graded with CTCAE V3.0. Multivariate analyses investigated associations of pre-treatment or treatment variables with AEs.

Time to first occurrence of an AE was modeled by the Fine-Gray method. Results: From 05/11/2007 - 01/21/2014, 100 patients were registered from 20 centers, of which 92 were analyzable. Median follow up was 54 mos (range 4-97); median age was 70 (IQR: 65-74). Initial Gleason score was 7 in 48%, and PSA >10 ng/ml in 16%. Median dose of EBRT was 74 Gy (IQR: 70-76). Androgen deprivation was combined with salvage BT in 16%. Median interval from prior EBRT was 85 months (IQR: 60-119). The primary endpoint was evaluable in 87(95%) of the 92 patients. Twelve (14%) experienced late grade 3 GI/GU AEs (1 proctitis; 1 urethral fistula; the remainder being urinary frequency, incontinence, and retention). There were no treatment-related grade 4 or 5 AEs. No pre-treatment variable predicted late AEs, including prior EBRT dose and elapsed interval. Higher BT dose (D90: isodose covering 90% of the target volume) predicted both occurrence of late AE (OR 1.24; 95% CI 1.01-1.52; p=0.04) and time to occurrence (HR 1.19: 95% CI 1.02-1.38; p=0.03). Although the prescribed dose was constant, the delivered dose varied considerably. The median D90 was 150 Gy (IQR: 140-159 Gy) but with a maximum of 209 Gy. Although median V150 (% ETV receiving ≥150% of prescribed dose) was 50%, the range was 18-90%.

Conclusions: This is the first prospective multicenter trial to report outcomes of salvage LDR BT for post EBRT LR. The rate of late grade 3 AEs (14%) was not unacceptable by the predetermined protocol specification, without any grade 4-5 events, comparable to a study of primary EBRT + LDR (WR Lee 2007; RTOG 0019). The only factor predictive of late AEs was implant dose, underlining the need for meticulous planning and technique to limit the final delivered dose. Clinical outcomes for efficacy will be reported when minimum 5-yr follow-up is met. Support: This project was supported by grants U10CA180868 and U10CA180822 from the NCI.
Brachytherapy was delivered in 5 once or twice weekly fractions of 5-6 Gy/fraction with MRI based treatment planning. Patients were excluded if they underwent perineal template-based interstitial brachytherapy. **Results:** A total of 230 cervical cancer patients treated between 2007-2016 were identified, 39/230 (17%) demonstrated an incomplete response (PET-IR) on follow up centrally reviewed PET/CT scan performed at a mean interval of 3.3 months following completion of treatment. 2 year overall survival in all patients with PET-IR was 75%. After a median follow up of 17 months a total of 10/39 (26%) patients with PET-IR suffered a local recurrence (LR). The 2 year overall survival (OS) in patients with a LR was 37.5%, while the 2 year OS in patients with PET-IR and no subsequent LR was 96%. A total of 15/39 patients with a PET-IR underwent a DW-MRI post-treatment. A total of 5/15 post-treatment DWI-MRI’s were interpreted as positive by central review (mean apparent diffusion coefficient (ADC) of 1050 x 10-6 mm2/s), 4/5 DW-MRI positive patients suffered a histologically confirmed local recurrence at a mean interval of 4.1 months following treatment completion, while one patient had negative biopsy and has been followed an additional 14 months and is without evidence of disease recurrence. Additionally, 10/15 DW-MRI studies were interpreted as negative, and none of these patients suffered a local recurrence. In this setting, DW-MRI Positive Predictive Value (PPV) was 80%, Negative Predictive Value (NPV) was 100%, Specificity was 91%, and Sensitivity was 100%. **Conclusions:** Incomplete PET/CT response was documented in 17% of centrally reviewed patients following MRI based brachytherapy for cervical cancer. The false positive rate of PET-IR was 74%, and integration of functional MRI helped further differentiate true positives from false positives. The value of functional MRI requires further validation in a prospective large dataset, as this imaging modality may allow for earlier intervention and salvage treatment in those with PET-IR.

**Scientific Session: Socioeconomic Proffered Papers**
**Friday, April 21, 2017**
**3:30 PM - 4:30 PM**

**PP31**
**Presentation Time: 3:30 PM**
**Factors Associated with Willingness to Invest in a New HDR Isotope**
Raymond Mailhot Vega, MD, MPH1, Wesley Talcott, BA1, Omar Ishaq, MD1, Fauzia Shaikh, MD1, Christina Small, MPH2, Tamara Duckworth, MS1, Carmen Perez, MD, PhD1, Peter B. Schiff, MD, PhD1, William Small, Jr., MD2, Matthew Harkenrider, MD2.

1Radiation Oncology, NYU Cancer Center, New York, NY, USA, 2Radiation Oncology, Loyola University Chicago, Chicago, IL, USA.

**Purpose:** The introduction of Co-60 as an HDR source for gynecological tumor management to the U.S. market provides a new alternative to the most commonly utilized source of Ir-192. Financially, its longer half-life with fewer exchanges over time may increase investment; however, with its higher energy, some centers may have to increase shielding should they pursue Co-60. A cost-benefit analysis (CBA) can assist decision makers faced with such a business choice. As part of our CBA analysis, we surveyed radiation oncologists nationally to determine their acceptable willingness-to-pay (WTP) thresholds for additional shielding requirements should an HDR source more cost-effective than Ir-192 become available. With the survey completed, we sought to determine what respondent factors were associated with willingness to invest in a new HDR isotope. **Materials and Methods:** A nationwide survey of U.S. radiation oncologists was conducted from June to July 2015. In addition to assessing WTP thresholds for shielding, the survey assessed demographic characteristics of respondents and factors that may influence decision making of source selection. Respondents who self-identified as decision makers in institutional radiotherapy (RT) equipment purchase and acquisition were asked how much they would be willing to spend on shielding should a source more cost-effective than Ir-192 be commercially available. Subsequent analyses of categorical data to identify respondent factors associated with selected WTP for shielding expansion were conducted using chi-square and Fisher’s exact test. **Results:** 509 surveys were attempted, 440 surveys were completed, and 280 respondents self-identified as decision-makers in equipment purchase and are included in analysis. Approximately 62% of respondents had been board-certified for more than 10 years. The median selection for WTP for one-time shielding investment should a source more cost-effective source than Ir-192 become available was $50-75K, and the most common answer was less than $25K (25%). Amount of money that decision-makers were willing to invest for shielding (knowing the source would be cost-effective) was not significantly associated with their knowledge of Co-60 (p=0.38), involvement in selection or purchase of brachytherapy sources or applicators (p=0.51), their center’s
performing HDR brachytherapy for gynecologic cancer (p=0.63), their involvement in HDR brachytherapy planning for gynecologic tumor management (p=0.99), their attendance of any national conferences specific for brachytherapy within the past year (p=0.08), number of afterloaders at their facility (p=0.600), number of practitioners at their center who perform brachytherapy (p=0.77), ABS membership (p=0.085), or their having met with brachytherapy vendors within the past 12 months (p=0.145). Higher WTP selection was statistically significantly associated with higher number of attendings employed at a respondent’s center (p=0.01). **Conclusions:** Self-identified decision makers in RT equipment acquisition had low willingness to invest in shielding should an HDR source more cost-effective than Ir-192 become available. Both ABS membership and having attended a national conference specific for brachytherapy trended towards statistical significance, and higher number of attendings employed at a respondent’s center was statistically significantly associated with higher WTP selection. Given the results, it is possible that larger centers with greater exposure to brachytherapy may be more likely to adopt a new HDR source. While centers shielded for Co-60 may pursue such a source, it appears that the market is unfavorable for Co-60 with little investment interest in centers that would require shielding expansion.

**PP32**

**Presentation Time: 3:39 PM**

**Quality of Life After I-125 Seeds Implantation in Patients with Advanced Malignant Tumor**

Panfeng P. Wang, Master, Muyi Zhang, Bachelor, Zhe Ji, Doctor, Yuliang Jiang, Doctor, Junjie Wang, Postdoctor. Department of Radiotherapy in Peking University Third Hospital, Beijing, China.

**Purpose:** I-125 seeds implantation has been widely used in local treatment of malignant tumor. It has the advantage in high dose of target area and low dose of normal tissue. However, except the prostate cancer, it is mostly used for palliative treatment for recurrent or relapse in advanced malignant tumor in order to suppress tumor development and improve the quality of life of patients. The aim of this study was to investigate the changes in QOL for patients with advanced malignant tumor after I-125 seed implantation. **Materials and Methods:** Our research is a prospective study and uses the convenience sampling method to choose the patients with advanced tumor in the Department of Radiation Oncology in a Beijing top three hospital. We designed the questionnaire to investigate patients’ situation. Our questionnaire included the patients’ normal conditions, diseases conditions and the core quality of life scale (EORTCQLQ-C30) made from the European Organization for Research on Treatment of Cancer. Patients finished the questionnaire before and 24 hours after they accepted the seed implantation. Then we got the conditions of 1 and 3 months after the seeds implantation by the telephone follow-up survey. We used the SPSS17.0 to statistics all the data. **Results:** From July to November in 2016, 42 patients were included in the study (24 male and 18 female), the average age was 58.86±14.13 (25–91). The patients’ EORTCQLQ-C30 scale score in 24 hours after the seed implantation, 1 month after the seed implantation was better than preoperative acore. The EORTCQLQ-C30 scale score in 1 month after the seed implantation was highest than others. The EORTCQLQ-C30 scale score when 3 month after the seeds implantation was lower than 1 month after the seed implantation but higher than perioperative score. Details are showed in Table 1. **Conclusions:** The seeds implantation can improve the quality of life in patients with advanced malignant tumor. When 3 month after the seed implantation, patients’ quality of life get obviously improved. But after 3 months, the patients’ quality of life get declined which may be influenced by the tumor progression.
Social and Racial Divides in the Utilization of Brachytherapy for Common Malignancies

Zachary D. Horne, MD, Goundappa K. Balassubramani, PhD, Paniti Sukumvanich, MD, PhD, Sushil Beriwal, MD

1Department of Radiation Oncology, University of Pittsburgh Cancer Institute, Pittsburgh, PA, USA, 2Department of Epidemiology, University of Pittsburgh Graduate School of Public Health, Pittsburgh, PA, USA, 3Department of Gynecologic Oncology, University of Pittsburgh Cancer Institute, Pittsburgh, PA, USA.

Purpose: Brachytherapy (BT) is an essential component of or viable standard of care treatment for a number of common malignancies, including prostate, endometrial, and cervical cancers. Recent data have been presented on the declining use of BT nationwide and we sought to evaluate socioeconomic factors which may impact its utilization in patients. Materials and Methods: We utilized the National Cancer Data Base to examine trends for brachytherapy use in low/high risk prostate, operable stage 1 type 1 endometrial, and stage 2/3 cervical cancer patients as influenced by socioeconomic factors. A multivariable backwards conditional binomial regression model was utilized to determine sociodemographic factors which influenced the use of BT over other definitive treatment modalities. Results: A total of 440,355 cases were evaluated: 134,408 low-risk prostate, 138,081 high-risk prostate, 143,281 stage 1A/B endometrial, and 27,232 stage 2-3 cervical cancer patients. Patients with the highest income were less likely to receive a brachytherapy-containing treatment regimen compared to those in the lowest income quartile: likelihood ratio 0.822 (95%CI 0.801-0.844, p<0.001). Similarly, patients living in areas with the highest high school graduation rates were significantly less likely to receive brachytherapy than those regions with the lowest graduation rates: likelihood ratio 0.816 (95%CI 0.793-0.840, p<0.001). Living in an urban setting also decreased the likelihood of receiving brachytherapy compared to living in a rural setting: likelihood ratio 0.896 (95%CI 0.841-0.955, p=0.001). Compared to Caucasian patients, African American patients treated with brachytherapy more frequently: likelihood ratio 1.213 (95%CI 1.182-1.246, p<0.001). Patients who had private insurance were less likely to receive brachytherapy compared to those with government insurance: likelihood ratio 0.706 (95%CI 0.693-0.719, p<0.001). Higher educational status, private insurance, residing in a major metropolitan area, and Caucasian race all continued to be associated with decreased utility of brachytherapy-containing regimens on multivariable regression analysis. Conclusions: From a large, population-based analysis, it is evident that

Table 1: Changes on the quality of life

<table>
<thead>
<tr>
<th>items</th>
<th>Before the seeds implantation in 24h</th>
<th>after the seeds implantation in 24h</th>
<th>1 month after the seeds implantation</th>
<th>3 month after the seeds implantation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total score in EORTCQLQ-C30</td>
<td>82.63 ± 10.419</td>
<td>86.38 ± 20.853</td>
<td>96.75 ± 21.029</td>
<td>89.86 ± 22.645</td>
</tr>
<tr>
<td>Total health performance in 1 week</td>
<td>4.10 ± 1.708</td>
<td>4.26 ± 1.624</td>
<td>4.8 ± 1.389</td>
<td>4.11 ± 1.491</td>
</tr>
<tr>
<td>Total quality of life in 1 week</td>
<td>4.14 ± 1.719</td>
<td>4.26 ± 1.712</td>
<td>4.83 ± 1.403</td>
<td>3.94 ± 1.893</td>
</tr>
</tbody>
</table>
disparities in care exist as a result of social and racial factors. These gaps need to be further examined in an effort to provide standard of care therapy to all patients.

PP34  
**Presentation Time: 3:57 PM**

**The Successful Implementation of High Dose Rate 192-Ir Brachytherapy for Cervix Cancer in a Low-Middle Income Country**

Sommer Nurkic, MD, MPH1, Ana I. Ocampo, MD2, Mario José Pinell Gadea, MD3, Mario Jose Vicente, MD4, Anielka Lucia Velasquez, MD4, Lisbeth Concepcion Lopez Peralta, MD2, Franck Soto Herrera, MD5, Osmara Calero Romero, MD2, Francisco Lopez Tenorio, MD2, Harving Lorente Zamora, MD2, Luis Matamoros Munguia, MS6, Luis Matamoros Munguia, MS2, Anamaria R. Yeung, MD1.

1Radiation Oncology, University of Florida College of Medicine, Gainesville, FL, USA, 2El Centro Nacional de Radioterapia, Managua, Nicaragua.

**Purpose:** In Nicaragua, cervix cancer kills more women than any other type of cancer. In an effort to improve access to treatment and efficiency, Nicaragua, with the help of the IAEA, started a high-dose-rate (HDR) brachytherapy program in 2007. This report details the practical implementation of HDR brachytherapy at the Centro Nacional de Radioterapia, the only radiotherapy (RT) treatment center in the country. **Materials and Methods:** Patients are treated with external-beam radiotherapy (EBRT) to 46-50 Gy at 2 Gy per fraction to the pelvis. A gynecologic exam is performed weekly during EBRT and, once the cervical os is visualized, brachytherapy is initiated. HDR is delivered in 4 fractions of 7 Gy twice weekly. HDR treatment takes place in 2 separate phases: treatment preparation and treatment delivery. Treatment preparation is completed in the procedure room equipped with an exam table with stirrups. A nurse anesthetist provides conscious sedation using a combination of midazolam, fentanyl, and propofol, depending on availability. Using aseptic technique, a Foley catheter is placed with 7 cm³ contrast in the balloon, the uterus is sounded and then dilated, and the brachytherapy applicators are placed in the uterus and vagina. Most cases are done using fixed geometry tandem and ring with a rectal blade. Vaginal packing is generally not used. Immobilization of the applicators is achieved by taping gauze around the applicators and over the perineum. The patient is then transferred to a stretcher and transported to a separate HDR room to begin the treatment delivery process. HDR treatment is performed with the patient on the same stretcher to minimize motion. AP and lateral films are taken using portable x-ray equipment for planning and verification. Physics staff digitize Point A, rectal point, and bladder point. A standard plan is loaded prescribing 7 Gy to Point A, and is approved by the physician. If the dose to the rectal or bladder points exceeds the constraint, the applicator is adjusted or vaginal packing is added and films are repeated. **Results:** Nearly 10 years after the HDR program was first implemented, the center is treating 11 to 15 women with HDR brachytherapy for cervix cancer daily, depending on the age of the HDR source. Fixed geometry applicators a library of standard plans streamlines treatment delivery. Because the entire procedure is carried out in 2 separate rooms, patients can be staggered and thus more patients treated daily. The procedure room and HDR treatment room are turned over every 45 minutes. **Conclusions:** HDR brachytherapy for cervix cancer has been successfully established in Nicaragua, a developing country with limited resources and a high burden of disease. Success was enabled with a dedicated HDR room apart from EBRT rooms, and with implementation of a multi-phase treatment preparation and delivery workflow. Additionally, streamlining treatment with a fixed-geometry applicator and library of standard plans maximizes treatment efficiency and accuracy. Significant challenges remain in regards to patient access, dated technology/software, and equipment maintenance. Nicaragua, provides an example of successful implementation of an HDR program in a resource-limited environment which could serve to guide other countries in similar circumstances.

PP35  
**Presentation Time: 4:06 PM**

**Starting a Prostate HDR Program in a Young Cancer Center - 1st Year Experience**

Aimee Lauzon, MSc1, É Piché, DEC1, S Roy, MD2, T Thibeault, DEC2, S Lacoste, DEC2, F Vallejo C, MSc1, É Létourneau, MSc1, L Igiabashian, MD1, G Mok, MD2, B Carozza, MSc1, A Bourgeois, DEC1, C Paillé, DEC1, J Fanizzi, DEC1, F Hobela, MSc1, M P. Chagnon, DEC1, E M Marques, DEC1, S Fortin, DEC1, C Canuel, BSc(N)1, I Tremblay, BSc(N)1, P D Drouin, MSc1, Danny Duplan, MD1.

1Radiation oncology, CISSS Laval, Laval, QC, Canada, 2Anesthesiology, CISSS Laval, Laval, QC, Canada.
The radiation oncology department at CISSS Laval (Laval, Canada) was inaugurated in February 2012. Our prostate High Dose Rate (PHDR) brachytherapy program began in September 2015 with the commissioning of Oncentra Prostate. The first PHDR patient was treated on January 12 2016 with success. **Purpose:** To efficiently implement a PHDR brachytherapy program while maintaining focus on continuous improvement. To treat patients in under 2.5 hours **Materials and Methods:** A schematic process was designed to streamline a patient’s clinical trajectory from consultation to treatment, and to follow-up. An estimation of the predicted number of patients per year was calculated and different treatment schedule scenarios were considered depending on the availability of resources from the Anesthesiology Department. A calendar was utilized to plan group meetings every three weeks for follow-up and troubleshooting of the implementation of the PHDR program. Materials and equipment were pre-purchased, although many additional materials were added as needed. Acceptance testing was done for three prostate stepper templates, one stepper holder, dose calculation, data transfer, needles, insertion needle and ultrasound endorectal probe. Software was installed according to equipment, methods and local user preferences. A quality assurance program was developed for the ultrasound unit and prostate brachytherapy components. Initial on-site training was completed with Elekta (Stockholm, Sweden), followed by observation sessions at Sunnybrook (Toronto, Canada) and CHUM Notre Dame (Montréal, Canada). There were many consultations with other Québec centers. Multidisciplinary training included radiation oncologists, physicists, radiation therapists, brachytherapy nurses, anesthesiologists and respiratory therapists. Each personnel of the multidisciplinary team had specific steps to learn and perform according to our institutional protocol. Comprehensive MosaiQ electronic documentation templates were created, including care plans, eScribe documents, assessments, and quality check lists. The emergency procedure was reviewed to include the treatment of a PHDR patient under general anesthesia. Radiation safety training sessions were given to the anesthesiology and day surgery teams. Our PHDR protocol was evaluated and optimized by an iterative process, including four dry runs. Times between each step in the protocol were recorded for every patient including: time of patient’s arrival, general anesthesia duration, first needle insertion, contouring, plan approval, treatment delivery, end of procedure and the time of discharge from the recovery unit. **Results:** In 2016, 29 patients were treated with PHDR brachytherapy. All 29 patients underwent general anesthesia. We observed a general tendency for mean procedure duration to go down. The average time lapse between the patients going under general anesthesia and being treated was 3 h 29 min for the first 14 patients, and 2 h 12 min for the last 15 patients. The first PHDR patient was treated in 5 hours. 8 patients were treated in more than 3.5 hours, 7 patients in between 2.5 and 3.5 hours, and 14 patients in less than 2.5 hours. The PHDR protocol “for beginners” was updated twelve times, in which every detail was considered important. Seemingly trivial elements, such as a bracelet for patient identification, pre-procedure checklist revision, air ventilation evaluation for anesthetic gases, and patient positioning to avoid pressure points should not be overlooked. **Conclusions:** The implementation of a new PHDR brachytherapy program should be approached as a continual improvement process. Pre-planning of every detail and communication between all members of the multidisciplinary team is imperative for successful protocol implementation. An iterative validation process was fundamental in improving the efficacy of our PHDR brachytherapy procedure. Using this approach it was possible for us to improve both quality and efficiency. **Acknowledgements:** Dr Maroie Barkati, Dr Gerard Morton, Dominic Béliveau-Nadeau, Don Larsen

**PP36**

**Presentation Time:** 4:15 PM

**Reducing Prostate High Dose Rate Brachytherapy Treatment Planning Duration Through Targeted Interventions**

*Amishi Bajaj, BA1, Mark Korpics, BS1, Brendan Martin, MA2, Michael Mysz, MS3, Ahpa Plypoo, MS1, Hyejoo Kang, MS1, Murat Surucu, PHD1, John Roeske, PHD1, William Small, MD4, Matthew Harkenrider, MD4, Abhishek Solanki, MD, MS1.*

1Radiation Oncology, Loyola University Chicago, Maywood, IL, USA. 2Clinical Research Office, Loyola University Chicago, Maywood, IL, USA.

**Purpose:** We developed a high dose rate (HDR) prostate brachytherapy program in September 2015. As our program grew, we aimed to improve our workflow efficiency from implant to treatment. We analyzed our process to identify improvements in efficiency in the implant procedure and treatment planning durations over time. **Materials and Methods:** All patients were enrolled on a prospective institutional IRB-approved protocol. The same two brachytherapists performed all implants. Our process includes transrectal ultrasound-guided catheter placement followed by CT-based planning and treatment delivery using an Ir-192 afterloader. 13.5 Gy x 2 fractions in 2
implants was used as monotherapy, and 15 Gy x 1 was used as a boost. We recorded the duration of the operative procedure and the duration from completion of CT simulation to completion of treatment planning (which includes physician contouring, catheter identification, and treatment plan optimization). Over the course of our experience, we implemented multiple interventions to improve our treatment planning time, including simultaneous contouring and catheter identification/planning, use of a dose constraint “dashboard,” and others. We compared the implant procedure durations for LDR and HDR cases to identify changes in procedure time. We also evaluated for changes in the HDR implant procedure duration over successive cases by comparing our mean HDR treatment planning time between chronologic quartiles of patients. To account for correlation among multiple HDR plans per patient, significance (p) was determined using univariable linear mixed effects models with random intercepts for each patient. P<0.05 was considered statistically significant. Results: The cohort included 61 consecutive patients who received HDR as either a boost (n=18) or monotherapy (n=41), for a total of 100 implant procedures and plans. 51 consecutive patients treated with LDR brachytherapy were used for comparison. There was a trend towards shorter implant procedure duration for HDR patients (Mean implant procedure time was 60.08 minutes (standard error [SE] 2.12) for LDR and 54.98 minutes (SE 1.76) for HDR; p=0.07). There was no statistically significant change in HDR implant procedure duration with increasing number of cases (p=0.60). The mean treatment planning duration was 3.91 hours (SE 10.95 minutes) for the first 25 patients. This was significantly shorter for the 2nd 25 patients (mean=2.79 hours, SE 10.95 minutes; p<0.001), and for the 3rd and 4th quartile groups of patients (mean=2.49 hours, SE 10.95 minutes; p=0.001 and mean=2.27 hours, SE 10.95 minutes; p<0.0001) when compared to the first quartile. Conclusions: Through multiple interventions to improve our workflow efficiency for patients undergoing prostate HDR brachytherapy, we were able to reduce the treatment planning duration by over 40%, optimizing our clinical throughput and allowing for patients to complete treatment more quickly. In our new HDR program, the catheter implant procedure has similar duration to the LDR seed implant procedure.

Scientific Session: Breast Snap Orals (E-Poster)
Friday, April 21, 2017
5:45 PM - 6:45 PM

BSOR1  Presentation Time: 5:45 PM
Use of Phantoms to Simulate Breast Brachytherapy Insertion
Harry C. Brastianos, MD PhD1, Thomas Vaughan, Msc2, Andras Lasso, PhD2, Thomas Ungi, PhD2, Gabor Fitchinger, PhD2, Conrad Falkson, MD1.
1Radiation Oncology, Queen’s University, Kingston, ON, Canada, 2School of Computing, Queen’s University, Kingston, ON, Canada.
Purpose: One method to deliver radiation to patients with early stage breast cancer is accelerated partial breast irradiation. This treatment targets the post-surgical tumor cavity which is considered the highest risk of recurrence. When performing this treatment, interstitial catheters are placed at the tumor bed and the area surrounding it. The breast shape and cavity position change throughout the procedure making positioning of the catheters a challenge. To achieve the desired position and spacing, we will combine real-time electromagnetic guidance (EM) and ultrasound (US) to guide catheter insertions. Materials and Methods: Plastic phantoms were constructed with a simulated tumor cavity that was visualized with both CT and ultrasound. The catheter insertions in the control arm were achieved using ultrasound guidance. A tissue-locking needle is placed within the tumor cavity and provides a rigid reference. The cavity is contoured in the ultrasound and creates a virtual model. An EM tracked needle guide is pointed toward the tumor bed and the catheter needle is guided into the tissue. Additional parallel catheters are planned on the virtual view based on the first catheter insertion implanted within the tumor cavity. The guiding software is built on 3-D slicer (www.slicer.org) and SlicerIGT (www.slicerigt.org) open source platforms. In the experiment conducted, 11 to 15 catheters were inserted in for phantoms. The goal of the experiment was to place each catheter within the tumor bed with 1 cm spacing within each catheter. The first he phantoms had catheter needles inserted with ultrasound only, while the other two was conducted under combined EMT-US guidance. All four insertions were conducted by the same operator and the position of the catheters were confirmed and measured on CT. Results: Under sole US guidance in the two phantoms, 18 out of 26 catheters passed through the tumor bed or were within 1 cm. The average mean spacing was 0.82 cm with a 0.6 to 1.5 range. Under combined EMT-US guidance, 29 out of 29 catheters passed through the tumor bed or were within 1 cm. The average mean spacing was
1.02 with a 0.6 to 1.33 cm range. Conclusion These experiments on plastic phantoms confirm that EM tracking can be used to place catheter needles inside the tumor cavity. Further verification experiments will need to be conducted with different operators. Research is also being conducted to translate this technique to patient trials. Conclusions: These experiments on plastic phantoms confirm that EM tracking can be used to place catheter needles inside the tumor cavity. Further verification experiments will need to be conducted with different operators. Research is also being conducted to translate this technique to patient trials.

BSOR2

Impact of the Dosimetric Consequences from Minimal Displacements Throughout the Treatment Time in APBI with SAVI Applicators

Shereen Chandrasekara, Medical Physics Msc¹, Silvia Pella, PhD, DABR¹², Mikko Hyvarian, Medical Physics Msc¹, Janeil Pinder, Medical Physics Msc².

¹Physics, Florida Atlantic University, Boca Raton, FL, USA, ²Medical Physics, 21st Oncology, Boca Raton, FL, USA.

Purpose: To assess the variation in dose received by the organs at risk (OARs), that can occur during treatment planning of breast cancer by SAVI applicators and also to determine the importance of providing proper immobilization. Materials and Methods: A retrospective analysis of 20 patients treated with SAVI applicators at SFRO Boca Raton, from 2015/2016 were considered for this study. Treatment planning teams did not see any significant changes in their CT scans through scout images. As a result initial treatment plan was used for the rest of 10 treatments. The CT scans of these patients, taken before each treatment were separately imported in to the treatment planning system and paired with the initial CT scan after completing the contouring. Two sets of CT images were fused together with respective to the applicator, using landmark registration. Dosimetric evaluations were performed. Dose received by skin, ribs and PTV(Planning target volume) on CT images with respect to the initial treatment plan were recorded including the maximum dose, average dose and the minimum dose.

Results: Contours of any of the OARs were not exactly similar when CT images were fused on each other. Deduction in volumes of PTV and cavity was noticed. Small deviations in displacements were also observed from the SAVI applicator to the OARs. There was always a difference between the doses received by the OARs and PTV between treatments. The maximum dose varied between 10% and 20% in ribs and skin surface. The minimum dose varied between 5% and 8% in ribs and skin. The average dose varied between 15% and 20% in ribs and skin. The 0.1cc doses to OARs showed an average change of 10% of the prescribed dose. Similarly PTV was receiving a different dose than the estimated dose in the initial treatment plan. Statistical Analysis show there is a difference for number of treatments between the estimated and delivered doses under 5% significant level. Conclusions: The variation in volumes of OARs and isodoses near the OARs, indicate that the estimated doses to OARs on the planning system may not be the same dose delivered to the patient in all the 10 fractions. Similarly PTV receiving a lesser dose than the prescribed dose is affecting the quality of the treatment. This study reveals the urgent need of improving the immobilization methods when treating APBI with SAVI applicator. It appears that taking a CT scan before each treatment and replanning is necessary to minimize the risk of delivering undesired high doses to the critical organs due to inter fractionation motion of SAVI device. But patient positioning, motion, respiration and observer differences throughout the treatment time including the time lap between the planning and delivering the treatment, can arise the complications of delivering the accurate estimated dose. Using Vac Lock and positioning cushions can limit the motion during treatments. Image guided brachytherapy can improve the quality of the treatment. But for further improvement adjustable registration before each treatment.
Skin Dose Estimation for Contura Multi-Lumen Balloon Breast Brachytherapy
Y. Jessica Huang, PhD, Vadim Pigrish, MS, Fan-Chi Su, PhD, Adam Paxton, PhD, Matthew Poppe, MD, Kristine E. Kokeny, MD, Prema Rassiah-Szegedi, PhD, Hui Zhao, PhD, Bill J. Salter, PhD, David K. Gaffney, MD, PhD.
Radiation Oncology, University of Utah, Salt Lake City, UT, USA.

Purpose: Maximum skin dose is highly dependent on skin to balloon distance when using Contura MLB for APBI treatment. An accurate estimation of maximum skin dose is obtained from planning on a CT before each fraction. In the interest of following ALARA principles, however, daily ultrasound images are often used instead of CT to monitor skin-balloon distance. In our experience, over the course of treatment, the skin-balloon distance often decreases with time, which can lead to a higher skin dose than reflected in the treatment plan. We also found that as long as the ultrasound probe was repositioned with appropriate skin marks, the ultrasound skin distance measurements correlated well with the skin-balloon distance variations found in CT. The purpose of this study is to present a workflow which uses the pre-treatment ultrasound skin distance measurement to estimate the maximum skin dose that would be predicted by the planning CT. With the estimated maximum skin dose, clinicians can then determine whether a re-CT and re-plan are required. This proposed workflow can help minimize imaging dose from CT and further improve treatment efficiency and outcome.

Materials and Methods: Five patients treated with Contura MLB were analyzed retrospectively using Nucletron Oncentra Brachy Treatment Planning System. All of
the patients received a total dose of 34 Gy in 10 fractions in 5 days (two fractions per day). The number of CTs taken for each patient ranged from 3 to 6, depending on their clinical situation. For every patient, a brachytherapy treatment plan (Day0 Plan) was created on the planning CT. A virtual structure (SkinMax) was used to determine the maximum skin dose. The SkinMax structure is a structure located outside of the skin surface close to the balloon and was generated by applying an extended margin to the balloon and then subtracting the body. The Day0 Plans were retrospectively reconstructed onto all the other available CT datasets to generate the DayX Plans. On each of the DayX Plans, the skin-balloon distance was determined and a skin maximum dose was obtained (SkinMax_{DayX}). On the Day0 Plan, several virtual structures were also generated to simulate the skin maximum dose when the skin-balloon distance became smaller, a situation we often observe. These virtual structures were labeled SkinMax-\(d\) mm, where \(-d\) was the skin-balloon distance delta; for example the SkinMax-1 mm was used to represent a skin-balloon distance that is 1 mm less than the planning CT. The doses from SkinMax-\(d\) mm were compared to SkinMax_{DayX} with the skin-balloon distance for DayX in order to determine if the dose estimation using SkinMax-\(d\) mm virtual structure can be used to estimate the actual maximum skin dose for that day. **Results:** The average percentage difference between the predicted values (SkinMax-\(d\) mm) and actual SkinMax on the CT image was -0.31%, ranging between -7.24% and 4.35%. The attached plot shows the results from one typical patient, who had Day0, Day1, and Day4 CT with skin-balloon distance delta (skin distance DayX - skin distance Day0) of 2 mm (Day1) and 6 mm (Day4). The resulting differences between the predicted and actual SkinMax dose were 2.48% (Day1) and 4.35% (Day4). It was found for all of the patients in this study that the ultrasound predicted SkinMax-\(d\) mm value could be used to accurately represent the maximum skin dose without need to acquire a daily CT. **Conclusions:** By using a new workflow based on creation of virtual structures defined on the planning CT, ultrasound measured skin-balloon distances can be used to accurately estimate skin maximum doses. This information will be useful for patients with high skin maximum dose in the initial plan, which could trigger a new CT acquisition and a new plan if the skin-balloon distance delta exceeded a predefined tolerance value. This can result in elimination of extra imaging dose from CT and facilitate treatment efficiency for patients treated with Contura MLB brachytherapy.
Purpose: To assess the best approach in accepting a treatment plan for APBI Savi patients. Should we run a treatment verification test prior to delivering to the patient? Should we take and check the CT scan for each fraction in regards to the initial one, in dosimetric terms? Do we need deformable registration and adaptive planning for each fraction?

Materials and Methods: A retrospective study of 10 patients treated with the Savi applicators were considered for this study. The CT scans taken before each treatment were imported into the treatment planning system and registered with the initial CT scan. The images were fused together with respect to the applicator, using the Landmark registration feature. Dosimetric evaluations were performed. The dose received by the skin, ribs and PTV-eval on CT images with respect to the initial treatment plan that was used for the 10 fraction to deliver the dose, were recorded including the maximum, average, and minimum dose delivered to each of the 10 treatment that included the first fraction. The treatment plan made on the initial scan as has the isodoses and dose volume histogram (DVH) shown above. This treatment plan is delivered to all the fraction for the patients we’ve chosen in the study but this is not a scan performed before any of the fractions delivered. The structures reconstructed in the registered CT scan of the first fraction pre-delivery verification do not match the structures made in the initial plan on the CT scan taken post implantation on the day of surgery and planning. We made visible only the skin surface and the ribs since those are the most sensitive and important. Results: All the structures displayed changes in volume over the 10 fractions of treatment. The cavities reduction in volume was considerable with a maximum reduction of over 10%. The PTV-eval is covered better due to this fact while the critical organs manifest an increase in the total and maximum dose delivered. Ribs and skin surface that are required by B39 protocol to be monitored can acquire maximum dose of 20% TO 30% respectively. Conclusions: A dosimetric evaluation prior to the initial treatment and prior to each of the 10 fractions is proven to be necessary. Each fraction’s CT scan must be co-registered with the initial plan’s CT scan and the structures reconstructed for a dosimetric evaluation Deformable registration and adaptive planning if needed have to be performed for each fraction if more than 1 fraction are prescribed and the initial plan is being used in treatment.

BSOR5

Local Failure by Biological Subtype After Accelerated Partial Breast Irradiation Using Single-Entry Catheters

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Purpose: Tumor biology is being recognized as an important indicator of prognosis and the risk of ipsilateral breast tumor recurrence (IBTR). The biological features of breast cancer are seminal criteria in published selection guidelines for accelerated partial breast irradiation (APBI), and were recently evaluated in a study of interstitial brachytherapy APBI. (1) This study evaluates IBTR by biological subtype for women treated with single-entry catheter accelerated partial breast irradiation (sAPBI). Materials and Methods: 1054 patients were treated with sAPBI (34 Gy in 10 fractions at 1 cm) from 2002-2014. 809 women with invasive cancer having known ER and HER2 status and at least 1-year follow-up treated using MammoSite (n=187), Contura (n=229), or SAVI (n=393) sAPBI are included in this study. IBTR was determined for 4 groups: ER+/Her2-, ER+/Her2+, ER-/Her2-, and ER-/Her2-. Actuarial 5-year outcomes were analyzed by the Kaplan-Meier method. Results: Mean and median ages were 63 and 64 years. The median tumor size was 1.2 cm. Only 10 women did not have axillary sampling and 24 women had positive nodes (12 were N0i+). 86% (n=696) of women were ER+/Her2-, 4.6% (n=37) were ER+/Her2+, 1.7% (n=14) were ER-/Her2+ and 7.5% (n=61) were ER-/Her2-. With a median follow-up time of 40 months, the crude and actuarial 5-year IBTR are presented in Table 1. Conclusions: Over the 12-year span of this study, surgeons and radiation oncologists were reluctant to treat patients other than phenotypic Luminal A breast cancer with sAPBI. The actuarial 5-year IBTR of 4.6% for ER+/HER2- supports sAPBI in this subgroup, but since only 14% of the cohort was double-negative or HER2-positive, statistical power in these subgroups is lacking. Therefore, caution should be exercised in treating double-negative or HER2+ with sAPBI until randomized trials such as NSABP B39/RTOG1413 are published with subset analysis. 1. Anderson BM, Kamrava M, Wang P, et al. Locoregional recurrence by molecular subtype after multicatheter interstitial accelerated partial breast irradiation: Results from the Pooled Registry Of Multicatheter Interstitial Sites research group. Brachytherapy. 2016; 15: 788-795.
TABLE 1

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BSOR6  
Presentation Time: 6:10 PM
Accelerated Partial Breast Irradiation in the Era of Large Gene Array Genetic Testing  
Linda A. Smith, Breast Surgeon⁠¹, Robert R. Kuske, Radiation Oncologist⁠².
¹Comprehensive Breast Care, Albuquerque, NM, USA. ²Arizona Breast Cancer Specialists, Scottsdale, AZ, USA.
Purpose: Breast cancer care has improved significantly over the past decade, and better surgery, radiotherapy, and systemic therapy has resulted in improved survival and better quality of life. There have been jumps in technology in each of these fields. Genetic testing has likewise progressed from the early days of single gene testing when it frequently took months for results. Currently, multiple gene tests examining dozens of genes can be run in a matter of hours. NCCN guidelines recommend testing for GI cancers, melanoma, sarcoma, and many other malignancies. Large panel testing now reveals unexpected positive genes and variants of unknown significance (VUS). It is imperative for the radiation oncologist to familiarize him/herself with genetic testing because results impact therapeutic strategies, especially accelerated partial breast irradiation (APBI) eligibility. Materials and Methods: 372 patients with stages 0, 1, and 2 were treated with APBI between 2009 and 2016 by a single breast surgeon with special training in breast cancer genetics and a single radiation oncologist. The Hughes risk model predicted the risk of known genetic mutations, followed by a more detailed pedigree for those patients requesting testing. Results: Thirty percent of the reviewed patients did not qualify for testing given current guidelines. Seventy patients of the tested patients had results available. One patient was known to be BRCA-1 at the time of treatment. Another patient with bilateral breast cancer was BRCA-2 at the time of treatment. Other pathogenic genes discovered were ATM and CHEK2, both of moderate penetrance, prompting recommendations for yearly MRI due to ongoing risk. VUS were registered in a national archive. Of the 253 patients tested for pathogenic mutations, 27 (11%) had VUS, 5 (2.0%) had a CHEK-2 mutation, 1 (0.4 %) had an ATM mutation, and 4 (1.6%) had BRCA 1 or 2 mutations. Conclusions: ASTRO guidelines deem patients with BRCA 1,2 mutations to be “unsuitable” for APBI. There is concern about subsequent 2nd primary breast cancers, and there is an absence of data supporting APBI in these patients because no study has allowed them. Some women, however, will insist on breast conservation therapy, and the same issues exist for whole breast irradiation (WBI) as APBI. Management of this population must be customized and decisions made after prolonged discussion. Our hypothesis is that APBI may be appropriate for this group because APBI would allow more options for salvage mastectomy with reconstruction, since a broader tissue exposure (integral dose) with WBI increases wound-healing complications, capsular contracture, or reconstruction failure. Patients with lesser penetrance mutations such as ATM, CDH1, CHEK2, PALB2, PTEN, STK11, TP53 may be appropriate for APBI, but yearly MRI surveillance should be considered.

BSOR7  
Presentation Time: 6:15 PM
Clinical and Toxicity Outcomes in Asian Women with Limited Breast Volume Using Multicatheter Accelerated Partial Breast Irradiation
Johann I. Tang, MBBS, FRANZCR1, Vicky Koh, MBBS, FRANZCR1, Yiat Horng Leong, MBBS, FRANZCR1, Philip Iau, MBBS, FRCS2, Shaik Buhari, MBBS, FRCS2.

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Purpose: Accelerated partial breast irradiation (APBI) using the multicatheter method has excellent cosmesis and low rates of long term toxicity. However, there are few studies looking at the feasibility of this procedure in Asian women with limited breast volume. This study aims to look at clinical and toxicity outcomes in this patient cohort.

Materials and Methods: We identified 121 patients treated with APBI at our centre between 2008 and 2014. The median follow up for our patient group was 30 months (range 3.7-66.5). The prescribed dose per fraction was 3.4Gy x 10 fractions. In our study population, 71% of our patients were Chinese while 15% (n=19) of our patients were of other Asian ethnicity. Results: In our study, the median breast volume was 850 cc (range 216-2108) with 59.5% (n=72) patients with a breast size of less than 1000cc. The average PTV was 134 cc (range 28-324). The number of catheters used ranged from 8 to 25 with an average of 18 catheters used per patient. We achieved an average dose homogeneity index (DHI) of 0.76 in our patients. The average D90(%) was 105% and the average D90(Gy) was 3.7 Gy per fraction. The median volume receiving 100 % of the prescribed dose (V100), was 161.7cc (range 33.9-330.1), 150% of the prescribed dose (V150) and 200% of the prescribed dose (V200) was 39.4cc (range 14.6-69.6) and 14.72cc (range 6.48-22.25) respectively. Our dosimetric outcomes were excellent even in patients with breast size under 1000cc. There were no cases of grade 3 skin toxicity or acute pneumonitis. Two patients had a post-op infection and 2 patients had fat necrosis post procedure. Conclusions: Multicatheter HDR APBI is a safe and feasible procedure that can be carried out with minimal toxicity in Asian patients with breast sizes under 1000cc.

BSOR8 Presentation Time: 6:20 PM
Disparities and Trends in Brachytherapy Utilization by Race for Patients with Breast and Prostate Cancer
Ozer Algan, MD, Sheila Algan, MD, Terence Herman, MD.
University of Oklahoma, Oklahoma City, OK, USA.

Purpose: To evaluate patterns and disparities in brachytherapy utilization by race in patients diagnosed with breast cancer or prostate cancer using data from the National Cancer Database. Materials and Methods: The NCDB is a comprehensive national database that captures approximately 70% of newly diagnosed cancer patients in the US. Patients diagnosed with non-metastatic breast cancer (BC) or prostate cancer (PC) were identified in the PUF 2013 data file encompassing years 2004-2013. Brachytherapy use was defined as patients undergoing intracavitary or interstitial low dose rate (LDR) or high dose rate (HDR) treatments as a part of their radiotherapy treatment regimen. Race categories were identified as White, Black, American Indian, Asian, or Hawaiian/Polynesian. Categorical data were summarized using descriptive statistics. Univariate chi-square analysis was used to evaluate for disparities and trends in brachytherapy use. Multivariate logistic regression analysis was performed to evaluate variables associated with brachytherapy usage while adjusting for covariates. This study was reviewed by our institutional IRB prior to initiation. Results: A total 3,000,050 patients with non-metastatic breast cancer (1,889,302 patients) or prostate cancer (1,110,748 patients) were identified. The median age for patients undergoing brachytherapy was higher compared to those not undergoing brachytherapy (breast cancer: 64 vs 60 years, prostate cancer: 67 vs 65 years, p<0.001). In patients with breast cancer, 3.4% of patients underwent brachytherapy as some component of their treatment. When evaluated by race, the rate of brachytherapy use was 3.6% for white patients, 2.3% for black patients, 2.3% for Native American patients, 1.4% for Asian patients and 1.2% for Hawaiian/Polynesian patients (p<0.001). The use of brachytherapy increased from 1.6% in 2004 to 4.6% in 2008, and then decreased to 3.4% in 2013. When evaluated by race, the utilization of brachytherapy over time demonstrated similar trends, although the differences in utilization rates continued to remain significant between races (p<0.001). For patients with prostate cancer, brachytherapy utilization for the entire study period was 11.6% (White 11.7%, Black 11.4%, Native American 10.3%, Asian 10.2% and Hawaiian/Polynesian 10.4%, p<0.001). The rate of brachytherapy utilization for PC demonstrated a steady decline over time (17.0% in 2004 vs 6.1% in 2013, p<0.001). This trend was seen, for all of the racial groups evaluated (17.3% to 6.0% for white, 15.6% to 7.0% for black, 13.0% to 5.9% for Native American, 13.8% to 5.6% for Asian, and 12.7% to 3.9% for Hawaiian/Polynesian patients, p<0.001). Race was statistically significant for brachytherapy utilization on both univariate and multivariate analysis. This was true both for patients with breast cancer as well as for patients with prostate cancer. Conclusions: There were differences in
brachytherapy utilization by year of diagnosis and race for patients with breast cancer as well as for patients with prostate cancer.

**BSOR9**

**Presentation Time: 6:25 PM**

**Intraoperative Radiation (IORT) as Adjuvant Radiation Monotherapy for Early-Stage Breast Cancer Patients Treated with Breast Conserving Surgery**

Gary M. Proulx, MD.

*Radiation Oncology, Massachusetts General Hospital, Exeter, NH, USA.*

**Purpose:** Partial Breast irradiation is now an appropriate technique for delivering adjuvant radiation for properly selected patients who undergo breast conserving treated. We report the clinical outcomes for such patients treated at Exeter Hospital with electronic 50Kv brachytherapy alone as Adjuvant Radiation Treatment for Early-Stage Breast Cancer.

**Materials and Methods:** Ninety-four (94) patients with either pT1a (n=5), pT1b (n= 27), pT1c (n=24), or pT2(≤3 cm, N=10), all pN0, pTis (n=28) breast cancer were treated with IORT as adjuvant monotherapy at the time of partial mastectomy +/- sentinel lymph node biopsy. Patient criteria for treatment with IORT as monotherapy included DCIS or IDC up to 3 cm; negative margins (no ink for IDS and >2mm for DCIS) and negative lymph nodes; conformity of balloon to surrounding breast tissue, and the skin bridge distance from balloon surface to skin of >1 cm in multiple regions assessed using ultrasound. An internal lead shield was placed over the chest wall treatment cavity before the radiation treatment, and pre-loaded radiation plans for balloon inflation sizes ranging from 30 cc to 60cc were utilized. 2000cGy was prescribed to the balloon surface. **Results:** A total of ninety-six IORT treatments were performed between 11/2/2011 to the present involving ninety-four patients (Two patients treated for bilateral breast disease with IORT to both breasts). The median age of patients was 67 years (range 46-86 years). At a median follow up of 26.5 months (range: 1 - 62 months, the local control was 97% (93 of 96 cases). Two local recurrences (LR) within 2 cm of the tumor bed treatment site; one LR in an axillary lymph node. (*Table 1*) Cosmesis assessment by physician score sheet criteria: 76% scored “excellent cosmesis” at one month post-treatment, and the remaining 24% scored “excellent cosmesis” at their 6-12 month follow ups. Patient reported cosmetic satisfaction: 100% reported being very pleased with the treatment experience and treatment outcome on follow up visits. Patients were treated with Antiestrogen with predominantly either Tamoxifen or Arimidex (Table 1) Of the Ninety-Two patients with ER+, twenty-two had either suboptimal treatment (n=9) with 7 patients with < 4 months of treatment and 2 patients with < 1 yr of therapy. The 3 patients with local or local regional failure either stopped antiestrogen treatment early(n=2) or declined use (n=1). **Conclusions:** With early follow up, our experience with treating the properly selected Early-Stage Breast Cancer (T1, small T2 N0) patients with IORT using electronic 50Kev brachtherapy demonstrates its low rate of local failure and high rate of excellent cosmesis in a community hospital setting. Further follow up is needed with our series of patients and also in larger (ideally prospective randomized) trials before more definitive conclusions about outcomes can be made.

*TABLE 1*

<table>
<thead>
<tr>
<th>Histology</th>
<th>Receptor Status/</th>
<th>Local Control</th>
<th>Local Failure</th>
<th>Regional</th>
<th>Distant</th>
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<tr>
<td>DCIS= 29</td>
<td>ER+/PR+ =76</td>
<td>93/96 (97%)</td>
<td>2</td>
<td>1</td>
<td>0</td>
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<tr>
<td>IDC =63 (8 with LVI)</td>
<td>ER+/PR=15</td>
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<tr>
<td>ILC = 4 (2 with LVI)</td>
<td>ER-/PR=4</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Metaplastic =1</td>
<td>ER+/PR not reported =1</td>
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</table>

**BSOR10**

**Presentation Time: 6:30 PM**

**Initial Evaluation of Multicatheter Brachytherapy Technique for Lumpectomy Cavity Boost**

Aman Saini, BS, Steven Sckolnik, MD, Robert Kuske, MD.

*Arizona Center for Cancer Care, Scottsdale, AZ, USA.*
Purpose: Lumpectomy cavity radiotherapy boost after breast conserving surgery and whole breast irradiation reduces local cancer recurrence. This boost is typically delivered with external beam photons or electrons, encompassing the postoperative surgical cavity and a surrounding margin of normal breast tissue. External beam radiotherapy boost correlates with increased rates of breast fibrosis and may impair cosmetic outcomes. Multicatheter breast brachytherapy (MCBB) is an approach to deliver dose-escalated high dose rate radiation to the lumpectomy cavity while limiting additional radiation exposure to normal breast tissue and adjacent organs. This study evaluates the feasibility of using a multicatheter brachytherapy approach for cavity boost when combined with whole breast external beam radiotherapy. Materials and Methods: A retrospective chart review examined 25 consecutive patients receiving whole breast radiotherapy with a lumpectomy cavity boost delivered by MCBB from 2012-2016. Indications for multicatheter boost were hormone receptor triple negative disease, lymph node positivity, high grade disease, extensive LVI or young age. All 25 patients had MCBB delivered prior to external beam whole breast radiation. The whole breast prescription dose ranged from 4160-5040cGy and boost dose from 1000-1800cGy. The most common fractionation schemas for breast brachytherapy were 250cGy or 300cGy twice daily for 2-3 days. The median number of catheters used in an implant was 22 with a range of 14-32. The cavity was expanded symmetrically by 1.5-2.0cm to encompass microscopic disease. HDR brachytherapy was delivered using an IR-192 source. Results: Brachytherapy target coverage was evaluated and the mean target volume receiving 90 and 100% of prescribed dose was 98.5% and 93.3% respectively. The mean treatment volume receiving prescription dose was 199cc. 200% hot spots were limited to 10.6cc, while maximum skin dose was 249cGy/fx and maximum rib dose was 225cGy/fx. 1 of 25 patients developed an acute infection during treatment and required antibiotics while completing the duration of her therapy. Conclusions: Multicatheter breast brachytherapy boost prior to whole breast radiotherapy is a new approach to delivering treatment for patients with high risk features following breast conserving surgery. This approach was well tolerated by patients with only one instance of treatment related acute toxicity. Dosimetric evaluation was excellent and demonstrates a sparing of adjacent breast tissue, chest wall and skin. Dose escalating therapy to the lumpectomy cavity with the highest risk of recurrence while minimizing radiation exposure to normal breast tissue and surrounding organs has the potential to maximize the therapeutic ratio of treatment.

BSOR11 Presentation Time: 6:35 PM
Clinical Experience Using Accelerated Partial Breast Irradiation: First 101 Patients Treated at Gamma West Cancer Services
Brandon Fisher, DO.
Gamma West Cancer Services, Bountiful, UT, USA.
Purpose: We report our experience and outcomes with accelerated partial breast brachytherapy (APBI) for early stage breast cancer, both invasive and non-invasive breast cancers. The cancer was treated with breast-conserving therapy consisting of a lumpectomy followed by accelerated partial breast irradiation. Materials and Methods: From 2002 to 2010, 101 patients (median age, 66 years) with stage 0-IIA breast cancer received breast-conserving surgery and APBI. All patients underwent excision with negative margins before starting APBI. 101 Patients were treated with APBI brachytherapy; 81 with multi-catheter brachytherapy, 15 with MammoSite and 5 with Contura.
They received radiation therapy of 34 Gy to the lumpectomy bed alone. The median tumor size was 12mm. Toxicities were graded according to the Radiation Therapy Oncology Group (RTOG) acute radiation morbidity scoring criteria and the Radiation Therapy Oncology Group and European Organization for Research and Treatment of Cancer late radiation morbidity scoring scheme. Cox multivariate analysis for local control was performed using histology, age, estrogen receptor status, tumor size, grade, margin, and nodal status. Results: With a median follow-up of 89 (range, 0-154 months) the 5-year actuarial risk of an ipsilateral breast tumor recurrence was 3.6% (95%CI 1.2%-10.9%). Other 5-year actuarial risks were regional failure 0%, distant metastasis 3.3% (95CI 1.1%-9.8%) cause-specific survival 97.7% (95CI 91.3%-99.4%), overall survival 92.8% (95%CI 84.6%-96.7%), and new contralateral cancers 1.0% (95%CI 0.2%-7.1%). On multivariate analysis, no factors were associated with an increased risk of local recurrence. APBI for early stage breast cancer was associated with excellent local control and survival rates; furthermore, 80% of the patients had good to excellent cosmesis. Conclusions: These findings are in agreement with recent reports in the literature supporting the efficacy of treating patients with APBI. This treatment resulted in excellent long-term local control and cosmesis outcomes.
Ten Year Results of Accelerated Partial Breast Irradiation (APBI) Using Interstitial Multicatheter High Dose Rate Brachytherapy (HDR BT) After Breast Conserving Surgery for Low Risk Invasive In Situ Breast Cancer

Sylwia Kellas-Sleczka, PhD,1 Brygida Bialas, PhD,1 Marta Szlag, PhD,2 Piotr Wojcieszek, PhD,1 Agnieszka Cholewka, MSc,2 Marek Fijalkowski, MD,1 Tomasz Krzyztofiak, MD,1
1Brachytherapy Department, Maria Sklodowska-Curie Memorial Cancer Center and Institute of Oncology Gliwice Branch, Gliwice, Poland, 2Radiotherapy And Brachytherapy Planning Department, Maria Sklodowska-Curie Memorial Cancer Center and Institute of Oncology Gliwice Branch, Gliwice, Poland.

Purpose: To report results for 415 patients treated at a single institution with APBI using interstitial multicatheter high dose rate brachytherapy (HDR BT) after breast conserving surgery for low risk invasive and in situ breast cancer.

Materials and Methods: From July 2006 to September 2016, 415 women with low risk invasive and ductal carcinoma in situ after BCS underwent APBI using interstitial multicatheter HDR brachytherapy at our department. In the analyzed group, 140 patients were followed up for 5 years or longer. The patients found eligible for APBI were ZUBROD 0 or 1, age ≥50 years, T1-2N0M0, T≤3cm, unifocally, invasive carcinoma without angioinvasion, minimal surgical margin 2mm or DCIS (minimal margin at least 5mm), without EIC (extensive intraductal component), positive estrogen receptors. The interval between surgery and HDR BT was less than 12 weeks. Most patients underwent APBI under local anesthesia. The fractional dose was 4Gy delivered in 8 fractions (total dose 32Gy) twice a day with a minimum 6 hour break. The primary endpoint was local recurrence.

Results: The median age was 63 years (range 47-85 years). There were no serious complications during the procedure. All women completed treatment without interruptions. In 71 (17.1%) cases, we noticed a hematoma following catheter insertion, typically dissolving within 2 weeks. The treatment was well tolerated. Six patients (1.4%) developed local inflammation, requiring oral antibiotic therapy. In 83 cases (20%) prophylactic antibiotic therapy was applied. PTV range was 17.4-172.4cm³. The median D10 and D2 for the lungs were 29.2% and 38.5% reference dose, respectively. The median skin dose was 40.5% reference dose (range 17-67%). The median PTV100 was 95%, DHI 0.68 and COIN 0.69. The median follow-up was 54 months (range 4-121 months). In group with at least 5-yr observation - 73 months (range 61-121 months). There were no late serious complications. In the entire patient group, we found 4 failures (0.96%), including 3 local recurrences and distant metastases in one patient.

Conclusions: Interstitial multicatheter APBI allows to spare critical organs from unnecessary radiation. In our group of patients, implant parameters were satisfying, correlated with good tolerance and effectiveness.

Scientific Session: Miscellaneous Snap Orals (E-Poster)
Friday, April 21, 2017
5:45 PM - 6:45 PM

Radiation-Emitting Expandable Stents for Portal Vein Tumor Thrombosis

Jin-He Guo, MD.

Intervention, Zhong-Da Hospital, Nanjing, China.

Purpose: We aim to assess the outcomes of an irradiation portal vein stent for portal vein tumor thrombosis.

Materials and Methods: The study was approved by the institutional review board. Written informed consent was obtained from all patients before enrollment. Between April 2013 and March 2016, 46 participants with PVTT were recruited for the treatment with an irradiation portal vein stent (self-expandable stent loaded with 125I seeds) at our center. Transarterial chemoembolization (TACE) was conducted after stenting. The outcomes were measured in terms of technical success, complications, stent patency, and overall survival. Results: The technical success rate achieved 95.65% (44/46). No severe stenting- or radiation-related complications were observed. The median stent patency period was 12.0 months (IQR: 9.1, 14.0). The median survival was 13.0 months (IQR: 10.9, 15.3).

Conclusions: The irradiation portal vein stent placement is a feasible and safe technique to treat PVTT, and prolong the patency time. This is a promising technique for combining recanalization of an occluded portal vein and brachytherapy for PVTT, which allows TACE to be performed following stenting.
Analysis of Related Factors the Incidence of Postoperative Pneumothorax After CT-Guided Iodine-125 Implantation in the Treatment for Patients with Lung Cancer

Xiaodong Huo, MD. Bin Huo, MD, Haitao Wang, MD, Shude Chai, MD, Lei Wang, MD, Qiang Cao, MD.
Department of Oncology, The Second Hospital of Tianjin Medical University, Tianjin, China.

Purpose: To analyze the impact factor of incidence of pneumothorax after percutaneous computed tomography-guided permanent iodine-125 implantation as therapy for lung cancer. Materials and Methods: We retrospectively analyzed the data of 821 patients with complete data of iodine-125 implantation of lung cancer through lung in October 2002 to October 2012. 198 cases of pneumothorax occurred and analyzed the related factors. Results: Postoperative CT findings of pneumothorax in 198 cases, the rate was 24.1%. Single variate analysis showed that the average depth of the needle insertion, whether the patient had COPD, the presence of atelectasis, the number of the implanted stitches, the operation time, the needle insertion angle and the tumor diameter were correlated with the postoperative neumothorax incidence ($X^2=10.293, 11.463, 5.310, 8.868, 13.348, 9.326, 16.504, P<0.05$). The incidence of pneumothorax occurred in 176 patients with COPD (65 cases) (36.9%). The depth of the needle insertion needle was less than 6 cm (205 cases), 8 to 12 cm (378 cases) and 12 cm (238 cases) (29.8%) in 29 patients (14.1%), 98 (25.9%) and 71 patients (29.8%). The number of needles was < 5 (183), 5 to 10 (408) and > 10 (230) The incidence of postoperative pneumothorax was 31 cases (16.9%), 92 cases (22.5%), 75 cases (32.6%); operation time <10min (198 cases), 10 ~ 20min (412 cases), > 30min (211 (13.6%), 101 (24.5%) and 70 (33.2%), respectively. There were 19 patients (14.4%) with postoperative pneumothorax in 132 patients with pulmonary atelectasis. The multivariate logistic regression analysis showed that the prior four factor are risk factors of pneumothorax (OR=1.676, 2.147, 1.827, 2.368), the last one is protective factor (OR=0.367). Conclusions: When the lesion is far away from the chest wall, patients with COPD, intraoperative implantation of patients with more needle, the iodine-125 implantation should be fully taken into account the possibility of pneumothorax. Reduce the number of puncture needle, shorten the operation time and the presence of atelectasis can reduce incidence of pneumothorax.
Efficacy and Safety of Stents Loaded with I-125 Seeds Versus Conventional Stents Treatment for Patients with Medium Terminal Cancer of Esophagus: Meta-Analysis and Systematic Review
Dingkun Hou, MD, Shude Chai, MD, Haitao Wang, MD, Bin Huo, MD, Xiaodong Huo, MD, Lei Wang, MD, Jinhuan Wang, MD, Li Zang, MD, Hao Wang, MD, Lili Wang, MD, Qiang Cao, MD. Department of Oncology, The Second Hospital of Tianjin Medical University, Tianjin, China.

Purpose: To evaluate the clinical effectiveness and safety of stents loaded with I-125 seeds versus conventional stents. Materials and Methods: Literatures were searched in PubMed, EMBase, Cochrane Library, CBM,CNKI,Wanfang Data and other electronic databases from inception to November 2016. Two reviewers independently screened studies according to the inclusion and exclusion criteria, extracted data and assessed quality of the included studies independently, meta-analyses were performed using RevMan 5.3. Results: A total of 5RCTs and 14CCTs involving 1211 patients were included. ① Study of Mean Survival: The mean survival time of the I-125 stent group was significantly higher than that of the control group (mean difference = 4.11, 95% CI [2.16,6.07] P <0.0001) Stent group. ② Study on the incidence of restenosis after operation: The recurrence rate of esophageal cancer stenosis was lower than that of common stent group (RR=0.65,(95%CI [0.47,0.90] P =0.01)). The incidence of restenosis after 3 months: The available data showed that the incidence of re-staging of I-125 stent in the treatment group was lower than that of the normal stent group( RR=0.23,(95%CI[0.12,0.62] P=0.002). The incidence of restenosis after 12 months: The available data showed that the incidence of re-staging of esophageal carcinoma stenosis was not significantly different between stents loaded with the I-125 seeds group and the conventional stents group( RR=0.47,(95%CI [0.14,1.53] P=0.21), ④Postoperative bleeding:RR=0.80,(95%CI [0.52,1.23] P =0.30);Postoperative pain:RR=1.06,(95%CI [0.88,1.27] P =0.55);Postoperative stent shift:(RR=0.53,(95%CI [0.27,1.05] P =0.07). The incidence of complications was not statistically significant. There was no difference in the incidence of complications between the two groups. Conclusions: The available data suggested that I-125 stent is superior to common stent in the treatment of advanced esophageal cancer. There were no differences in the incidence of complications between I-125 stenting and conventional stenting. However, due to the limited quality of the included studies, more high-quality and multicenter studies are needed to verify the above conclusion.

Unresectable Hepatocellular Carcinoma with Tumor Thrombus in the First Order Portal Vein Branch Treated by Linear Iodine125 Seeds Strand Implantation Combined with Transarterial Chemoembolization: A Propensity Sore Analysis
Zi-Han Zhang, MD, Jian-Jun Luo, MD, Zhi-Ping Yan, MD. Zhongshan Hospital, Fudan University, Shanghai, China.

Purpose: To evaluate the safety and efficacy of Iodine125 seeds strand implantation combined with transarterial chemoembolization (TACE) to treat unresectable hepatocellular carcinoma (HCC) complicated with tumor thrombus in the first order portal vein branch. Materials and Methods: This single-center retrospective study involved 76 HCC patients with tumor thrombus in the first order portal vein branch received Iodine125 seeds strand implantation combined with TACE (Group A, n=20) and TACE alone (Group B, n=56), to compare time to progression (TTP) and overall survival (OS) by propensity-score analysis. Results: During a mean of 11.7 ± 7.3 months (range 1.9 - 46.1 months) follow-up, Group A had longer median TTP and OS than Group B (p < 0.001). Multivariate Cox analysis revealed that TACE combined with Iodine125 seeds strand implantation treatment strategy was an independent predictor of favorable OS. In the matched cohort, the median OS and TTP were significantly longer in Group A than Group B (19 pairs; OS, 28.0 ± 5.0 vs 8.9 ± 0.3 months, p < 0.001; median TTP,
22.1 ± 3.5 months vs 6.8 ± 0.5 months, p < 0.001). **Conclusions:** Iodine125 seeds strand implantation combined with TACE might be a safe and effective palliative treatment option for tumor thrombus in the first order portal vein branch.

**Purpose:** To evaluate the feasibility, efficacy and safety of CT-guided iodine-125 seeds implantation combined with chemotherapy for locally advanced pancreatic carcinoma. **Materials and Methods:** Thirty-two patients (14 males and 18 females; mean age 62 years, range, 38-82 years) with locally advanced pancreatic cancer were enrolled in this study. Each case was diagnosed by contrast-enhanced computed tomography (CT) and biopsy. The tumor was classified as stage III in 7 patients and stage IV in 25 patients according to the TNM staging system (UICC, 2002). A median number of 52 iodine-125 seeds (range, 25-80) were implanted into pancreatic tumor under CT guidance. Postoperative dosimetry was routinely performed for all cases. The actuarial median D90 of the implanted iodine-125 seeds was 120 Gy (range, 100-140 Gy). The particle activity ranged from 0.5-0.8 mCi. In addition, 16 patients received routine gemcitabine chemotherapy 1 week after brachytherapy. Survival time was calculated using the Kaplan-Meier method and difference was assessed with the log-rank test. **Results:** Median follow-up time was 13 months (range, 3-24 months). Visual analog scale pain score on 7 days, 1 and 3 months after therapy was decreased from 5.76 ± 1.93 before operation to 2.67 ± 1.03, 1.68 ± 0.84 and 2.06 ± 1.13, respectively (p< 0.05). The tumor
response rate was 62.5\%(20/32), with an overall local control rate of 87.5\% (28/32). The 1-year and 2-year tumor control rates were 88.7\% and 79.1\% respectively. The median overall survival time of 14 months(95\% CI, 10.18-17.82), while the overall 1-,2-year survival rates were 52.1\% and 12.2\%. The median survival time of patients at stage III was longer than that of those at stage IV (18 months vs 10 months, P=0.038). In the group of stage IV, The median survival time of patients who received and did not receive chemotherapy after the procedure was 16 months(95\% CI, 13.82-18.18) and 9 months(95\% CI, 7.38-10.62) respectively (p=0.008). No serious complications were observed. **Conclusions:** Iodine-125 seed implantation provides a safe and effective method to relieve pain, control local tumor growth. Combined with chemotherapy, this procedure prolongs the survival of patients with stage IV pancreatic disease without additional complications.

**MSOR6**  
Presentation Time: 6:10 PM  
Preliminary Clinical Experience from a Phase I Feasibility Study of a Novel Permanent Unidirectional Intraoperative Brachytherapy Device  
Neil K. Taunk, MD, MS\(^1\), Gil’ad Cohen, MS\(^2\), Amandeep S. Taggar, MD\(^1\), Antonio L. Damato, PhD\(^2\), Christopher Crane, MD\(^2\), John Cuaron, MD\(^1\), Garrett M. Nash, MD, MPH\(^1\), J. Joshua Smith, MD, PhD\(^1\), Julio Garcia Aguilar, MD, PhD\(^1\), Abraham J. Wu, MD\(^1\).  
\(^1\)Department of Radiation Oncology, Memorial Sloan Kettering Cancer Center, New York, NY, USA, \(^2\)Department of Medical Physics, Memorial Sloan Kettering Cancer Center, New York, NY, USA, \(^3\)Department of Surgery, Memorial Sloan Kettering Cancer Center, New York, NY, USA.
**Purpose:** Intraoperative radiation therapy (IORT) is delivered at the time of surgery, often in previously radiated areas, to improve local control after maximal surgical resection of the target lesion. Advantages of IORT are 1) dose-limiting normal organs can be moved or shielded during surgery and 2) the tumor bed can be directly visualized. IORT is commonly delivered using high-dose rate radiation with a HAM applicator. CivaSheet (CivaTech Oncology, Research Triangle Park, NC) is a novel planar, unidirectional low-dose-rate (LDR) brachytherapy implant. Potential advantages of CivaSheet over intraoperative electrons and HAM IORT include 1) low-dose rate administration may allow higher biologically equivalent dose (BED), 2) accurate identification of the treated area on followup imaging, 3) improved apposition of the sources to the target, and 4) no shielded OR is required. We initiated the first clinical feasibility trial and report the initial experience from the first three patients enrolled. **Materials and Methods:** The CivaSheet consists of Pd-103 sources shielded on one side by gold embedded in a bioabsorbable polymer. After surgical resection and placement of the device, patients will be monitored for disease response, toxicity, and stability of the sources at 7 days, then 1, 2, 3, 6, 12, 18, and 24 months with CT scan. Ten patients will be enrolled for the primary objective of feasibility, defined as >70% successful implantation of enrolled patients with CivaSheet (patients requiring conversion to HDR IORT are considered failures). Secondary objectives include 30 and 90-day toxicity, local control, and implant stability. **Results:** At the time of this report, the study is on pre-planned interim hold. All three have colorectal adenocarcinoma and were treated with induction chemotherapy and neoadjuvant chemoradiation (NCRT) to 50.4Gy in 28 fractions. Patient 1 is a 45-year-old woman with stage III rectal cancer. She completed NCRT without significant radiographic response. During low anterior resection, the CivaSheet (prescribed to 100Gy to 0.5cm) was placed along the sacrum where the posterior aspect of her tumor was tethered to bone over an 8x4cm area. Patient 2 is a 58-year-old woman with multiply recurrent rectal cancer. She was treated with NCRT and total mesorectal excision. She had an initial pelvic recurrence after three years later with resection and 20Gy in 5 fractions re-irradiation. She recurred again one year later and had resection followed by implantation of the CivaSheet along the left pelvic sidewall to treat a 4x12cm area to 100Gy. Patient 3 is a 69-year-old man with a cT4 rectal adenocarcinoma status-post NCRT with minimal response. However the CivaSheet could not be uniformly apposed to the sacrum due to its concavity. IORT was therefore delivered using a HAM applicator and the CivaSheet was deemed not feasible for this case. Both successful CivaSheet implants required less than 25 minutes operating time and show excellent geometric stability of the device on CT imaging 7 and 30 days after implantation without evidence of local recurrence or acute toxicity. **Conclusions:** Two patients have successfully undergone placement of the CivaSheet in this first-ever clinical trial of this novel intraoperative brachytherapy device. One patient was not deemed feasible for CivaSheet due to lack of suitable attachment points, suggesting that careful patient selection is important to the feasibility of this technique. Early results show excellent 30-day stability of the device with no apparent toxicity.

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**Histopathological Analysis of Naïve Swine Esophagus Irradiated with a Brachytherapy Stent Demonstrated Favorable Tissue Tolerance of High Mucosal Tissue Doses**

**Presentation Time: 6:15 PM**

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**MSOR7**

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Purpose: Self-expanding metal stents (SEMS) appear to be the most effective treatment for dysphagia in palliative patients suffering from malignant esophageal cancers (EC), providing immediate relief to dysphagia in a single treatment step. Recent recommendations from the European Society of Gastrointestinal Endoscopy further recommend the use of brachytherapy in addition to stenting in patients with longer life expectancies due to possible improved survival advantage and quality of life [Spaander et al. Endoscopy 48, 939-948 (2016)]. However, the equipment and clinical expertise necessary for intraluminal brachytherapy is not readily available in most communities. In this study we present a brachytherapy stent designed to deliver clinically relevant radiation doses to ECs using commercially available brachytherapy sources. This pilot study aimed to assess the histopathological effects of the radioactive SEMS in the naïve porcine esophagus.

Materials and Methods: A radioactive carrier stent was designed to apply a dose of 60 Gy to a depth of 5mm within the esophageal wall over 2 months. The stents contained 60 $^{125}$I brachytherapy seeds (Seeds-in-carrier, GE Healthcare) 6 strands of 10 seeds each of source strength 0.53 U/seed. One dummy (non-radioactive sources) and 3 radioactive stents were implanted into the esophagus of Yucatan minipigs. Stents were left in place for up to 43 days after implant, and one pig survived 10 weeks after stent removal. Animals were monitored biweekly via endoscopy and fluoroscopic imaging throughout the study. At end of life, a full necropsy was performed and esophageal and surrounding tissues were collected for histopathological analysis.

Results: Swine esophageal tissue received doses ranging from 39-48 Gy at the prescription depth of 5mm and 132-160 Gy at the mucosal surface. Irradiated tissues were assessed histopathologically at 0, 1, and 10 weeks after stent removal and non-irradiated control tissues were assessed at stent removal. Endoscopic assessment of all irradiated animals found increasingly pronounced and permanent infolding of the proximal stent flare over time, eventually resulting in early stent removal. At stent removal, all animals (experimental and control) had numerous benign mucosal polyps (<5mm) at both stent flares. Within 6 weeks of removal, however, mucosal polyps were nearly resolved and tissue regained a normal appearance. At gross necropsy, small amounts of necrotic tissue as well as mucosal polyps were observed along the entire length of the tissue adjacent to the radioactive stent (mostly adjacent to the stent flares). No systemic effects related to radiation were observed.
Conclusions: Our results demonstrated that a brachytherapy stent delivery is feasible and may be reasonably safe for irradiated healthy tissue. Although irradiation >130 Gy affected the mucosal tissue, stent-related injury appeared to cause more substantial damage to the tissue. Both experimental and control animals showed the most marked tissue reaction at the stent flares (only the stent body was impregnated with brachytherapy seeds). Tissue reactions along the stent body were consistent with stent related tissue erosion and, although likely enhanced by radiation exposure, were not consistent with injury caused solely by radiation. Physical placement of the stent was most likely the cause of the reaction than the radiation. One animal, assessed up to 10 weeks after stent removal showed nearly complete healing of the esophageal tissue. Future studies will assess safety in a larger cohort of animals with escalated radiation doses and different radionuclides to better understand the effects of RBE.

A Novel Irradiation Stent for the Treatment of Malignant Hilar Biliary Obstruction: A Case Series
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Department of Interventional Radiology and Vascular Surgery, Zhongda Hospital, Southeast University, Nanjing, China.
Purpose: To assess the feasibility, safety and preliminary efficacy of the irradiation biliary stent to treat hilar malignant biliary obstructions. Materials and Methods: A total of eleven patients with hilar malignant biliary obstructions and symptomatic jaundice were consecutively recruited to receive the percutaneous placement of irradiation stent. The irradiation stent was designed as a double-layer stent consisting of an outer iodine-125 radioactive seeds loaded stent and an inner self-expandable metallic stent. The seeds loaded stent was firstly implanted and the self-expandable nitinol stent was immediately followed through the same guidewire and 10-F sheath. Technical success rate, complications, and time to recurrent biliary obstruction were evaluated. Successful stent placement was considered when the irradiation stent was deployed in the target position of the biliary tract with full expansion and complete overlap between the inner and outer stents. Results: Technical success rate achieved 100% (11/11), with six irradiation stents (diameter of 10 mm and lengths of 50-70 mm) successfully placed in six patients. The activity of iodine-125 seeds used on the irradiation stent was 0.8 mCi. The median calculated surface radiation dose at the dose prescription point was 72 Gy (range 58-89 Gy). There was no immediate complication of the procedures. The radiation related neutropenia was observed in one patient. The median time to recurrent biliary obstruction was 367 days (interquartile range 79-472 days). Conclusions: This pilot study shows the feasibility and preliminary efficacy of this irradiation stent to treat the malignant hilar biliary obstruction, with tolerable complication.
Custom Mold Technique with 3D Printed Applicator “Shell” in Penile HDR Brachytherapy

Laszlo Voros, MS¹, Gilad N. Cohen, MS¹, Peter W. Piechocinski, BS², Andre Platzman, BS¹, Erik S. Anderson, MD, PhD², Amandeep S. Taggar, MD, MSc², Marisa A. Kollmeier, MD², Antonio L. Damato, PhD¹.

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Purpose: Delivery of penile mold brachytherapy requires construction of a custom applicator for each patient. This is done manually using a two steps process: first, an imprint of the penis is made with dental putty; then it is fitted with HDR catheters spaced approximately 1 cm apart. (Figure 1. left) which are then covered with an additional layer of putty to completely embed them in the mold. All patients were treated to a total of 40 Gy in 10 twice daily fractions. We sought to assess feasibility of generating 3D printed applicators to streamline the applicator building process in HDR brachytherapy for penile cancer. Materials and Methods: 5 patients treated with HDR mold brachytherapy at our institution for penile cancer were included in this retrospective study. Non-clinical prototyping and theoretical testing of a new procedure for applicator construction was performed. With the new procedure, a
patient specific (diameter and length) 3D printed applicator (printer: Objet260 Connex3, biocompatible plastic: MED610, Stratasys, Israel) “shell” with the embedded channels for source delivery would be fabricated before simulation. Gaps between the applicator and the treatment area are filled with medical grade liquid silicon rubber at simulation to perfectly conform around the individual anatomy. A planning study was performed using the clinical scans with the simulated new applicator positions. Maximum dose to the urethra, and minimum and maximum dose to the CTV (median volume 20.8 cc, range 13.5-27.5 cc) and GTV (median volume 3.5 cc, range 1.2-6.1 cc) were compared between clinical and simulated plans and reported as a % of the prescription dose. A 2-tailed paired T-test was used to assess statistical significance (p < 0.05) of the difference between the two sets of plans. Results: Printing of the 3D applicator was feasible; a prototype is shown in Figure 1 (right). No statistically significant difference was observed between the DVH metrics of the clinical and the simulated plans. Mean value for all patients of the maximum urethra dose was 113% clinical vs. 108% simulated (p = 0.06); minimum CTV dose 75% vs. 86% (p = 0.10); maximum CTV dose 238% vs. 149 % (p = 0.15); minimum GTV dose 102% vs. 100 % (p = 0.48); maximum GTV dose 161% vs. 150 % (p = 0.09) respectively for clinical vs. simulated plans. Conclusions: This work demonstrates a feasible mold preparation using 3D printed outer shell mold design for penile cancer HDR brachytherapy. Preliminary results show that this novel design result in treatment plans of at least equivalent quality than a hand-fabricated mold. We expect that 3D mold fabrication may provide more consistent catheter symmetry and improved efficiency in mold construction.
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Purpose: To compare the efficacy of three-dimensional conformal radiotherapy (3D-CRT), surgical resection and iodine-125 radiation therapy (I\(^{125}\)RT) in single brain metastasis of non-small cell lung cancer (NSCLC). Materials and Methods: 206 NSCLC patients with single brain metastasis were analyzed. 77 patients received 3D-CRT, 75 patients underwent craniotomy, and the other 54 patients received iodine-125 radiation therapy. Survival time without new brain metastasis, improvement of functional status (KPS) and median survival time were compared between groups. Besides, causes of death in patients were randomly recruited. Results: For 3D-CRT group, craniotomy group, and I\(^{125}\)RT group, respectively, 1-year local control rate were 82%, 78.9%, 90.5%; the KPS improvement rate were 82.6%, 88.9%, 92.8%; the median survival time was 8.7 months, 8.9 months and 11 months. Statistical analysis showed that I\(^{125}\)RT is better than surgical treatment for local control rate, and is also superior to 3D-CRT for KPS improvement. Most importantly, I\(^{125}\)RT can get a significantly longer median survival time than the other two treatments (P<0.05). For the causes of death, Patients died of metastatic brain tumor recurrence (51%) and new brain metastasis (28.3%) are the two major factors accounted for patient’s death, while 21.7% of patients died of causes unrelated to brain. Conclusions: Based on the fact that local recurrence is the major cause of death for patient with single brain metastasis of non-small cell lung cancer, iodine-125 radiation therapy, with advantages of dosimetry (compared to 3D-CRT) and a wider range of treatment (compared to surgical resection), can significantly improve the local control rate, prolong median survival time, lessen complications and improve life quality, which give it a promise of popularization and application.

MSOR11

Prescription Depth in Surface Skin Brachytherapy

Presentation Time: 6:35 PM

Domingo Granero, PhD1, Javier Vijdane, PhD2, Facundo Ballester, PhD3, Silvia Rodriguez, MD4, Jose Perez-Calatayud, PhD5.

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Purpose: Skin brachytherapy is a well-established treatment modality and its use has increased significantly in recent years. There are different techniques according to the size, depth and superficial shape of the lesion and consequently different applications/applicators are used. For superficial lesions, molds, flaps and shielded applicators are used, being interstitial implant the selected option for deeper lesions. In 2015, the American Brachytherapy Society (ABS) published a report of literature summary and best practices used in non-melanoma skin cancer (NMSC). This Report recommends the use of the interstitial option for CTV deeper that 5 mm. For superficial NMSC, the ABS Report indicates a typical prescription depth of 5 mm for molds and flaps and 3 mm for the shielded applicators as Valencia or Leipzig, being these values based on clinical reported practice. The purpose of this study is to analyze the potential physics reasons of these prescription depth differences. Materials and Methods: To evaluate the dose distribution differences between the different applications we have used the raw data of Monte Carlo and experimental published studies together with new specific MC simulations: 1) Moulds: 5x5 cm\(^2\) with catheters 10 mm apart at three different distances from the skin, to mimic different scenarios used by different departments; these are 2.5, 7.5 and 12.5 mm. Data for the 2.5 mm case have been taken from Granero et al (Med Phys 2014) using MC Geant4. A specific MC simulation using Geant4 has been performed for the 7.5 and 12.5 mm distance. Dwell positions were activated each 5 mm. 2) Flaps: 5x5 cm\(^2\) with catheters 10 mm apart at a distance of 5 mm from the skin from Vijdane et al (Brachytherapy 2012) using MC Geant4. Dwell positions were activated each 5 mm. 3) Valencia 30 mm diameter: From Granero et al (Med Phys 2008) using MC Geant4. 4) Leipzig 30 mm diameter: From Perez-Calatayud et al (IJROBP 2005) using MC Geant4. 5) Esteya 30 mm diameter: From Candela et al (JCB 2015) with ionization chamber measurements The dose distributions have been characterized by percent...
depth doses (PDD, normalized at surface). Surface dose has been obtained extrapolating from the values at 1 and 2 mm. **Results:** The Figure shows the resulted PDDs for: Valencia, Leipzig and Esteya 30 mm diameter at central axis. 5x5 cm² mould mesh with catheters at 0.25, 0.75 and 1.25 mm from the skin and Freiburg Flap. It can be seen that for Valencia and Leipzig applicators the PDD at 3 mm is around 72% which is coincident with the PDD of the rest of applications at 5mm. **Conclusions:** Comparing the PDDs of the different applicators-applications it is showed the equivalence in gradient for 3 mm in case of Valencia & Leipzig with 5 mm for the case of moulds, flaps and Esteya, supporting the ABS prescription depth recommendations.

**MSOR12**  
**Presentation Time:** 6:40 PM  
**High Dose-Rate Brachytherapy Treatment of Psoriasis of the Nail Bed Using Custom Made Micro Applicators**  
Ivan M. Buzurovic, PhD, Desmond A. O’Farrell, MS, Mandar S. Bhagwat, PhD, Scott Friesen, MS, Thomas Harris, MS, Jorgen L. Hansen, MS, Robert A. Cormack, PhD, Phillip M. Devlin, MD.  
Radiation Oncology, Dana-Farber/ Brigham Women’s Cancer Center, Harvard Medical School, Boston, MA, USA.  
**Purpose:** Psoriasis of nails is a chronic autoimmune diseases of skin. Patients are often resistant to topical medication, vitamin D ointment or phototherapy, and therefore they receive corticosteroids injections to the nail bed. In this work we report on the compassionate use of the high dose-rate (HDR) brachytherapy to the nail beds using the custom made micro applicators. **Materials and Methods:** Initially, the patient was diagnosed with psoriatic nail beds refractory to receiving monthly subunguinal injection and with significant pain and discomfort on both hands. In this case, the role HDR brachytherapy treatment was to stimulate T cells, a significant component of the inflammatory infiltrate of psoriatic lesions, for increased immune response. The clinical target was defined as the length from the finger tip to the proximal interphalangeal joint (first knuckle). For the accurate and reproducible setup in multi-fractional treatment delivery a custom made applicator was designed. Five ProGuide (Elekta Brachytherapy) needles having length of 200 mm each were embedded into the dense plastic mesh and covered with 5 mm bolus material for each micro applicator. Five micro applicators were design for each finger resulting in use of 25 catheters in total. The stability of the setup was achieved using the plastic base on which the patient positioned the hand. The aquaplast cover was molded to the dorsal hand to immobilize both hand and micro applicators. The marker wires were placed inside the catheter for adequate visualization on the CT images. The patient was scanned with a 1.25 mm slice thickness to allow for the accurate digitization of the catheter. Oncentra Brachy planning system Version 4.3.0.410 (Elekta Brachytherapy) was used for the treatment planning. The prescription dose for the HDR treatment was 21.6 Gy in 12 fractions to the clinical target. **Results:** The catheter reconstruction was
uncomplicated due to good visibility of the markers, and the treatment planning resulted in a favorable dose distribution. The prescription dose was planned to the depth of anterior distal phalanx allowing for the sparing of non-targeted tissue. Total number of the active dwell positions was 145 with step size of 5 mm. Total treatment time was 115 seconds with 7.36 Ci associated activity of the Ir-192 source. Due to the robust design, the applicator was used repeatedly during the whole multi-fractional course of treatment. The patient tolerated treatment well. The treatment resulted in good pain control and the patient did not require further injections to the nail bed. After this initial treatment additional two patients with the similar symptoms received HDR brachytherapy. The treatment outcome was favorable in all 3 cases. Conclusions: In this study the HDR brachytherapy treatment of the psoriasis of the nail beds was presented. The initial experience revealed that such technique was well tolerated and resulted in adequate control of the disease. A larger cohort of patients will be required for additional conclusions related to potential long-term clinical benefits or toxicity.

Scientific Session: Breast Proffered Papers
Saturday, April 22, 2017
9:00 AM - 10:00 AM

PP37 Presentation Time: 9:00 AM
Long-Term Outcomes of Women with Invasive Non-Ductal Breast Cancers Treated with Multicatheter Interstitial Accelerated Partial Breast Irradiation
Bethany M. Anderson, MD1, Mitchell Kamrava, MD2, Pin-Chieh Wang, PhD2, Peter Chen, MD3, John K. Hayes, MD4, D Jeffrey Demanes, MD2, Robert Kuske, MD5.
1University of Wisconsin, Madison, WI, USA, 2University of California-Los Angeles, Los Angeles, CA, USA, 3William Beaumont Hospital, Royal Oak, MI, USA, 4Gamma West Cancer Services, Salt Lake, UT, USA, 5Arizona Breast Cancer Specialists, Scottsdale, AZ, USA.

Purpose: Our objective is to determine oncologic outcomes for women with invasive non-ductal breast cancer treated with multicatheter interstitial accelerated partial breast irradiation (mAPBI). Materials and Methods: Data from 5 institutions with experience delivering mAPBI was collected from patients treated between 1992 and 2013. We report the outcomes of 110 women with 111 invasive non-ductal breast cancers, all with at least 1 year of follow-up. All patients were treated with mAPBI, using either high-dose-rate (n = 100) or low-dose-rate (n = 11) technique. Histologies included invasive lobular cancer (ILC; n = 55), tubular (n = 30), mucinous (n = 19), medullary (n = 4), papillary (n = 1), adenoid cystic (n = 1), and unspecified nonductal (n = 1). The Kaplan-Meier method was used to calculate overall survival (OS), in-breast tumor recurrence (IBTR), regional nodal recurrence...
(RNR), contralateral breast event (CBE), and distant metastasis (DM) rates. A univariate proportional hazard model was performed to estimate the risks of IBTR using the following variables: histology, age, grade, T-stage, N-stage, ER, PR, her2, margin status, dose rate, receipt of chemotherapy, and receipt of endocrine therapy. Results: The median age of our patient cohort was 62 years. With a median follow-up time of 7 years, the 10-year OS of our patient cohort was 90.0%. The 5 and 10-year IBTR rates were 7.3% for ILC and 2.0% for non-lobular cancer (p = NS). For ILC, the RNR rate was 2.7% at 5 years and 12.0% at 10 years, as compared with 0% at 5 and 10 years for non-lobular histologies (p = 0.018). The 10-year CBE rate was 4.8% for ILC and 9.1% for non-lobular cancer (p = NS). DM developed in 15.3% of women with ILC and 3.3% with non-lobular cancers at 10 years (p = 0.059). High grade correlated with increased risk for IBTR (HR 12.7, p = 0.038) and estrogen receptor positivity correlated with decreased risk for IBTR (HR 0.1, p = 0.049). Conclusions: In our cohort of women with early-stage ILC and other invasive non-ductal histologies treated with mAPBI, the outcomes of both patient groups are favorable. An increase in RNR risk from 2.7% at 5 years to 12.0% at 10 years was noted in ILC patients, however, which warrants continued consideration of this histology within the “cautionary” group for APBI as we await additional studies with long-term follow-up.

PP38 Presentation Time: 9:09 AM
Long-Term Outcomes of Accelerated Partial Breast Irradiation via Multi-Catheter Interstitial HDR Brachytherapy
Prashant Gabani, MD, Maria Thomas, MD, PhD, Jacqueline Zoberi, PhD, Laura Ochoa, RN, PhD, Melissa Matesa, RN, Imran Zoberi, MD.
Radiation Oncology, Washington University School of Medicine, Saint Louis, MO, USA.
Purpose: Accelerated Partial Breast Irradiation (APBI) has been established as a viable adjuvant therapy for early stage breast cancer patients. The 2016 ASTRO Consensus Statement (CS) for APBI contain important changes, but it remains unclear if the new guidelines predict long term outcomes. Given the limited long term outcomes data for APBI, we aim to report the 10-year outcomes of APBI delivered using multi-catheter interstitial brachytherapy (ISI) stratified by the 2016 ASTRO CS. Materials and Methods: Patients with early stage breast cancer treated with APBI via ISI between 2002 and 2007 were prospectively enrolled in a registry with the aim of studying their outcomes. Patients selection criteria for APBI at our institution includes: age ≥ 40 years at the time of diagnosis, breast conserving surgery with pathologic findings of Tis (≤ 3 cm), T1, or T2 (≤ 3cm) disease, unifocal tumor, negative margins by at least 2 mm, and negative axillary nodes by axillary lymph node dissection or sentinel lymph node biopsy. These patients received HDR brachytherapy with the intent to deliver 34 Gy in 10 fractions. As part of the analysis, patients were stratified into suitable, cautionary, and unsuitable groups based on the 2016 ASTRO CS for APBI. 10-year clinical outcomes were compared between the three groups including ipsilateral breast tumor recurrence (IBTR), regional failure (RF), freedom from distant failure (FFDF), cancer-specific survival (CSS), progression free survival (PFS), and overall survival (OS) using Kaplan-Meier method. Toxicity and cosmetic data were also collected as part of the prospective registry. Results: A total of 181 patients were enrolled in the prospective registry. The median age at diagnosis was 61.5 years and follow up time was 9.9 years. ASTRO CS stratification led to 66 suitable, 88 cautionary, and 27 unsuitable patients. The median PTV volume, number of catheters used, and dose homogeneity index was 164.5 cc [57.6 - 669.0 cc], 21 [9 - 28], and 0.82 [0.56 - 0.95] respectively. The median V100, V150, and V200 was 233.5 cc, 48.6 cc, and 16.8 cc respectively. For the entire cohort of 181 patients, only 10 patients developed IBTR. At 10 years, there was no difference in the rate of IBTR (6.40% vs. 9.70% vs. 5.90%, P = 0.779) (Fig 1A.) between the three groups. For the entire cohort, RF, FFDF, CSS, PFS, and OS was 3.0%, 97.4%, 97.1%, 89.0%, and 79.8% respectively. Unsuitable patients had a trend towards a lower CSS (98.3% and 98.5% vs. 88.5%, P = 0.088) (Fig 1B). There was no difference in OS between the three groups (82.9% vs. 79.5% vs. 71.9%, P = 0.701) (Fig 1C). There was no statistically significant difference between the three groups with respect to RF, FFDF, PFS, or OS. On univariate analysis, tumor size, close margins, grade 2 tumors, and presence of lymphovascular space invasion were predictive for IBTR. Grade 3 tumors and patients receiving hormone therapy were associated with lower OS. On multivariate analysis, the only factor predictive for IBTR was grade 2 tumors. There were no predictive factors for OS on multivariate analysis. Grade 1 or 2 skin toxicity was present in 44 patients, and grade 3 skin toxicity in only one patient. There were no grade 4+ skin toxicities observed. Thirty-seven patients developed fat-necrosis, of which only two patients required surgery for management. Only one patient developed a rib fracture. A total of 172 patients had either excellent or good
cosmesis, with fair and poor cosmesis present in only 9 patients. **Conclusions:** APBI using ISI offers an excellent local control in appropriately selected patients. The 2016 ASTRO CS did not stratify patients with respect to IBTR or other important clinical endpoints at 10 years in this series. A trend towards a lower CSS was noted for unsuitable patients, without any differences in OS or PFS. We show that APBI remains as an appropriate option for carefully selected patients with early-stage breast cancer.

**PP39**

**Presentation Time: 9:18 AM**

**Fractionation Trends in Breast Cancer and Implications in Partial Breast Irradiation**

Daniel M. Trifiletti, MD, Timothy N. Showalter, MD, MPH, Kara D. Romano, MD, Einsley Janowski, MD, PhD, Shayna L. Showalter, MD, Surbhi Grover, MD, MPH.

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**Purpose:** To analyze the national trends in breast radiotherapy fractionation over the past decade. **Materials and Methods:** The National Cancer Database was queried for women with pTis-pT3, pN0, cM0 breast carcinoma (ductal or lobular) treated with breast conserving surgery and breast radiotherapy (RT) from 1998-2012. Patients were grouped based on the total number of radiotherapy fractions delivered into four groups: conventional fractionation (ConvFx, 25-33 fractions), hypofractionation (HypoFx, 15-24 fractions), accelerated partial breast RT (APBI, 10 fractions), and intraoperative RT (IORT, 1 fraction delivered on the day of surgery). Patients with alternative schedules were excluded. Trends were analyzed graphically, and univariable (UVA) and multivariable (MVA) analyses were performed to investigate factors associated with the receipt of APBI or IORT. **Results:** 371,145 patients met inclusion criteria. Trends analysis demonstrates a clear increase in APBI from 1998-2008, at which point hypofractionation became increasingly popular and APBI stabilized. Among APBI patients (n = 5,787), the predominant RT modality was HDR brachytherapy (71%). On MVA, several factors were associated with APBI over other fractionations (all p < 0.001): later year of diagnosis; older age; ductal histology; smaller tumors; estrogen receptor positivity; lower grade; and increased patient distance from treating facility (OR 2.16 if over 100 miles). Similar factors were associated with the receipt of IORT, including patients living a further distance from the hospital (OR 8.18 if over 100 miles). **Conclusions:** While APBI utilization increased sharply from 2000-2008, the use of APBI has stabilized since 2008 with a concomitant increase in use of hypofractionation. We hypothesize that this is related to several factors, including the relative strength of clinical data between fractionation techniques,
possible controversy regarding selection criteria for APBI, and external forces including reimbursement rates, which generally favor external beam RT approaches.

Figure: Trends in breast cancer fractionation in the National Cancer Database

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**PP40**

A Quantitative Evaluation of Pd-103 Permanent Breast Seed Implant Mark-Up Procedure

Danielle Anderson, PhD1, Deidre Batchelor, PhD1, Michelle Hilts, PhD1, Marie-Pierre Milette, PhD1, Juanita Crook, MD2.

1Physics, BCCA - SAH Centre for the Southern Interior, Kelowna, BC, Canada, 2Radiation Oncology, BCCA - SAH Centre for the Southern Interior, Kelowna, BC, Canada.

**Purpose:** Permanent breast seed implant (PBSI) is an attractive adjuvant treatment for early stage breast cancer following lumpectomy. However, because target localization is heavily dependent on ultrasound guidance and treatment team experience, widespread implementation remains challenging. The purpose of this study is: (1) to investigate the stability of a series of external landmarks in locating the seroma centroid, and (2) to evaluate the impact on the dose distribution of using these external landmarks to guide the implant. **Materials and Methods:** Fifteen consecutive PBSI patients treated during 2016 were included in the study. Two to four weeks before the implant, a CT simulation is acquired with the patient positioned on a breast board, and planning performed using MIM Symphony (Cleveland, OH, USA). On the day of the implant, to help guide implant set-up in the operating room, the patient undergoes a mark-up procedure at the CT simulator. The fiducial needle (FN) entry point and the projection of the implant center are temporarily marked on skin based on room-coordinate moves from external landmarks - a nipple marker and/or lateral tattoo. All marks (medial and lateral tattoos, nipple marker, FN entry, and implant center) have radiopaque markers placed on them and a pre-implant CT is acquired. The original (planning CT) seroma contour is deformed to the pre-implant CT using MIM Maestro, and is adjusted by an expert reviewer if
necessary. The distance between external landmarks and seroma centroid was measured and compared for the two CT images. The potential influence of choice of primary guiding external landmark on dosimetry was simulated by evaluating and comparing the dose distributions resulting from positioning the treatment plan on the pre-implant CT using each of four different markers (lateral tattoo, nipple marker, FN entry point, and implant center). The CTV (seroma) and an evaluative target volume (ETV; 0.5 cm margin on CTV) coverage was scored. **Results:** The change (mean ± SD) in landmark position with respect to seroma centroid between the planning CT and pre-implant CT in each orthogonal direction, and the total displacement, are plotted in figure 1. The mean change in displacement between all external landmarks and the seroma centroid was less than 5 mm in each orthogonal direction. The five landmarks all had similar consistency in position with respect to the seroma centroid, except the medial tattoo was significantly better at locating the seroma centroid in the medial-lateral direction. None of the landmarks chosen to guide plan placement resulted in a significant difference in dosimetry. The 60 plans created had a median ETV V90% of 97.2% (range 52.7 - 100%), and 80% of the plans resulted in a CTV V100 > 98%. **Conclusions:** Reproducible patient positioning on a breast board and careful definition of key external landmarks pre-implant are valuable in providing an approximate location of the internal seroma. Localizing the treatment plan using external landmarks achieved acceptable seroma coverage in the majority of cases. A pre-implant mark-up procedure is thus recommended to complement and facilitate an accurate implant, but ultrasound guidance remains invaluable to verify the target location and avoid instances of inadequate target coverage.

**PP41**

**Presentation Time: 9:36 AM**

**Seed Distribution Stability in Permanent Breast Seed Implant Brachytherapy**

Michelle Hilts, PhD1,2, Cassidy Northway, BSc1,2, Deidre Batchelar, PhD1,2, Daniel Morton, MSc1,3, Marie-Pierre Milette, PhD1,2, Juanita Crook, MD1.


**Purpose:** Permanent Breast Seed Implant (PBSI) is completed in a single outpatient session and is an attractive treatment option for patients with early stage breast cancer. However concern has been raised over seeds potentially shifting over time from their implanted positions. In this study we evaluate the stability of the implanted seed distribution in PBSI over the month immediately following implant. **Materials and Methods:** 31 consecutive patients who received PBSI were eligible for this study. Two patients were excluded as not all post-implant CT scans were available. For the remaining 29 patients, post-implant CTs obtained on day of implant (Day0) and
approximately one month later (Day30) were retrospectively analyzed. All post-implant seromas were defined from the seroma contoured on planning CTs using deformable image registration and adaptive contouring, then evaluated and edited by the radiation oncologist as required. A medical physicist identified implanted seeds on all CT images. Rigid registration of Day0 and Day30 CTs using seroma as region of interest was performed to assess the spatial correspondence of the centre of mass (COM) of the 90% isodose volumes. The following were recorded from Day0 and Day30 CTs: 90% contiguous isodose cloud size (volume, dimensions - ML, AP, SI) and position (COM coordinates), the maximum (max) spread between all implanted seeds in each direction (ML, AP, SI), the distance of each seed from its distribution COM, and number of seeds located within the seroma. Paired t-tests were used to test for significant differences between Day0 and Day30. Results: There was an average of 33±11 days between Day0 and Day30 scans. A total of 2107 of 2108 implanted seeds were identified, mean±SD of 73±16 seeds per patient. 90% isodose cloud volumes significantly (p<0.0001) decreased over time (mean±SD, 8±5%). This decrease was observed in 28/29 cases and was paralleled by significant decreases in dose cloud dimensions in the SI (7±8mm, p<0.0001) and ML (2±6mm, p=0.0633) directions; a slight increase in AP dimension was not significant. However position of the 90% dose volume COM remained consistent Day0 to Day30, within 2mm for all cases. The max spread between seeds increased over time in all directions; mean increases of 13±27mm, 16±22mm and 7±14mm in the ML, AP and SI directions respectively. This was most significant in the AP direction (p=0.0006) where the max spread increased in 86% of cases. Figure 1a shows the distance of each implanted seed from its respective seed distribution COM at Day0 and Day30. The mean distance differs only slightly (1±4mm) between Day0 and Day30, however outliers at larger distances are more apparent for the Day30 seeds which allows for the, apparently contradictory, decrease observed in the 90% contiguous isodose cloud. This increased movement in some “outlier” seeds at Day30 is clear in Figure 1b which shows that the max distance of any seed from COM is an average of 19±24mm greater at Day30 than at Day0 (p=0.0002). The number of seeds located within the seroma did not change predictably (increasing in 18/29 and decreasing in 11/29 cases) or significantly (p=0.3487). Further, the number of seeds within specific seroma quadrants (Sup/Ant, Sup/Post, Inf/Ant, Inf/Post) did not change significantly (0.1518<p<0.7579). Conclusions: Between implant day and one month following PBSI, the 90% isodose volume was found to decrease, without any significant change in the position of seed cloud COMs or in the number of seeds found within the seroma, likely paralleling seroma shrinkage. Outlier seeds were apparently left behind in this process, showing an increase in maximum spread. Any impact of observed changes on implant quality remains to be determined.

PP42
Feasibility and Clinical Value of CT-Guided 125I Brachytherapy in Pain Palliation of Bone Metastases from Breast Cancer
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Purpose: This study sought to evaluate feasibility and clinical value of computed tomography (CT)-guided iodine 125(\(^{125}\text{I}\)) brachytherapy in pain palliation of bone metastases from breast cancer. Materials and Methods: From January 2014 to July 2016, 83 patients with moderate to severe pain caused by bone metastasis from breast cancer who underwent either CT-guided \(^{125}\text{I}\) brachytherapy (n=39) or external beam radiotherapy (EBRT) (n=44) were enrolled. Brief Pain Inventory-Short Form (BPI-SF) was performed at different period of treatment. The univariate and multivariate analyses were used to determine the predicting effect on pain palliation in the presence of demographic and clinical variables. To evaluate therapeutic safety, treatment related-complications were also recorded. Results: In brachytherapy group, 42 procedures of \(^{125}\text{I}\) seed implantation were performed in 39 patients, and primary success rate of procedure was 92.3%. Compared to EBRT group, \(^{125}\text{I}\) brachytherapy group represented a superior performance in “worst”, “medium” and “now” pain palliation during the development of pain. Similarly, brachytherapy showed a better improvement in interference of pain than EBRT. The univariate and logistics regression analyses identified \(^{125}\text{I}\) brachytherapy was an important advantageous factor in development of pain palliation. Moreover, \(^{125}\text{I}\) brachytherapy did not increase incidence of severe complications. Conclusions: CT-guided \(^{125}\text{I}\) brachytherapy is a feasible and valuable treatment in pain palliation of bone metastases from breast cancer.

\(^{125}\text{I}\) Seed Implantation Procedure. Treatment plan system calculated the position of brachytherapy applicator and number of implanted seeds in the three-dimensional space (a, b). A postoperative CT scan was performed to verify the position and intensity of \(^{125}\text{I}\) seed (c), then generated a dose volume histogram (DVH) included isodose curves of different targets (d).
Effect of Different Hypofractionated Regimens Combination on Clinical Outcomes in Prostate Cancer Patients Treated with High Dose-Rate Brachytherapy Boost

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Purpose: To evaluate the effect of different combinations of hypofractionated regimens on clinical outcomes in prostate cancer patients treated with external beam radiotherapy (EBRT) and high dose-rate (HDR) brachytherapy.

Materials and Methods: Between 1999 and 2011, 849 prostate cancer patients were treated in our institution with EBRT and HDR boost. During this period, we used different hypofractionated EBRT and HDR brachytherapy regimens in order to improve the outcomes and convenience for the patients. We combined and converted these different regimens into a biologically effective dose (BED) based on the formula: \((nd[1+d/(α/β)])\) assuming an \(α/β\) of 1.5. According to BED results, patients were divided into three BED groups (BED < 250 Gy; 250 < BED < 260 Gy and BED > 260 Gy). The effect of BED on biochemical failure (Phoenix definition) and PSA nadir (nPSA) were evaluated at 5-year. Kruskal-Wallis test was used to test the mean difference of BED between the three BED groups and multivariate regression model was performed to predict the predictor factors of PSA failure and 5-y nPSA ≥ 0.4 ng/mL. Results: Mean age and median follow-up were 66 years and 65 months, respectively. ADT was used in 41.6% of the patients. The mean BED was significantly different between the three BED groups: BED < 250 Gy (215±26); 250 < BED < 260 Gy (257±1) and BED > 260 Gy (268±2) (p<0.001). The 5-year biochemical failure free survival were 97.3%, 94.3% and 95.5% in the BED < 250 Gy, 250 < BED < 260 Gy and BED > 260 Gy groups, respectively (p=0.452). The percentage of patients with 5-y nPSA < 0.4 ng/ml was 85.7%, 89.5% and 95.5% in BED < 250 Gy, 250 < BED < 260 Gy and BED > 260 Gy, respectively (p=0.030). In multivariate logistic regression, patients in BED > 260 Gy group were significantly, more likely to remain free from nPSA ≥ 0.4 ng/mL compared to those in BED < 250 Gy group (OR: 0.345, 95%CI: 0.124-0.962; p=0.042). In multivariate Cox regression, only ADT use was associated with a significantly increased risk of PSA failure (HR= 2.874, 95%CI: 1.456-5.676, p=0.002). BED groups had no significant effect on gastrointestinal toxicity. However BED > 260Gy group was associated with a slight increase in urinary toxicity. Conclusions: The different hypofractionated regimens used in our institution showed that an increase in BED is correlated with an improvement of biochemical control defined by a nPSA < 0.4 ng/ml. Meanwhile, it is also associated with a slight increase, but clinically acceptable urinary toxicity.

PP44 Presentation Time: 10:39 AM

Long-Term Outcome of Low-Dose Rate Brachytherapy with 1-125 Seeds as a Monotherapy for High-Risk Prostate Cancer Patients

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Purpose: To report long-term outcome of patients treated with 1125 low-dose-rate brachytherapy (LDR-BT) as a monotherapy for high-risk prostate cancer with a minimum five years follow-up after the LDR-BT. Materials and Methods: A group of 423 patients with clinically localized prostate cancer treated with 1125 LDR-BT between July 2004 and October 2011 at the Tokushima University Hospital were identified. Of the 423 patients, 175 (41.4%) had low-risk disease, 189 (44.7%) had intermediate-risk disease, and 59 (13.9%) patients had high-risk disease. Cohorts were categorized according to D’Amico’s risk classification, and biochemical outcomes plus overall survival were examined. Biochemical failure was defined as nadir prostate-specific antigen (PSA) level + 2 ng/mL. Results: A total of 423 patients met the criteria with a median follow-up of 97 months (range 18-146 months). The median age was 67.5 years (range 49-82) at the time of treatment. The 5- and 10-year biochemical failure-free survival rates were 100 and 98.7% for low-risk group, 95.2 and 93.0% for the intermediate-risk group 84.3 and 81.8% for the high-risk group, respectively. Of the 59 high-risk patients, age during 65 to 75 years group has significant superior biochemical failure-free survival rates compare to other age group (93.3 vs. 75.0% at five years, p=0.04). Treatment
Feasibility and Dosimetric Outcomes of MRI-Based Planning for Delivery of High-Dose-Rate Brachytherapy for Prostate Cancer

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Purpose: To evaluate the feasibility and dosimetric outcomes of MRI planning for improved target and normal tissue definition for treatment of prostate cancer with High-Dose-Rate brachytherapy (HDRBT). Materials and Methods: From August 2015 to January 2017, 81 unique patients with newly diagnosed localized prostate cancer were treated for a total of 100 outpatient brachytherapy procedures using MRI based treatment planning. All patients underwent operative placement of MRI-compatible transperineal brachytherapy catheters under transrectal ultrasound guidance. Patients then underwent T2-weighted fast spin-echo acquisition on either a 1.5T or 3T MRI. These images were used for target and normal tissue delineation, catheter reconstruction, and brachytherapy treatment planning. Pre-treatment DVH goals to the target were: $D_{90}=95\%$, $V_{90}=95\%$, $V_{100}=90\%$, $V_{150c}=30\%$, $V_{200c}=15\%$. DVH goals to normal structures were: urethra $D_{0.1cc}\leq115\%$, bladder $D_{1cc}\leq75\%$, rectum $D_{1cc}\leq75\%$, neurovascular bundle $D_{0.1cc}\leq100\%$, penile bulb $D_{1cc}\leq100\%$. Patients were treated with HDRBT monotherapy at 14 Gy/fx x 2 or external beam radiotherapy (45-56 Gy) followed by single fraction HDRBT boost of 14-15 Gy. Procedure times were recorded from start to end of catheter insertion and template fixation (A-B), MRI and treatment planning (B-C), start to end of HDRBT delivery (C-D), HDRBT delivery completion to start of catheter removal in operating room (D-E), and start to end for catheter removal (E-F). We defined time from start of catheter insertion to completion of treatment as (A-D) and total treatment package time as (A-F). Dosimetric outcomes were recorded from the treatment planning system. Results: The median pre-treatment prostate specific antigen (PSA) level for patients with newly diagnosed prostate cancer was 7.83 ng/mL (range: 1.9-84 ng/mL). The median follow up time from date of diagnosis to last follow up was 8.4 months. Median post-treatment PSA was 0.6 ng/mL (range: <0.1-12.45 ng/mL). Median target volume was 45.6cc (range: 15.4-127.3cc). For treatment planning, CTV = PTV. Median volume receiving prescription dose was 53.7cc (range: 22.4-141.9cc), and median selectivity index was 0.88 (range: 0.6-1.05). Median values for target dosimetry were as follows: $D_{90}=100.0\%$ (range: 71.7-107.2\%), $V_{90}=95.6\%$ (range: 82.6-99.6\%), $V_{100}=90.0\%$ (range: 77.0-97.5\%), $V_{150c}=27.5\%$ (range: 17.4-43.4\%), $V_{200c}=9.9\%$ (range: 4.7-21.0\%). Median urethra $D_{0.1cc}$ was 113.2\% (range: 100.8-125.1\%). Median bladder $D_{1cc}$ was 70.2\% (range 40.6-87.7\%) and median rectum $D_{1cc}$ was 53.6\% (22.3-75.2\%). Median left neurovascular bundle $D_{0.1cc}$ 86.6\% (range: 64.1-246.6\%), right neurovascular bundle $D_{0.1cc}$ 88.2\% (range: 59.3-131.0\%), and penile bulb $D_{1cc}$ 39.5\% (range: 0.0-117.4\%). Median total treatment package time (A-F) was 5:59 (range: 3:31-9:45). Median time from start of catheter insertion to completion of treatment (A-D) was 4:40 (range: 3:01-7:30). Median times for catheter implantation and template fixation were 0:32 (range: 0:14-1:17) (A-B), MRI and treatment planning 3:33 (range: 2:01-5:21) (B-C), HDRBT treatment delivery 0:21 (range 0:12-0:57) (C-D), time from HDRBT delivery completion and start of catheter removal 1:04 (range: 0:06-4:19) (D-E), and time for catheter removal 0:10 (range: 0:04-0:31) (E-F). Conclusions: MRI-based treatment planning is feasible for the delivery of HDRBT for prostate cancer. We met stringent dosimetric criteria despite more accurate target and normal tissue definition with MRI imaging. Treatment package time was reasonable although opportunity remains for improved efficiency between HDRBT delivery and catheter removal. We have adopted MRI as our standard imaging modality for HDRBT for prostate cancer. Future directions are to correlate erectile structure dosimetry with post-treatment erectile function.
MRI-Based Prostate Brachytherapy - Imaging with and without an Endorectal Coil for Post-Implant Quality Assurance

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MD Anderson Cancer Center, Houston, TX, USA.

Purpose: High spatial and high contrast resolution images are important for accurate post-implant dosimetry in prostate low-dose-rate (LDR) brachytherapy. Compared to CT, MRI offers excellent soft tissue contrast and exquisite depiction of prostate subglanular and surrounding anatomy. However, MRI is limited in its signal-to-noise ratio (SNR) (and therefore spatial resolution) and inability to directly visualize the radioactive seeds. Using a combination of a positive MRI contrast marker technology [1], an endorectal coil (ERC), and an optimized imaging protocol, we recently demonstrated that it is possible to identify both the anatomy and the radioactive seeds (via positive MRI contrast markers) with MR images from a single acquisition [2]. In this work, we present our initial experience of acquiring prostate brachytherapy post-implant MR images without an ERC and compare the images to those acquired with an ERC in the same patients. Imaging without an ERC obviously incurs an SNR loss but has several potential advantages including increased clinical throughput, better patient tolerance, and lower cost.

Materials and Methods: A total of five patients were scanned on a 1.5T Siemens Aera MR scanner (Siemens Healthcare, Erlangen, Germany). All the patients were implanted with LDR radioactive seeds and C4 positive MRI contrast markers (Sirius, C4 Imaging, Bellaire, TX) and imaged on the same day after their implant. Each patient was first imaged with a two-channel ERC (Invivo, Gainesville, FL) in combination with a scanner provided external pelvic array coil, and then imaged with only the pelvic array coil and the ERC removed. We use a trueFISP pulse sequence (3D CISS or Constructive Interference in Steady State, Siemens) which provides high SNR and T2/T1 image contrast. The scan protocol when the ERC was used is presented in Ref. [2]. The protocol was adjusted slightly for use when the ERC was removed because of lower intrinsic SNR. The detailed parameters for both scan protocols are summarized in Table I. Results: Figure 1 shows a representative set of CISS images acquired from one patient with (a) and without (b) the ERC. Image (a) shows excellent delineation of both the prostate and C4 markers (red arrows). In contrast, image (b) exhibits a noticeable reduction in SNR in the prostate area, despite a larger voxel volume. Further, the conspicuity of the seed markers is reduced in (b) when compared to (a). Nonetheless, the prostate and its surrounding anatomical structures, as well as some of the C4 markers and the tracks of the radioactive seed strands remain identifiable. Per a preliminary analysis by a dosimetrist, the number of the seed markers that were directly identified was reduced by two-thirds and the time to complete the dosimetry planning increased by 50% when comparing the images without and with the ERC. Conclusions: Being able to perform accurate dosimetry using MR images without ERC is important for more widespread adoption of MRI in prostate brachytherapy. Our results indicate that despite reduced intrinsic SNR, optimization in pulse sequences and scan protocols shows promise in achieving images of sufficient quality to visualize both anatomy and MRI markers adjacent to the radioactive seeds. Additional technical development such as higher field strength, better pulse...

**Table 1.** Scan parameters used for imaging with and without ERC.

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<tr>
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<th>FOV (cm)</th>
<th>Slice thickness (mm)</th>
<th>Slice resolution, oversample (%)</th>
<th>Slices</th>
<th>Ns</th>
<th>Phase resolution, oversample (%)</th>
<th>TR/TE (ms)</th>
<th>Flip angle</th>
<th>Bandwidth (Hz/pixel)</th>
<th>NEX</th>
<th>Scan time (min:s)</th>
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<tr>
<td>With ER coil</td>
<td>15</td>
<td>1.2</td>
<td>50, 8.3</td>
<td>96</td>
<td>256</td>
<td>100, 100</td>
<td>5.2/2.51</td>
<td>53°</td>
<td>558</td>
<td>1</td>
<td>4:12</td>
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<tr>
<td>Without ER coil</td>
<td>15</td>
<td>1.4</td>
<td>50, 10</td>
<td>80</td>
<td>256</td>
<td>75, 90.1</td>
<td>5.22/2.24</td>
<td>60°</td>
<td>558</td>
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**Figure 1.** Comparison of the MR images acquired for the same patient with (a) and without (b) the ERC.

**PP47**

**Validation of MRI to US Registration for Focal HDR Prostate Brachytherapy**

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**Purpose:** High dose rate (HDR) prostate brachytherapy can achieve long-term disease control. Multiparametric Magnetic Resonance Imaging (mpMRI) allows identification of gross tumor (GTV) in order to boost or target lesions. However, a significant number of clinics are using ultrasound (US) as their planning imaging modality due to its low cost and real time capability; but can’t identify the position of the GTV. Therefore, a registration is needed between mpMRI and US images to accurately delineate the GTV. The goal of the study was to develop and validate a new 3D Slicer MRI to US registration module for focal HDR prostate brachytherapy treatment. **Materials and Methods:** In this study, eleven patients with prostate cancer who underwent HDR brachytherapy, with lesions visible on mpMRI, were selected for the validation. T2-weighted 3D variable-flip-angle TSE images with 1mm isotropic voxel and diffusion weighted images were acquired on a 1.5T SIEMENS Magnetom, using surface coils,
for prostate and GTV contouring. 3D US images, with 0.5 mm thick slice, were obtained with Oncentra Prostate (OcP) system using BK Flex Focus 400. The new module is incorporated in 3D Slicer and is using SlicerProstate and SlicerRT extensions, with the validated BRAINS method, to perform rigid and deformable registration. The module allows DICOM-RT structures to be imported while contours transformed from rigid and deformable transformations can be exported in RT structures for direct use in treatment planning system (TPS). The rigid registration is performed on both MRI and US prostate surface meshes. The deformable B-spline registration is performed after an initial rigid registration to elastically align the binary 3D label maps. To validate the module, prostate contours were obtained by an experienced Radiation Oncologist on both MRI and US images; common points were also identified on US and MRI registered images. Dice and Hausdorff indices were obtained to validate the registration. In addition, volumes were compared and Target Registration Errors (TRE) were calculated for the centroid and common points. A paired t-test was used to compare the methods. Results: The complete registration step is performed in a clinically acceptable time of less than 5 minutes. RT structures were successively imported into OcP TPS, a requirement for brachytherapy procedures. The module offers Dice and Hausdorff metric with TRE calculation to assess the accuracy of the registration. Fig. 1 shows a representative registration between MRI (blue) and US (red) contours for a) rigid and b) deformable registration. The deformable registration allows a better representation of the prostate at the time of brachytherapy as it can correct the US endorectal probe deformation. Dice indices were found to be 0.93 ± 0.01 and 0.87 ± 0.05 for the deformable and rigid registration, respectively. Fig. 1 shows c) maximum, mean and 95% confidence interval Hausdorff value for rigid and deformable registration. Rigid and deform MRI volumes (39.6 ± 12.1, 39.4 ± 12.2 cm³) were not statistically different (p > 0.05) from reference US volumes (38.6 ± 11.9 cm³). TRE between centroid position was 2.10 ± 0.98 and 0.37 ± 0.14 mm for the rigid and deformable registration, respectively. Fig. 1 shows d) TRE found between common points identified in US and rigid or deformable MRI images. Deformable registration was found significantly better than rigid registration in terms of Dice, Hausdorff and TRE (p < 0.01). Conclusions: In conclusion, deformable registration was significantly more accurate than rigid registration for brachytherapy MRI-US fusion. In average, both Hausdorff distance and TRE for common points are within 2mm. This study demonstrates that the deformable registration is sufficiently accurate and precise for use in focal HDR prostate brachytherapy.
Automated Prostate Brachytherapy Seed Detection on Post-Implant MRI Using Novel Martin Algorithm
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Purpose: Post-prostate brachytherapy MRI provides improved anatomical details, but lacks efficient methods for identification of seed locations compared to CT. Given the poor soft tissue contrast with CT alone and the potential for errors in the MRI-CT coregistration process, the use of a brachytherapy seed detection algorithm using only MRI would provide accuracy for both seed identification and organ contouring, hence improving the reliability of post implant dosimetry. The purpose of this study, therefore, is to present a novel method of automated seed detection using only MRI.

Materials and Methods: Twenty-three consecutive patients undergoing permanent prostate implant with stranded seeds were included in this study. Each strand contained seeds and positive MRI contrast markers that replaced spacers. Post-implant MRI included a modified T2 weighted, constructive interference in steady state (CISS) MRI sequence developed for brachytherapy seed identification. Morphological image analysis using diffusion enhanced edge detection was used to extract brachytherapy strands followed by registration to 3D reconstruction of the brachytherapy pre-plan. Brachytherapy seeds were then assigned and identified within each strand. Seed locations on MRI detected by the automated algorithm were compared to those identified manually by a brachytherapy dosimetrist. The algorithm was implemented using MATLAB.

Results: The average (±S.E.) number of brachytherapy strands detected by the algorithm was 96% (±2%), and the average (±S.E.) number of seeds detected was 89% (±1%). The average (±S.E.) distance between seeds detected via the algorithm compared to manual identification was 2.2 mm (±0.2 mm). The average time to perform the analysis per patient was 48 minutes on a standard desktop computer compared to 2-3 hours for manual detection of seeds.

Conclusions: Automated detection of post-implant prostate brachytherapy seeds on MRI is feasible with good accuracy enabling MRI only post-implant dosimetry and reduces the number of brachytherapy seeds which need to be identified manually. Future refinements of the algorithm will focus on improved seed detection and reduced computational time.

Scientific Session: GYN Snap Orals (E-Poster)
Saturday, April 22, 2017
11:30 AM - 12:30 PM

GSOR1
Understanding Outcome Beyond EQD2 in Tandem and Ovoid Cervical Cancer Brachytherapy Treatments
Emma Fields, MD1, Michael Waters, PhD2, Rakhi Melvani, MD2, Nitai Mukhopadhyay, PhD3, Dorin Todor, PhD1.
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Purpose: The current ABS and GEC-ESTRO recommendations for reporting and adding the effects of BT and external beam (EB) RT doses are based on BED and EQD2, both of which are implicitly considering homogeneous dose distributions using either the prescription dose (PD) per fraction (typically a minimum dose encompassing the target volume) or D90 to the high-risk (HR)-CTV. Neither of these quantities can fully capture the effects of dose inhomogeneity, inherent and believed critical in brachytherapy. The purpose of this study is to analyze the clinical results of consecutive women with locally advanced cervical cancer, modelling the data for local control. Two radiobiological quantities previously proposed - EUBED and gBEUD - computed for extended ranges of α/β, α and ‘a’ were examined, together with EQD2, Dxx and Vxx, for both CTV and the volume encompassed by PD.

Materials and Methods: 31 patients with cervical cancers(FIGO stage IB2-IV) were treated with 142 T&O fractions between 9/2013 and 11/2016 and were followed up for an average of 488 days (range 27-1133 days). HR_CTV and OARs (bladder, rectum, sigmoid) were contoured by a single physician. All plans were optimized using a ‘two-step’ optimization procedure, previously described, with the goal of maximizing D90(HR_CTV), minimizing dose to OARs, while maintaining the pear aspect of the PD iso-surface. Dosimetric data, structures and
3D spatial dose distributions were extracted from TPS and radiobiological quantities (BED, EQD2, EUBED and gBEUD) computed offline. Standard EQD2 was evaluated based on D90 to HR_CTV. EUBED and gBEUD were calculated for each fraction after a voxel-based conversion from dose to BED, for both HR_CTV and the volume encompassed by PD. A range of α/β values were considered, from 5.9Gy to 20.9Gy. Additionally, we explored multiple α values (range 0.15-0.7Gy⁻¹) with smaller values typically associated with radioresistant tumors. Similarly, the free parameter ‘α’ in gBEUD allowing a variable emphasis on hot/cold spots was explored in the range [-5,5].

Distributions of the two populations (patients with recurrence and disease free) were compared using the 2-sample Kolmogorov-Smirnov test at 3% significance. Results: The mean CTV was 41.1cm³, with a range from 21.1-84.0cm³. D90 for the series was 98.2±10.6 %PD showing the use of a consistent planning method and objectives. Among the patients followed up, 8 have recurred (four have deceased) and 23 have no evidence of disease. The average time to recurrence was 265 days (range 10-608 days), while the average disease free survival was 506 days, with a maximum follow-up of 1210 days. EUBED and gBEUD, computed for CTV, for the all α values and ‘α’ values between -5 and 1, produced very similar results, despite the two different methods of voxel-BED ‘integration’. None of the usual dosimetric parameters (Vxx, Dxx, CTV volume, TRAK, etc.) were able to distinguish the recurring patients from the disease free ones, with the exception of gBEUD for α≥1.5 (p=0.012).

Conclusions: It is generally accepted that while there is no consensus on how to report high dose volumes for intracavitary brachytherapy at present, these high dose volumes are regarded as important. Based on our clinical data, we believe that gBEUD, with an ‘α’ exponent larger than 1.5, has to ability to ‘integrate’ high doses delivered with T&O in a manner that is strongly correlated with clinical outcome. Even though historically gBEUD associated negative exponent values with tumor control and positive values with toxicity, in the case of T&O distributions, a positive exponent emphasizes the importance of hot dose volumes, likely to play a significant role in cure. The clinical implications of this finding are huge - instead of focusing on D90 and EQD2 perhaps we should be integrating the inhomogeneity in real time and tracking the gBEUD to ensure the best outcomes for our patients.

**GSOR3**

**Presentation Time: 11:40 AM**

**Sustainable Gynecological Brachtherapy in an Increasingly Cost-Aware Healthcare System: Conversion of Labor-Intense Interstitial Brachtherapy to Hybrid Intracavitary Brachtherapy for Locally Advanced Cervical Cancer**

Brandon A. Dyer, MD, Stanley Benedict, PhD, Yi Rong, PhD, Sonja Dieterich, PhD, Richard K. Valicenti, MD, Jon Paul Hunt, CMD, Eliseo E. Montemayor, RT, Jyoti S. Mayadev, MD.

**Radiation Oncology, University of California Davis Comprehensive Cancer Center, Sacramento, CA, USA.**

**Purpose:** Intertitial (IS) and hybrid (H) brachytherapy (BT) techniques allow for improved dose coverage and normal tissue sparing vs standard intracavitary (IC) BT in selected cervical cancer patients (pts), with IS being more complex, labor intensive, and requiring specialized physician and team training. With the decline in brachytherapy utilization trends, to add value and access to patient outcome improvement with BT, simple, efficient, and teachable techniques are needed. We examined our institutional efficiency and utilization trends over time for IC, H, and IS techniques and the theoretical ability for patient-specific conversion from an IS to H implantation for improved value. **Materials and Methods:** We reviewed cervical cancer pts treated consecutively and definitively at our institution using either IC, H, or IS techniques from 2007 - 2017. For IC cases, we collected process efficiency data related to physician, dosimetry, and physics planning time. For H and IS procedures, we collected patient demographics and radiotherapy (RT) treatment plan information. Additionally, we performed expert review for the potential to convert an IS to H implant. Statistical analyses were performed using two-tailed t-test with significance of p < 0.05. **Results:** From 2007 - 2017, 197 cervical cancer pts were treated definitively with EBRT and BT: 158 IC, 14 H, and 25 IS. From 2010 - 2013 there was a significant difference in the number of IS pts vs H pts, 13 vs 3 (p = 0.03); however, from 2014 - 2017 the number of IS pts vs H pts were equivocal, 12 vs 11 (p = 0.90). Patient demographics and treatment related specifics are listed in Table 1. The IS pts had higher FIGO stage (p = 0.03) and more IS pts died from disease failure, Table 1. Average HR-CTV volumes and dimensions were significantly larger in the IS vs H group, Table 1. Dosimetric analysis revealed a higher D2ccB and S in the IS vs H group, 4.9 Gy vs 4.4 Gy (p = 0.01), 3.8 Gy vs 2.7 Gy (p < 0.01), respectively. D2ccR was less in the H vs IS group, 3.4 Gy vs 4.0 Gy (p < 0.01). Retrospective expert review of IS plans revealed that 7 of 25 (28%) pts could have been converted from IS to H implantation, Table 1. For each IC, H, and IS fraction the median physician planning time was 18 min, 28 min, and 59 min, respectively; dosimetry planning time was 40 min, 47 min and 63 min, respectively; physics
review time was 11 min, 13 min, and 23 min, respectively; package time (defined as physician, dosimetry, and physics time) was 69 min, 84 min, and 158 min, respectively. IS implant took longer compared with IC and H implants for all metrics (p < 0.01).

### Table I. Patient demographics and brachytherapy data for H and IS treatments.

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</table>
| Per-fraction average HR-CTV (VUcm^2) (in cm)
| Average              | 68                   | 88            | <0.01  |
| Minimum              | 37                   | 39            |        |
| Maximum              | 143                  | 153           |        |
| Per-fraction average HR-CTV diameter (cm)
| Commissural          | 3.4                  | 6.6           | <0.01  |
| Transverse           | 4.3                  | 3.8           | <0.01  |
| Proximodistal        | 3.3                  | 4.2           | 0.10   |
| Per-fraction average HR-CTV (cm)
| B2                   | 1.9                  | 2.2           | <0.01  |
| B3                   | 1.6                  | 1.7           | <0.01  |
| B4                   | 1.6                  | 1.6           | <0.01  |
| B5                   | 1.7                  | 1.7           | <0.01  |
| B6                   | 2.0                  | 2.0           | <0.01  |
| B7                   | 1.8                  | 1.8           | <0.01  |
| B8                   | 1.7                  | 1.7           | <0.01  |
| Per-fraction average HR-CTV (Gy)
| Commissural          | 1.2                  | 1.3           | <0.01  |
| Transverse           | 2.0                  | 2.0           | <0.01  |
| Proximodistal        | 2.2                  | 2.2           | <0.01  |

Conclusions: Value optimization in brachytherapy highlights increasing efficiency with outcome improvement. With the decreasing BT utilization, simpler BT techniques are needed. Our study suggest that complex IS implants can be potentially converted to a simplified H technique without compromising dose coverage and normal tissue metrics. Furthermore, our data shows that transitioning to H-BT reduces the total treatment package time by 50% (p < 0.01). H-BT represents not just an alternative to IS-BT, but a true replacement for IS-BT in selected pts, thus helping reduce the cost and labor burden in an increasingly cost-aware healthcare system while providing excellent patient outcomes.

GSOR4

Presentation Time: 11:45 AM

Survival Outcomes in Women with Early Stage Uterine Non-Endometrioid Carcinoma with Adjuvant Chemotherapy and Vaginal Brachytherapy Alone

Joon Lee, MD, Charlotte Burmeister, MS, Ahmed Ghanem, MD, Ibrahim Aref, MD, Mohamed Elshaikh, MD.

Radiation Oncology, Henry Ford Hospital, Detroit, MI, USA, Public Health Sciences, Henry Ford Hospital, Detroit, MI, USA.

Purpose: To investigate survival outcomes and recurrence patterns in women with early stage uterine non-endometrioid carcinoma (NEC) treated with adjuvant platinum-based chemotherapy and vaginal brachytherapy alone. Materials and Methods: This was an institutional review board (IRB)-approved study of 83 women with FIGO stage I-II uterine NEC who were without residual disease after undergoing surgical staging at our institution.
In addition to descriptive analyses of patient demographics, tumor characteristics, and adjuvant treatment received, univariate log-rank analyses and Cox regression multivariate analyses were performed to identify patterns and predictors of recurrence-free (RFS), disease-specific (DSS), and overall survival (OS). **Results:** Median age for the study cohort was 65 years. Fifty-eight women (70%), 11 women (13%), and 14 women (17%) were diagnosed with 2009 FIGO stage IA, IB, and II NEC, respectively. Forty-five women (54%) were diagnosed with uterine serous carcinoma, 20 women (24%) with carcinosarcoma, 11 women (13%) with clear cell carcinoma, and 7 women (9%) with mixed carcinoma. All women underwent surgical staging with a median number of dissected lymph nodes of 17. Ten women (12%) had positive peritoneal cytology. Median high dose rate (HDR) brachytherapy dose was 30 Gy in 5 fractions prescribed to the surface of the upper 4 cm of the vagina. Carboplatin-paclitaxel was the most common chemotherapy regimen. After a median follow-up of 25.9 months, tumor recurrence was diagnosed in 10 women (12%); 8 with distant metastases, one with an isolated pelvic metastasis, and one with an isolated vaginal cuff recurrence. 5-year RFS, DSS, and OS were 81%, 80%, and 76%, respectively. On multivariate analysis, both old age and positive peritoneal cytology were statistically significant predictors of DSS and OS (p < 0.05).

**Conclusions:** Our study suggests that excellent rates of vaginal and pelvic control can be achieved with surgical staging followed by adjuvant chemotherapy and vaginal brachytherapy alone in early stage uterine NEC. Due to high rates of distant failures, optimization of systemic treatment is warranted in this cohort of patients.

**GSOR5**

**Presentation Time: 11:50 AM**

**Detecting Applicator Displacement During HDR Interstitial Brachytherapy for Gynecologic Malignancies**

William Taylor, MS, Iman Washington, MD, Mike Carlson, DMP, Allison Quick, MD.

*Radiation Oncology, The Ohio State University, Columbus, OH, USA.*

Purpose: Applicator displacement during HDR interstitial brachytherapy (HDR-ISBT) for primary or recurrent gynecologic cancers is a concern. Needle displacement can be detected by checking the position and length of each needle prior to treatment. However, these measurements are relative to the template and do not detect displacement of the entire applicator apparatus. The purpose of this study is to determine if the applicator displacement can be identified by characterizing the position of the applicator, pubic symphysis, and gold seed markers with respect to the HRCTV. Dosimetric changes to target volumes as a result of displacement will also be investigated.

Materials and Methods: This study retrospectively evaluates patients with a gynecologic malignancy who underwent HDR-ISBT at our institution. Prior to applicator placement, two gold seed markers were placed in the cervix or vagina to mark superior and inferior extent of disease. Following placement of the vaginal obturator, template, and interstitial needles under fluoroscopic guidance, a post-implant CT and MRI were performed. Treatment plans were created using Varian’s BrachyVision™ Brachytherapy Planning Version 13.6 (Varian Medical Systems, Inc., Palo Alto, CA). Treatment was delivered once on the day of implant and then twice daily over the next 2 days. A CT scan was performed prior to the morning treatments on days 2 and 3 which were registered to the original planning CT dataset using three reference objects: template (including the vaginal obturator), pubic symphysis, and gold seed markers. The HRCTV was retrospectively recontoured on each CT dataset by the same board certified Radiation Oncologist. The centroid of the HRCTV was tracked as a surrogate of changes in the location of the reference objects. To evaluate the possible dosimetric changes to the original HRCTV used for treatment, the HRCTV was copied from the CT dataset on day 1 to the CT datasets on day 2 and 3 using the applicator registration. The target was then re-copied to the reference CT dataset after a spatial transformation from the pubic symphysis and gold marker fusions.

Results: 6 patients and 18 CT datasets were reviewed. 5 of the 6 patients had 2 gold markers identified on CT and the other patient had only 1 gold marker. The position of the seeds relative to one another was 0.4 ± 0.2 cm from day 1 to day 3, excluding 1 patient who exhibited a possible seed migration of 1.3 cm. The results for this patient were excluded from further analysis. The average displacement of the re-contoured HRCTV with respect to the template, pubic symphysis, and gold markers were 1.03 ± 0.75 cm, 0.88 ± 0.50 cm, and 0.67 ± 0.24 cm, respectively (Figure 1). The HRCTV coverage on average changed by -9.4% ± 13.2% and -12.6% ± 16.5% using the pubic symphysis and gold seed marker registration techniques, respectively. For 1 patient, the change in target coverage was greater than -35.0% for both techniques.

Conclusions: Gold markers show minimal displacement during the course of HDR-ISBT and have a smaller average displacement from the HRCTV than the template and pubic symphysis. This data suggests that gold markers may act as a surrogate to monitor target motion and detect applicator displacement.
Considerable differences, as much as -35.0%, were noted in target coverage based on the various registration techniques.

**GSOR6**

**Presentation Time: 11:55 AM**

**Impact of Adaptive Planning on Image-Guided Perineal Brachytherapy for Gynecologic Malignancies**

Adam Gladwish, MD,1 Ananth Ravi, PhD,1 Lucas Mendez, MD,1 Melanie Davidson, PhD,1 Laura D’Alimonte, MHSc1, David D’Souza, MD,2 Matt Wronski, PhD,1 Eric Leung, MD1.

1Radiation Oncology, Sunnybrook Health Sciences Centre, Toronto, ON, Canada, 2Radiation Oncology, London Regional Cancer Program, London, ON, Canada.

**Purpose:** To determine the dosimetric impact of adaptive planning in image-guided gynecologic brachytherapy (IGBT) utilizing a trans-perineal interstitial approach, specifically in regards to organ motion and implant deformation. **Materials and Methods:** 26 patients with a total of 81 (one patient treated twice) interstitial fractions were selected for analysis. Each patient was treated with 3 fractions given over a 24 hour period utilizing a single insertion. A planning MRI and CT-scan were acquired prior to the first fraction. A verification scan was taken immediately (within 1-hour) following the second fraction. Two evaluation frameworks were established for comparison with the planned first fraction. First, the initial treatment plan generated on the planning CT was registered (via implant) with the verification CT to determine the ‘true’ second fraction dosimetry. Second, to determine the effect of interfraction implant motion alone, the catheter positions from the verification scan were used in conjunction with the initial plan and planning CT. Differences in tumor D90, bladder and rectum D2cc were assessed in both frameworks by subtracting from the original plan. Evaluations were made in terms of absolute dose as well as EQD2, with and without external beam contribution where applicable. **Results:** All patients were treated between October 2014 - August 2016. Mean age was 75 years (range 47 - 87). Recurrent endometrial cancer represented 38% (10) of the cases, primary vaginal cancer 35% (9) and other diseases for the remainder. External beam was given prior to brachytherapy in 22 (85%) cases. A median of 16 (range 8 - 25) catheters were used. Median prescription dose was 700 cGy (range 600 - 700 cGy). From implant to evaluation, the mean tumor D90% decreased significantly (36 cGy (5.0%), p<0.01), rectal D2cc was significantly higher (32 cGy (12.2 %), p=0.02) if
uncorrected and bladder dose was not significantly altered, likely owing to the influence of sub-vesicular vaginal lesions in this cohort. Interfraction implant motion between planning and verification contributed to the reduction in tumor D90% (24 cGy, p<0.01), but no significant effect was seen in bladder or rectal dose. When evaluated in EQD2 with external beam contribution all mean dosimetric changes reported were within 3%. **Conclusions:** Adaptive planning represents an important aspect of perineal based interstitial IGBT, with the absolute impact being ameliorated by the relative contribution of EBRT and BT. Given the short interval from treatment delivery to verification scan, this analysis reflects the anticipated benefit of real time adaptive planning. The absence of adaptation would tend to reduce tumor dose and increase OAR dose. This results from a combination of both organ and implant motion.

**GSOR7**
**Presentation Time: 12:00 PM**
**Outcomes of Locally Advanced Cervical Cancer Patients Following the Use of the Hybrid Intracavitary and Interstitial Utrecht Tandem and Ovoids Applicator in an Outpatient Setting**
Amanda Rivera, MD, Keyur J. Mehta, MD, Ravindra Yaparpalvi, MS, Hsiang-Chi Kuo, PhD, Sujith Baliga, MD, Shalom Kalnicki, MD.
1Radiation Oncology, Montefiore Medical Center, Bronx, NY, USA, 2Albert Einstein College of Medicine, Bronx, NY, USA.

**Purpose:** Patients with locally advanced cervical cancer with either bulky disease or parametrial involvement commonly require an external beam parametrial boost in conjunction with tandem and ovoid brachytherapy or an interstitial implant that is performed under general anesthesia and requires an inpatient hospital stay. The purpose of this retrospective review was to assess outcomes of patients treated for locally advanced cervical cancer with the use of intracavitary and interstitial implantation via the Utrecht™ applicator in the outpatient setting. **Materials and Methods:** A total of 46 patients were treated for cervical cancer with a combination of external beam radiotherapy (EBRT) and hybrid intracavitary/interstitial brachytherapy from 2010 to 2016 at our institution. Patients were prescribed an EBRT dose of 45-54 Gy and brachytherapy was administered in 6-7 Gy/fraction over 4-5 insertions. Patients were pre-medicated prior to each fraction with low dose narcotic pain medication and a low dose of benzodiazepine. The applicator was then inserted with placement of interstitial needles under CT guidance to assure tumor coverage and avoidance of organs at risk. CT-image based contouring, treatment planning and plan evaluation was then performed according to the published GEC ESTRO guidelines. Outcomes data including local control, distant metastases and distant metastasis free survival were assessed. Time to event was recorded as the time from treatment end date to most recent imaging, follow-up with radiation oncologist or gynecologic oncologist, or death. The Kaplan Meier method was used to estimate local control, and distant metastasis free survival. Local control was defined as the absence of an in-field failure. Distant metastases were defined as out of field recurrences. Genitourinary and gastrointestinal toxicities were recorded according to the CTCAEv4.0. **Results:** Forty-six patients fully completed a prescribed course of Utrecht™ brachytherapy, amounting to 223 total brachytherapy treatments. The FIGO stage distribution was IB1(2), IB2 (3), IIB (19), IIIA(1) and IIIB(21). A median of 10 needles were used per course of brachytherapy. Median follow up was 16.3 months. There were eight locoregional failures and sixteen distant failures. There were three patients that failed solely within the cervix, one that failed in the irradiated regional lymph nodes and four patients that failed both locally and distantly. Local control at 1, 2, 3, and 4 years was 90.4%, 87.6%, 87.6%, and 87.6%, respectively. Distant metastasis free survival at 1, 2, 3, and 4 years was 85%, 79%, 72.4%, and 63%, respectively. One patient had grade 5 radiation cystitis 5 years after treatment. This patient had hematuria requiring transfusions and a bladder perforation. There was one grade 3 vesicovaginal fistula, one grade 3 colonic fistula, one grade 3 colonic hemorrhage, and one grade 3 ureteral stricture. **Conclusions:** The use of a hybrid intracavitary and interstitial brachytherapy applicator in lieu of an external parametrial boost or traditional interstitial implantation demonstrates excellent local control and low toxicity profile in the treatment of locally advanced cervical cancer. This represents a feasible alternative for select cases where tumor coverage cannot be attained with standard tandem and ovoids applicators.

**GSOR8**
**Presentation Time: 12:05 PM**
**Deformable Registration for MRI Based Brachytherapy - Ready to Replace MRI with Applicator in Place?**
Junzo Chino, MD, Anna Rodrigues, PhD, Oana Craciunescu, PhD.
Radiation Oncology, Duke Cancer Institute, Durham, NC, USA.
Purpose: MRI based brachytherapy (BT) has resulted in excellent local control and low toxicity rates, however, in many practices, it is a significant logistical challenge to obtain an MRI with the applicator in place. Deformable registration of pre-BT MRI HRCTV and uterine body contours with a CT with applicator in place may represent a possible solution, however the accuracy of such generated contours is unknown. Materials and Methods: Women under treatment for cervical cancer with definitive chemo-radiotherapy were identified who had both a pre-BT MRI in the last week of EBRT and an MRI at the time of first BT fraction with the applicator in place. An HRCTV was contoured as per GEC-ESTRO guidelines on the MRI with applicator in place as standard institutional practice (termed ‘true BT HRCTV’). Under a retrospective IRB approved protocol, an HRCTV was defined on the pre-BT MRI, and deformably registered with the BT CT with applicator in place via MM software (Cleveland OH). A workflow was created to perform: 1) uterus based rigid registration between the pre-BT MRI and BT CT; 2) Contour-based (uterus) deformable registration between the pre-BT MRI and BT CT; 3) transferred the deformed pre-BT HRCTV and Uterus contours onto BT CT. The preBT deformed HRCTV was then compared to the true BT HRCTV via Dice Similarity Coefficien (DSC), Jaccard similarity coefficient (JSC) and Hausdorff distance (HD) measure. Results: The first seven cases form the content of this report, all treated in 2016. It was found that grayscale matching alone resulted in no useable contours for treatment planning. However, by contouring a separate uterine body contour in both the preBT MRI and the true BT CT, that useable contours could be generated for comparison to true BT HRCTVs. With the uterine body contour method, the median DSC of the two HRCTV was 0.78 (IQR 0.745-0.795), median JSC was 0.63 (IQR 0.595-0.665), and Median Max Hausdoff Distance was 1.61 (IQR 0.93-2.695). Conclusions: Gray scale deformable registration was unable to adequately deform a preBT HRCTV for use in treatment planning. By creating an intermediary uterine contour, useable HRCTVs were possible, and the DSC and JSC showed a moderate degree of accord. The Hausdoff distance however did show large maximum displacements, that would likely affect treatment planning. Future work will concentrate on comparing to a physician directed side by side cognitive fusion of pre BT MRI and BT CT contours, as well as to determine modifiable factors associated with poor deformable registration performance.

GSOR9 Early Outcomes and Impact of a Hybrid IC/IS Applicator for a New MRI-Based Cervical Brachytherapy Program
Matthew M. Harkenrider, M.D.1, Murat Surucu, PhD1, Grant Harmon, BS1, Michael Mysz, MS1, Steven Shea, PhD2, John Roeske, PhD1, William Small Jr., MD FACRO FACR FASTRO1.
1Department of Radiation Oncology, Loyola University Chicago, Stritch School of Medicine, Maywood, IL, USA, 2Department of Radiology, Loyola University Chicago, Stritch School of Medicine, Maywood, IL, USA.

Purpose: Brachytherapy is an integral component in the curative management of cervical cancer. Recent studies have demonstrated the most favorable outcomes with magnetic resonance imaging- (MRI) based brachytherapy and a combined intracavitary/interstitial (IC/IS) applicator. The aim of this study is to report early outcomes and determine how doses to the target and organs at risk (OAR) change over time especially after incorporation of an IC/IS applicator in a new MRI-based cervical brachytherapy program. 

Materials and Methods: Loyola University Medical Center began an MRI-based cervical brachytherapy program in July 2014 and accrued patients on an institutional prospective study. We accrued 33 patients who completed definitive external beam radiotherapy (EBRT) and MRI-based cervical brachytherapy. A hybrid IC/IS applicator was obtained in May 2016. Only patients with ≥3 months follow up were included in the assessment of disease control and late toxicity. All 33 patients were included in the dose assessment analysis of minimum dose to 90% of the high-risk clinical target volume (D90 HRCTV) and minimum dose to the maximally irradiated 2 cubic centimeters (D2cc) to OAR. Eras were defined arbitrarily into first half (early) and second half (later) for the IC only era (n=13 each), and the IC/IS era was separated due the difference in applicator availability (n=7). Median doses and interquartile ranges (IQR) were reported where appropriate. Doses in these eras were compared with student’s t-test. Kaplan-Meier method was used to estimate disease control and survival. Results: Among 27 patients with ≥3 months follow up, the median follow up was 14.7 months (range 3.8-26.9 months). Median patient age was 55 years (range 29-84 years). Squamous cell carcinoma comprised 81.5% of the population. Median stage was IIB (range IB1-IVB), and 14 patients (51.9%) were node positive. The median 2 Gy equivalent dose (EQD2) of the D90 HR-CTV for entire radiotherapy course was 88.0 Gy (range 80.0-104.4 Gy). Weekly concurrent chemotherapy, most commonly cisplatin, was delivered in 92.6% of patients for a median of 5 (range 0-6) cycles. Rate of 1-year local control, non-cervical pelvic control,
distant metastasis-free rate, and overall survival were 84.0%, 96.0%, 78.5%, and 91.3%, respectively. Absolute rate of late grade 3 toxicity was 14.8% without grade 4 toxicity. Among all 33 patients when comparing early and later eras of IC only, there was no difference in median D90 HR-CTV or D2cc of the bladder, rectum or sigmoid. The median D90 HR-CTV did not significantly change - 88.0 Gy (IQR 5.8), 88.0 Gy (IQR 3.2), 92.9 Gy (IQR 4.4) in the early IC, later IC, and IC/IS era (p=0.05), respectively. The median D2cc rectum was similar at 73.6 Gy (IQR 5.2) and 65.1 Gy (IQR 11.8) (p=0.30) for the early and later IC eras, respectively, but significantly decreased to 62.6 Gy (IQR 9.6) (p=0.01) from the early IC to the IC/IS era. There was no difference among eras for D2cc of the bladder or sigmoid. When comparing the entire IC era to the IC/IS era, the median D90 HR-CTV trended toward an increase from 88.0 Gy (IQR 4.0) to 92.9 Gy (IQR 4.4) (p=0.11). Meanwhile the median D2cc bladder trended toward a decreased dose from 87.5 Gy (IQR 15.6) to 83.6 Gy (IQR 16.1) (p=0.09), and median D2cc rectum significantly decreased from 69.3 Gy (IQR 11.6) to 62.6 Gy (IQR 9.5) (p=0.01) in the IC and IC/IS eras, respectively. There was no difference in dose to the sigmoid between IC and IC/IS eras. Conclusions: There was no significant difference in eras of concurrent radiochemotherapy with IC only MRI-based brachytherapy. We did not find a learning curve within the IC only era but found that incorporation of an IC/IS generated the greatest improvement in our new MRI-based brachytherapy program. With incorporation of an IC/IS hybrid applicator, we were able to decrease doses to the rectum and bladder while numerically increasing the D90 of the HR-CTV. These early results are promising with favorable local control and comparable high-grade toxicity rate to what has been reported by other groups. Longer follow up is required to assess local control and toxicity among these eras.

GSOR10  
Intracavitary versus Intracavitary/Interstitial HDR Brachytherapy for Cervical Cancer: Dose Difference to High Risk Clinical Target Volume

Kamal Akbarov, PhD, Elchin Guliyev, PhD, Nigar Aliyeva, Dr, Ruslan Huseynov, Dr.
Radiotherapy, National Center of Oncology, Baku, Azerbaijan.

Purpose: Today brachytherapy is still an important tool allowing radiation oncologists to escalate the dose of ionizing radiation to the cervical carcinoma. Traditionally intracavitary (IC) applicators (ring/tandem or ovoid/tandem) have been used for this purpose. But recently combination of intracavitary and interstitial (IC/IS) applicators introduced in clinical practice in dedicated radiotherapy centers with the aim to increase of radiation dose delivered to treatment target. The purpose of our study was to compare mean doses to high risk clinical target volume (HRCTV) and organs at risk in patients with locally advanced cervical cancer treated by IC and combined IC/IS brachytherapy. Materials and Methods: We analyzed brachytherapy plans of 89 patients with IIA - IIIB stage uterine cervical cancer which were treated at National Center of Oncology, Baku, Azerbaijan from 2013 to 2016. Median age of patients was 51 years (31-76); 16 (18%) patients had IIA, 41 (46,1%) - IIIB, 4 (4,5%) - IIIA and 28 (31,4%) - IIIB stage cervical cancer. Histological analysis showed 82 (92,1%) cases of squamous cell cancer and 7 (7,9%) adenocarcinomas. All patients received external beam radiotherapy (without central shielding) to the pelvis in 2 Gy daily fractions, 5 times weekly up to 46 Gy. Beginning with the first fraction of external beam radiotherapy patients also received cisplatin in dose 40 mg/m2 weekly during 5 weeks. After minimum of 40 Gy of external irradiation high dose rate (HDR) brachytherapy (192Ir source) was initiated: two sequential fractions of 7 Gy delivered by one IC/IS application and repeated in one week. We used ring-tandem applicator and titanium interstitial needles in amount of 2 to 6 (median 4 needles). Planning and dose calculations were done on 2 mm paratransversal MRI slices. Results: We calculated dose to HRCTV and organs at risk on plans with and without loading the needles. Studentized statistic method was used for statistical evaluation of the results. For all statistical tests p<0.05 was considered significant. Combined IC/IS technique allowed significantly increase dose to HRCTV in comparison with IC technique - mean D90 to HRCTV increased from 78,2±15Gy to 86,7±12Gy (p<0.05). No significant difference in doses to organs at risk was found. Conclusions: Image guided combined IC/IS HDR brachytherapy allows significantly increase the dose to HRCTV without raising dose to organs at risk and by this way to make a therapeutic window wider. However more patients and longer follow up time is necessary to evaluate the late toxicity of treatment. KEYWORDS: Cervical cancer; Image guided brachytherapy; Interstitial brachytherapy.

GSOR11  
Competency Evaluation for Gynecologic Brachytherapy for Radiation Oncology Residents
Allison Quick, MD1, Curt Walker, PhD2, Doug Martin, MD1.
1Radiation Oncology, Ohio State University, Columbus, OH, USA, 2Office of Evaluation, Curriculum Research & Development, Ohio State University College of Medicine, Columbus, OH, USA.

Purpose: To develop and validate the use of a competency checklist for residency training in gynecologic brachytherapy.

Materials and Methods: A training program for gynecologic brachytherapy was developed with three major components including: 1) an annual brachytherapy curriculum based on current ASTRO and ABS guidelines 2) a clinical skills lab using pelvis simulator models and 3) a formal simulation exam. A 17 item ring and tandem procedure checklist was developed by two gynecologic brachytherapy experts and was used during the formal simulation exam. Each expert independently observed and evaluated residents (n=7) performing the procedure during their simulation examination. Expert raters completed the procedure checklist by choosing one of three response options: Not Done/Not Seen, Attempted/Needs Improvement, and Well Done for each procedural task. We conducted multiple psychometric measures of the procedural checklist to collect validity evidence to support judgments derived from rater evaluations. We examined the frequency of each response using descriptive statistics. We calculated percent rater agreement of each procedural task by coding rater agreement as ‘disagree’ or ‘agree’. We calculated Cohen’s kappa coefficients to determine the inter-rater agreement of responses for each resident. We calculated the non-parametric correlation coefficients (kendall’s tau-b) among the 17 procedural tasks. We calculated a measure of instrument reliability (cronbach’s alpha) to determine how well the individual checklist items appeared to converge on a singular activity (i.e., steps in an overall procedure). Finally, we calculated an additional measure of reliability (intraclass correlation coefficient: two-way random effects model) to determine whether the independent raters agreed across all checklist items.

Results: Percent agreement across all procedural tasks ranged from 0-100%. Cohen’s kappa coefficients of inter-rater agreement ranged from 0.26 - 0.81, indicating agreement across multiple residents. Non-parametric correlation coefficients ranged from -0.84 - 0.77 and tasks 8, 11, 12, and 16 were all items that had similar endorsements between the two raters. Raters agreed on their assessments of learner abilities on those specific tasks. Taken together, these activities could be closely linked to each other and require similar skills to perform. The instrument had moderate internal reliability (cronbach’s alpha (12 items) = 0.68). Five tasks (4, 6, 7, 10, 14) were removed from this analysis because each had minimal or no variability in the responses. Results of the two-way random effects model indicate moderate agreement between the two raters in the activities they observed and endorsed for the student learners; average measures (ICC (2,k)) = 0.579 (p=0.004).

Conclusions: A 17 item checklist developed to assess resident competency in ring and tandem gynecologic brachytherapy showed moderate instrument reliability and moderate agreement between the 2 raters. Rater agreement was similar for technical skills regarding brachytherapy applicator placement and removal. Further work will be done utilizing the checklist during resident’s gynecologic radiation oncology rotation to evaluate patient based brachytherapy skills.
GSOR12

Presentation Time: 12:25 PM

The Role of Interstitial Brachytherapy in Gynecologic Malignancies. The Importance of MRI Compatible Applicators in Volume Definition and Treatment Planning

Silvia Rodriguez Villalba, MD, PhD, 1 Antonio Otal Palacin, MSc, 1 Jose Richard Sancho, MSc, 1 Rosa Cañon Rodriguez, MD, PhD, 1, Antonio Otal Palacin, MSc, 1, Jose Richard Sancho, MSc, 1, Manuel Santos Ortega, MD, PhD, 1, Antonio Otal Palacin, MSc, 1, Jose Richard Sancho, MSc, 1, Manuel Santos Ortega, MD, PhD, 1, Antonio Otal Palacin, MSc, 1, Jose Richard Sancho, MSc, 1, Manuel Santos Ortega, MD, PhD, 1.

1Radiation Oncology, Hospital Clinica Benidorm, Benidorm, Spain, 2Radiation Oncology, Hospital Quiron Torrevieja, Torrevieja, Alicante, Spain, 3Radiotherapy Department, Hospital Universitario La Fe, Valencia, Spain.

Purpose: Image guided BT (IGBT) with the incorporation of magnetic resonance imaging (MRI) plays a very important role for planning, allowing significant improvement of control rates and decreasing toxicity. In gynecological tumors, interstitial BT (IBT) encompasses target volumes that cannot be treated with standard applicators. We present the clinical and dosimetry results of 85 patients treated with IBT from December 2005 to May 2016: with MUPIT and CT-based planning (53 patients. 62%) and with an intracavitary/interstitial perineal template totally compatible con MRI (MRIT) (32 patients. 38%) with dosimetry based exclusively in MRI.

Materials and Methods: Sixty-four patients (75%) had primary locally advanced cervix carcinoma (Group 1); and the remaining 21 patients (25%) had recurrent disease (hysterectomy (100%) +/- EBRT with (24%) or without (10%) BT (Group 2). Eighty-three (98%) patients were treated with EBRT (median 50 Gy (45-55 Gy). Exclusively BT was employed in 3 patients (2%) of the Group 2. Six 4-Gy fractions were prescribed to CTV over four days, six hours apart in Group 1. In Group 2, 6-8 fractions between 3.45 and 5.50 Gy were administrated. GTV at diagnosis and the GTV at the time of the BT were unified in a single CTV (including GTV, HR-CTV and IR-CTV and dose constraints based in GEC ESTRO/ABS recommendations for MRI -based treatments). Results: CTV volumes defined in MRIT were significantly (p < 0.05) smaller than those with MUPIT. Median CTV in Group 1 was 135,31 cc (26,20-329 cc), median CTV with MRIT was 102,25 cc (26,2-161 cc) and with MUPIT 169,75 cc (81,8-329). Median CTV in Group 2 was 109,82 cc (10-286,24 cc), median CTV with MRIT was 48,35 cc (10-156 cc) and with MUPIT 114,20 cc (33,83-286,24 cc). Median D90 CTV in Group 1 was with MRIT 79,40 Gy (62,5-84,20 Gy) and with MUPIT 75,65 Gy (69-82 Gy). Median D90 CTV in Group 2 was with MRIT 44,05 Gy (31,30-68,70 Gy) and with MUPIT 72,7 Gy (27,3-83,20 Gy). Median rectum D2cc in Group 1 was with MRIT 71,84 Gy (58,3-83,7 Gy) and with MUPIT 75,25 Gy (69,80-132,10 Gy). Median rectum D2cc in Group 2 was with MRIT 28,6 Gy (16,5-63,20 Gy) and with MUPIT 67,85 Gy (20,8-82,7 Gy). Median bladder D2cc in Group 1 was with MRIT 77,25 Gy (60,5-90,10 Gy) and with MUPIT 79,85 Gy (71-123). Median bladder D2cc in Group 2 was with MRIT 36,15 Gy (22-90,5...
PhD William T. Hrinivich, BSc Robotically PSOR2 that focal salvage HDR brachytherapy is well tolerated and effective. The TV and 1 in both in and outside the TV. 

Post rate was 71%. There was no significant change in EPIC urinary or bowel domains. To date, 12 patients have had a Median IPSS at baseline, 1 3 included: TV V 9 mm (range 7 20), and TV at time of HDR was 6.1 mL (range 2.2-50cc). The ultrasound-based HDR brachytherapy prescription dose was 27Gy divided over two implants separated by 1 week to the target volume (TV) with dose constraints to the urethra and rectum. Follow-up PSA, IPSS, EPIC QOL and CTCAE v4.0 toxicities were collected. Results: 15 patients (mean age 73 years) were enrolled in the study. Median follow up was 30 months (range 12-42). At initial presentation, there were 5, 8 and 2 low-, intermediate- and high-risk disease, and initial XRT dose was 70-78Gy. The Gleason score of the local recurrence was 6, 7 and 8, respectively, and not classified in 1 patient. The pre-HDR median PSA was 4.13 (range 1.30 - 9.29). The median diameter of the recurrence on MRI was 9 mm (range 7-20), and TV at time of HDR was 6.1 mL (range 2.2-16.1). The median dosimetric endpoints included: TV V100 96.3%, TV D90 110.9%, urethral D10 64.5% and rectal D10 36.0%. No acute/late GU/GI grade 3-5 toxicities, nor urinary retention, were observed. The most common acute toxicity was frequency and nocturia. Median IPSS at baseline, 1-, 3-, 6-, 12-, 18-, 24-months was 4, 8, 5, 5, 8 and 5 (p=0.72). Three year PSA failure free rate was 71%. There was no significant change in EPIC urinary or bowel domains. To date, 12 patients have had a post-HDR MRI (median 612 days), of which 1 patient had persistent disease in the TV, 1 patient recurred outside of the TV and 1 in both in and outside the TV. Conclusions: Early toxicity, QOL and PSA failure-free data suggests that focal salvage HDR brachytherapy is well tolerated and effective.

**Scientific Session: Prostate Snap Orals (E-Poster)**

**Saturday, April 22, 2017**

**11:30 AM - 12:30 PM**

**PSOR1**

Three Year Results of a Prospective Study on Focal Salvage HDR Prostate Brachytherapy After Previous Definitive External Beam Radiotherapy (XRT)

Hans Chung, MD, FRCPC1, Laura D’Alimonte, MRT(T), BSc, MHSc1, Andrew Loblaw, MD, FRCPC1, Ananth Ravi, PhD1, Matt Wronski, PhD1, Melanie Davidson, PhD1, Masoom Haider, MD, FRCPC2, Gerard Morton, MBBCh, FRCPG.

1Radiation Oncology, Sunnybrook Odette Cancer Center, Toronto, ON, Canada
2Medical Imaging, Sunnybrook Health Sciences Centre, Toronto, ON, Canada.

**Purpose:** Whole-gland salvage options (e.g. surgery) for those with local recurrence after XRT can be problematic due to a risk of serious complications (e.g. fistula, incontinence, bladder neck contracture). With multiparametric MRI exhibiting greater than 70% sensitivity in detecting viable cancer within the prostate, focal therapy, as definitive or salvage therapy, is being investigated. The objectives of this pilot study are to explore the toxicities, QOL and efficacy of focal salvage HDR brachytherapy in patients with MRI-visible biopsy-confirmed local recurrence after previous definitive XRT. **Materials and Methods:** Eligible patients included: multiparametric 3T MRI visible biopsy confirmed local recurrence >30 months after XRT, negative metastatic workup, IPSS <15, post-XRT PSA <10ng/mL, prostate volume ≤50cc. The ultrasound-based HDR brachytherapy prescription dose was 27Gy divided over two implants separated by 1 week to the target volume (TV) with dose constraints to the urethra and rectum. Follow-up PSA, IPSS, EPIC QOL and CTCAE v4.0 toxicities were collected. Results: 15 patients (mean age 73 years) were enrolled in the study. Median follow up was 30 months (range 12-42). At initial presentation, there were 5, 8 and 2 low-, intermediate- and high-risk disease, and initial XRT dose was 70-78Gy. The Gleason score of the local recurrence was 6, 7 and 8-10 in 1, 7 and 6, respectively, and not classified in 1 patient. The pre-HDR median PSA was 4.13 (range 1.30 - 9.29). The median diameter of the recurrence on MRI was 9 mm (range 7-20), and TV at time of HDR was 6.1 mL (range 2.2-16.1). The median dosimetric endpoints included: TV V100 96.3%, TV D90 110.9%, urethral D10 64.5% and rectal D10 36.0%. No acute/late GU/GI grade 3-5 toxicities, nor urinary retention, were observed. The most common acute toxicity was frequency and nocturia. Median IPSS at baseline, 1-, 3-, 6-, 12-, 18-, 24-months was 4, 8, 5, 5, 8 and 5 (p=0.72). Three year PSA failure free rate was 71%. There was no significant change in EPIC urinary or bowel domains. To date, 12 patients have had a post-HDR MRI (median 612 days), of which 1 patient had persistent disease in the TV, 1 patient recurred outside of the TV and 1 in both in and outside the TV. Conclusions: Medical Imaging, Sunnybrook Health Sciences Centre, Toronto, ON, Canada.

**PSOR2**

Robotic-Assisted 3D Ultrasound-Guided High-Dose-Rate Prostate Brachytherapy

William T. Hrinivich, BSc1, Douglas A. Hoover, PhD2, Kathleen Surry, PhD2, David D’Souza, MD2, Aaron Fenster, PhD1, Eugene Wong, PhD4.
Purpose: Conventional trans-rectal ultrasound-guided high-dose-rate prostate brachytherapy (HDR-BT) treatment planning requires a 3D image of the prostate reconstructed by manually stepping the probe in the superior/inferior direction while acquiring axial images using the transverse transducer. HDR-BT also requires imaging each needle tip at the time of insertion using the longitudinal transducer, oriented to capture each needle by manually rotating the probe about its long axis. Conventional manual probe manipulation is subject to three major limitations; 1) stepping the probe in the superior/inferior direction may introduce anatomical motion during imaging, 2) the 3D image produced using the transverse transducer has the lowest spatial resolution component in the needle insertion direction, and 3) when manually rotating the probe to image each needle tip at the time of insertion, the user must estimate the probe angle that will capture the desired needle, then manually check and adjust this angle until that needle is found. Decreasing motion during imaging, improving image spatial resolution, and providing automatic probe rotation for needle tip imaging during insertion may improve needle tip localization accuracy and decrease HDR-BT procedural time. Materials and Methods: We have implemented a robotic device that eliminates the need for manual probe rotation by tracking and controlling the angle of the ultrasound probe using a motor. This device enables sagittal reconstruction of a 3D image using the longitudinal transducer by rotating the probe, thereby eliminating superior/inferior probe motion during imaging, providing increased spatial resolution in the needle insertion direction, and providing automatic probe angle initialization for individual needle tip imaging during insertion. The device was used to perform ten HDR-BT procedures, during which the conventional manual imaging technique using the transverse transducer was also completed for comparison. Needle end-length measurements were acquired following needle insertion, providing a gold standard for needle insertion depths. Results: 147 needles were analyzed from ten patients. Figure a-b) provides example co-registered robotically and manually-reconstructed images from a single patient. Based on post-operative comparison of the imaging results with needle end-length measurements, the robotic and manual imaging techniques provided insertion depth errors within ±3 mm for 84% and 57% of needles respectively as shown in Figure c). Conclusions: Robotically-assisted 3D ultrasound using the longitudinal transducer provides decreased needle insertion depth errors relative to conventional manual 3D ultrasound using the transverse transducer, attributed to decreased anatomical motion and improved image spatial resolution in the needle insertion direction. The robotically-assisted workflow appears to be feasible, providing the image plane of each needle during insertion without requiring the user to manually rotate the probe. Based on these results we are commissioning the robotic imaging system for routine HDR-BT treatment planning, and will report further results and details of the clinical workflow.

Figure a-b) Example axially- and sagittally-reconstructed 3D images from a single patient. c) Boxplots of needle insertion depth errors for 147 needles from 10 patients using axial and sagittal imaging. Centre-lines indicate median value, and boxes indicate inter-quartile range.
Placement of an Absorbable Rectal Hydrogel Spacer in Patients Undergoing Low-Dose-Rate Brachytherapy with Pd-103 Seeds
Amandeep S. Taggar, MD MS, Tomer Charas, MD, Emily Weg, MD, Marisa Kollmeier, MD, Michael J. Zelefsky, MD.
Radiation Oncology, MSKCC, New York, NY, USA.
Purpose: Rates of rectal toxicity after low-dose-rate brachytherapy for prostate cancer are dependent on rectal dose which is associated with rectal distance from prostate and implanted seeds. Placement of a hydrogel spacer between the prostate and rectum has been proven to reduce rectal dose in the setting of external beam radiotherapy. We present our experience with placement of rectal hydrogel spacer following LDR brachytherapy and assess its impact on dosimetry as well as acute rectal and urinary toxicity. Materials and Methods: Between January and December 2016, 48 patients had placement of a hydrogel rectal spacer, SpaceOAR™ (Augmenix Inc. Waltham, MA) immediately following Pd-103 seed implant done during the same procedure. Brachytherapy was delivered as a monotherapy to 13 out of 48 (27%) patients, as a part of combination with external beam to 28 (58%) patients or as a salvage treatment to 7 (15%) patients. Post-implant dosimetry was performed immediately after the procedure, and was assessed using VariSeed™ (Varian Medical System, Palo Alto, CA) software. Separation achieved with rectal spacer was measured at mid-gland using the intraoperative CT scan. Acute toxicity was assessed retrospectively using RTOG/EORTC radiation toxicity grading system and international prostate symptom score (IPSS) by reviewing charts of all patients with minimum follow-up of 3 months. Results: Median (range) age and follow up were 68.9 years (43.4-84.4 years) and 3.6 months (0-9.2 months). On average, 12.9 mm (4.5-21.6 mm, standard deviation 3.6 mm) separation was achieved between prostate and rectum with implantation of the rectal spacer and resultant median rectal V100 was 0 (0-0.1%). Median prostate volume, dose to 90% of gland (D90) and volume receiving 100% dose (V100) were 26.7 ml (11.8-66), 110% (87-137%) and 94% (84-100%), respectively. Urethral D20, dose to 5cc (D5cc) and 1cc (D1cc) of urethra were 121% (83-170%), 131.5% (87-247%) and 141% (90-376%), of the prescribed dose, respectively. Rectal D2cc and D1cc were 21.5% (10-62%) and 17.6% (8-52%). At the time of first follow-up after completing all treatments, 8 patients reported acute rectal toxicity: four had grade 1 diarrhea, three had grade 1 proctitis, and one had grade 1 rectal bleeding. There was a significant increase in IPSS from baseline to 3 months post treatment; median 4 (0-20) versus 11 (0-29) (p-value 0.006). Conclusions: Injection of rectal spacer is feasible in the post LDR brachytherapy setting and reduces dose to the rectum with acceptable acute toxicity rates. Prostate and urethra dosimetry do not appear to be affected by the placement of a spacer. Further prospective studies with long term follow up are warranted to assess its impact on reduction of late rectal toxicity.

PSOR4
Are Standard Dosimetric Parameters Accurately Representing the Dose to the Bladder Neck in MRI-Guided High Dose-Rate Prostate Brachytherapy?
Joelle Helou, MD, MSc,1,2, Alejandro Berlin, MD, MSE,1,2, Jette Borg, PhD,1,3, Alex Rink, PhD,1,3, Bernadeth Lao, BSc., CCRP,2, Aravindhan Sundaramurthy, MD,1,2, Peter Chung, MD,1,2.
1Department of Radiation Oncology, University of Toronto, Toronto, ON, Canada, 2Radiation Medicine Program, Princess Margaret Cancer Centre, Toronto, ON, Canada, 3Department of Medical Physics, Princess Margaret Cancer Centre, Toronto, ON, Canada.
Purpose: The dose to the bladder neck has been reported to be a predictor of urinary toxicity after radiation therapy. However bladder neck is only well visualized on Magnetic Resonance Imaging (MRI) and not routinely included in brachytherapy treatment planning. Herein, we propose to assess the relationship between the dose to the bladder neck and standard dosimetric parameters in patients treated with MRI-guided high dose-rate brachytherapy (HDR-BT) boost as well as its association with acute urinary toxicity. Materials and Methods: From April 2013 to July 2016, thirty-seven patients received HDR-BT single 15-Gy implant, followed by external beam radiotherapy (EBRT) as part of a prospective phase II clinical trial. Acute toxicity was assessed prospectively using the Common Terminology Criteria Adverse Events, version 4.0. Transperineal HDR brachytherapy catheters were first inserted using a multiparametric MRI with stereotactic navigation, followed by MRI-based treatment planning. A Foley catheter was inserted in the bladder for the duration of the procedure with and the Foley balloon inflated with diluted X-ray contrast. Standard organs at risk (OAR) including urethra, bladder and rectum were delineated and dosimetric parameters collected prospectively. Bladder neck was delineated in retrospect on T2-weighted images by one radiation oncologist and reviewed by an independent radiation oncologist. Linear and logistic regression models
were used as appropriate to assess the relationship between bladder neck dose and other dosimetric parameters as well as its association with urinary toxicity. SAS University Edition was used for all the analyses. A two-tailed p-value of ≤0.05 was considered statistically significant. Results: The median bladder neck volume contoured on MRI (figure 1 - light orange) was 0.55 cc (IQR: 0.35-0.71). The median dose received by 0.01 cc of the bladder neck (BNDmax) was 20.2 Gy [Interquartile range (IQR): 17.9-26.1 Gy]. The median dose received by 0.01 and 0.5 cc of the urethra (UDmax) was 19.6 Gy (IQR: 18.8-21.2) and 17.4 Gy (IQR: 16.9-17.9) respectively. Acute Grade 2 urinary toxicity was observed in 8 patients (22%). On simple linear regression, none of the standard urethral parameters was significantly associated with BNDmax. There was a trend towards significance between UDmax and BNDmax (p=0.096), with a model R-square of 0.08. Thus 8% of the total amount of variation in BNDmax is represented by UDmax. BNDmax was not associated with an increased grade 2+ urinary toxicity, probably as a result of a small number of events. Conclusions: Our data suggest that dose to the bladder neck is not accurately represented by the standard dosimetric parameters used in HDR-BT. Further validation of the predictive value of this parameter is needed. Meanwhile, MRI allows a more accurate delineation of bladder neck, thus it is worthwhile including bladder neck contours and constraints into brachytherapy treatment planning if an MRI is available.

PSOR5

Gastrointestinal Toxicity and Colorectal Cancer Screening in the Setting of Prostate Brachytherapy

L. Matthew Scala, MD, Michael Wong, MD, Praneet Kaur, CMD, Anthony Ventura, MS, Joseph Hastings, MD, MPH, Subir Nag, MD.

Cancer Treatment Center, Kaiser Permanente Santa Clara, Santa Clara, CA, USA.

Purpose: Fecal immunochemical testing (FIT) is an accepted method for colorectal cancer screening. The impact of prostate brachytherapy/radiotherapy on the accuracy of this method is unknown. The reported rate of FIT positivity in average-risk patients in the literature is 6-7%. We aim to compare this to the FIT positivity rate in patients screened after undergoing combined high-dose-rate (HDR) and external radiotherapy for prostate cancer and report on GI outcomes after combination therapy. Materials and Methods: Retrospective review of 53 consecutively treated patients undergoing combination single-fraction HDR brachytherapy (15 Gray to the prostate) and hypofractionated supplemental external beam radiotherapy (EBRT) (4000 cGy in 16 fractions to the prostate and seminal vesicles) at a high-volume center. Median follow-up was 39 months. Results: Median age was 66 yrs (range: 51 - 83 yrs). The percentage of patients in the NCCN low, intermediate, and high risk class patients was 0%, 45%, and 55% respectively. Median PSA was 9.7 (range: 4.1 - 53). Kaplan-Meier (KM) freedom from biochemical failure per Phoenix definition at 3 yrs was 95% (95% CI: 87 - 100%) and 82% (95% CI: 67 - 96%), in intermediate- and high-risk patients, respectively. 19 of 53 patients (36%) underwent a post-HDR/EBRT FIT test at a median of 33 months. Of these, 5 had a positive result (26%). 32 patients had undergone a colonoscopy prior to HDR/EBRT (60%). Crude rates of CTCAEv.4 late GI toxicity grade 0, 1, and 2 were 92%, 6%, and 2%, respectively. No patient had grade 3 or greater GI toxicity. KM freedom from ≥ grade 1 late GI toxicity was 96% (95% CI: 90 - 100%) at median follow-up for all patients. In patients who underwent a screening colonoscopy ≤ 36 months versus >36 months prior to brachytherapy, KM estimate of freedom from ≥ grade 1 late GI toxicity was 100% versus 87%,
respectively (p=0.055). In patients who had a brachytherapy rectal D2cc of <70% vs ≥70%, KM estimate of freedom from ≥ grade 1 late GI toxicity was 98% (95% CI: 94 - 100%) vs 67% (95% CI: 13 - 100%), (p=0.054).

Conclusions: Patients undergoing HDR/EBRT have a high rate of post-treatment FIT positivity. Screening colonoscopy should be considered prior to brachytherapy to potentially reduce the risk of late GI toxicity. Rectal D2cc during single-fraction prostate brachytherapy should be kept to <70% of prescription dose, if possible.
agonists are often used to reduce prostate volume but are associated with toxicities that affect quality of life. The purpose of this study was to examine the efficacy and toxicity of Degarelix, a gonadotropin-releasing-hormone-antagonist, for prostate downsizing prior to BT. **Materials and Methods:** 50 patients were accrued to this Institutional research ethics board approved Phase 2 study from 02/2012 to 11/2015 (clinicaltrials.gov: NCT01446991), 38 with intermediate-risk and 12 with high-risk prostate cancer. Patients were either 1) appropriate for BT monotherapy but had evidence of PAI or 2) required androgen ablation for oncologic reasons and had a prostate volume > 40 cc. Baseline prostate mapping transrectal ultrasound (TRUS) was performed on all patients followed by a Degarelix loading dose of 240mg. A second injection of 80mg was given at week 4, and a repeat TRUS was performed at week 8. If sufficient downsizing had occurred, BT was performed within 4 weeks with no further Degarelix given. If necessary, a 3rd injection was given at 8 weeks with re-assessment at 12 weeks. Those requiring Degarelix for oncologic reasons had their 8 week TRUS for BT planning but did not discontinue Degarelix. PSA, testosterone, LH and FSH were measured every 3 months after BT until 12 months. **Results:** Of the 50 patients accrued, one was excluded because of metastatic disease, and 2 did not have an 8-week TRUS available for analysis, leaving 47 for assessment of downsizing. The median prostate volume was reduced from 66cc (Interquartile Range [IQR]: 54-81) to 48cc at 8 weeks (IQR: 41-62cc); representing a median decrease of 26%(IQR: 21-31%). MRI prostate volume at one month post implant was stable (median 45cc, IQR: 37-58cc). Transition zone reduction was 33%, from a median of 38cc to a median of 25cc at 8 weeks. Eight patients continued degarelix for oncologic reasons, leaving 39 analyzable for testosterone recovery. Of these, 28 received 2 injections (8 weeks) and 11 had 3 injections (12 weeks). 74% of these had complete recovery of testosterone to baseline at a median of 56 weeks (IQR: 34-100) from the final injection. However, recovery to the age-adjusted normal range was quicker, occurring in 90% at a median of 35.0 wks. Neither baseline testosterone, nor age, predicted the time to testosterone recovery (p = 0.08 and p = 0.95 respectively). The median baseline FSH was 7.5 (IQR: 5-11). FSH was suppressed during Degarelix but at 6 mos from the final injection, FSH was elevated (median 12, 5.8-15.2), and remained high through to 12 months (median 15, IQR: 8.5-23.2, p<=0.001). The median baseline LH was 5.0 (IQR: 3.0-7.0); LH was also suppressed throughout treatment but remained elevated through to 12 months (median 7.2, IQ range: 5-15.5, p = 0.001). The mean baseline SHIM score was 13 but for patients with no or minimal erectile dysfunction (SHIM>15; median 22), there was little recovery by 6 months but improvement by 12 months (median 13, IQR: 7-15) post-implant. There was no significant difference in IPS score between weeks 0 and 8 despite prostate volume reduction (median baseline IPSS: 8 and at 8 weeks: 9, p=0.49). **Conclusions:** Degarelix is effective for prostate downsizing prior to prostate BT with a median volume decrease of 26% by 8 wks. Despite the short course of treatment, and eventual testosterone recovery, FSH and LH remain elevated beyond 12 months. This study was sponsored by an unrestricted research grant from Ferring.
respectively Mild(73%, 45%, 58%, 84%, 50%) Moderate (27%, 38%, 33%, 21%, 33%) and Severe (0%, 17%, 8%, 5%, 17%). Two patients (6.7%) required urinary catheterization for more than 24 hours. There was a significant decrease in EPIC Sexual Summary Scores at 1, 3, 6 and 12 months with mean intrapatient differences compared to baseline of -17 points (p=0.01), -18 points (p=0.02) and -17 points (p=0.01) respectively. There was also a significant decrease in EPIC Urinary Summary Scores at 1 month only (-20 points, p<0.001). This same trend was seen at 3 months (-5 points p=0.07), 6 months (-4 points p=0.15), and 12 months (-3 points p=0.22) but was not statistically significant. There were no statistically significant differences in the EPIC intestinal domain.

Conclusions: This is the first report of this cohort of patients treated with 2 fraction HDR monotherapy. This regimen shows rates of toxicity and health related quality of life that appear acceptable as compared to other treatment modalities. These results are also comparable with other reports with similar treatment regimens. Further study will be required to determine the optimal dose and fractionation for HDR prostate monotherapy. Early PSA results will be presented at time of conference.

PSOR9  Presentation Time: 12:10 PM
Prostate Brachytherapy Procedural Training: Incorporation of Related Procedures in Resident Training and Competency Assessment
Michael R. Folkert, MD PhD, Neil B. Desai, MD.
Radiation Oncology, UT Southwestern Medical Center, Dallas, TX, USA.
Purpose: There is great concern that residents do not receive adequate procedural training during residency. Prostate brachytherapy, for example, is an area where many residents feel their training is inadequate, but participation in sufficient cases to gain competency may be difficult. Prostate brachytherapy requires multiple competencies to perform safely and effectively, and it may be possible to develop those competencies outside of prostate brachytherapy procedures. This work describes the development of teaching techniques focusing on developing critical competencies for prostate brachytherapy using related clinical procedures that support other aspects of radiation oncology practice. Materials and Methods: For prostate brachytherapy, key competencies identified include patient selection, patient positioning, transrectal ultrasound imaging, treatment planning, needle placement, source delivery, post-implant dosimetry, and post-procedure complications management. Four of these
procedures (patient positioning, transrectal ultrasound imaging, needle placement, and complications management) are also performed in the process of transperineal rectal spacer placement (TRSP), a procedure increasingly performed in many institutions, including many where prostate brachytherapy is not actively performed. Trainee involvement in TRSP has been implemented at our institution for approximately 12 months, and “comfort level” with these procedures was assessed prior to and following participation in these procedures. Trainees were also asked how many procedures they felt (in their opinion) they would need to perform to reach independent competency. (See attached Table for procedure domains and “comfort level” assessments) Results: In the past 12 months, 8 of 12 trainees at our institution have participated in TRSP procedures; 2 of these trainees had prior experience with prostate brachytherapy or other endorectal procedures and were excluded from further analysis. Prior to performing TRSP procedures, median comfort level for competency domains relevant to prostate brachytherapy included patient positioning (median 1, range 0-2), transrectal ultrasound imaging (median 1, range 0-1), and needle placement domains including fiducial placement and hydrodissection (median 1, range 0-1 and median 0, range 0-1, respectively). Median number of TRSP procedures performed by assessed trainees to date was 4 (range 1-6). Following TRSP procedure training, median comfort level increased by a median of 1 point for patient positioning (median 3, range 1-3), 1.5 points for transrectal ultrasound imaging (median 2.5, range 1.3), and needle placement domains increased by a median of 1 point for fiducial placement and 1.5 points for hydrodissection (median 2, range 1-3 and median 2, range 1.3, respectively). No trainees felt that they were ready to perform these competencies completely independently at this evaluation timepoint, responding that a median of 5 additional cases (ranges 1-6 for patient positioning, 3-6 for transrectal ultrasound imaging, 3-10 for fiducial placement, and 4-10 for hydrodissection) would be necessary. Conclusions: Optimally, all radiation oncology trainees will be exposed to sufficient prostate brachytherapy volume to attain comfort level with the procedure to do so independently once they enter practice, but this is currently not the case for many graduates. Increasing trainee involvement in related procedures that allow development of core competencies may help facilitate increased comfort with skills critical to the independent performance of prostate brachytherapy. Tables: Procedure domain assessment and "comfort level."

<table>
<thead>
<tr>
<th>Rectal Spacer Competency</th>
<th>Prostate Brachytherapy Competency</th>
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<tr>
<td>Patient positioning for endocavitary procedures</td>
<td>Patient positioning for endocavitary procedures</td>
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<tr>
<td>Transrectal ultrasound placement and operation</td>
<td>Transrectal ultrasound placement and operation</td>
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<tr>
<td>Administration of local anesthetics</td>
<td>Treatment planning</td>
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<tr>
<td>Fiducial seed placement</td>
<td>Needle placement</td>
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<tr>
<td>Hydrodissection</td>
<td>Source delivery</td>
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<td>Rectal spacer placement</td>
<td>Post-implant dosimetry</td>
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<tr>
<td>Post-procedure complications management</td>
<td>Needle placement</td>
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"Comfort Level" Assessment

0 not comfortable at all
1 comfortable with direct, hands on supervision
2 comfortable with attending present offering suggestions/advice only
3 comfortable doing independently

PSOR10

Single Radiation Therapy (EBRT) vs Combined Treatment (EBRT + BT) in Intermediate and High Risk Prostate Cancer. Are We Sure That Exclusive EBRT Is a Valid Approach Treatment Mode?
Silvia Rodriguez Villalba, MD, PhD1, Jose Richart Sancho, MsC1, Antonio Otal Palacin, MsC1, Jose Perez-Calatayud, PhD, MsC1, Manuel Santos Ortega, MD, PhD1.
Purpose: Brachytherapy (BT), High Dose Rate (HDR) or Low Dose Rate (LDR) are employed as a boost for intermediate (IR) (PSA 10-20 ng/ml, Gleason ≤ 7 and ≤ T2c) and high risk (HR) (PSA >20 ng/ml, Gleason 8-10 and ≥T3) prostate cancer. A retrospective analysis in 335 consecutive organ confined prostate cancer patients has been made for evaluating the clinical results and toxicity comparing EBRT exclusive with combined treatments of EBRT and a BT component. Materials and Methods: Median age was 70 years (range 48-87 y). Median PSA at diagnostic was 11.3 ng/ml (range 2.6-500 ng/ml). Median Gleason 7 (range 2-10). A MRI for staging was done in 266 pts (79%). 323 patients (96%) have received androgen deprivation therapy (ADT) (6 months in IR and 24 months in HR). We have treated 167 (50%) patients staged as IR and 168 (50%) patients staged as HR. One hundred and four patients (31%) have received exclusive EBRT (IGRT-IMRT. Median dose 75, 6 Gy (range 50.4-81 Gy), 63 patients (19%) EBRT (Median 45 Gy (45-50.4 Gy) plus LDR BT (100 Gy) and 168 patients (50%) pelvic EBRT (Median 50.4 Gy (45-60 Gy) plus HDR BT (10 Gy in IR patients, 2 fractions of 9.5 Gy or 1 fraction of 15 Gy in HR patients). Results: At the time of this analysis, December 2016, the median follow up was 51 months (range 5-144 m). Overall survival (OS) was 95%, 90% and 71% at 12, 24 and 60 months respectively in patients treated with exclusive EBRT, 95%, 93% and 66% at 12, 24 and 60 months respectively in patients treated with EBRT+LDR BT and 99%, 99% and 97% at 12, 24 and 60 months respectively in patients treated with EBRT+HDR BT (p=0.007). Cause specific survival (CSS) was 97%, 96% and 86% at 12, 24 and 60 months respectively in patients treated with exclusive EBRT, 98%, 98% and 60% at 12, 24 and 60 months respectively in patients treated with EBRT +LDR BT and 99%, 99% and 98% at 12, 24 and 60 months respectively in patients treated with EBRT +HDR BT (p=0.04). Pelvic lymph node failure (PLF) was 97%, 96% and 91% at 12, 24 and 60 months respectively in patients treated with exclusive EBRT, 98% at 12, 24 and 60 months respectively in patients treated with EBRT +LDR BT and 98% in patients treated with EBRT +HDR BT (p=0.04). Distance failure (FD) was 93%, 90% and 86% at 12, 24 and 60 months in patients treated with exclusive EBRT, 97% at 12, 24 and 60 months in patients treated with EBRT+ LDR BT and 99%, at 12, 24 and 60 months when EBRT +HDR BT is employed (p=0.015). There are not differences with statistical significance in local control (LC) (p NS). Toxicity has been analyzed based CTCAE 4 criteria. There is not acute G3 toxicity. Four patients (1%) had acute urinary obstruction (one treated with exclusive EBRT, one with EBRT + LDR BT and 2 treated with EBRT + HDR BT). Chronic GI toxicity grade 3 (Radiation rectitis) has been developed in 28 pts (8%), 16 patients treated with exclusive EBRT, 3 patients treated with EBRT + LDR BT and 9 patients treated with EBRT + HDR BT without statistical significance (pNS) between them in the univariate analysis. In all cases (100%) toxicity has been resolved being treated with Argon laser (Median 1 application (1-5). Conclusions: In our experience, combination modalities with BT techniques achieve more intensity treatments with statistical improvements of overall survival, cause specific survival, pelvic lymph node control and distance control in IR and HR prostate cancer patients, with less toxic events, mainly related to gastrointestinal damage.

PSOR11 MRI-Guided Transperineal Prostate Biopsy Using Commercially Available Prostate Biopsy Planning Systems
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¹Peninsula Cancer Center, Poulsbo, WA, USA, ²CHI Franciscan Health, Port Orchard, WA, USA, ³Olympic Medical Center, Port Angeles, WA, USA, In Health Imaging, Poulsbo, WA, USA.

Purpose: To evaluate the feasibility, safety and outcomes of MRI-guided transperineal prostate biopsy using commercially available prostate biopsy planning systems. Materials and Methods: Forty five patients underwent MRI-guided prostate biopsy using a transperineal approach under general anesthesia. For each patient, a pre-biopsy multiparametric MRI (mpMRI) scan was obtained and imported into a commercially available prostate biopsy planning system (MIM™ or Variseed™). Transverse images were then reoriented from the supine to dorsal lithotomy position. Dividing the prostate into an apical and base section, an array of transperineal biopsies spaced 5-10mm apart was planned with additional biopsies targeting mpMRI-identified PI-RADS 3, 4 or 5 lesions. Biopsy procedures were carried out in the dorsal lithotomy position using a transrectal ultrasound with brachytherapy stepper and template grid. Matching of the planning mpMRI images to live ultrasound images was achieved using

Presentation Time: 12:20 PM
the template grid as a reference. **Results:** All patients successfully underwent their biopsy procedure as planned. An average of 27 biopsy specimens were obtained per patient (range 11-38). Prostate cancer of any grade was identified in 47% (21/45) of patients and Gleason score ≥ 7 disease was identified in 40% (18/45) of patients. Twenty four percent (7/29) of PI-RADS 3 lesions, 36% (12/33) of PI-RADS 4 lesions, and 81% (13/16) of PI-RADS 5 lesions were pathologically confirmed prostate cancer. All PI-RADS 5 lesions associated with cancer were found to identify GS ≥ 7 disease. Eleven patients had pathologically confirmed lesions that were not identified on mpMRI. Four among those 11 patients harbored mpMRI-unidentified GS≥8 disease. Post biopsy urinary retention requiring temporary catheter placement occurred in two (4.4%) patients and no patients experienced post biopsy infection. **Conclusions:** MRI-guided transperineal prostate biopsy using commercially available prostate biopsy planning systems is feasible and safe. This method allows pathologic confirmation of lesions identified by mpMRI and can reveal additional clinically significant prostate cancer not identified by mpMRI.

**GYN Posters**

**PO01**

**Overall Treatment Days (OTD) Relationships of BRT Boost. The Treatment Timing Effectiveness on Survival**

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Radioterapia Oncologica, Cosenza, Italy.

**Purpose:** To evaluate in gynaecological cancers effectiveness on survival of two schedules of HDR BRT different for treatment timing and the impact on survival of OTD. **Materials and Methods:** By November 2008 to April 2012 95 pts. with endometrial cancer (no recurrences) treated in adjuvant according this treatment schedule: 18 Gy in 3 fractions as Boost after EBRT (50 Gy/5 weeks) or Reverse boost before the same EBRT. Same technique for each patient as for EBRT as for BRT. We compared survival curves of these groups. As we noted that the OTD were different in considered schedules (slightly shorter in Reverse) we also evaluated this univariate factor in comparison of survival curves. We also evaluated the impact of median OTD on survival of entire population of the study. Comparison done with the Kaplan Meier method. **Results:** Two groups: Boost (45 pts.) versus Reverse (50 pts.). Median follow-up of entire population 5.35 years (range 1.13-7.33); in Boost recorded median age 58 (range 31-84); stage distribution was pT1b 7 pts., pT1c 26, pT2 11, other stages 1; grading distribution G1 11 pts., G2 32, G3 2; lymph node status performed in 38 pts. (N0=36, N1=2) in other 7 NX; in Reverse median age 69 (range 41-84); stage distribution was pT1b 12 pts., pT1c 25, pT2 10, other stages 3; grading distribution G1 9 pts., G2 32, G3 9; lymph node status performed in 43 pts. (N0=39, N1=4) in other 7 NX. The late toxicity as G3- G4 was 4 pts. in Boost group and 2 in Reverse population. Only relapse recorded in 1 (alive) of group Boost. Groups resulted comparable for these parameters. Survival comparison that considered Boost vs Reverse resulted slightly favourable to Reverse group, median 5.83 vs. 4.81 years (P=0.70). Median OTD of Boost resulted 62 vs. 44 days of Reverse without significant impact on survival. The only OTD that worst survival resulted ≥ 60 days with 70 pts. treated (median 46) vs others 25 pts. (median 86, range 62-159 OTD). P=0.21. **Conclusions:** Second schedule of HDR BRT is more effective in gynaecological cancers with acceptable toxicity compared to first schedule. Reverse boost is method to minimize chance of geographic miss in pts. with vaginal cuff without damage like fibrosis or stenosis by EBRT and also to improve scheduling of entire treatment. To avoid acute toxicity and minimize OTD we now prefer the Reverse schedule.
PO02
Clinical Outcomes and Dosimetric Optimization in CT Based Interstitial Brachytherapy Using MUPIT in Gynecological Malignancy
Vibhay Pareek, Radiation Oncology, Rajendra Bhalavat, Radiation Oncologist, Manish Chandra, Radiation Oncologist.
Radiation Oncology, Jupiter Hospital, Mumbai, India.
Purpose: To evaluate the clinical outcomes and dose optimization using CT based planning in gynecological malignancy (Cervical and endometrial cancer) undergoing interstitial (MUPIT) brachytherapy Material and Methods: 30 patients histologically diagnosed endometrial or cervical malignancy and underwent hysterectomy who received external beam radiation followed by HDR interstitial brachytherapy with MUPIT. The clinical target volume and organs at risk were delineated and optimization done for optimum CTV coverage and sparing of organs at risk. The Coverage Index (CI), dose homogeneity index (DHI), overdose index (OI), dose non-uniformity ratio (DNR), external volume index (EI), conformity index (COIN) and dose volume parameters recommended by GEC-ESTRO were evaluated. The patients were followed up and toxicities were graded as per the RTOG scales and local control rates and disease free survival were evaluated Results: The mean CTV volume and D90 and D100 were calculated. The OARs which included Bladder and rectum were assessed for the volume along with D2cc, D1cc and D0.1cc were assessed for bladder and recto-sigmoid. Mean CI, DHI, OI, DNR, EI, COIN were evaluated. The median follow up was assessed and as per the RTOG toxicity scale was used to evaluate the toxicities on follow up for the patients. The Local Control rate and Disease free survival were assessed for the same. Conclusions: CT based planning using MUPIT for gynecological brachytherapy implants has good outcomes as assessed in our study. Plan evaluation and documentation using various indices and parameters recommended by GEC-ESTRO assist in objective evaluation and reproducibility and correlate with clinical outcomes in the disease.

PO03
3D Printing Individual Applicator Used for Interstitial Brachytherapy in Recurrent Cervical Cancer

Ang Qu, M.D, Haitao Sun, M.S., Junjie Wang, Ph.D, Anyan Zhao, M.D, Ping Jiang, M.D, Xu Li, Undergraduate. Radiation Oncology, Peking University Third Hospital, Beijing, China.

Purpose: To evaluate the advantage and feasibility of 3D printing individual applicator assist for interstitial brachytherapy in recurrent cervical cancer. Materials and Methods: 1 case of cervical cancer with vaginal recurrence (two lesions) after radical radiotherapy was placed with cylinder applicator for CT simulation. After delineation of target volumes and organs at risk, three kinds of planning were designed by cylinder applicator, 3D printing applicator integrated with body surface and individual needle track, perineal template. The dosimetry parameters and injuries had been compared by different planning. Results: GTV left and GTV right were 16.73ml and 4.18ml respectively. The D90 of GTV left and GTV right were 1.5Gy(L) and 2.14Gy(R), 5.68Gy(L) and 5.22Gy(R), 5.68Gy(L) and 5.87Gy(R) by different planning in cylinder applicator, 3D printing applicator and perineal template. The D100 were 1.74Gy(L) and 1.14Gy(R), 2.84Gy(L) and 3.45Gy(R), 2.94Gy(L) and 3.60Gy(R), respectively. The V100 was 5% (L), 2.6% (R), 5% (L) and 2.6% (R), 95.4% (L) and 96.9% (R), 95.6% (L) and 92.2% (R), respectively. Rectum D2cc were 4.05Gy, 1.68Gy, 1.79Gy, respectively. Bladder D2cc were 2.33Gy, 4.20Gy, 2.28Gy, respectively. The planning with cylinder applicator got poorer quality, and the doses of target and ORAs were similar in the planning with 3D printing applicator and perineal template. On the other hand, cylinder applicator brachytherapy was non-invasive, and the others both used 5 needles. The puncture depth in 3D printing applicator and perineal template were 7.60+/−1.15cm, 10.52+/−1.00cm, respectively. Conclusions: With 3D printing individual applicator, the planning was feasible and injuries were less, compared with other ways. We got precise pre-operation planning. No acute rectal reactions and bladder reactions had been found in this patient.

PO04
To Avoid Dosimetric Uncertainties About a Possible Movement of the Applicator, After Positioning, Centering and Execution HDR Brachytherapy in Cervical Cancer

Francesca Vallerga, Radiation Oncologist, Claudio Arboscello, Radiation Oncologist, Renato Chiarlone, Radiation Oncologist. asl 2 Savonese, S.S. Brachytherapy Ospedale San Paolo, Savona, Italy.

Purpose: The purpose of this report is to avoid dosimetric uncertainties about a possible movement of the applicator. Occasionally, movement patient from the couch used for the treatment in the bunker and the centering room and back, can caused dose variation of brachytherapy reference points. At our institution, this problem is not covered, because the treatment and the TC scanning are performed in the same bunker, so as to avoid any risk of applicator movement. Materials and Methods: From January 2016 to December 2016, in our institute 13 women with biopically diagnosy of local advanced cervical cancer were treated with 3 fraction HDR brachytherapy intracavitary implants after pelvic EBRT with volumetric arc therapy ± Chemiotherapy associated. Brachytherapy dose High risk CTV as per GEC-ESTRO guidelines delivered 21 Gy in 3 fractions (700cGy for single fraction), in about 13 days overall. ICRU- GEC-ESTRO 89 (review 2016) prescription points (A, B, P, bladder, and rectum) were used. Results: All patients have received spinal anesthesia, so no sedation, presence of anesthetist and nurse in the room during the entire planning time for monitoring parameters and discharge on the same day. At each implantation, all patients had a urinary catheter in situ and received bowel enema before undergoing planning CT simulation. Medical and physical planning time has had maximum duration of 1 hour, currently in phase of acceleration to get to less than 30 minutes. Each brachytherapy insertion had a different plan generated prior to treatment delivery used Oncentra Brachy treatment planning. Dose volume histogram was generated and treated volume to the prescription dose was recorded for each fraction, assessing the importance of a reduction in the size of the ovoid during the treatment cycle, depending on response to brachytherapy. All cases (BT treatment) were performed in the same bunker of TC scanning so as to avoid any risk of applicator movement and what surely implies greater comfort for patients. There were no acute side effects (G0 RTOG scale), longer times to exclude late toxicity. Conclusions: In conclusion, the possibility of using a single bunker to TC scanning and execution HDR brachytherapy treatment allows us to prevent unintentional movement of the applicators and greater comfort for the patient.
Patterns of Local Recurrence After Hybrid of Intracavitary and Interstitial Brachytherapy for Locally Advanced Cervical Cancer
Naoya Murakami, MD, PhD1, Kazuma Kobayashi, MD1, Tomoyasu Kato, MD, PhD2, Satoshi Shima, MD1, Yuri Shimizu, MD1, Keisuke Tsuchida, MD1, Tairo Kashihara, MD1, Ken Harada, MD, PhD1, Kana Takahashi, MD, PhD1, Rei Umezawa, MD, PhD1, Koji Inaba, MD, PhD1, Yoshinori Ito, MD1, Hiroshi Igaki, MD, PhD1, Jun Itami, MD, PhD1.
1Department of Radiation Oncology, National Cancer Center Hospital, Tokyo, Japan, Tokyo, Japan, 2Department of Gynecologic Oncology, National Cancer Center Hospital, Tokyo, Japan, Tokyo, Japan.

Purpose: Since 2012, locally advanced uterine cervical cancer patients whose tumor cannot be well covered by conventional intracavitary brachytherapy (ICBT), especially to the lateral direction, underwent hybrid of intracavitary and interstitial brachytherapy (HBT). The purpose of this study was to investigate the patterns of recurrence after HBT. Materials and Methods: A retrospective analysis was done of clinical outcomes of locally advanced uterine cervical cancer patients (T1b2-4a) treated with primary radiation therapy between January 2012 and November 2015. Patients with distant metastasis other than para-aortic lymph node were excluded from this study. Local recurrences were categorized into uterus or parametrium. Results: Our study population consisted of 43 patients. Median follow-up was 23.2 months (range 13.2-71.4). Two-year overall survival, progression free survival, and local control rate were 83.5%, 55.3%, and 84.4%, respectively. Seven patients experienced local recurrence (15.9%). Five local recurrence were categorized into uterus and two into parametrium, respectively. Late adverse effect greater than 2 were seen in 3 patients. Conclusions: HBT showed favorable local control for tumors which cannot be well covered by ICBT. Lateral tumor spread was well controlled by additional interstitial needles.

PO06 Cumulative Dosimetric Evaluation of the Organs at Risk in Vaginal Cuff Brachytherapy with Multi-Lumen Cylinder Applicators
Nicolaë Dumitru, MS1, Marjan Shojaei, MS1, Janeil Pinder, MS1, Silvia Pella, PhD1,2, Theodora Leventouri, PhD1.
1Physics/Medical Physics, Florida Atlantic University, Boca Raton, FL, USA, 21st Century Oncology, Boca Raton, FL, USA.

Purpose: To develop a method to evaluate the cumulative dose of organs of risk when using the Multi-Channel Cylindrical applicators in vaginal cuff brachytherapy and to identify a more consistent treatment planning and delivery protocol for all the gynecological brachytherapy with high dose rate (HDR). Materials and Methods: A retrospective analysis of 30 patients treated in 2015 with the Multi-Lumen Cylindrical Applicator with 3 cm diameter, were considered for this study. A total of 150 fractions were evaluated, each of patient receiving 5 fractions with 5 Gy each, delivered twice a week and prescribed to the applicator’s surface for 2/3 of the vaginal length. The CT scans of these patients, taken for treatment plan were separately imported into the treatment planning system and registered with the initial CT scan after completing the structure segmentation in each CT scan. Two sets of CT images at a time were registered together with respective to the applicator, using landmark registration. Dosimetric evaluations were performed after a cumulative dose was calculated and a dose volume histogram was generated for each patient. The maximum doses received by the rectum wall, bladder wall, bowels and PTV were analyzed to determine the total dose distribution over the entire prescribed treatment. Results: No volume of any of the critical organs was exactly similar when CT images were fused to each other. Depending on the depth of the insertion the PTV varied minimally. Each plan was performed independently and cumulated one at a time to the initial one until all 5 fractions were added to the initial fraction. There is a difference between the doses received by the critical organs between treatments and for the points of maximum does. The PTV volumes vary from fraction to fraction. The maximum dose varied between 12% and 27% in rectum wall and bladder wall. The minimum dose varied between 2% and 7% in rectum wall and bladder wall. The average dose varied between 9% and 21% in rectum wall and bladder wall. The cumulative treatment does not indicate a total maximum dose exceeding the tolerances for the rectum and bladder. Conclusions: The variation in volumes of organs at risk (OAR)s and isodoses near the OARs, indicate that the estimated doses to OARs on the planning system may not be the same dose delivered to the patient in all the fractions. There are no major differences between the prescribed dose and the delivered dose over the total number of fractions. Variation in the length of the cylinder part implanted into the vagina and PTV’s coverage indicates an inconsistency in the entire vaginal cuff in all five fractions. In some cases, the critical organs will benefit if the consecutive plans will be made after the CT scans are registered with the initial.
All the cases studied indicate the need of establishing a protocol of planning that accounts for all the delivered fractions during treatment. The new protocol must introduce a demand for consistency in the planning of the 5 fractions and eventually deformable registration and adaptive planning to be applied for each of the 5 fractions.

**PO07**

**Image Guided High Dose Rate Intracavitary Brachytherapy in the Treatment of Medically Inoperable Early Stage Endometrioid Type Endometrial Adenocarcinoma**

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**Purpose:** The purpose of this case series is to describe the treatment and outcomes of a cohort of patients with medically inoperable early-stage (AJCC Stage T1a or T1b) endometrial cancer with 3-D image guided high dose rate (HDR) intracavitary brachytherapy. **Materials and Methods:** A retrospective chart review was performed of 15 patients who underwent treatment between 2010-2016. Staging of disease was performed by physical exam, computed tomography (CT), pelvic ultrasound, and pelvic magnetic resonance imaging (MRI). Treatment planning was based on CT imaging. Gross Tumor Volume (GTV) was defined as the MRI or ultrasound demonstrated endometrial stripe width, with the entire uterine corpus, cervix, and proximal 4-5cm of the vaginal wall representing the Clinical Target Volume (CTV). Dosimetry calculations were performed using GTV and CTV definitions in all patients. Followup data was obtained from electronic medical records. **Results:** Eight patients underwent 45 Gy external beam radiation therapy (EBRT) in 25 fractions followed by 5 fractions intracavitary HDR brachytherapy. Seven patients underwent intracavitary HDR brachytherapy only in 4 or 5 fractions. In all patients, mean cumulative dose to 90% (D90) of GTV was 95.99 Gy in equivalent dose in 2 Gy fractions (EDQ2, α/β=10). Mean cumulative D90 of CTV was 51.64 Gy EDQ2. Average followup was 29 months. Four patients died from concurrent disease at an average of 36 months after completion of treatment. Except for one patient (T1b, Grade 2) who recurred at 36w following completion of treatment (6.6%), all patients remained disease free. Side effects were minimal, and included grade 1-2 diarrhea and dysuria most commonly. No treatment limiting toxicity was seen. **Conclusions:** In patients who are poor surgical candidates and have early stage endometrioid type endometrial adenocarcinoma, image guided high-dose rate brachytherapy is an alternative to surgery with minimal side effects and a potentially high response rate.

**PO08**

**125I Seed Implantation in the Treatment of 3 Cases of Recurrent Cervical Cancer**

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Oncology Dep.1 of Hebei General Hospital, Shijiazhuang, China.

**Purpose:** To observe the curative effect of ultrasound and CT guided 125I radioactive seeds implantation in the treatment of recurrent cervical cancer vaginal metastases. **Materials and Methods:** Three patients with cervical cancer vaginal metastases after EBRT and HDR brachytherapy underwent 125I seeds implantation guided by CT and ultrasound. A per-plan was performed before the operation and the PD was 40-70GY. The seeds activity was 0.3-0.6mCi and the seeds number was 10-40. A post-plan was carried out right after the operation and the D90 was 45-67Gy. **Results:** After 4 months 3 patients reached PR. 3 cases did not occurred postoperative vaginal fluid flow and bleeding, and only 1 case occurred 4 seeds shedding. **Conclusions:** CT and ultrasound-guided 125I radioactive seeds implantation was safe, effective and feasible for recurrent cervical cancer vaginal metastases. It provides a new treatment for the patients with recurrent cervical cancer vaginal metastases after radiotherapy and surgery.

**PO09**

**Use of Deformable Registration to Assess Dose to Normal Tissue for HDR Vaginal Implants**

Vrinda Narayana, Ph.D\(^1\), Varsha Kumar, Student\(^2\).

\(^1\)Providence Hospital, Southfield, MI, USA, \(^2\)International Academy, Bloomfield Hills, MI, USA.

**Purpose:** To study the feasibility of deformable registration in order to assess the dose to normal tissue over the course of the brachytherapy treatment for patients that received vaginal HDR treatments. **Materials and Methods:**
Ten sequential patients who received a high dose rate (HDR) treatment to the vagina using a cylinder were entered into the study. Patients in the study received HDR treatments over 3 or 4 fractions to a total dose of 17-24 Gy to a point 5 mm from the surface of the cylinder. Patients received a CT before each HDR treatment and the normal tissue was contoured. The bladder and rectum was contoured for every fraction on all patients. A standard HDR plan was used to treat the patient. The CT dataset from the first fraction was used as the primary dataset and datasets from subsequent fractions were deformed and registered to the first fraction. The deformed registration was assessed visually by tissue overlay methods and by the deformable warp maps. Jacobian maps were used to check the change in the voxel volume due to deformation. Results: Dose to bladder and rectum for the combined HDR fractions was determined based on the deformable registration. Conclusions: Deformable registration can be used to assess the dose to normal tissues for simple HDR brachytherapy treatments like vaginal treatments using the cylinder. Use of deformable registration to combine brachytherapy and external beam cannot be performed with the current commercially available algorithms. Both tissue and applicators are deformed with the current deformable registration models. Deformation cannot selectively deform just the tissue and leave the applicator rigid or completely remove the applicator from a dataset. This makes deformable registration unusable for situation with CT datasets that have an applicator for the HDR treatments and the external beam treatment dataset that does not have the applicator in the patient. Deformable registration can successfully be used to determine sum dose to normal tissues for patient receiving HDR treatments to the vagina.

PO10

The Consistency of Treatment for GYN Cancer with HDR Using MLC

Marjan Shojaei, Master Student, Silvia Pella, PhD, Nicolae Dumitura, Master Student, Shereen Chandrasekara, Master Student.

Florida Atlantic University, Boca Raton, FL, USA.

Purpose: High dose rate (HDR) brachytherapy is a highly localized mode of radiation therapy that has a very sharp dose fall-off. Thus one of the most important parts of the treatment is the immobilization. The smallest movement of the patient or applicator can result in dose variation to the surrounding tissues as well as to the tumor to be treated. Our purpose is to revise the MML Cylinder treatments and their localization challenges. Since every millimeter of misplacement counts the study will look into the necessity of increasing the immobilization and localization during scanning, planning and treatment delivery. Materials and Methods: A retrospective analysis of 125 treatment plans of 25 patients each generated in the treatment planning system Oncentra looking into the applicator’s placement in regard to the organs at risk. Motion possibilities for each applicator intra and inter fractionation with their dosimetric implications were covered and measured in regard with their dose variance. The localization immobilization devices used were assessed for the capability to prevent motion before and during the treatment delivery. Results: We focused on the 100% isodose on central axis and rotational displacement due to possible rotation analyzing the dose variations to the bladder and rectum walls. The average dose variation for bladder was 15% of the accepted tolerance, with a minimum variance of 11.1% and a maximum one of 23.14% on the central axis. For the off axis measurements, we found an average variation of 16.84% of the accepted tolerance, with a minimum variance of 11.47% and a maximum one of 27.69%. For the rectum we focused on the rectum wall closest point to the 120% isodose line. The average dose variation was 19.4%, minimum 11.3% and a maximum of 34.02% from the accepted tolerance values.
PO11
Dynamics of the Vaginal Wall Dose in HDR Interstitial Brachytherapy for Gynecological Cancer: Phantom vs. Patient Case
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Purpose: To investigate the dynamics of the vaginal wall dose by modifying relative dwell time and needle position (DTNP) between the vaginal surface needles and a central obturator needle for interstitial brachytherapy (ISBT). To the best of our knowledge, there is no systemic evaluation of the vaginal wall dose in ISBT.

Materials and Methods: A patient undergoing ISBT was selected as the patient case, and for comparison, the phantom case was generated as same as the patient case but with parallel needle positions. The vaginal wall was contoured as 0.5 cm expansion around the vaginal surface of the obturator. The prescribed ISRT dose to the reference target point was 2,000 cGy in 4 fractions. Six different treatment plans were generated with geometric optimization (GO) by modifying DTNP on the vaginal surface needles and a central obturator needle, and compare with V_{150%} and D_{2cc} of the vaginal wall dose from dose-volume histograms: Plan 1: vaginal surface needles (100%), central needle (100%). Plan 2: vaginal surface needles (reduced 50%) compared to Plan 1. Plan 3: vaginal surface needles (reduced 0%) compared to Plan 1. Plan 4: vaginal surface needles (100%), central needle (no dwell). Plan 5: vaginal surface needles (no dwell), central needle (100%). Plan 6: vaginal surface needles (no dwell), central needle (200%).

Results: The V_{150%} was much larger in the patient case (49.3%) due to un-parallel needles without modification compared to the phantom case (14.3%) (Table). Among the 6 Plans, reduced dwell time (Plan 3) and no dwell time (Plan 5) on the vaginal surface needles had a lowest vaginal wall doses with the use of an central obturator needle in both cases (Fig): In comparison of Plan 1, 3 and 5 in the patient case, V_{150%} was 49.2%, 19.0% and 21.3%, respectively. D_{2cc} was 4,115 cGy, 3,310cGy and 3,651cGy, respectively which were limited around each loaded needle. Conclusions: Modification of DTNP is able to reduce significantly high dose volume of the vaginal wall from exceeding 150% of the prescription dose in the patient case. However, patient-specific graphic optimization is needed which is depend on the degree of un-parallel needle placement. Understating these dynamic of the vaginal wall dose will improve dose optimization of ISBT and may reduce vaginal morbidities.

PO12
Early Institutional Experience with Intracavitary Multichannel Vaginal Cylinder Brachytherapy Boost
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**Purpose:** To review initial cases regarding case selection and dosimetry achieved for vaginal brachytherapy (BT) boost; to optimize use and planning objectives for future multichannel vaginal cylinder (MCVC) cases. **Materials and Methods:** Seven cases of vaginal tumour were treated with external beam radiotherapy (EBRT; 45 Gy in 25 fractions) +/- chemotherapy, followed by intravaginal brachytherapy using a MCVC between January 2015 and January 2017. Three cases were primary vaginal carcinoma; 4 cases were vaginal recurrence of uterine carcinoma (2 of which had previous vaginal vault brachytherapy; 1 with recurrence in-field of previous brachytherapy, 1 recurring distal to previous brachytherapy). In all cases, palpable tumour was <5mm thick at time of boost brachytherapy planning; 4 cases were in the upper vagina, and 3 cases in the distal vagina. Five cases were planned using CT images, and 2 were planned without dedicated planning CT using clinical measurements. Dosimetry was assessed using CT-obtained data, where available; prior brachytherapy dose was included for the in-field vaginal vault recurrence. **Results:** The median HR-CTV was 13.5 cc (range 4.6 - 35.5 cc), with a median total equivalent dose to 90% (EQD2 D90) of 74.6 Gy10 (SD +/- 22.2). The median equivalent dose to 2 cc (D2cc) for the bladder, rectum, and sigmoid were 59.3 Gy1 (SD 15.6), 60.5 Gy3 (SD 8.6), and 52.3 Gy3 (SD 12.3), respectively. Median follow-up to date has been 16 months (SD 7.5). Two patients with distal vaginal disease had Grade 3 late toxicity (CTCAE v3); one, who was noted to have declined dilator use, had vaginal obliteration; one patient with a distal vaginal primary had local ulceration at 11 months, pathologically revealed radiation-induced atypia with no residual malignancy. No other acute or late toxicity of Grade 3 or higher was found for vagina, bowel or bladder. For the patients seen in follow-up to date (n=6), all had complete clinical response. **Conclusions:** MCVC provides a useful modality to preferentially treat conformal target areas (i.e., HR-CTV) within the vaginal canal that is less resource-intense than the alternative of interstitial brachytherapy boost. Further refinement of volumetric dose objectives for primary vaginal and recurrent uterine carcinoma, and a better understanding of vaginal dose tolerance, is needed to optimize use of MCVC. In our experience, apical/upper vaginal lesions may be challenging to achieve optimal target volume dosimetry without high vaginal doses, but distal vaginal locations are more susceptible to radiation toxicity.

**PO14**

**Systematic Checking of the Location of Brachytherapy Applicators in the Treatment of the Vaginal Cuff: Necessity to Guarantee Treatment Success**

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**Purpose:** Adjuvant vaginal cuff brachytherapy (BT) is well established. The use of High dose rate (HDR) treatments with several fractions, requires a strict control of each application, to ensure the adequate treatment avoiding set up errors as the recently reported by the Patient Safety Committee of the American Brachytherapy Society (ABS)[1]. If 3D based CT dosimetry is not done in each fraction, other image confirmation of applicator position must be employed to verify that the applicator is in contact with the vaginal mucosa atraumatically (i.e., HR-CTV) within the vaginal canal that is less resource-intense than the alternative of interstitial brachytherapy boost. Further refinement of volumetric dose objectives for primary vaginal and recurrent uterine carcinoma, and a better understanding of vaginal dose tolerance, is needed to optimize use of MCVC. In our experience, apical/upper vaginal lesions may be challenging to achieve optimal target volume dosimetry without high vaginal doses, but distal vaginal locations are more susceptible to radiation toxicity.

Before the first insertion, two seeds of silver are placed in the vaginal cuff with a needle with a spacer to guarantee the exactly place in the vaginal mucosa surface for the display of the correct position of the cylinder. After the first insertion all patients (100%) underwent a pelvic x-ray, 31 (91%) in the second insertion and 32 (94%) in the third. **Results:** In 21% of the cases (7 patients) x-ray showed a wrong placement of the cylinder in the first insertion, in 6% (2 patients) of the second and in 12% (4 patients) of the third. In all those cases, after the relocation, the x-ray is repeated to ensure the correct positioning. It is very unusual the case in which one of the seeds fall out.

**Conclusions:** The correct placement of devices of brachytherapy is essential for adequate administration of the

PO15
Implementation and Advantages of a Pre-Planning Technique for Interstitial Gynecological Brachytherapy
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Purpose: To present the implementation of a pre-planning technique for interstitial gynecological brachytherapy. A multi-needle interstitial pre-plan based on images of the patient with a vaginal cylinder inserted and a virtual template is created. The number and depth of needles in the pre-plan are used as guidance during the interstitial procedure. This technique is evaluated by a retrospective comparison between pre-planned and actual implanted needles and positions. Materials and Methods: A pre-planning procedure was performed on thirteen patients one to two weeks prior to interstitial needle placement. All patients were imaged with CT while MRI was also used for six patients. Images were acquired with a vaginal cylinder of similar diameter to the Syed/Neblett central rod (Best medical) inserted. The target and OARs were delineated on the images by the physician. A virtual Syed/Neblett template developed in the treatment planning system (Elekta Oncentra v. 4.3) was used to reconstruct needles. The needles were adjusted until their optimal positions and insertion depths were found. The needle information from this pre-plan, along with ultrasound, was used as guidance by the physician in the OR for needle insertion. Retrospectively, the pre-planned needle count and insertion depth were compared with the actual implant record and differences were assessed. Results: The pre-plan procedure allowed the optimum locations and depths of needles to be determined prior to insertion in the OR. Using pre-plan needle data, an ideal implant can be achieved in an OR with only ultrasound guidance. The average difference between the pre-planned and actual needle insertion depth was $1.3 \pm 1.1$ cm. The maximum needle count difference between the pre-plan and the actual implant was $\pm 2$ needles. Conclusions: A successful interstitial gynecological brachytherapy treatment requires optimum needle insertion. This pre-plan technique facilitates this and has been implemented for routine use with Syed/Neblett applicator-based interstitial implants.

PO16
How Often Are Advanced Vaginal Recurrences Amenable to Intracavitary Brachytherapy After External Beam Radiotherapy?
Feasibility of Pneumo-Occluder Balloon in Place of Vaginal Packing During Ring and Tandem HDR Brachytherapy for Cervical Cancer

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Purpose: In order to reduce toxicity during cervical cancer brachytherapy, vaginal packing is used to distance the ring and tandem from the bladder and rectum. However, packing can be uncomfortable, time consuming, and the quality of packing is user-dependent. We investigate feasibility and safety of using a vaginal distention device typically used in gynecologic surgeries (a balloon pneumo-occluder), as compared to vaginal packing. Materials and Methods: This study reviewed 28 high dose rate (HDR) brachytherapy fractions from seven patients with cervical cancer, delivered via ring and tandem with either vaginal packing (n=11) or pneumo-occluder balloon (n=17). After device placement, each patient underwent computed tomography (CT) and magnetic resonance imaging (MRI) simulations. Rectum, bladder and sigmoid were contoured on CT. The high-risk clinical target volume (HR-CTV) was contoured on MRI. Treatments were prescribed to point A, while ensuring adequate coverage of HR-CTV. For this study, the 28 plans were renormalized to a prescription dose of 5 Gy. The D2cc (minimum dose of radiation received by the most exposed 2cc volume) of the bladder, rectum and sigmoid was extracted for each fraction. A t-test was used to compare doses to OARs between pneumo-occluder and packing.

Results: Use of the pneumo-occluder balloon was well tolerated by patients. There were no technical failures with the device. Median (range) D2cc for rectum, sigmoid and bladder in treatments using the pneumo-occluder was 2.2Gy (1.3-3.8), 3.5Gy (1.9-4.5), and 4.4Gy (1.6-7.0), respectively. Median (range) D2cc for the same structures in treatments using vaginal packing was 2.2Gy (1.3-2.6), 3.6Gy (2.8-4.9), and 5Gy (3.9 - 6.0), respectively. There is no significant difference between OAR dose between these vaginal distention methods (P>.05 for all). Conclusions: Our results indicate feasibility of using a pneumo-occluder for vaginal distention in HDR brachytherapy. The radiation doses to OARs using this approach are no different than using vaginal packing. Figure 1 T1W 3D parasagittal MRI images with vaginal packing soaked in gadolinium (left) and balloon pneumo-occluder (right) filled with a solution of gadolinium doped water.
PO18

Boosting Rectovaginal Disease Using Multi-Channel Capri Balloon Applicator Brachytherapy

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Purpose: Recurrent or primary vaginal disease located in the rectovaginal septum presents a challenging clinical location for interstitial brachytherapy given reported complications of rectovaginal fistulas post-treatment. This study evaluates the dosimetry of conformal boost to persistent gross recurrent disease in the vagina with a non-invasive, balloon based, multi-channel (MC) Capri™ vaginal brachytherapy applicator in patients with rectovaginal gynecologic cancer following whole pelvis radiation. Materials and Methods: All patients had fiducial markers placed at the site of gross disease, and were treated with whole pelvis radiation to a dose of 45 Gy in 25 fractions. Following whole pelvis radiation, patients were treated with Ir-192 HDR vaginal brachytherapy. Patients underwent sizing using the balloon-based, MC Capri™ applicator (Varian Medical Systems, Palo Alto, CA, USA) expanded to maximum capacity with saline to a median maximum horizontal cross sectional diameter of 4.50 cm. A CT scan was performed with the applicator in place. Target volume was defined as the gross tumor volume delineated by fiducial markers and expanded by 3 mm to create the planning target volume (PTV). Using Brachytherapy Planning in the Eclipse treatment planning system (Varian, Palo Alto, CA, USA), dosimetry of the conformal boost plan was manually optimized to achieve 100% coverage of PTV coverage using a prescription of 4 Gy per fraction using the minimum number of catheters and dwell positions closest to the target volume. Maximum dose to 2 cm³(D2cm³) to bladder and rectum, as well as vaginal mucosal surface points ipsilateral and contralateral to PTV 400 cGy and biologically equivalent dose in 2Gy equivalents (EQD2) for bladder and rectum were calculated using a prescription of 4Gy x 6 fractions with α/β of 3. Results: Five plans were evaluated from 5 patients with vaginal cancer (2) and endometrial cancer (3) with gross vaginal cuff recurrences. Each patient was planned with separate plans representing each individual insertion. The average GTV and PTV taken from the 14 plans was 5.00 cm³ and 6.30 cm³, respectively with a PTV average depth of 1.1 cm. The median number of loaded catheters used in each optimized plan was 3 (range, 2-4 catheters). The average D99, D95 to PTV for all plans was 3.89 Gy and 3.92 Gy, respectively. Average D2cm³ to bladder was 3.02 Gy (range 1.01-4.36 Gy), and average D2cm³ to rectum was 3.22 Gy (range 2.23-5.08 Gy). The average maximum dose to ipsilateral vaginal mucosa was 12.79 Gy (range 2.04-33.0 Gy), while the average maximum dose to the contralateral vaginal mucosa was 9.8 Gy (range 0.99 Gy-7.46 Gy). Average EQD2 total for 45 Gy external beam and 6 fractions of 4 Gy for bladder and rectum was 67.5 Gy and 69.5 Gy, respectively. Conclusions: Although ABS Consensus Guidelines for vaginal cancer suggest that lesions with a thickness exceeding 5 mm cannot be adequately treated with a vaginal cylinder, we demonstrate that with the Multichannel Balloon Capri™ applicator, PTV depths averaging 1cm from vaginal surface were able to be prescribed using a multicatheter approach with clinically acceptable bladder, rectal and vaginal doses. Preliminary data suggests that the use of the Multicatheter Capri™ applicator may be an alternative approach to using an interstitial implant for selected patients with small vaginal recurrences located at the rectovaginal septum, however,
a larger cohort of patients with long-term follow-up is required to assess long-term clinical outcomes using this technical approach.

Figure 1. PTV in red shown with fiducial markers located on right lateral vaginal wall for patient treated with Capri™ multichannel vaginal applicator demonstrating 100% isodose line of 4 Gy in yellow, and the rectum and bladder contoured in green and orange, respectively.

PO19
Acute Catheter Complications from Perineal Interstitial Brachytherapy (ISBT) in Gynecological Cancer Patients: A Prospective Analysis of Organ Injury, Infections and Radiological Needle Intrusions
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Purpose: Interstitial Brachytherapy (ISBT) is an effective component in the treatment of gynecological cancers due to its ability to achieve highly conformal doses of radiation to the target. However, there are concerns of potential acute complications from this technique due to the apparent invasiveness of interstitial catheter needles. As a result,
ISBT has yet to be widely adopted in radiation oncology centres. The goal of this study is to evaluate the safety of ISBT applicator implantations by studying the acute complications and radiological organ needle intrusions in patients treated with the perineal template technique. **Materials and Methods:** 49 patients at a single institution treated with high-dose rate perineal ISBT from September 2014 to April 2016 were included in a prospective registry trial. Median age of patients was 65 with a total of 16 cervical cancer patients, 13 vaginal, 13 recurrent endometrial, 2 vulva and 3 others. ISBT insertions were performed using a perineal template with a clinically-guided technique (no real-time imaging). Post-procedure, patients underwent CT or MRI with no attempt to adjust needle depth or positioning after review of images. Post-operative adverse events were graded with CTCAE V3.0 during inpatient stay and at the 6-week follow-up visit. CT planning images were independently reviewed by two radiation oncology trainees to record the number of needles intruded into organs. Discrepancies were resolved by a board-certified radiologist. **Results:** Median follow-up time was 3 months. 42 patients were initially treated with external beam radiation therapy to the pelvis with a dose of 45 Gy (median). A total of 76 applicator insertions were performed; 22 patients received 1 implant while 27 had two. The median number of needles used for each insertion was 17 and 19 respectively; 28 patients had radiological evidence of needle intrusion(s) to at least one pelvic organ. From the 76 insertions, the most commonly intruded organs were bladder (18 needles) followed by bowel (15) and rectum (12). A total of 9 acute toxicities could be attributable to interstitial needles; 4 patients developed hematuria during inpatient stay (2 G1, 2 G2) while no gastrointestinal complications were found. 4 patients developed perineal infections post-procedure (3 G2, 1 G1); 1 patient had vaginal bleeding requiring transfusion. **Conclusions:** Perineal ISBT is an effective treatment for locally-advanced gynecological cancers. Despite occasional observed radiological catheter intrusions, there are low rates of organ complications from this procedure. No acute bowel injury from needles were found in any patients. Concern of needle complications from ISBT should not be a barrier to adopting this technique for effective treatment of locally advanced tumors.

**PO20**

Feasibility Study of Toxicity Outcomes Using GEC-ESTRO Contouring Guidelines on CT Based Instead of MRI-Based Planning in Locally Advanced Cervical Cancer Patients

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**Purpose:** To report late rectal and bladder toxicity outcomes of a CT-based image-guided brachytherapy (IGBT) technique for treatment of cervical cancer. **Materials and Methods:** Between 2008 and 2014, 95 women with International Federation of Gynecology and Obstetrics stage IB to IVA cervical carcinoma treated with definitive concurrent cisplatin-based chemotherapy and external beam radiation therapy 50.4 Gy in 28 fractions followed by planned prescription dose of 7 Gy × 4 fractions of high-dose-rate IGBT was retrospectively reviewed. At each implantation, all patients had a urinary catheter in situ and received bowel enema before undergoing planning CT simulation. A high-risk clinical target volume (HRCTV) as per GEC-ESTRO guidelines and the entire cervix, rectum, and bladder was contoured on the simulation CT according to Radiation Therapy Oncology Group Gynaecology Contouring Atlas. Reported doses to HRCTV and organs at risk were recorded. Toxicities were recorded using National Cancer Institute Common Terminology Criteria for Adverse Events version 3. **Results:** The median followup time was 29 months. The mean HRCTV equivalent dose in 2 Gy fractions (EQD2) of external beam radiation therapy combined with brachytherapy was 80 Gy (standard deviation [SD], 11), and the rectal doses to 2 cm^3 (D2cc) EQD2 and bladder D2cc EQD2 were 74 Gy (SD, 6) and 79 Gy (SD, 15), respectively. Twenty-two patients (23%) had grade 2 proctitis and 10 patients (11%) had grade 3 proctitis. Four patients (4%) had grade 2 cystitis and two patients (2%) had grade 3 cystitis. No patients had ≥ grade 4 toxicity. **Conclusions:** Despite CT-based brachytherapy planning, reported organ at risk toxicity was still significant compared with reported MRI-based planning series. Coimplementation of interstitial IGBT using the European Study on MRI-guided Brachytherapy in Locally Advanced Cervical Cancer (EMBRACE) protocol or using intensity-modulated radiation therapy during the external beam phase treatment might help to limit these late toxicities.

**PO21**

Dual-Tandem Brachytherapy for Stage I Endometrial Cancer: An Eight-Year Experience
Transition from LDR to HDR Brachytherapy for Cervical Cancer: Evaluation of Tumor Control, Survival, and Toxicity

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Purpose: In 2012, our institution transitioned from low dose-rate (LDR) brachytherapy to high dose-rate (HDR) brachytherapy. There is a growing body of literature reporting outcomes of these two treatment techniques across different settings, although large comparative analyses are limited. We report clinical outcomes following brachytherapy for cervical cancer at our institution over a continuous 10-year period. Materials and Methods: From 2004-2014, 258 women (184 LDR, 74 HDR) were treated with tandem & ovoid brachytherapy in the multidisciplinary management of FIGO stages IA-IVB cervical cancer. Clinical and treatment-related prognostic factors including age, stage, smoking status, relevant doses, and toxicity data were recorded. Results: Median follow up for the LDR and HDR groups was 46 months and 12 months, respectively. The majority of patients (92%) received external beam radiotherapy as well as concurrent chemotherapy (83%) prior to the start of brachytherapy. 139 patients (52% and 58% of the LDR and HDR groups, respectively (p = 0.08)) were former or current smokers. For all stages, the 1-year local control (LC) and overall survival (OS) rates were comparable between the LDR and HDR groups (87% vs. 81%, p = 0.12; and 75% vs. 85%, p = 0.16), respectively. Factors associated with OS on multivariate analysis (MVA) include age, stage, and nodal involvement. On MVA, severe toxicity (acute or chronic) was higher with HDR than LDR (24% vs. 10%, p = 0.04). Additional prognostic factors associated with increased severe toxicity include former/current smokers and total dose to lymph nodes (Table 1). Conclusions: This comparative retrospective analysis is among the largest CT-based HDR series reported and provides a direct comparison of outcomes.
compared to LDR at the same institution. These data demonstrate equivalent LC and OS for cervical cancer patients of all stages treated with LDR and HDR brachytherapy techniques. Acute and chronic toxicity increased shortly after the implementation of HDR, highlighting the importance of continued refinement of HDR methods, including manual dose optimization and integrating advanced imaging. Further refinement of 3D image-guided treatment planning is critical to improving both disease control and toxicity in the future.

I. Analysis of prognostic factors associated with severe toxicity (CTACe v4.03 grade 3-5, acute or chronic).

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Abbreviations: OR; odds ratio, CI; confidence interval, CTCAE; Common terminology criteria for adverse events version 4.03, ECOG; Eastern Cooperative Oncology Group Performance Status, Equivalent Dose in 2 Gy fractions. P-values <0.05 on multivariate analysis are bolded.

* Analyzed as a continuous variable

PO25
Evaluation of Distortions in Electromagnetic Navigation of Catheters for Image-Guided Gynecological Brachytherapy
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Purpose: Ultrasound has traditionally been used for intraoperative needle guidance in interstitial gynecological brachytherapy (IGBT); however, this approach suffers from significant imaging artifact making accurate guidance difficult. Electromagnetic Navigation (EMN) has recently emerged as a potential intraoperative guidance tool to supplement the live anatomical information provided by ultrasound (US). Errors in needle positions obtained by EMN systems frequently result from ferromagnetic operating room equipment and have thus far limited the technology’s clinical adoption. This study aims to quantify the effects of magnetic field distortion of several IGBT-specific operating room configurations on the accuracy of the EMN system, with the overall intent of enabling
improve guidance for IGBT. Materials and Methods: A brachytherapy phantom was constructed that consisted of two parallel plates, separated by 12 cm in the superior-inferior (SI) direction, with a 6 cm x 5 cm array of grid positions in the anterioposterior (AP), and left-right (LR) directions, respectively. Nine 6F Proguide needles (Elekta AB, Stockholm, Sweden) were placed at regular, symmetric grid positions. An Aurora EMN system (Northern Digital Imaging Inc, Waterloo, ON, CAN) - consisting of a magnetic field generator (FG) and tracked EM sensors - was used to track a single 5-degree-of-freedom (DOF) sensor mounted at the tip of the needles. A 6-DOF reference sensor was mechanically secured to the brachytherapy phantom such that the physical distances to the holes in the grid were known to within 0.1 mm. Position tracking of the needle sensor was initiated for 200 frames at 40Hz. Positional tracking occurred for a number of environments including a baseline environment with no magnetic distortion, and operating room configurations with and without several pieces of operating room equipment including: stirrups, surgical cart, and US for various FG positions. Errors were reported as axial deviations from grid positions relative to the baseline condition. Results: Fig 1 shows the axial position error for needle positions for the above- and below-bed placement of the FG. FG placement below the bed produced significantly larger distortions in sensor position with larger standard deviations for all configurations. The above-bed configuration yielded < 1 mm error for all configurations with the largest deviation (0.04 ± 0.13 mm in the LR direction, and 0.42 ± 0.10 mm in the AP direction) caused by the introduction of the US probe posterior to the needle grid. Conclusions: Although EMN provides a much needed form of guidance in IGBT procedures errors caused by magnetic field interference limit the applicability of these systems in the clinical environment. Minimizing the distortion from EMN may rely on a combination of proper setup of proximal equipment as well as adjusting for systematic distortions. It is expected that supplemental data on out-of-plane distortion, dynamic tracking error, and finer distortion mapping for the above configurations will be completed by the conference date.

Fig 1. Sensor error measurements in the AP and LR directions relative to the fixed reference sensor for above- and below-bed configurations. Clean room refers to an empty room with no magnetic distortion present.

PO26
Does Variable 192Ir Dose Rate Affect Vaginal Toxicity in High-Dose-Rate Brachytherapy?
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Purpose: Relative to the schedule of standard clinical source exchanges performed quarterly, the treatment dose rate of \textsuperscript{192}Ir based HDR brachytherapy can vary by more than a factor of two between patients treated immediately before and after a source exchange. Since the potency of a radiation dose is highly dependent on the rate of dose delivery, its clinical impact on tumor control as well as normal tissue complication should be carefully examined. In this study, we investigated whether the varying dose rate in HDR brachytherapy had any impact on acute and late vaginal toxicity. Materials and Methods: The theoretical impact of varying dose rate between source-exchanges was examined using the Linear-Quadratic model. The generalized Lea-Catcheside formalism was used to calculate the dose protraction factor, $G$, which models the DNA double strand break repair and its effect on intertrack exchange-type chromosome aberrations over treatment delivery. The GEC-ESTRO guideline for sublethal damage repair half-time of 1.5 hours was used. The clinical impact of varying dose rate on both acute and late vaginal toxicity was analyzed using a cohort of 205 patients with endometrial cancer treated with HDR brachytherapy (18-21 Gy in 3 fractions). The reported acute on-treatment vaginal symptoms and the incidence of late grade 1 or higher vaginal stenosis occurring $>$90 days after treatment were each graded using the CTCAE. For this investigation, grading of both early and late vaginal toxicity was changed to a binary definition of present or absent. Delivery time information was individually collected for each patient based on prescriptions (6 or 7 Gy per fx), cylinder size (2.3, 2.6, or 3.0 cm diameter), and active length (4-7 cm). The source activity was retrospectively calculated using initial source strength measured at exchange and elapsed time since exchange. Statistical analysis using independent sample T-tests were run to compare source strength between patients with/without ≥ grade 1 acute or late toxicity, excluding patients who had a source exchange occur between fractions. This study was granted institutional review board approval. Results: The dose protraction factor ($G$) across a typical source exchange period varied from 0.957 (105 days post source exchange) to 0.990 (day of source exchange), which resulted in more than 10\% difference in cell-kill between a treatment delivered before and after a source change. The small variation in $G$ is consistent with the relatively large intrafraction repair half-time taken from GEC-ESTRO guideline - $G$ can become significant if intrafraction repair half-time is shorter. If radiation-induced cell damage is the main cause of vaginal toxicity, the theoretical analysis predicts more vaginal toxicity would occur among patients treated at higher activities (i.e., shortly after the source exchange). For the cohort of 205 patients, 42 patients and 63 patients developed grade 1 or higher early or late vaginal toxicity, respectively. There were 18 source exchanges completed across the time period of this analysis. The source strengths at the time of treatment varied from 3.79 Ci to 9.77 Ci. Excluding patients who had a source exchange between fractions (n=34), activity was not found to have a statistically significant correlation with acute (p=0.487) or late (p=0.430) vaginal toxicity. As such, our study revealed a discordance between theoretically predicted and clinically observed dependence of vaginal toxicity incidence rate on source strength in HDR brachytherapy. Conclusions: While radiobiological analysis indicates more vaginal toxicity would occur among patients treated at higher dose rate, our clinical dataset showed no significant evidence that source activity was correlated to early (p=0.487) or late (p=0.430) vaginal toxicity. This discordance between theoretical prediction and clinical data indicates that dose rate is unlikely the primary cause of vaginal toxicity in HDR brachytherapy.
Salvage EBRT and HDR Brachytherapy for Isolated Vaginal Recurrence of Endometrial Cancer in Patients with No Prior Adjuvant Therapy
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Radiation Oncology, University of California San Francisco, San Francisco, CA, USA.

Purpose: The goal of the study was to evaluate clinical outcomes for women with isolated vaginal recurrence of endometrial cancer after hysterectomy without adjuvant radiation or chemotherapy, who received salvage treatment with both external beam radiation therapy (EBRT) and high dose rate (HDR) brachytherapy. Materials and Methods: 30 women with recurrences treated between 2000 and 2010 were included in this single institution retrospective study. Median time to recurrence from surgery was 16.7 months, range 3.2 to 170.7 months. Median age at recurrence was 73 years, range 57 to 94 years. Initial histology was endometrioid adenocarcinoma in 25 patients (83%); others were papillary serous, clear cell, or adenosquamous. Initial disease was known to be grade 1 or 2 in 19 patients (63%), and 2009 FIGO stage IA in 19 patients. All patients received pelvic EBRT in 1.8 Gy daily fractions to a total of 45 or 50.4 Gy. Interstitial brachytherapy was used in 27 patients (90%) and 3 received intracavitary brachytherapy only. CT-based inverse planning was used for all patients. The median brachytherapy EQD2 dose was 24 Gy, range 16 to 33.3 Gy. The median total EQD2 dose was 68.3 Gy, range 63 to 77.6 Gy. Three patients received concurrent hormonal or cytotoxic systemic therapy with salvage radiation. Kaplan-Meier estimates of overall survival (OS), cause specific survival (CSS), progression free survival (PFS), locoregional failure free survival (LRFFS), and distant failure free survival (DFFS) were calculated. Univariate Cox proportional hazard ratio models were used to identify features prognostic for outcomes. Results: Median follow-up for vital status was 76.4 months, range 10.8 to 149.2 months. Median follow-up for disease status was 57.7 months, range 0 to 103.3 months. At last follow-up, 12 patients (40%) had died of which 7 (23%) were due to endometrial cancer progression. At last follow-up for disease status, 8 patients (27%) had known disease recurrence after salvage, with 3 patients (10%) recurring locoregionally and 5 patients (17%) recurring with distant metastases. Of the 3 patients with locoregional failure, 2 had died. Of the 5 patients with distant failure, all 5 had died. The 5-year Kaplan-Meier estimated OS, CSS, and PFS were 77%, 83%, and 75% respectively. The 5-year LRFFS and DFFS were 87% and 86%. Initial grade of disease (1-2 vs. 3) was prognostic for OS, CSS, and DFFS (5-year OS 95% vs. 29%, p = 0.005). Initial stage of disease (IA vs. > IA) was prognostic for CSS, PFS, and DFFS (5-year CSS 93% vs. 74%, p = 0.025). Initial stage remained prognostic for DFFS when restricted to 23 patients with stage IA or IB disease only (5-year DFFS 100% vs. 50%, p = 0.043). There was one treatment related death from small bowel obstruction 11 months after completion of salvage radiation, otherwise no reported grade ≥ 3 toxicity. Conclusions: Salvage EBRT and HDR brachytherapy resulted in a high rate of long-term locoregional control. Treatment was generally well tolerated.
Initial higher grade and higher stage disease were associated with distant failure (Figure 1) and cancer related mortality.

PO28
The Prognostic Value of Lymphovascular Space Invasion in Locoregional Endometrial Cancer by Adjuvant Treatment and Stage
Samual Francis, MD\textsuperscript{1}, Dustin Boothe, MD\textsuperscript{1}, Theresa Werner, MD\textsuperscript{2}, Aaron Wolfson, MD\textsuperscript{3}, David Gaffney, MD, PhD\textsuperscript{1}.
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Purpose: Lymphovascular space invasion (LVSI) is a known independent prognostic factor. Therefore, treatment decisions are often made based on the presence or absence of LVSI. However, LVSI as a determinant of treatment benefit has not been fully elucidated. Materials and Methods: A cohort from the National Cancer Database for endometrial cancer from years 2004-2012 was obtained. Patient demographic, tumor and treatment characteristics were compared with chi-squared analysis. Univariate and multivariate analysis was performed to assess the impact of LVSI on overall survival (OS). Survival analysis was performed utilizing log-rank and Kaplan Meier methods.

Results: A total of 32,150 patients with stage IB-III endometrial cancer were available for analysis with a median follow up of 30 months. Thirty percent were LVSI positive. On multivariate analysis, FIGO stage II (HR 1.27, p<0.001), FIGO stage III (HR 2.56, p<0.001), LVSI (HR 1.94, p<0.001) were associated with increased risk of death, while lymph node surgery (HR 0.76, p<0.001), external beam radiation (EBRT) (HR 0.82, p<0.001), and brachytherapy (HR 0.76, p<0.001) were associated with improved survival. There was no significant difference in survival between those receiving EBRT and brachytherapy alone (p>0.05). Among those receiving radiation, LVSI positive patients were less likely to receive brachytherapy than LVSI negative patients (66% vs 52%). 4-year OS for LVSI negative patients was 87% without radiation and 90% with radiation (p=0.006). For LVSI positive patients, 4-year OS was 63% without radiation and 73% with radiation (p<0.001). On subgroup analysis, LVSI positive patients experienced an OS benefit from radiation for stages I and III, but not stage II. Conclusions: Lymphovascular space invasion is an independent prognostic factor in all stages of locoregional endometrial cancer and predicted OS in stage I and III patients. Use of brachytherapy alone was less common in LVSI positive patients, but was not associated with a worse prognosis.
Disparities in Utilization and the Survival Value of Brachytherapy for Cervical Cancer in California

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1UC Davis Medical Center, Sacramento, CA, USA, 2California Cancer Registry, Sacramento, CA, USA, 3UC San Diego, San Diego, CA, USA, 4UCSF Medical Center, San Francisco, CA, USA, 5Cedars-Sinai Medical Center, Los Angeles, CA, USA.

Purpose: Despite the known benefit of brachytherapy for locally advanced cervical cancer, utilization of brachytherapy is declining nationally. Recent data from the National Cancer Database demonstrates about 45% of women receive external beam, chemotherapy and brachytherapy for the definitive management of cervical cancer. Less is known regarding potential regional differences with compliance with recommended standard of care treatment. We evaluated the use and the effect on survival of brachytherapy as part of definitive cervical cancer treatment in California. In addition, we investigated demographic, socioeconomic, and location factors that influenced trends in brachytherapy utilization. Materials and Methods: All residents of California diagnosed with cancer are required by law to be reported to the California Cancer Registry (CCR). Using data from the CCR, we identified patients with a new diagnosis of cervical cancer stage FIGO stage IB2-IVA from 2004-2014 treated with external beam radiotherapy (EBRT). We examined the trends in the use of brachytherapy based on age, race, socioeconomic status (SES), histology, stage, and year, and region within California. We used multivariable logistic regression analysis to determine predictors of use of brachytherapy. Using Cox proportional hazards, we examined the impact of a brachytherapy boost vs external beam boost on overall survival. Results: We identified 4,481 patients with complete radiation boost information (brachytherapy vs. EBRT). Distribution by FIGO stage was 11% IB2; 32% II, 54% III, 4% IVA. About a third of patients (36%) were white, 6% black, 41% Hispanic, and 16% Asian. Nearly half (45%) of patients were treated with a brachytherapy boost after EBRT, 18% were treated with an EBRT boost, and 37% were treated without a boost modality. There was no substantial increase or decrease in

![Figure 1. Overall survival for women with FIGO stage IB-II based on lymphovascular space invasion (LVSI) status and receipt of radiotherapy (RT).](image-url)
brachytherapy use over time 2004-2014. There was no significant difference in predictors for a brachytherapy boost for SES or race. There was substantial variation in the use of brachytherapy by region of residence within California, with regions surrounding Sacramento having rates of 67%, San Francisco 60%, San Diego 51%, but areas around Los Angeles and Orange County being as low as 30%. Survival analysis showed better survival with the use of brachytherapy compared to no boost, HR 1.16, 95% CI 1.02-1.31, p=.022 among the entire cohort. As patients aged, the use of brachytherapy decreased, and there was a worse survival for the oldest patients, HR 4.05, 95% CI 3.05-5.39, p<0.001. Asian and Hispanic patients had slightly better survival than whites (HR 0.787 and 0.781, p=0.016 and 0.0013, respectively). Poorer survival was observed for black patients (p=0.002), those who lived in lower SES neighborhoods (p=0.005), higher stage (p<0.0001), poorly differentiated tumors (p<0.0001). Conclusions: The overall utilization in California for a brachytherapy boost in locally advanced cervical cancer was low at 45% during this period, with a subsequent decrease in survival outcomes. There was significant variation with the utilization of brachytherapy by location in California and increasing age. We also found disparities in survival for patients with low SES, black patients, and higher stage. As we strive for outcome improvement in cervical cancer, we need to target increasing access and disparities to receipt of brachytherapy for quality and value in healthcare delivery in California.
Table 1. Survival analysis of patients for patients of cervical cancer using a Cox proportional hazards model (N =2644*)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hazard Ratio</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
<th>ProbChiSq</th>
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<tr>
<td>Boost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Brachytherapy</td>
<td>1.000</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>None</td>
<td>1.157</td>
<td>1.021</td>
<td>1.311</td>
<td>0.0223*</td>
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<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50 years</td>
<td>1.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>50-59 years</td>
<td>1.189</td>
<td>1.010</td>
<td>1.401</td>
<td>0.0381*</td>
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<tr>
<td>60-69 years</td>
<td>1.503</td>
<td>1.253</td>
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<td>70-79 years</td>
<td>1.996</td>
<td>1.623</td>
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<td>80+ years</td>
<td>4.053</td>
<td>3.051</td>
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<td>Race</td>
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<td></td>
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<tr>
<td>Non-Hispanic White</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
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<td>1.159</td>
<td>1.877</td>
<td>0.0016*</td>
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<td>Hispanic</td>
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<td>0.908</td>
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<td>0.648</td>
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<td>SES Quintile</td>
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<tr>
<td>5 (highest)</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>1.093</td>
<td>0.850</td>
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<td>1.073</td>
<td>1.729</td>
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<td>1.114</td>
<td>1.785</td>
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<td>Stage</td>
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<tr>
<td>IB2</td>
<td>1.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>II</td>
<td>1.238</td>
<td>0.960</td>
<td>1.595</td>
<td>0.0998</td>
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<td>1.903</td>
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<td>IVA</td>
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<td>3.148</td>
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<td>Histology</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squamous cell carcinoma (8050-8130)</td>
<td>1.000</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>Adenocarcinoma (8140-8490)</td>
<td>1.259</td>
<td>1.063</td>
<td>1.490</td>
<td>0.0076*</td>
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<tr>
<td>Other</td>
<td>1.194</td>
<td>0.945</td>
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<tr>
<td>Grade</td>
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<tr>
<td>Well differentiated</td>
<td>1.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Moderately differentiated</td>
<td>1.354</td>
<td>1.018</td>
<td>1.801</td>
<td>0.0374*</td>
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<tr>
<td>Poorly differentiated</td>
<td>1.782</td>
<td>1.343</td>
<td>2.364</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Undifferentiated/Anaplastic</td>
<td>1.175</td>
<td>0.767</td>
<td>1.800</td>
<td>0.4584</td>
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</table>

*Observations with missing/unknown predictor information were removed from the analysis.

*Indicates a significant p-value.
Five Years Outcomes of Image Guided Brachytherapy (IGBT) with Inverse Planning for Locally Advanced Cervical Cancer
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Department of Radiation Oncology and Department of Physics, CHU de Québec and Université Laval, Quebec, QC, Canada.

Purpose: In locally advanced cervical cancer, IGBT enables dose escalation. Very few centers use inverse planning for dose optimization. The aim of this study is to assess the efficacy of Inverse Planning Simulated Annealing (IPSA), as a 3D optimization tool, as well as treatment toxicities. Materials and Methods: From January 2010 to November 2015, 56 patients with locally advanced cervical cancer were treated with External Beam Radiotherapy (EBRT) and concomitant platinum based chemotherapy, followed by IGBT. A CT-SCAN was used for treatment optimization. The week before brachytherapy, an MRI was acquired and used as a guide for contouring. IPSA was used for IGBT optimization. Kaplan-Meier estimates at 2 years were calculated for cancer specific survival (CSS) and overall survival (OS). The 2 years cumulative incidences of local, locoregional and distant failure were also determined. G3 and G4 late toxicities were reported, using CTCAE v4.0. Results: Median follow-up was 26 months. Most patients (71.4%) had squamous cell carcinomas. Mean EBRT dose was 45.62±1.34 Gy. Among the 56 patients, FIGO stage IA2/IIB, IB2/IIA1/IIA2, IIIB, IIIA/IIIB, IVA were respectively, 7.1%(4), 16.1%(9), 58.9%(33), 16.1%(9), 1.8%(1). Forty eight percent (27) had lymph node involvement. Mean D90 at target was 85.07±3.73 Gy (EQD2 10). Mean D2cc in EQD2 for rectum, sigmoid and bladder were respectively: 63.38±6.68 Gy, 63.34±7.50 Gy and 74.27±9.14 Gy. The incidences of local failure, locoregional failure and distant failure were respectively: 5.36% (3), 8.93% (5) and 23.21% (13). The 2 years CSS and OS were 80.9% and 77.5%. No grade 4 or higher late toxicity was diagnosed. Late grade 3 toxicity developed in 11 patients (4 GI, 2 GU, 2 vaginal fistulas and 1 pulmonary embolism). Conclusions: IGBT boost using IPSA, combined with EBRT and concomitant chemotherapy, in locally advanced cervical cancer, is as effective as other optimization methods to provide excellent local control and minimal severe toxicities.

PO33
Feasibility of a Biomechanical Model Based Deformable Image Registration for MRI Guided CT-Based Brachytherapy for Locally Advanced Cervical Cancer
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Radiation Oncology, University of California Davis Comprehensive Cancer Center, Sacramento, CA, USA.

Purpose: Pre-implantation magnetic resonance image is readily available to guide high-dose-rate (HDR) brachytherapy treatment for cervical cancer patients, but is historical fraught with difficulty in utilization due to variations in target volume introduced by the brachytherapy applicators. To increase the value of target delineation and efficiency in image guided brachytherapy for cervical cancer, deformable image registration of the pre-implantation MRI and planning CT scans for brachytherapy continues to be appealing. We propose that the pre-MRI can be used to guide CT-based brachytherapy following a workflow using a commercially available biomechanical model based (MORFEUS) deformable image registration (DIR) for cervical cancer treatments. Materials and Methods: In this retrospective pilot study, five cervical cancer patients previously treated with HDR brachytherapy were included. Each patient received an MRI without the brachytherapy applicator (pre-MRI) and a CT image prior to treatment with the applicator inserted (post-CT). A set of structures, including rectum, bladder, uterus, vagina, and femoral heads were contoured on both MRI and CT images for each patient. The high risk clinical target volume (HRCTV-MRI) and gross target volume (GTV-MRI) were delineated by the attending on the pre-MRI image. The post-CT image had a prospectively drawn HRCTV-CT during the time of brachytherapy treatment. The contours from the MRI and CT were then converted to model-based segmentations (MBS) for deformation use. The pre-MRI was registered with and deformed to the post-CT based on the MBS structures in the Raystation treatment planning system. A deformed GTV was then projected on the post-CT image (GTV-CT), and correlated with the HRCTV-CT. The deformation accuracy of this approach was also evaluated using volume and center of mass (COM) differences. Results: Morfeus algorithm required controlling regions of interests (ROIs) in the MBS form for image deformation between MR and CT images. Bladder, rectum, cervix, and uterus ROIs were used for each DIR. We found no improvement in terms of DIR accuracy with including the femoral heads. When compared the physician-drawn structures to the DIR-mapped structures, the volume differences on CT ranged from 1.22 to 2.85 cc for
uterus, and 0.01 to 25.69 cc for cervix. The differences in COM between physician-drawn HR-CTV and DIR-mapped GTV on CT images ranged from 0.42 cm to 1.95 cm. The uterus was found to be the most relevant structure with the COM difference (p=0.11), since it is enclosing the subject of interest (GTV). Results demonstrated that the accuracy and integrity of the DIR were superior when the volumes of rectum and bladder, as well as the locations of ROIs relative to each other remained consistent between pre-MRI and post-CT scans. Conclusions: In the era of value based medicine and image guidance in gynecologic brachytherapy, we strive to increase efficiency and target accuracy with deformable image registration. The results from our pilot study indicate that it is feasible to utilize the pre-MRI through the biomechanical model based image deformation for guiding the CT-based brachytherapy treatment in defining the target for cervical cancer. We continue to work on the clinical application of the MORFEUS DIR algorithm for patients with cervical cancer. High accuracy and reliability can be achieved with consistent rectum and bladder volumes, as well as consistent relative ROI locations between pre-MRI and post-CT images.

Figure 1: Deformable and rigid image registration between pre-MRI (in blue) and post-CT (in grey) in (a) transversal, (b) coronal, and (c) sagittal views. For each panel, the figure on the left shows the deformable image registration, and the figure on the right shows the rigid image registration. ROIs for rectum, bladder, uterus, and cervix are shown in burgundy, brown, orange, and pink colors. The physician-drawn GTV on MR and mapped GTV on CT are both shown in yellow. The solid lines represent the structure on the primary image (CT); and the dashed lines represent the structures on the secondary image (MR). Dashed lines are shown well-matching with the solid lines with deformation.

PO34
High Dose-Rate Tandem and Ovoid Brachytherapy in Cervical Cancer: Dosimetric Predictors of Disease Control and Toxicity
Daniel M. Trifiletti, MD1, M. Sean Peach, MD, PhD1, Bethany J. Horton, PhD2, Neil R. Shah, MPH1, Bruce Libby, PhD1, Timothy N. Showalter, MD, MPH1.
1Radiation Oncology, University of Virginia Health System, Charlottesville, VA, USA, 2Department of Public Health Sciences, University of Virginia Health System, Charlottesville, VA, USA.

Purpose: To investigate the rate of and factors influencing gastrointestinal (GI) and genitourinary (GU) toxicity following high dose-rate (HDR) tandem and ovoid brachytherapy in the treatment of locally advanced cervical cancer. Materials and Methods: A retrospective chart review of patients with locally advanced cervical cancer treated at our institution was performed. Inclusion criteria included patients treated with HDR and with CT-based planning. Statistical analyses aimed to develop clinical and dosimetric predictors for GI and GU toxicity following HDR brachytherapy according to CTCAE v4.0 grading criteria. Cumulative doses were calculated using the linear-
quadratic model and compared to published American Brachytherapy Society (ABS) guidelines. **Results:** Fifty-six women met inclusion criteria. Eight patients (14.3%) developed a grade 3+ GI toxicity, 4 patients (7.2%) developed a grade 3+ GU toxicity, 3 patients (5.4%) developed a grade 3+ hematologic toxicity, and 4 patients (7.2%) developed a grade 3+ non-hematologic/GI/GU toxicity. Among patients with grade 3+ GU toxicity, 1 (25%) had dose of 80 Gy or less, 1 (25%) had dose between 80 and 90 Gy, and 2 (50%) had dose greater than 90 Gy. A cumulative bladder D2cc threshold of 90 Gy permitted a 5.6% rate of grade 3+ GU toxicity, compared to a 3.6% rate of grade 3+ GU toxicity if a threshold of 80 Gy is adhered to (Figure). Among patients with grade 3+ GI toxicity: 2 (25%) had rectal D2cc of 65 Gy or less, 3 (37.5%) had dose between 65 and 75 Gy, and 3 (37.5%) had dose greater than 75 Gy; 1 (12.5%) had dose of 65 Gy or less, 5 (62.5%) had dose between 65 and 75 Gy, and 2 (25%) had dose greater than 75 Gy. A cumulative rectal D2cc threshold of 75 Gy resulted in a 16.1% rate of grade 3+ GI toxicity, versus a 18.2% rate of grade 3+ GI toxicity if a threshold of 65 Gy is adhered to. A cumulative sigmoid D2cc threshold of 75 Gy permitted a 14.6% rate of grade 3+ GI toxicity, compared to a 4.5% rate of grade 3+ GI toxicity if a threshold of 65 Gy is adhered to. **Conclusions:** In clinical practice, a relatively high rate of GI and GU toxicity is possible even with adherence to current ABS guidelines for dosimetric objectives. Every attempt should be made to minimize dose to normal organs, including targeting cumulative D2cc organ doses well below standard objectives. Grade 3+ GI toxicities were observed even with cumulative rectal D2cc less than 65 Gy. We suggest considering more stringent cumulative D2cc dosimetric goals than in current ABS guidelines: less than 80 Gy for the bladder and less than 65 Gy (or as low as achievable without compromising local control) for the rectum and sigmoid.

**Miscellaneous Posters**

**PO36**

**Investigation of a New Device to Improve Dosimetric Outcomes in Intravascular Brachytherapy**

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**Purpose:** Coronary artery disease is amongst the main causes of death in developed countries. Percutaneous Transluminal Coronary Angioplasty (PTCA or angioplasty) is a procedure used to open stenotated (narrowed) arteries. Restenosis (reenarrowing) of the treated vessel is a major complication of PTCA. A metal mesh tube (stent) is expanded inside the vessel to prevent restenosis. Tissue stress incurred during angioplasty and stenting can provoke rapid proliferation of neointimal cells leading to in-stent restenosis (ISR). Intravascular brachytherapy (IVBT), a form of internal radiotherapy, is used to treat ISR. Renewed interest in IVBT is being expressed as a treatment for patients with ISR in Drug Eluting Stents. Existing catheter based intravascular brachytherapy devices use a guidewire that is mounted on the outside of the delivery catheter. This has been shown to reduce the dose to target tissue behind the guidewire by as much as 35% from Sr-90/Y-90 based devices. If IVBT seeds with a hollow center were developed such that a guidewire could run interior to the seeds we hypothesize that localized dose reductions from guidewires in IVBT should vanish. Treatment times may also be reduced when using IVBT devices with a guidewire in the center because the radioisotope can be placed closer to the edge of the delivery catheter which should increase the dose delivered per particle to the target arterial walls. The activity of a source can be increased by increasing the total amount of active core material in each seed. Cylindrical shell seeds should be able to carry more active material than seeds currently used in IVBT because area scales with $r^2$. Each of these factors motivates the investigation of IVBT devices with cylindrical shell seeds and interior guidewires. We perform a dosimetric analysis to evaluate the viability of one such device. **Materials and Methods:** A dosimetric analysis of an experimental Sr-90/Y-90 based device using cylindrical shell seeds with a guidewire in the center and of an existing Sr-90/Y-90 based device (Novoste Beta Cath) was performed in a Monte Carlo based particle simulation (Geant4). Absorbed dose was calculated in water as a function of distance from the source and theta. **Results:** Dose delivered around the experimental device in water is homogeneous as a function of theta. Dose delivered around the Novoste Beta Cath 3.5F with guidewire varies greatly with theta and is reduced by as much as 49% at 2 mm (the target distance) in regions behind the guidewire. Dose per particle from both devices are approximately equivalent. The amount of active core material in the experimental device was increased by 25% compared to the Novoste Beta Cath. **Conclusions:** The experimental device considered delivers a homogeneous dose as a function of theta around the device with the potential for 25% greater activity than the Novoste Beta Cath. New IVBT devices can rectify existing dosimetric issues and decrease treatment times which may help improve patient outcomes.
Diagram of intravascular brachytherapy devices tested
(Left) Novoste Beta Cath 3.5F (Right) Experimental device

Dose as a function of theta in water, normalized to 22 Gy at 2 mm.
(Left) Novoste Beta Cath with guidewire (Right) Experimental Device

Dose at 2 mm as a function of theta
Purpose: To observe the therapeutic and application effect of CT-guided 3D print coplanar template in brachytherapy. Materials and Methods: 20 patients were recruited in our study. Of all the patients, 10 patients received brachytherapy by CT-guided 3D print coplanar template, and the rests, as the control group, by manual methods. During two days before the surgery, the patients received the CT scan and the dicom image data were collected. And then the preoperative plan was made and real-time plan in operation and dose verification after-operation were recorded and to see whether they satisfied quality evaluation system for particle implantation in Columbia Cancer Center. Descriptive and analytical statistics were performed using SPSS17.0 software. Comparisons for two pairs were performed using the Students-t test. Values of P<0.01 were considered to indicate statistically significant differences. Results: The dose error rate among the experimental group patients (who received brachytherapy by CT-guided 3D print coplanar template) and the control group (who received therapy by manual-assisted) has statistical significance (P < 0.01). Statistics shows that the general operation time of experimental group was shorter than the control group. Compared preoperation and after-surgery, D90 and CI in experimental group and CI in control group had no statistical significance (P = 0.155, P = 0.279, P = 0.147), while D90 and CI in the control group and EI in the experiment group had statistical significance (P = 0.029, P = 0.002, P = 0.025). Conclusions: Brachytherapy using 3D print coplanar template could improve the accuracy of needle path and implanted particle position, obtaining better effect and safety than the manual methods. Works mentioned above can not only ensured the needles distribution but also the uniformity of the intraoperative and preoperative plan-dose. The advantages such as reducing the frequency of CT scans, the operation time and the surgery study time can also easily observed. Operation on this kind can also ensure the optimum of source distribution, avoiding the cold area and hot spot of the dose distribution.
The Initial Study on the Dosimetry and Safety of Self-Expandable Esophageal Stent Loaded with $^{125}$I Seeds in Treatment of Esophageal Cancer

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**Purpose:** To study on the dosimetry and safety of self-expandable esophageal stent loaded with $^{125}$I seeds in the treatment of advanced esophageal cancer. **Materials and Methods:** Inclusion criteria: the primary and recurrence esophageal cancer, dysphagia scores (Grade 3-4), ECOG 0-2, thoracic esophagus cancer, excluding esophageal fistula and the external pressure stenosis. From July 14 of 2014 to April 28 of 2016, 28 experimental patients were divided into two subgroups, Group A-10 cases of the primary group without radiotherapy: 8 cases of primary malignant esophageal stenosis who cannot tolerate or refuse surgery or radiotherapy, and 2 cases of anastomotic recurrence after esophagectomy who refuse radiotherapy; Group B-18 cases of the recurrence group after radiotherapy: 16 cases of esophageal cancer who had local recurrence or been uncontrolled after radiotherapy and 2 cases of postoperative anastomotic recurrence after radiotherapy. The whole group was including 17 cases of dysphagia scores Grade 3 and 11 cases of Grade 4, 27 cases of Squamous cell carcinoma and 1 case of Adenocarcinoma, 6 cases of locating to the upper part of thorax, 14 cases of the middle part of thorax, 4 cases of the lower part of thorax and 4 cases of the anastomotic stoma. Iodine activity: 0.4 ~ 0.8 mCi, three group of prescription dose: 50 ~ 70 Gy, 70 ~ 90 Gy, 90 ~ 110 Gy. Design the preoperative plan by TPS with the Thoracic Contrast CT, and plan to bundle 6 particles each layer with 1.0 cm layer interval. According to the preoperative plan, book particles and stents, and plant the stent, then examine for postoperative dose verification by TPS after third days. **Results:** The stents were successfully placed in the diseased esophagus in all 28 patients. The median survival time was 150 days, and the survival rates of 30, 90, 150 days were 88.5%, 60.4%, 46% respectively. The median survival time of Group A and Group B were 300, 72 days respectively. The interval time between previous treatment and recurrence included <6 months group, 6 ~ 12 months group and >12 months group. The median survival time were 41.6, 16 days respectively. The single factor analysis showed that the main factors influencing survival were the history of treatment and the interval time between previous treatment and recurrence, the differences was statistically significant ($P = 0.026/0.03$). The Iodine activity did not show a statistically significant effect on survival time ($P = 0.728$). The Primary Group: the median survival time of the higher activity group (0.6 ~ 0.8 mCi) and the lower group (0.4 ~ 0.5 mCi) were 367, 300 days respectively, the two groups had no statistically significant ($P = 0.076$). The D90 of postoperative did not show a statistically significant effect on survival time ($P = 0.066$), the median survival time of 50-70 Gy, 70-90 Gy and 90-110 Gy were 115 d, 300 d and 47 d respectively. 26 (92.9%) patients experienced dull chest pain after stent insertion, 23 (82.2%) of them tolerated the pain without medication. And 3 (10.7%) patients suffered severe chest pain,
who needed with narcotic analgesics treatment. Gastrointestinal Hemorrhage occurred in 8 (28.6%) patients in four groups combined during follow-up, 2 patients were controlled, 6 (21.4%) patients died from acute massive hemorrhage. 2 cases were malignant restenosis of postoperative anastomotic recurrence after radiotherapy, and 3 cases were uncontrolled of esophageal cancer after radiotherapy within 3 months. No complete migration of stents was demonstrated. The single factor analysis showed that the main factors influencing death were gastrointestinal hemorrhage and chronic consumption (the median survival time: 26d, 150d, \( P = 0.04 \)). **Conclusions:** Esophageal stent with \(^{125}\text{I}\) seeds implantation is a effect treatment to relieve the symptoms of dysphagia and prolong the survival time of esophageal cancer patients. Our study showed that the higher activity group had a better tendency advantage than the other group in the Primary Group. 70-90Gy group had a better tendency advantage than other groups. And we need to study further to find the best prescription dose and Iodine activity. Hemorrhage is the main factor of short survival time after esophageal stent implantation. The higher risks patients are cases of postoperative anastomotic recurrence after radiotherapy, and uncontrolled of esophageal cancer after radiotherapy within 3 months.

**PO41**

125\(^{I}\) Brachytherapy Alone for Recurrent or Locally Advanced Salivary Gland Cancers of Maxillary Region

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**Purpose:** To present our treatment experiences and results, and to evaluate the feasibility and effectiveness of 125\(^{I}\) brachytherapy in recurrent and/or locally advanced salivary gland cancers of maxillary region. **Materials and Methods:** Thirty-six patients with recurrent and/or locally advanced salivary gland cancers of maxillary region received 125\(^{I}\) implant brachytherapy in Peking University School and Hospital of Stomatoloy from 2010 to 2015. Eighteen cases were recurrent cases after prior surgeries and radiation. And other 18 cases were primary tumors. All patients received interstitial 125\(^{I}\) seeds implant alone under the 3D individual template guide. The prescribed dose was 120-160Gy. The activity of 125\(^{I}\) seeds were 18.5 to 33.3 MBq per seed. The number of seeds implanted was 16-125 (median 55). **Results:** Followed 6-65 months (median 38 months), the 2-year, 5-year local control rates were 86.5% and 60.2%, respectively. The 2-year, 5-year overall survival rates 93.8% and 66.2%. Tumors >6cm had significantly lower local control and survival rates. No severe complications (RTOG 3-4) were observed during the follow-up. **Conclusions:** 125\(^{I}\) brachytherapy was an elective alternative to treat local advanced unresectable or recurrent salivary gland cancers of maxillary region with few complications. **Figure legends** Fig1A: Myoepithelial carcinoma in the left maxillary region. Fig1B: Make the preplan to confirm the needle pathway and seeds sites. Fig1C: Implant the 125\(^{I}\) radioactive seeds guided by 3D printed individual template. Fig1D: CT images showed the needles guided by 3D printed individual template. Fig1E: 125\(^{I}\) radioactive seeds distribution in CT images after implantation. Fig1F: No recurrence occurred 2 years after implantation.
PO43
The Clinical Use of I-125 Brachytherapy to Treat Malignant Adenogenous Tumors Invaded Cranial Base Area
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Purpose: The purpose of this article is to make analysis and summary of patients using I-125 brachytherapy to treat malignant adenogenous tumors which invaded cranial base area, and to evaluate the preliminary prognosis and correlative factors. Materials and Methods: This study selected 24 patients who had malignant adenogenous tumors which invaded cranial base area and were admitted in Department of Oral & Maxillofacial Surgery, Peking University, School of Stomatology between the year 2007 and 2015. All of the patients were given a definite diagnose of pathology, in which 14 were diagnosed as adenoid cystic carcinoma, 3 were acinic cell carcinoma, 3 were mucoepidermoid carcinoma, 2 were pleomorphic adenoma with malignant transformation, 1 was adenocarcinoma, 1 was myoepithelial carcinoma. The area of tumor invaded included anterior, lateral and middle cranial base and 1 of 24 was primary tumor, the others were recurrent. All of the patients received I-125 brachytherapy, after which treatment quality examination were taken, and they were interviewed regularly to observe the outcomes and complications. Survival rate, distant metastasis and security of treatment were evaluated, and correlative factors of prognosis were analyzed which included age, pathology diagnosis, diameter of the tumor, area of tumor invasion and history of radiotherapy. Results: 1. The follow-up time of the 24 patients with malignant adenogenous tumors invaded cranial base area which received I-125 brachytherapy were 3-76 months. The median follow-up time were 27 months, and 14 patients were dead until the follow-up ended. 2. The result of quality verification showed that the D90 of all patients were equal or greater than 95%PD, the dosage at the center of the target area ranged from 160 to 275Gy, which indicated the dosage of GTV (Gross tumor volume) met the requirement of treatment and no “cold region” was detected. 3. During the period of interview, symptoms and dysfunction were observed in 7 patients, 2 patients had radiotherapy reaction of level 3-4. Conclusions: 1. I-125
brachytherapy is a safe, effective and minimally invasive technique to treat malignant adenogenous tumors invaded cranial base area. 2. The result of survival analysis proved 1-125 brachytherapy treating malignant adenogenous tumors which invaded cranial base area has definite clinical effect; There was obvious difference of survival rate between patients who had local recurrence and who didn’t (p=0.047); To those who had distant metastasis, especially in the lung, this treatment can also obtain fair short-term efficacy while life quality remains unchanged. 3. The result of correlative factors analysis of prognosis showed the diameter of tumor is correlative factors (p=0.047, OR=0.106) while patient’s age, area of tumor invasion, pathology diagnosis and history of radiotherapy are not. 4. The sample volume of this group of patients was small, and the follow-up time had obvious difference, the long-term prognosis and survival rate need further analysis; the dose distribution in PTV (Planning target volume) and important structures around need further research.

PO45
Directional LDR Intraoperative Brachytherapy for Head and Neck Cancer
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Purpose: This study investigated the feasibility of using intraoperative directional brachytherapy for treatment of squamous cell carcinoma of the oropharynx. The patient had received a prior course of external beam therapy of 70 Gy in 2015. Due to positive margins near the carotid after the resection, and the increased risk of additional external radiation, brachytherapy was considered as a treatment option. Materials and Methods: A commercially available flexible, bio-absorbable polymer membrane embedded with an array of discrete Pd-103 sources was utilized for the implant. The Pd-103 sources were spaced 8 mm apart on a rectangular grid. Unidirectional dose was achieved by a 0.05 mm thick gold disk-shaped foil on the reverse side of each source. A dose of 120 Gy at 5 mm depth was prescribed. After the resection, the entire sheet was placed on the treatment area in the patient to determine the needed dimensions. The polymer sheet was then removed and easily cut to size with scissors leaving 26 Pd-103 sources remaining. The surgeon used 3.0 vicryl sutures for attachment in a concave shape near the carotid artery, where there was a positive margin. The gold foil was positioned to protect the neck flap and closure. The surgical team completed the procedure and the patient recovered without any problems. Results: The patient received a CT scan in the Radiation Oncology department. The images were transferred to the Varian Variseed computer for a post plan. The treatment plan indicated that the sources remained in position in a concave array pattern. Due to the dose fall-off of Pd-103, the calculated dose to critical structures was minimized. Conclusions: The surgical implant of the sheet proceeded as expected with no complications. The post plan indicated that the sheet remained in position with the radioactive side contacting the treatment area. Directional LDR intraoperative brachytherapy is a feasible treatment strategy for positive margins near the carotid artery.
PO46

Nuclei Size Distribution as a Predictor for Radiosensitivity with $^{192}$Ir Brachytherapy

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Purpose: Ionizing radiation sterilizes tumor cells or inhibits cell cycling mainly by damaging the DNA in the tumor cell nucleus. However, tissue response to ionizing radiation varies widely between different tissue and tumor types, and types of radiation. The variation of radiation response may also vary between patients. Identification of the causes of this variability in radiation sensitivity could have important implications for cancer therapy. It is well known that the variance of specific energy imparted per cell (dose per cell) increases with decreasing cell size. The size of cells and nuclei depends on tissue type, cell cycle, and malignancy, all of which also vary between patients. Given the importance of DNA damage, the dose to cell nuclei is probably the most relevant quantity for dose response correlations. The aim of this study was to characterize radiosensitivity for cell lines from cancer types commonly treated with brachytherapy by associating the induction of double strand breaks (DSBs) from $^{192}$Ir brachytherapy irradiation to nuclei size distribution variation within a cell population. Materials and Methods: The proposed cell lines selected for this study comprise the cervix HeLa (CCL-2™, ATCC) and prostate PC-3 (CRL-1435™, ATCC) adenocarcinoma cells based on its applicability in clinical brachytherapy treatments. Both cell lines were plated in 60 mm cell culture dishes at a seeding density of $1.0 \times 10^6$ cells/5 mL overnight prior to irradiation experiments. The in vitro treatment apparatus composed of a mold surface applicator constituted of catheters for the afterloader housing the $^{192}$Ir radiation source with solid water slabs positioned above and below the radioactive source in order to ensure optimum scatter conditions. The modeling of the irradiation setup was performed with a
commercial dose treatment planning system for the prescribed doses of 0, 1, 2, 4, and 6 Gy. Intranuclear DAPI and γ-H2AX multi-staining protocol followed after irradiation for nuclei region and induced DSB detection, respectively. Fluorescent-labeled cell lines for each dose were quantified with image-flow cytometry (Amnis ImageStream X Mark II, EMD Millipore) and analyzed via its corresponding IDEAS software. Cell and nuclei size distribution were calculated per individual diameters designated by bright field and DAPI fluoresced regions, respectively. DSB computation was isolated to DAPI fluoresced regions to identify the induction of DSB within the nuclei solely due to clustered damage from ionizing radiation. A count above five DSBs per cell was chosen to be indicative of high selective DSB damage due to the prescribed doses. **Results:** Overall, image-flow cytometry demonstrated that the cervix HeLa cell and nuclei sizes ranged considerably smaller in comparison to the prostate PC-3 cell line. HeLa cell sizes ranged between 13-24 µm with a mean of 18 µm, whereas PC-3 cell sizes ranged between 16-31 µm with a mean of 24 µm. Within the point of interest for DSB damage, HeLa nuclei sizes ranged between 7-17 µm with a mean of 11 µm, whereas PC-3 nuclei sizes ranged between 9-23 µm with a mean of 15 µm. The provided figure presents fluoresced regions of irradiated HeLa cells and its interpretation for DSBs. **Conclusions:** As a preliminary study, we found that the cell and nuclei size distribution between the HeLa and PC-3 cells differ, in which this will impact the DSB distribution based on the overlay of energy distribution from brachytherapy radiation treatments.
PO49
Iodine-125 Implantation Combined with Radiofrequency Ablation in the Treatment of Hepatocellular Carcinoma: A Meta Analysis
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Purpose: To evaluate the efficacy and safety of iodine-125 implantation combined with radiofrequency ablation (RFA) in the treatment of hepatocellular carcinoma, so as to provide references for clinical practice and study.

Materials and Methods: Randomized controlled trials (RCTs) of RFA-125I seed implantation based-therapy were identified by electronic searches in the Cochrane Library, PubMed, Wan fang, VIP, CNKI and other electronic databases. Meta-analysis was conducted by the Cochrane Collaboration RevMan 5.2 software. For qualitative data, data mainly adopts descriptive methods. The quality of the evidence and the grade of recommendation were evaluated using the Jadda scale. Results: A total of 4 RCTs involving 300 patients were included. The results of meta-analyses showed that: There were significant differences between the RFA-125I seed implantation group and the RFA group in 1-, 2-, 3-year survival rate, with OR=2.92, 95% CI(1.23, 6.93), P=0.01 VS OR=2.48, 95% CI(1.27, 4.85), P=0.008 VS OR=2.16, 95% CI(1.21, 3.83), P=0.009, respectively, also recurrence rate and efficacy. There was no significant difference in the adverse events. Conclusions: Compared with RFA alone, RFA-125I seed implantation can improve quality of life, treatment response and survival rate.
PO50
Iodine-125 Seed Implantation in the Treatment of Locally Recurrent Sacrococcygeal Chordoma: Report of 3 Cases and Review of Literature
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**Purpose:** To investigate the efficacy of iodine-125 seed implantation in the treatment of sacrococcygeal chordoma.
**Background:** Chordoma is rare in low to intermediate-grade malignant tumors originated from the rudimental notochord cells of embryonic period. Radical resection is the main therapeutic method, however, postoperative local recurrence rate is as high as 44%, and the treatment after LR has been plagued clinicians. **Materials and Methods:** 3 patients with sacrococcygeal chordoma treated (radioactive iodine-125 seed implantation therapy after postoperative local recurrence after radiotherapy) in our department were analyzed retrospectively. A per-plan was performed before the operation and the PD was 80-100 Gy. The seeds activity was 0.6-0.7 mCi and the seeds number was 80-90. A post-plan was carried out right after the operation and the D90 was 84-98 Gy. **Results:** 3 cases patients of sacrococcygeal chordoma of postoperative local recurrence after radiotherapy underwent radioactive iodine-125 seed implantation therapy in our department, patients' pain gradually ease after operation. After 6 months 3 patients reached PR. **Conclusions:** Radioactive iodine-125 seed implantation therapy can effectively ease the pain of patients with sacrococcygeal chordoma, improve the quality of life, can be used as the preferred method of treatment of patients with sacrococcygeal chordoma of postoperative local recurrence after radiotherapy.

PO51
Iodine-125 Salvage Therapy for Recurrent Gliomas
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**Purpose:** To investigate the feasibility and efficacy of the treatment of recurrent intracranial glioma with iodine-125 particles, as a method of promoting tumor target area dose and high salvage therapy. **Materials and Methods:** Summarize the clinical data of 88 patients with recurrent gliomas after surgery or radiotherapy in 5 hospitals from China, and to investigate the therapeutic effect of iodine-125 brachytherapy. Operation time is from December 2003 to November 2015, a total of 86 iodine-125 particles brachytherapy, focus on the target area and dose, efficacy and safety. **Results:** PD110-210 Gy, median PD145 Gy in patients with gliomas after surgery; PD60-130 Gy, median PD85 Gy in patients with recurrent gliomas after radiotherapy. The overall survival (OS) of patients with recurrent gliomas and recurrence of gliomas after radiotherapy is 7-144 months and 12-60 months, respectively. The mean progression free survival is 11 months and 9 months. **Conclusions:** The therapeutic effect of iodine-125 seeds in the treatment of intracranial recurrent glioma is wide, with fewer complications and obvious curative effect, increasing the chances of a salvage treatment for patients. Iodine-125 seeds can be used as salvage therapy for glioma recurrence.

PO52
The Role of Real-Time Optimization of Radioactive Seed Implantation in Treatment of Gliomas
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**Purpose:** To study the role of real-time optimization of 125I seed implantation in the treatment of gliomas. **Materials and Methods:** Thirty-eight cases were enrolled in this retrospective study. 21 cases with 24 lesions involved from October 1st 2013 to September 30th 2015 were only performed preoperative planning and postoperative verification. 17 cases with 21 lesions involved from October 1st 2015 to September 30th 2016 were additional performed real-
time optimization during the operation. D90, mPD, V90, V100, V150, and V200 were recorded. D90 and mPD were compared between preoperative planning and postoperative verification. V90, V100, V150, and V200 were compared of the inter-group postoperative verification. Paired t test was used to compare the difference within group. Independent sample test was use to compare the difference between groups. Results: There were no difference in D90 and mPD between preplan and post-plan of a group, but were difference of B group. There were difference in V90, V100, and V150 of post-plan between A group and B group but no difference in V150 and V200.  
Conclusions: Real-time optimization during operation could insure the good measure of preoperative planning to guarantee the reasonable distribution of postoperative dose and is of great value in the brachytherapy of brain tumors.

PO53  
The Influence of Target Volume by CT-MRI Image Fusion in Brachytherapy for Intracranial Malignant Gliomas  
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Purpose: To study the influence of target volume by CT-MRI image fusion in brachytherapy for intracranial malignant gliomas. Materials and Methods: Sixteen cases were enrolled in this prospective study. CT-enhanced images and MRI-enhanced images collected in the same period were transmitted to image processing workstation and fused into CT-MRI images, and then 18 pairs of plan tumor volume (PTV) were delineated in CT enhancement, MRI enhancement and CT-MRI by therapy planning system, and finally difference was compared between each two group by paired t test. Results: The value of PTVMRI enhancement was 66.12±29.01cm³, of PTVfusion was 60.12±29.10cm³, and of PTVCT enhancement was 69.04±29.83cm³. There were no difference between PTVMRI enhancement and PTVfusion, but were difference between PTVCT enhancement and PTVfusion. Conclusions: The improving accuracy of malignant gliomas'target volume sketched by CT-MRI image fusion is more suitable for the setup of preoperative plan to ensure the success of the operation.

PO54  
Endoscope-Guidable Multichannel Applicator for Brachytherapy of Esophageal Cancer  
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Purpose: To optimize the dose prescription to the target by sparing healthy tissue for High-Dose-Rate brachytherapy (BT) treatment of esophageal cancer, a novel multichannel endoscope-guidable esophageal applicator design is introduced. Materials and Methods: The BT applicator consists of ten 5 french plastic tubes (lumenCare® Azure, Nucletron) which are equidistantly mounted around a 8 mm plastic catheter. This catheter has an inner bore diameter of 6.5 mm, through which a paediatric endoscope can be inserted to guide the optimal placement of the BT applicator, and an outer diameter of 12 mm. The entire BT procedure is performed under general anaesthesia allowing better patient compliance and stable applicator geometry. Through the endoscope the exact location and dimensions of the tumor are recorded and marked with clips and an submural injected contrast-agent Jopamidol (Jopamiro 300mg J/ml, Patheon S.p.A Italy) . Than the BT applicator is inserted with guidance of the paediatric endoscope and fixed. For treatment planning, a CT scan (Siemens, Somatom Definition AS) with 2mm slice thickness is acquired with BT-applicator in place. Selection of prescribed dose, the treatment length, prescription depth, and definitions of the essential target sectors (in portions of min. 36°) to avoid to treat the entire circumference is based on the information from Endoscopy and CT. Dwell positions are activated only in the relevant peripheral catheters, without a central source to treat the superficial tumors involving not more than 50% of the esophageal circumference. Results: For the standard prescription depth of 5mm into the esophageal wall at a
target sector of 108 ° (dose 100% = 5-7 Gy per fraction for 3 fractions) the surface dose on the target side is 333% and 145% in 3mm tissue depth, while the contralateral normal tissue wall receives a dose of 36% at 5mm, 44% at 3mm and 64% at the surface. In comparison to a central source design in standard esophageal BT applicators, the dose would be 220% on the applicator surface, 130% in 3 mm and 100% in 5 mm for the entire circumference of the target area. **Conclusions:** The novel esophageal applicator design gives more individualized treatment options and allows reducing the dose to normal tissue in comparison to standard treatments, as well as an endoscopic guided applicator placement. Clinical use of this novel applicator design is feasible and was successfully implemented in two patients at our institution.
Clinical setting of the endoscope-guidable multichannel BT applicator

Endoscopic view of the tumor ~30% of the circumference

Endoscopic view through the BT applicator into esophagus

Isodose distribution of multichannel esophageal BT applicator

- Central channel (single) versus multichannel

- Dose distribution at different distances from the applicator:
  - 5 mm: 36% (100%)
  - 3 mm: 44% (130%)
  - Surface: 64% (220%)
  - 5 mm: 333% (220%)
The Therapeutic Value of 3D Printing Template Assisted $^{125}$I Seed Implantation in the Treatment of Liver Malignant Tumor

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**Purpose:** This study is to explore the therapeutic value of 3D printing template-assisted $^{125}$I seed implantation in the treatment of liver malignant tumor. **Materials and Methods:** 1. General Information 15 cases liver tumor patients were treated with 3D print template-assisted $^{125}$I seed implantation for group A, and 25 cases liver tumor patients were treated with $^{125}$I seed implantation without template auxiliary as control for group B. 2. Instrument and Equipment • 3D printing template. 1122 type photosensitive resin. Brachytherapy planning system, TPS: Prowess Panther Brachy v5.0. $^{125}$I seed: type 6711-99, Particle activity 0.8mCi, energy 27-35keV, half-life period 59.4days. 3. Therapeutic method • Preoperative plan and 3D template print. Group A, according to the nidus to choose supine position or prone position. Set three hemispherical plastic tag near the operative area. Line in 5 mm thick layer of CT scans, including the whole liver and the position mark point. Transfer the result in Dicom format to the TPS system, delineate target region and setting Prescription dose as 12000cGy, simulate inserting pin, adjust the pin and the particle position to make the dose conform to the condition: 1. The minimal periphery dose = prescription dose. 2. D90 > mPD. 3. V100>95%. After preoperative plan finished, enter the 3D printing system, print templates and order the particle. Group B: all procedures are just like group A except enter the 3D printing system, print templates. 3.2 Therapeutic process Place the template according to the positioning mark, use 18G puncture needle to inset focus, recheck CT, if conform to the plan, then chose the 2nd place to inset needle just like the same way. If it’s not conform to the plan, redo the puncture until the needle’s place conform to the plan. With 3 needle fixed template and liver, inset 18G needles according the template guided under local anesthesia, recheck CT, make sure all needles’ place are right and then place seeds as the plan. 3.3 Postoperative validation Do CT immediately after the seed implantation, all conditions just as former. Transfer the result in Dicom format to the TPS system to verified postoperative. Receive postoperative isodose curve, dose volume histogram and other parameter. 4. Follow-up, therapeutic evaluation and side effects observed All patients who have accept $^{125}$I seeds implantation treatment recheck CT or MRI after 1, 2 and 3 month. Compare nidus’ size with 2 month ago. Measure the biggest diameter of the tumor, add all nidus’ diameter and analyzed statistically. According to RECIST 1.1 Evaluation criteria in solid tumors, there are CR, PR, NC and PD, RR: (CR+PR)/ The number of cases of follow-up x100%. 5. Statistical method Two groups of data was performed by Chi-square Test and measurement data was performed by t-test on spss 19.0. P < 0.05 indicates statistical significance. **Results:** All patients of the two groups were finished $^{125}$I particles implantation treatment successfully (tab.1). Compare with group B, group A took shorter time, D100, V100 are more close to prescribed dose, V150 is more smaller and dose distribution is more precise, difference between the groups has statistically significant. Efficacy comparison of the two group as shown in the table 2, difference between the groups has no statistically significant. Complication comparison as shown in the table 3. **Conclusions:** This study suggests that 3D printing template-assisted $^{125}$I seed implantation in the treatment of liver malignant tumor could reduce operation time, optimizing radiation dose distribution and has a satisfactory results. But because of it is a retrospective study with less number of samples, there exist some bias effect such as compliance of the patients. In the future, we need large-scale prospective randomized study to validate the clinical value of 3D printing template-assisted $^{125}$I seed implantation in the treatment.
### Tab. 1 The data of operation results

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>t value</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation time (min)</td>
<td>42.5±19.3</td>
<td>67.6±37.2</td>
<td>2.4</td>
<td>0.01*</td>
</tr>
<tr>
<td>Operation times (times)</td>
<td>1.3±0.6</td>
<td>1.5±0.8</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Stay in hospital (days)</td>
<td>7.1±5.2</td>
<td>9.7±6.8</td>
<td>1.27</td>
<td>0.11</td>
</tr>
<tr>
<td>D90(cGy)</td>
<td>1242±2324</td>
<td>1098±3656</td>
<td>1.37</td>
<td>0.18</td>
</tr>
<tr>
<td>D100(cGy)</td>
<td>1030±2489</td>
<td>776±2582</td>
<td>3.06</td>
<td>0.04*</td>
</tr>
<tr>
<td>V100(%)</td>
<td>95.4±6.5</td>
<td>89.6±8.4</td>
<td>2.29</td>
<td>0.01*</td>
</tr>
<tr>
<td>V150(%)</td>
<td>62.1±14.2</td>
<td>73.6±15.6</td>
<td>2.33</td>
<td>0.01*</td>
</tr>
</tbody>
</table>

* difference between the groups has statistically significant

### Tab. 2 The response number (rate) results. n(%)  

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
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<tbody>
<tr>
<td>CR</td>
<td>3</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>PR</td>
<td>10</td>
<td>66.7</td>
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</tr>
<tr>
<td>NC</td>
<td>1</td>
<td>6.7</td>
<td>1</td>
</tr>
<tr>
<td>SD</td>
<td>1</td>
<td>6.7</td>
<td>3</td>
</tr>
<tr>
<td>Response number (rate)*</td>
<td>13/15</td>
<td>86.7</td>
<td>21/25</td>
</tr>
</tbody>
</table>

*χ²=0.05 p>0.05 difference between the groups has no statistically significant

### Tab. 3 The complications of permanent iodine-125 implantation. n(%)  

<table>
<thead>
<tr>
<th>Complication</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>7</td>
<td>46.7</td>
</tr>
<tr>
<td>Fever</td>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>Massive bleeding</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Seeds miFgition</td>
<td>2</td>
<td>13.3</td>
</tr>
</tbody>
</table>
On EM Reconstruction of a Multi Channel Shielded DMBT Tandem Applicator for Cervical Cancer Brachytherapy: A Feasibility Study

Emmanuel Racine, Ph.D.1, Daline Tho, MSc1, Harry Easton, Ph.D.2, William Song, Ph.D.2, Luc Beaulieu, Ph.D.1.

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Purpose: The emergence of EM tracking technologies is currently paving the way for a variety of novel applications in the medical field. In this work, a demonstration of the technology is presented for reconstruction of the individual channels of a prototype shielded direction modulated brachytherapy (DMBT) tandem applicator. The technique has the potential to considerably speed up planning and quality assessment tasks in the clinic.

Materials and Methods:
A shielded, multi-channel prototype DMBT tandem applicator has recently been developed at the Sunnybrook Health Sciences Centre, Toronto, Canada. It is comprised of six longitudinal channels of 1.3 mm in diameter, spaced by 1.95 mm along a circular pattern. The applicator is shielded by an MR-compatible tungsten alloy with a total length of 256 mm. Channels were reconstructed with an electromagnetic system (NDI Aurora® V3) using a 5 degree-of-freedom sensor. Each reconstructed channel was registered on its corresponding reference channel obtained from CAD drawings of the applicator, and projection errors were computed with respect to the reference trajectory. A joint registration of the intra-body part of the applicator (a straight segment 62 mm from the tip) for three channels was also performed, which allowed to assess the accuracy of EM reconstructions by the measurement of inter-channel distance errors.

Results: As shown in Table 1, projection errors of 0.4 ± 0.3 mm, 0.3 ± 0.2 mm and 0.6 ± 0.3 mm were measured for the three individually registered channels. The joint registration of the intra-body part of the three channels with their reference counterparts yielded corresponding inter-channel distance errors of 0.3 ± 0.3 mm, 1.1 ± 0.5 mm and 0.4 ± 0.2 mm.

Conclusions: This experimental study has shown that EM reconstruction of this shielded tandem applicator appears feasible and can yield sufficient accuracy for potential integration into clinical workflow. It additionally proves attractive for its speed and convenience, as well as its potential for improving overall assurance of treatment quality.

Table 1 – Summary of error measurement statistics for individual and paired reconstruction analyses

<table>
<thead>
<tr>
<th>Channel ID</th>
<th>Projection (inter-channel distance) error [mm]</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
</tr>
<tr>
<td>2</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>0.1</td>
</tr>
<tr>
<td>2 – 5</td>
<td>0.0</td>
</tr>
<tr>
<td>2 – 4</td>
<td>0.1</td>
</tr>
<tr>
<td>4 – 5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

PO57
Commissioning Considerations When Implementing Eye Physics Eye Plaques and Plaque Simulator Treatment Planning System
Sheridan Griffin Meltsner, PhD, Anna Rodrigues, PhD, Zheng Chang, PhD, Oana Craciunescu, PhD.
Duke University Medical Center, Durham, NC, USA.

Purpose: Commissioning an eye plaque system for the treatment of ocular melanoma is complicated by the lack of uniformity in the way such systems are used clinically. Eye plaque brachytherapy has been and is often still planned using in-house spread sheets as second check calculations or even as the primary dose calculation. The use of a FDA approved treatment planning system such as Varian BrachyVision is not ideal as it does not account for the inhomogeneities of the plaque. This work provides a guideline to assist in the comprehensive commissioning of the Eye Physics (EP) eye plaques and Plaque Simulator (PS) treatment planning system (TPS). Both starting a new eye plaque program from scratch and switching from Collaborative Ocular Melanoma Study (COMS) plaques planned with BrachyVision (BV) provide some unique challenges.

Materials and Methods: The commissioning process...
PO58

125iodine Brachytherapy via a Trans-Superior Vena Cava Approach in Patients with Metastases in Middle Mediastinal Lymph Nodes

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The Second Hospital of Shandong University, Jinan, China.

Purpose: Certain metastasis-containing middle mediastinal lymph nodes cannot be approached by standard CT-guided brachytherapy. We here describe a novel trans-superior vena cava approach for such nodes. The aim of this prospective study was to assess the safety and clinical value of 125iodine (I) brachytherapy via a trans-superior vena cava approach in patients with metastases in middle mediastinal lymph nodes. Materials and Methods: From February 2008 to October 2011, 32 patients with 43 pathologically confirmed metastasis-containing mediastinal lymph nodes underwent CT-guided percutaneous 125I brachytherapy via a trans-superior vena cava approach (Fig 1). Complications and treatment responses were analyzed. Variations in blood pressure, heart rate, hemoglobin concentration and oxyhemoglobin saturation before, during and after the procedure were recorded, as were complications, including hemorrhage, pneumothorax and development of Breuer’s reflex. Treatment response was assessed according to the response evaluation criteria for solid tumors Version 1.1. Results: According to follow-up CT examination after 6 months, 22 patients (68.75%) achieved complete responses and four (12.5%) partial responses. One patient died of myocardial infarction. Overall response rate was 81.25%, with a local control rate of 87.5%. The median survival was 25.7 months, with progression-free survival of 19.74 ± 0.81 months. The 1-year and 3-year overall survival rates were 53.13% and 28.13%. Variations in blood pressure, heart rate, HGB and SO2 before, during and after the procedure were not significant. There were minimal immediate or delayed complications, including slight hemorrhage and pneumothorax; no complications were severe. Conclusions: It was demonstrated that middle mediastinal lymph node metastases can be approached and effectively treated by CT-guided 125I brachytherapy via a trans-SVC approach. This approach is safe, and had no serious complications in our series. The main limitation of this study is the absence of a randomized control trial with a control group treated by...
EBRT, surgery or chemotherapy. We plan to treat more patients with this novel approach, and may conduct a randomized control trial.

**PO59**

**Mandibular Growth in Pediatric and Adolescent Survivors of Parotid Gland Cancer Treated with Interstitial Brachytherapy**

Wen-Jie Wu, MD¹, Lei Zheng, MD¹, Jian-Guo Zhang, BSMed¹, Guang-Yan Yu, PhD¹, Ting-Zhong Liu, MD², Hong Gao, MD³.
Purpose: Iodine-125 seed interstitial brachytherapy have been applied to parotid gland cancer in pediatric and adolescent for about 10 years, which have achieved over 90% local control rates and survival rates. Generally, the planning target volume was defined as 10-15 mm beyond the preoperative gross tumor volume, which inevitably covered nearly all the parotid gland and the condyle. As the condyle was the mandibular growth center, mandibular growth may be influenced in pediatric and adolescent survivors. Although brachytherapy is more conformal than external beam radiotherapy, the mandibular growth was inevitably influenced. The relationship between the dose of condyle and the measurements of mandible was analyzed in this research. Materials and Methods: From August 2007 to November 2011, 11 pediatric and adolescent survivors of parotid gland cancer treated with Iodine-125 seed interstitial brachytherapy as a sole or adjuvant modality were included retrospectively. Ranging from 2 to 14 years old by the time of diagnosis, the patients had a median age of 12 years. Four patients were male and 7 were female. The condyle of these patients was covered in the planning target volume and the follow-up time was over 5 years. The condyle of the affected side was delineated as organ at risk and the dose was calculated in the brachytherapy treatment planning system (Beijing Atom and High Technique Industries). Computed tomography data before and 5 years after brachytherapy were imported into ProPlan CMF 1.4 software, in which the linear mandibular measurements and 3D cephalometry were analyzed. The fore-and-aft variations of the mandibular body and the mandibular ramus of bilateral sides were measured and calculated, respectively. The bivariate correlation procedure was used to analyze the relationship between the dose of condyle and the increment of mandible growth based on SPSS 13.0 for Windows. Results: The median dose of the affected condyle was 57.6 Gy. The median increment of mandibular ramus and body between the normal side and the affected side were 5.59 mm and 5.62 mm, respectively. The increment of mandibular ramus were positively correlated with the dose of condyle, and the Pearson's correlation coefficient (0.763) was significant at the 0.05 level (p value = 0.006). Moreover, the increment of mandibular body were positively correlated the dose of condyle but the Pearson's correlation coefficient (0.569) was not significant at the 0.05 level (p value = 0.068). Conclusions: Preliminary results yielded that the higher dose of the condyle was affected, the more mandibular growth was influenced, especially for the mandibular ramus. Nevertheless, the impact was acceptable in these pediatric and adolescent survivors of parotid gland cancer treated with interstitial brachytherapy.
PO60
Benefits of CT-MRI Fusion in Iodine-125 Seed Implant Brachytherapy Planning for Malignant Brain Tumors
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1Interventional Medical Center, The Affiliated Hospital of Qingdao University, Qingdao, China, 2Department of Imaging and Interventional Radiology, The Chinese University of Hong Kong, Hong Kong, China, 3School of Instrumentation Science & Opto-electronics, Beihang University, Beijing, China.

Purpose: To compare the dose difference calculated by CT image only and CT-MRI fused image, and verify the usefulness of CT-MRI fusion in brachytherapy planning for malignant brain tumors. Materials and Methods: From November 2015 to October 2016, 12 patients with single malignant brain tumor (high grade gliomas, 6 cases; metastases, 6 cases) were implanted with 125I radioactive seeds in the affiliated hospital of Qingdao University. Both enhanced MRI images and enhanced CT images were obtained preoperatively and they were fused with an in-house developed toolkit (iFusion). The CT-MRI fusion based preplan and the single preoperative enhanced CT based preplan were generated by a brachytherapy planning system (TPS). 125I seed implantation in tumors were implemented by the guidance of CT-MRI fusion based preplan and were optimized by preoperative enhanced CT-

Figure. (A, B) The condyle was surrounded by the tumor and postoperative quality verification showed matched peripheral dose of the condyle was 155.1 Gy in the extreme case. (C, D) The mandibular ramus and body of the left side 7 years after were distinctly developmental retardation compared with that before brachytherapy.
MRI and intraoperative CT fused images in real time. Post plan evaluation was performed by inputting preoperative enhanced CT-MRI and postoperative CT fused images into TPS one week after implantation. The PTV, PD, D90, V100, and V200 for CT-MRI fusion preplans were compared with CT preplans and CT-MRI fusion post plans by paired t test respectively. **Results:** The average number of seeds implanted per patient was 49.6 (range: 25-80). The activity of the seeds ranged from 0.6 mCi to 0.74 mCi, and the PD was 100-130 Gy. Mean PTV, PD, D90, V100 and V200 were 60.0 cm³ (SD: 36.8), 112.5 Gy (SD: 8.7), 125.7 Gy (SD: 10.1), 95.3% (SD: 1.2%) and 49.4% (SD: 3.7%), respectively for the enhanced CT preplan, 59.6 cm³ (SD: 36.4), 112.5 Gy (SD: 8.7), 126.0 Gy (SD: 9.7), 95.5% (SD: 1.3%) and 49.3% (SD: 4.0%) for the CT-MRI fusion preplan, and 59.9 cm³ (SD: 36.7), 112.5 Gy (SD: 8.7), 124.7 Gy (SD: 12.1), 92.8% (SD: 8.8%) and 49.6% (SD: 4.5%) for CT-MRI fusion post plan. On average, preplans based on both modalities met our planning goals. Although V200 examined were significantly different (p < 0.05), the difference in absolute magnitude between the two techniques was small and not of clinical significance. All parameters above for CT-MRI fusion preplans did not differ significantly from those of post plans (p > 0.05). **Conclusions:** Fusion of preoperative enhanced CT with enhanced MRI appears to lead to acceptable agreement with enhanced CT-based dosimetric parameters in preplan evaluation. Brachytherapy using intraoperative CT integrated with preoperative enhanced MRI provides more assistance for the tailoring of dose distribution to the tumor topography while sparing the surrounding tissues or organs. The postoperative dosimetric verification demonstrated the benefits of CT-MRI fusion preplan. Besides, this integrated system allows true real-time feedback during surgery and offers high precision and orientation. **Keywords:** CT, MRI, image fusion, brain tumor, brachytherapy

**PO61**

**3D Printed Individual Template Combined Surgical Navigation System Guided I-125 Interstitial Brachytherapy for Pediatric Skull Base Tumors**

Peng Chen, Master, Dan Zhao, Master, Xiao-Ming Lv, M.D., Lei Zheng, M.D., Jie Zhang, M.D., Jian-Guo Zhang, B.S.Med.

*Peking University School of Stomatology, Beijing, China.*

**Purpose:** The aim was to explore the application of 3D printed individual template combined surgical navigation system guided I-125 interstitial brachytherapy for pediatric skull base tumors. **Materials and Methods:** Nine pediatric patients with skull base tumors were included in this retrospective study from December 2014 to December 2016. The site of these tumors were infratemporal fossa, pterygopalatine fossa etc. which were inoperable and critical. It was nearly impossible to perform radical surgical treatment or will result in deformities and poor quality of life, especially in pediatric patients. These patients in our study underwent I-125 interstitial brachytherapy combined with chemotherapy and (or) surgical resection. A pre-plan was performed in the brachytherapy treatment planning system software based on CT and MRI images. The 3D printed individual template was designed in Geomagic software based on the pre-plan and made through rapid prototyping technique. Template data in STL format images of CT and MRI were imported into the iPlan CMF software. CT and MRI images were fused together and matched with template to gain the navigation plan, which was transferred to the surgical navigation system before brachytherapy. The needles were implanted using the 3D printed individual template and navigation plan guidance to avoid skeleton structure of skull base and critical vessels and ensure that all needles were in the target area. Treatment quality verification was performed in treatment planning system based on post-implantation CT.

The histological type and I-125 seed activity were collected. **Results:** Eight histological types were confirmed in these nine pediatric skull base tumors: 1 malignant rhabdoid tumor (1/9), 1 primitive neuroectodermal tumor (1/9), 1 synovial sarcoma (1/9), 2 embryonal rhabdomyosarcomata (2/9), 1 alveolar rhabdomyosarcoma (1/9), 1 mesenchymal benign tumor (1/9), 1 inflammatory myofibroblastic tumor (1/9), 1 myofibroma. The implantations of all patients were performed successfully under 3D printed individual template combined surgical navigation system guidance. Activity of the seeds was 18.5-29.6 MBq. The dose volume histograms (D90, V100, V150) meet the treatment requirement well. **Conclusions:** 3D printed individual template combined surgical navigation system guided I-125 interstitial brachytherapy for pediatric skull base tumor is minimal invasive and accurate with cosmetic and functional result. However, the treatment efficacy and quality of life needs further research.
Efficacy and Safety of CT-Guided I-125 Seed Implantation for Advanced Pancreatic Cancer: A Meta-Analysis

Hao Wang, MD, Haitao Wang, MD, Xiaodong Huo, MD, Bin Huo, MD, Shude Chai, MD, Lei Wang, MD, Lili Wang, MD, Li Zang, MD, Dingkun Hou, MD, Jinhuang Wang, MD, Qiang Cao, MD.

Department of Oncology, The Second Hospital of Tianjin Medical University, Tianjin, China.

Purpose: To systematically evaluate the efficacy and safety of I-125 seed implantation for advanced pancreatic cancer.

Materials and Methods: We searched CNKI, WanFang, CBM and Cochrane Library, Pubmed, Embase from inception to November 2016 to collect randomized controlled trials (RCTs) of I-125 seed implantation for advanced pancreatic cancer. Two reviewers independently screened literature, extracted data and assessed the risk bias of included studies, and then meta-analysis was performed by using Revman 5.3 software.

Results: A total of 12 RCTs involving 689 patients were included. The results of meta-analysis showed that: the objective respond rate (ORR) [OR=3.24, 95%CI (2.33, 4.52), P<0.00001], 6 month survival rate [OR=3.61, 95%CI (1.53, 8.52), P=0.003], 12 month survival rate [OR=4.80, 95%CI (2.40, 9.57), P<0.00001] and pain relief rate were higher than those in the control group. In addition, there were no significant differences between both groups in the 2 year survival rate [OR=2.36, 95%CI (0.47, 11.74), P=0.29] and the adverse reaction rate [OR=4.94, 95%CI (1.05, 23.23), P=0.04].

Conclusions: Compared with control group, I-125 seed implantation is effective in the treatment of advanced pancreatic cancer. It can improve the objective respond rate, short-time survival rate and pain relief rate. In addition to seed malposition, there was no significant increase in the incidence of related adverse events. Due to the limited quality and quantity of included studies, more high quality and larger sample studies are needed to verify the above conclusion.

Non Excision of Hepatocellular Carcinoma with Portal Vein Tumor Thrombus I-125 Particle Implantation Combined with TACE Treatment Compared with Meta Evaluation of Simple TACE Treatment: A Meta Analysis
Haitao Wang, PhD, Li Zang, MD, Bin Huo, MD, Lei Wang, MD, Xiaodong Wang, MD, Qiang Cao, MD, Lili Wang, MD, Jinhuan Wang, MD, Dinling Hou, MD, Dingkun Hou, MD, Hao Wang, MD, Shude Cai, MD. Department of Oncology, The Second Hospital of Tianjin Medical University, Tianjin, China.

**Purpose:** To compare the clinical effect and safety of combination of transcatheter arterial chemoembolization (TACE) and $^{125}$I seeds with TACE alone for hepatocellular carcinoma (HCC) with portal vein tumor thrombus (PVTT).

**Materials and Methods:** PubMed, EM—base, the Cochrane Library, CBM, Wan Fang Data. CNKI database were used for searching literatures about controlled clinical trials of comparison of the combination of TACE and $^{125}$I seeds with TACE alone for HCC with PVTT. To compare the efficiency, survival rate and survival rate of $^{125}$I combined with TACE and simple TACE in two hepatocellular carcinoma patients with portal vein tumor thrombus. The research quality was evaluated according to the Cochrane system evaluation method. RevMan 5.3 was used for Meta analysis.

**Results:** A total of 712 patients in eight studies were included in this study. The meta analysis showed that the clinical effect of the combination of TACE and $^{125}$I seeds for treatment of HCC with PVTT were significantly better than that of TACE alone. Including the 1-year survival rate (95%CI: 0.10-0.24 OR=0.17, P<0.00001), 2-year survival rate (95%CI:1.30-2.01 P=0.32, OR=2.49), total effective rate (95%CI:1.32-8.37 P=0.01, OR=3.33). While the fever (95%CI:0.8-4.77 P=0.006, OR=1.27), nausea and vomiting (95%CI:0.73-3.62 OR=1.63, P=0.23) and abdominal pain (95%CI:0.46-3.247 P=0.68, OR=1.23) showed no significant difference between the groups.

**Conclusions:** Compared with TACE alone, the combination of TACE with $^{125}$I seeds for the treatment of HCC with PVTT has advantages in improving the local efficacy and overall survival, and the safety is higher.

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PO65
Dosimetry Study of Radioactive I-125 Seeds Implantation for Malignant Tumor Assisted by 3D Printing Coplanar Templates
Kaixian Zhang, Professor.
Department of Oncology, Tengzhou People's Central Hospital, Tengzhou, China.

**Purpose:** To compare the preoperative and postoperative dosimetry results for 3D printing coplanar templates auxiliary radioactive I125 seeds implantation to treat malignant tumor, and discusses the accuracy of treatment.

**Materials and Methods:** A total of 32 patients registered from Nov 2015 to Dec 2016 who were applied with 3D printing coplanar templates auxiliary radioactive I125 seeds implantations in the Tengzhou Central People’s Hospital were included in this study. The primary disease, including 9 cases of lung cancer, breast cancer and esophageal cancer in 5 cases, pancreatic cancer, cervical cancer, gastric cancer, colorectal cancer, liver cancer in 2 cases, bladder cancer, evil black, primary focal unknown each 1 case. 36 locations including 10 cases of lung, 5 cases of neck lymph nodes, 2 cases of abdominal lymph nodes, 3 cases of pelvic, 3 cases of vertebral bodies, 2 cases of pancreas, 2 cases of portal vein, the rest of the 9 cases. Collection within 3 days of enhanced CT in preoperative planning design. Draw the tumor target volume (GTV) and adjacent threatening organs (OAR), set prescription dose and particle activity, determine the direction of needle way, calculate the number of particles, simulated particle spatial distribution, determine the particle spacing and arrangement, calculate the exposure dose GTV and OAR.
Ultrasonically Guided Percutaneous Implantation of Iodine-125 Seeds in Pancreatic Carcinoma

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¹Department of General Surgery, China-Japan Union Hospital, Jilin University, Changchun, China, ²Department of Ultrasound, China-Japan Union Hospital, Jilin University, Changchun, China.

Purpose: To assess the effectiveness of ultrasonically guided percutaneous implantation of Iodine-125 seeds in pancreatic carcinoma

Materials and Methods: Between Jan 2005 and Jan 2016, 137 patients with pancreatic carcinoma, initially treated with iodine-125 seeds implantation interstitial brachytherapy, in China-Japan Union Hospital of Jilin University, were included in this retrospective study. Of the 137 patients, 90(66%) men and 47 (34%) women, mean age 60.1 (range 33-85) years; 81 had a tumor in the head of pancreas, 56 in the body and/or tail; 9 were diagnosed with stage I disease, 12 were diagnosed with stage II disease, 93 with stage III, and 23 with stage IV underwent the procedure. All the patients were confirmed adenocarcinoma of the pancreas by fine-needle aspiration biopsy under ultrasound guidance percutaneous. Fifty-one of 81 patients with jaundice received a biliary stent treatment before I-125 seed implantation; the other 30 patients did percutaneous transhepatic cholangio drainage (PTCD). The indication in all cases, 110 was severe abdominal and/or back pain. Dose distribution was calculated using a brachytherapy planning system (TPS), eighteen-gauge implantation needles and implantation gun were used for I-125 seeds implantation in tumor. All the brachytherapy implants were performed in operation room under general anesthesia. After determining the target, according to the TPS, 18-gauge implantation needles were inserted into the tumor through the skin surface guided by ultrasound, which kept the needles away from the pancreatic duct, biliary tract, blood vessels, transverse colon. If the tumor located at the back of stomach, the needles puncture through the stomach to the tumor. The distance between the adjacent implantation needles was approximately 1 cm. After that, I-125 seeds were released using implantation gun, 0.5-1 cm apart upon withdrawing the needles. All the 137 patients entered the follow-up phase immediately after the seed implantation. No patients were lost to follow-up. Patient symptoms were assessed, the clinical examination, blood sampling, and imaging studies, including chest X-ray, abdominal and pancreas computed tomography scans and ultrasonography were taken at the first, second, and 4th month post intervention. After that, evaluation was given every 2-3 months or sooner if a new clinical sign or symptom appeared. The survival status, clinical benefits, objective curative effects were analyzed to assess the effectiveness of interstitial I-125 seed implantation.

Results: No patient died in the perioperative period. Median survival time of the whole group was 15.0 months, whereas from Stage I to IV was 25.5, 20.1, 15.3 and 7.1 months, respectively. Compared with the date of coordination group of the committee on pancreatic cancer Chinese Anti-cancer Association, the median survival time was significantly longer. For the severe abdominal and/or back pain patients, 91.8% (101/110) experienced completed or partial pain relief, and showed satisfactory palliative effect. Conclusions: Patients with pancreatic carcinoma can benefit from I-125 seed implantation in terms of survival time, pain relief and quality of life.
Delineation of Target Volume of Iodine125 Brachytherapy in the Treatment of High-Grade Gliomas
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1The First Affiliated Hospital of Xinxiang Medical University, Xinxiang, China, 2Beihang University, Beijing, China, 3Interventional Center, The Affiliated Hospital of Qingdao University, Qingdao, China.
Purpose: To study how enlarging target area of iodine-125 brachytherapy influences the therapeutic effects and complications in the treatment of high-grade gliomas. Materials and Methods: A retrospective analysis was performed in 120 patients with high-grade gliomas from 14 Chinese hospitals. They were classified into two groups: Enlarging group with its planning target volume (PTV) 0.3-1cm bigger than the gross tumor volume (GTV), and control group with its PTV equivalent to GTV. The therapeutic effects and complications were observed. Results: In the premise of similar operative methods, prescription dose, treatment history, age, gender and other variables, Enlarging group had a significantly prolonged overall survival time (OS) and progression-free survival time (PFS) in comparison of control group, as well as a higher degree of complication. Conclusions: In the treatment high-grade gliomas with iodine-125 brachytherapy, it is reasonable to expand the target area and cover extra 0.3-1cm around GTV, which can significantly improve curative effects in company with controllable complications.

PO70
Value of Fusion of MRI and CT in Brachytherapy
Yang Gao, Ph.D.; Guo Nan, Ph.D.; Xiaokun Hu, M.D.
1School of Instrumentation Science & Opto-electronics Engineering, Beihang University, Beijing, China, 2Interventional Center, The Affiliated Hospital of Qingdao University, Qingdao, China.
Purpose: To develop a fast, accurate and robust method of fusing intra-operative computed tomography (CT) with pre-operative magnetic resonance imaging (MRI) and evaluate the impact of using the fused data on 125Iodine (I125) seeds implanted brachytherapy for Intracranial tumors. Materials and Methods: A retrospective review of records was performed on a cohort of 10 consecutive patients who underwent I125 seeds implanted brachytherapy for recurrent, metastases and other brain tumors entities with fusing CT and MRI volumetric image which we recently developed and implemented an automated fusion algorithm. Adjusted analysis was performed to compare the accuracy of location of catheters, planning target volume (PTV) and the conformity index (COIN) with or without this method. Results: The accuracy of per catheter insertion was 91.2% after image fusion and 83.2% without this method. There was a significant difference between PTV with CT images and PTV with CT-MRI fused data (69.04±29.83 cm³ vs. 60.12±29.10 cm³), and for the conformity index (0.76 vs. 0.89, p<0.05). Conclusions: The proposed MRI and CT image fusion method enable a quantitative assessment of images under evaluation, and improve the efficacy of the seeds implanted. The additional information obtained from the fused images can be well utilized for more precise location of catheters and lesion. Experimental results prove that the fusion algorithm is robust and reliable in clinical practice.

PO71
Iodine-125 Seed Implantation and Percutaneous Stenting in the Treatment of Pancreatic Cancer with Obstructive Jaundice
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The Second Hospital of Shandong University, Jinan, China.
Purpose: The aim of this study was to retrospectively evaluate the efficacy of iodine-125 seed implantation on survival of patients with malignant obstructive jaundice (locally advanced pancreatic carcinoma) treated with metallic stent. Materials and Methods: In the retrospective study, 26 patients with locally advanced pancreatic carcinoma presented with obstructive jaundice were treated with stents insertion. 12 of the 26 patients underwent CT-guided Iodine-125 Seed Implantation 7 days after the procedure and the other 14 patients were treated only with best supportive care. The actuarial D90 of the implanted iodine-125 seeds ranged from 110 Gy to 130 Gy (median,120Gy). The activity ranged from(0.5-0.6mci) (median,0.55 mCi). The follow-up period ranged from 3 to 20 months (median, 8.5 months). We did not find any statistically significant differences in ECOG score and tumor stage between these two groups of patients. Survival was analyzed using Kaplan-Meier method and log-rank test. Results: The median overall survival time of the 26 patients was 6.78 (95% CI 3.13-10.43) months. In the group of patients treated with iodine-125 seeds implantation and with stent insertion, the median survival time was 11.96
(95% CI 7.34-16.58) months. In the group of patients treated only with stent implantation the median survival was 5.82 (95% CI 5.51-6.13) months. The overall survivals in the iodine-125 seed combined group were higher than the only best supportive care group (p=0.011). **Conclusions:** This study shows combined with Iodine-125 seed implantation could extend the survival in the patients with pancreatic cancer and obstructive jaundice.

**PO72**

**Effectiveness and Safety of Sublobar Resection Combined with $^{125}$I Implantation on Early Lung Cancer a Systematic Review**

Lili Wang, Graduate Student$^1$, Bin Huo, Graduate Student$^2$, Haitao Wang, Doctor$^2$, Shude Chai, Doctor$^2$, Lei Wang, Graduate Student$^2$, Hao Wang, Graduate Student$^2$, Dingkun Hou, Graduate Student$^2$, Xiaodong Huo, Doctor$^2$, Li Zang, Graduate Student$^2$, Fenghua Liu, Doctor$^1$, Jinhuan Wang, Graduate Student$^2$, Qiang Cao, Undergraduate Student$^2$, Xin Li, Graduate Student$^1$.

$^1$Department of Oncology, Key Laboratory of Cancer Prevention and Therapy, Cancer Institute and Hospital of Tianjin Medical University, Tianjin, China, $^2$Department of Oncology, The Second Hospital of Tianjin Medical University, Tianjin, China.

**Purpose:** To evaluate the efficiency of sub-lobectomy combined with $^{125}$I implantation for early non-small cell lung cancer (NSCLC) who underwent radical lobectomy. **Materials and Methods:** We performed an electronic literature search in PubMed, Embase, Cochrane Library, CNKI, Wanfang database, and Chinese CBM database (from the date of building the database to November 2016). In addition, we also checked the bibliographies of retrieved articles.
The clinical studies on efficiency of sub-lobectomy combined with I125 implantation for early lung cancer were included. **Results:** 16 studies (n=1354) were included. Among them, four studies compared the efficiency of sub-lobectomy with $^{125}$I implant versus simple sub-lobectomy in the treatment of early-stage lung cancer. Meta-analysis showed that there was no difference in outcome between patients treated with or without brachytherapy although brachytherapy had a tendency to reduce local recurrence (OR = 0.24, 95% CI = [0.05-1.07], P = 0.06). Twelve studies described the efficiency of sub-lobectomy combined with $^{125}$I seed implantation in the treatment of early stage lung cancer. The result showed that the local control rate was 96.1%, the probability of regional relapse or distant metastasis was 19.1%, and the mean survival rate of 1-year, 2-year and 5-year were 84.9%, 74.9% and 32.1%, respectively. **Conclusions:** The limited current evidence showed that $^{125}$I implantation for early lung cancer is effective and safe and has a tendency to decrease local control rate. Although the level of evidences is low, it merits further study to provide high quality evidences.

**PO73**

**High Resolution 3D Dosimetry for LDR Ocular Brachytherapy**

Anna E. Rodrigues, PhD$^1$, Suk Whan Yoon, BS$^1$, Mark Oldham, PhD$^1$, John Adamovics, PhD$^2$, Sheridan Meltsner, PhD$^1$, Oana Craciunescu, PhD$^1$.

$^1$Radiation Oncology, Duke University Medical Center, Durham, NC, USA, $^2$Radiation Oncology, Heuris Pharma, Skillman, NJ, USA.

**Purpose:** 3D dosimetric verification for eye plaque dosimetry remains challenging. Typically, clinical quality assurance of the eye plaque is often satisfied with the assay of seeds from the same batch as used in the eye plaque.
Eye plaques can be sent pre-built from the manufacturer, which further underscores the need for additional quality assurance, as the seeds in the eye plaque cannot be assayed. The purpose of this study is to explore the feasibility of using a high resolution 3D dosimeter for independent end-to-end test of an eye plaque program and even potentially for patient-specific eye plaque quality assurance. **Materials and Methods:** A clinical plan using an EP2031 eye plaque (Eye Physics) loaded with I-125 seeds (IsoAid Advantage) was used in this study. Dosimetry was experimentally verified with optical CT scans of PRESAGE®, a radiochromic 3D plastic dosimeter doped with radiosensitive leuco dye. Spherical dome (2.2 cm circular base radius) dosimeters with the approximate curvature of a human eye were produced for this study. A novel pre and post diffuse-background optical CT scanning protocol was performed with optical index matching to improve surface imaging down to 1 mm at a small cost in geometrical resolution away from the plane of focus. The dosimeter was irradiated to a dose of 30.5 Gy at a prescription depth of 4mm. Dose calculations were performed with Plaque Simulator (v6.4.3, Eye Physics), our primary treatment planning system, and with BrachyVision (v13.6, Varian), which acts as our secondary independent dose calculation check. Plaque Simulator utilizes a TG-43 based methodology modified to account for the inhomogeneous environment surrounding the sources, like the high Z eye plaque material (gold) and collimated slot geometry, while BrachyVision uses the TG-43 formalism calculated in water. Dose calculation grids sizes were non-uniform varying between 0.5 and 1.0 mm laterally and between 0.25 and 2.0 mm in front of the plaque for Plaque Simulator and 2.5mm³ for BrachyVision. Dosimeter data was smoothed with a 0.1mm³ Gaussian distribution and down sampled to a resolution of 3mmx3mmx0.1mm. Dose distributions were normalized to the respective prescription depth and compared. **Results:** 2D dose distributions for the dosimeter, Plaque Simulator, and BrachyVision are shown in (a), (b), and (c), respectively. The comparison of profiles along the central axis is shown in (d). Beyond 4mm, all three methods matched reasonably well. Below 4mm, as expected, the dosimeter is in better agreement with the Plaque Simulator results, as the later takes into account the non-homogeneous environment of the plaque. Limitations of the current optical CT scanner are ring artifacts due to the dosimeter oscillating up and down during scans. **Conclusions:** Preliminary results demonstrate the feasibility of using PRESAGE® for high resolution 3D dosimetry of LDR ocular brachytherapy. High resolution 3D dosimetry could provide patient-specific eye plaque quality assurance and serve as an independent end-to-end test for eye plaque programs.
Radioactive Seed Implantation for Lung Cancer Brachytherapy Assisted by Template-Guided Combined Rib Drilling Technique: A Feasibility Study
Bin Huo, MD, Shude Chai, MD, Haitao Wang, MD, Xiaodong Huo, MD, Lei Wang, MD, Qiang Cao, MD, Lili Wang, MD, Li Zang, MD, Jinhuan Wang, MD, Hao Wang, MD, Dingkun Hou, MD.
Oncology, The Second Hospital of Tianjin Medical University, Tianjin, China.

Purpose: To assess the feasibility of using radioactive seeds implantation under template combined with rib drilling technique assistance by CT guided for lung cancer. Materials and Methods: 21 patients with lung cancer that underwent radioactive seeds implantation in the second hospital of Tianjin Medical University from January 2015 to June 2016. Dicom data were acquired by the chest CT scan before implantation, and the radiation treatment planning system (TPS) was introduced to carry out the plan, the prescription dose was 120Gy. In addition to the conventional needle design, the special design of penetrating rib is adopted in the dose cooling zone due to rib occlusion, using rib drilling technique to establish the real channel, and applying template to control implantation. The distribution of implanted needles and seeds were observed by CT scanning, and dose verification was performed immediately after the operation. Intraoperative and postoperative complications were observed and recorded. Results: All patients tolerated brachytherapy well under intraoperative template and rib drilling technique assistance. The mean GTV, seed numbers, needle numbers, D90, V100 and V200 were 47.6, 33, 10, 12765.1Gy, 92.6%, and 34.8%, respectively, in postoperative verification and 46.4cc, 33, 10, 12433.8Gy, 95.2%, and 28.8%, respectively, in preoperative plans (P=0.012, 0.930, 0.267, 0.179, 0.032, and 0.003). The satisfaction rate was 90.5% after the operation. The incidence of pneumothorax was 19%. The incidence of pulmonary hemorrhage was 9.5%. The incidence of pleural cavity was 4.7%. The incidence of sputum with blood was 19%. No massive hemoptysis. The incidence of particle displacement was 9.5%. Other serious complications were not found. Conclusions: The application of template combined with rib drilling technique in radioactive seeds implantation is safe and feasible, and the precise positioning can significantly improve the preoperative plan conformity, avoid the blindness of manual operation. It has important value for the standardization and quality control of the treatment for lung cancer.

PO75

125I Brachytherapy in the Palliation of Painful Bone Metastases from Lung Cancer After Failure or Rejection of Conventional Treatments
Zhanwang Xiang, MD.
Medical Imaging and Interventional Radiology, Sun Yat-sen University Cancer Center, Guangzhou, China.

**Purpose:** This study sought to assess the safety and effect of $^{125}$I seed implantation for palliation of painful bone metastases from lung cancer after failure or rejection of conventional treatments.

**Materials and Methods:** 89 patients with painful bone metastases secondary to lung cancer were consented and enrolled in this study from June 2013 to May 2015. All patients had failed or refused conventional treatments underwent percutaneous CT-guided $^{125}$I seed implantation. The Brief Pain Inventory (BPI) was used to measure pain intensity prior to treatment ($T_0$), 2, 4, 6, 8 and 12 weeks ($T_2$, $T_4$, $T_6$, $T_8$ and $T_{12}$) after treatment in a 24-hour period. Analgesic, quality of life (QOL) scores and complications were also recorded. Four patients were excluded as they were lost to follow-up or had incomplete data.

**Results:** 85 patients with 126 bone metastases from lung cancer were treated. There were significantly lower scores after treatment in the visual analog scale (VAS) and analgesic. The VAS scores for worst pain was 6.3±1.8 at $T_0$. At $T_2$, $T_4$, $T_6$, $T_8$ and $T_{12}$, the score in a 24-hour period decreased to 4.9±1.2 (P<0.01), 3.7±1.3 (P<0.01), 3.4±1.2 (P<0.01), 2.6±0.9 (P<0.01), and 1.4±0.8 (P<0.01) respectively. Comparison of QOL scores showed improvements including sleep, appetite, spiritual state, and fatigue at $T_2$, $T_4$, $T_6$, $T_8$ and $T_{12}$ when compared to $T_0$. No serious complications or massive bleeding were observed.

**Conclusions:** $^{125}$I brachytherapy is a safe and effective method for palliation of painful bone metastases from lung cancer after failure or rejection of conventional treatments.

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**PO76**

**Effect of $^{125}$I Interstitial Brachytherapy on Pulmonary Function in Patients with Early Non-Small Cell Lung Cancer**

Xiaodong Huo, MD. Bin Huo, MD, Haitao Wang, MD, PhD, Shude Chai, MD, Lei Wang, MD, Qiang Cao, MD, Lili Wang, MD, Li Zang, MD, Jinhuan Wang, MD, Hao Wang, MD, Dingkun Hou, MD.

Department of Oncology, Second Hospital of Tianjin Medical University, Tianjin, China.

**Purpose:** To evaluate the effect of CT-guided $^{125}$I interstitial brachytherapy on lung function in patients with early non-small cell carcinoma (stage IA, IB) who were unable or unwilling to undergo surgery. **Materials and Methods:** From October 2006 to June 2014, a total of 58 patients with early non-small cell lung cancer received $^{125}$I interstitial brachytherapy. According to pre-treatment pulmonary function test, patients were divided into COPD group and non-COPD group, 6 months to detect changes in lung function. The changes of pulmonary function were detected between 2 and 6 months after operation. **Results:** The dose ($D_{90}$) of 90% target volume was (114.3 ± 10.2) Gy, the target volume percentage ($V_{90}$) of 90% dose coverage was 92.3% ± 7.2%, and the median value of matched peripheral dose (MPD) 112.8 Gy. 58 patients with COPD group of 16 patients (10 males and 6 females); not
combined COPD group of 42 patients (28 males and 14 females). The FEV1% of patients with COPD before and after treatment were 40±8.3 and 41±6.9 (p=0.421), respectively. The FEV1% of patients without COPD was 81±28 and 83±32 (p=0.782) before and after treatment, respectively. (p=0.563) before and after treatment in the COPD group, respectively. However, in the COPD group before treatment, there was significant difference in the levels of lung carbon monoxide (LDCO) were 11±6.4 and 14±5.6 (p=0.019). There was no significant difference in the tumor volume before treatment between COPD group and non-COPD group (18 ± 7, 21 ± 5, p=0.568). The tumor weight reduction in COPD group and non-COPD group was 18 ±7, 7 ± 3 (p<0.001); 21 ± 5, 9 ± 6 (p<0.001). According to postoperative quality verification MPD and $D_{90}$ is divided into > 110Gy group and ≤ 110Gy group, there was no significant difference in FEV1% and FVC% between the patients with or without COPD. Conclusions: $^{125}$I brachytherapy has no significant effect on FEV1% and FVC% in patients with early non-small cell lung cancer, but DLCO is improved in patients with tumor significantly reduced and without COPD.
### Table 1: two groups of patients with the general situation

<table>
<thead>
<tr>
<th></th>
<th>NO-COPD</th>
<th>COPD</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td>73 ± 3.8</td>
<td>75 ± 4.4</td>
<td>0.794</td>
</tr>
<tr>
<td>Follow-up time (days)</td>
<td>125 ± 68</td>
<td>122 ± 83</td>
<td>0.723</td>
</tr>
</tbody>
</table>

### Table 2: NO-COPD patients with $^{125}$I brachytherapy before and after pulmonary function tests

<table>
<thead>
<tr>
<th>Test items</th>
<th>Before implantation</th>
<th>After implantation</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV1 (L)</td>
<td>2 ± 0.62</td>
<td>2 ± 0.48</td>
<td>0.894</td>
</tr>
<tr>
<td>FEV1 %</td>
<td>81 ± 28</td>
<td>83 ± 32</td>
<td>0.782</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>3 ± 0.47</td>
<td>3 ± 0.65</td>
<td>0.912</td>
</tr>
<tr>
<td>FVC %</td>
<td>88 ± 20.7</td>
<td>91 ± 18.8</td>
<td>0.832</td>
</tr>
<tr>
<td>DL CO *</td>
<td>11 ± 6.4</td>
<td>14 ± 5.6</td>
<td>0.019</td>
</tr>
<tr>
<td>DL CO %*</td>
<td>61 ± 18</td>
<td>69 ± 20</td>
<td>0.021</td>
</tr>
</tbody>
</table>

### Table 3: COPD patients with $^{125}$I brachytherapy before and after pulmonary function tests

<table>
<thead>
<tr>
<th>Test items</th>
<th>Before implantation</th>
<th>After implantation</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV1 (L)</td>
<td>1 ± 0.17</td>
<td>1 ± 0.28</td>
<td>0.764</td>
</tr>
<tr>
<td>FEV1 %</td>
<td>40 ± 8.3</td>
<td>41 ± 6.9</td>
<td>0.421</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>2 ± 0.3</td>
<td>2 ± 0.4</td>
<td>0.683</td>
</tr>
<tr>
<td>FVC %</td>
<td>61 ± 15</td>
<td>60 ± 13</td>
<td>0.615</td>
</tr>
<tr>
<td>DL CO</td>
<td>12 ± 3</td>
<td>13 ± 2</td>
<td>0.563</td>
</tr>
<tr>
<td>DL CO %</td>
<td>48 ± 11</td>
<td>49 ± 12</td>
<td>0.652</td>
</tr>
</tbody>
</table>

### Table 4: two groups of patients with $^{125}$I brachytherapy before and after tumor volume changes

<table>
<thead>
<tr>
<th>Patients</th>
<th>Before implantation</th>
<th>After implantation</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPD</td>
<td>18 ± 7</td>
<td>7 ± 3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NO-COPD</td>
<td>21 ± 5</td>
<td>9 ± 6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>P</td>
<td>0.568</td>
<td>0.735</td>
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</tr>
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</table>

### Table 5: Compares the pulmonary function of the two groups according to the post-implantation quality verification MPD

<table>
<thead>
<tr>
<th>Patients</th>
<th>MPD</th>
<th>&gt;110Gy group</th>
<th>≤110Gy group</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPD FEV1 %</td>
<td>41 ± 7.6</td>
<td>40 ± 5.8</td>
<td>0.732</td>
<td></td>
</tr>
<tr>
<td>COPD FVC %</td>
<td>60 ± 11</td>
<td>61 ± 9</td>
<td>0.634</td>
<td></td>
</tr>
<tr>
<td>NO-COPD FEV1 %</td>
<td>82 ± 20</td>
<td>83 ± 15</td>
<td>0.754</td>
<td></td>
</tr>
<tr>
<td>NO-COPD FVC %</td>
<td>90 ± 16.5</td>
<td>91 ± 18.3</td>
<td>0.865</td>
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</tr>
</tbody>
</table>

### Table 6: Compares the pulmonary function of the two groups according to the post-implantation quality verification D90

<table>
<thead>
<tr>
<th>Patients</th>
<th>D90</th>
<th>&gt;110Gy group</th>
<th>≤110Gy group</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPD FEV1 %</td>
<td>40 ± 6.6</td>
<td>41 ± 6.8</td>
<td>0.728</td>
<td></td>
</tr>
<tr>
<td>COPD FVC %</td>
<td>60 ± 13</td>
<td>61 ± 12</td>
<td>0.647</td>
<td></td>
</tr>
<tr>
<td>NO-COPD FEV1 %</td>
<td>82 ± 11</td>
<td>83 ± 14</td>
<td>0.736</td>
<td></td>
</tr>
<tr>
<td>NO-COPD FVC %</td>
<td>90 ± 15</td>
<td>91 ± 16</td>
<td>0.846</td>
<td></td>
</tr>
</tbody>
</table>
Percutaneous Image-Guided Permanent $^{125}$I Implantation for Treating Recurrent Head and Neck Cancer, 2000-2015
Suqing Tian, MD, Junji Wang, Prof.
Department of Radiation Oncology, Peking University Third Hospital, Beijing, China; Peking University Third Hospital, Beijing, China.

Purpose: To investigate the therapeutic efficacy of percutaneous image-guided permanent iodine-125 implantation as salvage therapy for recurrent head and neck cancer from a single institute analysis of the years 2000 to 2015.

Materials and Methods: A total of 154 patients (101 male, 53 female; mean age 53.4 years, range 30-74 years) with recurrent head and neck cancer were included in this study. The diagnosis of each case was verified by CT, MRI and biopsy. A median number of 46 $^{125}$I seeds (range, 12-86) per patient were implanted into recurrent head and neck cancer by image-guided needle puncture. The specific activity of $^{125}$I ranged from 0.55 to 0.80 mCi per seed and the median D90 was 120 Gy (range, 90-153 Gy). Patients were followed-up by examination and by contrast-enhanced computed tomography (CT) to evaluate treatment responses. Survival was analyzed using the Kaplan-Meier method.

Results: During a median follow-up period was 37 months (range: 5-74 months), the response rate of tumor was 82.6%. Overall median control time was 24.0 months (95% CI, 8.1-39.8). The local control rate was 57.8% at 1 year and 34.5% at 2 years. The overall median survival was 28 months (95% CI, 4.4-35.5), while the overall 1-, 2- year survival rates were 61.9%, 38.1%, respectively. No serious complications were observed postoperatively and during the follow-up period. On univariate analysis, improved local control of recurrent head and neck cancer was associated significantly with favorable stage, tumor volume, D90. On univariate analysis, improved survival was associated significantly with stage, tumor volume, D90. Good performance status. On multivariate analysis, stage, D90 and tumor volume maintained significance for the local control. Among the selected parameters, age and stage appeared significantly correlated with overall survive in multivariate analysis. Conclusions: image-guided brachytherapy using $^{125}$I seed implantation was a safe and effective therapeutic technique for treating recurrent head and neck cancer.

PO78
CT-Guided $^{125}$I Brachytherapy in the Treatment of Distant Metastases in the Oral Cavity and Maxillofacial Region
Huzheng Yan, MD, Fujun Zhang, MD, PhD, Fei Gao, MD, PhD, Zhiqiang Mo, MD.
Sun Yat-sen University Cancer Center, Guangzhou, China.

Purpose: We aimed to evaluate the feasibility and clinical effectiveness of CT-guided $^{125}$I brachytherapy for distant oral and maxillofacial metastases. Materials and Methods: We retrospectively analyzed 65 patients with 84 distant oral and maxillofacial metastases. Thirty-one patients with 38 lesions received $^{125}$I brachytherapy (group A) and 34 with 46 lesions received external beam radiotherapy (EBRT; group B). Results: Median follow-up time was 16 months. The 3-, 6-, 12-, 18- and 24-month local control rates for group A were 83.9%, 75.9%, 66.7%, 38.4% and 25.0%, respectively; for group B they were 76.5%, 62.5%, 43.8%, 25.0% and 0.0%, respectively (p<0.05); the median local tumor progression-free survival times were 14 and 9 months, respectively. Group A had a better local tumor progression-free survival (LTPFS) relative to group B (p<0.001; HR, 6.961 [95%CI, 2.109, 9.356]). Cox proportional hazards regression analysis indicated that $^{125}$I brachytherapy, tumor size and primary pathological type were the independent factors affecting LTPFS. Additionally, $^{125}$I brachytherapy showed better performance in relieving patient clinical symptoms relative to EBRT (p<0.05). Group A also had fewer complications than group B, especially regarding grade 3/4 complications according to Radiation Therapy Oncology Group grading criteria. Mean overall survival times in groups A and B were 17.1 and 14.8 months, respectively. Conclusions: CT-guided $^{125}$I brachytherapy is feasible and safe for distant oral and maxillofacial metastases; it achieved a better local control rate, longer LTPFS and fewer complications without compromising overall survival compared with EBRT.
Clinical Efficacy of CT-Guided $^{125}$I Seed Implantation Therapy for the Patients with Vertebral Metastasis

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**Purpose:** To evaluate the clinical efficacy of the CT-guided radioactive iodine-$^{125}$ ($^{125}$I) seed implantation treatment in the patients with vertebral metastasis. **Materials and Methods:** Forty-six vertebral metastasis patients with 87 Vertebral body invaded were enrolled in this study retrospectively from 2011 to 2016. All the patients underwent the CT-guided $^{125}$I seed implantation therapy via the standard procedures. The clinical indexes including the University of Texas MD Anderson Cancer Center (MDA) criteria for tumor responses, numerical rating scale (NRS) for pain degree, Karnofsky Performance Status (KPS) for life quality, Tokushahi score for prognosis evaluation and the radiation dose were evaluated and recorded before and after operation. The follow-up evaluation was performed at least 3 months later after operation. Finally, differences between pre- and post-operation in these clinical indexes were compared. **Results:** Operations for all patients were successful. The median number of seeds implanted in lesions was 30.5 (range,5 to 106), and the postoperative target verified dose $D_{90}$ was $11232.35\pm1815.02$ cGy. Patients were followed for a median of 6 months (range: 3-34 months). The response rate(CR+PR) was 63/87 (72.4%). The NRS and KPS were both significantly improved in the follow-up ($P<0.05$). Pain control rates of 3-month, 6-month and 12-month were 94.5%, 86.4%, 71.7% respectively. The overall survival was 10 months, which was longer than the time evaluated by Tokuhashi score. The survival rates were 90.9%, 77.6%, 51.4 % at 6, 12, and 24 months, respectively. **Conclusions:** CT-guided $^{125}$I seed implantation is an...
effective and safe palliative care for the vertebral metastasis patients, which can effectively relieve the pain and improve the life quality.

**PO80**

**YouTube as a Source of Patient Information: Assessing Quality of Information in Brachytherapy Education Videos**

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**Purpose:** YouTube is the third most popular website in the world and is also a major web-based video-sharing platform of online healthcare resources. Despite being a major resource of healthcare information, videos uploaded on YouTube are not peer-reviewed, and their contents are not screened for scientific accuracy prior to being uploaded. There is declining use of brachytherapy for treatment of various cancers, and lack of awareness about advantages of this modality may contribute to this trend. Our study aimed to determine the quality of brachytherapy patient education videos with respect to informed consent guidelines from the American College of Radiology.

**Materials and Methods:** A YouTube search was performed in early November 2016 to identify the top ten most viewed videos for the terms “brachytherapy”, “prostate brachytherapy”, “breast brachytherapy”, “cervical brachytherapy”, “gynecological brachytherapy”, and “skin brachytherapy”. From these 60 videos, only educational videos explaining brachytherapy and created for a public audience were included, and videos that were duplicates or created for personal use were excluded. The video source, length, number of likes, dislikes, comments, and views were collected. Three independent reviewers assessed the quality of videos using a customized ‘brachytherapy informed consent checklist’ (Figure) and provided comments regarding perceived commercial bias. These reviews were used to group videos into “below standards” (received a yes on 0-3 of the first 10 survey questions from all 3 reviewers), “approaches standards” (received a yes on 4-7 of the first 10 survey questions from all 3 reviewers), and “meets standards” (received a yes on 8-10 of the first 10 survey questions from all 3 reviewers) classifications.

**Results:** Twenty-eight videos were analyzed. Fourteen videos (50%) were below standards, 13 (46.4%) approached standards, and 1 (3.6%) met standards. By site, breast brachytherapy videos had the most videos approaching standards at 6 (46.2%). The median number of video views was 4482.5 (range 212-415,007). Fourteen videos (50%) were uploaded by a hospital, private practice group, or a physician, whereas 5 (17.9%) came from a private vendor. The average video length was 6:02 (range 1:25-24:11), and the sole video that met standards had the longest length. The average number of likes was 41.7 (range 0-606). Fifteen videos (53.6%) had perceived commercial bias, and all were below or approaching standards. **Conclusions:** Most brachytherapy-related YouTube educational videos created for a public audience are below standards of informed consent and have a commercial bias. As more people access healthcare information online, there is a significant need for quality brachytherapy educational videos to be created and uploaded.
Clinical Efficacy of CT-Guided Iodine-125 Seed Implantation Therapy in Unresectable Superficial Skin Cancer

Purpose: Skin cancers are the most common malignancies occurring in developed countries and its incidence is increasing worldwide. We aimed to assess the effectiveness of CT-guided iodine-125 seed implantation therapy in patients with unresectable superficial skin cancer from any histotype. Materials and Methods: Eight patients with an average age of 64 years (range, 51-80 years) were enrolled between 2012 and 2016 in Zhongshan hospital of Dalian university, with 4 year follow-up for the earliest treated patient. All of tumors are located in superficial. There are 1 tumor in the scalp, 1 tumor in nosewing, 2 tumors in chest wall, 3 tumors in abdominal wall and 1 tumor in vulva. Prior seed implantation, all of tumors were scanned by computed tomography (CT). Then, gross tumor volume (GTV) was delineated by treatment plan system (TPS). The median tumor size was 45.87±25.73 mm. The prescription dose is 121±19.6 Gy. The distance between seeds is 5mm in individual needle. During implantation, 13.50±10 punctures were performed for each patient, and a total of 108 punctures were recorded. Meanwhile, a total of 387 seeds were implanted with an average of 48 (range, 7-150) seeds per patient, and the success rate was 100%. The activity of each seed ranged from 0.4 to 0.8mCi. Results: Follow-up period was 6 to 50 months. Tumor response which was demonstrated on repeated CT image 2 months post-treatment revealed partial response (PR) in 8 cases. Maximum dose in skin is 120.45±50.27 Gy. Two cubic centimeter dose (D2 cc) is 58.13±23.56 Gy.
skin toxicity was not observed in all patients. Serve chronic skin toxicity noted in 2 patients, whose GTV borderlines are less than 5mm from skin surface and skin max dose relatively high in all patient. Skin toxicity was associated with GTV borderline and max dose but not tumor size, suggesting TPS was indispensable. **Conclusions:** These data suggested that CT-guided percutaneous implantation of 125I seeds in a superficial skin was relatively safe and effective for treating unresectable superficial skin cancer. Side-effects mostly appeared in skin and correlated with GTV borderline and skin maximum dose.

**PO82**  
**Implementation of a Leipzig Surface HDR Treatment Program with 3D Printing**  
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**Purpose:** We implemented an HDR program to treat small, superficial skin lesions with a Leipzig-style cone (Varian GM11010080). Patients will be simulated with a 3D printed model of the applicator to ease in the placement of the virtual applicator. The patient treatment is planned in Eclipse using a virtual applicator which is built into Varian’s solid applicator library. A hand calculation using the published data provides an independent check of the calculated treatment time. **Materials and Methods:** First, the length of the applicator and Transfer Guide Tube (GM19001010) were verified using a racetrack ruler and measurement wire. A well chamber and electrometer were used to verify the central dwell position in the surface applicator. EBT3 GAFChromic Films and OSLD nanoDots were exposed using all four Leipzig-style cones: 3.0, 3.5, 4.0 and 4.5 cm, at a depth of 0.3 cm to verify dose profile and output, respectively. The solid model applicator and cones were converted directly from the Varian XML library into Stanford PLY format and printed using PLA filament on a MakerBot Replicator 2. **Results:** The total length of the Leipzig-style applicator and the transfer guide tube was measured as 99.3 cm. The max dwell position, 98.7 cm, was determined after 4 repeated measurements of outputs at various dwell positions. Both of these measurements agree with Varian's published values in the Instructions for Use manual. The dose profiles from our films demonstrate a 1.68 ± 0.85 cm spread of the 80% isodose line which is comparable to the published values of approximately 1.6 cm. The OSLD nanodot measurements for absolute dose are within 5% of the calculated values. The 3D-printer model of the applicator was CT simulated and compared to the applicator in Varian’s solid applicator library (see image 1). **Conclusions:** An HDR program treating small skin lesions is implemented by utilizing the Varian Leipzig-style applicator. Using a 3D-printed model of the applicator for CT simulation, the placement of the virtual applicator in treatment planning can be achieved more accurately.

**PO83**  
**Alpha-Particle Brachytherapy: Translation of Pre-Clinical Data to the Initiation of First Trials in Patients with Squamous Cell Carcinoma**  
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**Purpose:** A unique intra-tumoral alpha radiation based tumor ablation treatment termed **Diffusing Alpha emitters Radiation Therapy** (DaRT) was developed in our laboratories. DaRT provides, for the first time, an efficient method for treatment of the entire volume of solid tumors by alpha radiation. We summarize our preclinical results and describe the initiation of the first clinical trial in humans with skin squamous cell carcinoma in order to evaluate
their response to Alpha DaRT Seeds containing Radium-224. **Materials and Methods:** Radium-224 loaded sources are inserted into solid tumors and release by recoil short-lived alpha-emitting atoms (Rn-220, Po-216, Pb-212, Bi-212, Po-212, Ti-208). These atoms disperse in the tumor, and spray it with highly destructive alpha radiation. The decay products diffuse in the tumor mass to a distance of at least 5 mm. Thus, a sizable fraction of the tumor is irradiated by alpha particles, and because of their short half-life, only small amounts of the isotopes disperse in the body. **Results:** Insertion of such radioactive sources into experimental solid tumors resulted in tumor necrosis, significant retardation of tumor growth, extended survival, and reduced lung metastases in animals bearing murine squamous cell carcinoma (SCC), lung, pancreatic, colon, prostate and breast mouse derived tumors, and human derived tumors implanted in nude mice. Feasibility clinical studies will be performed with 35 patients with histopathological confirmation of skin or head and neck squamous cell carcinoma. Tumor size ≤ 5 centimeters in the longest diameter (lesions without nodal spread). Treatment will be delivered based on a CT-based pre-treatment plan using the Alpha DaRT kit. The kit contains two elements, the Ra-224 loaded Alpha DaRT Seeds and a specially designed Alpha DaRT Applicator. The radioactive seeds each carrying a low dose of 2 µCi will be placed 6 millimeters from each other to achieve at least 10 Gy at any point in the tumor. The total 224Ra activity administered is about 5 µCi per gram of tumor. The radioactive seeds will be implanted at a distance of at least 1 centimeter from major blood vessels (e.g., carotid artery, etc.) and vital organs including the larynx, trachea and esophagus. CT will be used to check the position of the radioactive seeds. Four To six weeks after treatment imaging and physical examination will be performed. In case there is evidence of tumor remaining, it will be surgically removed and will be sent for histopathological examination. **Conclusions:** DaRT relies on alpha particles and thus, effective against hypoxic tumors. DaRT seeds can be produced with various intensities, sizes and shapes and enable custom designed seeds for individual patients to deliver a more effective and conformal treatment to unresectable tumors and metastatic lesions. The DaRT approach using alpha brachytherapy with its enhanced radiobiological potential and treatment flexibility is expected to be more effective and more safe in tumor eradication than gamma and beta radiation. Clinical studies in skin and locally advanced head and neck cancer are underway and preliminary outcomes will be reported.

**Physics Posters**

**PO85**

**Positional QA of HDR Source in Vascular Brachytherapy**

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**Purpose:** Peripheral arteries such as the superficial femoral, popliteal and tibial arteries have high rates of restenosis after percutaneous interventions. The risk of restenosis is reduced by radiation therapy. High Dose Rate (HDR) brachytherapy of the femoral to the popliteal artery spans long treatment lengths. If the treatment length is greater than the maximum length allowed within the TPS, two treatment plans need to be generated such that the distal dwell of the second plan is positioned at the correct location with respect to the proximal dwell of the first plan. The prescribed dose is typically 20Gy delivered in a single fraction, and hence it is advisable to check that there is no overlap between adjacent dwells of the 2 plans before the treatment is delivered. In the present work we illustrate how a device, like the Matrixx ion chamber array, available in many clinics can be successfully accessed to assess the adjacent positions from split plans, and determine the positional fidelity. **Materials and Methods:** The Elekta microSelectron afterloader allows a maximum of 48 dwells in a single channel. A step size of 1.0cm is optimal for vascular treatments. This restricts the maximum treatment length to 47cm, while the clinical need to treat lengths greater than 50cm is not uncommon. To meet this requirement 2 plans that together span the entire treatment length have to be generated. For this work the treatment length was taken to be 60cm, with no offset. 2 plans each with a treatment length of 30cm were created. The first plan had 31 dwells starting at 150cm, while the plan for the treatment of the remaining had 30 dwells, starting at 120cm. The radiation dose for 3 possible scenarios is investigated: the 31st dwell and the 1st dwell in the 2nd plan are separated by the correct distance of 1cm. This required an offset of 1cm in the 2nd plan. The other two situations represented a possible planning miscalculation which would cause an overlap of adjacent dwells or a doubling of the separation to 2cm between them. The setup is shown in figure 1. A lumen catheter was placed flush against the surface of the Matrixx ion chamber array, such that
the dwells of the 2 plans adjacent to each other would lie approximately in the center of the Matrixx. The three combinations of plans were delivered, and integrated dose for each combination was measured separately. **Results:** The dose profiles over the entire length of Matrixx are shown in figure 2. A correct separation of 1cm between adjacent dwells of the 2 plans shows a profile without crests or troughs, while expectedly, the overlap shows a large increment in dose, while a 2cm separation (called ‘underlap’) causes the dose to drop between these dwells by a significant amount. **Conclusions:** Matrixx can be advantageously used to address an important clinical issue of matching of edges of adjacent treatment regions. Due to the device’s ability to provide real time data, the entire QA procedure takes less than 30min, and large changes in dose profiles emphatically show that any miscalculation in the planning system can be recorded and corrected to prevent patient harm.

**Figure 1**

**Figure 2**

**PO86**

**Dose Distribution Verification with Radiochromic Films in Brachytherapy**

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**Purpose:** Fast and easily repeatable methods for commissioning procedures for brachytherapy treatment planning systems are needed. Radiochromic film dosimetry with Gamma analysis is widely used in external beam quality
assurance procedures and planar film dosimetry is also increasingly used for verification of the dose distribution in BT applications. The aim of this study was a dosimetric verification of the calculation algorithm used in TPS for single step position and gynecological applicators. Materials and Methods: Calibration data was collected by separately irradiating 14 sheets of Gafchromic® EBT films with the doses from 0.25 Gy to 8.0 Gy using HDR Ir-192 source. Films during irradiation procedure were placed at different depths in the phantom and in the opposite orientation to the long axis of the source. Next standard vaginal cylinders of three diameters were used in the water phantom. Measurements were performed without any shields and with three shields combination. Additionally ring applicators with 26 and 30 mm diameters and a 60 mm intra-uterine tube with 60º bent angle were used for verification. Measured dose distribution has been checked and compared with the calculated spatial distribution of dose generated in the treatment planning system. The dose calculation has been performed according to the TG43 report. To compare two images presenting absorbed dose (measured and planned) analysis gamma factor (3%, 3mm) has been used. Results: Calibration curve was determined as third-degree polynomial type. For single dwell position comparison of the measured doses distribution and the corresponding dosegrids from TPS has showed that dose distribution around source may be measured using radiochromic films in certain dose range. The few areas of the images showed deviations from the acceptance criteria, mainly because of defects of films. For all used diameters of unshielded cylinder and for all shields combinations Gamma analysis were performed and showed that over 90% analyzed points meets Gamma criteria (3%, 3mm). For the 26 mm and 30 mm rings, the average gamma ranged, respectively, from 0.1 to 0.44 and from 0.1 to 0.27. In both cases, 99% of the measured points corresponded with the calculated data. Conclusions: Dose verification with film dosimetry requires exceptional precision due to the high dose gradient. Gamma analysis showed excellent agreement between the dose distribution calculated using TPS and measured by Gafchromic films, thus showing the viability of using film dosimetry in brachytherapy.

PO87
The Influence of Needle Depth on the Accuracy of the Dose When 125I Seeds Implanted in Malignant Tumors Guided by 3D Print Template
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Purpose: To investigate the influence of needle depth on the accuracy of the dose and the position of the needle tip when 125I seeds implanted in malignant tumors guided by 3D print template. Materials and Methods: From August 2015 to March 2016, 11 patients were selected undergo 3D print template guided 125I seeds implantation in Hebei General Hospital. According to the needle depth, it was divided into group A (≤5cm), B (5cm < X≤10cm) and C (>10cm). To select the same point in the same level of preoperative and intra-operative CT as the coordinate system's origin, to construct a three dimensional space coordinate system (X.Y.Z.axis) through three dimensional treatment planning system. To record the same needle tip in the preoperative and intra-operative treatment planning system coordinates (X.Y.Z numerical value). The preoperative data was defined as a benchmark, to calculate the difference ratio in X numerical value, Y numerical value and Z numerical value of each group and the general. The D90, V90, V100, V150 and seeds number pre and post operation were collected and compared. Results: The mean difference ratio in X numerical value, Y numerical value and Z numerical value of general group was 0.12±0.33, 0.39±0.38, 0.04±0.57 respectively. The mean difference ratio in X numerical value, Y numerical value and Z numerical value of group A was 0.17±0.8, 0.12±0.68, 0.4±4.47 respectively. The mean difference ratio in X numerical value, Y numerical value and Z numerical value of group B was 0.17±0.8, 0.12±0.68, 0.4±4.47 respectively. The mean difference ratio in X numerical value, Y numerical value and Z numerical value of group C was 1.26±4.49, 0.19±0.85, -0.23±3.08 respectively. The mean difference ratio in X numerical value, Y numerical value and Z numerical value of general group was 0.48±2.53, -0.08±0.72, 0.18±3.89 respectively. The mean D90, V90, V100, V150 and seeds number pre-operation was (8777.1±2443.8) cGy, 93.5%±0.3%, 89.6%±1.4%, 59.4%±5.1%, 68.5±13.3 respectively. The mean D90, V90, V100, V150 and seeds number post-operation was (8643.7±2636.2)cGy, 92.9%±0.5%, 88.8%±1.9%, 59.4%±6.8%, 68.9±12.3 respectively, the difference of D90, V90, V100, V150 and seeds number between pre and post operation was not statistically significant (p > 0.05). Conclusions: The needle tip position may change less when the depth of the needle was less than 5cm, the needle tip position changes within a certain range, the dose parameters in postoperative plan show no difference compared with preoperative plan.
Dwell Energy Density Distribution Index in High-Dose-Rate Brachytherapy for Cervical Cancer
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Purpose: Dwell Energy Density Distribution Index (DEDDI) has been developed to describe dosimetric characteristics of High-dose-rate (HDR) Accelerated Partial Breast Irradiation (APBI) as an adjunct to dose conformality, homogeneity, and dose distribution. However, the clinical utility of the DEDDI has not been validated in cervical cancer. The energy density effects on clinical local control of the target lesion are not well understood. In this study, the DEDDI was applied to describe dosimetric characteristics of HDR brachytherapy for cervical cancer.

Materials and Methods: This study included ten randomly selected HDR brachytherapy cervical cancer cases treated at our center between 2014-2016. Five cases were treated with a Tandem and Ring applicator, and five were treated with a Miami multichannel applicator. DEDDI is a function of source activity, total dwell time, total number of the dwell positions, and volume of interest. For simplification of the calculation, the source activity was normalized to 10 Ci, and the volume of the interest was selected as Prescription Isodose Volume (PIV). Two approximation assumptions were applied in this calculation. The first was the number of dwells and the second was the dwell position, which reflects the distance and density of energy at the point of interest in the volume of interest. Finally, the data were compared with the values from our previous study of the DEDDI in HDR APBI.

Results: For the selected Tandem and Ring applicator cases, mean PIV was 76.90 cc with standard deviation (SD) of 18.7 cc. Mean number of dwells was 25 (SD = 3), total dwell time was 340 seconds (SD = 70), and DEDDI was 0.185±0.035 Cis/cc. For selected Miami applicator cases, mean PIV was 92.6 cc (SD = 63.5), number of dwells was 27 (SD = 15), total dwell time was 312 seconds (SD = 187), and DEDDI was 0.246±0.266 Cis/cc. These values of DEDDI for cervical cancer HDR brachytherapy were on average an order higher than DEDDI for HDR APBI, in which PTV was selected as the volume of interest.

Conclusions: Based on our current assumption, HDR Tandem and Ring brachytherapy for cervical cancer has less variation in DEDDI compared with the Miami multichannel applicator. Further investigation is needed to develop a DEDDI spatial calculation formula fit to environments on different physical scales and apply it to other radiotherapy modalities.

CT-Guided Implantation of Iodine-125 Seed for Locally Recurrent Urothelial Carcinoma After Failure of Conventional Chemotherapy: A Case Report
Purpose: The objective of this was to summarize the efficacy and safety of CT-guided implantation of Iodine-125 seed for locally recurrent urothelial carcinoma after failure of conventional chemotherapy. Materials and Methods: CT-guided implantation of radioactive iodine-125 seed was applied in treating a patient with locally recurrent urothelial carcinoma after failure of conventional chemotherapy. The incidence of complications was recorded and the results were evaluated and analyzed. The patient was followed up to 1,3,6 months after operation. Results: Post-implant D90, V100, V150 and V200 were 130.5GY, 92.9%, 69.0%, and 45.0%. Repeat CT scan 1,3,6 months following the procedure revealed complete response (CR). There was no serious complications detected during the follow-up period. Radioactive iodine-125 seed implantation can improve the target volume dose, with the high doses of radioactive iodine-125 seed, the tumor, which was refractory and insensitive to chemotherapy, can be effectively controlled and complications are less than conventional chemotherapy. Conclusions: CT-guided iodine-125 seed implantation appeared to be a safe, useful and less complicated treatment option for locally recurrent urothelial carcinoma after failure of conventional chemotherapy. However, the longterm efficacy of this treatment needs further follow-up.
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Improving Dose Accuracy of HDR Brachytherapy Treatment of Skin Lesions Using Freiburg Flap Applicator Based on Reference Radiochromic Film Dose Measurements

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Purpose: Current HDR brachytherapy treatment planning systems (TPS) utilize the AAPM TG-43 datasets which assume full water phantom approximation in dose calculations. For skin treatments with the Freiburg flap (FF) applicator, this represents a setup different than the actual clinical situation where contributions of backscatter originating above the applicator and air gaps between the applicator spheres are missing. Aims of this work are twofold: to experimentally evaluate the dose calculation accuracy during surface treatments with the FF applicator at different depths, and to suggest means of improving the delivered dose accuracy in light of experimental results.

Materials and Methods: Absolute doses were measured using a reference EBT3 model GAFCHROMIC™ film dosimetry system within a Solid Water™ (SW) phantom at five different depths (0, 0.5, 1, 2 and 3 cm) with respect to the phantom surface (Figure 1(a)). The impact of bolus (0, 0.5, 1, 2 and 3 cm thicknesses) placed on top of the applicator was investigated for two treatment plan loadings created using MasterPlan™ (Ver 4.1): 5 cm × 5 cm, and 11 cm × 11 cm (Figure 1(b) top). The vertical axis in these top subfigures represents direction along which dose values were calculated at different depths. The measured and calculated dose values were compared in terms of percentage difference to the calculated dose. Dose prescription was 6 Gy at 1 cm depth and this choice was based on dose uncertainty established during film calibration. Results: Figure 1(b) (bottom) depicts the influence of bolus thickness on dose difference between TPS and film measurements. As expected, TPS systematically underestimated the actual delivered dose. For depths beyond 2 cm (for smaller targets, i.e. 5 cm × 5 cm) and 1 cm (for larger targets, i.e. 11 cm × 11 cm), the actual systematic error is less than 3%, which is also the uncertainty limit of our radiochromic film dosimetry system. At shallower depths, addition of 2 cm bolus for smaller lesions as well as 1 cm bolus for larger lesions will provide a dose difference of less than 3%. Conclusions: In this work, we investigated the impact of lack of full scattering conditions on the use of FF applicator and corresponding percent difference between calculated and measured doses using an EBT3 radiochromic film dosimetry system. Differences of up to 6% at the surface were observed if no bolus was added on top of the applicator. To reduce this dose error to less than 3% along the central axis (including surface), one needs to add at least a 2 cm bolus for lesions smaller than 5 cm × 5 cm, and 1 cm bolus for larger lesions.
Figure 1: (a) Experimental setup with 3 cm bolus. Five slabs of Solid Water™ positioned below the applicator were indented to accommodate film pieces (1” × 2” in size) to alleviate any impact of air gaps. Bottom 5 cm slab was added to provide sufficient backscatter to measurement films. (b) Impact of bolus thickness on dose difference between TPS calculation and film measurements for two experimental setups: 5 cm × 5 cm (top-left), and 11 cm × 11 cm (top-right); dose difference histograms with numbers in parentheses representing dose values calculated at corresponding depths (bottom).

PO94
Automatic Post-Implant Reconstruction in Permanent Breast Seed Implant (PBSI) Using Simulated Annealing
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PO95
Development of a Nomogram for Use in Physics Pre-Treatment Check of HDR Prostate Brachytherapy

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Purpose: Nomograms are well established in Low Dose Rate (LDR) Brachytherapy to estimate the number of seeds for a prostate volume. This concept can be applied to High Dose Rate (HDR) Brachytherapy to provide a second check of the dose calculation and assess plan and implant quality. In 2011, Pujades et al. published findings on the use of a nomogram in LDR and HDR prostate brachytherapy at 2 separate institutions in Valencia, Spain. This work seeks to validate the use of nomograms in HDR brachytherapy and provide a linear fit correlation from the

Materials and Methods: Planned seed locations and needle tracks and post-implant seed locations for seven patients were imported into MATLAB (R2016a; The MathWorks, Inc., Natick MA). Post-implant seed locations were identified in the treatment planning system using the CT scan taken approximately 15 days after the implant, due to previous work suggesting that this is the most appropriate time to perform post-implant dosimetric analysis in PBSI. The centres-of-mass of the planned and post-implant seed clouds were rigidly registered to obtain a consistent coordinate system. A software algorithm was developed to match planned seeds to their corresponding post-implant seeds using stochastic optimization. The simulated annealing objective function incorporated two terms: (i) distance between matched planned and post-implant seed locations and (ii) distance between seed centres within needle tracks compared to the plan. The starting point for the algorithm was chosen such that the planned and post-implant seed pair in closest proximity was defined as a match. Each subsequent match was defined as the next unmatched seed pair separated by the smallest distance. To constrain the algorithm to predominantly local searches, matches to exchange were selected probabilistically based on their contribution to the overall objective function. Results obtained by the algorithm were compared to manual reconstructions done by an experienced observer. Using these manual reconstructions, match deviations were calculated as the distances between each correct match. This does not directly correspond to delivery error, as the registration is performed using the centres-of-mass of the seed clouds, rather than those of the seroma contours. Ten iterations of the algorithm were run for each patient to assess convergence to a consistent solution. Results: This cohort of patients had a median (range) of 58 (32-78) seeds implanted and underwent their post-implant CT scan a median (range) of 13 (13-16) days after implant. Two patients had median (range) match deviations of 4.1 (1.8-6.2) mm and 4.4 (1.0-14.7) mm respectively; for each of these patients, the algorithm obtained a median of 100% correct matches on 10 iterations. For the other five patients, the median (range) amalgamated match deviation was 6.9 (0.6-38.8) mm. For this cohort, with considerably larger match deviations, the automated algorithm lacked consistency in performing matches. The objective function for the correct solutions were lower than the solutions found by the algorithm, therefore methods to reduce the solution space or more effectively probe it are being investigated. Further adjustments, potentially including manual intervention by the user, may be necessary for these patients. Conclusions: The existence of an algorithm to automatically reconstruct the implant in PBSI is an extremely useful tool for clinics implementing the technique, allowing them to quickly analyze implant quality. Such algorithms exist for permanent prostate seed implant; however mobility of seeds within the breast and coalescence of needle tracks due to healing of edema in the 15 days following the implant renders this a unique problem in the context of PBSI. Future work will include the continued improvement of the algorithm, testing on a larger patient population, and generalization to other time points to increase the utility of the algorithm.
Materials and Methods: The HDR prostate brachytherapy treatment plan data were collected from 2014 through 2016, over 300 plans in total, including several monotherapy and boost prescriptions from a single institution, Cancer Treatment Centers of America (CTCA) Southeastern. The Ir-192 HDR source and the Varian VariSource™ iX Afterloader were used in conjunction with the Varian Eclipse Treatment Planning System (versions 10.0, 11.0, and 13.6) for treatment planning and dose calculation. All treatment plans were evaluated based on American Brachytherapy Society consensus guidelines for high-dose-rate prostate brachytherapy. The air kerma strength (\(\mu\)Gy-m\(^2\)/h) and total treatment time (sec) were recorded and normalized by the prescription dose (Gy). The normalized total air kerma strength was then plotted against the CTV treatment volume (cm\(^3\)) and the slope of the line and intercept were calculated. Results: The normalized total air kerma strength (cm\(^2\)) was plotted against the CTV treatment volume (cm\(^3\)) in Figure 1. The resulting linear regression line was determined to be 

\[ y = (5.38 \times 10^{-2})x + 2.079 \]

with a correlation coefficient \(R^2\) of 0.870. The \(R^2\) value of the data from our institution was comparable to the data from the two different institutions, Institution A and Institution B, published by Pujades et al., which had the \(R^2\) values of 0.888 and 0.940, respectively. The standard deviation was found to be 0.311 cm\(^2\). Out of 309 HDR plans, 98.7% of the plans were within 3 standard deviations and 70.6% of the plans were within 1 standard deviation of the line of best fit.

Conclusions: Based on these data, this nomogram will be used in the clinic as a safety check of the dose calculation. The data from all new HDR prostate brachytherapy plans will be evaluated against this nomogram, and those that fall outside 3 standard deviations of the best fit line will be investigated before treatment delivery. Future
work will consider additional factors such as D95, V150, V200, and number of needles implanted in an attempt to develop an institution-independent nomogram.

**PO97**

**Dose Distributions for Balloon Brain Brachytherapy with I-125 and Cs-131 Solutions**

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**Purpose:** The GliaSite® Balloon Brachytherapy System (IsoRay Medical, Inc, Richland, WA) has been used for intracavitary treatment of patients with malignant brain tumors following surgical resection. While dose calculations for $^{125}$I have been performed and updated by Dempsey et al. (1998) and Monroe et al. (2001), dose distributions with the $^{131}$CsCl solution have not been previously investigated. To provide information indicated in Sec. 4.M of the TG-167 report, the purpose of this study is to determine TG-43 dosimetry parameters for image-guided dose calculations beyond the manufacturer-provided lookup tables correlating dose with treatment time, prescription dose, and prescription depth. **Materials and Methods:** The GliaSite balloon applicators can be inflated to diameters from 10 to 40 mm. Dose distributions for the applicators and radionuclides were characterized using Monte Carlo (MC) methods and the TG-43 formalism to characterize the volumetric radionuclide solution as a single point-like source. The MCNP6 radiation transport code was used to estimate the dose rate distributions in the vicinity of the balloon filled with $^{125}$I or $^{131}$Cs solutions for absorbed dose in either water or brain tissue (400 mm diameter spherical phantoms). Dose to water, brain, or dose to water in brain were scored with the MCNP6 F6 and *F4 tallies to obtain the spatial dose distribution for then deriving the TG-43 parameters. Polar angles $\theta$ ranged from 0° to 180° (1° sampling) with the balloon nipple defined at $\theta=0^\circ$ and the catheter at $\theta=180^\circ$. Sampling of radial distance $r$ was every 0.1 mm beyond the balloon surface for $r<50$ mm, every 1 mm for $50<r<100$ mm, and every 10 mm for $100<r<150$ mm. Two established prescriptions were either 50 Gy at 5 mm from the transverse plane or 60 Gy at 10 mm from the transverse plane. Each simulation used $10^9$ photon histories. As recommended in the TG-138 report, an uncertainty analysis was performed to identify the components that most influenced the total dosimetric uncertainty. **Results:** Absorbed dose results were intercompared to evaluate the influence of changing balloon diameter, radionuclide, and medium as shown in the figure where dose was normalized to 100% at a depth of 10 mm from the balloon surface on the transverse plane. Rows 1-3 depict doses with inverse-square corrections in water for a 10 mm diam. balloon, in water for a 30 mm diam. balloon, and in brain for a 30 mm diam. balloon. Based on a pointwise geometry function, the 2D anisotropy functions exhibited nearly spherical dose distributions except for balloons < 20 mm diameter and for $d<3$ mm where geometric and self-shield effects became pronounced. Monotonic trends with balloon diameter were observed for the radial dose functions for either radionuclide or phantom medium, where $r>1$ cm values were consistently higher for $^{131}$Cs over $^{125}$I with a ratio up to 1.8 at $r=150$ mm. Brain was less attenuating than water and exhibited high dose gradients for all combinations of balloon diameter and radionuclide. The dose to brain results were similar to the dose to water in brain results. Overall, the standard uncertainty for $D(r=35$mm, $\theta_0)$ and $D(r=50$mm, $\theta_0)$ for a $^{131}$Cs-filled 30 mm diam. balloon was 0.77% and 0.93%, respectively. The largest uncertainty components were the mass-attenuation coefficients and the mass-energy absorption coefficients (approximately 0.7%), which were outside control of the investigation. Therefore those uncertainties under our control (e.g., balloon design variations, MC code physics, tally estimator volume averaging, photon history statistics) were minimized towards decreasing the overall dosimetric uncertainties of this study.
Conclusions: A 2D dosimetric approach for image-guided treatment planning of liquid-filled cranial balloon brachytherapy has not previously been possible. This study presents the requisite dosimetry parameters to realize this goal, and also makes comparisons among the different variables to glean insight on this novel means of delivering brachytherapy.

PO98
A Novel Tapered Applicator for Vaginal High Dose Rate Brachytherapy
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Purpose: Post-hysterectomy HDR vaginal brachytherapy is commonly performed with standard fixed-diameter vaginal cylinders ranging in size from 2-4 cm. Optimal dose distribution is achieved when the applicator tip and wall make direct contact with the vaginal mucosa at the apex. When the vaginal apex diameter is substantially larger than the introitus, a narrower cylinder may be selected to comfortably traverse the introitus, which can in turn result in air pockets between the cylinder and apex mucosa. For sufficiently large gaps, underdosing may potentially compromise treatment efficacy. To address this, we designed a tapered, two-piece, interlocking plastic vaginal brachytherapy applicator that minimizes patient discomfort while maximizing mucosa-cylinder contact at the vaginal apex. Materials and Methods: We designed a tapered, two-piece vaginal brachytherapy applicator using a 3D computer-assisted design (CAD) software platform and printed our prototype using a jetted photopolymer ABS-like proprietary resin. The applicator was constructed of two separate interlocking pieces which form a tapered cylinder when secured together in its final locked position. A central channel for HDR catheter delivery is surrounded by integrated alignment tracks comprised of curved surfaces to minimize radiation leakage. The two-piece design enables a two-step insertion, such that the base half is first inserted to the apex followed by gently guiding the top half over interlocking parallel alignment tracks until it is securely locked into position. Due to the tapered design of the applicator, at no point during the positioning does its diameter in the region of the introitus
exceed that of a standard 3cm cylinder, and when secured in its final position, the diameter is approximately 50% reduced. We performed dosimetric planning studies to characterize and compare the dosimetric properties of the tapered applicator to a standard 3cm cylinder. **Results:** We applied a library template plan corresponding to a prescription of 700cGy delivered to 5 mm depth from the surface of 3cm cylinder to the tapered applicator. The dose distribution surrounding the tapered applicator is depicted and compared with that of a standard 3cm diameter cylinder in Figure 1. The distribution at the apex is identical between the two applicators. In the region of the taper, the mucosal surface dose resulting from the tapered design could theoretically exceed that of a standard cylinder. In the template depicted, with an activated treatment length of 4cm, the dose measured at the surface of the tapered region was reassuringly very low. The dose fall off in the region of the taper surface ranged from 500cGy at the start of the taper to 250cGy at 1 cm in the caudal direction. Therefore, for an activated treatment length of up to 4 cm, the dose distribution surrounding the novel applicator is nearly identical to that of a standard 3cm cylinder and results in likely negligible differences in surface dose at the taper. **Conclusions:** We designed, fabricated, and tested a novel 3D printed applicator which maintains the simple uniform dosimetry of a standard vaginal cylinder while easing the challenge of placement in patients with narrow vaginal introitus. A clinical study is being planned to assess applicator fit, comfort, and in-vivo dosimetry.

![Figure 1: 7.0 Gy per fraction delivered to 0.5cm from applicator surface. A typical dose distribution for an activated treatment length of 4cm is shown above (5 activated dwell positions, 1cm apart).](image)

**PO99**

Monte Carlo Simulation of Microscopic Dose Enhancement of Glucose Conjugated Gold Nanoparticles for the I-125 Radioactive Seeds Brachytherapy

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**Purpose:** To investigate the microscopic energy deposition effect of glucose conjugated gold nanoparticles (Glu-GNPs) within a tumor irradiated by I-125 radioactive seeds on the nanometer/cell scale, and to quantify the...
corresponding microscopic dose enhancement factor (mDEF) around Glu-GNPs based on the real intra-cellular localization and spatial distribution of Glu-GNPs. **Materials and Methods:** The spectra of secondary electrons from atoms of gold and molecules of water under I-125 seeds irradiation of colorectal CL-187 cells cultured with culture medium added with Glu-GNPs was simulated with the Monte Carlo code Geant4. The simulation was based on the real Glu-GNPs intra-cellular localization and distribution observed with a transmission electron Microscope (TEM). The gold/water electron dose point kernels and corresponding mDEF was computed based on the simulated spectra of secondary electrons. **Results:** The influence of secondary electron was increased by a factor up to 100 over radial distances of 10 um, when Glu-GNPs was added. For the tested Glu-GNPs size and concentration, the microscopic energy deposition increased by a factor up to 500 and 100 in the area immediately surrounding the Glu-GNPs and 5 um far from the Glu-GNPs. The mDEF around the Glu-GNPs ranged from 10 to 100 within 5-30 um far from Glu-GNPs, and decreased to less than 5% beyond a radial distance of 50 um. The formation of intracellular nanoparticle clusters increased the maximum mDEF by more than 100% within 10 um from the clusters. **Conclusions:** Glu-GNPs can significantly enhance the microscopic energy deposition for I-125 radioactive seeds brachytherapy of tumors. The significant microscopic dose enhancement effect is limited within 30 um from the Glu-GNPs. The active tumor targeting strategy using Glu-GNPs is beneficial to maximize the radiobiological benefit from brachytherapy using I-125 radioactive seeds, especially the formation of Glu-GNPs clusters within the tumor cells. The in vitro and in vivo experiments are undergone to verify the radiosensitization effect of Glu-GNPs.

**PO100**

**Attenuation and Backscatter from a Lead Shield Used in HDR $^{192}$Ir Brachytherapy**

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**Purpose:** In radiotherapy, microscopic dose enhancement factors are used to protect critical organs from exposure to unwanted radiation dose. This is also true for High Dose Rate (HDR) brachytherapy treatments. However, HDR brachytherapy treatment plans frequently have hundreds of dwell positions of the HDR source aligned in curvilinear directions that surround the lead shield protecting a critical organ. Lead is known to generate backscattered radiation. Treatment Planning Systems (TPS) that follow TG-43 calculation method do not account for attenuation or backscatter. Thus, the question of whether the attenuation of radiation from dwell locations above the shield is offset by backscatter from source when it is located to side of the shields cannot be answered in the plans generated by such TPS. The purpose of the present study is to understand the effect of lead shield on the organ absorbed dose for various seed dwell positions. **Materials and Methods:** Monte Carlo code Geant4 was employed to calculate the absorbed dose in a brachytherapy treatment using the Nucletron microSelectron-v2 HDR $^{192}$Ir seed. A spherical water phantom of diameter 15 cm, with a 2 cm lead slab of thickness 3 mm placed on the surface of the phantom is considered. This geometry is a simplified version of a full face treatment, with the lead representing an external eye-shield. The absorbed dose was recorded in voxels located at three different depths d = 3 mm, 5 mm and 10 mm under the slab. The HDR $^{192}$Ir seed was maintained at a radius of 7 cm, i.e. 3 mm above the surface of the water phantom. The variable in the calculation was its polar angle $\theta$ in the range of 0° to 90°. This geometry is depicted in fig 1a. The absorbed dose without lead shield was taken as reference. The relative dose ratio (RDR) was calculated. **Results:** The following discussions refer to fig 1b. For the dwell positions over the range $\theta = 0^\circ$ to $8^\circ$, HDR seed is well shielded by the lead slab and the RDR is smaller than 48.0%. Above $8^\circ$, RDR increases gradually with $\theta$ until it reaches the critical angle where RDR equals 100.0%. The critical angle is $14.2^\circ$, $12.0^\circ$ and $9.8^\circ$ for voxels at d = 3 mm, 5 mm and 10 mm, respectively. After the critical angle, the shield does not cover the voxels and RDR is higher than 1 because of the backscatter dose produced by the lead. However, the backscatter does not result in significant dose increases. Over the range of $0^\circ$ to $40^\circ$, the highest relative dose increase is 2.9%, 2.1% and 1.7% for voxels at d = 3 mm, 5 mm and 10 mm, respectively. For the dwell positions where $\theta$ is higher than $40^\circ$, the maximum relative dose increase is 4.2%, but the absolute dose increase is less than 0.001 cGy h$^{-1}$ U$^{-1}$ and not clinically significant. **Conclusions:** A 3mm thick lead shield provides good protection to the critical organs from high radiation dose when the seed dwell position is above it. When the seed moves to the side of the shield, there is a dose increase due to the backscatter produced by the lead. However, the backscatter dose is small and not clinically significant.
Figures (1a) schematic showing the geometry used for Monte Carlo simulations; (1b) relative dose ratio (RDR) as a function of the polar angle $\theta$ over the range of 0° to 40°. The inset figure is the same data plotted over the range of 9° to 15°.

PO101
Commissioning of HDR Brachytherapy Combined with an Applicator-Guided SBRT Boost for Advanced Cervical Cancer
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Purpose: There is emerging evidence that dose escalation to high-risk clinical target volume leads to improved clinical outcome in cervical cancer. At time of brachytherapy, options for patients with large residual disease include a parametrial boost which lacks precision, or the addition of interstitial needles which requires a specialized brachytherapy program. The option of combining HDR brachytherapy (HDRB) with stereotactic body radiation therapy (SBRT) boost is being explored at our institution as a viable alternative for interstitial brachytherapy. The aim of this study is to describe an EBT3 GAFCHROMIC™ film dosimetry system to be used in commissioning of this combined boost, and to evaluate effect of positional inaccuracies on the overall dosimetric outcome.

Materials and Methods: A FlexiCube™ phantom was modified to snugly fit an intrauterine tandem applicator and EBT3 film pieces (Fig. 1(a)). The phantom was CT-scanned and a high-risk clinical target volume (CTVHR,Total) was contoured with an extended arm at one side (Fig. 1(b)). The HDRB treatment was planned on Oncentra™ to cover the proximal CTVHR,Total with 7 Gy, and the distal volume outside the 100% isodose line was referred to as CTVHR,Distal. Isodose lines from HDRB plan were used as inputs to create dose shells needed to deliver complementary doses by a 10 MV three arcs plan in Eclipse™. After HDRB delivery by microSelectron v2, SBRT was delivered by TrueBeam™ within one hour using image-guidance by applicator geometry. Intentional 2D shifts were introduced to evaluate the effect on target volumes. Effect of film re-irradiation at different time gaps and dose levels was evaluated. Results: Film dosimetric accuracy, with up to 2 hours gap between irradiations, was shown to be unaffected. Inset of Fig. 1(c) shows 95% dose distribution of the combined HDRB and SBRT plan. The dashed line is selected for dose profile comparison between measurement and calculation and a 2D 2%/2mm gamma analysis showed agreement at the 99% level. Fig. 1(d) shows that shifts of more than 2 mm between tandem and SBRT isocenter resulted in suboptimal DVH affecting mostly D98% and D90% of CTVHR,Distal. Conclusions: In this study we evaluated a radiochromic film dosimetry system that was successfully used in commissioning of...
applicator-guided SBRT boost with HDRB for advanced cervical cancer. Intentional 2D shifts of more than 2 mm between the applicator and SBRT isocenter affected mostly D98% and D90% of the CTV$_{HR,Distal}$ DVH. Therefore, judicious applicator-based image guidance is mandatory when combining SBRT with HDRB. Limited intrafraction movement of the target with applicator in situ encourages the clinical applicability of this technique in light of achievable phantom-based experimental quality assurance level.

![Image](https://via.placeholder.com/150)

**Fig. 1:** (a) Modified slabs of the FlexiCube™ phantom showing grooves to snuggly fit the tandem applicator; (b) CT slice of the phantom showing CTV$_{HR,Total}$ with unfavorable topography in the x-direction; (c) Results of 95% dose distribution from Oncentra™ and Eclipse™ summed plan (inset): An exemplary film and TPS dose profile comparison; (d) Dosimetric effect of shifting SBRT plan isocenter (with respect to the applicator) on D98%, D90%, D50% and D2% metrics of CTV$_{HR,Distal}$ DVH. X: as defined in subfigure (b), Y: Axial plane perpendicular to X, Z, in: towards tandem, out: away from tandem.

**PO102**

**A Flexible Dual Balloon Constructed Applicator in Treating Anorectal Cancer - Dosimetric Considerations**
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Purpose: To assess the dosimetric implications of a dual balloon brachytherapy applicator for treating anorectal lesions. Materials and Methods: Different amounts of water were infused into the inner (0 cc to 50 cc) and outer balloon (65 cc to 115 cc) separately to study the asymmetrical distribution of the catheter, the radial distance of the catheter to target (d_r), the space of the inter catheter (d_s), and their dosimetric impact on target and uninvolved rectum. Results: Increasing the inner balloon volume directly increases both d_r and d_s. Inter-catheter spacing d_s had a strong inverse correlation (-0.881, p=0.007) with d_r. Both V150 to target and conformal index (COIN) were strongly and inversely correlated to d_r (-0.945/ p<0.0001, -0.934/p<0.0001). Dose to 2 cm^3 of rectum (R_{2cc}) was strongly correlated with d_r with a value of 0.791 (p=0.006). Only dose to 0.1 cm^3 of rectum (R_{0.1cc}) was significantly correlated with d_s (0.77, p=0.013). Figure 1 shows the dose distributions (iso-dose line: yellow-150%, magenta-100%, green-80%, cyan-50%) of different implant cases. Conclusions: The flexible dual balloon anorectal applicator allows customization of the distances of the active source positions to the target in relation to uninvolved rectal wall, which makes brachytherapy plans highly conformal. This dosimetric feasibility study will be utilized as a planning platform for our ensuing clinical trials in anal and low rectal cancer brachytherapy.
Comparison of Acuros and TG 43 Dose Calculation for SAVI APBI Treatments
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Purpose: To quantify the differences between TG 43-based homogeneous dose calculation and Acuros heterogeneous dose calculation for SAVI APBI treatments, considering common parameters used for plan evaluation. Materials and Methods: BrachyVision’s Acuros algorithm uses the Boltzmann transport equation to compute the dose in heterogeneous media, considering the scatter effects near interfaces. We assessed the effect of using Acuros for SAVI APBI treatments, because the literature on this topic is scarce and contradictory. Seventeen (8 right and 9 left breast) SAVI APBI patients were included in this study, using SAVI 10-1 (10), 8-1 (4), 6-1 (2), and 6-1 mini (1) devices. All plans used for treatments were performed in BrachyVision 11 using a TG43-based homogeneous dose calculation algorithm. The total dose was 34 Gy, delivered in 10 fractions, twice a day. The number of channels used was in the range 1-11, depending of the SAVI device, PTV_Eval size, and distances to skin and ribs. The TG43-based plans were evaluated and the following information was extracted: SAVI device used, cavity and PTV_Eval volume, distances to skin and ribs, if invaginated tissue and/or fluid or seroma were present in the cavity, % air-seroma volume versus PTV_Eval volume, and nominal total dwell time (TDT). Also, the following dosimetric parameters were obtained for each plan: PTV_Eval V90, V95, V150, V200, and mean dose; skin D0.1cc and D1cc; and ribs D0.1cc. Each plan was recomputed using Acuros algorithm with a resolution of 0.05 cm. The TDT parameter was set the same as for the original plans. The same dosimetric parameters as listed above were obtained from each plan and compared to the corresponding values obtained from the plans using the TG 43 formalism. The results were analyzed to assess the trend in values for Acuros versus TG 43 parameters, and to test for any correlation with geometry, anatomy (SAVI cavity, PTV_Eval volume, distances to skin and ribs) or TDT.

Results: For the original plans computed using the TG 43 formalism the SAVI cavity and PTV_Eval were in the range 9.2 - 55.9 cc (mean value 39.7 cc), and 37.6 - 118.1 cc (mean value 87.1 cc), respectively. The nominal TDT was in the range 138.1 - 340.2 sec (mean value 254.5 sec). The minimum distances to skin and ribs were in the range 1 - 32 mm (mean value 11.6 mm), and 2 - 34 mm (mean value 12.4 mm), respectively. The %air-seroma inside PTV_Eval was in the range 0 - 8.8% (mean value 1.3%). Twelve patients had fluid accumulation inside the SAVI cavity (amount estimated) and one patient had invaginated tissue. All dosimetric parameters decreased when using Acuros (p < 0.0001). PTV_Eval V90, V95, and mean value decreased up to 2.2% (mean 0.8%), 3.4% (mean 1.6%), and 12.2% (mean 5.2%), respectively. The PTV_Eval V150 and V200 decreased up to 4.0 cc (mean 1.7cc) and 1.5 cc (mean 0.8 cc), respectively. The skin D0.1 and D1cc had similar trend, decreasing up to about 9.0% (mean 3.7%). The ribs D0.1 cc decreased up to 7.4% (mean 4.2%). No correlation was found between the variation in dosimetric parameters when using Acuros and cavity size, or distances to skin and ribs. The reduction in PTV_Eval mean dose had a quasi-linear dependence on the TDT and PTV_Eval volume (decreasing when TDT or PTV_Eval volume increases).

Conclusions: This study showed that the TG 43 formalism overestimates the dose to PTV_Eval and critical structures. The heterogeneous dose is concurrently affected by various geometric and anatomic factors, and the effects cannot be predicted. Changing from TG 43 to Acuros dose computation should be done with caution for SAVI cases, as it may require a reassessment of the dosimetric criteria.

PO104
Value of Cumulative BED-EQD2 Assessment for Optimization of HDR Prostate Boost Plans
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Purpose: Retrospective review of 25 HDR prostate boost cases to evaluate plan quality after implementation of cumulative BED-EQD2 dosimetric objectives. Materials and Methods: For HDR prostate boost cases performed at our institution, an HDR boost dose of 13 Gy was delivered as a single fraction. This was delivered within 2 weeks before or after administration of EBRT to the prostate and seminal vesicles to a dose of 50 Gy in 25 fractions. HDR brachytherapy catheters were inserted under transrectal ultrasound guidance. Three fiducial markers were implanted to identify the prostate base and apex. CT images were acquired with the catheters in place. Dilute contrast was placed in the bladder for CT simulation, and an equal amount of saline solution was placed in the bladder for treatment. The HDR plan evaluations were performed using the following DVH criteria (based on ABS guidelines): prostate: V100 ≥ 95%, V150 ≤ 40%, V200 ≤ 14%, D90 ≥ 100%Rx; urethra: D0.1cc ≤ 125%Rx, D10% ≤ 118%Rx, V125 ≤ 1cc; bladder: D0.1cc ≤ 80%Rx, V75 ≤ 1 cc; rectum D0.1cc ≤ 80%Rx, V80 ≤ 0.5 cc. For each patient, a
cumulative (CUM) EBRT-HDR BED-EQD2 form was generated in advance for prostate, bladder, rectum, and urethra, to estimate the maximum allowable dose values for the HDR plan such that the cumulative DVH criteria were met. The most conservative scenario was assumed for these calculations (i.e., same hotspots for the EBRT and HDR plans). The actual dose values for the EBRT plan were used in these calculations if that plan was already generated (EBRT prior to the HDR). If the EBRT was delivered post HDR, the dose values for the EBRT portion were estimated for HDR optimization, and updated once the EBRT plan was generated. The CUM BED-EQD2 tolerances were based on the GEC-ESTRO guidelines: bladder D2cc ≤ 90, rectum D2cc ≤ 75; urethra D10%/D30%/D0.1cc ≤ 120/105/120, respectively. In addition to the parameters used to assess the HDR and CUM doses, other data such as prostate volume, total dwell time (TDT), Conformality Index (CI) and Heterogeneity Index (HI) were reported for all patients. Results: Twenty five consecutive, de novo, cases were included in this study, excluding two patients who had prior irradiation. The median prostate volume was 47.1 cc (range 27.7-113). The median number of needles implanted was 15 (range 10-19). Median Prostate V100 was 95.4 (range 94.0-97.8). For the initial three cases after implementing the ABS/GEC-ESTRO guidelines, the prostate V100 was slightly below the tolerance of 95% in order to keep all DVH values (for both HDR boost and composite plan) within the normal tissue constraints. For the remaining cases, if the CUM DVH criteria were met, the prostate V100 ≥ 95% constraint was enforced, even if some of the HDR boost values were slightly over tolerance. In 7 cases, one or more dose values for the HDR plan were slightly over the constraints (primarily urethra 10%, for which the EBRT dose was conservatively overestimated as being the planning dose), but the CUM BED-EQD2 values were kept within the tolerances for all cases. Median bladder/rectum CUM D2cc EQD2 were 69.9 (range 59.3-85.7) and 68.9 (range 47.4-74.1), respectively. Median urethra CUM D0.1cc, D10%, D30% EQD2 were 111.1 (range 104.8-120.0), 108.9 (range 104.2-116.0), and 101.9 (range 79.7-104.9), respectively. The median CI and HI were 0.7 (range 0.6-0.8) and 0.6 (range 0.5-0.7), respectively. The goals for these indexes were: CI > 0.8, HI > 0.6. The TDT median value was 488.6 sec (range 363.7-789.5). We found that the TDT has a quasi-linear dependence on the prostate volume. A second order polynomial was used for the fit to account for the TDT saturation at large prostate volumes. Based on the fit formula a TDT range was estimated per range of prostate volumes to be used as a second check tool for future HDR planning. Conclusions: By using a standardized procedure the planning consistency was increased. Using CUM BED-EQD2 guidelines provides additional optimization flexibility to ensure consistently good prostate coverage with the HDR plan, while meeting all CUM dose guidelines. Future evaluation of clinical outcomes would be necessary to validate this planning approach for HDR prostate brachytherapy boost.

PO105
Comparison of Dosimetric Evaluation Data of Pre- and Post-Operative Plans of the 3D-Printing Coordinative Coplanar Template and CT Guided Radioactive Seeds Implanting Surgery
Ran Peng, M.D., Yuliang Jiang, M.D., Zhe Ji, M.D., Fuxin Guo, M.D., Haitao Sun, M.S., Junjie Wang, M.D.
Department of Radiation Oncology, Peking University Third Hospital, Beijing, China.
Purpose: To introduce a 3D-printing coordinative coplanar template and to compare the consistency of the pre- and post-operative plans when the template was utilized to aid the CT guided radioactive seeds implanting surgery.
Materials and Methods: The coordinate and origin were introduced into the coplanar template which was used to aid the CT guided seeds implanting surgery. Cross curves, which defined the treatment center and the coordinate system, were drawn on patient’s body and revealed by lead points during simulation. Pre-operative plan was designed and the template was applied to reproduce it by fitting the coordinate system on the template to the cross curves on the surface of the body under the guidance of the laser lights, and by puncturing the needles into the tumor through the holes on the template according to the pre-operative plan. Intraoperative dose optimization was done to rule out the possible deviation of the relative position of the needle and the tumor. After radioactive seeds implantation, post-operative plans was done to reassure the tumor got enough dose. This study analyzed the dosimetric data of the pre and post-operative plans to confirm if the new system guaranteed the reproducibility of the pre-operative plan. The parameters collected included D90 (minimum dose received by the 90% volume of the GTV), V100, V150, V200 (percentage of volume of GTV received 100%, 150%, 200% of the prescription dose, respectively) and minimum peripheral dose (mPD), as well as conformal index (CI), external index (EI) and homogeneity index (HI). The R software (version 3.3.1) was used to do the statistical analysis. Paired-Wilcoxon tests were done to compare the dosimetric parameters and the p value less than 0.05 was considered statistically significant. Results: Fourteen patients were enrolled from August 2016 to November 2016 in our institution. The median age was 61.5
and the median KPS was 80. Fourteen tumors were treated, 10 of which were in the superficial tissue and 4 in the deep tissue. Specifically, 5 were in the abdomen, 2 in the pelvic, 3 in the chest and 4 in the neck or supraclavicular region. Pre-, intra- and post-operative plans were done for every patient. The median activity of the seeds is 0.625 mCi (0.55-0.75 mCi, 1 Ci=3.7×10^10 Bq), the median number of needles used were 9.5 (4-34) and the median number of implanted seeds were 52 (10-162). The comparison found no significant difference between the pre- and post-operative plans, which were shown in detail in the table. **Conclusions:** With the help of the 3D-printing coordinative coplanar template, the pre- and post-operative plans were in good consistency. 3D-printing coordinative coplanar template can be a suitable alternate of 3D-printing non-coplanar template to be utilized in the radioactive seeds implanting surgery in some appropriate patients.

**Table** Comparison of dosimetric evaluation data of pre- and post-operative plans of the 3D-printing coordinative coplanar template and CT guided radioactive seeds implanting surgery

<table>
<thead>
<tr>
<th></th>
<th>Pre-operation</th>
<th></th>
<th>Post-operation</th>
<th></th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tumor volume</strong></td>
<td>18.5</td>
<td>1.3-323</td>
<td>19.8</td>
<td>1.3-283.7</td>
<td>0.625</td>
</tr>
<tr>
<td><strong>D_90 (Gy)</strong></td>
<td>150.3</td>
<td>110-251</td>
<td>157.5</td>
<td>110-279</td>
<td>0.208</td>
</tr>
<tr>
<td><strong>mPD (Gy)</strong></td>
<td>77.8</td>
<td>31.4-130.9</td>
<td>78.6</td>
<td>58.1-144.8</td>
<td>0.104</td>
</tr>
<tr>
<td><strong>V_{100} (%)</strong></td>
<td>90.4</td>
<td>75.3-99.8</td>
<td>91.4</td>
<td>83.2-99.1</td>
<td>0.542</td>
</tr>
<tr>
<td><strong>V_{150} (%)</strong></td>
<td>62.2</td>
<td>33.8-92.6</td>
<td>62.7</td>
<td>41.9-87.6</td>
<td>0.754</td>
</tr>
<tr>
<td><strong>V_{200} (%)</strong></td>
<td>36.7</td>
<td>16.5-75.1</td>
<td>38.8</td>
<td>18.6-65.9</td>
<td>0.583</td>
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<tr>
<td><strong>Cl</strong></td>
<td>0.648</td>
<td>0.325-0.859</td>
<td>0.682</td>
<td>0.311-0.779</td>
<td>0.855</td>
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<td><strong>EI (%)</strong></td>
<td>34.5</td>
<td>4.9-207.8</td>
<td>27.5</td>
<td>11.7-221.6</td>
<td>0.119</td>
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<tr>
<td><strong>HI (%)</strong></td>
<td>28.7</td>
<td>7.6-61.5</td>
<td>32.5</td>
<td>11.1-54.3</td>
<td>0.952</td>
</tr>
</tbody>
</table>

**Figure** Picture of the template and CT guided radioactive seeds implanting surgery

PO106
Commissioning and Peripheral Dose Measurements of the AccuBoost D-Shaped Skin Dose Optimized Applicators
Ileana Iftimia, PhD, Michael Talmadge, MS, Per Halvorsen, MS.
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Purpose: To complete a series of commissioning measurements and tests to validate the functionality and assess the peripheral dose of the AccuBoost D-shaped Skin Dose Optimized (SDO) applicators SDO D45 and SDO D53.

Materials and Methods: All four (i.e., two SDO-D45 and two SDO-D53) applicators were visually inspected to assess for any sign of damage. The proper internal catheters were trimmed and inserted inside each applicator, and then the total length (Varian GammaMed source guide tube plus applicator) was checked using the 130 cm gauge wire. Validation of the dwell positions within each applicator was performed using GafChromic film. Measurements of the absolute dose delivered with each AccuBoost D-shaped SDO applicator were performed in solid water using a plane-parallel Markus ion chamber. The readings in solid water were converted to dose in water using a predetermined solid water-to-water phantom factor of 1.07. Using a “water-to-polystyrene” mass energy absorption coefficient of 0.97 for Ir-192, the dose in water was then converted to dose in polystyrene and compared with the manufacturer’s stated dose based on Monte Carlo modeling. Using GafChromic film, the combined dose profile of two opposed applicators in the treatment position was assessed to ensure that they are coaxial and that the center of the radiation profile agrees with the location of the applicators as indicated on the localization calipers. To verify the Monte Carlo calculated maximum Surface-to-Center-Dose (SCD) ratios, spot check measurements using Optically Stimulated Luminescence Dosimeters (OSLDs) were performed for both pairs of applicators, using phantoms comprised of flexible bolus material mimicking three separations (~3, 6, and 8 cm). Three OSLDs were used for each measurement: one placed at the central axis mid-plane and two at surface, on applicator’s long axis, at 2.5 cm and 2.75 cm from the center for the SDO-D45 and SDO-D53, respectively. A mid-plane dose of 2 Gy was delivered to the 90% isodose line using two parallel opposed, equally weighted beams. Also, a series of measurements was performed for these applicators to quantify the peripheral dose and to characterize the dependence upon target breast separation and gantry angle, using an experimental set-up intended to represent realistic scenarios. Compressible bolus material was used to simulate the target breast while a stereotactic breast and Iodine uptake thyroid phantom were used to mimic the contralateral breast and thyroid, respectively. OSLDs were placed on the medial surface of the contralateral breast phantom and inside the Iodine capsule insert of the thyroid phantom. A mid-plane dose of 2 Gy was delivered to the 90% isodose line using each pair of applicators. The OSLD measurements were reported as a percent of the mid-plane prescribed dose.

Results: All applicators were in good condition without any sign of damage. Their physical dimensions were in agreement with the nominal values. Radiochromic film measurements demonstrated that for all four applicators the numbers of dwell positions inside the applicators agree with the values from the vendor. The shift needed for a good applicator-grid alignment was within 0.1 cm. The dry-run test using film demonstrated that the shift of the dosimetric center is within 0.15 cm. The overall absolute dose uncertainty for a clinically relevant separation range of 5-8 cm was within ~5%. The SCD ratio measurements support the Monte Carlo-based values within ~5% agreement. The peripheral dose values were comparable with the ones previously measured for the Natural D-shaped applicators. For a separation range of 5-8 cm the measured contralateral breast and thyroid dose was 2-5% and 1-4% of the central axis mid-plane prescribed dose, respectively.

Conclusions: The tests confirmed that the D-shaped SDO AccuBoost applicators are functional and that a treatment plan using them can be delivered with acceptable accuracy. The quality assurance manual and guidance documents for clinical use developed for the Natural D-shaped applicators were updated to include these new D-shaped SDO applicators. The guidelines for applicator selection were modified to take into consideration the fact that central dose coverage is reduced if the cavity/tumor is located at shallow depths below the skin.

PO108
Identification of Catheter Displacements in HDR Prostate Brachytherapy Using a ‘Shift Image’ Reconstruction Technique
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Purpose: High-dose-rate (HDR) prostate brachytherapy can be performed using CT imaging for treatment planning. These images are a ‘snap-shot’ in time of the implant geometry and may not represent the geometry at the time of
treatment, some hours later. Uncorrected catheter displacement can have a significant impact on dosimetry. Catheter displacement can be identified with pre-treatment imaging, but this can be difficult to achieve in the treatment bunker, and often is limited to 2D techniques. We present a method to perform pre-treatment image verification, in the treatment bunker, by reconstructing the catheter positions in 3D for direct comparison with the treatment plan.

**Materials and Methods:** A phantom was positioned on our customised brachytherapy treatment couch comprising an integrated flat panel detector, which is also used for in-vivo source tracking[1]. A ceiling-suspended x-ray system was used to capture two ‘shift’ images of the implant, with an imaging geometry illustrated in figure 1. Corresponding catheter paths were identified in each shift image and were back-projected to create a 3D reconstruction of the implant geometry. Registration with the treatment plan was performed, and comparison of the measured and planned catheters was performed to identify displacement. The sensitivity of catheter displacement detection was investigated by applying known inferior displacements of 2, 3, 5 and 10 mm to the implanted catheters. **Results:** The ‘shift’ image reconstruction technique provided a geometrically correct reconstruction of the implant volume. Assessment of the catheter displacement throughout the implant volume was possible, and not just at the catheter tip as typically performed with 2D verification approaches. The measured inferior catheter displacements are shown in figure 2, where all measured catheters reflect the applied displacements, within the determined measurement uncertainty. **Conclusions:** We have demonstrated a 3D catheter reconstruction technique can be applied to HDR prostate brachytherapy to perform catheter displacement identification.

**PO109**
**Dose Comparison Between Pre-Plan and Post-Plan of 125I Seeds Brachytherapy Guided by 3D Printing Template**

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**Purpose:** To compare the dose differences between pre-plan and post-plan of seeds implantation guided by 3D printing template, and to discuss the dose accuracy of the seeds implantation. **Materials and Methods:** A total of 13 patient cases on August to December of 2015 in Hebei General Hospital underwent 3D printing template guide seeds implantation. All patients had been fixed as the position of operation and then performed CT scan. After preplan was designed, the 3D tamplates were printed. The tumors were punctured through needles holes predesigned. Another CT scan was used to confirm the locations of needles and then seeds were implanted into tumor according to preplan. Postplan was performed after the operation. The D90(minimum absorbed dose of 90% target volume), V90(90% prescription dose coverage volume percentage of target volume), V100, V150 and seeds number pre and post operation were collected and compared.

**Results:** The mean D90, V90, V100, V150 and seeds number preoperation were (87.09 ±33.63) Gy, 93.66%±1.04%, 90.09% ±0.89%, 59.73%± 6.48%, 58.25 ± 21.13, respectively. The mean D90, V90, V100, V150 and seeds number postoperation were(85.39 ± 34.39)Gy, 92.76% ± 1.89%, 88.63% ± 2.33%, 61.24 %± 4.64%, 58.92 ± 21.38, respectively. The difference of all data between pre and post operation was not statistically significant ($p > 0.05$). **Conclusions:** The dose parameters in postplan show no difference compared with preplan. For the fixed tumor, 3D print template guided seeds implantation may become an easy repeated and standard procedure.
Accurate Prediction of Total Radiation Time Based on the Correlation Between Total Reference Air Kerma and Clinical Target Volume in CT-Based HDR Prostate Brachytherapy

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Purpose: In order to accurately predict radiation time and estimate the volume enclosed by the prescription isodose, we performed correlation analysis between total reference air kerma (TRAK) and clinical target volume (CTV) in CT-based HDR interstitial prostate brachytherapy.

Materials and Methods: 170 prostate patients (243 plans: 181 Mono and 62 Combo plans) treated with interstitial HDR brachytherapy at our institution between January 2015 and November 2016 were retrospectively reviewed. Hemi- and focal-prostate gland cases were excluded from this study. CTV (whole prostate gland and proximal seminal vesicles) and organs at risk (OAR) were contoured on CT images using the Elekta Oncentra Brachy treatment planning system (TPS). The following doses were prescribed to the CTV: 7.25 Gy x 6, 9.5 Gy x 4, 10.5 Gy x 3, or 13.5 Gy x 2 fractions for Mono cases, 6 Gy x 4, 7 Gy x 3, 7.25 Gy x 3, 10.5 Gy x 2, or 15 Gy x 1 fraction for Combo cases, and 6 Gy x 6 fractions for salvage cases. Treatment plans were generated using inverse planning simulated annealing optimization to meet target coverage (CTV D90 > 100%, V100 > 97%, and V150 < 35%) and OAR constraints (rectum D0.1cc < 85%, bladder D0.1cc=80-95%, urethra D0.1cc < 110% of the prescription). VCTV, V100%, and TRAK normalized with the fractional dose (d) were acquired from the TPS. The relations between the parameters were calculated using linear and quadratic functions and evaluated with the coefficient of determination (R²). Total radiation time (T) was then predicted using the model with a given VCTV, d, and air kerma strength (Sk) and compared to the actual radiation time from the TPS. The relations between the parameters were calculated using linear and quadratic functions and evaluated with the coefficient of determination (R²). Total radiation time (T) was then predicted using the model with a given VCTV, d, and air kerma strength (Sk) and compared to the actual radiation time from the TPS. Results: The number of implanted catheters (18 ± 1, range: 13-25) was not correlated with the prostate target volume (79.0 ± 30.0 cm³, range: 27.1-194.8 cm³). Linear regressions (V100% = 1.2196·VCTV + 5.5118 (R²=0.978) and TRAK/d = 0.0437·VCTV + 2.2232 (R²=0.9767)) obtained from the analysis in Figure 1 show that V100% and TRAK have strong positive correlation with VCTV. Total radiation times for the given target volumes were predicted with T (sec) = (TRAK/d)-(d/Sk)-(3600 sec/h), where TRAK is in cGy cm², d is in cGy, Sk is in cGy·cm²/h, V100% is in cm³, and VCTV is in cm³. The mean % difference between the actual and the predicted radiation time was 0.21 ± 3.68 % (range: -9.91% - 11.14%). Conclusions: TRAK and treated volume were found to have a strong linear correlation with the target volume. Radiation time could be accurately predicted with the target volume, prescription dose, and source strength. This method could also be used to detect abnormal radiation time and treated volume for quality assurance (QA) process in CT-based HDR interstitial prostate brachytherapy.
Figure 1. (a) Scatter plot between the number of implanted catheters and CTV. (b) Scatter plot between V100% in the body ($V_{100\%}$) and CTV ($V_{CTV}$). (c) Scatter plot between TRAK/d and CTV ($V_{CTV}$). The fitted lines in (b, c) represent strong linear correlations. (d) Histogram plot of the % difference between the actual and the predicted radiation times.

PO111
The Value of SPECT/CT in Precision Dose Measurement of $^{125}$I Seed in Solid Water
Hongtao Zhang, MD$^1$, Zeyang Wang, MD$^1$, Gang Qiu, MD$^1$, Aixia Sui, MD$^1$, Juan Wang, MD$^1$, Gaofeng Shi, MD$^2$.

1Oncology, Hebei General Hospital, Shijiazhuang, China, 2Radiology, The 4th Affiliated Hospital of Hebei Medical University, Shijiazhuang, China.

Purpose: To determine the relationship between the dose and radioactive count value detected by SPECT / CT of $^{125}$I seeds in solid water phantom. To study the feasibility of γ-ray detected based precision dose measurement.

Materials and Methods: Seventy $^{125}$I seeds were put into solid water individually which activity were $1.48\times10^7$Bq, $1.85\times10^7$Bq, $2.22\times10^7$Bq, $2.59\times10^7$Bq, $2.96\times10^7$Bq, $3.33\times10^7$ and $3.7\times10^7$Bq respectively. In which, each activity had 10 seeds. SPECT/CT was used to scan the seeds perpendicular to the long axis with the slice thickness of 3.75 mm. The radioactive count values (X) were collected at the distance of 1-15mm from the center of seeds respectively, while the corresponding doses(Y) (Gy) were calculated. SPSS18.0 was used to analyze the relationship
between count value and dose and fitted curves. **Results:** There was an exponential relationship between the dose around $^{125}$I seed and the radioactive count value detected by SPECT/CT. The formula of $1.48 \times 10^7$, $1.85 \times 10^7$, $2.22 \times 10^7$, $2.59 \times 10^7$, $2.96 \times 10^7$, $3.33 \times 10^7$ and $3.7 \times 10^7$ Bq seeds were $Y=2.442 \times 1.006^x$, $Y=2.460 \times 1.006^x$, $Y=2.361 \times 1.006^x$, $Y=1.586 \times 1.006^x$, $Y=2.657 \times 1.006^x$, $Y=3.929 \times 1.006^x$, $Y=1.817 \times 1.006^x$ respectively. The formula of all activity was $Y=2.489 \times 1.006^x$. **Conclusions:** The count value around $^{125}$I seeds can be detected accurately by SPECT/CT and quantitated. The study provides useful experiment data for precision measurement of $^{125}$I seeds implantation. Radiation detecting based dose measurement may become a new noninvasive technology for dynamic dosimetric verification method after brachytherapy.

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**Prostate Posters**

**PO112**

**Early Quality of Life Outcomes for MRI-Assisted Prostate Brachytherapy Patients**

Ahsan Farooqi, MD PhD, Pierre Blanchard, MD PhD, Teresa Bruno, CMD, Rajat Kudchadker, PhD, Jihong Wang, PhD, Aradhana Venkatesan, MD, Tharak Bathala, MD, Jingfei Ma, PhD, Steven J. Frank, MD.

MD Anderson Cancer Center, Houston, TX, USA.

**Purpose:** MRI-assisted prostate brachytherapy (MRPB) offers advantages over transrectal ultrasound (USPB) based brachytherapy including superior delineation of prostate gland and dominant intraprostatic lesions (DIL) for precise target delineation. It also allows for direct visualization of key normal structures including the external urinary sphincter (EUS) and bladder neck, allowing for avoidance of these regions using pre-implant treatment planning, and potential sparing of treatment related bowel, sexual, and urinary symptoms. We sought to assess quality of life (QOL) information in patients treated at a single institution with MRI-assisted prostate brachytherapy. **Materials and Methods:** A total of 90 patients with localized prostate cancer were treated at our institution with MRPB in 2015 and 2016 on an IRB approved prospective registry. 25 patients were treated with I-125, 34 with PD-103, and 31 with Cs-131 seeds. MRI-treatment planning resulted in approximately 10% less activity per volume per nomogram. Patient-reported QOL and health status in these patients was recorded via the Expanded Prostate Cancer Index Composite (EPIC)-50 questionnaire given before at baseline and at regular follow-up intervals of 1, 4, and 8 months. EPIC scores were available for 51 patients at baseline, 66 patients at 1 month, 25 patients at 4 months, and
19 patients at 8 months. We used SAS statistical software along with the designated EPIC formula to calculate mean QOL scores (range 0-100, a higher score being associated with better QOL) for bowel bother (bb), sexual bother (sb), urinary bother (ub), urinary irritative (uir) and urinary incontinence (uin) symptoms. AUA/IPSS urinary scores (0-35, a higher score being associated with worse urinary symptoms) were also recorded for these patients at these time points. **Results:** At baseline, the mean QOL scores for MRPB patients were 95, 69, 88, 89, and 96 for bb, sb, ub, uir, and uin, respectively, with an average AUA score of 5.6. The trend in QOL from baseline to 8 months can be visualized below. Bowel and urinary symptoms are reduced during radiation treatment (i.e. 1 mo) and trend towards baseline levels by 8 months after the implant. Sexual bother symptoms, however, seemed to persist, with the lowest QOL score at 8 months. These data are comparable to historical QOL scores reported using the EPIC questionnaire on USPB patients. Mean AUA scores were 16.9, 9.6, and 8.6 at 1, 4, and 8 months post-implant, respectively. **Conclusions:** Early patient reported QOL outcomes with MRPB are encouraging. Efforts should be made to avoid implanting seeds into the EUS through MRI-based treatment planning. Continued follow-up is warranted to assess the value of MRPB with respect to clinical outcomes, cost reduction, and quality assurance.

PO113 High-Dose-Rate Prostate Brachytherapy: Evolution of Dosimetry in a Single Institution
Miren Gaztañaga, MD, Carlos Prieto, MsC, Gonzalo Vázquez, MD, Domingo Córdoba, MsC, David Flavio Martínez, MsC, Rosario Vidal-Aragón, BSN, Manuel de las Heras, MD.

**Purpose:** To independently evaluate the effects of the learning curve and the modifications in the implant procedure method on dosimetric parameters. **Materials and Methods:** Study included 105 patients treated with HDR prostate brachytherapy with Oncentra Prostate™ (Nuclotron, an Elekta company, Elekta AB, Stockholm, Sweden). Dosimetric data of from the first 35 patients ("ORIGINAL" series, treated in 2013) were compared with the last 35 patients treated with our previous implant method ("PAST" series, implanted in 2015), in order to assess the impact of the learning curve. These two series were compared as well with the first 35 patients treated with the modified technique ("CURRENT" series, from 2016) to estimate its impact on dosimetry. These modifications in the procedure included a peripheral distribution on the needles and the addition of a margin (+ 5 mm expansion around prostate in all directions but rectal) created with the aim of enhancing the results. 1-way ANOVA and Tukey HSD tests have been performed. **Results:** Prostate coverage and dose homogeneity significantly increased over time.
(mean V100 in the ORIGINAL series 96.7% vs. 98% in the PAST protocol, p<.01) whereas doses in urethra and rectum significantly decreased with the learning curve (mean D10 in urethra 123.7% in the ORIGINAL series vs. 113.8% in the PAST series p<.01; D2cc in rectum 61.7% in the ORIGINAL series vs. 52.9% in the PAST series p<.01). With the novel implant technique, the CURRENT series has a prostate coverage of V100 98.75% with a dose homogeneity index (DHI) of 0.73, as compared with V100 of 98.0% and a DHI of 0.71 in the PAST group, there is a minor (but positive) non significant improvement. There was a trend toward a decrease in high urethral doses with the CURRENT technique, with less variability, although the results were not statistically different (mean D10 113.8% vs. 112.9%), while maintaining rectal doses below the constraints. Conclusions: The learning curve (including the use of more restrictive constraints) has significantly improved the dosimetric quality of the HDR prostate brachytherapy implant. The addition of a margin and the distribution of the catheters in the periphery of the prostate may reduce the potential uncertainty related with catheter movement or reconstruction errors, increasing safety, and extends the dose beyond the capsule, without compromising dose homogeneity. There is a trend toward an improvement in urethral high doses. Although rectal doses remain below the prescription constraints, more restrictive constraints will be used in the future.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ORIGINAL Mean (SD)</th>
<th>PAST Mean (SD)</th>
<th>CURRENT Mean (SD)</th>
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<tr>
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<td></td>
<td></td>
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<tr>
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<td>110.70% (0.06)</td>
<td>109.09% (0.02)</td>
<td>110.13% (0.02)</td>
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<tr>
<td>V100</td>
<td>96.68% (0.03)</td>
<td>98.00% (0.01)</td>
<td>98.75% (0.01)</td>
</tr>
<tr>
<td>V150</td>
<td>37.04% (0.08)</td>
<td>28.35% (0.06)</td>
<td>26.36% (0.06)</td>
</tr>
<tr>
<td>V200</td>
<td>11.28% (0.03)</td>
<td>8.46% (0.02)</td>
<td>7.91% (0.03)</td>
</tr>
<tr>
<td>URETHRA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dmax</td>
<td>129.71% (0.07)</td>
<td>115.86% (0.03)</td>
<td>114.55% (0.01)</td>
</tr>
<tr>
<td>Dmean</td>
<td>112.98% (0.05)</td>
<td>101.94% (0.04)</td>
<td>102.60% (0.03)</td>
</tr>
<tr>
<td>D10</td>
<td>123.75% (0.05)</td>
<td>113.79% (0.03)</td>
<td>112.90% (0.01)</td>
</tr>
<tr>
<td>RECTUM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dmax</td>
<td>84.82% (0.07)</td>
<td>73.35% (0.05)</td>
<td>77.20% (0.03)</td>
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<tr>
<td>Dmean</td>
<td>50.19% (0.05)</td>
<td>45.95% (0.04)</td>
<td>49.18% (0.03)</td>
</tr>
<tr>
<td>D2cc</td>
<td>61.75% (0.06)</td>
<td>52.90% (0.04)</td>
<td>56.77% (0.04)</td>
</tr>
</tbody>
</table>

PO114
Correlating Acute and Chronic Genitourinary Toxicity and Dose-Volume Parameters in Ultrasound-Based Planning for High-Dose Rate Prostate Brachytherapy
Karna Sura, MD1, Robert Gemayel, BS1, Brandon Nguyen, BS2, Hong Ye, PhD1, Evelyn Sebastian, BS1, Amy Limbacher, BS, RT(T)1, Kevin G. Blas, MD1, Zachary A. Seymour, MD1, Daniel J. Krauss, MD1.
1Beaumont Health, Royal Oak, MI, USA, 2Oakland University William Beaumont School of Medicine, Rochester Hills, MI, USA.

Purpose: To establish associated dose-volume histogram (DVH) parameters with acute and chronic genitourinary (GU) toxicity in high-dose rate (HDR) prostate brachytherapy

Materials and Methods: 194 patients were included in our study who had received one implant and 4 fractions of 9.5 Gy within 48 hours between the dates of May 2002 to December 2008. Each patient underwent live trans-rectal ultrasound (TRUS) planning and treated with rectal probe removed. Toxicity was scored according to common terminology criteria for adverse events (CTCAE) from the National Cancer Institute version 3.0. Of our initial set, 134 patients had long-term toxicity outcomes. DVH comparisons were completed with Wilcoxon rank sum test. Predictors for acute and chronic grade 2+ GU toxicity were analyzed using univariate logistic regression analysis, p<0.05 was considered significant. Results: Median follow-up was 4.7 years. 18.7% of patients had acute grade 2+ GU toxicity with 2.9% of the patients having
experienced acute grade 3 GU toxicity. 17% had chronic grade 2+ GU toxicity with 3.5% of the patients experiencing chronic grade 3 GU toxicity. There were significant differences in urethral volume between V133%-V141% as well as V173%-V200% for those with and without acute GU toxicity (Figure 1A). There was no significant differences between those with and without chronic GU toxicity when comparing urethral DVH parameters (Figure 1B). Higher urethral Dmax (1.005, 95% CL: 1.000-1.010, p = 0.040) was associated with acute 2+ GU toxicity while there were no significant associations for chronic 2+ GU toxicity found on univariate analysis. **Conclusions:** Higher urethral doses were associated with acute GU toxicity; however, there were no significantly associated urethral DVH parameters for chronic GU toxicity. With the low rate of toxicity, our current brachytherapy constraints seem conservative, and dose escalation could be considered.

**PO115**

**Improved Rectal Dosimetry with the Use of SpaceOAR During High Dose Rate Brachytherapy**

Susan Y. Wu, MD, Lauren Boreta, MD, Ashley Wu, BS, Adam Cunha, PhD, Katsuto Shinohara, MD, Albert J. Chang, MD, PhD. UCSF, San Francisco, CA, USA.

**Purpose:** While several studies have attested to the effect of hydrogel-based rectal spacers in limiting rectal radiation dose in the treatment of prostate cancer, to date there have been no studies assessing the utility and dosimetric effect of SpaceOAR (Augmenix, Inc., Waltham, MA), the first polyethylene glycol-based hydrogel that has been approved by the FDA for use in prostate cancer patients, in the setting of high dose rate (HDR) brachytherapy. This study aims to demonstrate the feasibility of SpaceOAR placement at the time of HDR brachytherapy and associated improvements in rectal radiation dose.

**Materials and Methods:** Eighteen consecutive patients scheduled for HDR brachytherapy to the prostate and seminal vesicles in the treatment of prostate cancer underwent transperineal ultrasound-guided hydrodissection and placement of 10 cc of SpaceOAR hydrogel under epidural anesthesia. Treatment plans were generated using an inverse planning simulated annealing (IPSA) algorithm. Dosimetric outcomes for these eighteen patients were compared with thirty-six preceding patients also treated with HDR brachytherapy to the prostate and seminal vesicles without the use of SpaceOAR. Radiation doses prescribed were consistent between the two groups and ranged from 15 to 21 Gy: 15 Gy in one fraction for HDR boost in conjunction with external beam radiation, 18 Gy over three fractions for two implants in a salvage course, and 19 or 21 Gy in one fraction for HDR brachytherapy monotherapy. **Results:** Treatment plans for 54 patients were analyzed. There was no significant difference in age, pre-treatment PSA, prostate volume, Gleason Score, clinical stage, or prescribed radiation dose between those who received SpaceOAR and those who did not. Patients who received SpaceOAR hydrogel at the time of HDR brachytherapy had significantly lower radiation dose to the rectum as measured by volume in cubic centimeters (cc) (V80 <0.005 cc vs. 0.01 cc, p = 0.007; V75 <0.005 cc vs. 0.12 cc, p = < 0.0005; V70 of 0.04 cc vs. 0.46 cc, p < 0.0005; V60 of 0.61 cc vs. 1.76 cc, p < 0.0005). Patients who received SpaceOAR also had lower rectal radiation dose as measured by percent of contoured organ at risk (median V80 <0.005% vs. 0.010%, p = 0.003; V75 <0.005% vs. 0.14%, p < 0.0005; V70 of 0.09% vs. 0.88%, p < 0.0005; V60 of 1.16% vs. 3.08%, p < 0.005). There was no difference in bladder V80 in cc (p = 0.17), bladder V70 in cc (p = 0.17),
dose to 0.1cc of the penile bulb (p = 0.56), or dose to 0.1 cc of the urethra (p = 0.72) between the two groups. One patient who received SpaceOAR developed a peri-rectal abscess approximately one month after treatment. There were no other adverse events potentially related to SpaceOAR placement. Average follow-up time was 160 days overall, and 111 days for patients who received SpaceOAR. **Conclusions:** Transperineal insertion of SpaceOAR hydrogel at the time of HDR brachytherapy is feasible and decreases rectal radiation dose. Further follow-up is needed to assess the clinical impact of this dosimetric improvement and potential side effects of SpaceOAR placement.

**PO117**

**Correlating Acute and Chronic Gastrointestinal Toxicity and Dose-Volume Parameters Using Surrogate Rectal Contours in Ultrasound-Based Planning for High-Dose Rate Prostate Brachytherapy**

Brandon Nguyen, BS¹, Karna Sura, MD², Robert Gemayel, BS², Hong Ye, PhD², Evelyn Sebastian, BS², Amy Limbacher, BS, RT(T)², Kevin G. Blas, MD², Zachary A. Seymour, MD², Daniel J. Krauss, MD².

¹Oakland University William Beaumont School of Medicine, Rochester, MI, USA, ²Beaumont Health, Royal Oak, MI, USA.

**Purpose:** Accurate anatomic delineation of the rectal wall is difficult during prostate HDR brachytherapy planned using trans-rectal ultrasound (TRUS) imaging. To determine associated dose-volume histogram (DVH) parameters with acute and chronic gastrointestinal (GI) toxicity, we compared 2 different standardized methods for defining the rectum. **Materials and Methods:** 194 patients were included in our study who had received one implant and 4 fractions of 9.5 Gy within 48 hours. Each patient underwent live TRUS-based planning during treatment and was treated with rectal probe removed to minimize dose to the anterior rectal wall. Of our initial set, 134 patients had long-term toxicity outcomes. Retrospectively, each patients’ surrogate rectal contour was reviewed and fixed for errors, consisting of a “triangle” with the point anteriorly at the midline. In order to standardize contours and minimize any subjectivity, an additional rectal probe contour was created, which outlined the entire probe. Toxicity was scored according to common terminology criteria for adverse events (CTCAE) from the National Cancer Institute version 3.0. Dose-volume histogram (DVH) comparison was completed with Wilcoxon rank sum test. Predictors for acute and chronic grade 2+ GI toxicity were analyzed using univariate logistic regression analysis. **Results:** Median follow-up was 4.7 years. The surrogate rectal structure contour had significantly decreased mean volume compared to the rectal probe contour (3146 cc v 11674 cc, p<0.001). There was no difference in global Dmax (76.6% v 77.5%, p = 0.385) to either contoured structure. There was a significant difference in Dmin (35.3% v 25.1%, p<0.001) and Dmean (54.3% v 45.5%, p<0.001). When comparing DVH parameters (Figure 1), there was a significant difference in volume up to V76% comparing the surrogate and rectal probe structure. Approximately 2% of patients had acute G2+ GI toxicity, and only 6% of patients had chronic 2+ GI toxicity with no G3+ toxicity present. There were no significant univariate or DVH parameter associations with acute G2+ GI toxicity. For chronic G2+ GI toxicity, there were significant differences between V96% and V99% although this was not clinically significant. There were no univariate associations for chronic GI toxicity. **Conclusions:** Due to the low toxicity rate, there were no clinically significant DVH parameters found amongst our cohort. Given the similar dose distribution at high dose, surrogate contours are safe to use although standardization is necessary to compare dose constraints, especially in the low-dose regions.
Day 0 Dosimetric Evaluation for LDR Prostate Brachytherapy May Be Superior to Day 30 Assessments by Providing Similar Quality Assurance Information at Earlier Time Points

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\textsuperscript{1}Dana-Farber Cancer Institute/Brigham and Women’s Hospital, Boston, MA, USA, \textsuperscript{2}Memorial Sloan Kettering Cancer Center, New York, NY, USA.

Purpose: Day 0 post-implant dosimetry is convenient and permits immediate correction of a suboptimal implant. However, unexpected declines in prostate D90 and V100 have been observed between day 0 and day 30. The purpose of this study is to determine whether day 0 dosimetric parameters can predict clinically significant declines in prostate dose coverage at day 30.

Materials and Methods: We analyzed patients, who underwent postimplant computed tomography (CT)-based dosimetry on days 0 and 30 after permanent prostate implantation with loose iodine-125 seeds. First, we characterized the geometric underpinnings of dosimetric declines through affine registration and decomposition. Then, we evaluated whether certain day 0 factors could aid in the identification of patients with clinically significant declines in prostate D90 (minimum dose received by 90% of the prostate gland), such that an acceptable day 0 D90 (\geq90\%) became unacceptable (<90\%) at day 30. For both objectives, we generated day 30 prostate contours based on the affine transformation of day 0 contours in order to reduce contouring variability between day 0 and day 30 scans. Results: Affine registrations were successfully performed for 147 of 151 patients. 20 of 30 patients with a decline in prostate D90 at day 30 had prostate stretching in the superior-inferior direction. On univariate regression, the prostate length in the superior-inferior direction (prostate z-length) at day 0 was significantly associated with changes in prostate D90 (p < 0.01) and V100 (prostate volume receiving 100\% of the prescription dose; p = 0.02). As shown in the figure, 9 of 10 patients with a clinically significant D90 decline had a day 0 prostate z-length \geq 3.5 cm (odds ratio 7.1; p = 0.04). Only 1 patient with a day 0 D90 \geq 100\% had an unacceptable D90 at day 30. Conclusions: The prostate z-length can aid in the identification of patients with significant declines in target coverage at day 30. These data suggest that day 0 evaluation may be the preferred alternative to day 30 for a majority of patients.
Acute Toxicity in Low Risk Prostate Patients: Low Dose Rate vs High Dose Rate Brachytherapy Monotherapy

Silvia Rodriguez Villalba, MD, PhD1, Antonio Otal Palacin, MSc1, Jose Richart Sancho, MSc1, Jose Perez-Calatayud, MSc1, Manuel Santos Ortega, MD, PhD1.

1Radiation Oncology, Hospital Clinica Benidorm, Benidorm, Spain, 2Radiotherapy Department, Hospital Universitario La Fe, Valencia, Spain.

Purpose: Brachytherapy (BT) in all their modalities, Low dose rate (LDR) and High Dose Rate (HDR) are used in early stages of prostate cancer. At present, all available clinical data regarding these two techniques suggests that they are equally effective, providing high tumor control rates. We compare our experience retrospectively considering acute toxicity in patients with low risk patients (D’Amico classification) treated with LDR BT or HDR BT in monotherapy. Materials and Methods: Between January 2004 and June 2016 we have treated 113 low risk patients (T1-T2b, PSA ≤ 10 ng/ml, Gleason ≤ 6) with BT as an exclusively treatment, 85 patients with LDR with permanent I-125 seeds and 28 with HDR Ir-192. LDRBT patients: Median age 68 years (48-81 y), median Gleason 5
(2-7), median value of PSA at diagnosis 7.3 ng/ml (2.5-16.3). In 25 cases (29%) the prescription dose was 145 Gy and in 60 (71%) 160 Gy. Thirty-three (39%) received hormonal treatment. **HDRBT patients:** Median age 70,5 years (55-80 y), median Gleason 6 (3-8), median value of PSA at diagnosis 9.08 ng/ml (3-19.75). All patients were treated with 2 applications of 13.5 Gy in monotherapy. Twenty (71%) received hormonal treatment. **Results:** We have analyzed the acute genitourinary (GU) and gastrointestinal (GI) toxicity of both treatments following criteria CTCEV.4. Results are showed in the Table. There are not Grade 3 o 4 acute toxicity. **Conclusions:** In this analyses, the genitourinary toxicity increased when the patient is treated with LDR BT, including 2 patients (3%) who needed urinary catheter after the implant. We did not find any differences in gastrointestinal toxicity with and excellent tolerance in both groups.

<table>
<thead>
<tr>
<th>GU TOXICITY</th>
<th>GRADE 0 LDR/ HDR</th>
<th>GRADE 1 LDR/ HDR</th>
<th>GRADE 2 LDR/ HDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAEMATURIA</td>
<td>100%/ 100%</td>
<td>0% 0%</td>
<td>0% 0%</td>
</tr>
<tr>
<td>CYSTITIS</td>
<td>35% / 100%</td>
<td>3% / 0%</td>
<td>21%/0%</td>
</tr>
<tr>
<td>INCONTINENCY URINARY</td>
<td>97%/87%</td>
<td>0% 8%</td>
<td>3%/4%</td>
</tr>
<tr>
<td>OBSTRUCTION URINARY</td>
<td>60%/100%</td>
<td>15% 0%</td>
<td>30% 0%</td>
</tr>
<tr>
<td>URINARY FREQUENCY/URGENCY</td>
<td>41%/69%</td>
<td>9%/0%</td>
<td>47%/4%</td>
</tr>
<tr>
<td>URINARY RETENTION</td>
<td>94%/100%</td>
<td>3%/0%</td>
<td>3%/0%</td>
</tr>
<tr>
<td>GI TOXICITY</td>
<td>94%/100%</td>
<td>3%/0%</td>
<td>3%/0%</td>
</tr>
<tr>
<td>DIARRHEA</td>
<td>100%</td>
<td>3%/0%</td>
<td>3%/0%</td>
</tr>
<tr>
<td>RECTAL INCONTINENCY</td>
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<td>6%/4%</td>
<td></td>
</tr>
<tr>
<td>RLCUH11S</td>
<td>94%/96%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PO120**

**Long-Term Outcomes from Low Dose-Rate Prostate Brachytherapy with Palladium-103 at a Single Institution**

M. Sean Peach, MD, PhD, Daniel M. Trifiletti, MD, W. Tyler Watkins, PhD, Kristine Bauer-Nilsen, Bachelor's, Dylan Campbell, Current Undergraduate, Bruce Libby, PhD, Timothy N. Showalter, MD, MPH.

UVA Health Center Department of Radiation Oncology, Charlottesville, VA, USA.

**Purpose:** To report the disease-specific outcomes of a large single institution experience of patients treated with low dose rate (LDR) prostate brachytherapy with palladium-103 (Pd-103). **Materials and Methods:** We retrospectively evaluated the disease-specific data at our institution for patients treated with Pd-103 LDR prostate brachytherapy from 1997-2016 and utilized univariate and multivariate analysis to analyze factors potentially influencing actuarial biological progression free survival (bPFS) and overall survival (OS) following brachytherapy. Brachytherapy planning, optimization, and data collection was performed using VariSeed (Varian Medical Systems, Palo Alto, CA). Post-treatment and nominal doses were calculated. Monotherapy dose ranged from 115-125 Gy and combination therapy utilized a brachytherapy dose of 90-100 Gy with an external beam radiotherapy (EBRT) boost of 45-46 Gy. Biological recurrence was defined by the Phoenix criteria ( nadir plus 2 ng/mL). Patient and disease characteristics were assessed including age, prostate volume, Gleason score (GS), pretreatment PSA (iPSA), clinical T-stage, NCCN risk group, presence of EBRT boost and presence of androgen deprivation therapy (ADT). **Results:** Our cohort included 393 patients with a median follow up of 8.75 years (0.1-17.8 years). The median age of patient's analyzed was 64-years-old (43-83), with 295 (75%) treated with Pd-103 LDR monotherapy, 98 (25%) treated with a combination of brachytherapy and EBRT boost and 193 patients (49%) receiving ADT. The mean iPSA was 8.75 ng/mL (0-103 ng/mL) and median prostate volume was 35.87 cc (16-90 cc). The 5-year and 10-year bPFS were 92.1% and 82.5%, respectively and 5-year and 10-year OS was 92.9% and 82.0%, respectively. On multivariate analysis, bPFS was only influenced by GS (HR 1.53, p=0.029), and OS was only influence by age (HR 1.05, p=0.023) and NCCN high-risk group (HR 2.47, p=0.049). Among patients with intermediate-risk disease, the addition of hormone therapy improved bPFS regardless of EBRT boost (p=0.036 among all intermediate risk
patients, p=0.033 among intermediate risk patients receiving combination therapy). ADT did not, however, impact OS among either of these subgroups. **Conclusions:** In one of the largest analyses to date of Pd-103 LDR brachytherapy, our findings confirm that Pd-103 LDR brachytherapy with long-term follow up is an effective treatment for prostate cancer. NCCN risk group predicts for bPFS and OS. Among intermediate risk patients, ADT improves bPFS regardless of presence of EBRT boost, but this does not translate into an effect on overall survival.

**PO121**

**Assessing the Relationship Between Dose-Volume Histogram Parameters and Late Rectal Toxicity in HDR Brachytherapy for Prostate Cancer**

Rodolfo Chicas-Sett, MD1,2, Dolores Farga-Albiol, MD1, Maria Jose Perez-Calatayud, MD1, Francisco Celada, MD1, Susana Roldan, MD1, Javier Burgos, MD1, Blanca Ibanez-Rosello, PhD1, Jose Maria Benlloch, PhD2, Jose Perez-Calatayud, PhD1,4, Alejandro Tormo, MD1.

1Radiation Oncology, La Fe Polytechnic and University Hospital, Valencia, Spain, 2Doctoral School, "San Vicente Mártir" Catholic University of Valencia, Valencia, Spain, 3Radiation Oncology, Recoletas Oncology Institute, Campo Grande Hospital, Valladolid, Spain, 4Radiation Oncology, Clinica Benidorm, Benidorm, Spain.

**Purpose:** To evaluate the ability of dose-volume histogram parameters (D0.1cc and D2cc) for predicting late rectal toxicity (LRT) after single-fraction high-dose-rate brachytherapy (HDRBT) boost and external beam radiotherapy (EBRT) in prostate cancer. **Materials and Methods:** From August 2010 to March 2015, three hundred (n=300) patients with National Comprehensive Cancer Network (NCCN) intermediate and high-risk prostate cancer were included. Treatment comprised a single-fraction HDRBT boost of 15.0 Gy plus EBRT (46.0 Gy delivered in 23 fractions) or a HDRBT boost of 9.5 Gy plus EBRT (60.0 Gy delivered in 30 fractions) if the seminal vesicles were infiltrated using real-time transrectal ultrasound-based planning. After HDRBT treatment delivery, four gold fiducial markers were implanted for image-guided radiotherapy. HDRBT was performed first, followed by computed tomography simulation 2 weeks later. EBRT was conducted after an additional 2-week interval. LRT was evaluated prospectively every 3 months after the end of the combined treatment using the Common Terminology Criteria for Adverse Events, version 4.0. The minimum dose received by the most exposed 0.1 and 2.0 cm³ volume of the rectum (D0.1cc/D2cc) was analysed by estimating the biologically equivalent rectal dose according to the recommendations of the Groupe Européen de Curiethérapie/European Society for Radiotherapy and Oncology and an ordinal regression and multivariate analysis was performed. **Results:** LRT was observed in 62 patients (20.7%) at a median follow-up of 33 (range, 2-68) months. The estimated 5-year OS and bDFS rates were 87.0% (95.0% confidence interval: 82.0-92.0%) and 90.0% (95.0% confidence interval: 83.0-98.0%), respectively. The mean ± standard deviation EQD2(α/β=3) doses for D0.1cc and D2cc were 80.3 ± 4.4 and 69.7 ± 3.6 for patients with Grade 0-1 and 80.4 ± 4.0 and 70.1 ± 2.7 for patients with Grade ≥2 LRT, respectively. Twenty-three (100%) patients who developed Grade ≥2 LRT received doses ≥65 Gy EQD2(α/β=3). Only 7 patients who were given a dose ≥75 Gy EQD2(α/β=3) developed Grade ≥2 LRT. A significant association was observed between D2cc and the probability of developing Grade 1-3 LRT (p=0.04). **Conclusions:** D2cc is associated with the occurrence of LRT in HDRBT-treated prostate cancer patients. The dose constraints proposed and recommended by experienced HDRBT centres must be investigated to determine the threshold dose thought long-term and prospective studies.

**PO122**

**An Evaluation of Needle Translations and Their Dosimetric Impact in CT Based Prostate High Dose Rate Brachytherapy Treatments**

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**Purpose:** Needle translations after prostate brachytherapy implantation and the resulting dosimetric impact on CT based treatment planning is a topic of controversy with published literature remaining mixed on its clinical significance. The purpose of this study is to evaluate the quality of our institutions procedure for prostate high dose rate brachytherapy implants by quantifying needle translations and their dosimetric impact between the treatment planning simulation CT and treatment delivery. **Materials and Methods:** Twenty implants, 40 CTs and 270 needles total were analyzed in this study. Patients were implanted with 5F plastic needles using a B-K grid. Upon implant completion, the grid was locked and the patient was placed on a custom mattress and special leg cushions with the intent of immobilizing the patient and reducing needle translations. The patient was transported from the OR to our
department on this mattress and remained immobilized in this position until treatment delivery was completed. Patients were transferred while in position on the custom mattress onto the CT table for the planning simulation scan. The simulation CT scan (sCT) was obtained with a 1mm slice thickness. The patient was held in an inpatient holding area while the physicians and physicists created a treatment plan. Upon plan completion the patient was transported in similar fashion to receive a repeat CT scan (rCT) with a 1mm slice thickness for evaluation of needle translations. Using the image registration software Velocity, Varian Medical Systems, rCT was registered to sCT using automatic rigid registrations with manual edits as needed. Gold markers placed at the base, mid gland and apex of the prostate during the implant were chosen as the primary target to evaluate the quality and accuracy of the registration. While viewing the sCT alone, contours were placed at the tip of each needle in the axial plane. Contours at the needle tips were then created for the rCT while viewing the rCT scan alone. All contours were recorded on the sCT dataset for study comparison. It was assumed that needle translations only occur in the craniocaudal direction. The coordinate of the center of each contour in that craniocaudal direction was recorded for each needle for each scan. The difference between the simulation and repeat coordinates were calculated. Implants with any needle retraction > 3mm were chosen for dosimetric evaluation. The 3mm tolerance was chosen based on a publication that found if all needles retracted 3mm or less, the target coverage would be within 95% of the original plan. The recorded translations for each individual needle were recreated in the planning system on the original treatment plan and dosimetry of the prostate, including a 6-10mm craniocaudal margin, and organs at risk were recorded. **Results:** The average needle translation was 1.06mm. The average maximum translation within a single implant was 2.35mm. 7% of the 270 needles had translations > 3mm. Only 1 implant had an average translation > 3mm. The average change in D90 for < 3mm average translations was -2.59%. The 1 implant with an average translation of 4.21mm demonstrated a D90 of 86% (18.5% reduction). Further evaluation of true prostate (without margin) demonstrated a D90 of 95% (10% reduction). Table 1 shows detailed results of the dosimetric evaluation. **Conclusions:** Dosimetric evaluation of this patient cohort confirmed small (<3mm) average translations do not result in clinically meaningful dosimetric changes and do not require adjustments prior to treatment delivery. The 1 implant with an average translation > 3mm resulted in significant degradation in target coverage which is consistent with previously reported literature. The overall procedure and steps taken at our institution to minimize needle shifts before treatment delivery are effective and result in a high quality implant. In the small chance a case with larger than expected needle translations occur, the inclusion of a craniocaudal margin on the prostate helps to ensure D90 values consistent with ABS guidelines.

**Table 1: Dosimetric evaluation of patients with single or average needle translations greater than 3mm**

<table>
<thead>
<tr>
<th>Translation mm)</th>
<th>Δ(%) Prostate</th>
<th>Bladder with translations</th>
<th>Rectum with translations</th>
<th>Urethra with translations</th>
<th>Urethra+2mm with translations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg</td>
<td>Max</td>
<td>D90</td>
<td>V100</td>
<td>V75 (cc)</td>
<td>V75 (cc)</td>
</tr>
<tr>
<td>1</td>
<td>1.56</td>
<td>3.0</td>
<td>-2.6</td>
<td>-2.8</td>
<td>0.35</td>
</tr>
<tr>
<td>2</td>
<td>2.08</td>
<td>3.0</td>
<td>-3.5</td>
<td>-3.2</td>
<td>0.05</td>
</tr>
<tr>
<td>3</td>
<td>1.30</td>
<td>8.0</td>
<td>0.3</td>
<td>-0.2</td>
<td>0.22</td>
</tr>
<tr>
<td>4</td>
<td>2.64</td>
<td>5.0</td>
<td>-2.1</td>
<td>-2.6</td>
<td>0.00</td>
</tr>
<tr>
<td>5</td>
<td>4.21</td>
<td>5.0</td>
<td>-18.5/-10.7</td>
<td>-12.0/-7.9</td>
<td>0.00</td>
</tr>
<tr>
<td>6</td>
<td>3.07</td>
<td>4.0</td>
<td>-5.1</td>
<td>-4.6</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**PO123**

Retrospective Dose Volume Histogram Analysis of High Dose Rate Prostate Brachytherapy Patients with Hydrogel Spacer Implantation

Sean Xavier Cavanaugh, MD¹, Steven Daniel Crawford, MS¹,², Joseph Scott Dick, MS¹,², Patricia Nicole Schantz, MS¹,², Tiffany Tsui, MS¹,², John Swanson, PhD¹,².

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Purpose: A commercially available bioabsorbable hydrogel system—a mixture of a precursor (trilysine buffer solution and polyethylene glycol powder) and accelerator (salt buffer)—is implanted between the prostate and rectum of men undergoing radiation therapy for prostate cancer. Use of this device provides additional separation between the prostate and rectum, ostensibly reducing rectal injury due to proximity of the high dose target. This study investigates rectal sparing achieved in high dose rate (HDR) prostate brachytherapy patients with hydrogel spacer implantation. Materials and Methods: One-hundred and forty-three monotherapy HDR prostate brachytherapy cases were selected from the patient population treated from July 2015 to December 2016. Patients were selected based on a treatment regimen of 13.5 Gy per fraction. Of these cases, 32 fractions were delivered to patients with implanted hydrogel rectal spacers while 111 fractions were treated without the use of this or any other rectal sparing device. For this patient cohort, the dose volume histogram (DVH) from the previously calculated plan was used to obtain D_{1cc}, D_{2cc}, and maximum rectal dose statistics based on rectum contours drawn on the planning CT dataset by the dosimetrist at the time of treatment planning. To compare to conventionally fractionated external beam radiation therapy (EBRT), the equivalent dose in 2 Gy fractions (EQD2) was calculated for each rectal dose statistic. Statistical analysis software was employed for data analysis. Results: The D_{1cc}, D_{2cc}, and maximum dose to the rectum for cases in which the hydrogel spacer was implanted prior to treatment were compared to cases treated without rectal sparing devices. Results with and without hydrogel spacer implantation were as follow: D_{1cc} was 7.9±0.2 Gy and 8.4±0.5 Gy, respectively; D_{2cc} as 7.1±0.2 Gy and 7.5±0.4 Gy, respectively; and the maximum dose to the rectum as 10.7±0.4 Gy and 11.9±0.6 Gy, respectively. Reduction in maximum (p < 0.001) and small volumetric doses (p = 0.026 and 0.105 for D_{1cc} and D_{2cc}) to the rectum were observed in cases implementing the hydrogel rectal spacer. Considering a typical HDR prostate brachytherapy dose prescription of 27.0 Gy (two 13.5 Gy fractions) and an α/β = 3.0 for rectum, the average maximum EQD2 point dose for patients receiving hydrogel implants was 59.8±3.3 Gy compared to 71.9±3.0 Gy (p < 0.001) for those treated without the device. Conclusions: DVH analysis for the patient sampling with hydrogel implantation demonstrated statistically significant reduction in D_{max} and D_{TCC} metrics. When compared to plans without hydrogel implants, the average EQD2 of the max point dose to rectum for patients receiving hydrogel implants was lower and fell within the TD5/5 of 60 Gy, as recommended by Emami et al. Future clinical evaluation of these patients may allow for a statistical relationship between the observed dose reduction and clinical toxicity.

PO124 Patient-Reported Outcomes in Prostate Cancer Treated with a CT Based High Dose Rate Brachytherapy

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Purpose: High dose rate (HDR) brachytherapy is an important tool for management of prostate cancer. Brachytherapy alone or combined with external beam radiotherapy (EBRT) has demonstrated some of the most promising outcomes to date in the management of prostate cancer. There are abundant publications on the efficacy of radiotherapy tools for the management of prostate cancer but limited patient reported outcome series, especially using CT based HDR brachytherapy technique. We report our patient quality of life and toxicity outcomes using CT based HDR as monotherapy and boost as a definitive management tool for prostate cancer. Materials and Methods: One hundred thirty three patients with low to high risk prostate cancer received CT based HDR monotherapy (13.5 Gray x 2, n=76) or boost (9.5-10.5 Gray x 2, n=57) following EBRT between June 2012 and December 2015. Patient outcomes are assessed and studied with institutional IRB approval. PRO were collected at baseline and regular intervals after radiotherapy using Expanded Prostate Cancer Index Composite (EPIC-CP) questionnaire and American Urologic Association Symptom Score (AUASS). Reported domains include urinary incontinence, urinary irritation/obstruction, bowel, sexual and vitality/hormonal. Short-term (ST) changes are defined at less than 6 months while long-term (LT) changes are considered greater than 6 months. The EPIC-CP minimally important differences in changes in the urinary incontinence, urinary irritation/obstruction, bowel, sexual and vitality/hormonal domains were 1.0, 1.3, 1.2, 1.6 and 1.0, respectively. Results: One hundred and thirty three patients received CT based HDR brachytherapy and 128 are evaluable with minimal one year of follow up for PRO with a median follow-up of 26 months for the entire cohort. The AUASS peaked at one month, and continued to be evaluated at six months, until declining to baseline or below base line scores after one year for the entire cohort and
in both treatment groups. Mean sexual domain scores were significantly increased or worse than baseline at <6 months with a mean difference of 2.3 but returned to baseline at later post treatment time points with a mean difference of 1.0. Mean vitality/hormonal domain scores were significantly higher or worse than baseline at <6 months for the group receiving CT based HDR boost (mean increase of 1.47) while a non-significant mean change of 0.27 was observed in lower risk patients receiving monotherapy. Overall, non significant but increased scores were observed in all domains over time, both ST and LT. The largest non-significant mean change or worsening is in urinary incontinence domain scores in the ST for the boost cohort and LT for all men (mean 0.9+/-.1).

**Conclusions:** While ST sexual, vitality/hormonal, and AUASS declined with treatment, most PRO domains did not significantly change and distress was not otherwise reported by CT based HDR patients with ST or LT follow-up. A CT based HDR technique offers a well-tolerated treatment as monotherapy or boost with acceptable levels of patient reported toxicity.

### Table 1: Mean post treatment domain change after short-term and long-term follow-up

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Change considered significant</th>
<th>HDR Combined</th>
<th>HDR Boost</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST Incontinence</td>
<td>1</td>
<td>0.49</td>
<td>0.73</td>
</tr>
<tr>
<td>ST Irritation</td>
<td>1.3</td>
<td>0.84</td>
<td>0.6</td>
</tr>
<tr>
<td>ST Bowel</td>
<td>1.2</td>
<td>0.7</td>
<td>0.4</td>
</tr>
<tr>
<td>ST Sexual</td>
<td>1.6</td>
<td>2</td>
<td>2.67</td>
</tr>
<tr>
<td>ST Vitality/Hormonal</td>
<td>1</td>
<td>0.27</td>
<td>1.47</td>
</tr>
<tr>
<td>LT Incontinence</td>
<td>1</td>
<td>0.85</td>
<td>0.92</td>
</tr>
<tr>
<td>LT Irritation</td>
<td>1.3</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>LT Bowel</td>
<td>1.2</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>LT Sexual</td>
<td>1.6</td>
<td>1</td>
<td>0.83</td>
</tr>
<tr>
<td>LT Vitality/Hormonal</td>
<td>1</td>
<td>-0.2</td>
<td>0.08</td>
</tr>
</tbody>
</table>

**PO125**

**Early Outcomes in a Prospective Phase I/II Trial of MRI Assisted Focal Boost Integrated with HDR Monotherapy for Low and Intermediate Risk Prostate Cancer**

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**Background:** There is growing evidence for the use of High Dose Rate (HDR) brachytherapy as monotherapy for the treatment of low and intermediate risk prostate cancer patients. With the increasing availability of magnetic resonance imaging (MRI) there is an opportunity to further escalate dose to the dominant intraprostatic lesion (DIL). We report early outcomes of this prospective phase I/II trial. **Materials and Methods:** Eligible patients had low- and intermediate risk prostate cancer, IPSS < 16, were medically eligible for HDR brachytherapy treatment and had an identified DIL on multiparametric MRI (mpMRI) prior to brachytherapy treatment. Patients were treated with 19 Gy delivered in one fraction to the whole prostate. At the time of brachytherapy, cognitive co-registration or radially weighted contour based deformable registration was performed to delineate the DIL volume. A 0-5mm expansion was applied to the DIL to define the PTV DIL, with a DIL PTV D90 to receive ≥ 23Gy based on previous experience. Toxicity was assessed using CTCAE v.4.0 at baseline, 6 weeks 3, 6, 9 and 12 months post brachytherapy. **Results:** A total of 37 patients have undergone HDR monotherapy treatment with an integrated DIL
boost with a median follow up of 9 months. The median age was 69 years (range 46-80). At presentation, median PSA was 6.1 ng/mL (range 2.5-16.4). Four, 27, and 6 patients had low, low intermediate and high intermediate risk disease. Baseline characteristics were PIRAD 5 (n=20) and PIRAD 4 (n=17), median prostate volume was 37.9 cc (range 18-54). The median DIL volume was 2.79 cc (range 1.14-7.8). The median DIL D90 was 27 Gy (range 19-35.8). No patients experienced acute or late grade 2+ GI toxicity. The percentage of acute grade 2 GU toxicity were as follows; retention 62%, frequency 18%, urinary tract pain 6%. One patient had acute clot retention requiring catheterization x1 day and has been catheter-free since. **Conclusions:** The use of mpMRI to define and further escalate dose to the DIL using HDR monotherapy is feasible with minimal acute toxicities. Further long term follow up is required to determine the efficacy of treatment, and impact on quality of life and late toxicities.

**PO126**

**Comparing Low Dose Rate and High Dose Rate Prostate Brachytherapy Implant Dosimetry**

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**Purpose:** We developed a prostate high dose rate (HDR) brachytherapy program in September 2015. Prior to this we performed exclusively low dose rate (LDR) brachytherapy. Our objective was to compare our institution’s HDR and LDR dosimetry to identify strengths of both approaches. **Materials and Methods:** We performed a retrospective cohort study comparing the dosimetry of patients treated with LDR and HDR brachytherapy by the same two brachytherapists. All HDR patients were treated on a prospective institutional IRB-approved protocol. We used I-125 for LDR (prescription dose 145 Gy as monotherapy and 110 Gy as a boost) and Ir-192 for HDR (prescription dose 13.5 Gy x 2 fractions in 2 implants and 15 Gy x 1 as a boost). Dose-volume-histogram data were compared for HDR and LDR cases for structures used in planning for both approaches. Target V200, V150, V100, V95, D90, rectum V100, rectum D2cc, and rectum D1cc were compared between LDR and HDR patients. Due to HDR plans being nested within patients, significance (p) was determined using a linear mixed effects model with random intercepts for each patient. P<0.05 was considered statistically significant. **Results:** The study cohort consisted of 112 patients treated from 2012-2016. 51 patients received LDR, 61 patients received HDR (100 total implants). 23 patients had brachytherapy as a boost, 91 (81.2%) had cT1a-c disease, and 21 (18.8%) had cT2a-c disease. Gleason score 6, 7, and 8-10 were present in 52 (46.4%), 52 (46.4%), and 8 (7.2%) patients. 41 (36.6%) and 57 (50.9) had low and intermediate risk disease, respectively. Median pre-treatment PSA was 6.43 (interquartile range [IQR] 4.93-9.29). As described in the table, patients receiving HDR had lower target V200, V150, V100, and V95, while there was no difference in D90. Rectum D2cc was similar between LDR and HDR, but rectum D1cc was lower in the HDR group. Rectum V100 was zero for all patients with HDR, and higher for LDR. **Conclusions:** In our series of patients treated by the same brachytherapists, patients receiving HDR brachytherapy had lower V150 and V200 within the target, and lower rectal doses compared to our LDR patients. Target coverage was also better in the HDR patients, although D90’s were similar.

<table>
<thead>
<tr>
<th></th>
<th>HDR</th>
<th>LDR</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Target V200% (Standard Error [SE])</td>
<td>7.69 (0.52)</td>
<td>13.83 (0.74)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Mean Target V150% (SE)</td>
<td>29.06 (1.29)</td>
<td>43.20 (1.54)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Mean Target V100% (SE)</td>
<td>96.05 (1.79)</td>
<td>83.15 (2.04)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Mean Target V95% (SE)</td>
<td>97.95 (0.33)</td>
<td>93.42 (0.42)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Mean Target D90 [% of prescription] (SE)</td>
<td>106.82 (0.99)</td>
<td>105.64 (1.45)</td>
<td>.50</td>
</tr>
<tr>
<td>Mean Rectum D 2 cc Gy [% of prescription] (SE)</td>
<td>66.18 (1.19)</td>
<td>67.95 (1.52)</td>
<td>.36</td>
</tr>
<tr>
<td>Mean Rectum D 1 cc Gy [% of prescription] (SE)</td>
<td>71.64 (1.32)</td>
<td>81.71 (1.68)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Mean Rectum V100% [cc] (SE)</td>
<td>0 (0)</td>
<td>0.46 (0.04)</td>
<td>-</td>
</tr>
</tbody>
</table>
PO127
Twice vs Single Applications in High Dose Rate Brachytherapy (HDR) Boost. Same Results in High Risk Prostate Cancer Patients?
Silvia Rodriguez Villalba, PhD, MD, Antonio Otal Palacin, PhD, Jose Richart Sancho, MPh, Jose Perez-Calatayud, MPh, Manuel Santos Ortega, PhD, MD, Carolina Domingo, PhD, MD.
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Purpose: HDR brachytherapy (BT) boost is utilized for dose escalation in the treatment of clinically localized high risk prostate cancer. We report two different regimens, 2 applications of 9.5 Gy related to one application of 15 Gy as a boost to external beam radiotherapy (EBRT) in a large cohort of patients treated in a single institution. Materials and Methods: We reviewed retrospectively data of 95 patients treated for clinically localized prostate cancer, High risk patients (D’Amico classifications) with curative intent between August 2009 and December 2015. All patients received either IMRT pelvic radiotherapy (Median 50.4 Gy ) in combination with a HDR in two regimens: 2 fractions of 9.5 Gy (69 patients. 73%) separated one week before May of 2014 or a single fraction of 15 Gy (26 patients. 27%) after these date. Treatment was delivered using an out-patient intraoperative ultrasound-based technique with the patient under spinal anesthesia and sedation. BT boost was administrated 3-4 weeks after finishing EBRT according our protocol in all the patients. Results: Median age 59 years (51-82 y). Median Gleason 7 (3-10) and median value of PSA at diagnosis 11 ng/ml (2, 26-106 ng/ ml). Fifty patients (16%) were diabetic, 49 (52%) high blood pressure and 16 (17%) were under an anticoagulant treatment. Eighty five patients (95%) were staged with a magnetic resonance (MRI). Ninety four patients (99%) received androgen deprivation (AD) and 29 (31%) as neoadjuvant treatment. Median AD was 24 months (5-24 m). All patients had a personally follow-up. Follow-up assessment was with CTCAE v.4 and blood test with PSA at 12 weeks, every 4 months for the first year and then every 6 months. After 5 years of follow up, it is done once a year. Median follow-up is 39 months (8-83 m). At December of 2016, 83 patients (87%) are alive without disease, 2 (2%) have died of tumor and 10 patients (11%) have died of other causes. Overall survival at 12, 24 and 60 months are 99, 96 and 96% % respectively for the patients treated with 2 fractions and 100 % at 12 and 24 months for patients treated with a single fraction without statistical significance (p NS). Biochemical control is 100% in both groups. Local control is 100% in both groups, lymph node control is 99% (one retroperitoneal recurrence in a patient treated with 2 fractions) and 4 patients have bone metastases (all patients treated with 2 fractions regimen) without statistical significance (p NS). There is not acute genitourinary (GU) or gastrointestinal (GI) toxicity grade 3. One patient (1%) needed a transurethral resection because chronic obstruction and another surgical treatment of urethral stenosis. Five patients (5%) developed rectitis grade 3 (3 treated with 2 fractions of 9.5 Gy and one patient treated with 1 fraction of 15 Gy) in a median time of 8 months (3-29 m). All of them were solved with Argon laser. There are not difference in adverse grade 3 rectal events between both groups (p = NS). Due to the low number of other toxicities reported in follow-up, multivariate analysis was not done. Conclusions: Prostate HDR boost delivered in a single 15 Gy treatment fraction compares favorably in terms of toxicity to 2 fractions of 9.5 Gy, one week apart. Longer follow-up is needed to compare clinical results in terms of overall survival and local control.

PO128
Clinical Application of Pre-Treatment Image Verification of Catheter Positions for HDR Prostate Brachytherapy
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Purpose: Swelling of the prostate and perineum occurs and over the time period between imaging (for treatment planning) and treatment delivery, causing the catheter positions (and hence displaced planned source dwell positions) to potentially shift relative to the anatomy. Displaced catheter positions unaccounted for at treatment can produce a perturbed dose distribution relative to the prostate and surrounding organs at risk. Re-imaging the patient, ideally in the treatment bunker, prior to treatment delivery is desirable in order to verify the position of the catheters relative to the surrounding anatomy. We have established a pre-treatment imaging approach using our Brachytherapy Image Guided Verification (BIGV) system. Pre-treatment image verification of the catheter positions are performed in the treatment bunker and compared directly to the treatment planning system. In this work we
present the clinical results for 14 HDR prostate patients, where pre-treatment verification was performed on images acquired immediately prior to treatment delivery. **Materials and Methods:** Pre-treatment imaging was performed for 28 treatment fractions, (2 fractions per patient) with the positions of the implanted catheters at each treatment fraction verified using the BIGV system. This system which consists of a flat panel detector (FPD) embedded into the brachytherapy treatment couch and a ceiling suspended x-ray device. The patient was setup on the treatment couch and aligned above the sensitive region of the FPD. Radio-opaque x-ray markers were inserted into the plastic proguide catheters in order to verify the positions relative to previously implanted gold prostate fiducial markers. The ceiling suspended x-ray system was positioned above the patient and an anterior-posterior (A-P) x-ray image was acquired with the FPD. The gold prostate fiducial markers were identified and registered with the markers identified in the treatment plan. A comparison of planned and measured catheter positions was then performed relative to the prostate. Catheter tip positions were compared and the agreement of the catheter path through the prostate region was evaluated for all catheters with inserted x-ray markers. Observed catheter displacements at treatment were re-created on the treatment plan to assess any dosimetric impact. **Results:** The average registration uncertainty between the A-P image and the TPS for the gold fiducial markers was 0.9 mm (s.d.0.4 mm, max 1.7 mm). The largest catheter displacement was observed for fraction 1 with an average catheter tip displacement in the inferior direction of 10.8 mm. The average inferior catheter tip displacement for fraction 2 was 1.5 mm (s.d. 0.9 mm, max. 3.3 mm). The catheter paths through the prostate region agreed to within 2mm, as shown in figure 1 (blue planned, red measured catheter paths), suggesting minimal lateral displacement of the catheter positions. **Conclusions:** Pre-treatment imaging has been performed to verify catheter positions, with the patient in the treatment position, immediately prior to treatment delivery. The measured catheter displacements observed for fraction 1 were on average greater than fraction 2, and suggests the rate of perineum swelling is important and may result in a deviated dose distribution. The BIGV system which enables direct comparison of planned catheter positions with measured positions, immediately prior to treatment, permit the introduction of adaptive planning techniques in HDR prostate brachytherapy.
PO129
Focal Radiosensitization of Brachytherapy: Determining the Optimal Design of Drug Eluting Implants
Christian V. Guthier, Ph.D.1, Anthony V. D'Amico, M.D., Ph.D.1, Martin T. King, M.D., Ph.D.1, Paul L. Nguyen, M.D.1, Peter F. Orio, M.D.1, Srinivas Sridhar, Ph.D.2,1, G. Mike Makrigiorgos, Ph.D.1, Robert A. Cormack, Ph.D.1.
1Department of Radiation Oncology, Brigham and Women's Hospital and Dana-Farber Cancer Institute, Boston, MA, USA, 2Department of Physics, Nanomedicine Science and Technology Center, Northeastern University, Boston, MA, USA.
Purpose: In-situ drug release concurrent with radiation therapy has been proposed as a means to enhance the therapeutic ratio of permanent prostate brachytherapy. Both brachytherapy sources and brachytherapy spacers have been proposed as potential eluters to release drugs directly into the prostate. This work models the biologic effect of implantable eluters of radio-sensitizer in conjunction with brachytherapy to determine which of the proposed methods is the preferred delivery approach. Materials and Methods: The combined effect of implanted drug eluters and radioactive sources were modeled in a manner that allowed selection of eluter location to optimize biologic effect for a range of model parameters. The retrospective study includes 20 patients previously treated with LDR
brachytherapy from which prostate geometries, source and spacer positions were extracted. The biological effect of drug concentrations was calculated by using the steady state solution to the diffusion equation including an elimination term characterized by the diffusion-elimination modulus ($\phi_b$). Radiosensitization was assumed to be dependent on drug concentration up to a saturation concentration ($c_{sat}$). For a given number of eluters ($n_e$) the clinical objective was to find the best possible configuration of eluters, for a given drug delivery vehicle that maximizes the biological effect. **Results:** The biologic effect was calculated for prostate volumes from 11 cm$^3$ to 64cm$^3$, $\phi_b$ from 0.01 mm$^{-1}$ to 1 mm$^{-1}$, $c_{sat}$ from 0.05 to 8.0 times the steady state drug concentration released from the surface of the eluter and $n_e$ from 10 to minimum number of either number of used spacers or seeds. For the parameter space of ($\phi_b$, $c_{sat}$)=$\{[0.01, 0.25],[0.05, 4]\}$ that results in a large fraction of the gland being maximally sensitized, drug eluting spacers or sources produce equal increase in biologic effect. For the remaining ($\phi_b$,$c_{sat}$)-space eluting spacers are preferable. Placing drug eluting implants in planned locations throughout the prostate results in even greater sensitization than using only source or spacer locations. **Conclusions:** Drug eluting brachytherapy spacers offer a means to increase the biologic effect of brachytherapy implants with no change in treatment process. Incorporating additional needle placements to allow the freedom to place spacers independently of source placement offers a means to increase the therapeutic ratio with relatively minor modifications of the implant process.

**PO130**  
**Single Fraction High Dose Rate Brachytherapy as Monotherapy in Intermediate Risk Prostate Cancer: Early Clinical Outcomes**  
Royal Adelaide Hospital, Adelaide, Australia.  
**Purpose:** To report early urinary (GU), gastrointestinal (GI) adverse events (AEs) and PSA outcomes after single fraction high dose rate brachytherapy as monotherapy (HDR-M) for intermediate risk (NCCN risk category) prostate cancer using real-time trans-rectal ultrasound (TRUS) based planning. **Materials and Methods:** Between April 2015 and September 2016, a total of 40 consecutive patients with intermediate risk prostate cancer were treated with a single fraction of 19 Gy (n=10) or 20 Gy (n=30) HDR-M. None received hormone therapy. Real time US based planning technique was used. Genito-urinary (GU) and gastro-intestinal (GI) toxicity were assessed using the International Prostate Symptom Score scale (IPSS) and RTOG scales (GI/GU) scales. Biochemical relapse was defined according to the Phoenix Consensus definition (PSA nadir + 2μg/L). **Results:** Median age was 69y (range, 51y-84y) and median follow up was 9 months (range, 3-22 months). All patients tolerated the procedure well with no intraoperative or perioperative complications. No patient developed urinary retention. Five (12.5%) patients developed Grade 2 urinary toxicity which returned to baseline by 3 months. There was no ≥ Grade3 urinary toxicity (including urinary strictures). Median IPSS at baseline was 6, increased to 9 at 1month, returning to 6 at 3months. No patient developed any Grade of GI toxicity. After a median follow up of 9 months there were no biochemical failures. Cumulative percentage of patients with PSA ≤ 1 ml at 6 months was 30% with PSAs continuing to fall in all patients as of last follow up. Median percentage PSA fall at 1, 3, and 6 months was 47%, 70% and 79% respectively compared to iPSA. **Conclusions:** This is the first report of the use of single fraction HDR brachytherapy as monotherapy in prostate cancer from Australia. This treatment is well tolerated with early results showing low GU/GI adverse events and good early PSA outcomes. Longer follow up is needed to assess long-term outcomes and toxicities.

**PO131**  
**US-Planned HDR Prostate Brachytherapy Boost: Acute and Late Toxicity**  
Laurie Pilote, MD$^1$, Juanita Crook, MD$^1$, Miren Gaztañaga Boronat, MD$^2$, Ana Ots, MD$^3$, Jasbir Jaswal, MD$^4$, Jim Rose, MD$^5$, Audrey Tétreault-Laflamme, MD$^6$, Deidre Batchelor, PHD$^4$, Matthew Shmid, PHD$^1$, Cynthia Araujo, PHD$^1$, Marie-Pierre Millette, PHD$^1$, Francois Bachand, MD$^1$.  
$^1$BC Cancer Agency, KELOWNA, BC, Canada, $^2$Dalhousie University, Halifax, NS, Canada, $^3$United Lincolnshire Hospitals, Madrid, Spain, $^4$BC Cancer Agency, Fraser Valley, BC, Canada, $^5$BC Cancer Agency, Abbotsford, BC, Canada, $^6$Centre Hospitalier Universitaire de Sherbrooke, Sherbrooke, QC, Canada.  
**Purpose:** HDR prostate brachytherapy has been combined with external beam (EBRT) for over 2 decades, using a wide range of dose and fractionation schedules. Rates of complications, such as urethral strictures, are reported from
2-30%. We evaluate acute and long term urinary and bowel toxicity in our first 5 years’ experience. **Materials and Methods:** From 06/2011 to 05/2016, 123 patients with localized upper tier intermediate and high risk prostate cancer were treated by 192-iridium HDR brachytherapy (BT) combined with EBRT. Patients were entered in 3 consecutive IRB-approved clinical trials (NCT01248741, NCT01605097 and NCT01936883) and data was collected prospectively. In all cases US-planned HDR BT preceded EBRT, which started within 7 days and delivered 46 Gy in 23 fractions (81% 3DcRT, 19% IMRT/VMAT), with fiducials placed at the time of HDR for image-guidance. Initially 20 Gy in 2 fractions in 2 separate implants was prescribed (42%), moving later to 15 Gy in 1 fraction (58%). HDR planning constraints were prostate V100 ≥98%, and V125: 55-62%, urethra Dmax <115% and rectal D1cc ≤70%. Tumor stage was T1c: 16%, T2: 77% and T3: 7%. Gleason score was 7 in 68% and 8-10 in 32% of patients. Median PSA was 10.1 (range: 1.7-35.8). 65% were upper tier intermediate risk and 35% high risk. Fifty-four percent had androgen ablation (< 6 months: 7.5%, 6 months: 21.5%, 9-12 months: 60%). Median prostate volume at the time of HDR delivery was 35 cc (range: 14-82). Toxicities were graded using the Common Terminology Criteria for Adverse Events, version 3.0. **Results:** Median follow-up is 24.3 months (range: 7-68.8) but differed between the two fractionation schedules, being 42.8 months for 20 Gy/2 (range: 22.6-68.8) and 16.7 months for 15 Gy/1 (range: 7-42.6). Catheterization (all cases used clean intermittent self-catheterization) was required for obstructive symptoms in 4 patients (3.3%) and continued for 1-5 weeks during EBRT. Three of 4 patients were in the 15 Gy single fraction group. The average prostate volume for these patients was 48 cc versus 37 cc for the whole cohort. One case was precipitated by urinary tract infection. Acute Grade 1 GU toxicity occurred in 52%, G2 in 13%, and G3 in 3.3% of patients. Acute Grade 1 GI toxicity occurred in 43%, G2 in 5.7%, with no G3 or G4 toxicity. Late Grade 1 GU toxicity occurred in 40%, Grade 2 in 7.3%, and Grade 3 in 4.0% of patients. Of these, late Grade 1 hematuria was reported by 5.7% and Grade 2 in 1.6%. Urethral strictures occurred in 3.3% (n=4) after an average of 2.8 years (range: 2.2-3.5 years), equally divided between the two fractionation schemes. All 4 have been effectively managed, 3 with a single visual internal urethrotomy (VIU) and one with cystoscopy and dilatation. Late Grade 1 GI toxicity was seen in 14.6%, G2 in 7.3% of patients, and G3 in 3.2%. One patient had a colostomy for a sigmoid stricture outside the HDR radiation volume. Rectal bleeding occurred in 11 patients (8.9%), Grade 1 in 7 patients, and G3 in 4, after an average of 17.5 months (range 3-35). Three of the 4 patients with grade 3 bleeding received 15 Gy in 1 fraction, despite the shorter median follow-up. The average rectal D1cc for all patients was 61.5% (range 51%-71%) and was not higher for those who experienced rectal bleeding and those who did not (p=0.43). **Conclusions:** US-planned HDR brachytherapy as 2 fractions of 10 Gy or a single 15 Gy combined with EBRT is well tolerated with late grade 2 GU toxicity in 7.3% and grade 3 in 4.0%. Urethral strictures were seen in 3.2% and grade 3 rectal bleeding in 3.2%. A single 15 Gy is convenient and cost-effective but observed toxicity may increase with longer follow up as only 50% have reached the median time for toxicity development.

**PO132**

**Salvage LDR Brachytherapy in Local Relapse After Radical Prostatectomy**

Renato Chiarlone, Chief Unità Complessa di Radioterapia1, Francesca Vallerga, Radiation Oncologist1, Claudio Arboscello, Radiation Oncologist1, Emilio Gastaldi, Urologist2, Nunzia Ciscognetti, Physician3.

1Radiology and Radiotherapy, S.Paolo Hospital, Savona, Italy, 2Urology, S.Paolo Hospital, Savona, Italy, 3Physical Medics, S.Paolo Hospital, Savona, Italy.

**Purpose:** Patients with adenocarcinoma of the prostate treated with radical prostatectomy (RP) have a 10% risk of developing local recurrence within 10 years. The possibilities of treatment in these cases, including surgery or adjuvant radiotherapy, are not well defined. Brachytherapy is a well established first-line treatment option. We report on a series of seven patients with pathologically confirmed localized local relapse in prostate fossa after retropubic or robotic prostatectomy treated with LDR interstitial brachytherapy, a novel fast effective potentially curative therapy after surgery with limited risk of incontinence and rectal complications. **Materials and Methods:** We proposed LDR interstitial brachytherapy in prostate fossa recurrence, after retropubic or robotic prostatectomy, when biopsy is confirmed (TRUS-guided); patients had no evidence of nodal or distant metastasis on imaging or bone scan. Relapses are investigated on endo-rectal ultrasonography and mpMR. No one has done hormone therapy or radiotherapy after surgery. Patients underwent computed tomography-based dosimetry 1 month after implantation. Follow-up examinations were scheduled every 3 months for the first year after BT and then every 6 months. Post-operative evaluation was performed in accordance with the American Brachytherapy Society Guidelines. **Results:** We considered 7 patients (median age 73 ys) with a median of 9 years local recurrence after
radical prostatectomy RP (range 5-15 ys) as attached patients table. Range target-volume was 10 to 18 cc and the implanted quick-link seeds 10-27 with 120-160 Gy to PTV. With a median follow-up of 30 months (range 16-40 m.) only two patients developed biochemical failure at 10 and 24 months from PSA-nadir post-implant. Toxicity was defined according to the RTOG: 3 ps. had Grade 2 adverse genitourinary events with increment of IPSS (4-5 points) for six months. There were no Grade 3 or higher adverse events. **Conclusions:** Ultrasound-guided trans peri-anal brachytherapy is a novel fast effective potentially curative second-line therapy after surgery or EBRT failure, with limited risk of incontinence and rectal complications. Larger series of patients with longer follow-up are needed to define the oncological role of this procedure.

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**Breast Posters**

**PO133**

**The Importance of Having a Daily CT Scan During SAVI Treatments for Breast Cancer Patients Using Deformable Registration**

Shereen Chandrasekara, Medical Physics Msc.  
*Physics, Florida Atlantic University, Boca Raton, FL, USA.*

**Purpose:** Imply the importance of having a daily CT scan during SAVI Treatments for Breast Cancer Patients using Deformable Registration. Case Report. **Materials and Methods:** An analysis of a Breast Cancer patient treated with SAVI applicators at SFRO Boca Raton in 2015 was considered for this study. Treatment planning teams did see significant changes in her daily CT scans through scout images. As a result initial treatment plan was replaced and new Treatment Plan was made for the treatment purpose daily. To verify the change in dose and importance in having a daily CT scan, CT scans of this patient taken before each treatment were separately imported into the treatment planning system and paired with the initial CT scan after completing the contouring. Deformable registration is performed to find the dose received by skin, ribs and PTV (Planning target volume) to examine the change in doses. **Results:** There is a noticeable change in doses that imply the adverse effects that can happen to this
patient, if we avoid taking a daily CT scan to monitor the shift of the applicator during the Treatment. **Conclusions:** It appears that taking a daily CT scan throughout the treatment is necessary to minimize the risk of delivering undesired high doses to the critical organs due to inter fractionation motion of SAVI device. However more clinical trials are needed to verify this aspect and the reasons of such deviations for some patients.

**PO134**

**Five Years Survival, Seroma, Recurrences and Mets in Accelerated Partial Breast Irradiation (APBI) with SAVI and CONTURA**

Muhammad A. Shah, MS, Michael J. Anderson, MD, Ali S. Meigooni, PhD, Raul T. Meoz, MD, Joseph Contino, MD, Souzan El-Eid, MD, Josette Spotts, MD, Margaret Terhar, MD, Craig Koontz, MS.

Radiation Oncology, Comprehensive Cancer Centers of Nevada, Las Vegas, NV, Henderson, NV, USA.

**Purpose:** Accelerated Partial Breast Irradiation is a treatment technique that is used to treat certain type of breast cancers. The most recent treatment strategy is designed for radiation delivery twice a day for 5 days. There are different techniques / Applicators that are used to achieve this goal. SAVI (Strut adjusted volume implant) and CONTURA are two types of treatment applicators that are presently used in USA. These devices have multiple catheters that are designed to optimize dose to the treatment volume and reduce dose to the skin and ribs.

**Materials and Methods:** APBI is one of the treatments for breast cancer patients after lumpectomy. The device for APBI can be either a SAVI device or a balloon (CONTURA). Also recently Best industries have introduced a device that is called Best balloon. One of the advantages of this treatment modality is that patients complete their treatment in 5 days (two fractions per day six hours apart). Treatment plan is performed with the help of CT scan images. Usually an Ir-192 isotope is used for these treatments in USA. At CCCN, in Las Vegas, these treatments are currently offered with Elekta’s HDR unit (microselectron with Ir-192 isotope). All patients have CT planning scans 24-48 hours following the insertion of the brachytherapy device. Treatment usually begins the following Monday. The CT scan is repeated prior to fractions 1, 5 and 9 for the strut based implants. The patients with balloon based implants undergo breast ultrasound within the treatment room prior to each fraction. Patients are treated to a dose of 3400 cGy in 10 fractions. Treatment volume is defined by a 1 centimeter margin around the implant device. 5mm margin is provided between the skin and the treatment volume. For SAVI treatments every effort is made to achieve the goal of 95% dose covering 95% of the treatment volume (RTOG recommendation is 90% dose to 90 % Volume). At the same time, in order to eliminate the toxicity, V200 is kept below 10 cc to 12 cc (RTOG recommendation is 20 cc). V150 is kept below 30 cc (RTOG recommendation is 50 cc). Also doses to skin and ribs are controlled to eliminate any undesired results. Dose to skin is kept below 100 % of the prescription dose and dose to ribs is kept below 125 % of the prescription dose. Initially skin contour was drawn at the surface of the body scan. But later on this criterion was changed to extend the surface volume by 1 mm in the body and the dose is controlled to that Region of interest. **Results:** A total of 299 patients were studied from the beginning of the program in 2011 to Dec. 2016. However, 21 patients did not follow up so they are not included in the results. Also for 44 patients the follow up time was less then 6 months so they are also not included in the study. The maximum follow-up period is 5 years, whereas the minimum follow up period is 6 months. This data includes a total of 195 SAVI patients and 39 Contura patients (total of 234). The tabulated data show in the results are indicating the NED, Seroma, local recurrence, metastatic disease in other parts of the body and deceased patients. These results indicate a very impressive outcome from this treatment modality. After the study of 234 patients, local recurrence was found in only four patients **Conclusions:** The tables show that the results achieved with APBI are very good and patients are getting accelerated treatment with very good results and at the same time these patients are getting excellent cosmetic results. Our single institution, non academic, non SAVI collaborative group experience lines up at least very favorably in terms of outcome and toxicity.
PO135
Comparison of Clinicopathologic Fetures in Patients with Accelerated Partial Breast Irradiation (APBI) Eligible Breast Cancer Undergoing Whole Breast External Beam Radiation Therapy (EBRT) or Brachytherapy Based APBI
Alexis Schutz, BS, Ozer Algan, MD
University of Oklahoma, Oklahoma City, OK, USA.
Purpose: The purpose of our study was to compare clinical and histopathologic features for patients undergoing APBI vs EBRT. Materials and Methods: We performed a retrospective cohort study evaluating data collected from multidisciplinary breast cancer tumor board for patients undergoing surgery for breast cancer between 1/29/2013 and 7/8/2016. APBI eligible was defined as patients having invasive or in situ breast cancer with tumor size </= 3cm and lymph node negative status. This cohort was divided into patients undergoing brachytherapy for APBI (APBI group) vs those patients undergoing whole breast irradiation using EBRT (EBRT group). Comparison of clinicopathologic factors between the two groups were made using univariate Chi-Square analysis for categorical variables and t-test for continuous variables. This study was reviewed and approved by our institutional IRB.
Results: A total of 661 APBI eligible patients were identified (559 in EBRT group and 102 in APBI group). Median patient age was 60 years old for the EBRT group compared to 65 years old for the APBI group (p < 0.001). In the APBI group, lower percentage of patients had DCIS (15.7% vs 20%), or lobular cancer (2.9% vs 8%) but this difference was not statistically significant (p = 0.200). Median tumor size in the APBI group was 11 mm vs 12 mm in the EBRT group (p = 0.227). However, a larger percentage of APBI patients had tumor size </= 10mm (46.1% vs 35.4%) and tumor size </= 20 mm (92.1% vs 70.4%). In general, APBI patients had higher percentage of Grade 1 and 2 tumors (76.5% vs 61.6%, p=0.714) and higher mean ER (86.2% vs 65.5%, p<0.001) and PR (62.6% vs 45.8%, p < 0.001) staining scores and lower Ki67 scores (22% vs 36.3%, p < 0.001). Evaluation of discordant results between ER/Ki67, and Grade revealed slight differences, with more APBI patients having an ER > 50% and Grade 3 tumors (15.5% vs 14.9%), and fewer APBI patients having ER > 50 and high Ki67 values (3.53% vs 11.1%).
Conclusions: In our large single institution series, patients undergoing APBI tended to have smaller and less aggressive tumors, with fewer discordant features, compared to those patients treated with EBRT.

PO136
Infection Prevention Measures on Patients Undergoing High Dose Rate Brachytherapy for Breast Cancer
Raul T. Meoz, M.D., FACR1, Michael Anderson, MD1, Josette Spotts, M.D.2, Souzan El-Eid, M.D.2, Margaret Terhar, M.D.2, Joseph Contino, M.D.2, Ali Meigooni, PhD1, Muhammad Shah, M.S.1, Stacey Wright, R.T. (R) (T)1.
The purpose of this communication is to report our findings and measures being taken to prevent infections in patients receiving high-dose rate brachytherapy for breast cancer. We reviewed 268 patients treated with high-dose rate brachytherapy for breast cancer since June 2011 to July 2016. The patients have been treated with a variety of applicators including balloon applicators and strut-based applicators. We have identified four infections during this period of time, three in patients that received balloon applicators and one patient treated with a SAVI device. These infections were identified either at treatment end and/or at time of the first post-radiation follow-up; all cases have been successfully treated with antibiotics experiencing full recovery. We have looked at all possible sources of infection and developed a protocol to minimize the infection risk as much as possible. For the last three years, our process of cleaning transfer tubes includes taken a culturing off all the tubes at the end of the treatment cycle per patient. A total of 280 samples have been sent with only three returning any bacterial growth. Neither one had been associated with a current infection of a patient. Those catheters were immediately discarded. The radiation oncology staff has been instructed on infection prevention and infection control procedures for these patients. Sterile approach and materials are used when handling the external catheters and sterile techniques to clean, disinfect, and redress the area after each treatment. Patients are routinely placed on antibiotics at the time of the catheter insertion and continue antibiotics throughout the treatment course. For patients with balloon applicators we use breast ultrasound as pretreatment QA BID. We use single use sterile ultrasound gel. Any transfer tubes that are suspect from contamination with wound drainage are discarded right away. Routinely we set aside a set of transfer tube for each patient throughout the treatment. Then at the end of the treatment, this set is completely sterilized for use in other patients.

PO137
Accelerated Partial-Breast Irradiation (APBI) Using High Dose-Rate Interstitial Brachytherapy for Invasive Ductal Carcinoma (IDC)
Anna Tao, Jekwon Yeh, MD, Saagar Seth, Rajesh Khanijou, MD, Kenneth Tokita, MD, Albert Mesa, MS, Lucy Barnes, MS.
Cancer Center of Irvine, Irvine, CA, USA.
Purpose: To review our clinical outcomes in patients with IDC treated with partial breast irradiation +/- whole breast irradiation. Materials and Methods: Between 2007 and 2014 a total of 61 patients were treated with APBI HDR brachytherapy +/- whole breast irradiation. All patients had negative surgical margins at lumpectomy. 44 patients received 34Gy BID through a multi-catheter interstitial brachytherapy device. 17 patients received APBI as a boost (10Gy) in conjunction with whole breast radiation (50Gy). PTV was tumor bed + 1cm margin. Median follow up was 34 months. Results: Average size of IDC was 17.8mm (S.D. = 11mm). Grade 1: 17%, Grade 2: 48%, Grade 3: 31%, N/A: 4%. 80% had estrogen receptor positive disease. 15 patients had lymph node positive (LN) disease. Of the LN positive patients, the average number of involved lymph nodes was 1. No patients had an in-breast recurrence. 2 patients developed recurrence in the ipsilateral axillary lymph nodes. One of these patients had node positive disease at lumpectomy but refused whole breast radiation. She only received brachytherapy only to the cavity and developed an axillary LN recurrence one month after radiation. The other patient had a T2N0 IDC and received whole breast radiation and brachytherapy boost and developed an axillary LN recurrence 6 months after finishing radiation. Conclusions: In our series we continue to show that partial breast irradiation remains an excellent treatment for optimizing local control for infiltrating ductal carcinoma.

PO138
Accelerated Partial-Breast Irradiation (APBI) Using High-Dose-Rate Interstitial Brachytherapy for Ductal Carcinoma In-Situ (DCIS)
Anna Tao, Jekwon Yeh, MD, Saagar Seth, Rajesh Khanijou, MD, Albert Mesa, MS, Lucy Barnes, MS, Kenneth Tokita, MD.
Cancer Center of Irvine, Irvine, CA, USA.
Purpose: To review our clinical outcomes in patients with DCIS treated with partial breast irradiation +/- whole breast irradiation. Materials and Methods: Between 2007 and 2014 a total of 21 patients were treated with APBI HDR brachytherapy +/- whole breast irradiation. All patients had negative surgical margins at lumpectomy. 16
patients received 34Gy BID through a multi-catheter interstitial brachytherapy device. 5 patients received APBI as a boost (10Gy) in conjunction with whole breast radiation (50Gy). PTV was tumor bed + 1cm margin. Median follow up was 38 months. **Results:** Average size of DCIS was 21.3mm (S.D. = 18mm). Grade 1 : 10%, Grade 2: 62%, Grade 3: 24%, N/A : 4%. 82% had estrogen receptor positive disease. Only 1 patient had an in quadrant breast recurrence. This developed 3 years after primary radiation and was a non-invasive recurrence treated with lumpectomy. No patients developed recurrence in the ipsilateral axillary lymph nodes. **Conclusions:** In our series we show that partial breast irradiation remains an excellent treatment for optimizing local control for Ductal Carcinoma In-situ.
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