Improving efficiency and reducing costs of MRI-Guided prostate brachytherapy using Time-Driven Activity-Based costing

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ABSTRACT

INTRODUCTION: Integrated quality improvement (QI) and cost reduction strategies can help increase value in cancer care. Time-driven activity-based costing (TDABC) is a bottom-up costing tool that measures resource use over the full care cycle. We applied standard QI and TDABC methods to improve workflow efficiency and reduce costs for MRI-guided prostate brachytherapy.

METHODS AND MATERIALS: We constructed process maps of the baseline prostate brachytherapy workflow from initial consultation through one year after treatment. Process maps reflected resources and time required at each step. TDABC costs were calculated by multiplying each process time by the cost per min of the resource(s) used at that step. We then used plan-do-study-act methodology to identify workflow inefficiencies and implement solutions to reduce resource consumption.

RESULTS: The highest cost components at baseline were the operating room (OR) (40%), imaging (8.7%), and consultation (7.6%). Higher-than-expected costs (3%) were incurred during surgery scheduling. After targeted QI initiatives, OR time was reduced from 90 to 70 min, which reduced overall cost by 5%. Personnel task downshifting reduced costs by 10% at consultation and 77% at surgery scheduling. Re-engineering of follow-up protocols reduced costs by 8.4%. Costs under the new workflow decreased by 18.2%.

CONCLUSIONS: TDABC complements traditional QI initiatives by quantifying the highest cost steps and focusing QI initiatives to reduce costs and improve efficiency. As payment reform evolves toward bundled payments, TDABC and QI initiatives will help providers understand, communicate, and improve the value of cancer care. © 2021 Published by Elsevier Inc. on behalf of American Brachytherapy Society.

Keywords: Brachytherapy; Quality improvement; Prostate; Time-driven activity-based costing; TDABC

Introduction

Advances in cancer treatment have led to substantial improvements in cancer outcomes for patients across the United States (1–3). These advancements, however, have made modern cancer therapy increasingly complex and costly (4) Value, defined as outcomes relative to costs,
has been proposed as a unifying framework for improving healthcare delivery (5). Improving the value of cancer care, therefore, requires accurate measurement of the health outcomes and costs associated with care delivery. Such measurement provides the baseline for using quality improvement (QI) efforts to improve the value of cancer care.

High-quality radiation therapy requires the coordinated effort of many individuals across many processes. Workflow inefficiencies and poor linkages between processes can lead to substantial frustration, workarounds, and increased costs to patients, providers, and payers. Continuous improvement of current processes is necessary to continue to provide high-value services. Accordingly, several organizations have promoted the study and adoption of QI processes in radiation oncology (6–8). The “plan-do-study-act” (PDSA) method of QI, with detailed documentation of procedures and frequent assessments of intended improvements, has been applied to improve radiation therapy processes (8–10).

Modern QI interventions, however, do not typically measure cost (11), and hospital cost accounting, which uses traditional costing methods such as the ratios of cost-to-charges or relative value units, provides estimates of actual resource consumption by clinical and administrative processes based on charges rather than the cost of underlying resource utilization (12,13). Time-driven activity-based costing (TDABC), in contrast, can measure accurately the cost of resources used across a full cycle of patient care. TDABC has been used across a variety of industries to measure costs and improve workflows, but has only recently been introduced in cancer care (14–16).

In this study, we used process mapping and TDABC to assess baseline processes and costs for low-dose rate prostate brachytherapy (PB), considered a low-cost therapeutic modality for prostate cancer (17). We then implemented PDSA methods to improve workflow efficiency and TDABC re-analysis to assess the financial impact of QI initiatives in PB.

Methods and materials

Process mapping

The PB monotherapy workflow was specifically chosen for this pilot analysis, given its favorable outcomes (18), cost profile (17) and defined workflow processes. For this study, we used a PB monotherapy workflow using pre-loaded stranded Iodine-125 seeds. We used a Siemens G20 TRUS machine (Siemens Medical Solutions, Malvern, PA) for image acquisition and the Variseed (Varian Medical Systems, Palo Alto, CA) treatment planning system (version 8.0). We chose one year after the brachytherapy seed implantation as the study endpoint to capture the largest proportion of costs, which accrue during the first year of therapy (16). Initial baseline analysis was conducted on PB cases from 2014 and 2015, and post-QI intervention re-process mapping and re-analyzing of costs were done on the newer workflows during the 2015–2017 timeframe. The technique, as assessed in this manuscript, was kept constant during this timeframe.

Clinical and administrative teams created process maps of the baseline prostate brachytherapy workflow for the full cycle of care (Fig. 1a). This care cycle began with initial patient registration and radiation oncologist consultation; it ended one year after brachytherapy. Figure 1b represents a “drill-down” process map of the consultation workflow. Each resource (i.e., personnel, equipment, or facility) involved in each step in the care cycle was noted for each activity. The time (in min) required at each activity was also recorded, based on time estimates by the clinical and administrative teams and time-motion studies of specific components of the process (19,20). Time-motion studies were conducted on several major processes, including preregistration, consultation, operating room and intra-op dosimetry (including pre-op, op, and post-op activities), post-op dosimetry, peer review, and post-op follow-up.

TDABC calculation

TDABC analyses were conducted as previously described (14,21). Briefly, each activity in the process map was associated with a single or multiple resources (personnel, equipment, facility). The clinical team worked with the finance team to calculate capacity cost rates (CCR), which are the cost per min of each resource(s) used in the brachytherapy care cycle (12). The finance team comprised analysts from our institution’s financial planning and analysis division. The finance team had the broad capability of conducting TDABC calculations and conducting analytics using the institution’s enterprise data warehouse, which links clinical, administrative, and financial data. Compensation data based on job codes were obtained from the institutional PeopleSoft (Oracle Inc., Redwood Shores, CA) payroll application. Fully allocated costs included employment costs, such as salary and benefits, direct costs associated with treatment, and indirect costs. The total salary and benefit expense for a particular job group was divided by the annual number of work min in a year, adjusted for non–productive and indirect work time, to calculate the CCR. Capacity cost rates reflect both direct and indirect costs and reflect the actual cost to the provider for having personnel, equipment, or facilities available for delivering care, as described previously (20). Calculations would start with direct costs for each type of resource involved in a patient’s care, such as personnel, facilities, supplies, and support services. Indirect (“overhead”) costs that are also associated with patient-facing resources that support these direct services, such as information technology, billing, human resources, and other space or facilities, were added proportionally to direct costs (19,20). The practical capacity for each resource was calculated based on insti-
tutional standards for daily availability for clinical care, vacation, educational time, historical patient volumes, and downtime due to maintenance, repair, and scheduling fluctuations (20,22).

The cost of performing each activity in the process map could then be calculated by multiplying the time elapsed during the activity in min by the CCR for the resources used during the activity. Costs associated with depreciation of radiation therapy and diagnostic imaging equipment were also embedded into the cost analysis using a simple depreciation model based upon institutional and manufacturer’s recommendations. The total TDABC cost for the full cycle of brachytherapy was calculated as the sum of the cost of all patient activities from initial consultation to one year after the PB implant. TDABC costs were adjusted for inflation to FY2018. The TDABC software used for this analysis calculated average process times without availability of ranges or quartiles.

**Quality improvement initiatives**

Clinical and administrative teams jointly reviewed the initial baseline prostate brachytherapy workflow. These teams comprised physicians (radiation oncologists, clinical residents or fellows, anesthesiologists, radiologists), nurses, advanced practice providers (APP, such as physician assistants or nurse practitioners), patient schedulers, and departmental administrators, depending upon the specific workflow being evaluated. Team members reviewed processes within the visually depicted process maps. Discussions centered on perceived inefficiencies (including personnel, equipment (including electronic health record and physician order entry), and facilities) within the current baseline workflow, such as poor linkages between activities and inefficient use of personnel and other resources at various steps (Table 1). The financial teams also presented baseline TDABC costs for each of the processes in the PB workflows. These teams then implemented integrated PDSA methodology to reduce resource consumption in the highest-cost processes. Some initiatives, such as shifting pre-registration activities to the day before consultation, obtaining images and bloodwork the day before consultation, and changes to follow-up protocols, were completed within a few months, whereas other initiatives, such as implementing electronic orders for work-up, consultations, and operating room (OR) scheduling, took over a year, owing to deployment of a new electronic health record system during these QI initiatives. As these QI initiatives
were implemented, new workflows were re-mapped and re-analyzed with TDABC to measure changes in resource utilization.

Results

Analysis of the baseline PB workflow revealed that 40% of the total care cycle cost was incurred in the OR (Fig. 2A). The OR, though used relatively briefly, required costly equipment and staff, including several highly skilled physicians, technicians, physicists and/or dosimetrists, and nurses. The MRI scan represented 8.7% of total cost; consultation represented 7.6%; and radiation treatment planning, with the assistance of physics and dosimetry, also represented 7.6%. Higher-than-expected costs were incurred during surgical scheduling (3.0%) and peer review (4.2%). Further analysis revealed an inefficient system of surgery scheduling that required direct physician input into the process.

QI initiatives, using PDSA methodology, highlighted several opportunities to make changes to the baseline workflow (Table 1). Previous studies have eliminated Day 30 follow-up, imaging, and dosimetry (23–26). Standardizing the set of bloodwork and imaging orders improved
the efficiency of the consultation day by moving these processes to the day before consultation. Standardized orders also allowed task downshifting, that is, substituting mid-level providers for physicians during the ordering process, which allowed physicians to sign orders only after they had been entered into the electronic medical record rather than both creating and signing the orders. Over time, further collaboration with members of the radiology and radiation oncology departments allowed direct input of MR images into the brachytherapy treatment planning software and creation of a streamlined protocol for the brachytherapy MRI scan. Standardized physician templates further streamlined the daily brachytherapy clinic workflow by limiting the number of follow-up appointments, frequency of imaging and dosimetry, and maximizing the number of new consultations. For the OR specifically, baseline process order sets were mainly paper-based, but computerized physician order entry (CPOE) using a new electronic health record (EHR) system streamlined pre-operative and post-operative order sets, which did reduce physician and/or clinical team time before and after the operation. Additionally, the new MRI imaging workflows with MIM software allowed the planning MRI and/or ultrasound fusion to be projected within the OR (using a remote desktop). This reduced time for intra-operative ultrasound imaging registration and intra-operative dosimetric optimization.

After implementation of these interventions, OR time decreased from an average of 90 to 70 min, which led to 5% decrease in overall costs. Process step re-organization and personnel substitution at consultation (for instance, from physician to APP) and surgery scheduling (from mainly physician and APP to APP, nursing, and patient services coordinator) further lowered relative costs by 10% and 77%, respectively, in each of these workflows. Changes to follow-up frequency, imaging, and dosimetry decreased overall costs an additional 8.4%. Overall costs for the new workflow decreased by 18.2% from the baseline workflow (Fig. 2B).

Discussion

Our pilot study demonstrated the feasibility of using TDABC to (1) measure baseline process workloads and costs, (2) methodically and strategically identify areas for process improvement, and (3) measure the impact of focused QI initiatives in cancer care delivery.

Traditional QI methods seek to optimize processes that are of highest value, thereby reducing sources of variation and controlling process quality. TDABC complements these traditional methods by measuring the costs of existing processes, identifying process and cost-reduction opportunities, and quantifying cost savings from any implemented process improvements. With TDABC, our PDSA initiatives were focused on the costliest portions of the treatment cycle, helping to eliminate administrative and clinical processes, and variation in treatment protocols, that do not improve value. TDABC also allowed measurement of the financial benefits from proposed QI initiatives, enabling a return-on-investment calculation for potential future process changes. It has also increased cost awareness in our clinical and administrative QI initiatives. TDABC, however, does require the rigorous integration, coordination, and input of clinicians, financial analysts, and administrators (14).

In this study, the radiation therapy team specifically sought to identify inefficient processes that could be streamlined, resources that could be more effectively substituted, and steps that could be eliminated entirely. Initial discussions among faculty and staff identified several QI focus areas, as summarized in Table 1. For instance, moving the pre-registration and blood work steps to the day before consultation relieved bottlenecks and allowed more time for interpretation of external records and internal laboratory work and imaging scans. Coordinated discussions among physicians and APPs also revealed opportunities for the APP to assist with entering orders in the electronic medical records, which helped to reduce physician and nurse resource utilization throughout the process by consolidating the activity to a single staff member who had the proper skillset to understand clinical documentation but also coordinate physician OR scheduling and clinic scheduling. We hypothesized that the OR would be a large contributor of costs during PB, but were surprised it was as much as 40% of the total cost. Future cost reduction initiatives could focus on shifting the implant, when appropriate, to an Ambulatory Surgery Center or freestanding clinic. Furthermore, regular prostate brachytherapy group meetings led to new collaborations between radiologists and radiation oncologists, such as the creation of a prostate brachytherapy—specific MRI protocol that substantially shortens the time patients spend on the MRI machine (27,28). The pilot study initiatives led to an 18% decrease in provider cost at our institution. Other studies report cost reductions by as much as 25–35% (29), which suggests that there is further room to improve our process with future QI iterations. Furthermore, in this study, we were unable to quantify the cost reduction (or revenue reduction) impacts of various QI initiatives (Table 1), owing to the challenges with isolating the impact of a single intervention on multiple activities over a care cycle.

To maintain and build upon the improvements seen in our study, we plan to leverage the EHR by capturing timestamp data, tying patient-related clinical activities to resources, and tracking baseline and future time and effort for activities (12) to continuously update comprehensive process maps for each clinical pathway, a task that will require unprecedented coordination of clinical, administrative, and financial teams. Although our smaller scale project could be done via manual calculation of TDABC, large-scale prospective efforts will require dedicated soft-
ware solutions that can link clinical workflows directly to TDABC costs. This study also represents an iterative approach to QI using PDSA and TDABC for prostate brachytherapy but can also be applied more broadly to other areas in radiation oncology, including stereotactic body radiation therapy and intensity-modulated radiation therapy, or fields of medicine, including surgical, and medical oncology sub-specialties.

References