UROLOGYPRACTICE

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Determining the True Costs of Treating Small Renal Masses Using Time Driven, Activity Based Costing

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Abstract

Introduction: We report the implementation of time driven, activity based costing for competing treatments of small renal masses at an academic referral center.

Methods: To use time driven, activity based costing we developed a process map outlining the steps to treat small renal masses. We then derived the costs of supplying every resource per unit time. Known as the capacity cost rate, this included equipment and its depreciation (eg price per minute of the operating room table), personnel and space (eg cost per minute to rent clinic space). We multiplied each capacity cost rate by the time for each step. Time driven, activity based costing was defined as the sum of the products for each intervention.

Results: Robot-assisted laparoscopic partial nephrectomy was the most expensive treatment for small renal masses. It was 69.7% more costly than the most inexpensive inpatient modality, laparoscopic radical nephrectomy ($17,841.79 vs $10,514.05). Equipment costs were greater for laparoscopic radical nephrectomy than for open partial nephrectomy. However for laparoscopic radical nephrectomy vs open partial nephrectomy the lower personnel capacity cost rate due to faster operating room time (195.2 vs 217.3 minutes, $p = 0.001$) and shorter length of stay (2.4 vs 3.7 days, $p = 0.13$) were the primary drivers in lowering costs. Radiofrequency ablation was 48.4% less expensive than laparoscopic radical nephrectomy ($5,093.83 vs $10,514.05) largely by avoiding inpatient costs. Renal biopsy contributed 3.5% vs 12.2% to the overall cost of robot-assisted laparoscopic partial nephrectomy vs radiofrequency ablation but it may allow for increased active surveillance.

Abbreviations and Acronyms

AS = active surveillance

CCR = capacity cost rate

LOS = length of stay

LRN = laparoscopic radical nephrectomy

OPN = open partial nephrectomy

RALPN = robot-assisted laparoscopic partial nephrectomy

RALRN = robot-assisted LRN

RFA = radiofrequency ablation

SRM = small renal mass

TDABC = time driven, activity based costing

Submitted for publication April 16, 2015.

No direct or indirect commercial incentive associated with publishing this article.

The corresponding author certifies that, when applicable, a statement(s) has been included in the manuscript documenting institutional review board, ethics committee or ethical review board study approval; principles of Helsinki Declaration were followed in lieu of formal ethics committee approval; institutional animal care and use committee approval; all human subjects provided written informed consent with guarantees of confidentiality; IRB approved protocol number; animal approved project number.

Supported by the H & H Lee Surgical Research Scholar Program (AAL) and the Veterans Affairs Office of Academic Affiliations through the Veterans Affairs/Robert Wood Johnson Clinical Scholars Program (HJT).

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Conclusions: Using time driven, activity based costing we determined the relative resource utilization of competing small renal mass treatments, finding significant cost differences among various treatments. This informs value considerations, which are particularly relevant in the current health care milieu.

Key Words: kidney neoplasms; cost allocation/methods; value-based purchasing; costs and cost analysis; practice management, medical

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With increasing detection of incidentally detected SRMs and greater national focus to avoid the overtreatment of indolent tumors[1] determining the value of treatment, defined as the ratio of quality of care delivered to the health care dollars spent,[2] has become of paramount importance. However analyzing the quality of care delivered is complicated by the multitude of SRM treatment options. Nephron sparing surgery remains the gold standard,[3] although RFA,[4] cryoablation[5] and AS[6] demonstrate excellent cancer specific survival. Similarly research foci illuminating cost differences remain sparse,[7] further complicating the value equation.

Although numerous outcomes studies for SRM treatment continue to be published, the value agenda cannot be pushed forward until antiquated costing analyses are improved. Current models include arbitrary charges and cost expenditures that provide neither transparency nor confer a recommendation for improvement.[8] Moreover these costs rely primarily on the inpatient setting, failing to capture the total costs incurred by a specific patient during the duration of care for a specific disease process.[9] Meanwhile emphasis continues to be placed on the development of cost containment strategies, including ACOs (accountable care organizations) and bundled payment programs.[10] For these to be successful health care systems must accurately track the true costs of care for entire disease processes. Only by achieving this goal may providers maximize the value of health care delivery in accordance with changing reimbursement models.

TDABC is a time tested costing paradigm traditionally applied in industry, which when introduced into health care enables hospitals and providers to systematically trace the costs of a disease process across an episode of care.[11] TDABC encapsulates personnel, space, materials and equipment costs in the inpatient and outpatient settings while also considering the average time that a patient spends with each resource.[12] Furthermore TDABC creates a cost algorithm that may be compiled across multiple health care organizations that provide care for a particular patient to determine the total costs of a defined episode of care.[7]

In this study we describe our experience with TDABC to outline the costs of treating a SRM from the initial urology clinic visit through intervention and the first followup visit at an academic referral center. TDABC allows for providers and hospital administrators to accurately quantify and assess the costs of clinical, administrative and operative processes so that this information can be used to redesign or optimize inefficient clinical processes.

Materials and Methods

Background

To determine the actual cost of care for treating a SRM we incorporated the TDABC method as originally described by Kaplan and Anderson at Harvard Business School.[12] Under this model our health care team at UCLA traced the path of a patient throughout the episode of care for treatment of a SRM. This involved identifying the cost of care for every resource used in treatment, including space, materials and equipment, and personnel, and also calculating the average time that a patient spent with each resource. The episode of care was then defined as the summation of the quantity of resource units multiplied by the price per unit time of that resource.

Defining the Process Map

We assembled a team of clinicians, business analysts, clinical administrators, operative administrators and nurse supervisors to define each resource involved in treating a SRM and then developed step-by-step process maps of all clinical and administrative processes used. For each treatment algorithm we defined the episode of care as starting from the initial preoperative visit and ending at the first followup visit after intervention (fig. 1). [F1

The specific interventions analyzed followed AUA (American Urological Association) practice guidelines[13] and were the most commonly used SRM procedures at our institution, including RFA, cryoablation, OPN, LRN, RALPN, RALRN and AS. We captured data on all SRMs treated at UCLA from March 2013 to January 2015 using mean operative time and LOS estimates derived from our 129 most recent SRM surgical cases, including 27 RFAs, 14 cryoablations and 110 renal biopsies. Open radical nephrectomy for SRM was not performed frequently enough

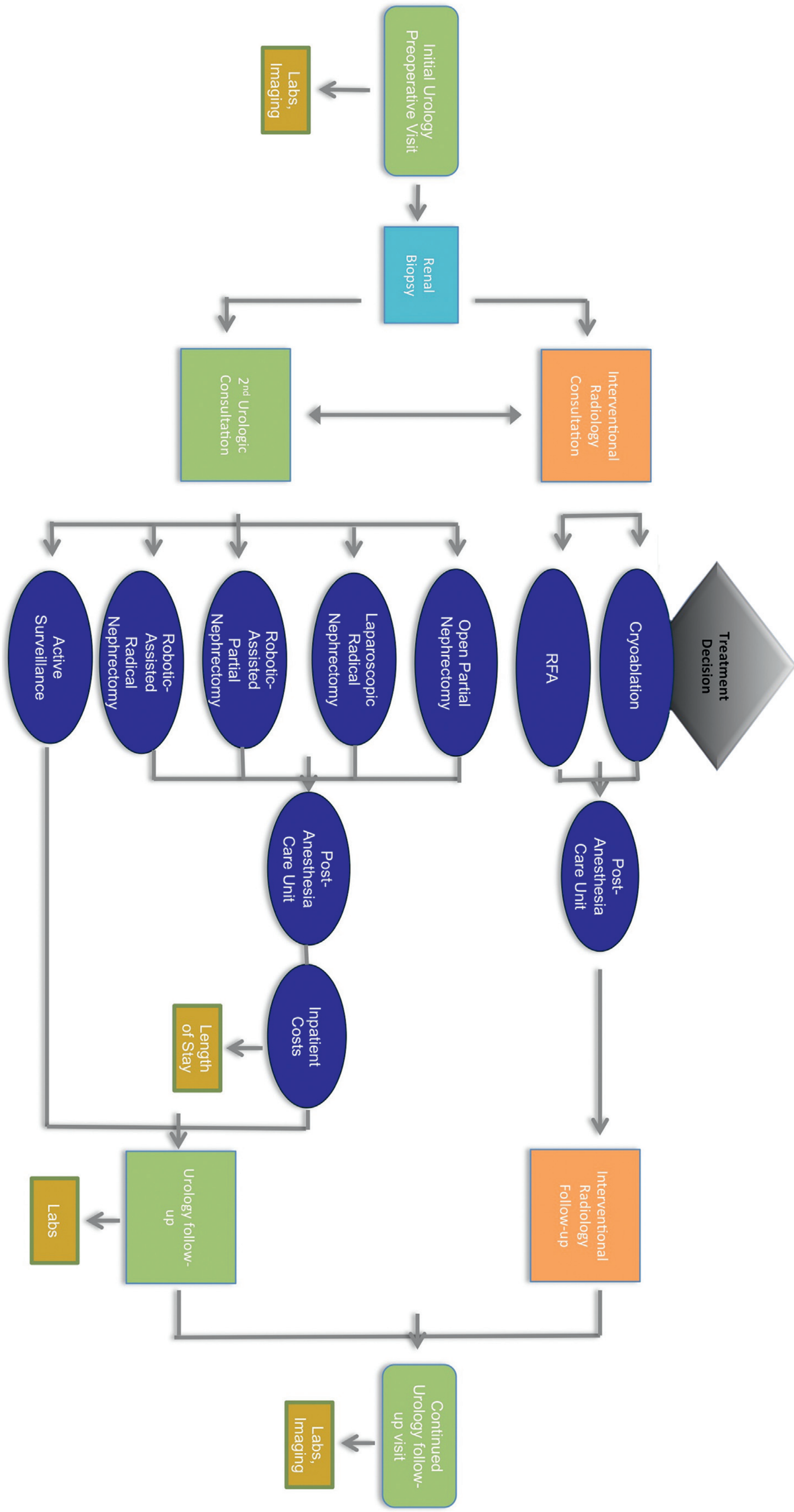

Figure 1. Macroscopic process map outlines major steps of SRM treatment from initial urology visit through first followup after intervention.

to be included in our study since there were only 3 cases. Additionally given the increasing use of renal biopsy to assist in the management of SRM, we incorporated this cost but left it distinct as not every patient undergoes biopsy prior to intervention.

We next created more detailed process maps for each step to capture every resource involved. For instance, figure 2 shows a process map representing day of treatment care. These maps also demonstrate the variability of care by introducing the likelihood of the occurrence of each particular step, such as the probability of performing a basic metabolic panel on postoperative day 1. The end result was an average based on all probabilities. The time needed to complete each step was sampled.

Estimating CCR and Price per Unit of Resource

We first determined the institutional CCR or the amount used per minute for each resource involved in the process maps, including materials (eg price per minute of the Bookwalter retractor). personnel (eg salary per minute of a licensed vocational nurse) and space (eg cost per minute per square foot of clinic space). The numerator of this equation comprised the total costs accrued for the materials, equipment and personnel used to treat a patient. Equipment and material costs included depreciation, maintenance and repair, utilities and disposable instruments. Personnel costs included salary and costs of space. The latter costs also took into account the average indirect expenses to support each person, including benefits, administrative support, malpractice insurance, office expenses, training, travel and information technology support when relevant.

We then estimated the available capacity for every resource available for productive work measured in minutes. For personnel we used the entire calendar year and subtracted the time unavailable for each person due to vacations, holidays, weekends and any continuing education requirements. The CCR of each resource was calculated by dividing the total cost of supplying that resource by its available capacity. Finally the Mann-Whitney U test was used to compare differences in operative time and LOS among inpatient approaches.

Deriving Total Costs to Compare Treatment Interventions

To calculate the total cost of caring for an average patient during a complete cycle of care for each intervention we multiplied the total time spent on each resource at a process step by its CCR. The costs of any disposable instruments at each process step were also included. The summation of the process steps in each treatment algorithm resulted in the total cost of each intervention. We then compared the relative and absolute differences in price for each SRM intervention and assessed the impact of renal biopsy on overall costs. The institutional review board deemed this study exempt from review.

Results

RALPN represented the most expensive treatment for SRM. It was 69.7% more costly than the least costly inpatient treatment, LRN ($17,841.79 vs $10,514.05). RALRN and OPN were the second and third most expensive treatments at $15,819.24 and $12,610.30, respectively, while AS was the least costly treatment modality at $1,018.50 (fig. 3, *A*). Although equipment costs were greater for LRN vs OPN, the decreased personnel CCR from faster operating room times (195.2 minutes, 95% CI 184.8−205.2 vs 217.3, 95% CI 210.3−223.7, $p = 0.001$) and shorter LOS (2.4 days, 95% CI 1.6−3.2 vs 3.7, 95% CI 3.4−4.0, $p = 0.13$) were the primary drivers in lowering costs. RALPN was 12.7% more costly than RALRN largely due to instrument costs (eg additional robotic needle drivers and bulldog clamp). Operative time was estimated at $37.63 per minute while each day of inpatient hospitalization was estimated at $1,713.00.

Aside from AS, RFA and cryoablation were the least costly interventions at 48.4% and 51.4% of the cost of LRN ($5,093.83 and $5,406.42, respectively), driven largely by avoidance of inpatient hospitalization costs. When performed, renal biopsy comprised 3.5% of the total cost of RALPN vs 12.2% for RFA. Nonetheless it may discriminate for the increased use of active surveillance and associated cost reductions since it amounted to only 3.5% (RALPN) to 9.7% (LRN) of the total cost of any inpatient intervention.

The urological consultation itself added minimally to the total overall cost of care as did the cost of preoperative and postoperative laboratory studies. For instance the preoperative workup including 2 urology consultations and laboratory tests contributed 6.0% to the total cost of LRN vs 3.5% to the cost of LRN ($243.10). The table shows the total cost breakdown for LRN.

Discussion

Several recent health care reform initiatives, including PPACA (Patient Protection and Affordable Care Act), have aimed to improve the quality and cost efficiency of health

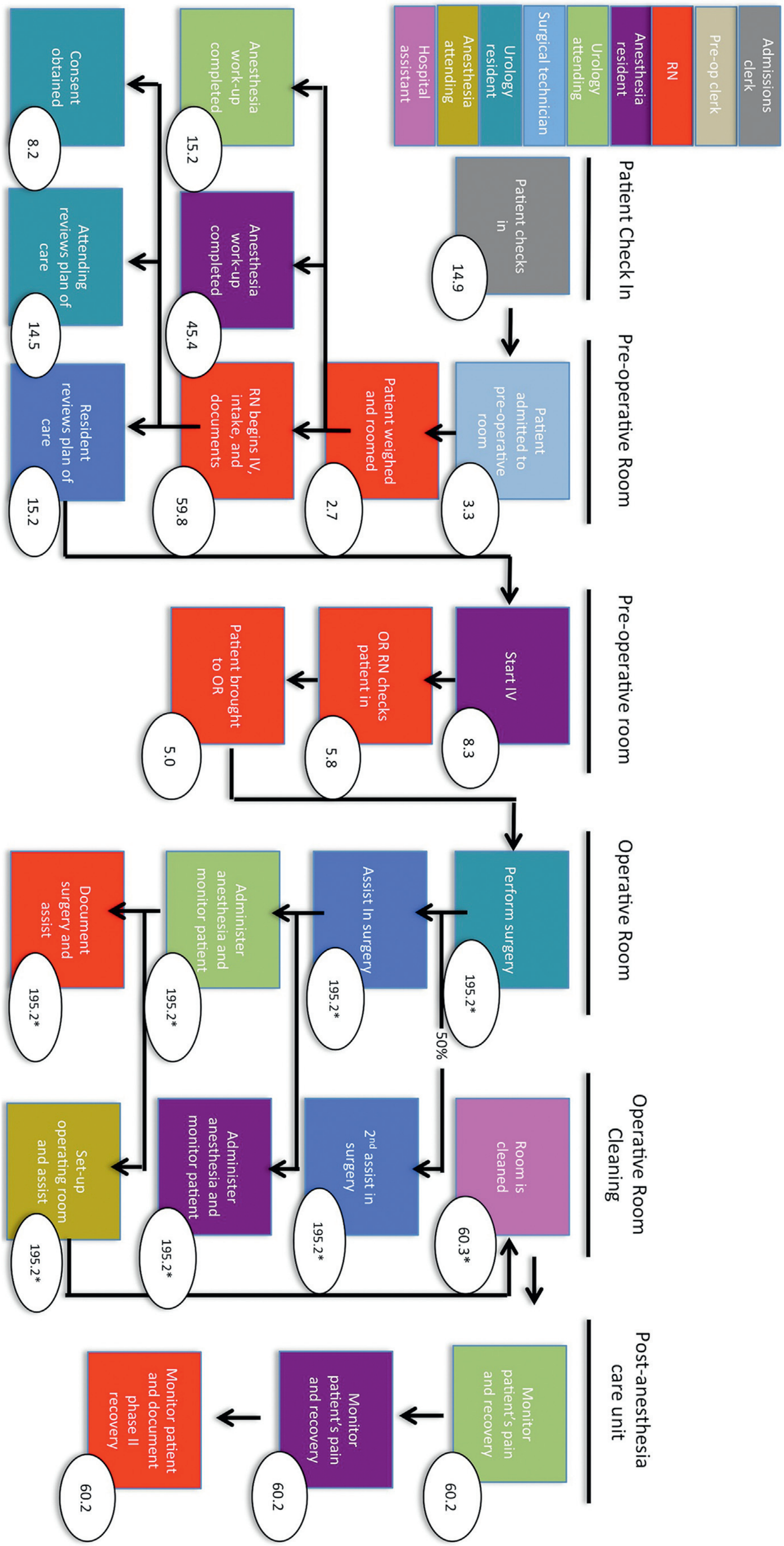

Figure 2. Step-by-step process map of all clinical and administrative processes used to complete day of treatment care inpatient intervention for SRM. Values (ovals) indicate average time per step. *IV*, intravenous. *OR*, operating room. Asterisk indicates estimated LRN.

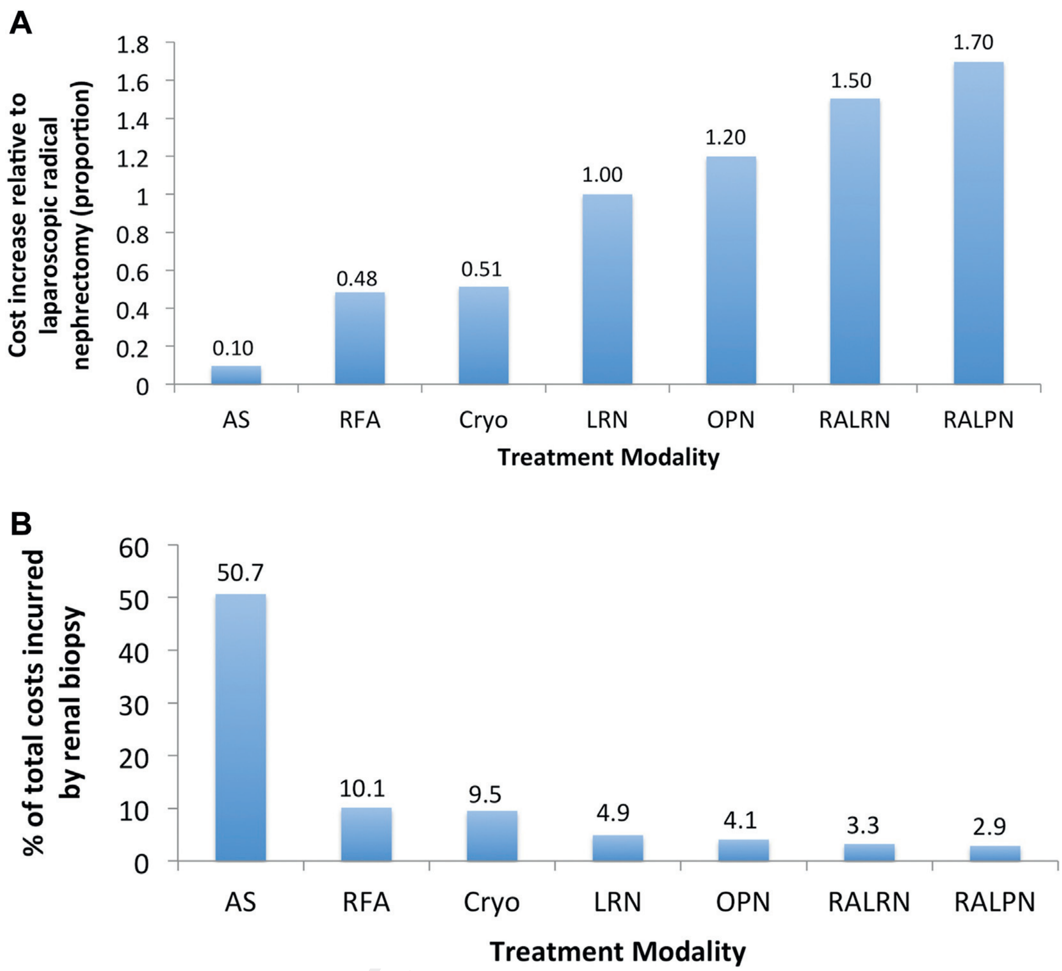

Figure 3. *A*, cost increase relative to LRN for each treatment modality for SRM from initial urology visit through first followup visit. *B*, percent of total costs incurred by renal biopsy for each SRM intervention. *Cryo*, cryoablation.

care in the United States. The lack of transparency coupled with variability in the cost of care has hindered progress toward creating a uniformly high value health care system.[14,15] For example, a recent study examining the cost of total hip arthroplasty demonstrated greater than $100,000 variation in price with multiple hospitals unwilling to share their information.[16] Furthermore The Dartmouth Atlas of Health Care suggested that reducing variation in health care spending would decrease Medicare spending by at least 30% while simultaneously improving care.[17] In this study we used TDABC to quantify the cost of care for the management of SRM, a condition characterized by a heterogeneous clinical course and a multitude of treatment options.

Our study has several important findings. To our knowledge we are the first to use TDABC to assess the economic burden of care in treating SRM, assessing not only direct material costs (eg surgical instruments) but also the pro rata share of medical provider time and effort. In contrast to prior studies the methods in our study allowed for the ability to parse cost drivers on the levels of personnel, infrastructure and materials.[18] TDABC has been hailed as 1 of 3 strategies to fix the ailing health care conundrum.[9]

Our study shows that RFA and cryoablation are less expensive (48% to 51%) alternatives to other curative modalities for SRM. These differences stem mostly from the avoidance of inpatient hospitalization. RFA, cryoablation and partial nephrectomy for clinical T1a tumors demonstrate similar 5-year overall, cancer specific and recurrence-free

Table.
Proportion of total costs of each LRN step

	% Total Cost
Urology visit:	
New	1.3
Return	1.0
Followup	0.5
Renal biopsy	6.0
Preop treatment unit	2.8
Operating room	47.8
Post-anesthesia care unit/inpatient stay	40.5

survival rates.[4] Thus the significant cost reduction for RFA and cryoablation may have profound implications for how to manage SRMs as health care systems grapple with the financial pressures of cost containment. However it is worth noting that these cost estimates do not encapsulate the cost of intermediate term and long-term followup (beyond 3 months), which may degrade the cost advantage of ablative treatment compared to other modalities. Previous literature suggests that thermal ablation is associated with threefold greater use of computerized tomography compared to OPN and RALPN.[19] Additionally RFA and cryotherapy have not shown equivalent recurrence-free or cancer specific survival for a T1a mass according to a large consortium of urological experts.[20]

With increased utilization of renal biopsy prior to intervention[21] and improved risk stratification, as confirmed by SRM final pathology,[22] renal biopsy may serve a pivotal role in attenuating the overtreatment of indolent tumors. As such the need to understand the cost impact of renal biopsy is critical. Our study reveals a relatively low burden for renal biopsy with this procedure comprising 3.5% of the cost of RALPN vs 12.2% of the cost of RFA (fig. 3, *B*). Additionally renal biopsy may expand the role of AS by helping identify the approximately 20% of SRMs with benign histology that are resected based on suspicion of malignancy.[23] Whether patients on AS will need repeat biopsies with time to assess for changes in genomics must still be determined.

The TDABC infrastructure also offers broad implications for improving the efficiency of health care delivery. Health care organizations may use these process maps to identify redundant tasks (eg multiple clerks checking in a patient) and improve stepwise efficiency (minutes spent discharging a patient). Because of this study, we now send patient information on SRMs before their visit to streamline the physician encounter. Investigation into whether this also improves patient satisfaction is ongoing. Furthermore because every minute in the operating room is costly, we have also met regularly with our operations and quality officers to explore ways to improve operative room utilization and room turnover.

Finally our TDABC model focuses on resource consumption, identifying costs that may be missed via more conventional methods. Whereas previous studies estimated the cost of 1 minute of operating time at $15 to $20,[24] this estimate failed to account for surgeon and anesthesia costs, CCR and the increased costs of robotic and laparoscopic equipment. Accordingly our study demonstrates that the shorter LRN operating room time and reduced LOS were the main drivers in decreasing the overall economic burden of care. However this advantage was attenuated by the use of robotic assistance, of which the capital purchase cost ($1.85 to $2.3 million for the da Vinci® Xi model) and disposables are significant.[25] Although this is supported by recent literature,[26] others contend that robot-assisted surgery may improve access to partial nephrectomy, an underused procedure, thereby reducing the overall burden of care by decreasing the amount of medical treatment required for chronic kidney disease.[27] Inevitably understanding the quality of care provided and the cost are essential to determine the overall value of robotic surgery.

Our study must be interpreted in the context of the study design. 1) To determine the CCR of each process map step the duration of clinical activities was directly measured. Providers were asked to provide minimum and maximum process times of activities for which time data were unavailable, thus potentially introducing recall bias. 2) Input data on the cost processes were generated from a tertiary care institution and our findings may not be generalizable to the community setting. However TDABC may serve as a template for other institutions to use for potential reform opportunities. 3) TDABC assesses the cost burden placed on the health care institution rather than on the individual and it does not encompass patient costs such as medication copayments or indirect costs such as lost work productivity and convalescence. As reimbursement models shift from fee-for-service to ACOs and bundled payments, understanding cost at a detailed level is of paramount importance. Future studies will focus on delineating these indirect costs to the patient with time. 4) While understanding cost is essential, the value agenda relies on how outcomes and cost intertwine. Future studies at our institution aim to investigate this and previous literature suggests similar complication rates and 5-year oncologic outcomes for RFA and nephron sparing surgery.[4,28,29]

Altogether given these reported similarities in outcomes, cost serves as a major determinant of value in the treatment of patients with SRM.

Conclusions

As health care overhaul seeks to improve value, we incorporated a new and robust costing strategy, TDABC, to assess the total costs of SRM care from diagnosis through intervention and followup. By identifying the greatest cost consumers in our process maps we found that LRN was the least expensive inpatient modality while RFA and cryoablation were significantly less expensive, given the absence of hospitalization costs. Our findings underscore the need to assess variation in SRM outcomes by treatment to fully understand the true differences in value of each SRM intervention.

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