Analysis of Direct Costs of Outpatient Arthroscopic Rotator Cuff Repair

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Abstract

Arthroscopic rotator cuff surgery is one of the most commonly performed orthopedic surgical procedures. We conducted a study to calculate the direct cost of arthroscopic repair of rotator cuff tears confirmed by magnetic resonance imaging.

Twenty-eight shoulders in 26 patients (mean age, 54.5 years) underwent primary rotator cuff repair by a single fellowship-trained arthroscopic surgeon in the outpatient surgery center of a major academic medical center. All patients had interscalene blocks placed while in the preoperative holding area. Direct costs of this cycle of care were calculated using the time-driven activity-based costing algorithm.

Mean time in operating room was 148 minutes; mean time in recovery was 105 minutes. Calculated surgical cost for this process cycle was $5904.21. Among material costs, suture anchor costs were the main cost driver. Preoperative bloodwork was obtained in 23 cases, adding a mean cost of $111.04.

Our findings provide important preliminary information regarding the direct economic costs of rotator cuff surgery and may be useful to hospitals and surgery centers negotiating procedural reimbursement for the increased cost of repairing complex tears.

Musculoskeletal disorders, the leading cause of disability in the United States,[1] account for more than half of all persons reporting missing a workday because of a medical condition.[2] Shoulder disorders in particular play a significant role in the burden of musculoskeletal disorders and cost of care. In 2008, 18.9 million adults (8.2% of the US adult population) reported chronic shoulder pain.[1] Among shoulder disorders, rotator cuff pathology is the most common cause of shoulder-related disability found by orthopedic surgeons.[3] Rotator cuff surgery (RCS) is one of the most commonly performed orthopedic surgical procedures, and surgery volume is on the rise. One study found a 141% increase in rotator cuff repairs between the years 1996 (~41 per 100,000 population) and 2006 (~98 per 100,000 population).[4]

US health care costs are also increasing. In 2011, $2.7 trillion was spent on health care, representing 17.9% of the national gross domestic product (GDP). According to projections, costs will rise to $4.6 trillion by 2020.[5] In particular, as patients continue to live longer and remain more active into their later years, the costs of treating and managing musculoskeletal disorders become more important from a public policy standpoint. In 2006, the cost of treating musculoskeletal disorders alone was $576 billion, representing 4.5% of that year's GDP.[2]

Paramount in this era of rising costs is the idea of maximizing the value of health care dollars. Health care economists Porter and Teisberg[6] defined *value* as patient health outcomes achieved per dollar of cost expended in a care cycle (diagnosis, treatment, ongoing management) for a particular disease or disorder. For proper management of value, outcomes and costs for an entire cycle of care must be determined. From a practical standpoint, this first requires determining the true cost of a care cycle—dollars spent on personnel, equipment, materials, and other resources required to deliver a particular service—rather than the amount charged or reimbursed for providing the service in question.[7]

Kaplan and Anderson[8,9] described the TDABC (time-driven activity-based costing) algorithm for calculating the cost of delivering a service based on 2 parameters: unit cost of a particular resource, and time required to supply it. These parameters apply to material costs and labor costs. In the medical setting, the TDABC algorithm can be applied by defining a care delivery value chain for each aspect of patient care and then multiplying incremental cost per unit time by time required to deliver that resource (**Figure 1**). Tabulating the overall unit cost for each resource then yields the overall cost of the care cycle. Clinical outcomes data can then be determined and used to calculate overall value for the patient care cycle.

In the study reported here, we used the TDABC algorithm

Figure 1. TDABC (time-driven activity-based costing) algorithm.

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to calculate the direct financial costs of surgical treatment of rotator cuff tears confirmed by magnetic resonance imaging (MRI) in an academic medical center.

Methods

Per our institution's Office for the Protection of Research Subjects, institutional review board (IRB) approval is required only for projects using "human subjects" as defined by federal policy. In the present study, no private information could be identified, and all data were obtained from hospital billing records without intervention or interaction with individual patients. Accordingly, IRB approval was deemed unnecessary for our economic cost analysis.

Billing records of a single academic fellowship-trained sports surgeon were reviewed to identify patients who underwent primary repair of an MRI-confirmed rotator cuff tear between April 1, 2009, and July 31, 2012. Patients who had undergone prior shoulder surgery of any type were excluded from the study. Operative reports were reviewed, and exact surgical procedures performed were noted. The operating surgeon selected the specific repair techniques, including single- or double-row repair, with emphasis on restoring footprint coverage and avoiding overtensioning.

All surgeries were performed in an outpatient surgical center owned and operated by the surgeon's home university. Surgeries were performed by the attending physician assisted by a senior orthopedic resident. The RCS care cycle was divided into 3 phases (**Figure 2**):

1. Preoperative. Patient's interaction with receptionist in surgery center, time with preoperative nurse and circulating nurse in preoperative area, resident check-in time, and time placing preoperative nerve block and consumable materials used during block placement.

2. Operative. Time in operating room with surgical team for RCS, consumable materials used during surgery (eg, anchors, shavers, drapes), anesthetic medications, shoulder abduction pillow placed on completion of surgery, and cost of instrument processing.

3. Postoperative. Time in postoperative recovery area with recovery room nursing staff.

Time in each portion of the care cycle was directly observed and tabulated by hospital volunteers in the surgery center. Institutional billing data were used to identify material resources consumed, and the actual cost paid by the hospital for these resources was obtained from internal records. Mean hourly salary data and standard benefit rates were obtained for surgery center staff. Attending physician salary was extrapolated from published mean market salary data for academic physicians and mean hours worked,[10,11] and resident physician costs were tabulated from publically available institutional payroll data and average resident work hours at our institution. These cost data and times were then used to tabulate total cost for the RCS care cycle using the TDABC algorithm.

Results

We identified 28 shoulders in 26 patients (mean age, 54.5 years) who met the inclusion criteria. Of these 28 shoulders, 18 (64.3%) had an isolated supraspinatus tear, 8 (28.6%) had combined supraspinatus and infraspinatus tears, 1 (3.6%) had combined supraspinatus and subscapularis tears, and 1 (3.6%) had an isolated infraspinatus tear. Demographic data are listed in **Table 1**.

All patients received an interscalene nerve block in the preoperative area before being brought into the operating room. In our analysis, we included nerve block supply costs and the anesthesiologist's mean time placing the nerve block.

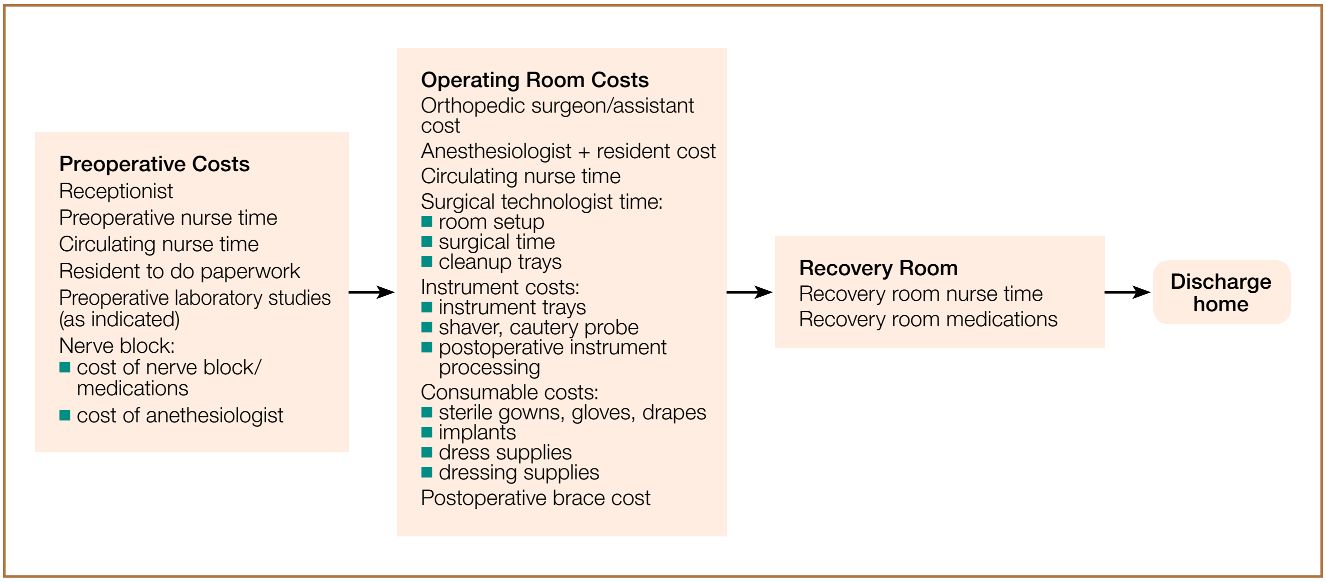

Figure 2. Direct surgical costs of rotator cuff surgery.

Table 1. **Patient Demographics**

Age, y	Sex	Laterality	Tendon Involved: Supraspinatus	Tendon Involved: Infraspinatus	Tendon Involved: Subscapularis
57	M	L	x	x	
58	M	R	x	x	
67	M	L	x	x	
57	M	R	x	x	
58	M	L	x	x	
53	M	L	x	x	
49	M	R	x	x	
52	F	R	x	x	
49	M	R	x		x
63	M	R	x		
54	M	L	x		
47	F	L	x		
56	F	R	x		
62	F	R	x		
68	F	L	x		
45	M	L	x		
52	F	R	x		
52	F	R	x		
54	F	L	x		
64	F	R	x		
69	M	L	x		
38	M	R	x		
50	F	R	x		
42	F	R	x		
53	M	R	x		
46	F	R	x		
59	F	L	x		
52	M	R		x	

In all cases, primary rotator cuff repair was performed with suture anchors (Parcus Medical) with the patient in the lateral decubitus position. In 13 (46%) of the 28 shoulders, this repair was described as "complex," requiring double-row technique. Subacromial decompression and bursectomy were performed in addition to the rotator cuff repair. Labral débridement was performed in 23 patients, synovectomy in 10, biceps tenodesis with anchor (Smith & Nephew) in 1, and biceps tenotomy in 1. Mean time in operating room was 148 minutes; mean time in postoperative recovery unit was 105 minutes.

Directly observing the care cycle, hospital volunteers found that patients spent a mean of 15 minutes with the receptionist when they arrived in the outpatient surgical center, 25 minutes with nurses for check-in in the preoperative holding area, and 10 minutes with the anesthesiology resident and 15 minutes with the orthopedic surgery resident for preoperative evaluation and paperwork. Mean nerve block time was 20 minutes. Mean electrocardiogram (ECG) time (12 patients) was 15 minutes. The surgical technician spent a mean time of 20 minutes setting up the operating room before the patient was brought in and 15 minutes cleaning up after the patient was transferred to the recovery room. Costs of postoperative care in the recovery room were based on a 2:1 patient-to-nurse ratio, as is the standard practice in our outpatient surgery center.

Using the times mentioned and our hospital's salary data—including standard hospital benefits rates of 33.5% for nonphysicians and 17.65% for physicians—we determined, using the TDABC algorithm, a direct cost of $5904.21 for this process cycle, excluding hospital overhead and indirect costs. **Table 2** provides the overall cost breakdown. Compared with the direct economic cost, the mean hospital charge to insurers for the procedure was $31,459.35. Mean reimbursement from insurers was $9679.08.

Overall attending and resident physician costs were $1077.75, which consisted of $623.66 for the surgeon and $454.09 for the anesthesiologist (included placement of nerve block and administration of anesthesia during surgery). Preoperative bloodwork was obtained in 23 cases, adding a mean cost of $111.04 after adjusting for standard hospital markup. Preoperative ECG was performed in 12 cases, for an added mean cost of $7.30 based on the TDABC algorithm.

We also broke down costs by care cycle phase. The preoperative phase, excluding the preoperative laboratory studies and ECGs (not performed in all cases), cost $134.34 (2.3% of total costs); the operative phase cost $5718.01 (96.8% of total costs); and the postoperative phase cost $51.86 (0.9% of total costs). Within the operative phase, the cost of consumables (specifically, suture anchors) was the main cost driver. Mean anchor cost per case was $3432.67. "Complex" tears involving a double-row repair averaged $4570.25 in anchor cost per patient, as compared with $2522.60 in anchor costs for simple repairs.

Discussion

US health care costs continue to increase unsustainably, with rising pressure on hospitals and providers to deliver the highest value for each health care dollar. The present study is the first to calculate (using the TDABC algorithm) the direct economic cost ($5904.21) of the entire RCS care cycle at a university-based outpatient surgery center. Rent, utility costs, administrative costs, overhead, and other indirect costs at the surgery center were not included in this cost analysis, as they would

Table 2. **Cost Breakdown**

Cost Category	Calculated Cost, $
Physician	1077.75
Nurse	222.87
Other personnel	121.79
Medication	720.94
Materials/consumables	3760.86
Total	5904.21

be incurred irrespective of type of surgery performed. As such, our data isolate the procedure-specific costs of rotator cuff repair in order to provide a more meaningful comparison for other institutions, where indirect costs may be different.

In the literature, rigorous economic analysis of shoulder pathology is sparse. Kuye and colleagues[12] systematically reviewed economic evaluations in shoulder surgery for the period 1980–2010 and noted more than 50% of the papers were published between 2005 and 2010.[12] They also noted the poor quality of these studies and concluded more rigorous economic evaluations are needed to help justify the rising costs of shoulder-related treatments.

Several studies have directly evaluated costs associated with RCS. Cordasco and colleagues[13] detailed the success of open rotator cuff repair as an outpatient procedure—noting its 43% cost savings ($4300 for outpatient vs $7500 for inpatient) and high patient satisfaction—using hospital charge data for operating room time, supplies, instruments, and postoperative slings. Churchill and Ghorai[14] evaluated costs of mini-open and arthroscopic rotator cuff repairs in a statewide database and estimated the arthroscopic repair cost at $8985, compared with $7841 for the mini-open repair. They used reported hospital charge data, which were not itemized and did not include physician professional fees. Adla and colleagues,[15] in a similar analysis of open versus arthroscopic cuff repair, estimated direct material costs of $1609.50 (arthroscopic) and $360.75 (open); these figures were converted from 2005 UK currency using the exchange rate cited in their paper. Salaries of surgeon, anesthesiologist, and other operating room personnel were said to be included in the operating room cost, but the authors' paper did not include these data.

Two studies directly estimated the costs of arthroscopic rotator cuff repair. Hearnden and Tennent[16] calculated the cost of RCS at their UK institution to be £2672, which included cost of operating room consumable materials, medication, and salaries of operating room personnel, including surgeon and anesthesiologist. Using online currency conversion from 2008 exchange rates and adjusting for inflation gave a corresponding US cost of $5449.63.[17] Vitale and colleagues[18] prospectively calculated costs of arthroscopic rotator cuff repair over a 1-year period using a cost-to-charge ratio from tabulated inpatient charges, procedure charges, and physician fees and payments abstracted from medical records, hospital billing, and administrative databases. Mean total cost for this cycle was $10,605.20, which included several costs (physical therapy, radiologist fees) not included in the present study. These studies, though more comprehensive than prior work, did not capture the entire cycle of surgical care.

Our study was designed to provide initial data on the direct costs of arthroscopic repair of the rotator cuff for the entire process cycle. Our overall cost estimate of $5904.21 differs significantly from prior work—not unexpected given the completely different cost methodology used.

Our study had several limitations. First, it was a single-surgeon evaluation, and a number of operating room variables (eg, use of adjunct instrumentation such as radiofrequency probes, differences in draping preferences) as well as surgeon volume in performing rotator cuff repairs might have substantially affected the reproducibility and generalizability of our data. Similarly, the large number of adjunctive procedures (eg, subacromial decompression, labral débridement) performed in conjunction with the rotator cuff repairs added operative time and therefore increased overall cost. Double-row repairs added operative time and increased the cost of consumable materials as well. Differences in surgeon preference for suture anchors may also be important, as anchors are a major cost driver and can vary significantly between vendors and institutions. Tear-related variables (eg, tear size, tear chronicity, degree of fatty cuff degeneration) were not controlled for and might have significantly affected operative time and associated cost. Resident involvement in the surgical procedure and anesthesia process in an academic setting prolongs surgical time and thus directly impacts costs.

In addition, we used the patient's time in the operating room as a proxy for actual surgical time, as this was the only reliable and reproducible data point available in our electronic medical record. As such, an unquantifiable amount of surgeon time may have been overallocated to our cost estimate for time spent inducing anesthesia, positioning, helping take the patient off the operating table, and so on. However, as typical surgeon practice is to be involved in these tasks in the operating room, the possible overestimate of surgeon cost is likely minimal.

Our salary data for the TDABC algorithm were based on national averages for work hours and gross income for physicians and on hospital-based wage structure and may not be generalizable to other institutions. There may also be regional differences in work hours and salaries, which in turn would factor into a different per-minute cost for surgeon and anesthesiologist, depending on the exact geographic area where the surgery is performed. Costs may be higher at institutions that use certified nurse anesthetists rather than resident physicians because of the salary differences between these practitioners.

Moreover, the time that patients spend in the holding area—waiting to go into surgery and, after surgery, waiting for their ride home, for their prescriptions to be ready, and so forth—is an important variable to consider from a cost standpoint. However, as this time varied significantly and involved minimal contact with hospital personnel, we excluded its associated costs from our analysis. Similarly, and as already noted, hospital overhead and other indirect costs were excluded from analysis as well.

Conclusion

Using the TDABC algorithm, we found a direct economic cost of $5904.21 for RCS at our academic outpatient surgical center, with anchor cost the main cost driver. Judicious use of consumable resources is a key focus for cost containment in arthroscopic shoulder surgery, particularly with respect to implantable suture anchors. However, in the setting of more complex tears that require multiple anchors in a double-row repair construct, our pilot data may be useful to hospitals and surgery centers negotiating procedural reimbursement for the increased cost of complex repairs. Use of the TDABC algorithm for RCS and other procedures may also help in identifying opportunities to deliver more cost-effective health care.

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This paper will be judged for the Resident Writer's Award.