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ORIGINAL ARTICLE

Factors influencing direct clinical costs of outpatient arthroscopic rotator cuff repair surgery

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Background: Very limited information exists about factors affecting direct clinical costs of rotator cuff repair surgery. The purpose of this study was to determine the direct cost of outpatient arthroscopic rotator cuff repair surgery using a unique value-driven outcomes tool and to identify patient- and treatment-related variables affecting cost.

Methods: Cost data were derived for arthroscopic rotator cuff repairs performed by 3 surgeons from March 2014 to June 2015 using the value-driven outcomes tool. Costs included overall total direct cost, which included facility utilization costs, medication costs, supply costs, and other ancillary costs. Univariate and multivariate regressions were performed to determine the effect of various patient-related and surgical-related factors on costs.

Results: There were 170 arthroscopic rotator cuff repairs performed during the study period. Multivariate analysis showed significant correlations between higher total direct cost and the presence of a subscapularis repair being performed ($P = .015$) and total number of anchors used ($P < .0001$). Higher body mass index, severe systemic illness, 1 of the 3 surgeons, biceps tenodesis using an anchor, and total sum of anchors were correlated with higher facility utilization costs ($P < .04$). Severe systemic illness, addition of a subscapularis repair, 1 of the 3 surgeons, and additional subacromial decompression were correlated with higher pharmacy costs ($P < .006$). The addition of a subscapularis repair, total sum of anchors, and severe muscle changes to the supraspinatus were correlated with higher supply costs ($P < .015$).

Conclusions: From a direct cost perspective, implementation of strategies to reduce overall costs should focus on reducing overall anchor quantity or price.

Level of evidence: Level IV; Economic and Decision Analysis Study

Keywords: Rotator cuff repair; cost; anchors; value; arthroscopic; outpatient

There has been increasing emphasis in medicine, and specifically in orthopedics, on the cost of health care and the value provided by health care practitioners.[2,5] Value is defined as a patient's perceived benefit per cost of an intervention.[11] The primary method of determining value is by performing a cost-effectiveness analysis of treatment.[1,5] Therefore, understanding the initial costs of health care delivered is an important initial step in ultimately performing a cost-effectiveness study to determine overall value. Unfortunately, there is limited information on the "true cost" of care delivered or direct

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clinical care costs. Direct clinical costs have historically been difficult to measure, and surrogates for direct cost, including billing or charges, have typically been used to estimate direct cost. These estimates are typically inaccurate.[10] More accurate tools include time-driven activity-based costing, although these are much more labor-intensive. Recently, a value-driven outcomes (VDO) tool has been developed using customizable cost methods to obtain accurate direct costs of a patient care episode by applying these methods to general ledgers of a health care system.[6]

Few authors have performed cost analyses in orthopedic sports medicine and shoulder surgery. Nwachukwu et al, in their recent systematic review of cost-effectiveness in orthopedics, noted that there is a paucity of literature on this topic relative to sports medicine[9]; they identified only 3 rotator cuff cost-effectiveness articles.[3,7,15] With >4.5 million U.S individuals affected and >250,000 rotator cuff repairs performed annually, rotator cuff repair is a critical procedure to assess for cost and value.[7] Despite the large number of repairs performed, there is a dearth of literature dealing with the cost of the surgery. Well-designed cost analysis studies examining rotator cuff repair surgery are required to optimize value of the procedure. Before one can fully define value of rotator cuff surgery, one must understand the predictors of cost relative to the population of patients, the pathologic process, and the surgery. The reliability of current and future analytic models relies on precise cost and outcome data.[13]

The purpose of this study was to determine the direct clinical care cost of outpatient arthroscopic rotator cuff repair surgery using a unique VDO tool that was designed to identify and to track direct costs of all aspects of clinical care and to identify various patient- and treatment-related variables affecting cost. The hypothesis of this study is that there will be higher costs associated with patients with greater comorbidities, more severe tears, and repairs requiring associated procedures or more implants to complete the reconstruction.

Methods

This was a retrospective cost identification analysis. Arthroscopic rotator cuff repairs performed at an outpatient academic medical center by 3 fellowship-trained surgeons from March 2014 to June 2015 were examined. The 3 surgeons perform rotator cuff repairs at 2 other hospitals, but those patients were not included because the other hospitals are inpatient facilities and a different population of patients is treated at those locations. Patients were identified from financial data available in a billing database associated with *Current Procedural Terminology* codes specific to rotator cuff repair surgery (29827). Patients included were those who had a complete arthroscopic repair of a full-thickness or partial-thickness tear of the supraspinatus or infraspinatus tendons. Patients were excluded if they had an isolated subscapularis tear or if a complete repair was not feasible. Electronic records were then queried to determine patient demographics, smoking status, body mass index (BMI), and American Society of Anesthesiologists (ASA) physical status. Surgical variables recorded included attending surgeon, repair construct (single row vs. double row), if a subscapularis repair was performed, if a subacromial decompression was performed, if a distal clavicle excision was performed, if a biceps tenodesis was performed using anchors, and overall number of anchors used per case.

Rotator cuff tear characteristics were recorded for each patient. Preoperative magnetic resonance images were reviewed by 3 orthopedic surgeons and analyzed for various tear characteristics. Data included tear severity (partial thickness vs. full thickness); tear retraction (distance from medial to lateral) assessed on the T2-weighted coronal image in the center of the supraspinatus using the lateral edge of the greater tuberosity as the reference point and the most lateral edge of the tendon; size of the supraspinatus and infraspinatus tears from anterior to posterior measured on the T2-weighted sagittal image at the most lateral aspect of the greater tuberosity; and degree of muscle atrophy, estimated by the Goutallier classification adapted for magnetic resonance imaging, determined from the T1-weighted sagittal images[4,12,14] at the cut just medial to the start of the scapular spine.

Cost data were derived for all cases during this period using the VDO tool. VDO is an initiative of the University of Utah Health Sciences Center, which includes University of Utah Health Care, University of Utah School of Medicine, and University of Utah Medical Group. The University of Utah Health Sciences Center serves as the Intermountain West's only academic health care system and includes 4 hospitals, 10 community clinics, >10,000 employees, and >1200 physicians.[6] VDO takes all costs recorded in the general ledgers of the health care system and the School of Medicine and identifies costs attributable to direct patient care. These direct care costs are then allocated to individual patient encounters. This cost allocation is determined by customizable cost methods that are applied to certain costs in the general ledger. These cost methods may include the allocation of large groups of costs (eg, a hospital unit's personnel costs) based on a patient's estimated use of that resource as well as the assignment of actual costs (eg, medication acquisition costs) based on a patient's actual use of that resource. Virtually all costs are accounted for, and updates can be made both to cost methods and to the specification of which methods should be applied to which general ledger costs.[6] Overall total direct costs included facility utilization costs, imaging costs, pharmacy costs, supply costs, and other ancillary service costs. Facility utilization costs include any general ledger expenses paid by the facility that relate to operation of a clinical unit where patients can be located. Examples of these clinical units include the emergency department, cardiology inpatient ward, and family medicine clinic. These general ledger expenses include nursing, space, and equipment. Costs assigned to inpatient visits are based on the time the patient spent in that unit, and costs assigned to outpatient visits are based on the average facility expenses for a visit to that clinic. Whereas building depreciation costs are considered indirect costs, equipment depreciation is a direct expense of utilization of that equipment. Therefore, equipment depreciation is a cost allocated to the cost category most appropriate for that particular piece of equipment, such as facility utilization, imaging, laboratory services, supply costs, or other ancillary services.

Statistical analysis

A multivariate regression analysis was used to identify predictors of costs for rotator cuff repairs. Health care costs typically do not follow a normal distribution. Therefore, generalized linear models with the distribution family being dictated by the results of a modi-