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ORIGINAL ARTICLE

An analysis of surgical and nonsurgical operating room times in high-volume shoulder arthroplasty

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Background: A significant portion of operating room time in shoulder arthroplasty is devoted to nonsurgical tasks. To maximize efficiency and to increase access to care, it is important to accurately quantify surgical and nonsurgical time for shoulder arthroplasty. This study aimed to evaluate surgical vs. nonsurgical time and to assess the viability of using a 1-surgeon, 2-operating room model.
Methods: An institutional database was used to identify all primary and revision shoulder arthroplasty cases from February 2011 through December 2013. Time intervals were analyzed, including anesthesia and positioning time, surgical time, conclusion time, and turnover time.
Results: We identified 1062 shoulder arthroplasties. The average anesthesia and positioning time was 48.2 ± 11.7 minutes, surgical time was 122.7 ± 36.4 minutes, and conclusion time was 10.5 ± 7.0 minutes. Average turnover time at our institution was 40 minutes. An average of 58.8 ± 13.8 minutes (33.2%) of the patient's time in the operating room was not surgical. A 1-room surgical model, with each case following the next, would allow 3 arthroplasties to be performed in a 10-hour surgical day. A 2-room model would allow 4 cases to be performed in a 9-hour surgical day or 5 in an 11-hour day. In this 2-room model, there would be no time in which the surgeon is absent for any surgical portion of the case.
Conclusion: For a high-volume shoulder arthroplasty practice, a 2-room model leads to greater efficiency and patient access to care without sacrificing the surgeon's presence during surgical portions of the case.
Level of evidence: Basic Science Study; Hospital Efficiency Study

Keywords: Shoulder arthroplasty; overlapping surgery; operating room efficiency; prolonged operative time; revision shoulder arthroplasty; practice management

The number of shoulder arthroplasties performed in the United States is progressively increasing.[6,16,21,23] As the federal government attempts to reduce health care costs and expand access to care through the Patient Protection and Affordable Care Act,[22] there is an increasing emphasis on value-based care over surgical volume. It has been shown that surgeons and hospitals performing high-volume shoulder arthroplasties produce consistently better outcomes.[12,25,26]

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Therefore, in shoulder arthroplasty, value and volume appear to be inextricably linked. Surgeons and their hospitals are therefore incentivized to evaluate methods to increase efficiency and volume without jeopardizing patient care or safety.

Several institutions have investigated strategies to improve operating room efficiency, including system design,[18,20,28] dedicated orthopedic operating rooms,[27] team assessment,[2,14,20] Lean and Six Sigma methodology,[5] and parallel processing.[9,28] In addition, it has been shown that simply studying a hospital's operative efficiency leads to improved efficiency.[7,8,29,30]

In shoulder arthroplasty, a significant portion of operating room time is nonsurgical due to anesthesia, beach chair positioning, and transfer of the patient to and from the operating room. Whereas 2-room surgery has been practiced in certain high-volume institutions,[3,19,32] it is a practice that has recently been scrutinized.[10,19,24] Given this controversy, an understanding of operating room timing would help clarify safe and efficient operative practices. To our knowledge, no one has quantified the true operating room time in shoulder arthroplasty and determined how much of the time in the operating room is dedicated to nonsurgical tasks. Furthermore, no study has evaluated the viability of a model in which 1 surgeon is managing 2 operating rooms.

The purpose of this study was to quantify the amount of time in the operating room that is surgical vs. nonsurgical for shoulder arthroplasty at a high-volume institution. Based on the recorded times, we aimed to compare a model of a representative surgical day with 1 surgeon managing 1 room vs. 2 rooms without any portions of the surgical time overlapping. We hypothesized that a significant portion of operating room time is dedicated to nonsurgical tasks that would allow use of a 2-room surgery model with the attending surgeon present during all surgical portions of the case. A secondary objective of this study was to identify predictors of prolonged surgical time. We hypothesized that increased case complexity, such as revision arthroplasty, would be associated with increased operative and preparation time.

Methods

An institutional database was used to identify all shoulder arthroplasty cases from February 2011 through December 2013. All arthroplasties were performed by 1 of 6 fellowship-trained shoulder surgeons. These surgeons were all members of a high-volume private practice that performed all cases at an academic, tertiary referral center. Surgical cases were identified by querying an institutional database by *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes. The codes searched were 79.31, open reduction of fracture of humerus; 80.01, arthrotomy for removal of a prosthesis without replacement; 81.80, anatomic total shoulder arthroplasty (ATSA); 81.81, shoulder hemiarthroplasty (SH); 81.82, repair of recurrent dislocation of shoulder; 81.83, other repair of shoulder, arthroplasty; 81.88, reverse total shoulder arthroplasty (RTSA); and 81.97, revision joint replacement upper extremity. These codes were not entirely specific, so individual operative reports identified by this broad query were reviewed to identify the patients who truly underwent primary and revision shoulder arthroplasty.

In addition, from this database, demographic and clinical variables for each patient were identified, including age, gender, body mass index (BMI), procedure performed, and medical comorbidities. Medical comorbidities were analyzed both in 17 independent categories[31] and in aggregate by calculating the age-adjusted Charlson Comorbidity Index (CCI).[4,31] The CCI is a previously validated quantification of a patient's medical conditions using ICD-9-CM codes, originally designed to determine 10-year mortality risk. All cases were subdivided into primary and revision ATSA, SH, and RTSA. Revision surgery was defined as any procedure in which a preexisting arthroplasty was explanted and a new arthroplasty implanted.

Time intervals and description of times, where applicable, were adapted from the Association of Anesthesia Clinical Directors Procedure Times (AACDPT).[11] However, because of the need to determine the time interval between time of skin incision and time of skin closure, time definitions outside of the AACDPT were additionally used. Anesthesia and positioning time (APT) was defined as time interval between the patient's arrival in the room and the procedure/surgical start time, defined as time of skin incision. Notably, interscalene blocks were not performed in the operating room but were performed in the preoperative holding area. Therefore, the APT does not include the time to perform the block. We defined APT to include positioning time, not just anesthesia time as defined by the AACDPT. Surgical time (ST), not defined by the AACDPT, was the time interval between the procedure start time and the surgical end time, defined as time of skin closure. Conclusion time (CT), not defined by the AACDPT, was the time interval between the surgical end time and the time at which the patient left the room. Turnover time (TT) was calculated as the time from 1 patient's exiting the operating room and the arrival of the next patient. TT was not able to be accurately retrieved from the patients' medical records, and so we prospectively calculated our institution's mean TT for shoulder arthroplasty cases on the basis of a sample of 30 consecutive primary and revision arthroplasty cases. A model was created in which the attending surgeon was present for the entirety of the ST. A second, "most efficient" model was created in which there was no delay between the 2 rooms. This model would leave no gap time between the conclusion of TT from the prior case and the beginning of APT for the next case, that is to say, the next patient would be brought to the operating room as soon as it becomes available. The amount of ST that the surgeon would miss in this model was calculated. All data were collected by 2 resident physicians and 2 medical students in the department of orthopedic surgery at the affiliated academic hospital.

Reverse stepwise multivariable regression analysis was performed to identify independent correlators of prolonged ST and nonoperative time (sum of APT, CT, and TT). The independent variables tested were surgeon, primary vs. revision, procedure performed (ATSA, RTSA, SH), age, BMI, gender, and CCI. A 2-tailed P value of $< .05$ was considered a statistically significant difference. All statistics were calculated with Microsoft Excel (2013; Redmond, WA, USA) and SPSS Statistics (version 20.0; IBM, Armonk, NY, USA).