Total Shoulder Arthroplasty in Older Patients

Increased Perioperative Morbidity?

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Abstract

Background More elderly patients are becoming candidates for total shoulder arthroplasty with an increase in frequency of the procedure paralleling the rise in other total joint arthroplasties. Controversy still exists, however, regarding the perioperative morbidity of total joint arthroplasty in elderly patients, particularly those 80 years of age and older.

Questions/purposes We asked whether perioperative complications and mortality, transfusion requirements, inpatient length of stay, and discharge disposition after total shoulder arthroplasty were similar in patients 80 years and older compared with those in younger patients.

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research. This work was performed at the University of Pennsylvania, Philadelphia, PA, USA.

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Methods We retrospectively compared the 90-day complications, mortality, and other perioperative variables after total shoulder arthroplasty in 40 patients (43 shoulders) aged 80 years and older (Group A; mean age, 82 years) with 46 patients (47 shoulders) younger than 70 years (Group B; mean age, 61 years).

Results We found no differences in complication rates between Group A and B, including systemic (26% versus 11%) and local (5% versus 9%) complications or major (7% versus 2%) and minor (23% versus 17%) complications. There were no deaths in either group. Group A had an increased transfusion requirement (16% versus 2%) and a decreased number of direct to home discharges (67% versus 98%). Presence of systemic complications predicted increased length of stay in patients overall and in Group A patients.

Conclusions Total shoulder arthroplasty can be performed in patients 80 years and older with rates of perioperative complications and mortalities comparable to those of younger patients, although these older patients may require a longer period of institutional care before return to home and may be more likely to require a blood transfusion.

Level of Evidence Level III, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

More patients are becoming candidates for total shoulder arthroplasty with an increase in frequency of the procedure paralleling the rise in other total joint arthroplasties [5]. Total shoulder arthroplasty is indicated in the treatment of primary and secondary arthritic conditions of the shoulder with survivorship rates comparable to other joint

arthroplasties at short-, mid-, and long-term followup and substantial improvements in objective measures such as ROM, strength, and shoulder outcome scores [5, 7, 8, 32, 33, 36, 38, 40]. Rates of complete to near-complete pain relief have ranged from 68% to 91% among patients [7, 32] with greater than 90% reported patient satisfaction using standardized measures such as the Constant-Murley [32], American Shoulder and Elbow Surgeons [32], UCLA scores [32], and the Simple Shoulder Test [32].

With the rising life expectancy of patients and growing number of elderly patients as well as the increased prevalence of osteoarthritis with age, older and potentially sicker patients are becoming candidates for total shoulder arthroplasty. Both primary and revision THAs and TKAs have become more common in older and sicker patients with patients 80 years of age and older demonstrating high rates of improved function, pain relief, and patient satisfaction by standardized measures as well as prosthesis survival [1–4, 9, 19, 20, 25–27, 29, 34]. A recent study of 6989 THAs in patients 80 years of age and older from the Finnish National Registry reported an overall revision rate of 2.8% and prosthesis survivorship of 94% at 10 years [25].

Despite these promising reports, however, increasing age has been associated with an increased risk of major perioperative complications and mortality in both THA and TKA [21, 28, 30, 31]. A report of 26,320 THAs and TKAs compared perioperative complications of patients 80 years of age and older with patients aged 65 to 79 years and found older patients were 3.4 times more likely to die, 2.7 times more likely to sustain a myocardial infarction, and 3.5 times more likely to develop pneumonia [21]. Postoperative confusion, urinary tract infection, and increased length of stay (LOS) were also more common in the older patient group [21]. Increased age may also be associated with an increase in preoperative medical comorbidities, which has been independently linked to an increase in perioperative complications, mortality, and LOS in total joint arthroplasty, including total shoulder arthroplasty [15, 17]. Therefore, controversy still exists regarding the safety of total joint arthroplasty in elderly patients, particularly those 80 years of age and older. This issue may be most concerning in elderly patients undergoing total shoulder arthroplasty, because nearly all of the research to date has focused on THA and TKA. One study of seven patients older than 90 years of age reported no perioperative complications or mortalities [6]. Other studies in general populations show perioperative complications rates ranging from 1.2% to 7.55% [10, 11, 16] and perioperative mortality rates ranging from 0% to 0.58% [10, 11, 16, 23, 39] after total shoulder arthroplasty.

We therefore determined whether (1) rates of complications (both systemic medical and local orthopaedic) and mortality were increased in patients older than 80 years in

comparison with a younger group of patients; (2) there were differences in secondary outcome variables (transfusion requirement, inpatient LOS, discharge disposition) between patient groups based on age; and (3) preoperative and intraoperative variables (American Society of Anesthesiologists Physical Status grade, preoperative hemoglobin, cigarette smoking status, body mass index, use of interscalene block anesthesia, method of humeral prosthesis fixation, operating room time, and blood loss) contributed to any observed differences between the two groups in the primary and secondary outcomes.

Patients and Methods

We retrospectively reviewed 1106 shoulder arthroplasties performed at one institution from January 2000 to June 2008 to identify our primary study population of patients 80 years of age and older. We excluded all shoulders treated without placement of a glenoid component (ie, hemiarthroplasty, hemiarthroplasty with glenoid reaming or glenoid resurfacing), leaving 733 total shoulder arthroplasties. Sixty-two arthroplasties were performed in patients 80 years of age or older at the time of surgery. Of these we excluded patients of revision arthroplasty ($n = 4$) and primary reverse total shoulder arthroplasty ($n = 15$), leaving a total of 43 primary total shoulder arthroplasties performed in 40 patients ($n = 3$ bilateral arthroplasties) 80 years of age and older (Group A). There were 12 men and 28 women in this group with a mean age of 82 years (range, 80–90 years) at the time of surgery. As a younger comparison group, patients younger than 70 years and not younger than 50 years at the time of surgery were selected from a representative year within the middle of the study period (2005). Of the 129 total shoulder arthroplasties performed during this period, 63 met the age criteria. Cases of revision arthroplasty ($n = 13$) and primary reverse total shoulder arthroplasty ($n = 3$) were excluded, leaving a total of 47 primary total shoulder arthroplasties performed in 46 patients ($n = 1$ bilateral arthroplasty) as our younger, comparison study population (Group B). There were 27 men and 19 women in this group with a mean age of 61 years (range, 50–69 years) at the time of surgery. From the inpatient and outpatient charts of both groups, we determined the patients' preoperative medical status, inpatient hospital course, and outpatient postoperative followup for the first 90 days after surgery. Three patients in Group A and four patients in Group B had incomplete outpatient postoperative followup in the 90-day period for assessing morbidity and mortality as a result of one or more missing surgeon notes. In Group A, one patient had incomplete 6- and 12-week followup, and two patients had incomplete 12-week followup. In Group B, one patient

had incomplete 6- and 12-week followup, and three patients had incomplete 12-week followup. These patients were still included in the analysis because their inpatient records were complete. Minimum followup was 2 weeks (mean, 11.5 weeks; range, 2–12 weeks) for Group A and 2 weeks (mean, 11.4 weeks; range, 2–12 weeks) for Group B. No patients were recalled specifically for this study; all data were obtained from medical records.

All patients received preoperative medical evaluation and clearance before surgery. Certain variables were collected as measures of preoperative medical status, including the American Society of Anesthesiologists Physical Status (ASA PS) grade (1–6) [35], preoperative hemoglobin, cigarette smoking status, and body mass index (BMI), including those patients meeting obesity criteria ($\text{BMI} \geq 30 \text{ kg/m}^2$). The ASA PS classification system is used to assess the fitness of a patient for surgery before beginning anesthesia and consists of six categories (PS 1: normal, healthy patient; PS 2: patient with mild, systemic disease; PS 3: patient with severe, systemic disease; PS 4: patient with severe, systemic disease that is a constant threat to life; PS 5: moribund patient who is not expected to survive without the operation; PS 6: brain-dead patient whose organs are being removed for donor purposes) [35].

In Group A (patients age 80 years and older), all 43 of the total shoulder arthroplasties were primary procedures. The etiology of glenohumeral arthritis was osteoarthritis in 37 cases, inflammatory or rheumatoid arthritis in three, posttraumatic in two, and postsurgical in one. The humeral component was uncemented in 32 cases and cemented in 11 cases. Eight of the primary cases had an additional procedure performed (rotator cuff repair in three, distal clavicle excision in three, rotator cuff repair with distal

clavicle excision in one, and anterior acromioplasty with distal clavicle excision in one).

In Group B (patients younger than 70 years), all 47 of the total shoulder arthroplasties were primary procedures. The etiology of glenohumeral arthritis was osteoarthritis in 37 cases, inflammatory or rheumatoid arthritis in two, posttraumatic in two, postsurgical in five, and avascular necrosis in one. The humeral component was uncemented in 42 cases and cemented in five cases. Eleven of the cases had an additional procedure performed (rotator cuff repair in two, distal clavicle excision in four, removal of hardware in two, proximal humeral osteotomy in one, posterior glenoid bone grafting in one, and lipoma excision in one).

Preoperative and intraoperative variables were compared between groups using univariate analysis with independent continuous variables evaluated using T statistics and categorical variables evaluated using chi-square test or Fisher test, where appropriate (Table 1). Group A had a decreased preoperative hemoglobin ($p = 0.01$), number of smokers ($p = 0.01$), mean BMI ($p = 0.0004$), and number of obese patients ($p = 0.006$), compared with Group B. Group A and Group B had similar ASA grade distribution ($p = 0.10$), use of interscalene nerve block (ISB) ($p = 0.10$), uncemented humeral prostheses ($p = 0.07$), operating room time ($p = 0.85$), and estimated blood loss ($p = 0.06$) (Table 1).

Total shoulder arthroplasty was carried out in the beach chair position under general anesthesia with or without regional anesthesia (ISB in 38 of 43 patients in Group A and 46 of 47 patients in Group B). One ISB in the older cohort was aborted because the patient could not tolerate the procedure. An intraoperative Foley catheter was not routinely used. All operations were performed by one of

Table 1. Comparison of preoperative and intraoperative data between patient groups

Variable	Group A (n = 43)	Group B (n = 47)	p Value
Age (years)	82 (2)	61 (5)	
ASA PS grade	Grade 1–2: 22 (51%) Grade 3–4: 21 (49%)	Grade 1–2: 32 (68%) Grade 3–4: 15 (32%)	0.10
Preoperative hemoglobin (g/dL)	13.1 (1.2)	13.7 (1.3)	0.01
Smoker (number)	0 (0%)	7 (15%)	0.01
BMI (kg/m^2)	26.6 (3.4)	30.6 (6.4)	0.0004
Obese ($\text{BMI} \geq 30$) (number)	11 (23%)	24 (51%)	0.006
ISB (number)	38 (88%)	46 (98%)	0.07
Uncemented humeral prosthesis (number)	32 (74%)	42 (89%)	0.07
OR time (minutes)	147 (40)	149 (38)	0.85
EBL (mL)	280 (145)	338 (145)	0.06

Means and SDs have been reported for continuous variables (age, hemoglobin, BMI, OR time, EBL), whereas frequency distributions have been reported for categorical variables (ASA PS grade, smoker, obese, ISB, uncemented prosthesis); continuous variables were compared using T statistics, whereas categorical variables were compared using chi-square or Fisher tests, where appropriate; ASA PS = American Society of Anesthesiologists Physical Status; BMI = body mass index; ISB = interscalene nerve block, OR time = operating room time; EBL = estimated blood loss.

four fellowship-trained shoulder surgeons (JAA, DLG, MLR, GRW). A standard deltopectoral approach was used in all cases ($n = 90$). The glenohumeral joint was accessed by takedown of the subscapularis tendon by tenotomy (1–2 cm medial to the lesser tuberosity), direct takedown off of the lesser tuberosity, or lesser tuberosity osteotomy, depending on the surgeons' preference. A cemented, polyethylene glenoid component (anchor peg or keeled) was implanted in all cases, whereas either an uncemented or cemented stem was used on the humeral side. Additional surgical procedures, operating room time, and estimated blood loss were collected as intraoperative data as well.

Postoperatively, patients were started on a regimen for deep venous thrombosis (DVT) prophylaxis consisting of sequential compression devices alone or in combination with aspirin (325 mg orally, twice a day), enoxaparin (30 mg subcutaneously, twice a day), or warfarin (goal international normalized ratio of 2.0–3.0). After the preoperative dose, intravenous antibiotics (cefazolin or vancomycin) were administered for 24 hours after the surgery. All patients were mobilized early in the postoperative period either the day of surgery or the next morning. This included instruction from physical therapy on ROM exercises for the operative extremity consisting of passive external rotation and passive supine forward flexion of the shoulder and unrestricted elbow, wrist, and hand ROM. All patients were followed by a medical internist or cardiologist while in-house. At the time of discharge, patients were sent home ($n = 75$) or to a rehabilitation facility ($n = 1$) or skilled nursing facility ($n = 14$), depending on their health status and living situation.

Routine outpatient followup was at approximately 2 weeks, 6 weeks, and 12 weeks postoperatively. Passive shoulder ROM exercises as instructed in the hospital were continued for the first 6 weeks postoperatively, after which active shoulder ROM exercises were begun. Strengthening exercises for the shoulder were not started until 12 weeks postoperatively.

For the main objectives of the study, (1) complications and mortalities were collected on all patients in the perioperative period as well as data on (2) transfusion requirement, inpatient LOS (days), and discharge disposition. Complications were documented for all patients and classified as either systemic (medical) or local (orthopaedic) [31]. Systemic complications were grouped based on organ system (cardiovascular, pulmonary, neurologic, genitourinary). Potential local complications included intraoperative or postoperative periprosthetic fractures and postoperative prosthetic loosening on either the glenoid or humeral side, glenohumeral instability, rotator cuff tears, infection, nerve injury, deltoid dysfunction, persistent pain, or stiffness. Complications were further subcategorized into major and minor, depending on their severity [31]. Complications

were deemed major if they required surgical intervention or if they were considered life-threatening or could result in permanent functional impairment. Minor complications were those that necessitated additional observation or medical treatment but did not require surgery or were not a threat to life or permanent functional impairment [31]. The decision to transfuse was based on surgeon preference and presence of symptomatic anemia (tachycardia, hypotension, lightheadedness, etc). All patients who underwent transfusion had hemoglobin levels of less than 9.0 g/dL at the time of transfusion. As noted, patients were sent home ($n = 75$) or to a rehabilitation facility ($n = 1$) or skilled nursing facility ($n = 14$) at discharge, depending on their health status and living situation.

To address the two main objectives of the study, perioperative complications, mortalities, transfusion requirement, LOS, and discharge disposition were compared between the two patient groups (Groups A and B). Unadjusted, descriptive analysis using univariate statistics was initially performed with independent continuous variables compared using T statistics and categorical variables compared using chi-square test or Fisher test, where appropriate (Fisher test used for events of less than five). Means and SDs were reported for continuous variables and frequency distributions were reported for categorical variables. After univariate analysis, significant factors between groups were included in multivariate analyses to control for potential confounding variables. Preoperative and intraoperative variables found to be significant in univariate analysis (Table 1) were also included in the multivariate analyses to account for other potential perioperative factors that may contribute to observed differences between the two patient groups. Multivariate logistic regression analysis was performed to determine variables that were significant predictors of the categorical outcome age group (Group A, Group B) after adjusting for potential confounders. Results of the regression analysis were reported as 95% confidence intervals, odds ratios, and p values. Multivariate analysis was then performed to determine variables that were significant predictors of the continuous outcome, LOS (multivariate multiple regression analysis), and the categorical outcome, complications (multivariate logistic regression analysis) after adjusting for potential confounders to further evaluate potential contributing factors to the observed findings in the two patient groups. All statistical analyses were performed using SAS[®] Version 9.1 (SAS Institute Inc, Cary, NC).

Results

There were no differences between the two patient groups in rate of systemic ($p = 0.13$) and local ($p = 0.99$)

Table 2. Comparison of perioperative complications between patient groups

Variable	Group A (n = 43)	Group B (n = 47)	p Value
Age (years)	82 (2)	61 (5)	
Systemic complications (number)			
Cardiovascular	4 (1 major)	0	
Pulmonary	2	1	
Neurologic	4	2	
Genitourinary	1	2	
Total (number)	11 (26%)	5 (11%)	0.13
Local complications (number)			
Infection	0	1	
Nerve injury	0	1	
Fracture	2 (2 major)	2 (1 major)	
Total (number)	2 (5%)	4 (9%)	0.99
Overall complications (number)			
Minor	10 (23%)	8 (17%)	0.18
Major	3 (7%)	1 (2%)	0.35
Total (number)	13 (30%)	9 (19%)	0.12

Means and SDs have been reported for continuous variables (age), whereas frequency distributions have been reported for categorical variables (complications); categorical variables were compared using chi-square and Fisher test, where appropriate.

complications or major ($p = 0.35$) and minor ($p = 0.18$) complications (Table 2). The only major systemic complication was cardiovascular in origin with an 84-year-old woman in Group A having a myocardial infarction on the first postoperative day after a primary right total shoulder arthroplasty that ultimately required cardiac stenting. This patient also had an acute right lower extremity DVT that was treated with warfarin. Most of the minor complications were neurologic in origin with five of the six neurologic complications (four in Group A, one in Group B) attributed to acute delirium. All cases of acute delirium resolved by the time of discharge and were presumed to be the result of narcotic use. All three major local complications were intraoperative fractures that necessitated additional surgical procedures (two in Group A, one in Group B) (see Appendix for additional detail).

There were no deaths in either group.

Group A had an increased transfusion requirement ($p = 0.02$) and inpatient LOS ($p = 0.0008$) and a decreased number of direct to home discharges ($p < 0.0001$) compared with Group B (Table 3). Transfused patients in Group A ($n = 7$) had a mean preoperative hemoglobin of 11.9 and required 2.14 units of blood on average, similar to a preoperative hemoglobin of 11.5 and 2 units of blood in the one transfused patient in Group B.

Younger patients (Group B) were independently associated with decreased odds of need for transfusion and discharge other than home (Table 4). Operating room time

Table 3. Comparison of secondary perioperative outcome variables between patient groups

Variable	Group A (n = 43)	Group B (n = 47)	p Value
Age (years)	82 (2)	61 (5)	
Transfused (number)	7 (16%)	1 (2%)	0.02
Inpatient LOS (days)	3.0 (1.4)	2.1 (0.9)	0.0008
Home discharge (number)	29 (67%)	46 (98%)	< 0.0001

Means and SDs have been reported for continuous variables (age, LOS), whereas frequency distributions have been reported for categorical variables (transfused, home discharge); continuous variables were compared using T statistics, whereas categorical variables were compared using chi-square and Fisher tests, where appropriate; LOS = length of stay.

Table 4. Multivariate logistic regression analysis for patient age and presence of a complication

Variable	Odds ratio	p Value
Age (Group B)		
BMI	1.18 (1.05–1.32)	0.006
Transfused	0.08 (0.009–0.076)	0.03
Nonhome discharge	0.04 (0.05–0.36)	0.004
Presence of complication		
Uncemented prosthesis	3.84 (1.08–13.65)	0.04
LOS	2.82 (1.27–3.54)	0.004

Values are given as odds ratios with 95% confidence intervals in parentheses; all values that had a $p \leq 0.05$ were included; BMI = body mass index, LOS = length of stay.

($p = 0.02$) and presence of systemic ($p < 0.0001$) or major ($p = 0.05$) complications predicted increased LOS in patients overall, presence of systemic ($p = 0.002$) or minor ($p = 0.004$) complications predicted increased LOS in Group A, and smoking ($p = 0.005$) predicted increased LOS in Group B. Increased LOS predicted having a complication overall (Table 4). No other perioperative variables were associated with patient age, LOS, or having a complication.

Discussion

More patients 80 years of age and older are becoming candidates for total shoulder arthroplasty; however, few data are currently available on the safety of the procedure in these patients, and controversy still exists on its use in the elderly. We therefore (1) compared the perioperative morbidity and mortality in the first 90 days after total shoulder arthroplasty in patients 80 years of age and older and those younger than 70; (2) determined whether there

were differences in secondary outcome variables (transfusion requirement, inpatient LOS, discharge disposition) between patient groups based on age; and (3) determined whether a number of preoperative and intraoperative variables contributed to observed differences between the two patient groups.

There were several limitations to our study. First, our study relied on patient records in collecting the variables of interest. Although the inpatient records were essentially complete for each of the patients, postoperative outpatient followup was typically limited to three visits per patient within the first 90 days after surgery. Although major complications are unlikely to be missed or forgotten between visits, it is possible minor complications may fail to be noted at visits separated by up to 6 weeks. Second, the size of our study was also limited as a result of the low frequency of patients 80 years and older undergoing total shoulder arthroplasty. We performed only 43 primary total shoulder arthroplasties over nearly a 9-year period. As a result of the small numbers, our study may not have had the statistical power to detect certain differences between the two groups. For example, acute delirium was more common in the elderly patient group postoperatively, but no difference was seen in comparison to younger patients because of the small number of cases. Cautious use of narcotics and other medications that can alter mental status may still be recommended in patients 80 years and older based on this finding. Third, all operations in our study were performed by fellowship-trained shoulder surgeons experienced in total shoulder arthroplasty; therefore, the

generalizability of some or all of the findings should be considered with caution. Previous studies show mortality rates, complication rates, inpatient LOS, and discharge disposition depend on surgeon experience and volume with lower mortality and complication rates, shorter LOS, and more likely discharge directly to home after total shoulder arthroplasty by high-volume surgeons and in high-volume hospitals [13, 14, 16, 18, 22].

Patients 80 years of age and older in our study did not have an increased rate of perioperative complications (systemic or local, major or minor) in comparison to a younger patient group. No mortalities occurred in the perioperative period in either patient group. In contrast, patients 80 years of age and older had an increased transfusion requirement and a decreased number of direct to home discharges after controlling for potential confounding variables in the multivariate analysis. Several larger, epidemiologic studies have provided mean complication and mortality rates in the early perioperative period for patients of all ages undergoing total shoulder arthroplasty as well as data on mean LOS and discharge status [10, 11, 16, 23] (Table 5). Although the perioperative period length and definition of complications varied from study to study, our rate of major complications, including those in patients 80 years and older, was comparable to the rates quoted in these larger studies. Mortality rate, mean LOS, and rate of direct discharge to home were also comparable, even when looking only at the 80 years and older patient group. One previous study has examined mortality rates after total shoulder arthroplasty using the same 90-day perioperative

Table 5. Comparison of perioperative outcomes reported for total shoulder arthroplasty

Study	Number of cases	Age (years)	Database source	Mortality rate (%)	Complication rate (%)	Length of stay (days)	Direct discharge to home (%)
Jain et al. [16]	12,594	68.3	Nationwide Inpatient Sample database	0.3 (inpatient)	1.2 (inpatient)	3.9	72.4
Lyman et al. [23]	4931	66.4	New York Statewide Planning and Research Cooperative System database	0.24 (inpatient)		4.7 (2000–2003: 3.1)	
Farmer et al. [10]	994*	69.2	Maryland's Health Services Cost Review Commission discharge database	0 (inpatient)	7.55 (inpatient)	2.42	
Fehringer et al. [11]	793	64.4	Veterans Administration National Surgical Quality Improvement Program database	0.4 (30-day)	2.8 (30-day)	3.3	
Ricchetti et al. [current study]	43 (Group A)	82		0	7	3.0	67
	47 (Group B)	61		0	2	2.1	98
	90 (total)	71		0 (90-day)	4 (90-day)	2.5	83

* Cases in the study by Farmer et al. [10] were a combined population of total shoulder arthroplasties (n = 625) and shoulder hemiarthroplasties (n = 369).

period we used, reporting a 0.58% rate in 2953 patients (mean age, 63.6 years) [39].

Several other studies have examined transfusion rates for patients of all ages undergoing total shoulder arthroplasty [12, 24, 37]. Sperling et al. [37] reported an overall transfusion rate of 8.1% in 407 consecutive primary shoulder arthroplasties (mean age, 65.7 years). Millet et al. [24] reported a 25% rate in 124 shoulder arthroplasties (mean age, 63.8 years) that included revision surgeries, whereas Gruson et al. [12] reported a 43% rate in 196 shoulder arthroplasties (mean age, 67.2 years) that include revision surgeries and reverse prostheses. These rates are comparable to our transfusion rate both overall (8.9%) and in the 80 years and older patient group (16%). Transfusions were more common in older patients in all three studies, but only one study [12] reported increasing age as an independent risk factor. Preoperative hemoglobin was the only risk factor consistently seen across all three studies [12, 24, 37]. In our study, patients 80 years and older had a lower preoperative hemoglobin than the younger patient group and ultimately required more blood transfusions, but preoperative hemoglobin did not remain a predictor on multivariate analysis.

Churchill et al. [6] evaluated seven shoulder arthroplasties (five total, two hemi) in six patients 90 years of age and older (mean age, 93 years) with a mean followup of 2.2 years. No complications were specifically reported in this small group of patients, and one mortality occurred 13 months after surgery from pneumonia. No transfusions were required in any patients, and the mean LOS was 2.6 days (range, 2–3 days) with five of six patients discharged directly to home [6]. No younger patient group was used for comparison.

We found a relationship between increased LOS and presence of complications with presence of systemic complications predictive of increased LOS in patients overall and in patients 80 years and older. Although patients 80 years and older had a decreased rate of direct to home discharge, discharge disposition did not independently predict LOS. Older patients being discharged to a nursing facility may often stay in the hospital an additional day to qualify for benefits coverage under Medicare guidelines regardless of medical status. It does not appear that this issue of benefits coverage affected the association of LOS and discharge disposition in our study, but the chart records did not routinely mention this information for us to specifically address this question.

In conclusion, total shoulder arthroplasty can be performed in patients 80 years of age and older with rates of perioperative complications and mortalities comparable to those of younger patients, although these older patients may require a longer period of institutional care before return to home and may be more likely to require a blood

transfusion. Age alone should not be a deterrent when considering candidates for total shoulder arthroplasty.

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Appendix 1 (Additional description of patient complications)

All three major local complications were intraoperative fractures that necessitated additional surgical procedures (two in Group A, one in Group B). In Group A, an 80-year-old man undergoing a primary right total shoulder arthroplasty had a greater tuberosity fracture that required suture fixation, whereas another 80-year-old man undergoing a primary right total shoulder arthroplasty had a nondisplaced proximal humeral metaphyseal fracture that required the humeral stem to be converted from uncemented to cemented fixation. In Group B, a 64-year-old woman undergoing a primary right total shoulder arthroplasty had a long, oblique humeral shaft fracture that required cerclage cable fixation and conversion to a long-stem humeral component. The remaining fracture in Group B was in a 59-year-old man who fell 6 weeks after surgery and sustained a nondisplaced humeral shaft fracture distal to the tip of the humeral stem that healed with nonoperative management.

The remaining two local complications in Group B occurred in the same patient, a 52-year-old woman undergoing right total shoulder arthroplasty with removal of a screw from a prior Bristow procedure. She underwent intraoperative nerve monitoring for her procedure because of a history of shoulder surgery and a substantial loss of motion preoperatively. Axillary nerve potentials decreased intraoperatively and did not return to baseline at the conclusion of the case. An electromyogram postoperatively confirmed a persistent axillary nerve injury, but the patient never demonstrated any clinical deficit and no additional treatment was required. She also developed a small, superficial wound infection after surgery that resolved with 1 week of oral antibiotics.

References

1. Ballard WT, Callaghan JJ, Johnston RC. Revision of total hip arthroplasty in octogenarians. *J Bone Joint Surg Am.* 1995;77: 585–589.
2. Belmar CJ, Barth P, Lonner JH, Lotke PA. Total knee arthroplasty in patients 90 years of age and older. *J Arthroplasty.* 1999;14:911–914.
3. Berend ME, Thong AE, Faris GW, Newbern G, Pierson JL, Ritter MA. Total joint arthroplasty in the extremely elderly: hip and knee arthroplasty after entering the 89th year of life. *J Arthroplasty.* 2003;18:817–821.

4. Biau D, Mullins MM, Judet T, Piriou P. Is anyone too old for a total knee replacement? *Clin Orthop Relat Res.* 2006;448:180–184.
5. Bohsali KI, Wirth MA, Rockwood CA Jr. Complications of total shoulder arthroplasty. *J Bone Joint Surg Am.* 2006;88:2279–2292.
6. Churchill RS. Elective shoulder arthroplasty in patients older than ninety years of age. *J Shoulder Elbow Surg.* 2008;17:376–379.
7. Deshmukh AV, Koris M, Zurakowski D, Thornhill TS. Total shoulder arthroplasty: long-term survivorship, functional outcome, and quality of life. *J Shoulder Elbow Surg.* 2005;14:471–479.
8. Edwards TB, Kadakia NR, Boulahia A, Kempf JF, Boileau P, Nemoz C, Walch G. A comparison of hemiarthroplasty and total shoulder arthroplasty in the treatment of primary glenohumeral osteoarthritis: results of a multicenter study. *J Shoulder Elbow Surg.* 2003;12:207–213.
9. Ekelund A, Rydell N, Nilsson OS. Total hip arthroplasty in patients 80 years of age and older. *Clin Orthop Relat Res.* 1992;281:101–106.
10. Farmer KW, Hammond JW, Queale WS, Keyurapan E, McFarland EG. Shoulder arthroplasty versus hip and knee arthroplasties: a comparison of outcomes. *Clin Orthop Relat Res.* 2007;455:183–189.
11. Fehringer EV, Mikuls TR, Michaud KD, Henderson WG, O'Dell JR. Shoulder arthroplasties have fewer complications than hip or knee arthroplasties in US veterans. *Clin Orthop Relat Res.* 2010;468:717–722.
12. Gruson KI, Accousti KJ, Parsons BO, Pillai G, Flatow EL. Transfusion after shoulder arthroplasty: an analysis of rates and risk factors. *J Shoulder Elbow Surg.* 2009;18:225–230.
13. Hammond JW, Queale WS, Kim TK, McFarland EG. Surgeon experience and clinical and economic outcomes for shoulder arthroplasty. *J Bone Joint Surg Am.* 2003;85:2318–2324.
14. Hasan SS, Leith JM, Smith KL, Matsen FA 3rd. The distribution of shoulder replacement among surgeons and hospitals is significantly different than that of hip or knee replacement. *J Shoulder Elbow Surg.* 2003;12:164–169.
15. Humphries W, Jain N, Pietrobon R, Socolowski F, Cook C, Higgins L. Effect of the Deyo score on outcomes and costs in shoulder arthroplasty patients. *J Orthop Surg (Hong Kong).* 2008;16:186–191.
16. Jain N, Pietrobon R, Hocker S, Guller U, Shankar A, Higgins LD. The relationship between surgeon and hospital volume and outcomes for shoulder arthroplasty. *J Bone Joint Surg Am.* 2004;86:496–505.
17. Jain NB, Guller U, Pietrobon R, Bond TK, Higgins LD. Comorbidities increase complication rates in patients having arthroplasty. *Clin Orthop Relat Res.* 2005;435:232–238.
18. Jain NB, Hocker S, Pietrobon R, Guller U, Bathia N, Higgins LD. Total arthroplasty versus hemiarthroplasty for glenohumeral osteoarthritis: role of provider volume. *J Shoulder Elbow Surg.* 2005;14:361–367.
19. Joshi AB, Gill G. Total knee arthroplasty in nonagenarians. *J Arthroplasty.* 2002;17:681–684.
20. Keisu KS, Orozco F, Sharkey PF, Hozack WJ, Rothman RH, McGuigan FX. Primary cementless total hip arthroplasty in octogenarians. Two to eleven-year follow-up. *J Bone Joint Surg Am.* 2001;83:359–363.
21. Kreder HJ, Berry GK, McMurtry IA, Halman SI. Arthroplasty in the octogenarian: quantifying the risks. *J Arthroplasty.* 2005;20:289–293.
22. Lyman S, Jones EC, Bach PB, Peterson MG, Marx RG. The association between hospital volume and total shoulder arthroplasty outcomes. *Clin Orthop Relat Res.* 2005;432:132–137.
23. Lyman S, Sherman S, Carter TI, Bach PB, Mandl LA, Marx RG. Prevalence and risk factors for symptomatic thromboembolic events after shoulder arthroplasty. *Clin Orthop Relat Res.* 2006;448:152–156.
24. Millett PJ, Porramatikul M, Chen N, Zurakowski D, Warner JJ. Analysis of transfusion predictors in shoulder arthroplasty. *J Bone Joint Surg Am.* 2006;88:1223–1230.
25. Ogino D, Kawaji H, Kontinen L, Lehto M, Rantanen P, Malmivaara A, Kontinen YT, Salo J. Total hip replacement in patients eighty years of age and older. *J Bone Joint Surg Am.* 2008;90:1884–1890.
26. Pagnano MW, McLamb LA, Trousdale RT. Primary and revision total hip arthroplasty for patients 90 years of age and older. *Mayo Clin Proc.* 2003;78:285–288.
27. Pagnano MW, McLamb LA, Trousdale RT. Total knee arthroplasty for patients 90 years of age and older. *Clin Orthop Relat Res.* 2004;418:179–183.
28. Parvizi J, Johnson BG, Rowland C, Ereth MH, Lewallen DG. Thirty-day mortality after elective total hip arthroplasty. *J Bone Joint Surg Am.* 2001;83:1524–1528.
29. Parvizi J, Pour AE, Keshavarzi NR, D'Apuzzo M, Sharkey PF, Hozack WJ. Revision total hip arthroplasty in octogenarians. A case-control study. *J Bone Joint Surg Am.* 2007;89:2612–2618.
30. Parvizi J, Sullivan TA, Trousdale RT, Lewallen DG. Thirty-day mortality after total knee arthroplasty. *J Bone Joint Surg Am.* 2001;83:1157–1161.
31. Pulido L, Parvizi J, Macgibeny M, Sharkey PF, Purtill JJ, Rothman RH, Hozack WJ. In hospital complications after total joint arthroplasty. *J Arthroplasty.* 2008;23(Suppl 1):139–145.
32. Radnay CS, Setter KJ, Chambers L, Levine WN, Bigliani LU, Ahmad CS. Total shoulder replacement compared with humeral head replacement for the treatment of primary glenohumeral osteoarthritis: a systematic review. *J Shoulder Elbow Surg.* 2007;16:396–402.
33. Sajadi KR, Kwon YW, Zuckerman JD. Revision shoulder arthroplasty: an analysis of indications and outcomes. *J Shoulder Elbow Surg.* 2010;19:308–313.
34. Shah AK, Celestin J, Parks ML, Levy RN. Long-term results of total joint arthroplasty in elderly patients who are frail. *Clin Orthop Relat Res.* 2004;425:106–109.
35. Soderqvist A, Ekstrom W, Ponzer S, Pettersson H, Cederholm T, Dalen N, Hedstrom M, Tidermark J. Prediction of mortality in elderly patients with hip fractures: a two-year prospective study of 1,944 patients. *Gerontology.* 2009;55:496–504.
36. Sperling JW, Cofield RH, Rowland CM. Minimum fifteen-year follow-up of Neer hemiarthroplasty and total shoulder arthroplasty in patients aged fifty years or younger. *J Shoulder Elbow Surg.* 2004;13:604–613.
37. Sperling JW, Duncan SF, Cofield RH, Schleck CD, Harmsen WS. Incidence and risk factors for blood transfusion in shoulder arthroplasty. *J Shoulder Elbow Surg.* 2005;14:599–601.
38. Torchia ME, Cofield RH, Settergren CR. Total shoulder arthroplasty with the Neer prosthesis: long-term results. *J Shoulder Elbow Surg.* 1997;6:495–505.
39. White CB, Sperling JW, Cofield RH, Rowland CM. Ninety-day mortality after shoulder arthroplasty. *J Arthroplasty.* 2003;18:886–888.
40. Wirth MA, Rockwood CA, Jr. Complications of total shoulder-replacement arthroplasty. *J Bone Joint Surg Am.* 1996;78:603–616.