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Reverse shoulder arthroplasty for proximal humerus fracture: a more complex episode of care than for cuff tear arthropathy

Joseph N. Liu, MD[a], Avinesh Agarwalla, MD[b], Anirudh K. Gowd, MD[c], Anthony A. Romeo, MD[d], Brian Forsythe, MD[e], Nikhil N. Verma, MD[e,*], Gregory P. Nicholson, MD[e]

[a]*Department of Orthopaedic Surgery, Loma Linda University Medical Center, Loma Linda, CA, USA*
[b]*Department of Orthopaedic Surgery, Westchester Medical Center, Valhalla, NY, USA*
[c]*Department of Orthopaedic Surgery, Wake Forest University, Baptist Medical Center, Winston-Salem, NC, USA*
[d]*Department of Orthopaedic Surgery, The Rothman Institute, New York, NY, USA*
[e]*Midwest Orthopaedics at Rush, Rush University Medical Center, Chicago, IL, USA*

Background: The purpose of this investigation is to identify the in-hospital and 30-day postoperative complications for reverse total shoulder arthroplasty (RTSA) performed because of proximal humerus fracture (PHFx) vs. cuff tear arthropathy (CTA), and determine whether acute fracture is associated with differences in complications after RTSA.
Methods: The National Surgical Quality Improvement Program database was queried for RTSA performed for PHFx and CTA. This database contains surgical outcomes within 30 days after the index procedure. Patients underwent a 1:1 propensity matched based on preoperative demographics and comorbidities. Outcomes included operative time, length of stay (LOS), complications, transfusion, readmission, and discharge destination.
Results: A total of 1006 patients (503 per group) were included. With a PHFx, operative time was longer (129.5 ± 54.2 vs. 96.0 ± 40.0 minutes, $P < .001$), and the patients were more likely to have an adverse event (19.0% vs. 8.2%, $P < .001$), require transfusion (15.71% vs. 3.98%, $P < .001$), have longer LOS (3.8 ± 3.6 vs. 2.2 ± 1.7 days, $P < .001$), and were more likely to be discharged to an extended care facility (27.2% vs. 10.3%, $P < .001$). PHFx was an independent risk factor for an adverse event after an RTSA.
Conclusions: RTSA to treat PHFx is associated with longer LOS, increased complications, and discharge to an extended care facility compared with RTSA for CTA. Patients with PHFx require more health care resources than patients with CTA. It is imperative for surgeons, patients, families, governments, hospital systems, and insurance payers to recognize the differences in resource utilization for RTSA in treating PHFx compared with CTA.

No IRB approval was required for this retrospective study.

*Reprint requests: Nikhil N. Verma, MD, Midwest Orthopaedics at Rush, Division of Sports Medicine, 1611 W Harrison, St Chicago, IL 60612, USA.

E-mail address: nikhil.verma@rushortho.com (N.N. Verma).

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Surgical management for proximal humerus fractures (PHFx) typically includes open reduction internal fixation (ORIF), hemiarthroplasty (HA), or reverse total shoulder arthroplasty (RTSA). ORIF can provide stable anatomic fixation with restoration of the neck shaft angle; however, it is associated with complications in nearly 40% of cases.[1,7,11,17,21] Shoulder arthroplasty has been used as a way to circumvent the high complication rates and provide a quicker return to activity in the event of complex fractures.[4,16] In the setting of severe tuberosity comminution, rotator cuff pathology, or medical comorbidities, an RTSA is preferred as its construct is relatively independent from rotator cuff function.[9,13] Patients undergoing RTSA exhibit greater active forward elevation, external rotation, functional scores as well as a lower complication rate than those undergoing HA.[13,28] As a result, the incidence of RTSA performed to treat PHFx increased 406% from 2005 to 2012, whereas HA decreased by 47% over the same period.[12]

In the fee-for-service payment model, hospitals and health care providers are reimbursed for each individual service.[10] Recent changes to the health care system seek bundled payments for the entirety of the episode of care from the initial encounter through a predefined postoperative period—thus rewarding quality of care that minimizes additional encounters due to complications.[6,15] Reimbursement for RTSA is related to Medicare Severity Diagnosis-Related Groups 484 (major joint reconstruction or upper extremity reattachment without major complications) and 483 (major joint reconstruction or upper extremity reattachment with major complications). Although this system provides reimbursement based on complications, this system does not use specific diagnosis codes. Therefore, it cannot distinguish between various RTSA indications. In cuff tear arthropathy (CTA) or glenohumeral arthritis with clinical evidence of rotator cuff dysfunction, an RTSA can be performed electively.[13] However, an RTSA may be performed more acutely in patients with PHFx. As health care transitions toward using alternative payment models including bundled payments for episode of care, it is imperative to identify and stratify patients who may require increased resource utilization during the predefined period of bundled-payment distribution.

The purpose of this investigation was to identify the in-hospital and 30-day postoperative complications in patients undergoing an RTSA due to PHFx or CTA. We hypothesize that patients undergoing an RTSA due to PHFx have increased utilization of health care resources due to more challenging surgical procedures, longer hospital stays, increased risk of perioperative complications, and higher 30-day postoperative readmission rates in comparison with patients undergoing RTSA secondary to CTA.

Methods

This study used a retrospective cohort from prospectively collected data as part of the American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP). This registry contains demographics, comorbidities, lab values, and concomitant procedures with corresponding readmission and complication rates within 30 days of indexed procedure. Patients are identified through Current Procedural Terminology (CPT), and International Classification of Diseases Ninth and Tenth Revision (ICD-9, ICD-10).[14] The ACS-NSQIP database comprises a network of hospitals that are required to employ clinical reviewers with a background in health care to collect 274 variables from surgical procedures. The database implements several quality assurance measures, such as biweekly random internal audits, which have reported less than 1.8% inter-rater disagreement.[5,27]

Patients who underwent isolated RTSA (CPT: 23472) for the diagnosis of rotator cuff deficiency (ICD-9: 726.1, 727.61, 840.4 and ICD-10: M75.101, M75.102, M75.121, M75.122, M75.111, M75.112) or closed PHFx (ICD-9: 812.00, 812.01, 812.03, 812.09, 812.11, 812.20, 812.21 and ICD-10: S42.201A, S42.202A, S42.202K, S42.202P, S42.242A, S42.252A, S42.291A, S42.292A) were identified through the ACS-NSQIP database from 2005 to 2016. An RTSA was confirmed if patients had a CPT code for an RTSA as well as an ICD-9/10 code for rotator cuff deficiency or closed PHFx in their record on the day of surgery. Patients with a diagnosis of glenohumeral osteoarthritis were not included because this diagnosis is not specific for RTSA. It was not discernible whether the procedure was primary or secondary for the pathology. Patient demographics, including age, race, gender, smoking status, comorbidities, functional status, operative time, American Society of Anesthesiologists (ASA) physical status classification score, and laboratory values, were collected. An ASA score greater than 3 corresponded to severe systemic disease (New Classification of Physical Status). History of diabetes was reported as either insulin-dependent, oral medication only, or no diabetes. Patients in each group underwent a 1:1 propensity match for age, body mass index, dependent functional status, bleeding disorders, comorbidities, and ASA status. Laboratory values are recorded in the NSQIP database; however, these values were not used for matching because they were not available for all patients and their inclusion may have resulted in a reduced sample size and potential bias.

For each patient, length of hospital stay, readmission rate, and 30-day complications were collected. Complications that were queried included rate of infections (superficial or deep), dehiscence, pneumonia, reintubation, pulmonary embolism, postoperative renal failure, urine infection, stroke, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, transfusions, deep vein thrombosis, sepsis, and shock. Length of stay was defined as days from procedure and postoperative discharge. Minor complications included superficial surgical site infection, urinary tract infection, pneumonia, progressive renal insufficiency, or wound dehiscence. Severe complications included death, coma, placement on ventilator, unplanned intubation, stroke/cerebrovascular accident, thromboembolic event (deep vein thrombosis or pulmonary embolism), cardiac arrest, myocardial infarction, acute renal failure, sepsis, septic shock, return to the operating room (OR), or extended hospital stay (>3 days).[2] All values were collected in each interval year included (2005-2016), except readmission rate, which was only collected from 2011 to 2016.

Statistical analysis was performed using Rstudio software version 1.0.143 (R Foundation for Statistical Computing, Vienna, Austria). Propensity score matching was performed using the nearest-neighbor method. Outcomes with bivariate variables were compared with bivariate and multivariate Poisson regression with robust error variance. Statistical analysis was performed on the original cohort as well as the matched propensity cohort. Statistical significance was achieved with $P < .05$.

Results

A total of 1262 patients who underwent an RTSA were included in this investigation: 759 patients were treated for CTA and 503 patients were treated for PHFx. After propensity score matching, 503 patients were included in each group for a total of 1006 patients included in the analysis of this investigation.

Before matching, there was a statistically significant difference in age, race, operative time, sex, dependent functional status, ASA class distribution, operation within 30 days, and days between admission and OR (Table I). Furthermore, there were also statistically significant differences in the number of comorbidities per patient, history of myocardial infarction, congestive heart failure, stroke resulting in deficit, and bleeding disorder (Table II). After matching, variables that remained statistically different included operative time, gender, congestive heart failure, and days between admission and OR. Total surgical time was longer for patients undergoing an RTSA for a PHFx (129.5 ± 54.2 minutes vs. 96.0 ± 40.0 minutes, $P < .001$). There were statistically significant differences in serum lab levels for hematocrit, white blood cell count, platelet count, albumin, and blood urea nitrogen ($P < .05$) before and after matching (Table II).

There were differences in perioperative and 30-day postoperative complication rates for RTSA performed to treat CTA or PHFx (Table III). Patients with an RTSA for a PHFx were more likely to experience an adverse event (19.01% vs. 8.15%, $P < .001$), and bleeding requiring transfusion (15.71% vs. 3.98%, $P < .001$). In addition, patients undergoing an RTSA for a PHFx were more likely to be discharged to an inpatient facility (27.21% vs. 10.33%, $P < .001$) and had a longer length of stay after surgery (3.8 ± 3.6 days vs. 2.2 ± 1.7 days, $P < .001$).

When accounting for other variables, body mass index between 25-30 mg/kg^2 (relative risk [RR]: 0.63, 95% confidence interval [CI]: 0.4-0.9) and 30-35 mg/kg^2 (RR: 0.55, 95% CI: 0.4-0.9), history of bleeding disorder (RR: 2.05, 95% CI: 1.4-3.1), and low preoperative serum hematocrit (RR: 1.71, 95% CI: 1.2-2.4) were associated with greater risk of having a perioperative adverse event. In addition, diagnosis of a PHFx was an independent risk factor for an adverse risk event after an RTSA (RR: 1.73, 95% CI: 1.2-2.5) in comparison with a diagnosis of rotator cuff deficiency (Table IV). Nonsignificant measures from multivariate analysis is provided in Table S1.

Discussion

In this investigation, we demonstrate that patients undergoing RTSA for PHFx had an increased risk of postoperative adverse events, including increased transfusion rate, length of stay, and discharge to inpatient facility than patients undergoing RTSA for CTA. Importantly, these differences were observed in a propensity-scored matched cohort analysis that controlled for age, race, and medical comorbidities. These findings underscore the concept that RTSA for PHFx vs. RTSA for CTA represent 2 fundamentally different patient care scenarios. The risk for adverse events and need for health care resource utilization are vastly different. As alternative payment initiatives focusing on episode of care, such as bundled payments, become increasingly pervasive across health care reimbursement models, differential risk stratification in patients and procedures based on expected health care resource utilization becomes progressively important.

It has been previously described that hip arthroplasty secondary to hip fracture is associated with an increased risk of complications, non-homebound discharge, and readmission in comparison with patients undergoing arthroplasty due to osteoarthritis.[24,26] However, there is limited evidence that directly compares RTSA for PHFx vs. CTA or osteoarthritis. Wellmann et al[29] demonstrated that RTSA for CTA had statistically significant higher Constant scores in comparison with both fracture sequelae and revision for failed total shoulder arthroplasty. This finding demonstrates that preoperative etiology influences clinical outcomes after RTSA. Garcia et al[8] demonstrated that there was no difference in the rate of return to sport after RTSA due to CTA (80.9%) or PHFx (76.9%). However, this finding may be limited by a low sample size in the PHFx group. In the present investigation, we demonstrate that

Table I Demographic characteristics for patients undergoing reverse total shoulder arthroplasty for diagnoses of cuff tear arthropathy vs. proximal humerus fracture (PHFx)

	CTA unmatched (%)	PHFx unmatched (%)	*P* value	RCA matched (%)	PHFx matched (%)	*P* value
Patients, N (%)	759 (60.1)	503 (39.9)		503 (50)	503 (50)	
Age (yr), mean ± SD	70.9 ± 8.7	73.6 ± 9.6	**<.001**	73.0 ± 8.6	73.6 ± 9.6	.262
BMI (kg/m^2), mean ± SD	30.7 ± 7.2	30.5 ± 7.5	.600	30.8 ± 7.4	30.5 ± 7.5	.568
Obesity I (30-34.9 kg/m^2)	186 (24.4)	120 (23.9)	.812	111 (22.1)	120 (23.9)	.500
Obesity II (35-39.9 kg/m^2)	109 (14.3)	62 (12.3)	.310	74 (14.7)	62 (12.3)	.269
Obesity III (≥40 kg/m^2)	69 (9.1)	54 (10.7)	.327	47 (9.3)	54 (10.7)	.463
Operative time (min)	97.1 ± 38.7	129.5 ± 54.2	**<.001**	96.0 ± 40.0	129.5 ± 54.2	**<.001**
Male sex	342 (45.1)	96 (19.1)	**<.001**	281 (55.9)	96 (19.1)	**<.001**
ASA class	2.6 ± 0.6	2.8 ± 0.6	**<.001**	2.7 ± 0.5	2.8 ± 0.6	.267
1	7 (0.9)	6 (1.2)	.638	5 (1.0)	6 (1.2)	.762
2	302 (39.7)	146 (29.0)	**<.001**	151 (30.0)	146 (29.0)	.730
3	427 (56.1)	286 (56.9)	**.018**	329 (65.4)	316 (62.8)	.393
4	25 (3.3)	35 (7.0)	**.003**	18 (3.6)	35 (7.0)	**.016**
Dependent functional status	28 (3.7)	36 (7.2)	**.008**	25 (5.0)	36 (7.2)	.146
Alcohol use	6 (0.8)	1 (0.2)	.167	5 (1.0)	1 (0.2)	.101
Current smoker	85 (11.2)	58 (11.5)	.857	42 (8.4)	58 (11.5)	.092
Days to OR	0.0 ± 0.2	0.9 ± 2.0	**<.001**	0.0 ± 0.2	0.9 ± 2.0	**<.001**
Race						
White	664 (87.3)	454 (90.3)	.102	440 (87.5)	454 (90.3)	.161
Black	41 (5.4)	15 (3.0)	**.042**	27 (5.4)	15 (3.0)	.059
Asian	9 (1.2)	5 (1.0)	.754	3 (0.6)	5 (1.0)	.478
Other	47 (6.2)	29 (5.8)	.090	33 (6.6)	29 (5.8)	.600

CTA, cuff tear arthropathy; *SD*, standard deviation; *BMI*, body mass index; *ASA*, American Society of Anesthesiologists; *OR*, operating room.
Bold indicates statistical significance.

patients undergoing RTSA due to PHFx experience more complications than those with CTA or osteoarthritis despite controlling for patient factors. These patient populations may be different because patients with a fracture are at a lower heath state, experience more bleeding due to the presence of a fracture hematoma or possible polytrauma, and the procedure itself is technically more challenging due to an acute trauma and altered anatomy with compromised bone stock. In elective joint arthroplasty, patients can be medically optimized before surgery, whereas in acute traumatic cases, patients are unable to be optimized before operative management.

Previous systematic reviews have quantified the complication rate after RTSA due to CTA or PHFx. Petrillo et al[23] found a 17.4% complication rate that resulted in revision surgery in 7.3% of cases after RTSA performed for CTA. With regard to PHFx, Mata-Fink et al[19] identified 41 complications in 369 RTSA patients (11.1%), which was equivalent to the complication rate after HA. Longo et al[18] provided a more in-depth analysis of complications after RTSA performed for PHFx. The authors identified complications in 46.1% of cases, which included medical complications (5.8%), intraoperative complications (4.6%), postoperative complications (3.5%), as well as radiographic complications (31.7%), which included tuberosity malunion/nonunion or resorption in 21.2% of cases. The current literature suggests that RTSA secondary to PHFx has a higher rate of complications than RTSA performed for CTA. However, no previous studies accounted for comorbidities and age, which makes the comparison of RTSA for CTA or PHFx limited in scope. After controlling for patient demographics and medical comorbidities, we identified that patients receiving an RTSA to treat a PHFx had a higher overall complication rate, higher rate of transfusion, longer length of stay, and higher rate of discharge to an inpatient facility. In fact, despite potential confounding variables, we found that the diagnosis of PHFx was an independent risk factor for adverse events related to RTSA.

The Medicare Severity Diagnosis-Related Groups system does not indicate the diagnosis for which the procedure was performed. On the basis of our findings, hospitals and health care systems that have a higher percentage of fractures will be unfairly disadvantaged compared with those institutions that perform more elective arthroplasties because the former requires more resource utilization at the time of admission and in the postoperative period. Reimbursement is also dependent on regional and historical averages that may not reflect changes in case volume or type at individual hospitals. As health care transitions to alternative payment systems that share risk among the stakeholders, which rewards health care systems for

Table II Comorbidities for patients undergoing reverse total shoulder arthroplasty for diagnoses of cuff tear arthropathy vs. proximal humerus fracture (PHFx)

	CTA unmatched (%)	PHFx unmatched (%)	*P* value	RCA matched (%)	PHFx matched (%)	*P* value
Patients, N (%)	759 (60.1)	503 (39.9)		503 (50)	503 (50)	
Comorbidities, mean ± SD	1.0 ± 0.9	1.2 ± 1.0	**.046**	1.1 ± 0.9	1.2 ± 1.0	.283
Myocardial infarction	0 (0)	3 (0.6)	**.033**	0 (0)	3 (0.6)	.083
Cardiac surgery	1 (0.1)	1 (0.2)	.768	1 (0.2)	1 (0.2)	1.00
Angina	0 (0)	0 (0)	n/a	0 (0)	0 (0)	n/a
Hypertension	530 (69.8)	354 (70.4)	.851	353 (70.2)	354 (70.4)	.945
Congestive heart failure	2 (0.3)	9 (1.8)	**.009**	2 (0.4)	9 (1.8)	**.034**
Previous PCI	6 (0.8)	7 (1.4)	.298	6 (1.2)	7 (1.4)	.780
Renal failure	0 (0)	2 (0.4)	.082	0 (0)	2 (0.4)	.157
Dialysis	5 (0.7)	5 (1.0)	.508	1 (0.2)	5 (1.0)	.101
Stroke—with deficit	0 (0)	3 (0.6)	**.033**	0 (0)	3 (0.6)	.083
Stroke—without deficit	3 (0.4)	1 (0.2)	.545	3 (0.6)	1 (0.2)	.316
TIA	5 (0.7)	1 (0.2)	.246	5 (1.0)	1 (0.2)	.101
Metastatic cancer	1 (0.1)	1 (0.2)	.768	1 (0.2)	1 (0.2)	1.00
Steroid use	43 (5.7)	25 (5.0)	.275	27 (5.4)	25 (5.0)	.776
Weight loss	2 (0.3)	2 (0.4)	.676	1 (0.2)	2 (0.4)	.563
Bleeding disorder	22 (2.9)	28 (5.6)	**.017**	22 (4.4)	28 (5.6)	.384
Recent operation	0 (0)	3 (0.6)	**.033**	0 (0)	3 (0.6)	.083
IDDM	62 (8.2)	47 (9.3)	.458	48 (9.5)	47 (9.3)	.914
DOE	57 (7.5)	40 (8.0)	.829	44 (8.8)	40 (8.0)	.648
COPD	58 (7.6)	49 (9.7)	.215	34 (6.8)	49 (9.7)	.086
Serum lab, mean ± SD						
Hematocrit (%)	40.4 ± 4.4	35.7 ± 4.9	**<.001**	40.3 ± 4.6	35.7 ± 4.9	**<.001**
WBC (109 cells/L)	7.2 ± 7.1	8.9 ± 3.6	**<.001**	7.3 ± 2.7	8.9 ± 3.6	**<.001**
Platelets (109 cells/L)	260.1 ± 68.8	260.1 ± 89.3	**<.001**	241.8 ± 69.7	260.1 ± 89.3	**<.001**
INR	1.0 ± 0.2	1.1 ± 0.2	.121	1.1 ± 0.3	1.1 ± 0.2	.711
Creatinine (mg/dL)	1.0 ± 0.8	0.9 ± 0.7	**.028**	1.0 ± 0.6	0.9 ± 0.7	**.047**
Albumin (g/dL)	4.0 ± 0.5	3.7 ± 0.6	**<.001**	4.0 ± 0.6	3.7 ± 0.6	**<.001**
BUN (mg/dL)	19.3 ± 8.6	18.3 ± 8.5	**.045**	20.1 ± 9.1	18.3 ± 8.5	**.002**

CTA, cuff tear arthropathy; *SD*, standard deviation; *n/a*, not applicable; *PCI*, percutaneous coronary intervention; *TIA*, transient ischemic attack; *IDDM*, insulin-dependent diabetes mellitus; *DOE*, dyspnea on exertion; *COPD*, chronic obstructive pulmonary disease; *WBC*, white blood cell; *INR*, international normalized ratio; *BUN*, blood urea nitrogen.

Renal failure: wherein renal function has been compromised within 24 h before surgery; dialysis: acute or chronic renal failure requiring dialysis within 2 wk of indexed procedure; weight loss: considered as a greater than 10% decrease in body weight in 6-mo interval preceding surgery; recent operation: within 30 d of indexed procedure.

Bold indicates statistical significance.

optimal care and outcomes and do not provide adjustments for adverse events,[6,10,15] it is imperative to identify procedures or diagnoses that have an inherent higher risk of complications.

Recently, Centers for Medicare and Medicaid Services (CMS) altered reimbursement for total hip replacement secondary to proximal hip for fracture or osteoarthritis because these patient populations have significant differences in resource utilization.[26] RTSA performed to treat a PHFx is primarily performed in a more acute setting that removes the capability to perform preoperative planning. Adequate planning before elective surgery, such as RTSA for CTA, allows the patient and family to establish adequate postoperative care, which can reduce the length of stay and lower the risk of complications in the acute to subacute postoperative period. Based on the results of the present study, the same resource utilization discrepancy observed with hip arthroplasty is seen in the utilization of RTSA to treat a PHFx vs. CTA. Therefore, reimbursement systems should be adjusted to account for additional resources necessary for the added complexity of RTSA for PHFx, as evidenced by its longer operative time, increased postoperative complication rate, and increased risk of discharge to an inpatient setting.

As health care spending is increasingly scrutinized, value in health care has become a prevalent discussion.[25] In the treatment of PHFx, Nwachukwu et al[20] demonstrated that RTSA is cost-effective to both the payer and hospital, whereas HA is cost-effective to only the hospital. RTSA provides more consistent outcomes vs. HA and ORIF with less physical therapy needed in the postoperative period—resulting in significant savings to the health care

Table III Incidence of adverse events for patients undergoing reverse total shoulder arthroplasty for diagnoses of cuff tear arthropathy vs. proximal humerus fracture (PHFx)

	RCA unmatched		PHFx unmatched		*P* value	RCA matched		PHFx matched		*P* value	Overall matched	
	Number	Rate, %	Number	Rate, %		Number	Rate, %	Number	Rate, %		Number	Rate, %
Any adverse event	**57**	**7.51**	**96**	**19.01**	**<.001**	**41**	**8.15**	**96**	**19.01**	**<.001**	**137**	**13.6**
Mortality	1	0.13	2	0.40	.567	1	0.20	2	0.40	.563	3	0.30
Wound dehiscence	0	0.00	1	0.20	.399	0	0.00	1	0.20	.317	1	0.10
Sepsis	6	0.79	1	0.20	.488	3	0.60	1	0.20	.316	4	0.40
Pulmonary embolism	5	0.66	6	1.19	.362	5	1.00	6	1.19	.762	11	1.09
Myocardial infarction	2	0.26	1	0.20	.653	2	0.40	1	0.20	.563	3	0.30
Stroke	1	0.13	1	0.20	.638	1	0.20	1	0.20	1.00	2	0.20
Transfusion	**28**	**3.69**	**79**	**15.71**	**<.001**	**20**	**3.98**	**79**	**15.71**	**<.001**	**99**	**9.84**
DVT	7	0.92	1	0.20	.156	4	0.80	1	0.20	.179	5	0.50
UTI	3	0.40	7	1.39	.100	3	0.60	7	1.39	.204	10	0.99
Pneumonia	5	0.66	6	1.19	.362	4	0.80	6	1.19	.525	10	0.99
Unplanned intubation	4	0.53	4	0.80	.497	4	0.80	4	0.80	1.00	8	0.80
SSI	6	0.79	2	0.40	.488	2	0.40	2	0.40	1.00	4	0.40
Extended LOS	**9**	**1.19**	**38**	**7.55**	**<.001**	**7**	**1.39**	**38**	**7.55**	**<.001**	**45**	**4.47**
Return to the OR	11	1.45	12	2.39	.283	8	1.59	12	2.39	.366	20	1.99
Readmission	10	1.31	6	1.19	.850	8	1.59	6	1.19	.590	14	1.39
Discharge to IP facility	**56**	**7.4**	**137**	**27.2**	**<.001**	**52**	**10.33**	**137**	**27.21**	**<.001**	**189**	**18.79**
Average LOS	**2.0 ± 1.7**		**3.8 ± 3.6**		**<.001**	**2.1 ± 1.7**		**3.8 ± 3.6**		**<.001**		

CTA, cuff tear arthropathy; *DVT*, deep vein thrombosis; *UTI*, urinary tract infection; *SSI*, surgical site infection; *LOS*, length of stay (extended >3 d); *OR*, operating room; *IP*, inpatient.
Bold indicates statistical significance.

system.[3] With the current climate of cost containment in the United States, it is critical to define appropriate resource allocation per episode of care, and to develop improved understanding and capacity for risk adjustment. If risk is not adjusted based on evidence of increased complexity and complications, there will be incentives for avoiding or rationing the care provided to patients with a PHFx who are indicated for RTSA. Another example where the current system does not accurately reflect the cost of care is related to the difference for the much less expensive HA implant vs. the implants used in RTSA. Bundled payments can be skewed based on the propensity of using the HA component vs. a RTSA. For patients over the age of 70 years with PHFx, Osterhoff et al[22] determined that RTSA is the preferred economic strategy when compared with HA when considering the overall cost of care. Although RTSA has a higher cost initially due to the implant, when accounting for complications and quality of life, it proves to be a more cost-effective treatment modality in this population. Because of a lower incidence of complications postoperatively, RTSA has more economic utility.

Despite the significant findings of this investigation, the analysis should be analyzed within the context of its limitations. Because of the number of patients within the database, we were unable to match for variables that were not captured by the ACS-NSQIP database. Furthermore, patient selection in this investigation is subject to bias as the indication RTSA is limited by the diagnosis code and may vary between institutions as well as physicians within an institution. Presumably, patients selected for RTSA to treat a PHFx presented with more severe fracture patterns (3- and 4-part fractures) that were not amenable to reconstruction or had a high likelihood of poor outcome with another form of treatment. We were also unable to account for other factors that may influence postoperative complications such as the mechanism of injury, coexisting cuff tear, polytrauma, socioeconomic status, as well as the suitability of the patient's home to provide care for the patient in the postoperative period. It is possible that significant differences exist in the cost of each episode for RTSA due to PHFx or CTA. However, the cost associated with each procedure and hospital stay was unable to be queried from the database. Furthermore, the type of implant used in each patient was unable to be queried from the NSQIP database. It is possible that variations in types of implants may result in differences in the complication rates. Patients with a PHFx had a lower preoperative hemoglobin and hematocrit level. This may lead to more transfusions, which increase the number of adverse events accounted for in this investigation. Therefore, health care systems may prolong the duration of hospital stay in these patients to ensure that they have achieved adequate hemostasis. In the

Table IV Risk of developing any adverse event during surgery as related to patient demographics, comorbidities, and serum lab values

	Number	Adverse events N (%)	Statistical comparisons			
			Bivariate	Multivariate*		
			P value	RR coefficient	95% CI	*P* value
Overall	1006					
Body mass index (kg/m^2)			**.003**			
<25	216	48 (22.2)		Ref	–	
25-30	322	39 (12.1)		.634	0.4-0.9	**.016**
30-35	231	23 (10.0)		.554	0.4-0.9	**.011**
35-40	136	18 (13.2)		.762	0.5-1.3	.296
>40	101	9 (8.9)		.524	0.3-1.1	.078
ASA class			**<.001**			
1	11	1 (9.1)		Ref	–	
2	297	27 (9.1)		1.270	0.1-11.4	.831
3	645	95 (14.7)		1.702	0.2-14.7	.629
4	53	14 (26.4)		2.133	0.2-19.0	.497
Bleeding disorder			**<.001**			
No	956	120 (12.6)		Ref	–	
Yes	50	17 (34.0)		2.049	1.4-3.1	**.001**
Functionally dependent			**.001**			
No	945	120 (12.7)		Ref	–	
Yes	61	17 (27.9)		1.371	0.9-2.1	.157
Serum hematocrit			**<.001**			
Normal	575	49 (8.5)		Ref	–	
Low*	431	88 (20.4)		1.705	1.2-2.4	**.002**
Serum albumin			**<.001**			
Normal	909	111 (12.2)		Ref	–	
Low*	97	26 (26.8)		1.193	0.8-1.7	.367
Diagnosis			**<.001**			
CTA	503	41 (8.2)		Ref	–	
PHFx	**503**	**96 (19.1)**		**1.734**	**1.2-2.5**	**.003**

RR, relative risk; *CI*, confidence interval; *ASA*, American Society of Anesthesiologists; *CTA*, cuff tear arthropathy; *PHFx*, proximal humerus fractures. Low serum albumin: defined as <3.5 g/dL; low serum hematocrit: defined as <41 g/dL if male and <36 g/dL if female.
Bold indicates statistical significance.
* Variables are adjusted for all baseline characteristics listed in this table.

elective setting (ie, RTSA secondary to CTA), the patients' home and support can be optimized to care for the patient in a manner that cannot be performed for acute PHFx. Lastly, this investigation does not account for complications that extend outside the 30-day window and may miss complications that are within the 90-day global period.

Conclusion

RTSA to treat PHFx is associated with increased complication rate, longer length of stay, and increased likelihood of discharge to post-acute inpatient facility compared with elective RTSA to treat CTA. Patients with PHFx require greater utilization of health care resources than patients with CTA. These differences were persistent despite propensity score matching of preoperative variables. It is imperative for all stakeholders in the health care delivery system to appropriately recognize the expected differences in resource utilization for RTSA in treating PHFx compared with CTA.

Disclaimer

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Supplementary data

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