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Ninety-day readmissions following reverse total shoulder arthroplasty

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A R T I C L E   I N F O

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Level of evidence: Level IV, Case Series using Large Database Analysis, Treatment Study

Background: An adequate characterization of 90-day readmissions after primary reverse total shoulder arthroplasty (RTSA) on a national level remains to be undertaken. As bundled payment models become more prevalent, an improved understanding of readmission data will help to predict resource utilization and expenses.

Methods: All adult patients who underwent elective primary RTSA in 2014 in the National Readmission Database were included in the analysis. Two cohorts were created based on 90-day readmission status. Multivariate analysis was then performed to determine predictors of 90-day readmissions. Reasons for 30-, 60-, and 90-day readmissions were identified. Total hospital resource utilization was calculated.

Results: An estimated 25,196 patients were identified. The 30-, 60-, and 90-day rates of readmissions were 0.6%, 1.2%, and 1.7%, respectively. Diabetes (odds ratio [OR], 1.42; 95% confidence interval [CI], 1.14-1.78), hypertension (OR, 1.63; 95% CI, 1.28-2.08), paralysis (OR, 3.61; 95% CI, 1.63-7.97), and solid tumor without metastasis (OR, 2.72; 95% CI, 1.21-6.12) were identified as independent predictors of 90-day readmission. Ninety-day readmissions were associated with a significant increase in cost (P = .02). The most common related reason for 90-day readmission was hardware-related complications at all time points.

Conclusion: Although uncommon, 90-day readmissions after primary RTSA are associated with significant patient morbidity and consequently substantial hospital costs.

Reverse total shoulder arthroplasty (RTSA) is a procedure that can reliably restore function and provide pain relief in patients with existing rotator cuff arthropathy.[10,14,30] In 2003, RTSA was approved by the US Food and Drug Administration and its indications for use have expanded since its inception.[3,19] RTSA indications have progressed from glenohumeral arthritis with rotator cuff arthropathy to include a variety of shoulder pathologies including, but not limited to, proximal humerus fractures, revision arthroplasty, inflammatory arthropathies, and severe glenoid bone wear.[5,20,21,23,27] Although outcomes of RTSA may vary based on the underlying indication for surgery, when performed for rotator cuff tear arthropathy, 2 studies have demonstrated reliable long-term survivorship of RTSA ranging from 91% at 5 years[14] to 89% at 10 years.[9] In 2011, RTSA accounted for over one-third of all shoulder arthroplasty procedures in the United States,[17,28] and more recent data have suggested that this number is closer to 50%.[31]

The payment landscape in hip and knee arthroplasty has shifted from a fee for service model to a value-based reimbursement model. Multiple fixed payment models have subsequently been introduced by the Centers for Medicare and Medicaid Services, which have demonstrated satisfactory outcomes in certain arthroplasty settings.[7,13,24,26] An example of this is the Bundled Payments for Care Improvement (BPCI) model. This model reimburses a fixed amount for all services rendered during a predetermined time period of care, for example, 3 days before surgical admission and through 90-day postoperative period.[13] Because of the relative successes of these payment models in the aforementioned settings, their implementation in other common surgical settings such as RTSA seems to be inevitable.[16]

In light of the upcoming implementation of these cost-containment initiatives in RTSA and potential interest of surgeons and institutions in participation, an adequate characterization of the 90-day postoperative course is valuable. Identification of specific modifiable risk factors for complications and subsequent readmissions could offer significant utility and aid in resource utilization and formulation of bundled payments. Although some pertinent data have emerged in recent years, limitations in prior

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study designs offer opportunity for further analyses. We thus used the National Readmission Database (NRD), a relatively new database, which encompasses approximately 60% of all hospital readmissions in the United States in an attempt to offer insight into the incidence of, risk factors for, and reasons for 90-day readmissions in primary RTSA.

Materials and methods

Study population selection

We performed a retrospective database analysis using 2014 data from the NRD, which accounts for approximately 17 million US hospitalizations each year and is intended to extrapolate data to national readmission analyses. Although 2015 data are currently available, International Classification of Diseases, Tenth Revision (ICD-10) codes were implemented toward the third quarter in this year, creating a less generous sample size available for analysis. Consequently, we elected to use 2014 data as they were the most complete and recent dataset. This dataset is constructed using 27 state inpatient databases (SID), which accounts for 57% of all US hospitalizations. Sampling weights are then provided that allow for the analysis of an estimated 36 million discharges in the United States,[25] and all numbers presented in this study are estimations based off sampling weights provided by the Healthcare Cost and Utilization Project (HCUP). Institutional review board exemption was obtained from our institution for this study.

Inclusion and exclusion criteria

Using the ICD-9, Clinical Modification procedure codes,[32] all adult patients (>18 years of age) who underwent primary RTSA were identified. Nonelective admissions were then excluded. Patients were then divided into 2 cohorts based on whether or not they were readmitted within 90 days of the index hospitalization.

Patient and hospital characteristics

Patient characteristics were obtained from the NRD database. These included demographic information (age, sex, and race), diagnoses, and payer type. Hospital characteristics, including bed size and ownership, were evaluated.

Preoperative comorbidities were identified using ICD-9 and diagnosis-related group coding with the use of the HCUP Comorbidity Software. This software package identifies 29 patient comorbidities based off an Elixhauser Comorbidity Index, which was also calculated for each patient. Only commonly occurring comorbidities (occurring in >1% of our sample population) were selected for use in our statistical analysis. Comorbidity burdens were calculated using both the Elixhauser Comorbidity and Charlson Comorbidity Indices.

Patient outcomes and readmission analysis

The clinical classifications software was used to identify the underlying diagnoses for readmissions. The clinical classifications software groups together related ICD-9 codes to facilitate statistical analysis.[15] The most common of these diagnoses were then evaluated.

Unique to the family of HCUP produced datasets, the NRD allows for the analysis of readmissions using patient-specific identifiers. This allows for the longitudinal tracking of patients and their readmissions within the year of interest and across their entire geographic state of residence. However, should the patient be readmitted to another facility in a different state, the readmissions are then lost and ultimately coded as index admissions. Furthermore, these identifiers do not carry over from year to year in the NRD. Consequently, to capture 90-day readmissions, patients admitted during the last quarter of 2014 were excluded and any mortality during the index admission was excluded from the readmission analysis. We then quantified the following metrics: (1) the incidence of 90-day readmissions, (2) the primary diagnoses associated with the readmission, and (3) any procedure performed during the readmission. We performed the same analyses for 30- and 60-day readmissions to allow for comparison.

Length of stay and hospital costs

Hospital length of stay and total hospital costs were evaluated. Hospital costs were calculated using the cost-to-charge ratios provided by HCUP.[6] Costs were then adjusted for inflation using the Consumer Price Index. Aggregate hospital costs were recorded for patients who were readmitted by calculating the sum of the cost of the index hospitalization and the cost of the readmission.

Statistical analysis

The SPSS v24 (IBM Inc., Armonk, NY, USA) statistical software package was used for all analyses. Patient characteristics for both groups were analyzed with the use of $\chi^2$and Student *t* tests. A χ^2 test was used for categorical variables, and an independent Student *t* test was used to assess continuous variables. Multivariate logistic regression analysis was then used for the analysis of associations between patient demographic characteristics and comorbidities and the risk of 90-day readmissions. Only covariates found to have statistically significant associations with 90-day readmissions based on univariate analysis were included in the multivariate analysis. Hospital characteristics were additionally included in the multivariate analysis to further control for confounding. These calculated associations were reported as adjusted odds ratios (ORs) with 95% confidence intervals (CIs). A P value of <.05 was set as our measure of statistical significance.

Results

Patient and hospital characteristics

An estimated 25,196 patients who underwent primary RTSA were identified. There were no significant differences in terms of patient age between readmitted and non-readmitted patients. Readmitted patients had a higher prevalence of diabetes (25% vs. 21%; $P = .036$) and hypertension (80% vs. 71%; $P < .005$). However, comorbidity burdens, as determined by the Charlson Comorbidity Index (CCI) and Elixhauser Comorbidity Measure (ECM), were not statistically different between the readmitted and non-readmitted patients ($P = .494$ and $P = .966$, respectively). Additional patient characteristics and hospital data of the 2 cohorts are presented in Tables I and II.

Rates and predictors of readmission

There was no statistically significant difference in average length of stay for the index admission between the 2 cohorts ($P = .132$; Table I). The 30-, 60-, and 90-day rates of readmissions were 0.6%, 1.2%, and 1.7%, respectively. Diabetes (OR, 1.42; CI, 1.14-1.78), hypertension (OR 1.63; CI, 1.28-2.08), paralysis (OR, 3.61; CI, 1.63-7.97), and solid tumor without metastasis (OR, 2.72; CI, 1.21-6.12) were identified as independent predictors of 90-day readmission. Results of the multivariate logistic regression are shown in Table III.

Table I
Characteristics of patients undergoing readmission at 90 days

Parameter	Non-readmitted patients (N = 24,759)	Readmitted patients (N = 437)	*P* value
Age (yr)	72.3 (SD = 8.65)	73.0 (SD = 9.19)	.084
Female	15,651 (63%)	288 (66%)	
Length of stay (d)	2.3	2.5	.132
Disposition of patient			.063
Routine	14,593 (59%)	284 (65%)	
Transfer to short-term hospital	4037 (16%)	66 (15%)	
Other (SNF, ICF)	6080 (25%)	88 (20%)	
Primary payer			.809
Medicare	19,911 (80%)	357 (82%)	
Medicaid	474 (1.9%)	7 (1.6%)	
Private insurance	3165 (13%)	58 (13%)	
Self-pay/other	48 (0.19%)	0 (0.0%)	
Bed size of hospital			.562
Small	5395 (22%)	86 (20%)	
Medium	6482 (26%)	119 (27%)	
Large	12,883 (52%)	232 (53%)	
Ownership of hospital			.046
Government, nonfederal	2920 (12%)	61 (14%)	
Private, nonprofit	18,361 (74%)	331 (76%)	
Private, investor owned	3478 (14%)	45 (10%)	

SD, standard deviation; *SNF*, skilled nursing facility; *ICF*, intermediate care facility.

Total hospital cost and reasons for readmission

Patients readmitted during the 90-day postoperative period accrued total costs of $77,743 compared with $19,535 for patients who were not readmitted (*P* = .02). The most common reasons for related readmission at 30, 60, and 90 days were device-related complications, with 87%, 80%, and 68% of this cohort affected, respectively, at each time point. The most common device-related complication at each time point was dislocation of the prosthetic joint, with 53% at 30 days, 41% at 60 days, and 32% at 90 days. The second most common device-related complication at each time point was infection, with 15% at 30 days, 14% at 60 days, and 10% at 90 days. Other reasons for patient readmission at each time point can be viewed in Table IV. During the same time points, 96%, 91%, and 95%, respectively, of readmitted patients consequently required revision.

Discussion

The BPCI model reimburses a fixed amount for all services rendered during a predetermined time period of care and has already demonstrated success in the world of hip and knee arthroplasty.[7,8,13,24,26] A 2017 study compared a baseline group of 1427 total joint arthroplasties performed from 2009 to 2012 with a BPCI group of 461 total joint arthroplasties performed between 2013 and 2014. The authors found that the BPCI group had a 14% reduction in cost per episode, decreased length of stay, decreased 90-day readmission rate, and decreased average cost of readmission.[8] Because of the relative success of these payment models in hip and knee arthroplasty settings, and as the number of RTSAs performed annually continues to increase, inclusion of RTSA into bundled payment models seems to be inevitable. In these particular payment models, health care providers and institutions may be held financially liable if costs are in excess of a predetermined payment amount. In particular, hospital readmissions have been identified as a key quality metric and a basis for financial penalty. For example, in 2014, in the second year of the Medicare Hospital Readmissions Reduction Program, 2610 hospitals were fined a total of $428 million for excess all-cause readmissions.[1] On the contrary, providers and hospitals may be rewarded if cost savings occur. These financial responsibilities are enforced regardless of the relationship between the readmission and the index procedure and can extend to include up to the 90-day postoperative period.[4] A more thorough characterization of 90-day readmissions may prove useful in improving resource allocation and policy formation. Our study was the first large national study to present current 90-day readmission metrics in the setting of primary RTSA alone.

In the United States, government insurance is provided for both the elderly (Medicare) and low-income (Medicaid). Other individuals are covered with commercially purchased insurance through either their work or the marketplace. A few individuals simply self-pay. Our study includes all payer types, and we found a 1.7% 90-day readmission rate after primary RTSA. Two large comparative series looked at 90-day readmission rates after both primary total shoulder arthroplasties (TSAs) and RTSAs; these studies did not differentiate

Table II
Factors associated with patient readmissions at 90 days

Factor	Non-readmitted patients (N = 24,759)	Readmitted patients (N = 437)	*P* value
AIDS	9 (0.04%)	0 (0.0%)	1.000
Alcohol	308 (1.2%)	3 (0.7%)	.384
Deficiency anemias	2178 (8.8%)	32 (7.5%)	.307
Rheumatoid arthritis/collagen vascular disease	1719 (7%)	38 (8.6%)	.153
Chronic blood loss anemia	127 (0.5%)	3 (0.7%)	.495
Congestive heart failure	1034 (4.2%)	21 (4.5%)	.479
Chronic pulmonary disease	4869 (20%)	89 (20%)	.720
Coagulopathy	488 (2.0%)	10 (2.3%)	.601
Depression	4048 (16%)	57 (13%)	.070
Diabetes, uncomplicated	5140 (21%)	109 (25%)	.036
Diabetes with chronic complications	650 (2.6%)	11 (2.5%)	1.000
Drug abuse	148 (0.6%)	5 (1.1%)	.197
Hypertension	17,511 (71%)	350 (80%)	<.005
Hypothyroidism	4309 (17%)	71 (16%)	.564
Liver disease	339 (1.4%)	4 (0.9%)	.535
Lymphoma	126 (0.5%)	0 (0.0%)	.286
Fluid/electrolyte disorders	2042 (8.2%)	28 (6.4%)	.191
Metastatic cancer	24 (0.1%)	0 (0.0%)	1.000
Other neurologic disorders	1646 (6.6%)	26 (5.9%)	.621
Obesity	4051 (16%)	65 (15%)	.432
Paralysis	122 (0.5%)	7 (1.6%)	.007
Peripheral vascular disease	943 (3.8%)	14 (3.2%)	.604
Psychoses	669 (2.7%)	12 (2.7%)	.882
Pulmonary circulation disorders	389 (1.6%)	12 (2.7%)	.077
Renal failure	1842 (7.4%)	26 (5.9%)	.271
Solid tumor without metastasis	156 (1.0%)	7 (1.6%)	.024
Peptic ulcer disease	5 (0.02%)	0 (0.0%)	1.000
Valvular disease	1182 (4.8%)	22 (5.0%)	.748
Weight loss	128 (0.5%)	2 (0.5%)	1.000
Diabetes, uncomplicated	5407 (22%)	122 (28%)	.003
Diabetes, complicated	810 (3.2%)	11 (2.5%)	.495
Sleep apnea	2323 (9.4%)	40 (9.2%)	.926
Multiple sclerosis	84 (0.3%)	0 (0.0%)	.408
Tobacco use disorder	1741 (7.0%)	21 (4.8%)	.077
Charlson Comorbidity Index	0.84 (SD = 1.16)	0.88 (SD = 1.07)	.494
Elixhauser Comorbidity Index	0.49 (SD = 5.85)	0.50 (SD = 5.80)	.966

SD, standard deviation.

Table III
Independent predictors of 90-day readmissions

Factor	90-days	
	Odds ratio	*P* value
Diabetes, uncomplicated	1.42 (1.14-1.78)	.002
Hypertension	1.63 (1.28-2.08)	<.001
Paralysis	3.61 (1.63-7.97)	.002
Solid tumor without metastasis	2.72 (1.21-6.12)	.015

Table IV
Reasons for patient readmissions at 30/60/90 days

	30-day (N = 142) (%)	60-day (N = 292) (%)	90-day (N = 437) (%)
Complications of device	123 (87)	236 (80)	296 (68)
Dislocation of prosthetic joint	76 (53)	121 (41)	142 (32)
Infection or inflammatory reaction	21 (15)	41 (14)	45 (10)
Periprosthetic joint fracture	2 (1.4)	8 (2.6)	10 (2.2)
Acute posthemorrhagic anemia	39 (28)	66 (23)	83 (19)
Deep venous thrombosis	7 (5.0)	14 (4.8)	27 (6.1)
Acute renal failure	2 (1.4)	9 (3.1)	11 (2.5)
Urinary tract infection	7 (4.7)	10 (3.5)	17 (3.8)
Septicemia	0 (0.0)	0 (0.0)	4 (0.9)
Pulmonary embolism	0 (0.0)	0 (0.0)	2 (0.4)
Pneumonia	3 (2.0)	3 (1.0)	3 (0.7)

between the 2 procedures, as a specific ICD-9 code for RTSA was not implemented until 2011. The first study,[29] published in 2014, used 7 SID and found a 90-day readmission rate of 6.0%, whereas the second study,[2] using Medicare data, reported a 90-day readmission rate of 2.9%. In 2014, Mahoney et al[22] published a retrospective review study using hospital records from 2 institutional hospitals from 2005 to 2011 looking at readmission rates at 30, 60, and 90 days after shoulder arthroplasty procedures, which included hemiarthroplasty, TSA, and RTSA. After RTSA, the authors identified a 4.4% (8/180) 30-day readmission rate and a 2.2% (4/12) 60-day readmission rate; no patients were readmitted between 60- and 90-day period after RTSA. The higher rates published in these studies may be due to 2 reasons. First, our study looked at a single procedure rather than multiple types of arthroplasty procedures. Second, our study used a much larger database (NRD) and was therefore less likely to be swayed by a single surgeon or a single institution; Mahoney et al[22] evaluated 180 RTSAs, a substantially smaller number, potentially increasing error in their results.

Risk factors for readmission after RTSA have been described both in terms of comorbidity indices as well as individual risk factors. In our study, the CCI and the ECM were not statistically different between the readmitted and non-readmitted patients. Kim et al[18] compared the accuracy of the CCI and ECM for predicting adverse events and postoperative discharge destination after shoulder arthroplasty (TSA and RTSA). They used the National Inpatient Sample between 2002 and 2014 and found that a predictive model using the ECM, in combination with basic demographic variables, outperforms models using the CCI for predicting adverse events and discharge disposition. The authors go on to state that this finding may be used to anticipate resource utilization after shoulder arthroplasty. Although our study did not find differences between the readmitted and non-readmitted patients in terms of these comorbidity measurement tools, these predictive tools may well be found useful to identify high-risk patients as bundled payments become more widely adopted.[19]

In our study, readmitted patients had a higher prevalence of diabetes and hypertension, which were both found to independently predict 90-day readmission. There are currently no studies, to our knowledge, that identify risk factors in a solely RTSA patient population. Schairer et al[29] identified male sex, Medicare payer status, and transfer to a skilled nursing facility to be associated with the increased risk of readmission at 90 days, whereas Basques et al[2] found chronic obstructive pulmonary disease and age greater than 85 years to be associated with the increased risk of 30-day readmission. Both of these studies included TSA and RTSA and did not differentiate between the 2 procedures. A third study[33] looked at hospital readmissions after proximal humerus fractures treated by open reduction internal fixation, hemiarthroplasty, or RTSA using the SID from 7 states (the same database as Schairer et al[29]). The authors found a 15% 90-day readmission rate for RTSA; 80% of the RTSA readmissions were associated with medical complications (leading causes: deep vein thrombosis/pulmonary embolism and congestive heart failure) and 20% were associated with surgical complications. As compared with our study, the above studies include more than 1 surgical procedure and have a much smaller sample size, which may account for the discrepancies noted in readmission rates. This study is the first we are aware of to use a national database to examine risk factors for 90-day readmissions after primary RTSA.

In this study, device-related complications were the most common reason for related readmission after RTSA, with 87% at 30 days, 80% at 60 days, and 68% at 90 days. Furthermore, dislocation was found to be the most prevalent device-related complication, and during the same time points, 96%, 91%, and 95%, respectively, of readmitted patients consequently required some type of revision arthroplasty. As noted above, Zhang et al[33] found 20% of RTSA 90-day readmissions to be associated with surgical complications, 9.6% of which were due to dislocation. However, these data should be interpreted with caution as the population consisted of patients with proximal humerus fractures. Finally, medical diagnoses (eg, diabetes, hypertension) were identified as independent predictors of 90-day readmission, which emphasizes the value of preoperative medical clearance and even hospitalist comanagement; identifying these diseases preoperatively is of utmost importance.

There are several notable limitations to our study. Our NRD analysis was limited to the 90-day postoperative period and did not capture any complications of primary RTSAs presenting beyond this timeframe. Furthermore, the interpretation of the NRD requires the use of ICD-9 coding, which has been shown in some studies to lack in sensitivity and specificity.[11,12] The assessment of intraoperative factors (blood loss, surgical time, and surgeon) or accurate evaluation of preoperative factors such as laboratory values was not possible. The NRD is uniquely structured in that it does not allow for combining yearly datasets for the analysis of larger aggregate samples, and as a result, we limited our data analysis to a more recent year. In addition, tracking of patients across geographic states is not possible in the NRD; consequently, some patients may have been lost in the readmission analysis. Finally, concerning procedures performed on readmission, as ICD-9 procedure codes for revision arthroplasty are relatively nonspecific (revision of joint replacement of upper extremity, reverse total shoulder replacement, and other total shoulder replacement), it is difficult to decipher exactly what procedure was performed. We can only assume that the majority of these were indeed revision RTSAs. Nonetheless, this is the largest study to date to identify rates of revision in patients undergoing RTSA.

Intrinsic to the study design, the findings within this study are associations only and do not prove causality. Nevertheless, the use of the large NRD dataset is also a major strength of this study, as it allowed for the analysis of rare outcomes such as 90-day readmission in the relatively benign surgical setting of primary RTSA.

Conclusions

Although the incidence of 90-day readmission after primary RTSA appears low, these readmissions may be associated with significant patient morbidity and high reoperation rates. This ultimately translates into substantial increases in associated hospital costs. Knowledge of both the factors that increase the likelihood of 90-day readmissions and the reasons for readmission will hopefully aid in the understanding of readmission data and will help predict resource utilization, expenses, and aid in the formulation of bundled payments for patients undergoing RTSA.

Disclaimer

Steven J. Hattrup reports that he is a consultant for Zimmer-Biomet. The other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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