Original Article

Alcohol Abuse, Morbid Obesity, Depression, Congestive Heart Failure, and Chronic Pulmonary Disease are Risk Factors for 90-Day Readmission After Arthroscopic Rotator Cuff Repair

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Purpose: The purpose of this study was to report the rate and causes of 90-day readmissions after arthroscopic rotator cuff repair. **Methods:** A retrospective query from January 2005 to March 2014 was performed using a nationwide administrative claims registry. Patients and complications were identified using International Classification of Disease, Ninth Revision (ICD-9) and Current Procedural Terminology (CPT) codes. Patients who underwent arthroscopic rotator cuff repair (RCR) and were readmitted within 90 days after their index procedure were identified. Patients not readmitted represented controls. Patients readmitted were stratified into separate cohorts depending on the primary cause of readmission, which included cardiac, endocrine, hematological, infectious, gastrointestinal, musculoskeletal (MSK), neoplastic, neurological or psychiatric, pulmonary, and renal. Risk factors assessed were comorbidities comprising the Elixhauser-Comorbidity Index (ECI). Primary outcomes analyzed and compared included cause for readmission, patient demographics, risk factors, in-hospital length of stay (LOS), and costs. Pearson's chi-square was used to compare patient demographics, and multivariate binomial logistic regression was used to calculate odds ratios (OR) on patient-related risk factors for 90-day readmissions. **Results:** 10,425 readmitted patients and 301,625 control patients were identified, representing a 90-day readmission rate of 3.5%. The causes of readmissions were primarily related to infectious diseases (15%), MSK (15%), and cardiac (14%) complications. The most common MSK readmissions were osteoarthrosis of the leg or shoulder (24.8%) and spinal spondylosis (8.4%). Multivariate binomial logistic regression analyses demonstrated patients with alcohol abuse (OR, 1.42; $P < .0001$), morbid obesity (OR, 1.38; $P < .0001$), depression (OR, 1.35; $P < .0001$), congestive heart failure (OR, 1.34; $P < 0.0001$), and chronic pulmonary disease (OR, 1.28; $P < .0001$) were at the greatest risk of readmissions after RCR. **Conclusions:** Significant differences exist among patients readmitted, and those patients who do not require hospital readmission within 90 days following arthroscopic rotator cuff repairs. Readmissions are associated with significant patient comorbidities and were primarily related to medically based complications. **Level of Evidence:** Level III, prognostic, retrospective cohort study.

Introduction

With improvements in technology and broader indications for shoulder arthroscopy, the use of arthroscopy for rotator cuff repair has continued to steadily increase over the past decade and a half.[1-3]

This trend is anticipated to continue as the proportion of rotator cuff repairs done arthroscopically among orthopedic surgeons taking Part II of the American Board of Orthopaedic Surgery (ABOS) certification examination was recently reported to be 90%.[4]

Additionally, the rise in health care costs and passage of the Affordable Care Act has led to cost containment and quality-improvement initiatives to be implemented by the Centers of Medicare & Medicaid Services (CMS).[5] This has empowered private insurers to do so as well[6] and led to the exploration of alternative reimbursement models such as bundled-payment systems, which incentivize hospitals to be cost-efficient. Two specific areas that have been identified to decrease costs are reducing postoperative readmissions and length of hospital stay.[7] With rotator cuff repairs making up the largest proportion of all arthroscopic cases,[8] it is imperative for surgeons to understand the risk factors that may lead to readmission following this procedure.

Several studies have reported complication and readmission rates after shoulder arthroscopy to be approximately 0.86-1%.[8-11] A single study that specifically examined arthroscopic rotator cuff repairs reported a complication rate of 0.70%.[12] However, all these studies used the National Surgical Quality Improvement Program (NSQIP) database, which does not contain complications that occur beyond 30 days and cases performed at independent surgery centers, an increasing source of rotator cuff repair cases. In addition, reasons for readmission were notably lacking from the NSQIP database and listed as a potential limitation in these studies.[8,9,13]

Therefore, despite favorable outcomes following arthroscopic rotator cuff repair (RCR), an adequate characterization of 90-day readmissions following the procedure has not been well documented. The purpose of this study was to report the rate and causes of 90-day readmissions after arthroscopic rotator cuff repair. Our hypothesis was that 90-day readmission rates would be greater than previously reported 30-day readmissions rates, and patients with greater comorbidities were more likely to be readmitted following arthroscopic rotator cuff repair.

Methods

All work was performed at the Holy Cross Hospital and Holy Cross Orthopedic Institute. A retrospective query from January 1, 2005, to March 31, 2014, was performed using a nationwide administrative claims registry comprising a Medicare population (PearlDiver, Pearl-Diver Technologies, Fort Wayne, IN). Patients undergoing arthroscopic rotator cuff repair and any postoperative complications were identified using Current Procedural Terminology (CPT) codes and International Classification of Disease, Ninth Revision (ICD-9). Patients readmitted within 90 days after the index procedure were identified and served as the study cohort. Patients not readmitted within 90 days represented controls. Outcomes analyzed were reason for readmission, patient demographics, risk factors for readmission, in-hospital LOS after readmission, and readmission costs (sum of all costs, i.e., patient charges,

hospital costs and insurance claims). Patients readmitted were stratified into 10 separate subgroups depending on the primary cause of readmission: cardiac, endocrine, hematological, infectious, gastrointestinal, musculoskeletal (MSK), neoplastic, neurological or psychiatric, pulmonary, and renal causes.

Pearson's chi-square was used to compare patient demographics, and multivariate binomial logistic regression was used to calculate odds ratios (OR) on patient-related risk factors for 90-day readmissions. Risk factors assessed were those comorbidities, which comprise the Elixhauser-Comorbidity Index (ECI), which has been shown to be superior to the Charlson-Comorbidity Index (CCI) for observational studies (Table 1).[14] A P value less than .05 was considered statistically significant. The study received IRB Category 4 exemption.

Results

A total of 10,425 readmitted patients and 301,625 control patients were identified, representing a 90-day readmission rate of 3.5%. There was a statistically significant difference between the cohorts in age ($P < .0001$) and comorbidity burden, as measured by the mean ECI scores (9 vs. 5, $P < .0001$). Gender distribution between the two cohorts was equal ($P = .63$) (Table 1). The most common reasons for readmission were related to infection (15%), musculoskeletal (MSK) (15%), and cardiac (14%) complications. Complete readmission rates for each subgroup are displayed in Fig 1.

The most common MSK readmissions were osteoarthrosis of the leg or shoulder (24.8%) and spinal spondylosis (8.4%). Rotator cuff sprain and retearing of the repaired rotator cuff represented 5.2% and 2.0% of total MSK readmissions, respectively. When individual diagnoses were examined, the most common reasons for readmission overall were pneumonia (3.85%), pulmonary embolism (3.24%), coronary arthrosclerosis (2.94%), and postoperative infection (2.91%) (Table 2).

Multivariate binomial logistic regression analyses demonstrated patients with alcohol abuse (OR, 1.42; $P < .0001$), morbid obesity (OR, 1.38; $P < .0001$), depression (OR, 1.35; $P < 0.0001$), congestive heart failure (OR, 1.34; $P < .0001$), and/or chronic pulmonary disease (OR, 1.28; $P < .0001$) listed as comorbidities were at the greatest risk of readmissions after RCR. Age greater than 85 years (OR, 1.36; $P < .001$) and male gender (OR, 1.17; $P < .001$) were also risk factors for readmission. Complete list of patient-related factors associated with 90-day readmissions is shown in Table 3.

Readmissions that resulted in the longest in-hospital lengths-of-stay included neoplastic (5.6 days), neurologic/psychiatric (4.8 days) and infectious (4.7 days) related complications (Fig 2). Readmissions associated with the highest mean episode of care costs were neoplastic ($13,602), MSK ($10,903), and cardiac ($10,436) (Fig 3). While cardiac and MSK-related

Table 1. Comparison of Demographics of Readmitted Patients to Controls After Arthroscopic Rotator Cuff Repair Within the Medicare Population

Demographics	Readmitted (N = 10,425)		Controls (N = 301,625)		P Value
	n	%	n	%	
Age (Years)					<.0001[a]
<64	2,560	24.56	54,382	18.03	
65-69	2,719	26.08	108,465	35.96	
70-74	2,340	22.45	75,969	25.19	
75-79	1,733	16.62	43,252	14.34	
80-84	828	7.94	15,900	5.27	
85+	245	2.35	3,657	1.21	
Sex					.624 [a]
Female	5,247	50.33	152,561	50.58	
Male	5,178	49.67	149,064	49.42	
Region					**<.0001** [a]
Midwest	2,632	25.25	71,931	23.85	
Northeast	1,633	15.66	49,899	16.54	
South	4,771	45.76	133,890	44.39	
West	1,382	13.26	45,905	15.22	
Comorbidities					
Alcohol abuse	1,026	9.84	12,902	4.28	**<.0001** [a]
Blood loss anemia	878	8.42	10,627	3.52	**<.0001** [a]
Cardiac arrhythmias	4,842	46.45	86,886	28.81	**<.0001** [a]
Chronic pulmonary disease	5,960	57.17	112,854	37.42	**<.0001** [a]
Coagulopathy	1,982	19.01	28,191	9.35	**<.0001** [a]
Congestive heart failure	3,582	34.36	45,002	14.92	**<.0001** [a]
Deficiency anemia	5,769	55.34	100,633	33.36	**<.0001** [a]
Depression	4,741	45.48	82,209	27.26	**<.0001** [a]
Diabetes mellitus (complicated)	2,017	19.35	28,207	9.35	**<.0001** [a]
Diabetes mellitus (uncomplicated)	5,122	49.13	110,648	36.68	**<.0001** [a]
HIV	61	0.59	733	0.24	**<.0001** [a]
Hypertension	9,627	92.35	248,970	82.54	**<.0001** [a]
Hypothyroidism	3,506	33.63	82,810	27.45	**<.0001** [a]
Liver disease	1,496	14.35	23,843	7.90	**<.0001** [a]
Lymphoma	358	3.43	6,172	2.05	**<.0001** [a]
Metastatic cancer	594	5.70	10,668	3.54	**<.0001** [a]
Neurodegenerative disorders	1,924	18.46	28,306	9.38	**<.0001** [a]
Obesity (BMI, 30-39.9)	1,541	14.78	22,643	7.51	**<.0001** [a]
Morbid obesity (BMI, ≥40)	867	8.32	10,672	3.53	**<.0001** [a]
Paralysis	617	5.92	7,523	2.49	**<.0001** [a]
Peptic ulcer disease excluding bleeding	1,579	15.15	24,322	8.06	**<.0001** [a]
Peripheral vascular disease	3,883	37.25	69,040	22.89	**<.0001** [a]
Pulmonary circulation disorders	1,335	12.81	15,996	5.30	**<.0001** [a]
Renal failure	853	8.18	10,371	3.44	**<.0001** [a]
Rheumatoid arthritis	1,952	18.72	40,609	13.46	**<.0001** [a]
Valvular disease	3,036	29.12	57,763	19.15	**<.0001** [a]
Weight loss	1,183	11.35	11,735	3.89	**<.0001** [a]
ECI ± SD	9 ± 4		5 ± 4		**<.0001** [b]

BMI, body mass index; ECI, Elixhauser-Comorbidity Index; HIV, human immunodeficiency virus; RCR, rotator cuff repair; SD, standard deviation. Bolded values indicate significant difference.

[a]Assessed by Pearson's chi-square analyses.

[b]Assessed by independent samples t-tests.

readmissions represented the greatest mean costs per day ($3,097 and $3,088; Fig 4).

Discussion

Arthroscopic RCR is one of the most frequently performed orthopaedic procedures, routinely performed for the treatment of rotator cuff tears refractory to nonsurgical options.[2,15,16] Despite such high utilization, limited studies have described patient characteristics and risk factors related to 90-day readmissions among patient undergoing arthroscopy.[17] Our study found the readmission rate following arthroscopic RCR to be ~3.5%, which is consistent to our hypothesis. The three predominant causes for readmission were related to infectious diseases (15%), MSK (15%), and cardiac (14%). When looking at specific diagnoses, the leading causes of readmission were pneumonia (3.85%), pulmonary embolism (3.24%), coronary atherosclerosis
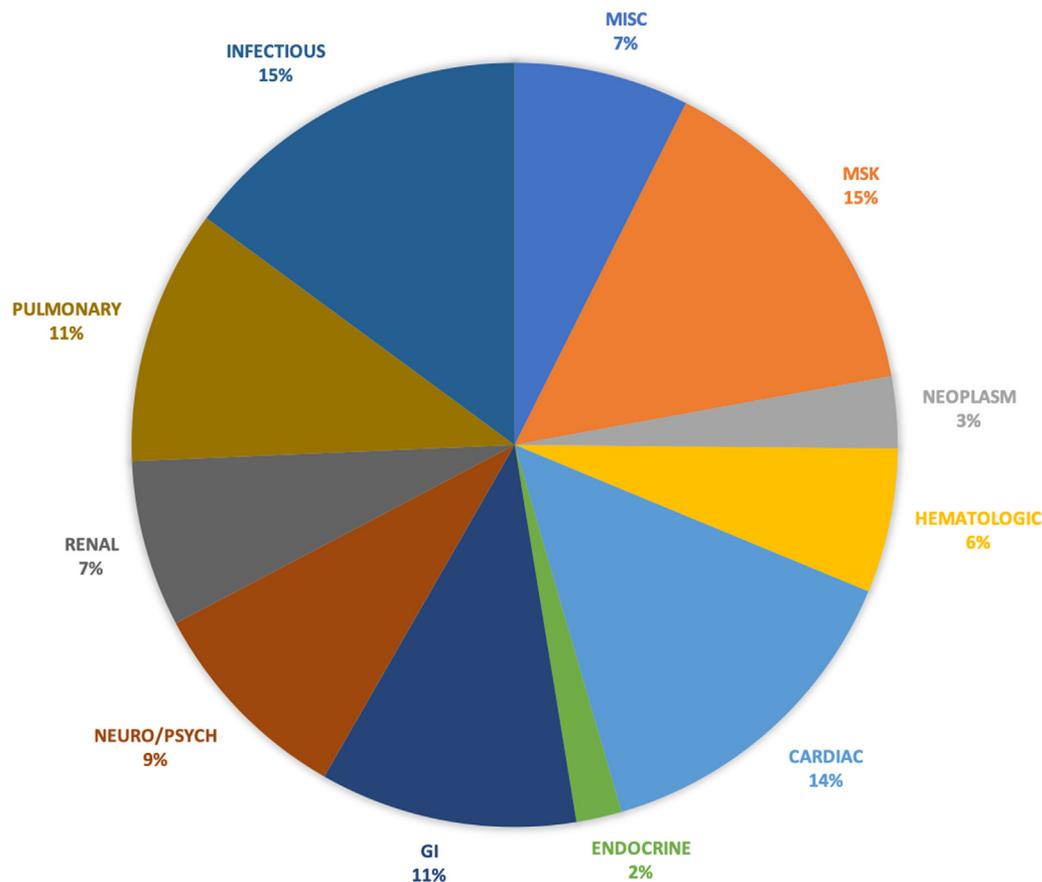
Fig 1. Readmission causes after arthroscopic rotator cuff repair.

(2.94%), and postoperative infection (2.91%). Multivariate analysis revealed primary risk factors for readmissions to be alcohol abuse, morbid obesity, depression, congestive heart failure, and chronic pulmonary disease. Arthroscopic RCR is one of the most frequently performed orthopaedic procedures, routinely performed for the treatment of rotator cuff tears refractory to nonsurgical options.[2,15,16] Despite such high utilization, limited studies have described patient characteristics and risk factors related to 90-day readmissions among patients undergoing arthroscopic.[17]

Previous literature consistently demonstrates several common medical comorbidities and substance abuse problems amongst patients who suffer from rotator cuff injuries. These include alcohol use, diabetes mellitus, hyperlipidemia, hypertension, concomitant musculoskeletal disease, obesity, and tobacco use.[18-24] In a case control study of 5,000 patients, Titchener et al. described increased BMI, lateral epicondylitis, carpal tunnel syndrome, trigger finger, Achilles tendinitis, oral corticosteroid use, and diabetes mellitus as comorbidities significantly associated with rotator cuff injuries.[18] Another study demonstrated long-term alcohol use to be a significant risk factor in the development of rotator

cuff tears.[20] Our study supports the findings of these studies and further details that readmission following arthroscopic RCR is associated with increased number of preexisting comorbidities. Moreover, surgeons should be aware that the proper screening of prevalent comorbidities (alcohol abuse, morbid obesity, and depression) are vital for patient outcome optimization.

The cause of readmission following arthroscopic RCR has been addressed in several studies.[8,25] Day et al. found a 30-day complication rate of 1.17% following arthroscopic RCR, with a greater incidence of medical complications compared to surgical (0.67% vs. 0.27%).[26] In a retrospective study of 15,015 patients undergoing arthroscopic shoulder procedures, of which 43% were rotator cuff repairs, Hill et al. observed the most common reasons for 30-day readmission were pulmonary embolism (PE), exacerbation of respiratory disease or respiratory failure, venous thromboembolism (VTE), postoperative pain, pneumonia, and wound complications. Using multivariate analysis, the authors demonstrated chronic obstructive pulmonary disease (COPD) as a predominant risk factor for 30-day readmission, consistent with our findings.[8] Similarly, Kosinski et al. found the most common complications associated with 30-day readmissions after outpatient

Table 2. Multivariable Regression: Patient Related Factors Associated with 90-Day Readmissions Following Arthroscopic Rotator Cuff Repair

Variables	Odds Ratio	95% CI	P Value[a]
Age (Years)			
75-79	0.99	0.92−1.06	.686
80−84	1.14	1.04−1.25	**.003**
>85	1.36	1.17−1.57	**<.001**
Sex			
Male	1.17	1.13−1.23	**<.001**
Risk Factors			
Alcohol abuse	1.42	1.32−1.52	**<.001**
Morbid obesity (BMI, ≥40)	1.38	1.27−1.49	**<.001**
Depression	1.35	1.30−1.42	**<.001**
Obesity (BMI, 30-39.9)	1.35	1.27−1.43	**<.001**
Congestive heart failure	1.34	1.27−1.41	**<.001**
Chronic pulmonary disease	1.28	1.22−1.33	**<.001**
Deficiency anemia	1.26	1.20−1.32	**<.001**
Paralysis	1.23	1.13−1.34	**<.001**
Weight loss	1.22	1.13−1.31	**<.001**
Neurodegenerative disorders	1.21	1.15−1.28	**<.001**
Cardiac arrhythmias	1.20	1.14−1.25	**<.001**
Blood loss anemia	1.19	1.10−1.29	**<.001**
Peptic ulcer disease excluding bleeding	1.18	1.11−1.25	**<.001**
Liver disease	1.17	1.10−1.24	**<.001**
Pulmonary circulation disorders	1.17	1.10−1.26	**<.001**
Diabetes mellitus (complicated)	1.16	1.10−1.24	**<.001**
Coagulopathy	1.15	1.09−1.21	**<.001**
Lymphoma	1.10	0.98−1.23	.105
Peripheral vascular disease	1.10	1.05−1.15	**<.001**
Hypertension	1.05	0.44−2.08	.904
Metastatic cancer	1.04	0.95−1.13	.391
Renal failure	1.02	0.94−1.10	.641
Rheumatoid arthritis	0.98	0.93−1.03	.496
Hypothyroidism	0.96	0.91−1.00	.051
Diabetes mellitus (uncomplicated)	0.95	0.72−1.28	.743
Valvular disease	0.95	0.90−1.00	.052

95% CI, 95% confidence interval; BMI, body mass index. Bolded values signify statistical significance.

[a]Assessed by Pearson's chi-square analyses.

Table 3. Common Reasons for Readmissions within 90 Days After Arthroscopic Rotator Cuff Repair

Cause of Readmission	%
Pneumonia	3.85
Pulmonary embolism	3.24
Coronary atherosclerosis	2.94
Postoperative infection	2.91
Chest pain	2.51
Atrial fibrillation	2.27
Obstructive chronic bronchitis	1.88
Acute kidney failure	1.80
Subendocardial infraction	1.67
Osteoarthrosis	1.40

RCR were of cardiovascular, infectious, and respiratory origin.[13] The causes of 90-day readmissions in our study are similar with what is reported in the literature, suggesting the majority of complications following arthroscopic RCR are due to medical complications, rather than associated with the reinjury or retear of the rotator cuff. However, these complications are likely associated with the index procedure itself, as surgical procedures carry inherent risk of infection and thromboembolic events.[27-29] The common postoperative infections encountered following surgical procedures include pneumonia and surgical site infections (SSI).[11,29] In a study of 7,457 patients undergoing various noncardiac surgical procedures, Kahn at al. found pneumonia to be the most common postoperative complication with an incidence of 3.0%.[29] Additionally, SSI's are a predominant cause of postoperative infections in surgical patients and account for 15% of total nosocomial infections.[30] Additionally, occurrence of venous thromboembolism in elective shoulder surgery arthroscopy vary, with reported rates ranging from 0.15% to 5.7%.[31,32] Overall, our findings appear to be consistent with previous literature regarding complications following arthroscopic RCR. Thus, surgeons should be aware that postoperative monitoring for an infection and thrombotic events is paramount to decreasing hospitalization.

Rates of rotator cuff retear after RCR vary greatly and are thought to be relatively high, with greatest occurrence within 6 months postoperatively.[33-39] Evidence supports a steadily increasing risk of retear in medium-to-large rotator cuff tears 10−15 months following arthroscopic RCR, after which retear rates appear to plateau at 20%.[40] Causes of rotator cuff retear after RCR are likely multifactorial. Studies have postulated causes of retear are affected by patient age, comorbidities, size of rotator cuff tears, and degree of fatty infiltration within the tear.[41-46] Varied reporting of retear rates are likely due to the aforementioned factors in addition to inconsistent time periods analyzed following the index procedure. Most studies of this nature analyze postoperative periods greater than 90 days.[40] However, Tanaka et al. reported retear rates of 2.9% in medium-sized rotator cuff tears 90 days following arthroscopic RCR.[47] Though scarce, existing literature supports our findings of retears being responsible for 2.0% of musculoskeletal related readmission 90 days following arthroscopic RCR.[47]

Literature regarding costs associated with readmission-related complications following arthroscopic RCR is lacking. However, data analyzing readmission costs attributed to complications found in our study, including cardiac, musculoskeletal, and neoplastic, are available.[48-53] Among the most common reasons for readmission in our study, musculoskeletal
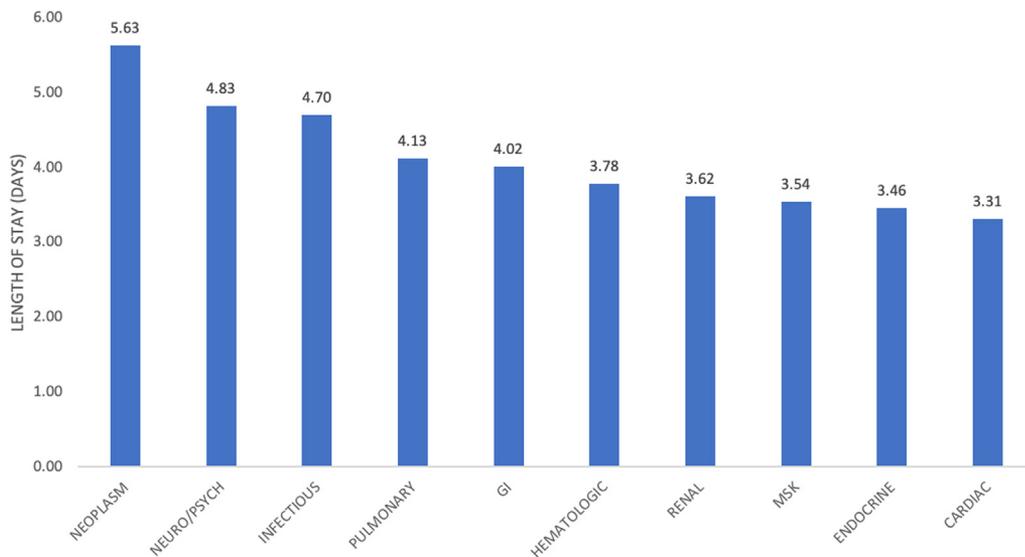
Fig 2. Mean length of stay in hospital based on readmissions causes.

complications' economic burden is commonly documented.[54-58] Further subgroup analysis revealed osteoarthritis (OA) of the knee and ankylosing spondylitis to be the most prevalent musculoskeletal causes of readmission. Not as predominant, although of great interest to orthopaedic surgeons, our study found infectious disease was the cause of significant costs following readmission, consistent with existing literature on the topic.[59,60] In a retrospective study of 4,571 patients, Perencevich et al. found patients who were diagnosed with surgical site infections (SSI) over an 8-week period, incurred nearly 3 times the costs than the control cohort.[59] Furthermore, the economic burden associated with complications of neoplastic origin have been documented in the literature.[51-53,61,62] Our study found cardiac, musculoskeletal, and neoplastic causes of readmission were associated with

the highest costs on a per day basis, respectively. Furthermore, neoplastic, MSK, and cardiac complications were responsible for the greatest total per episode costs following readmission, respectively.

The information in this study can help orthopaedic surgeons properly screen preoperative patients, as well as help optimize the care of patients that are considered higher risk for rehospitalizations. In the future, large cohort studies and multicenter studies are needed to identify the specific micro-organisms causing infection, as well to identify the proper postoperative protocols for decreasing thromboembolic events in order to decrease rehospitalizations following arthroscopic RCR.

Limitations

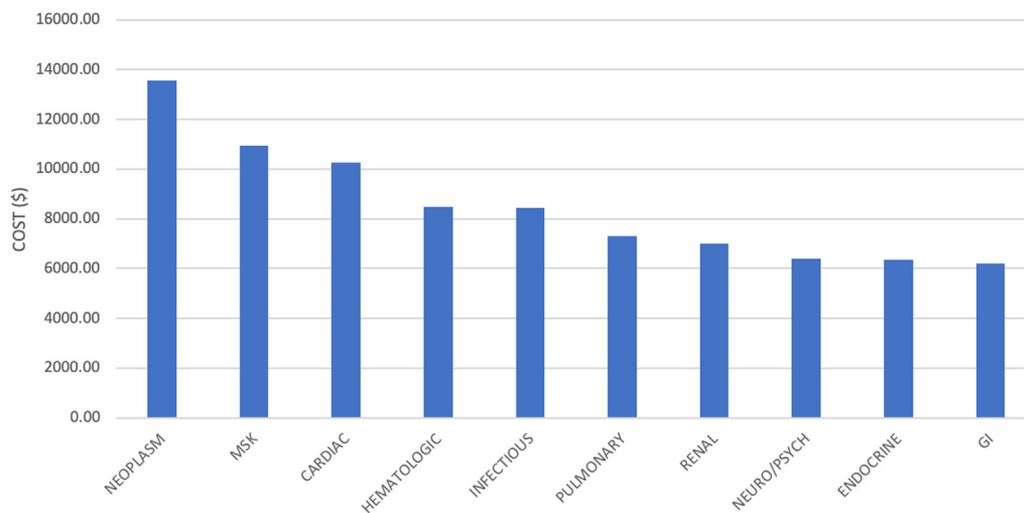This study is not without limitations. Because of the nature of the database, only Medicare patients from

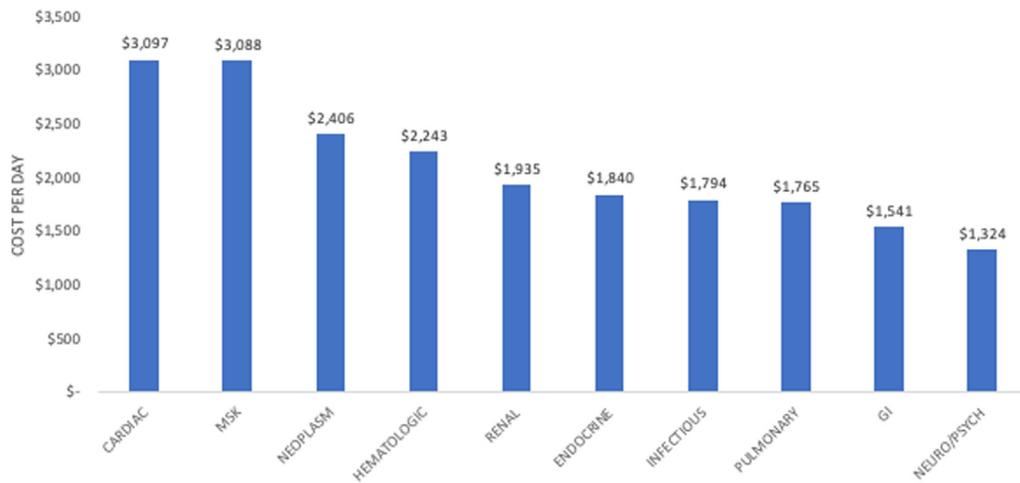**Fig 3.** Mean episode of care costs on causes of readmission.

Fig 4. Mean episode of care cost per day based on causes of readmission.

2005 to 2014 could be queried, which can contribute to a selection bias. Moreover, the data from these Medicare patients are associated with increased comorbidities, specifically in the <65-year-old population. The data may also not necessarily correlate with the commercial population or with the recent advances in arthroscopic surgery; however, the findings may still be generalizable and impact patient care. It was also not possible to analyze the timing of the causes for readmission between what the current literature reports at 30 days and our time point of 90 days. Additionally, the study relies on accurate reporting of ICD-9 codes, which have an error rate of ∼1%.[63,64] Because of the nature of the ICD-9 code-based criteria, it is not possible to determine the severity of the medical conditions, frequency of substance abuse, or interventional treatment patients may be undergoing for certain comorbidities. Furthermore, the results demonstrate statistical significance among several variables and 90-day readmission risk; this does not necessarily correlate with clinical significance.

Conclusion

Significant differences exist among patients readmitted and those patients who do not require hospital readmission within 90 days following arthroscopic rotator cuff repairs. Readmissions are associated with significant patient comorbidities and were primarily related to medically based complications.

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