Published in final edited form as:
Semin Arthritis Rheum. 2012 April ; 41(5): 689–697. doi:10.1016/j.semarthrit.2011.09.003.

Cardiopulmonary Complications after Primary Shoulder Arthroplasty: A Cohort study

Jasvinder A. Singh, MBBS, MPH[1,2,3], **John Sperling, MD**[3], and **Robert Cofield, MD**[3]

[1]Medicine Service and Center for Surgical Medical Acute care Research and Transitions (C-SMART), VA Medical Center, Birmingham, AL

[2]Department of Medicine and Division of Epidemiology, University of Alabama, Birmingham, AL

[3]Departments of Orthopedic Surgery, Mayo Clinic College of Medicine, Rochester, MN

Abstract

Objective—Study the frequency and predictors of 90-day cardiopulmonary complications following primary shoulder arthroplasty

Methods—We used prospectively collected data from the Mayo Clinic Total Joint registry from 1976–2008. We used univariate and multivariable-adjusted Cox regression analyses to examine the association of age, gender, body mass index (BMI), comorbidity assessed by Deyo-Charlson index, American Society of Anesthesiologist (ASA) class, implant fixation (cemented versus not) and underlying diagnosis with the risk of 90-day cardiopulmonary complications after primary shoulder arthroplasty. Odds ratio (OR) with 95% confidence interval (CI) and p-values are presented.

Results—3,480 patients underwent 4,019 primary shoulder arthroplasties. 90-day cardiac and thromboembolic complication rates following primary shoulder arthroplasty were 2.6% (92/3480) and 1.2% (42/3480). After multivariable-adjustment, age >70 years (OR, 2.7; 95% CI: 1.2–5.9; p-value= 0.01; relative to age <60), Deyo-Charlson comorbidity index of 1 or more (OR, 3.27; 95% CI:1.9–5.6; p<0.0001; relative to index of 0) and prior cardiac events (OR, 7.87; 95% CI: 4.89–12.68; p<0.0001; relative to no prior event) were associated with higher odds of 90-day cardiac complications. Due to few thromboembolic events, only univariate analyses were performed. Univariately, female gender, age >70 years, BMI 25–29.9 kg/m^2, Deyo Charlson index of 1 or more, underlying diagnosis of trauma, prior thromboembolic event and surgery type were each associated with significantly higher risk of 90-day thromboembolic event (p≤0.03 for all).

Conclusions—Cardiac and thromboembolic complications are uncommon after primary shoulder arthroplasty. Patients can be informed of their risk of cardiac complications following shoulder arthroplasty based on presence of risk factors.

Correspondence: Jasvinder A. Singh, MBBS, MPH, University of Alabama, Faculty Office Tower 805B, 510 20th Street S, Birmingham, AL 35294. Phone: 205-934-8158, Jasvinder.md@gmail.com.

Financial Conflict: There are no financial conflicts related directly to this study. J.A.S. has received speaker honoraria from Abbott; research and travel grants from Takeda, Savient, Wyeth and Amgen; and consultant fees from URL pharmaceuticals, Novartis, Takeda and Savient. J.S. has received royalties from Aircast and Biomet, consultant fees from Tornier and owns stock in Tornier. R.C. has received royalties from Smith and Nephew.

IRB approval: This study was approved by the Mayo Clinic Institutional Review Board and all investigations were conducted in conformity with ethical principles of research.

Keywords

Complications; shoulder arthroplasty; predictors; Cardiopulmonary; humeral head replacement

Shoulder arthroplasty is a common surgery performed for the treatment of shoulder disorders refractory to medical management. Total Shoulder Arthroplasty (TSA) and Humeral Head Replacement (HHR) are the two commonest surgical procedures performed for the treatment of shoulder pain. Significant improvements in pain, function and quality of life are reported by patients who undergo these procedures (1, 2). Since most shoulder arthroplasties are elective, it is important to estimate how commonly serious postoperative complications such as cardiac and thromboembolic complications occur and what factors are associated with them. Cardiac and thromboembolic complications are associated with significantly higher morbidity and mortality in arthroplasty patients (3)(4, 5). A better understanding of these potentially fatal complications after shoulder arthroplasty will allow both surgeons and patients to make better informed decisions regarding this elective procedure.

While these complications are well-recognized and well-studied in patients with knee and hip arthroplasty, only one study of adequate sample size has been published in patients undergoing shoulder arthroplasty (6). This study estimated the prevalence of pulmonary embolism at 0.2% of all primary shoulder arthroplasties between the day of surgery and postoperative day 7 between 1981 and 2001 (6). The small number of events prevented assessment of predictors of venous thromboembolism. To our knowledge, there are no published studies of correlates of cardiac and thromboembolic events following shoulder arthroplasty.

Our objectives were to assess the frequency of 90-day cardiac and thromboembolic complications after shoulder arthroplasty to update the findings from 10-years ago and to study their risk factors in a cohort of patients who underwent primary shoulder arthroplasty (TSA or HHR) at our institution.

Methods

Source population

We used the data from the Mayo Clinic Total Joint Registry from 1976 to 2008. This is a prospective joint registry that has captured every joint arthroplasty (knee, hip, shoulder etc.) performed at the Mayo Clinic, Rochester. Data including patient demographics, comorbidity and implant characteristics are captured at the time of arthroplasty. Patients are followed prospectively in the joint registry and outcomes including complications, mortality and pain and function are captured during clinic visits, medical records and/or standardized mailed and telephone-administered questionnaires (7) by dedicated, trained joint registry staff (8). Since the source of registry data are patient medical records, which are abstracted by trained, dedicated registry staff on an ongoing basis, similar to other studies (9, 10), no formal validation studies were designed/performed. Data from all patients in the total joint registry can be used for research purposes with minor exception of handful of patients who refuse permission to use their data for research purposes. The study was approved by the Mayo Clinic's Institutional Review Board.

Study cohort and outcome

The study cohort consisted of every primary shoulder arthroplasty, either primary TSA or primary HHR performed at the Mayo Clinic, Rochester between 1976 and 2008. The

outcome of interest included 90-day cardiac and thromboembolic events following primary shoulder arthroplasty.

Cardiac events were defined as new occurrence of a diagnostic code for myocardial infarction, congestive heart failure or cardiac arrhythmia within 90-days of primary TSA or primary HHR, using Mayo clinic's Hospital Adaptation of International Code for Diseases (H-ICDA) codes (11) or Berkson codes (12, 13) available from 1935 to current (Appendix 1). Thromboembolic event was defined as new occurrence of diagnostic codes for deep vein thrombosis or pulmonary embolism within 90-days of primary TSA or primary HHR.

Predictors of Interest

We examined whether the following variables were associated with our outcomes of interest: (1) Age, categorized as ≤60, 61–70 and >70 years (14);(2) Gender; (3) Prior cardiac events (MI, CHF, or arrhythmia), yes/no; (4) Prior thromboembolic event (DVT or PE), yes/no; (5) Body mass index (BMI): available from 1988, categorized as <25, 25–29.9 and ≥30 kg/m^2; (6) Comorbidity assessed by Deyo-Charlson index, a validated weighted index of 19 listed comorbidities (including cardiac, pulmonary, renal, hepatic disease, diabetes, cancer, HIV, etc.) (15, 16) with a score of 0 means that no comorbid condition is present and a higher score indicates more comorbidity, adapted from the original Charlson score ranging 0–37, categorized as 0 and ≥1; available from 1994; (7) American Society of Anesthesiologist (ASA) score: a validated measure of peri- and post-operative outcomes, categorized as class I-2 vs. 3–4.

Statistical Analyses

Descriptive statistics were reported for baseline clinical and demographic characteristics. Due to rare occurrence of cardiac and thromboembolic complications after elective arthroplasty, we made an a priori decision to combined TSA and HHR for all analyses. Analyses were done at the joint level. We used logistic regression for univariate and multivariable-adjusted analyses of 90-day cardiac and thromboembolic events. Variables assessed for association with each event included: age (categorized as ≤65 vs. >65), gender, ASA score (categorized as I-2 vs. 3–4), BMI, Deyo-Charlson Index (0 versus ≥1, since median was 0 and most patients has a score of 0 or 1), type of shoulder arthroplasty (TSA versus HHR), implant fixation and prior thromboembolic events or prior cardiac events for the respective model. Predictors with $p<0.05$ in the univariate logistic regression models were entered into multivariable logistic regression models. Odds ratios (and 95% confidence intervals) are reported. A p-value <0.05 was considered statistical significant.

Role of Funding Agency

The funding agencies had no contribution to research design, data analysis, manuscript preparation or decision to submit. No direct funds were provided for this study. Dr. Singh's time was protected for research by these grants.

Results

Cohort Characteristics and Occurrence of 90-day complications

3,480 patients underwent 4,019 shoulder arthroplasties, 2,588 TSA and 1,431 HHR. Mean age was 65 years (range 18–97 years) and 56% were women (Table 1). Mean Deyo-Charlson index score was 1, BMI was 29 Kg/m^2, ASA class was 3 or 4 in 43%, 83% were cemented, and the underlying diagnosis was osteoarthritis in 49%.

92 patients had 109 cardiac events within 90 days of primary shoulder arthroplasty (Table 2). 42 patients had 47 thromboembolic events within 90 days of primary shoulder

arthroplasty. Thus, the frequency of 90-day cardiac complications following primary shoulder arthroplasty was 2.6% and 90-day thromboembolic complications was 1.2%. More than 80% of both, cardiac and thromboembolic complications, occurred in years 1990 or later.

Risk Factors for 90-day Cardiac complications

In univariate analysis, age 61–70 and >70, body mass index, higher/worse ASA class of III/IV, higher Deyo-Charlson index, underlying diagnosis of osteoarthritis and prior cardiac event were significantly associated with higher risk of 90-day cardiac complications after primary shoulder arthroplasty(Table 3). Gender, BMI, ASA, implant fixation and the type of arthroplasty (TSA versus HHR) were not associated.

In multivariable analyses, age >70 years, higher Deyo-Charlson index and prior cardiac event were significantly associated with higher risk of 90-day cardiac events (Table 4). Underlying diagnosis of osteoarthritis was associated with borderline higher risk of 90-day cardiac event (p=0.05).

Risk Factors for 90-day Thromboembolic complications

In univariate analysis, female gender, age >70 years, higher body mass index, higher Deyo-Charlson index, underlying diagnosis of trauma and prior thromboembolic event were significantly associated with higher risk of 90-day thromboembolic complications after primary shoulder arthroplasty (Table 5). TSA was associated with significantly lower risk of thromboembolic complications compared to HHR. BMI, ASA class, implant fixation and the type of arthroplasty (TSA versus HHR) were not associated. Due to a small number of events, we did not perform multivariable analyses in order to avoid model over-fitting.

Discussion

In this study, we found that 90-day cardiac and thromboembolic complications following primary shoulder arthroplasty occurred in 2.6% and 1.2% respectively. Older age, higher comorbidity index and prior cardiac events were associated with higher risk of 90-day cardiac complications, after adjustment of other variables. In unadjusted analyses, female gender, age >70 years, higher body mass index, higher Deyo-Charlson index, underlying diagnosis of trauma, prior thromboembolic event and HHR (versus TSA) were significantly associated with higher risk of 90-day thromboembolic complications after primary shoulder arthroplasty. Since >80% of the events for both cardiac and thromboemebolic complications occurred 1990 or later, the findings are applicable to patients undergoing these procedures now and in the future. Several findings in our study are novel in absence of published data for post-shoulder arthroplasty complications.

We estimated the frequency of 90-day cardiac complications (MI, CHF, and arrhythmia) at 2.6% following primary shoulder arthroplasty (included primary TSA and primary HHR). In absence of any other published data regarding cardiac complications, our study is the first to provide estimates and details of types of cardiac complications after primary shoulder arthroplasty. One must keep in mind that diagnostic codes do not allow differentiation of the severity of cardiac events, for example symptomatic atrial fibrillation can not be differentiated from asymptomatic atrial fibrillation. The risk of thromboembolic events was 1.2%- - 0.9% had pulmonary embolism and 0.3% had deep venous thrombosis. Intuitively, clinically symptomatic thromboembolic events would be a subset of all thromboembolic events, which explains a slightly lower rate of confirmed pulmonary emboli (with ventilation-perfusion scans or spiral computerized tomography) in a previous report for a shorter period of observation from a joint registry (6). That pulmonary embolism was more

common than deep venous thrombosis after shoulder arthroplasty is an interesting observation from our study and needs to be examined in future studies. These estimates can provide guidance for fully informed patient consent and a detailed discussion between surgeons and patients prior to primary shoulder arthroplasty.

Prior respective events, cardiac and thromboembolic, increased the risk of 90-day postoperative respective complication by 9 times (adjusted for covariates) and 29 times (unadjusted), respectively. This is intuitive and expected. Our study provides the measure of this association and thus allows for risk stratification of patients with and without prior similar event. Such patients need to be warned regarding this significant increase in postoperative risk of these complications.

Two additional factors, age >70 (relative to age <60) and Deyo-Charlson index of 1 or more (relative to index of 0) were significant independent risk factors for cardiac complications after primary shoulder arthroplasty, after adjustment for other covariates. They were associated with 2.7–3.3 fold higher odds of cardiac complication. This has direct clinical relevance. Elderly patients and those with pre-existing comorbidities should be informed regarding higher risk of cardiac complications. Future studies should focus on whether specific comorbidities (diabetes, chronic obstructive pulmonary disease etc.) and disease severity are associated with risk of these complications and whether and their pre-operative management can decrease the risk of these complications.

Associations with thromboembolic complications were not multivariable-adjusted due to occurrence of few events. In unadjusted analyses, several factors were significantly associated with the risk of 90-day thromboembolic complications. These findings are at best hypothesis-generating and need confirmation in future studies. Female gender and age >70 years were each associated with higher odds of 90-day thromboembolic event. Higher BMI and higher comorbidity, an underlying diagnosis of trauma were associated with higher odds, while TSA (relative to HHR) was associated with lower odds of 90-day thromboembolic complication. Studies from other national registries are needed to assess and confirm these findings.

Our study has several limitations. The number of thromboembolic events was small, despite a 32-year study period. This prevented us from performing multivariable-adjusted analyses, therefore these findings are subject to confounding bias. We were unable to examine the effect of hospital volume and surgeon volume in a single-institution study, which might impact outcomes, as has been shown in patients with knee, hip and shoulder arthroplasty (17, 18) (19). However, in a single institution study, hospital volume is not relevant and with only two surgeons having performed majority of these procedures, surgeon volume is unlikely to be an important confounder in our analyses. We are unable to distinguish clinically serious from clinically non-serious events, since medical records were not reviewed for each complication due to limited resources. Our findings need to be confirmed in future studies from other registries/institutions. Lack of systematic evaluations to identify thromboembolism and cardiac events, likely led to under-detection and under-diagnosis. Therefore, these are conservative estimates and true incidence of these complications might be higher, It is desirable to conduct a multi-year multi-center prospective cohort study to assess the true rates of these events, but such a study may be cost-prohibitive and take a decade or longer due to rarity of these events. However, if it is mandated for reimbursement or quality assurance/quality improvement, such studies are feasible and would provide the much needed knowledge regarding these complications. Venous thromboembolism prophylaxis is not used routinely in patients undergoing shoulder arthroplasty. This study not designed to examine the frequency or effect of various cardiac prophylaxis regimens on risk of cardiac events, since this is was beyond the scope of this study. Strategies for

management of perioperative cardiac events have evolved over the study period, a factor that is likely related to risk of these events; however, this is unlikely to be confounder of our results. These data were not available in the joint registry and need to be examined in a future study. Temporal trends related to patient characteristics and indication for shoulder arthroplasty likely impact the risk of these outcomes, an aspect we were not able to analyze with these data due to small numbers. Future, larger studies should investigate this further.

In summary, the risk of 90-day cardiac and thromboembolic complications following primary shoulder arthroplasty is low. Several unmodifiable (older age, female gender) and modifiable (BMI, comorbidity) patient-level factors, as well as prior history of respective events are associated with 90-day complications after primary shoulder arthroplasty. These findings need to be confirmed. Potential improvement in outcomes of shoulder arthroplasty can be achieved by a better understanding of these complications and their risk factors.

Acknowledgments

We thank Scott Harmsen, MS and Cathy Schleck, BS for performing statistical analyses and Youlonda Lochler for providing the study cohort.

Grant support: This material is the result of work supported with National Institute of Health (NIH) Clinical Translational Science Award 1 KL2 RR024151-01 (Mayo Clinic Center for Clinical and Translational Research) and the resources and the use of facilities at the Birmingham VA Medical Center, Alabama, USA.

References

1. 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(4):396–402. Epub 2007/06/22. [PubMed: 17582789]
2. van de Sande MA, Brand R, Rozing PM. Indications, complications, and results of shoulder arthroplasty. Scand J Rheumatol. 2006; 35(6):426–34. Epub 2007/03/09. [PubMed: 17343249]
3. Aynardi M, Pulido L, Parvizi J, Sharkey PF, Rothman RH. Early mortality after modern total hip arthroplasty. Clin Orthop Relat Res. 2009; 467(1):213–8. Epub 2008/10/11. [PubMed: 18846410]
4. Baser O, Supina D, Sengupta N, Wang L, Kwong L. Impact of postoperative venous thromboembolism on Medicare recipients undergoing total hip replacement or total knee replacement surgery. Am J Health Syst Pharm. 2010; 67(17):1438–45. Epub 2010/08/20. [PubMed: 20720243]
5. Gangireddy C, Rectenwald JR, Upchurch GR, Wakefield TW, Khuri S, Henderson WG, et al. Risk factors and clinical impact of postoperative symptomatic venous thromboembolism. J Vasc Surg. 2007; 45(2):335–41. ; discussion 41–2. Epub 2007/02/01. [PubMed: 17264013]
6. Sperling JW, Cofield RH. Pulmonary embolism following shoulder arthroplasty. J Bone Joint Surg Am. 2002; 84-A(11):1939–41. Epub 2002/11/14. [PubMed: 12429752]
7. Smith AM, Barnes SA, Sperling JW, Farrell CM, Cummings JD, Cofield RH. Patient and physician-assessed shoulder function after arthroplasty. J Bone Joint Surg Am. 2006; 88(3):508–13. Epub 2006/03/03. [PubMed: 16510815]
8. Berry DJ, Kessler M, Morrey BF. Maintaining a hip registry for 25 years. Mayo Clinic experience. Clin Orthop Relat Res. 1997; (344):61–8. Epub 1997/12/31. [PubMed: 9372758]
9. Singh JA, Jensen M, Harmsen S, Gabriel S, Lewallen D. Cardiac and thromboembolic complications and mortality in patients undergoing total hip and total knee arthroplasty. Ann Rheum Dis. 2011 (in press).
10. Singh JA, Lewallen DG. Peptic ulcer disease and pulmonary disease are associated with risk of periprosthetic fracture after primary total knee arthroplasty. Arthritis Care Res (Hoboken). 2011 Epub 2011/07/13.
11. Commission on Professional and Hospital Activities, Hospital Adaptation of ICDA. 2. Vol. 1. Ann Arbor, MI: Commission on Professional and Hospital Activities; 1973.

12. Berkson J. A system of codification of medical diagnoses for application to punch cards, with a plan of operation. Am J Public Health. 1936; 26:606–12.
13. Kurland LT, Molgaard CA. The patient record in epidemiology. Sci Am. 1981; 245(4):54–63. Epub 1981/10/01. [PubMed: 7027437]
14. Singh JA, O'Byrne MM, Colligan RC, Lewallen DG. Pessimistic explanatory style: A PSYCHOLOGICAL RISK FACTOR FOR POOR PAIN AND FUNCTIONAL OUTCOMES TWO YEARS AFTER KNEE REPLACEMENT. J Bone Joint Surg Br. 2010; 92(6):799–806. Epub 2010/06/02. [PubMed: 20513876]
15. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987; 40(5):373–83. [PubMed: 3558716]
16. Charlson ME, Sax FL, MacKenzie CR, Braham RL, Fields SD, Douglas RG Jr. Morbidity during hospitalization: can we predict it? J Chronic Dis. 1987; 40(7):705–12. [PubMed: 3110198]
17. Katz JN, Barrett J, Mahomed NN, Baron JA, Wright RJ, Losina E. Association between hospital and surgeon procedure volume and the outcomes of total knee replacement. J Bone Joint Surg Am. 2004; 86-A(9):1909–16. [PubMed: 15342752]
18. Katz JN, Losina E, Barrett J, Phillips CB, Mahomed NN, Lew RA, et al. Association between hospital and surgeon procedure volume and outcomes of total hip replacement in the United States medicare population. J Bone Joint Surg Am. 2001; 83-A(11):1622–9. Epub 2001/11/10. [PubMed: 11701783]
19. 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-A(3):496–505. Epub 2004/03/05. [PubMed: 14996874]

Appendix 1. List of codes (HICDA and Berkson codes) for cardiac and thromboembolic events

HICDA

Myocardial Infarction

'04100000','04100110','04100111','04100112','04101000','04101110','04101111', '04101112','04101113','04102000','04102110','04102111','04102112','04102113', '04103000','04103110','04103111','04104000','04104110','04104111','04105000', '04105110','04105111','04105112','04105113','04105114','04106000','04106110', '04107000','04107110','04107111','04107112','04107120','04107130','04107140', '04107150','04107151','04109000','04109110','04109111','04109120','04109130', '04109131','04109132','04109133','04109134','04109140','04109150','04109160', '04109210','04110000','04110110','04110111','04110112','04110113','04110120', '04110130','04110131','04110140','04110141','04110150','04120000','04120110', '04120111','04120112','04120113','04120114','04120120','04120130','04120140', '04120180','04120190','04120191','04120200','04120210','04120220','04120230', '04120240','04120250','04120260','04120270','04120280','04120290','04120300', '04120310','04120311','04120320','04120321','04120330','04120331','04120340', '04120341','04120410','04120411','04121000','04121110','04121120','04121121', '04121122','04121123','04121124','04121130','04121131','04121132','04121140'

Congestive heart failure

'04110000','04110110','04110111','04110112','04110113','04110120','04110130', '04110131','04110140','04110141','04270000','04270110','04270111','04271000', '04271110','04271111','04271120','04271210','04271211','04271212','04271213', '04279000','04279100','04279101','04279110','04279111','04279112','04279113', '04279114','04279115','04279116','04279117','04279118','04279119','04279120',

‘04279130’,‘04279140’,‘04279150’,‘04279160’,‘04279210’,‘04279211’,‘04279212’, ‘04279213’,‘04279214’,‘04279310’,‘04279311’,‘04279410’,‘04279510’,‘04279520’, ‘04279530’,‘04279610’

Arrhythmia

‘04150000’,‘04150110’,‘04151000’,‘04151110’,‘04151111’,‘04151112’,‘04151120’, ‘04151130’,‘04152000’,‘04152110’,‘04152120’,‘04152130’,‘04152140’,‘04152210’, ‘04152220’,‘04152230’,‘04152231’,‘04153000’,‘04153110’,‘04153120’,‘04154000’, ‘04154110’,‘04154111’,‘04154112’,‘04156000’,‘04156110’,‘04156111’,‘04156120’, ‘04156121’,‘04156130’,‘04156131’,‘04156140’,‘04156141’,‘04157000’,‘04157110’, ‘04157120’,‘04157130’,‘04157131’,‘04157132’,‘04157140’,‘04157150’,‘04159000’, ‘04159110’,‘04159111’,‘04159112’,‘04159113’,‘04159114’,‘04159115’,‘04159120’, ‘04159121’,‘04159130’,‘04159140’,‘04159150’,‘04159151’,‘04159160’,‘04159210’, ‘04159310’,‘04159410’,‘04159411’,‘04159510’,‘04159600’,‘04159610’,‘04159611’, ‘04160000’,‘04160110’,‘04160111’,‘04160210’,‘04161000’,‘04161110’,‘04161111’, ‘04161112’,‘04161120’,‘04161130’,‘04161210’,‘04161310’,‘04161320’,‘04161321’, ‘04161323’,‘04162000’,‘04162110’,‘04162120’,‘04162130’,‘04162131’,‘04162132’, ‘04163000’,‘04163110’,‘04163111’,‘04163210’,‘04163211’,‘04163220’,‘04163230’, ‘04163240’,‘04164000’,‘04164110’,‘04164111’,‘04165000’,‘04165110’,‘04165111’, ‘04165120’,‘04165121’,‘04165122’,‘04165123’,‘04166000’,‘04166110’,‘04166111’, ‘04166112’,‘04166120’,‘04166121’,‘04166130’,‘04166131’,‘04166132’,‘04166133’, ‘04166134’,‘04166140’,‘04166141’,‘04166142’,

‘04166143’,‘04166150’,‘04166160’,‘04166210’,‘04166220’,‘04166230’,‘04166231’, ‘04167000’,‘04167110’,‘04167111’,‘04167112’,‘04167113’,‘04167114’,‘04167115’, ‘04168000’,‘04168110’,‘04168111’,‘04168120’,‘04169000’,‘04169110’,‘04169111’, ‘04169120’,‘04169130’,‘04169131’,‘04169140’,‘04169150’,‘04169160’,‘04169161’, ‘04169180’,‘04169181’,‘04169190’,‘04169191’,‘04169192’,‘04169193’,‘04169194’, ‘04169195’,‘04169196’,‘04169197’,‘04169198’,‘04169200’,‘04169210’,‘04169310’, ‘04169311’,‘04169400’,‘04169401’,‘04169402’,‘04169403’,‘04169410’,‘04169411’, ‘04169420’,‘04169421’,‘04169430’,‘04169431’,‘04169432’,‘04169433’,‘04169434’, ‘04169435’,‘04169436’

Deep venous thrombosis

‘04519511’

Pulmonary embolism

‘04500000’,‘04500110’,‘04500120’,‘04500130’,‘04500210’,‘04500220’,‘04500310’, ‘04500311’,‘04500320’,‘04500321’,‘04500322’,‘04500323’,‘04500324’,‘04500410’, ‘04500510’

BERKSON

Myocardial Infarction

‘023412’,‘023422’,‘023443’,‘023481’,‘023771’,‘0234X2’,‘0234X3’,‘0249Y4’

Congestive heart failure

‘023452’,‘023612’,‘023673’,‘023694’,‘023782’,‘0234X1’

Arrhythmia

‘023732’,‘023813’,‘023814’,‘023821’,‘023822’,‘023823’,‘023824’,‘023831’,‘023832’, ‘023833’,‘023834’,‘023841’,‘023842’,‘023843’,‘023844’,‘023851’,‘023852’,‘023853’, ‘023854’

Deep venous thrombosis

‘X56713’,‘024742’,‘024743’,‘024744’,‘X35671’,‘X35671’

Pulmonary embolism

‘024962’

Significance and Innovation

- 90-day cardiac and thromboembolic complication rates following primary shoulder arthroplasty was 2.6% and 1.2%, respectively.
- Age >70 years, higher comorbidity and history of prior cardiac events were independent risk factors for 90-day cardiac complications.
- Knowledge of risk factors for these complications allows better informed consent for patients undergoing primary shoulder arthroplasty.

Table 1

Clinical and demographic Characteristics of Study Population

	Total Shoulder Arthroplasty Mean (SD) [range] or %	Humeral Head Replacement Mean (SD) [range] or %	TSA and HHR combined Mean (SD) [range] or %
# patients (#shoulders)	**2,207 patients (2,588 shoulders)**	**1,349 patients (1,431 shoulders)**	**3,480 patients (4,019 shoulders)**
Age at surgery in years	65 (12) [19, 91]	63 (16) [18, 97]	64 (12) [18, 97]
Male/Female (%)	47%/53%	37%/63%	44%/56%
Deyo-Charlson Index	0.8 (1) [0, 13]	1.4 (2) [0, 13]	1.0 (1.8) [0, 13]
Implant fixation[a] (%)			
Cemented	96%	60%	83%
Uncemented	4%	40%	17%
Diagnosis			
Rheumatoid arthritis	17%	16%	17%
Trauma	15%	35%	22%
Tumor	1%	10%	5%
Osteoarthritis	63%	24%	49%
Rotator Cuff disease	2%	10%	4%
Other[b]	2%	5%	3%
Body Mass Index (BMI) [c], kg/m^2	30 (6) [16, 60]	28 (6) [15, 66]	29 (6) [15, 66]
ASA class[d]			
1 or 2	61%	49%	57%
3 or 4	39%	51%	43%

ASA, American Society of Anesthesiologists; SD, standard deviation

[a] Humeral and/or glenoid components were cemented.

[b] Other category for underlying diagnosis includes: avascular necrosis, ankylosing spondylitis, psoriatic arthritis, gout, Charcot arthropathy, dislocation, old injury, prior history of septic arthritis

[c] available from 9/1/1987 to present

[d] available from 11/1/1988 to present; 9 patients with total shoulder arthroplasty and 6 patients with humeral head replacement had missing ASA class

Table 2

90-day cardiac and thromboembolic complications after primary shoulder arthroplasty

	Number of events (%)
Cardiac Events	**92 patients with 109 events**
Myocardial infarction (MI)	12 (11%)
Congestive Heart Failure (CHF)	10 (9%)
Arrhythmia	57(53%)
MI and CHF	1 (1%)
MI and Arrhythmia	4 (4%)
Arrhythmia and CHF	4 (4%)
MI, CHF and arrhythmia	4 (4%)
Thromboembolic events	**42 patients with 47 events**
Deep Venous Thrombosis (DVT)	13 (28%)
Pulmonary embolism	24 (51%)
Pulmonary embolism and DVT	5 (11%)

Table 3

Univariate association of risk factors with 90-day cardiac complications after primary shoulder arthroplasty

	No cardiac event n (%)	90-day cardiac event n (%)	Univariate Odds Ratio (95% Confidence Interval)	p-value
Gender				
Female (n=2250)	2203 (98%)	47 (2%)	1.0 (ref)	
Male (n=1769)	1724 (97%)	45 (3%)	1.22 (0.81,1.85)	**0.34**
Age				
≤60 (n=1255)	1247 (99%)	8 (1%)	1.0 (ref)	
61–70 (n=1213)	1192 (98%)	21 (2%)	2.75 (1.21,6.220	**0.02**
> 70 (n=1551)	1488 (96%)	63 (4%)	6.60 (3.15,13.82)	**<0.001**
Body Mass Index (BMI)[a]				
< 24.9 (n=809)	788 (97%)	21 (3%)	1.0 (ref)	
25–29.9 (n=1094)	1058 (97%)	36 (3%)	1.28 (0.74,2.20)	**0.38**
≥30.0 (n=1224)	1191 (97%)	33 (3%)	1.04 (0.60,1.81)	**0.89**
American Society of Anesthesiologists[b]				
ASA Class 1,2 (n=1725)	1693 (98%)	32 (2%)	1.0 (ref)	
ASA Class 3 (n=1248)	1196 (96%)	52 (4%)	2.30 (1.47,3.60)	**<0.001**
ASA Class 4 (n=33)	26 (79%)	7 (21%)	14.24 (5.76,35.21)	**<0.001**
Deyo-Charlson Index				
Index =0 (n=2275)	2254 (99%)	21 (1%)	1.0 (ref)	
Index ≥1 (n=1744)	1673 (96%)	71(4%)	4.56 (2.79,7.44)	**<0.001**
Diagnosis				
Rheumatoid arthritis (n=685)	679 (99%)	6 (1%)	1.0 (ref)	
Trauma (n=867)	850 (98%)	17 (2%)	2.26 (0.89,5.77)	**0.09**
Osteoarthritis (n=1988)	1934 (97%)	54 (3%)	3.16 (1.35,7.38)	**0.008**
Other diagnosis[c] **(n=479)**	464 (97%)	15 (3%)	3.66 (1.41,9.50)	**0.008**
Implant fixation				
No cement (n=677)	662 (98%)	15 (2%)	1.0 (ref)	
Cement (n=3342)	3265 (98%)	77 (2%)	1.04 (0.60,1.82)	**0.89**
Surgery type				
HHR (n=1431)	1391 (97%)	40 (3%)	1.0 (ref)	
TSA (n=2588)	2536 (98%)	52 (2%)	0.71 (0.47,1.08)	**0.11**
Prior cardiac event				
no prior cardiac event (n=3603)	3567 (99%)	36 (1%)	1.0 (ref)	
prior cardiac event (n=416)	**360 (87%)**	**56 (13%)**	**15.41 (10.00,23.75)**	**<0.001**

Significant p-value is **in bold**; HHR, Humeral Head replacement; TSA, total shoulder arthroplasty

[a] available from 9/1/1987 to present;

[b] available from 11/1/1988 to present;

[c] Other category for underlying diagnosis includes: avascular necrosis, ankylosing spondylitis, psoriatic arthritis, gout, Charcot arthropathy, dislocation, old injury, prior history of septic arthritis

Table 4

Multivariable-adjusted association of risk factors for 90-day cardiac events after primary shoulder arthroplasty

	Odds Ratio (95% Confidence Interval)	p-value
Age < 60	1.0 (ref)	
Age 61–70	1.87 (0.80,4.38)	**0.15**
Age > 70	2.71 (1.24,5.91)	**0.01**
ASA Class 1,2	1.0 (ref)	
ASA Class 3	0.90 (0.55,1.49)	**0.68**
ASA Class 4	2.72 (0.93,7.95)	**0.07**
Charlson Index =0	1.0 (ref)	
Charlson Index ≥ 1	3.27 (1.90,5.60)	**<0.0001**
Diagnosis		
Rheumatoid arthritis	1.0 (ref)	
Trauma	2.32 (0.80,6.74)	**0.12**
Osteoarthritis	2.63 (1.00,6.91)	**0.05**
Other diagnosis	2.28 (0.78,6.71)	**0.13**
No prior cardiac event	1.0 (ref)	
prior cardiac event	7.87 (4.89,12.68)	**<0.0001**
Humeral Head Replacement	1.0 (ref)	
Total Shoulder Arthroplasty	**0.75 (0.45,1.26)**	**0.27**

Significant p-value is **in bold**.

[a] available from 9/1/1987 to present

[b] available from 11/1/1988 to present

Table 5

Univariate association of risk factors with 90-day thromboembolic events after primary shoulder arthroplasty

	no thromboem bolic event n (%)	90-day thrombo embolic event n (%)	Univariate Odds Ratio (95% Confidence Interval)	p- value
Gender				
Female (n=2250)	2218 (98%)	32 (2%)	1.0 (ref)	
Male (n=1769)	1759 (99%)	10 (1%)	0.39 (0.19,0.80)	**0.01**
Age				
≤60 (n=1255)	1248 (99%)	7 (1%)	1.0 (ref)	
61–70 (n=1213)	1203 (99%)	10 (1%)	1.48 (0.56,3.91)	**0.43**
> 70 (n=1551)	1526 (98%)	25 (2%)	2.92 (1.26,6.78)	**0.01**
Body Mass Index (BMI)[a]				
< 24.9 (n=809)	805 (99.5%)	4 (0.5%)	1.0 (ref)	
25–29.9 (n=1094)	1075 (98%)	19 (2%)	3.56 (1.21,10.50)	**0.02**
≥30.0 (n=1224)	1208 (99%)	16 (1%)	2.67 (0.89,8.00)	**0.08**
American Society of Anesthesiologists (ASA) [b]				
ASA Class 1,2 (n=1725)	1706 (99%)	19 (1%)	1.0 (ref)	
ASA Class 3 (n=1248)	1226 (98%)	22 (2%)	1.61 (0.87,2.99)	**0.13**
ASA Class 4 (n=33)	32 (97%)	1 (3%)	2.81 (0.36,21.60)	**0.32**
Deyo-Charlson Index				
Index =0 (n=2275)	2261 (99%)	14 (1%)	1.0 (ref)	
Index ≥1 (n=1744)	1716 (98%)	28 (2%)	2.64 (1.38,5.02)	**0.003**
Diagnosis				
RA (n=685)	681 (99%)	4 (1%)	1.0 (ref)	
Trauma (n=867)	850 (98%)	17 (2%)	3.41 (1.14,10.17)	**0.03**
Osteoarthritis (n=1988)	1975 (99%)	13 (1%)	1.12 (0.36,3.45)	**0.84**
Other diagnosis[c] **(n=479)**	471 (98%)	8 (2%)	2.89 (0.87,9.66)	**0.08**
Implant fixation				
No cement (n=677)	671 (99%)	6 (1%)	1.0 (ref)	
Cement (n=3342)	3306 (99%)	36 (1%)	1.22 (0.51,2.90)	**0.66**
Surgery type				
HHR (n=1431)	1406 (98%)	25 (2%)	1.0 (ref)	
TSA (n=2588)	2571 (99%)	17 (1%)	0.37 (0.20,0.69)	**0.002**
Prior thromboembolic event				
no thromboembolic event (n=3912)	3887 (99%)	25 (1%)	1.0 (ref)	
prior thromboembolic event (n=107)	90 (84%)	17 (16%)	29.37 (15.32,56.29)	**<0.001**

Significant p-value is **in bold**; HHR, Humeral Head replacement; TSA, total shoulder arthroplasty

[a] available from 9/1/1987 to present;

[b] available from 11/1/1988 to present;

[c] Other category for underlying diagnosis includes: avascular necrosis, ankylosing spondylitis, psoriatic arthritis, gout, Charcot arthropathy, dislocation, old injury, prior history of septic arthritis