Regional anesthesia decreases complications and resource utilization in shoulder arthroplasty patients

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Background: Regional anesthesia can be used as part of the anesthetic to optimize anesthesia and analgesia during shoulder arthroplasty, but little is known about the overall effect that regional anesthesia has on perioperative outcomes and resource utilization. We hypothesized that regional anesthesia may decrease complication rates and resource utilization in shoulder arthroplasty patients.
Methods: We examined administrative data from 588 US hospitals from 2010 to 2015. Logistic regression was used to examine the relationship between type of anesthesia and perioperative complications.
Results: Among patients who underwent shoulder arthroplasty, 79.1% (53,243) had general anesthesia alone, 17.8% (12,011) had general anesthesia and a nerve block, and 3.1% (2062) had a nerve block alone. Overall, the complication rate was 13.3% and 30-day mortality was 1.2 per 1000 (95% CI 0.9, 1.4). In adjusted analyses, patients who had general anesthesia alone (compared to general anesthesia and nerve block) had a 16% increase in all cause infectious complications (OR 1.16, 95% CI: 1.03, 1.31) and were 2.6 times more likely to develop pulmonary complications (OR 2.6, 95% CI: 1.14, 5.78). General anesthesia alone (relative to either block only *or* general anesthesia and block) was associated with substantial increases in the likelihood of blood transfusions, intensive care unit transfers, and prolonged length of stay.
Conclusion: Patients receiving regional anesthesia for shoulder arthroplasty may have a reduction in perioperative complications, the need for intensive care unit transfers, blood transfusions, and prolonged hospital stays.

Editorial comment
We already know that use of regional anesthesia for shoulder surgery is a safe technique that optimizes anesthesia and analgesia. This database analysis, including 67,316 shoulder surgery patients, revealed that utilizing regional anesthesia is associated with lower complication rate, less need for intensive care, fewer blood transfusions, and less prolonged hospital stay.

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Shoulder arthroplasty has become a common surgical approach for multiple chronic conditions. In the US alone, over 47,000 of these procedures were performed in 2008.[1] Shoulder arthroplasty can be associated with major systemic complications including infection, pulmonary embolus, myocardial infarction, and prolonged hospitalizations.[2,3] Waterman and colleagues reported that in 2004 patients having a shoulder arthroplasty the rate of postoperative complications was 3.34%, that included a 1.1% rate of major systemic complications and a 30-day mortality of 0.25%.[3]

Regional anesthesia is often performed for shoulder arthroplasty to optimize anesthesia and analgesia. Interscalene brachial plexus blocks have been demonstrated in multiple clinical trials to decrease postoperative pain.[4–6] Complications from this block can range widely: from nearly all patients having an ipsilateral diaphragmatic paresis; to the frequent occurrence of Horner's syndrome; and finally the more serious and rare complications of pneumothorax, nerve injury, and subdural or intervertebral foramina local injection.[7]

When compared with lower extremity joint replacement, there is need for more information regarding shoulder arthroplasty and possible associations (good or bad) between regional anesthesia and perioperative outcomes. Studner and colleagues examined 17,000 patients from 2007 to 2011 that underwent total shoulder arthroplasty. The study concluded that regional anesthesia, when added to general anesthesia, did not increase the complication rate or result in increased resource utilization.[8] However, the study was likely underpowered to detect if regional anesthesia could actually decrease complications and/or decrease resource utilization. The Studner study focused on the idea that regional anesthesia is safe. We think the next logical step in a large outcome study is to examine if regional anesthesia can actually be protective.

Therefore, we examined the extent to which regional anesthesia is associated with improvements in perioperative outcomes using data from a larger patient cohort. We also determined whether regional anesthesia was associated with reductions in healthcare utilization. We hypothesized that regional anesthesia would be protective from complications and therefore reduce resource utilization in shoulder arthroplasty patients.

Methods

We examined the relationship between the use of regional anesthesia and perioperative outcomes among patients who underwent shoulder arthroplasty. Data were obtained from Premier Research Services™. Premier Healthcare Database is a HIPAA-compliant administrative database providing information from over 700 US hospitals with comprehensive billing, cost, device, medication, and procedure information. Premier Healthcare Database is the largest acute care database in the United States, accounting for 20% of inpatient discharges.

This study used de-identified and publically available data by purchase; thus, it was deemed exempt from institutional board review by the Dartmouth College Committee for the Protection of Human Subjects.

Study population

Across years 2010–2015, we identified all patient records that had an International Classification of Diseases-9th revision-Clinical Modification (ICD-9-CM) procedure code for shoulder arthroplasty: total shoulder replacement (81.80), partial shoulder replacement (81.81), reverse shoulder replacement (81.88), and revision shoulder replacement (81.97). These years were chosen because they were the most recently available (at the time of analysis) and allowed an adequate sample size. We then identified three distinct anesthesia types based on administrative and billing data consisting of (1) general anesthesia, (2) combined general anesthesia-peripheral nerve block, and (3) peripheral nerve block alone.

Covariates

We extracted additional measures to be used as covariates in our statistical analyses. Patient sociodemographic characteristics included age, gender, and race/ethnicity (white, black, Hispanic, other). We also gathered information on the type of insurance coverage (Medicare, Medicaid, commercial, uninsured, other) and admission type (elective vs. urgent-emergent). Health system characteristics included number of hospital beds (< 299, 300–499, > 500), academic teaching status, and urban vs. rural location. Pre-existing medical conditions were identified and the overall comorbidity burden was assessed using the Deyo-Charlson method.[9,10] The Charlson comorbidity index is the gold standard tool to adjust for health status, but was not designed to use ICD-9 codes. Deyo developed an algorithm based on the Charlson method that used ICD-9 codes to assess overall comorbidity burden. For each surgical procedure, ICD-9 codes were used to identify surgical pathology (osteoarthritis, rheumatoid arthritis, rotator cuff pathology, other).

Outcomes

Perioperative complications were identified by using ICD-9-CM diagnosis codes defined in Appendix S1. Systemic complications included pulmonary embolism, cerebral infarction, pulmonary compromise, acute myocardial infarction, cardiac complications (non-myocardial infarction), pneumonia, other infectious complications, acute renal failure, and gastrointestinal complications. Definitions of “cardiac complications (nonmyocardial infarction)” and “pulmonary compromise” can be seen in table format in Appendix S2A and S2B. We calculated both the 30-day mortality and 30-day readmission rates. Thirty-day readmission and 30-day mortality were defined as all cause and were captured only for the hospital in which the surgery occurred. Using ICD-9-CM and billing data, healthcare related resource utilization was determined for the incidence of blood transfusions and mechanical ventilation. Lengths of stay were summarized as a binary measure for a clinically relevant prolonged event (4 days or longer).

Statistical analysis

We performed descriptive analyses to compare different anesthetic approaches in regards to socio-demographic characteristics, health status, and perioperative outcomes. We used a chi-square test to compare proportions and a Mann–Whitney test to compare measures of central tendency for continuous measures. For all analyses, we set the P-value for statistical significance to 0.05 (2-sided).

Logistic regression was used to examine the relationship between anesthesia type and the various outcomes. Final models were adjusted for age, gender, race/ethnicity, comorbidity, healthcare insurance, admission type, hospital size, hospital location, and hospital teaching status. These covariates were selected based on our a priori decisions and previous research with Premier examining lower extremity total joint arthroplasty.[11]

To determine if the definition of the surgical population (i.e. those identified by ICD-9-CM codes including revision surgery) affected our results in any meaningful way, we performed a sensitivity analysis. For the sensitivity analysis, we compared results with and without excluding those who had revision surgery and who were younger than 65. Additionally, to assess whether patients with missing anesthesia type impacted on the results, we conducted the analysis by both including and excluding those with missing anesthesia type data.

Results

We identified 75,146 patients that underwent shoulder replacement surgery at 588 hospitals between 2010 and 2015 in the Premier Healthcare Database. Anesthesia type was available for 67,316 of these patients and included: general anesthesia alone in 53,243 (79.1%), general anesthesia and a peripheral nerve block in 12,011 (17.8%), and block alone in 2062 (3.1%). Continuous regional anesthesia techniques were used in 1246 patients (1.9%). Among the patients who had continuous blocks, 89.8% also had general anesthesia, and 10.2% had the procedure performed under the block only.

Table 1 displays the patient and healthcare system related characteristics for the overall cohort and by anesthesia type. The majority of patients in all groups were over 65 and white. Most of the surgeries were performed in urban hospitals and in all groups the majority of procedures were performed in non-teaching hospital with less than 300 beds. There were no major differences in patient or hospital characteristics among the anesthesia type groups. The pre-existing comorbidity data are demonstrated in Table 2 and reveals similar levels of comorbidity burdens between anesthesia types, with the exception of small differences in rates of myocardial infarction (MI), dementia, and chronic obstructive pulmonary disease (COPD).

In unadjusted analyses the overall complication rate for any complication was 13.3%; 30-day mortality was 1.2 per 1000 (95% CI 0.9, 1.4) (Table 3). Of the systemic complications, the most common was cardiac (non-myocardial infarction) which occurred in 7.9% of all patients and included conditions such as atrial fibrillation. Although the need for mechanical ventilation was rare (0.7%), the need for

Table 1 Patient and healthcare system–related characteristics by anesthesia type.

Category	Overall *n* = 75,146 % (*n*)	General *n* = 53,243 % (*n*)	General/Block *n* = 12,011 % (*n*)	Block *n* = 2062 % (*n*)	Missing *n* = 7830 % (*n*)	*P* value*
Age (years)						
≤ 44	2.03 (1523)	1.99 (1060)	2.19 (263)	1.89 (39)	2.06 (161)	< 0.001
45–54	6.79 (5099)	6.86 (3653)	6.84 (821)	6.21 (128)	6.35 (497)	
55–64	21.88 (16,440)	21.88 (11,649)	22.44 (2695)	21.19 (437)	21.19 (1659)	
65–74	37.38 (28,088)	36.93 (19,660)	39.07 (4693)	38.94 (803)	37.45 (2932)	
≥ 75	31.93 (23,996)	32.34 (17,221)	29.46 (3539)	31.77 (655)	32.96 (2581)	
Gender (female)	58.62 (44,049)	58.62 (31,209)	57.71 (6932)	58.49 (1206)	60.05 (4702)	0.19
Race/ethnicity						
White	83.66 (62,866)	83.92 (44,683)	84.61 (10,162)	87.88 (1812)	79.30 (6209)	< 0.001
Black	4.42 (3319)	4.32 (2300)	5.47 (657)	4.66 (96)	3.40 (266)	
Hispanic	0.33 (248)	0.39 (207)	0.22 (27)	0.10 (2)	0.15 (12)	
Other	11.51 (8651)	11.27 (6002)	9.62 (1155)	7.37 (152)	17.14 (1342)	
Missing	0.08 (62)	0.10 (51)	0.08 (10)	0.00 (0)	0.01 (1)	
Admission type						
Urgent/Emergent	10.14 (7623)	10.89 (5796)	6.84 (821)	7.95 (164)	10.75 (842)	< 0.001
Elective	88.32 (66,372)	87.61 (46,644)	91.72 (11,017)	89.38 (1843)	87.71 (6868)	
Missing	1.53 (1151)	1.51 (803)	1.44 (173)	2.67 (55)	1.53 (120)	
Payer						
Commercial	25.05 (18,827)	24.80 (13,206)	25.79 (3098)	25.80 (532)	25.43 (1991)	< 0.001
Medicaid	2.75 (2065)	2.86 (1522)	1.95 (234)	2.76 (57)	3.22 (252)	
Medicare	69.43 (52,174)	69.69 (37,107)	69.69 (8250)	69.88 (1441)	68.66 (5376)	
Uninsured	0.60 (454)	0.58 (309)	0.58 (70)	0.39 (8)	0.86 (67)	
Other	2.16 (1626)	2.06 (1099)	2.99 (359)	1.16 (24)	1.84 (144)	
Hospital beds						
≤ 299	41.71 (31,347)	42.14 (22,437)	37.52 (4506)	45.34 (935)	44.30 (3469)	< 0.001
300–499	33.59 (25,241)	34.23 (18,223)	32.84 (3944)	32.15 (663)	30.79 (2411)	
≥ 500	24.70 (18,558)	23.63 (12,583)	29.65 (3561)	22.50 (464)	24.90 (1950)	
Hospital location						
Rural	11.50 (8643)	10.01 (5327)	11.24 (1350)	16.39 (338)	20.79 (1628)	< 0.001
Urban	88.50 (66,503)	89.99 (47,916)	88.76 (10,661)	83.61 (1724)	79.21 (6202)	
Teaching hospital						
No	61.34 (46,096)	63.11 (33,603)	58.35 (7008)	62.08 (1280)	53.70 (4205)	< 0.001
Yes	38.66 (29,050)	36.89 (19,640)	41.65 (5003)	37.92 (782)	46.30 (3625)	
Surgical path						
Osteoarthritis	68.33 (51.349)	67.48 (35,927)	72.25 (8678)	72.94 (1504)	66.92 (5240)	< 0.001
Rotator cuff	24.15 (18,150)	22.65 (12,059)	30.45 (3657)	29.34 (605)	23.36 (1829)	< 0.001
Other	8.60 (6462)	8.70 (4630)	8.34 (1002)	7.61 (157)	8.60 (673)	0.12
Deyo Index† (mean, 95% CI)	0.72 (0.71–0.73)	0.74 (0.73–0.75)	0.68 (0.65–0.71)	0.70 (0.63–0.77)	0.68 (0.64–0.71)	< 0.001

**P* value compares general, general/block, and block. †The index is a weighted score reflecting the comorbidity burden of a patient.

Table 2 Preexisting health conditions.

Comorbidity	Overall % (*n*)	General % (*n*)	General/Block % (*n*)	Block % (*n*)	Missing % (*n*)	*P* value*
Myocardial infarction	4.55 (3418)	4.67 (2487)	4.06 (488)	4.66 (96)	4.43 (347)	0.02
Peripheral vascular disease	2.33 (1748)	2.37 (1264)	2.14 (257)	1.70 (35)	2.45 (192)	0.05
Cerebrovascular disease	1.71 (1286)	1.76 (938)	1.48 (178)	1.65 (34)	1.74 (136)	0.10
Dementia	0.15 (113)	0.16 (83)	0.07 (8)	0.24 (5)	0.22 (17)	0.03
COPD	19.03 (14,297)	19.42 (10,338)	17.58 (2111)	18.19 (375)	18.81 (1473)	< 0.001
Rheumatic disease	5.61 (4217)	5.67 (3018)	5.64 (677)	5.67 (117)	5.17 (405)	0.99
Mild liver disease	0.56 (421)	0.58 (308)	0.53 (64)	0.29 (6)	0.55 (43)	0.21
Severe liver disease	0.10 (75)	0.11 (57)	0.07 (8)	0.05 (1)	0.11 (9)	0.34
Uncomplicated diabetes	20.12 (15,120)	20.21 (10,759)	19.37 (2327)	20.85 (430)	20.49 (1604)	0.08
Complicated diabetes	1.76 (1323)	1.84 (981)	1.59 (191)	1.41 (29)	1.56 (122)	0.07
Renal disease	6.38 (4794)	6.53 (3477)	6.21 (746)	6.26 (129)	5.64 (442)	0.41
AIDS	0.05 (40)	0.06 (30)	0.05 (6)	0.00 (0)	0.05 (4)	0.55
Paraplegia	0.14 (107)	0.14 (77)	0.16 (19)	0.10 (2)	0.11 (9)	0.79
Cancer	1.28 (965)	1.33 (706)	1.18 (142)	1.12 (23)	1.20 (94)	0.35

**P* value compares general, general/block, and block. Chi-square test used to compare proportions. COPD, chronic obstructive pulmonary disease; AIDS, acquired immune deficiency syndrome.

Table 3 Perioperative outcomes by anesthesia type

	Overall % (*n*)	General % (*n*)	General/Block % (*n*)	Block % (*n*)	Missing % (*n*)	*P* value*
Systemic complications						
Cerebrovascular event	0.09 (71)	0.11 (56)	0.07 (8)	0.05 (1)	0.08 (6)	0.36
Pulmonary compromise	0.80 (599)	0.86 (459)	0.66 (79)	0.29 (6)	0.70 (55)	0.002
Cardiac (non-infarction)	7.92 (5954)	8.01 (4265)	7.67 (921)	7.52 (155)	7.83 (613)	0.35
Pneumonia	1.20 (901)	1.22 (651)	1.04 (125)	1.50 (31)	1.20 (94)	< 0.001
All infections	3.76 (2822)	4.01 (2136)	2.95 (354)	2.86 (59)	3.49 (273)	< 0.001
Acute renal failure	2.19 (1649)	2.38 (1266)	1.82 (218)	1.50 (31)	1.71 (134)	0.66
Gastrointestinal complication	0.24 (178)	0.25 (135)	0.21 (25)	0.24 (5)	0.17 (13)	0.09
Acute myocardial infarction	0.23 (171)	0.24 (130)	0.15 (18)	0.34 (7)	0.20 (16)	0.31
Any complication	13.3 (9989)	13.8 (7320)	12.0 (1442)	12.0 (247)	12.5 (980)	< 0.001
Resource utilization						
Mechanical ventilation	0.68 (514)	0.72 (384)	0.64 (77)	0.48 (10)	0.55 (43)	0.31
Blood product transfusion	7.61 (5721)	7.98 (4247)	5.77 (693)	5.72 (118)	8.47 (663)	< 0.001
ICU admission	2.51 (1887)	2.75 (1464)	1.78 (214)	1.89 (39)	2.17 (170)	< 0.001
Prolonged length of stay†	12.6 (9462)	13.4 (7136)	9.2 (1109)	9.3 (192)	13.1 (1025)	< 0.001
Readmission‡ (30-day)	0.2 (149)	0.2 (106)	0.14 (17)	0.05 (1)	0.32 (25)	0.02
Mortality‡						
30-Day mortality	0.12 (87)	0.13 (69)	0.06 (7)	0.10 (2)	0.11 (9)	0.11

**P* value compares general, general/block, and block, chi-square test used to compare proportions. †Prolonged length of stay is 4 days or longer. ‡Refers to hospital in which the surgery was performed only.

postoperative ICU care occurred in 2.5% of the patients. Additionally, 7.6% of all patients received blood transfusions. Differences between anesthesia types were found for infectious complications, pulmonary compromise, ICU transfers, and prolonged lengths of stay.

Adjusting for age, gender, race, comorbidities, admission type, hospital bed size, hospital location, teaching status, patients having general anesthesia alone (relative to general anesthesia and nerve block) had a 16% increase in the likelihood of experiencing an infectious

Table 4 Adjusted† Odds Ratios for the Association between Anesthesia Type and Perioperative Complications.

	General vs. General/Block		General vs. Block	
	Odds Ratio (95% CI)	*P* Value*	Odds Ratio (95% CI)	*P* Value*
Systemic Complications				
Cerebrovascular event	1.26 (0.59, 2.66)	0.55	1.65 (0.22, 12.08)	0.61
Pulmonary compromise	1.11 (0.87, 1.41)	0.34	2.57 (1.14, 5.78)	0.02
Cardiac complications (non-infarction)	0.97 (0.90, 1.05)	0.59	1.04 (0.87, 1.23)	0.64
Acute myocardial infarction	1.34 (0.81, 2.21)	0.24	0.63 (0.29, 1.37)	0.25
Pneumonia	1.03 (0.85, 1.26)	0.71	0.73 (0.51, 1.06)	0.10
All infections	1.16 (1.03, 1.31)	< 0.01	1.32 (1.01, 1.72)	0.05
Acute renal failure	1.09 (0.94, 1.27)	0.27	1.42 (0.47, 2.08)	0.07
Gastrointestinal complication	1.08 (0.70, 1.67)	0.70	0.93 (0.38, 2.30)	0.38
Resource Utilization				
Mechanical ventilation	0.99 (0.77, 1,27)	0.94	1.23 (0.65, 2.33)	0.51
Blood transfusion (any)	1.24 (1.13, 1.35)	< 0.001	1.32 (1.08, 1.60)	0.006
Readmission‡ (30-day)	1.31 (0.78, 2.20)	0.29	3.78 (0.52, 27.16)	0.19
Prolonged length of stay	1.31 (1.22, 1.41)	< 0.001	1.40 (1.18, 1.65)	< 0.011
Intensive Care Unit stay§	1.35 (1.16, 1.59)	< 0.001	1.44 (1.03, 2.01)	0.03
Mortality‡ (30-day)	1.63 (0.74, 3.58)	0.22	1.13 (0.27, 4.68)	0.86

**P*-value compares general with either general and block or with block alone. †Adjusted for age, gender, race, comorbidities, admission type, hospital bed size, hospital location, teaching status. ‡Refers to Premier affiliated hospitals only; Prolonged length of stay defined as 4 days or more. §Defined as a hospital stay of 4 days or longer.

complication (OR 1.16; 95% (CI 1.03, 1.31) (Table 4). Additionally, patients having general anesthesia only (relative to block only) had a 2.6 times likelihood of developing pulmonary complications (OR. 2.6; 95% (CI 1.14, 5.78). In terms of resource utilization, general anesthesia alone (relative to either block only or general anesthesia and block anesthesia types) was associated with substantial increases in the likelihood of blood transfusions, ICU transfers, and prolonged length of stay.

Sensitivity analysis

Excluding revision surgery (n = 163) or limiting the analysis to the 65 and older patients did not result in any appreciable differences in the aforementioned results. Additionally, when including the missing anesthetic type patients, there were no appreciable differences in any of the outcome variables for general anesthesia vs. general anesthesia and block. When the inclusive analysis was repeated for general anesthesia vs. block, there was a slight attenuation of the protective effect of block for infectious complications (P = 0.051 vs. 0.046). Examining the percentage of patients that received any block year by year did not reveal any increase or decrease in utilization of nerve blocks over the study period. In 2010, 14.29% of patients had a block. This rate peaked at 20.92% in 2013 and then decreased again.

Discussion

This is the largest study for shoulder arthroplasty patients to examine the association between the use of regional anesthesia techniques and non-analgesic perioperative outcomes. We found that patients who have regional anesthesia as part of their anesthetic plan for shoulder arthroplasty may experience benefits in terms of reductions in systemic complications, the need for ICU transfers, blood transfusions, and prolonged hospital stays.

Our findings are especially relevant in that regional anesthesia is only utilized in a small fraction of patients undergoing shoulder arthroplasty surgery. Prior research from years 2007–2011, also using similar administrative data, found that 21% of patients had a nerve block for total shoulder arthroplasty surgery.[8] Despite the growth in ultrasound-guided regional anesthesia and the national emphasis on opioid reduction strategies, our data confirm the persistent low utilization (20.9%) of regional anesthesia techniques. Given that our data comes from a large cohort of hospitals and health systems in the United States, it is possible that on a population health level, increasing regional anesthesia techniques would translate into distinct health benefits and the reduction in resource utilization.

We were surprised to find that a block only anesthetic approach to shoulder arthroplasty was associated with a large reduction in the risk of pulmonary compromise. The interscalene nerve block causes ipsilateral diaphragmatic paralysis which could theoretically increase the risk for pulmonary compromise. Although it has been shown in a prior study[8] that having a brachial plexus block did not cause an increase in pulmonary complications, a protective effect was not identified. Our findings could be explained by avoiding the negative (bilateral) respiratory impact of general anesthesia. For instance, we know that for an average patient, general anesthesia decreases functional residual capacity perioperatively by 20%.[12] Alternatively, prior studies demonstrate that shoulder surgery patients that do not have regional anesthesia are exposed to more opioids.[4–6] This increase in opioid exposure could lead to respiratory depression and pulmonary complications.

We were also surprised to find general anesthesia alone (relative to general anesthesia and block or block alone) was a risk factor for all-cause infection. This finding could be explained by two separate theories or possibly a combination of the two. First, the general anesthesia alone group could have been exposed to more infectious agents given the prolonged hospital stays and increased ICU admissions. Secondly, there is growing evidence that regional anesthesia may blunt the magnitude of the immunosuppression and stress response associated with surgery and traditional general anesthesia.[13,14]

There are several limitations to our study that must be acknowledged. First, Premier data represents only 20% of the US discharges, and, therefore, may not be generalizable to other hospitals, countries, and health systems. Second, our study is observational in nature and thus, subject to potential residual unmeasured confounding. In our analyses, we accounted for a large number of important differences, but may have missed important unmeasured factors. Third, our data are derived from administrative data that have the potential for coding errors. Finally, 30-day readmission and mortality reflect best-case scenarios because if patients were cared for in other health facilities other than the one for the index surgery, their data would have not been captured. Similarly, patient data comes from their index admission and does not capture complications they may have been identified or presented after the initial admission. Fourth, there were small but statistically significant differences among the anesthesia groups which theoretically represents a selection bias favoring better outcomes in the nerve block groups. However, given the stability of our sensitivity analysis and adjustment model, we feel that the risk of selection bias (confounding from risk factors) is low.

Despite these inherent limitations, our large sample size across numerous different types of hospitals should make the outcomes applicable to a large audience compared to a single institution study. In the era of the medical home model of anesthesia, opportunities to limit complications and reduce resources are highly attractive.

On a population health level regional anesthesia for shoulder arthroplasty is associated with improved perioperative outcomes and may reduce hospital length of stay. Future prospective studies are warranted to examine whether the expansion of regional anesthesia services translates directly into improvements in perioperative outcomes in real time.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher’s web-site:

Appendix S1. ICD-9-CM codes used to identify complications.
Appendix 2A. Most common ICD-9 Codes used for pulmonary compromise outcome.
Appendix 2B. Most common ICD-9 Codes used for Cardiac (nonmyocardial infarction) outcome.