Original Article

Comparison of general versus isolated regional anesthesia in total shoulder arthroplasty: A retrospective propensity-matched cohort analysis

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ABSTRACT

Background: Intraoperative anesthetic typically consists of either general anesthesia (GA) or isolated regional anesthesia (RA).

Methods: A retrospective propensity-matched cohort analysis on patients undergoing TSA was performed to determine differences between GA and RA in regard to patient population, complications, LOS and hospital readmission.

Results: 4158 patients underwent TSA with GA or isolated RA. Propensity-matching resulted in 912 patients in each cohort. RA had lower overall in-hospital complications and greater homebound discharge disposition with lower 90-day readmission rates than GA.

Conclusion: After TSA, isolated RA was associated with lower in-hospital complications, readmission rates and odds of hospital readmission than GA.

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1. Introduction

Total shoulder arthroplasty (TSA) is the long-term standard of care to relieve pain and restore function for multiple pathologies such as osteoarthritis,^{1–4} rheumatoid arthritis,^{5,6} trauma,⁷ and osteonecrosis.^{8,9} When conservative management such as analgesics, physiotherapy and local cortisone injections fail, TSA reliably relieves pain and restores function.^{3,10,11} While techniques and implants may vary between surgeons, patients are typically anesthetized using two methods: general anesthesia (GA) with or without regional blockade and isolated regional anesthesia (RA).

GA is the most common form of anesthesia and has numerous merits. GA provides intraoperative amnesia, resulting in decreased patient awareness and recall,¹² and can be continuously administered during surgery without the patient moving. Lastly, the effects of GA can be easily prolonged or reversed if required, thus allowing appropriate adaptation during procedures of unpredictable duration. Despite these advantages however, GA by itself is inadequate

at providing local pain control in the immediate post-operative period.¹³ Furthermore, because GA suppresses normal autonomic functions (including breathing and cardiac responses),¹⁴ an anesthesiologist must be vigilant in monitoring patient vitals and controlling breathing through an endotracheal device. Previous authors have suggested that cerebral hypoperfusion is potentiated by inhalational agents used in GA,¹⁵ and a clinical trial by Koh et al. found that cerebral deoxygenation events were significantly more likely with GA as compared to isolated RA.¹⁶ Other side effects of GA are equally serious and include aspiration, short-term amnesia, nausea, vomiting, pruritis, and hoarseness.^{14,17}

RA is an effective anesthesia and analgesic technique for patients undergoing shoulder surgery.^{18,19} Typically, RA involves brachial plexus blockade from various anatomic approaches (interscalene, supraclavicular, infraclavicular). Utilization of RA was reported as early as 1929 by Strode in the treatment of upper extremity fractures, and its application can be traced as early as the late 1800s.²⁰ In addition to providing excellent intraoperative pain control, touted advantages of RA include improved postoperative pain control, decreased opioid use, and reduced recovery times compared to GA.^{21,22} Additionally, autonomic functions are preserved during RA, allowing the patient to regulate their own vital functions. Finally, several authors have reported on the

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efficacy of brachial plexus blockade in shoulder surgery in providing excellent muscle relaxation, greater hemodynamic stability, reduced PACU stay, decreased unplanned hospital readmission for pain control, increased operating room efficacy and greater patient satisfaction.^{23,17,14,24} Limitations of RA include the inability to perform intraoperative nerve monitoring, damage to vascular structures, and the potential for significant nerve palsy if improper technique is used.^{25,26}

While authors have agreed that isolated RA reduces time to discharge for patients undergoing ambulatory surgeries such as shoulder arthroscopy,^{27,28} no study has examined the impact of RA in the setting of TSA. In parallel with the rapidly accelerating utilization of TSA,^{29,30} healthcare continues to grow increasingly focused on quality, with reimbursements becoming more closely tied to outcomes.³¹ Thus, it becomes important to understand the role that anesthesia has in relation to hospital LOS, discharge disposition, in-hospital complications and readmission rates.

To appropriately answer these questions and assess the impact of GA versus isolated RA in the setting of elective TSA, we used a large inpatient database to perform a retrospective propensity-matched cohort analysis. Based on existing orthopaedic literature,^{32,33} we hypothesized that isolated RA would be associated with lower rates of in-hospital perioperative complications, shorter LOS, lower readmission rates and greater homebound discharge as compared to GA.

2. Methods

New York Statewide Planning and Research Cooperative System (SPARCS) database was queried to identify patients eighteen and older who underwent elective inpatient TSA between 2011 and 2014. We began our study in the year 2011 as it was the earliest year available for which we could accurately differentiate between anatomic total shoulder (aTSA) and reverse total shoulder (rTSA)

arthroplasty. Numerous peer-reviewed publications have used SPARCS for epidemiologic studies in orthopaedics.^{34–37}

International Classification of Diseases (ICD-9) codes 81.80 and 81.88 were used to identify patients undergoing aTSA or rTSA, respectively. Demographic information regarding patient age, gender, race, and insurance were collected. Concomitant medical comorbidities were identified using the Elixhauser Comorbidity Criteria, which has been previously validated in orthopaedic database studies.³⁸ Overall comorbidity burden was stratified into four groups: 0, 1, 2, and 3 or more comorbidities. ICD-9 codes 305.1 and V15.62 were used to identify patients with a history of tobacco use.^{39–41}

To best identify an elective cohort, patients with fracture-related diagnoses or those undergoing surgery for prior infection, tumor, or previous surgical complications were excluded. Primary diagnosis at time of initial arthroplasty was stratified into six groups: osteoarthritis, inflammatory arthritis, post-traumatic arthritis, cuff disorders, osteonecrosis, and miscellaneous arthritis. Matsen et al. used this methodology in a recent study that also used SPARCS database.⁴² Similar to their study, any patient with an ICD-9 code (V43.61, V43.62, or V43.63) indicating the existence of a previous upper-extremity arthroplasty at time of index surgery was eliminated to avoid ambiguity regarding contralateral shoulder procedures and/or elbow or wrist arthroplasty.⁴² Hospitals were stratified based on teaching status, urban or rural location, and bedsize: small (less than 200 beds), medium (200–400 beds), and large (greater than 400 beds).

Patients were stratified into two groups based on whether they received GA or isolated RA. The SPARCS database only records the single highest level of anesthesia provided, and thus patients who received general anesthesia at any point in the admission would only have a code for GA, regardless of whether they received concomitant regional blockade. Thus, patients who received GA without regional blockade and those who received GA with

Table 1
Unadjusted and propensity-matched baseline demographics between general and regional anesthesia.

	Type of Anesthesia			Type of Anesthesia		
	General 78.1% (3246) Mean (SD)	Regional 21.9% (912)	P value before matching	General 50% (912) Mean (SD)	Regional 50% (912)	P value after matching
Age	68.8 (9.8) % (n)	68.3 (9.9)	0.176	68.4 (9.7) % (n)	68.3 (9.8)	0.833
Age Subgroup						
Younger 55	8.1 (262)	7.9 (72)	0.651	7.8 (71)	7.9 (72)	0.586
55–65	23.0 (746)	24.3 (222)		24.3 (222)	24.3 (222)	
65–75	38.9 (1264)	39.1 (357)		38.6 (352)	39.1 (357)	
75–85	25.7 (834)	25.3 (231)		24.5 (223)	25.3 (231)	
85+	4.3 (140)	3.3 (30)		4.8 (44)	3.3 (30)	
Gender						
Male	43.8 (1421)	45.5 (415)	0.365	45.3 (413)	45.5 (415)	0.963
Female	56.2 (1825)	54.5 (497)		54.7 (499)	54.5 (497)	
Race						
Caucasian	87.7 (2845)	86.0 (784)	<0.001	87.0 (793)	86.0 (784)	0.941
Black	4.8 (156)	2.7 (25)		2.6 (24)	2.7 (25)	
Hispanic	2.2 (70)	2.6 (24)		2.4 (22)	2.6 (24)	
Other	5.4 (175)	8.7 (79)		8.0 (73)	8.7 (79)	
Insurance						
Medicare	65.0 (2110)	62.6 (571)	<0.001	64.3 (586)	62.6 (571)	0.581
Medicaid	2.5 (82)	1.2 (11)		0.8 (7)	1.2 (11)	
Private	24.5 (796)	32.5 (296)		30.5 (278)	32.5 (296)	
Work Comp	6.2 (200)	3.4 (31)		3.7 (34)	3.4 (31)	
Other	1.8 (58)	0.3 (3)		0.7 (7)	0.3 (3)	

Bold values indicate statistical significance which per our study was anything < 0.05

regional blockade were collapsed into a single group: GA. Patients within the RA group only received regional anesthesia during their TSA. The same methodology was used in a recent study examining the influence of anesthesia type in TJA.³²

Once anesthesia type, demographic, comorbidity, and hospital data were obtained, propensity-score matching to best account for potential selection bias in patients receiving either GA or isolated RA was performed. Propensity-score matching provides for an optimal assessment of treatment effect by balancing baseline covariates,^{43,44} and has been extensively utilized in orthopaedics,^{45–47} including a study similar to ours which compared GA to RA in TJA.³² We utilized nearest-neighbor matching without replacement, and included a total of 26 covariates in the algorithm.

The propensity-matched cohort was used to determine differences between GA and RA for hospital LOS (days), discharge disposition (homebound versus skilled-nursing facility/SNF), in-hospital complications, and readmission to hospital within 90 days of discharge. Similar to prior studies, hospital LOS was analyzed as both a continuous and binary variable (extended length of stay) defined as a hospital stay greater than geometric mean + (2 × SD).³² Student's T-tests were used for continuous variables, chi-square analysis for categorical variables, and multivariate logistic regression was performed to provide odds ratios within a 95% confidence interval. SAS® 9.3 (Cary, NC) was used for data collection and statistical analyses, with p-values <0.05 considered statistically significant. Institutional review board approval was not required as human subjects were not involved.

3. Results

Between 2011 and 2014, a total of 4158 patients who underwent either aTSA or rTSA with GA or isolated RA were identified. The majority of patients received GA (78.1%, 3246/4158), while the

remaining 21.9% (912/4158) received isolated RA. Table 1 outlines unadjusted and adjusted differences in baseline characteristics between anesthesia types. While all insurances received predominantly GA, Medicaid, Worker's compensation, and "other" demonstrated greater proportions of GA, while privately-insured and Medicare patients had highest rates of receiving isolated RA. No differences were observed in terms of age or gender; however black race was associated with highest rates of receiving GA ($p < 0.001$). Isolated RA in the setting of TSA was performed almost exclusively at urban, teaching hospitals ($p < 0.001$). Differences in hospital bed size were observed, as GA tended to be more evenly distributed amongst small, medium, and large hospitals whereas isolated RA was most prevalent in medium-sized facilities ($p < 0.001$).

Patients undergoing rTSA received GA more often than patients undergoing aTSA (83.0% vs 75.3%, $p < 0.001$). In terms of etiology of primary diagnosis, osteoarthritis of the shoulder was the most common indication for both GA (84.3%) and isolated RA (91.8%); Table 2 offers a comprehensive list of diagnoses according to anesthesia type, before and after propensity-matching. A positive history of tobacco use was associated with lower rates of GA administration as compared to patients without evidence of tobacco use (75.8% vs 78.9%, $p = 0.034$).

Concomitant medical comorbidities differed significantly between cohorts; complete descriptions are noted in Table 3, with both pre and post propensity-matching values displayed. Isolated RA was associated with greater rates of obesity as compared to GA (21.9% vs 16.9%, $p < 0.001$). By comparison, GA patients demonstrated a significantly greater prevalence of congestive heart failure, chronic pulmonary disease, diabetes, and peripheral vascular disease. GA was associated with a greater overall comorbidity burden, with 35.9% of patients receiving GA having 3 or more comorbidities as compared to only 27.9% of those receiving isolated RA ($p < 0.001$).

Table 2

Unadjusted and propensity-matched baseline hospital, implant and diagnoses between general and regional anesthesia.

	Type of Anesthesia			Type of Anesthesia		
	General (n = 3246) % (n)	Regional (n = 912) % (n)	P value before matching	General (n = 912) % (n)	Regional (n = 912) % (n)	P value after matching
Hospital Status						
Teaching	76.1 (2471)	96.3 (878)	<0.001	94.4 (861)	96.3 (878)	0.09
Non-teaching	23.9 (775)	3.7 (34)		5.6 (51)	3.7 (34)	
Hospital Bedsize						
<200	21.8 (707)	18.0 (164)	<0.001	19.5 (178)	18.0 (164)	0.303
200–400	52.3 (1698)	71.2 (649)		71.6 (653)	71.2 (649)	
>400	25.9 (841)	10.8 (99)		8.9 (81)	10.8 (99)	
Hospital Location						
Urban	90.9 (2952)	97.9 (893)	<0.001	97.5 (889)	97.9 (893)	0.6401
Rural	9.1 (294)	2.1 (19)		2.5 (23)	2.1 (19)	
Type of arthroplasty						
Anatomic TSA	62.1 (2014)	72.4 (660)	<0.001	73.0 (666)	72.3 (660)	0.793
Reverse TSA	37.9 (1232)	27.6 (252)		27.0 (246)	27.7 (252)	
Primary Diagnosis						
Osteoarthritis	84.3 (2735)	91.8 (837)	<0.001	92.9 (847)	91.8 (837)	0.800
Inflammatory Arthritis	1.5 (47)	0.9 (8)		0.6 (5)	0.9 (8)	
Post-Traumatic Arthritis	1.2 (39)	1.2 (11)		1.1 (10)	1.2 (11)	
Cuff Disorder	8.0 (258)	3.3 (30)		3.1 (28)	3.3 (30)	
Osteonecrosis	0.6 (20)	1.2 (11)		0.7 (6)	1.2 (11)	
Miscellaneous Arthritis	4.5 (147)	1.6 (15)		1.8 (16)	1.6 (15)	
History of Tobacco use						
Yes	25.6 (832)	29.2 (266)	0.034	28.2 (257)	29.1 (266)	0.679
No	74.4 (2414)	70.8 (646)		71.8 (655)	70.8 (646)	

Bold values indicate statistical significance which per our study was anything < 0.05

Table 3

Unadjusted and propensity-matched baseline medical comorbidities between general and regional anesthesia.

Comorbidities	Type of Anesthesia		P value before matching	General (n = 912) % (n)	Regional (n = 912) % (n)	P value after matching
	General (n = 3246) % (n)	Regional (n = 912) % (n)				
AIDS	0.03 (1)	0.00 (0)	0.781	0.0 (0)	0.0 (0)	N/A
Alcoholism	1.3 (43)	0.4 (4)	0.021	0.6 (5)	0.4 (4)	0.738
Congestive Heart Failure	3.0 (98)	0.8 (7)	<0.001	1.0 (9)	0.8 (7)	0.642
Chronic Pulmonary Disease	19.4 (630)	14.7 (134)	<0.001	14.3 (130)	14.7 (134)	0.842
Coagulopathy	1.4 (46)	1.5 (14)	0.755	1.8 (16)	1.4 (14)	0.713
Depression	15.3 (497)	13.1 (119)	0.092	12.3 (112)	13.1 (119)	0.673
Diabetes	20.7 (673)	11.1 (101)	<0.001	11.6 (106)	11.1 (101)	0.767
Drug Abuse	0.74 (24)	0.33 (3)	0.245	0.33 (3)	0.33 (3)	1.0
Hypertension	68.4 (2219)	57.0 (520)	<0.001	58.6 (534)	57.0 (520)	0.538
Hypothyroidism	15.6 (506)	16.0 (146)	0.757	17.5 (160)	16.0 (146)	0.415
Liver Disease	1.3 (43)	0.6 (5)	0.060	0.4 (4)	0.6 (5)	0.738
Neurologic Disorders	3.2 (103)	2.9 (26)	0.667	2.7 (25)	2.9 (26)	0.887
Obesity	16.9 (550)	21.9 (200)	<0.001	20.2 (184)	21.9 (200)	0.389
Obstructive Sleep Apnea	8.3 (268)	9.4 (86)	0.289	9.0 (82)	9.4 (86)	0.808
Peripheral Vascular Disease	2.9 (93)	0.9 (8)	<0.001	0.6 (5)	0.8 (8)	0.580
Chronic Renal Failure	4.8 (156)	3.0 (27)	0.017	2.2 (20)	3.0 (27)	0.376
Elixhauser Stratification						
Zero Comorbidities	12.5 (407)	14.7 (134)	<0.001	15.9 (145)	14.7 (134)	0.893
1 comorbidity	24.7 (803)	30.4 (277)		29.8 (272)	30.3 (277)	
2 comorbidities	26.9 (872)	27.1 (247)		27.2 (249)	27.1 (247)	
3 comorbidities	35.9 (1164)	27.9 (254)		27.0 (246)	27.9 (254)	

Bold values indicate statistical significance which per our study was anything < 0.05

As outlined in our methods, propensity-matching to adjust for baseline differences in covariates was performed. As our algorithm used one-to-one matching without replacement, we were left with an equal distribution of 912 patients in each cohort; 1824 total. Readjusted p-values and cohort distributions for each baseline covariate can be found in [Tables 1–3](#).

3.1. Outcomes

Differences in outcomes surrounding in-hospital complications were determined for the propensity-matched sample only, and can be found in [Table 4](#). While the majority of in-hospital perioperative complications did not differ significantly between groups,

Table 4

Differences in Outcomes between general and regional anesthesia for propensity-matched cohorts.

	Type of Anesthesia		Significance
	General (n = 912) Mean (SD)	Regional (n = 912)	
Length of Stay (days)	2.0 (1.3) % (n)	2.3 (0.9) % (n)	<0.001
Homebound Disposition			
Home	89.8 (819)	93.3 (851)	0.008
SNF	10.2 (93)	6.7 (61)	
In-hospital Post-operative Complications			
0 complications	90.9 (829)	90.9 (829)	0.002
1 complication	8.0 (73)	9.1 (83)	
2+ complications	1.1 (10)	0.0 (0)	
In-hospital postoperative complication			
CNS	0.0 (0)	0.0 (0)	n/a
Cardiac	0.22 (2)	0.44 (4)	0.687
Gastrointestinal	0.0 (0)	0.0 (0)	n/a
Genitourinary	1.32 (4)	0.88 (0)	0.368
DVT	0.0 (0)	0.0 (0)	n/a
Pulm. Embolism	0.11 (1)	0.22 (2)	0.563
Respiratory	1.32 (12)	0.55 (5)	0.081
Peripheral Vasc	0.0 (0)	0.11 (1)	0.317
Anemia	6.36 (58)	6.25 (57)	0.923
Hematoma/Seroma	0.11 (1)	0.0 (0)	0.317
Wound dehiscence	0.0 (0)	0.0 (0)	n/a
Acute renal failure	0.55 (5)	0.66 (6)	0.762
Infection	0.0 (0)	0.0 (0)	n/a

Bold values indicate statistical significance which per our study was anything < 0.05

respiratory complications trended towards being more significant in the GA group as compared to isolated RA (1.32% vs 0.55%, $p=0.081$). GA patients were significantly more likely to have 2 or more in-hospital postoperative complications (1.1% vs 0.0%, $p=0.002$) than those receiving isolated RA. While isolated RA patients tended to have a slightly greater LOS than GA patients (2.3 vs 2.0 days, $p<0.001$), GA was associated with a greater odds of extended LOS (OR 2.04, 95% CI 1.13–3.70, $p<0.001$). Additionally, GA was associated with greater rates of discharge to SNF than the use of isolated RA (10.2% vs 6.7%, $p=0.008$), representing an odds ratio of 1.60 (95% CI 1.13–2.22, $p<0.001$).

3.2. 90-day readmission rates

The overall 90-day readmission rate for entire cohort was 5.32% (97/1824). Patients receiving GA demonstrated greater rates of hospital readmission as compared to isolated RA (6.5% vs 4.2%, $p=0.036$), representing an odds ratio of 1.59 (1.05–2.42, $p<0.001$). While primary diagnosis at time of hospital readmission differed widely between anesthesia types, no statistically significant differences were observed (Table 5).

4. Discussion

Propensity-matched cohort analysis for patients undergoing TSA between 2011–2014 demonstrated that while associated with slightly longer LOS, isolated RA was associated with significantly greater rates of homebound discharge, lower total in-hospital complications, and reduced rates of hospital readmission than GA.

Before propensity-matching was performed, we noticed several notable differences in our unadjusted analysis. Compared to other races, black patients were more likely to receive GA. While we did not perform a multivariate analysis accounting for risk factors, previously published literature has reported that compared to other races, black race was independently associated with administration of GA (2.76, CI 1.96–3.88).⁴⁸ Similarly, we observed that privately-insured patients were much more likely to receive isolated RA than other insurances. This association with private insurance and the offering of more efficacious analgesia has been previously explored. Tighe et al. analyzed 3.9 million weighted ambulatory orthopaedic surgery procedures and found that after controlling for covariates, privately-insured patients were 2.62 times more likely to receive a nerve block for analgesic relief than

patients with self-care or charity reimbursement.⁴⁹ This phenomenon is not unique to orthopaedics, as numerous obstetrics studies have reported that private insurance and higher levels of maternal education are associated with greater rates of epidural anesthesia administration during labor and delivery.^{50,51}

In our unadjusted analysis, isolated RA was almost exclusively performed at urban, teaching hospitals – a trend that has been previously reported.^{52,49} The finding is likely associated with the overwhelming predominance of academic medical centers in urban regions, and the trend of isolated RA being performed primarily at academic centers where fellowship-trained faculty tend to practice.^{49,53}

With the exception of obesity, major medical comorbidities were more prevalent in patients receiving GA, a finding previously reported in TJA.^{33,54,55} Our observation that obese patients were more likely to receive isolated RA echoes current anesthesia trends, as obesity confers an increased risk of hypoxia in the perioperative setting,⁵⁶ and large doses of concomitant opioids associated with GA can significantly increase risk of respiratory depression and post-operative pneumonia in this high-risk cohort.^{57–59} These findings, along with the growing availability and popularity of ultrasound-guided RA result in the majority of obese patients now receiving regional blockade.^{60–63} Similar to obesity, tobacco history was associated with increased isolated RA administration. As smoking causes microvascular changes to lung parenchyma that predisposes patients to intraoperative laryngospasm and cardiovascular compromise, anesthesiologists often avoid GA in these patients, since certain induction agents themselves induce bronchoconstriction.^{64,65}

Our finding that patients receiving rTSA were more likely to receive GA is likely related to the greater overall comorbidity burden in patients undergoing rTSA as compared to aTSA.^{30,66–68} The subsequent observation that patients with a rotator cuff disorder diagnosis were more likely to receive GA can be attributed to the fact that rTSA, not aTSA, is performed for cuff tear arthropathy.^{30,67}

Overall, results from our unadjusted analysis demonstrating that patients receiving GA had greater comorbidity burden and were more likely to be treated at an urban teaching hospital are reflective of current trends within orthopaedics and anesthesia.

4.1. Propensity-matched cohort analysis

Results from our propensity-matched analysis demonstrate several significant findings that have not been previously reported in the context of shoulder arthroplasty. Our original hypothesis that isolated RA would result in shorter LOS was not corroborated by our results, as GA demonstrated a slightly shorter LOS than isolated RA (2.0 vs 2.3 days). While this observed difference is statistically significant, we feel that the mean difference of 0.3 days is not clinically significant, as it represents only a few hours between discharge times. Notably, GA was associated with two-times greater odds of having extended LOS (OR 2.04, CI 1.13–3.70, $p<0.001$), suggesting that when discharge was not expeditious, GA placed a significantly greater burden on hospital resources than isolated RA.

Our hypothesis that isolated RA would be associated with increased homebound discharge was validated, as 93.3% of patients receiving isolated RA were discharged home as compared to only 89.8% of GA ($p=0.048$). RA has numerous beneficial effects in upper extremity surgery such as reduction of subjective pain scores²³ and reduced narcotic intake^{21,69} resulting in earlier mobilization^{70,27} and improved patient satisfaction.^{71,19,23,17} The cumulative effects of these benefits may be reflective in our finding that isolated RA was associated with greater homebound discharge than GA.

Table 5
90-day readmission rates between general and regional anesthesia.

	Type of Anesthesia		Significance
	General (n=912) % (n)	Regional (n=912) % (n)	
Readmission within 90 days	6.5 (59)	4.2 (38)	0.036
Reason for Readmission			
Mechanical Prosthesis issue	8.5 (5)	13.2 (5)	0.510
Fluid & Electrolyte Disorder	5.1 (3)	2.6 (1)	0.563
Infection	10.2 (6)	7.9 (3)	0.746
Venous Thrombotic Related	3.4 (2)	0.0 (0)	0.251
Cardiac Complications	10.2 (6)	18.4 (7)	0.390
Respiratory Complications	10.2 (6)	7.9 (3)	0.706
Urinary Tract Infection	5.1 (3)	2.6 (1)	0.563
GI Complication	18.6 (11)	18.4 (7)	0.978
Neurologic Complication	3.4 (2)	13.1 (5)	0.158
Fracture	3.4 (2)	2.6 (1)	0.834
Miscellaneous	22.0 (13)	13.1 (5)	0.407

Bold values indicate statistical significance which per our study was anything <0.05

In our propensity-matched cohort, we did not observe differences in specific postoperative in-hospital complications. Of note, TSA is associated with significantly shorter LOS and lower complication rates than most other orthopaedic procedures.⁷² As such, it is possible that our failure to observe statistically significant differences could be due to traditionally lower prevalence of complication rates in TSA. In this regard, it is worth noting that respiratory complications trended towards being significantly greater in the GA cohort as compared to isolated RA (1.32% vs 0.55%, $p=0.081$), a finding extensively reported both in orthopaedics and anesthesia literature.^{73,32,65,74} GA is widely implicated in abnormal intraoperative diaphragmatic motion, atelectasis, and increased need for postoperative mechanical ventilation.^{75–77} Despite the lack of significant difference between specific postoperative complications, RA was associated with significantly lower rates of *aggregate* in-hospital complications, and no patients in the RA cohort had 2 or more post-operative complications.

Our overall 90-day readmission rate after TSA of 5.32% falls within previously published values ranging from 2.5%–7.3%.^{42,78,79} Our finding that GA was associated with an increased odds of hospital readmission within 90 days as compared to RA is similar to findings in TJA, and the first commentary within shoulder arthroplasty literature.^{80,32,81} With healthcare growing increasingly quality-focused and bundled-payment initiatives requiring hospitals to be financially responsible for all hospital readmissions within 90 days of discharge,^{31,82,83} the ability of physicians and hospitals to prevent complications and readmission is growing increasingly important. We did not observe significant differences in the reasons for hospital readmission between cohorts, which as previously suggested may be potentially attributed to low rates of occurrence. Notably however, isolated RA patients were readmitted more often for mechanical prosthesis-related issues, which presumably are *not* related to anesthesia modality, while GA was more often associated with readmission for medical complications.

4.2. Limitations

Our study has limitations inherent to database studies.⁸⁴ Errors in ICD-9 coding could potentially result in over or under-reporting of outcomes. The most significant limitation was our inability to differentiate between patients receiving just general anesthesia and those who received general with regional blockade. The addition of regional blockade to general anesthesia could potentially alter results, however as the SPARCS database only provides information for the single highest level of anesthesia provided, we cannot comment on these differences. This limitation is similar to studies that examine the effect of anesthesia type in TJA.³² Additionally, we were unable to comment on American Society of Anesthesiologists Classification, which would be useful in a study examining anesthesia-related outcomes. Due to the database nature of our study, we could potentially have under-identified certain inherent patient characteristics, however our large sample size and robust propensity-matching algorithm attempted to best control for all known variables, and was modeled off prior peer-reviewed publications.^{45,33,32,85} Our ability to successfully use propensity-matching to appropriately balance covariates and estimate treatment effects provides significant value to our study. Additionally, our data encompassing 2011–2014 is most reflective of current trends in orthopedics, providing physicians with clinically relevant and timely findings. Finally, our ability to report 90-day readmissions provides particularly useful data within the context of current healthcare regulations, potentially allowing hospitals to develop protocols and consensus guidelines regarding anesthesia modalities.

5. Conclusion

Our propensity-matched cohort analysis demonstrated that in the setting of TSA, isolated RA is associated with slightly longer mean LOS but significantly less odds of extended LOS. Furthermore, compared to GA, the administration of RA was associated with significantly lower rates of total in-hospital complications, reduced 90-day hospital readmissions, and greater homebound discharge. As healthcare continues to grow quality-conscious and reimbursements in orthopaedics become increasingly dependent on reducing complications and readmissions, physicians and multidisciplinary teams are encouraged to consider the potentially beneficial impact of isolated RA in appropriately selected patients undergoing TSA.

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Conflict of interest

The authors have none to declare.

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