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ORIGINAL PAPER

Epidemiologic data and trends concerning the use of regional anaesthesia for shoulder arthroscopy in the United States of America

David Ende[1] · Rodney A. Gabriel[1] · Kamen V. Vlassakov[1] · Richard P. Dutton[2] · Richard D. Urman[1,3]

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Abstract
Background Despite a growing body of literature illustrating the benefits of regional anaesthesia in shoulder arthroscopy, data on actual use of the technique in the United States is lacking. This study analyses epidemiologic data to describe current trends in anaesthetic practice for these procedures in the United States and highlights key associations with patient and provider demographic variables that may provide further insight.
Methods We analysed the large database from the National Anesthesia Clinical Outcomes Registry of the Anesthesia Quality Institute. Of the 26,568,734 records available and after applying our exclusion criteria, we identified 169,878 shoulder arthroscopies performed from 2010 to 2014. The cases concerned all types of arthroscopic surgical procedures performed regardless of pathology (e.g. arthritis, instability, rotator cuff tears) These cases were sorted into three anaesthetic types consisting of general anaesthesia alone (GA, 62 %), general plus regional anaesthesia (GA+RA, 36 %) and RA alone (RA, 2 %).
Results RA alone was more highly associated with board-certified anaesthesiologists practicing at university hospitals, older patients, patients with higher American Society of Anesthesiologists (ASA) classification and shorter procedures. RA is rarely used as the primary anaesthetic for these procedures across the country, while there is a steadily growing rate of GA+RA combination anaesthetics.
Conclusions Numerous advantages have been reported for utilizing RA and avoiding GA. The low rate at which RA is used as the sole anesthetic may represent room for improvement nationwide. GA+RA combination technique quickly became the predominant anaesthetic choice for shoulder arthroscopy during the five years of this analysis.
Level of Evidence: III

Keywords Shoulder arthroscopy · Anaesthesia · National Anesthesia Clinical Outcomes Registry · Anesthesia Quality Institute · Regional anaesthesia · Outcomes

Introduction

Shoulder arthroscopies are amongst the most common orthopedic procedures; greater than 1.4 million are performed worldwide each year [1]. First introduced in the 1980s as a mostly diagnostic procedure, the technique has evolved to provide a minimally invasive treatment option for many different shoulder pathologies [2]. The benefits of this minimally invasive technique versus open arthrotomy are numerous, including improved pain control and cosmesis and a relatively low complication rate [3]. Pain control, however, can still be challenging, with 20 % of patients reporting maximum pain imaginable on post-operative day one [4]. Despite the growing number of arthroscopic surgery on the shoulder and an overall increase in the peri-operative use of regional anaesthesia (RA), there appears to be a resistance to the use of RA as the sole anaesthetic for shoulder arthroscopies. Although the reason for this resistance is unclear, the perception that it takes longer to perform a regional anaesthetic, the risk of

✉ Richard D. Urman
rurman@partners.org

[1] Department of Anesthesiology, Perioperative and Pain Medicine, Brigham and Women's Hospital/Harvard Medical School, 75 Francis St, Boston, MA 02115, USA

[2] US Anesthesia Partners, Dallas, TX 75225, USA

[3] Department of Anesthesiology, Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02115, USA

complications and failed blocks have been hypothesised as concerns [5, 6].

There is no shortage of literature comparing regional (RA) and general (GA) anaesthesia for these procedures in a variety of settings. Regional anaesthesia has been shown to provide excellent intra-operative analgesia and muscle relaxation without systemic paralysis [7]. When GA is avoided, so, too are the risks associated with airway manipulation and the haemodynamic instability that is frequently encountered. As large doses of opioids are avoided, the incidence of post-operative nausea and vomiting is decreased as well. Despite lower opioid use, pain control and patient satisfaction are superior [8, 9]. Efficiency is also improved, with decreased operating room time, anaesthesia control time, post-anaesthesia care unit (PACU) time and fewer unplanned admissions [5, 10], which in turn decreases overall cost [11]. Lastly, all of these benefits are achieved with an extremely low complication rate [12, 13]. Despite this, GA is still the far more prevalent approach.

The primary aim of this study was to describe current variations in practice across the United States and provide some insight into which factors contribute to the choice of anaesthesia. To achieve this, we used the largest anaesthesia patient database in the country—the National Anesthesia Clinical Outcomes Registry (NACOR) of the Anesthesia Quality Institute (AQI) [14]. We evaluated an aggregation of all cases in this registry seeking to evaluate trends in anaesthesia practice, identify factors that may play a role in anaesthetic management of shoulder arthroscopies, as well as present outcome data associated with each anaesthetic choice. Our hypothesis was that there are many identifiable factors that influence anaesthetic choice and create variability of anaesthetic practice and that there may be an opportunity to increase the rate of RA in shoulder arthroscopy. Additionally, we hypothesised that there would be significant outcome differences depending on type of anaesthetia administered.

Materials and methods

Ethical approval

We received an exempt protocol approval for this study by the Brigham and Women's Hospital institutional review board.

Data source

In this study, we analysed data collected by AQI from January 2010 to December 2014. The data set consisted of 26,568,734 records accumulated through the NACOR from more than 100 heterogeneous sources. The database was accessed on 1 February 2015. Because patient records in the database are de-identified, it meets criteria of the Health Insurance Portability and Accountability Act to protect personal information and was exempt from the consent requirement by our institutional review board. NACOR is a voluntary-submission registry, with institutions that participate in the sharing of anaesthesia-related data and outcomes to evaluate the quality of care both nationally and locally. NACOR participants are a diverse group of private and academic practices from across the United States, and NACOR data are increasingly used to describe the scope of American anaesthesia care. The AQI database contains deidentified patient information and various data related to patient demographics, billing, procedural, diagnostic, and provider information, as well as reported adverse events [15–17].

Study sample

Shoulder arthroscopies were identified by including cases that had a primary surgical current procedural terminology (CPT) code of 29805, 29806, 29807, 29819, 29822, 29823, 29824, 29826, 29827, or 29828. Only cases that identified primary anaesthetic plan as either general (GA) or regional (RA) anaesthetic were included. All other cases, including cases where primary anaesthetic type was unknown, were excluded from the analysis. We also excluded all cases with American Society of Anesthesiologists Physical Status (ASA PS) class 6 and cases missing data for ASA PS class, age, sex, case duration, facility type, and region. Among surgery under GA, cases in which peripheral nerve block was used were extracted by identifying the existence of CPT codes 64415 (brachial plexus block, single shot) or 64416 (brachial plexus block with catheter).

Patient, intra-operative and facility characteristics were compared in the primary anaesthetic groups GA, GA+RA) and RA groups. Patient demographics included age, sex, and ASA PS class. Intra-operative data collected included case duration (in minutes), presence of an anaesthesiology resident, presence of a certified registered nurse anaesthetist (CRNA), board-certification status of supervising anaesthesiologist, and year of surgery. Facility characteristics collected were facility type and US regional. Facility types included university hospitals, large community hospitals (>500 beds), medium-sized community hospitals (100–500 beds), small community hospitals (<100 beds) and other facility types. United States regions included Northeast, Midwest, South, and West. Likewise, anaesthesia-related adverse outcomes were also compared. Outcomes were case delay, cardiac arrest, arrhythmia, extended recovery-room stay, haemodynamic instability, eye injury and unplanned admission. All outcomes recorded in NACOR are defined to have occurred either intra-operatively or up to discharge from the recovery room or admittance to the intensive care unit (ICU).

Statistical analysis

R Project for Statistical Computing (R version 3.1.2) was used to perform all statistical analyses. Welch's two-sample *t* test was used to compare means for continuous variables. *P* values < 0.05 were considered indicative of statistical significance. A univariate logistic regression model was fitted to test whether the various patient, intra-operative and facility characteristics were associated with: (1) the use of RA vs GA as primary anaesthetic; (2) the use versus no use of peripheral nerve blocks with GA. Results from the logistic regression were reported as odds ratios (ORs) with their associated 95 % confidence intervals (CIs). For each exposure group, a reference variable was defined and is reported in the appropriate tables. Clinical adverse outcomes and absolute counts for the described outcomes were also collected. The denominator for the counts was based on how many cases in NACOR were eligible to report that particular outcome. Pearson χ^2 was used to compare categorical variables between two groups.

Results

We identified 169,878 cases that met inclusion and exclusion criteria. Of these cases, 105,666 (62 %) were performed under GA, 60,765 (36 %) with GA+RA and 3447 (2.0 %) under RA alone. Patient demographics are documented in Table 1. Patients who received RA alone were on average older than those who received GA or GA+RA ($p < 0.001$). ASA class I patients were more likely to receive GA+RA ($P < 0.001$).

Table 2 presents intra- operative and provider data as well as cases broken down by year. A number of these variables show significant differences between groups. Intra-operative mean case duration was shortest for RA alone ($p < 0.001$), and cases taking ≤1 h were more likely to receive RA alone ($p < 0.001$ 11 % vs 8 % GA and 6 % GA+RA). While data on anaesthesia provider presence is significant, there was incomplete reporting, as noted by the "Unknown" line in Table 2. Despite this, we found that when RA alone was used, it was more likely to be with a board-certified anaesthesiologist present (79 % RA alone vs 55 % GA alone vs 48 % GA+RA, $p < 0.001$). The frequency of cases performed with RA alone declined significantly between 2010 and 2014, with 2010–2011 averaging 3.5 % of cases with RA alone and steadily declining to 1.2 % by 2014. However, the rate of GA+RA increased significantly during that time period, beginning with 7 % of GA+RA cases in 2010 and quickly increasing to 34 % in 2014. Figure 1 illustrates the trend of GA+RA becoming the most common anaesthetic type over the years of this analysis.

Descriptive data about the facilities in which these cases took place is available in Table 3. The majority of procedures were in surgical centres and medium-sized community hospitals. Only 2.3 % of these procedures took place at university hospitals and were the most likely to use RA alone ($p < 0.001$). Overall, however, they used RA the least, as illustrated in Fig. 2. While rates of RA alone are higher at university hospitals, it appears that the use of RA overall is lowest at university hospitals when accounting for the significantly decreased prevalence of GA+RA. Small community hospitals and outpatient surgical centres (which make up a very large portion of the "other" category), on the other hand, appear to be the most prevalent users of RA overall despite their low use of RA alone.

Table 1 Patient demographics

	GA alone		GA+RA		RA alone		*P*-value
	n	%	*n*	%	*n*	%	
Total	105,666	62.2	60,765	35.77	3447	2.03	
Age (years)							
Mean	51.77 ± 15.24		52.35 ± 14.9		54.11 ± 14.4		*<0.001*
<1	8	0.01	1	0	0	0	*<0.001*
1–18	3755	3.55	1855	3.05	59	1.71	
19–49	36,985	35	20,388	33.55	1051	30.49	
50–64	43,418	41.09	25,787	42.44	1523	44.18	
65–79	19,956	18.89	11,920	19.62	747	21.67	
80+	1544	1.46	814	1.34	67	1.94	
Sex							
Male	62,373	59.03	36,273	59.69	2020	58.6	*0.021*
Female	43,293	40.97	24,492	40.31	1427	41.4	
ASA PS							
I	32,058	30.34	19,634	32.31	809	23.47	*<0.001*
II	51,606	48.84	29,456	48.48	1871	54.28	
≥III	22,002	20.82	11,675	19.21	767	22.25	

ASA PS American Society of Anesthesiologists Physical Status, *GA* general anaesthetic, *RA* regional anaesthetic

Table 4 shows results of two binomial logistic regressions comparing RA alone vs GA alone and GA ± RA. These regression models were constructed to determine whether key variables were associated with anaesthetic type and to perhaps shed some light on which variables may influence anaesthetic decision making in shoulder arthroscopy. Patient, provider and location factors had significant associations.

There was a significant association of anaesthetic type and age, with increasing age associated with increasing likelihood of RA alone. Patients ≥80 years old, however, showed no significant difference in likelihood to receive GA+RA vs GA alone. ASA classification proved to have significant variability, although patients with ASA ≥II had a significantly higher likelihood of RA alone vs GA alone. Case duration >1 h was associated with either GA alone or GA+RA, while RA alone was less likely to be of longer duration. RA alone was statistically associated with having a board-certified

Table 2 Intra-operative data

	GA alone		GA+RA		RA alone		*P*-value
	n	%	*n*	%	*n*	%	
Total	105,666	62.2	60,765	35.77	3447	2.03	
Case duration (minutes)							
Mean case duration	115.78 ± 88.26		113.28 ± 50.77		104.59 ± 60.83		*<0.001*
0–60 min	8631	8.17	3590	5.91	369	10.7	*<0.001*
61–180 min	89,829	85.01	53,217	87.58	2850	82.68	
>180 min	7206	6.82	3958	6.51	228	6.61	
Resident status							
Resident present	4829	4.57	1534	2.52	232	6.73	*<0.001*
Resident not present	32,150	30.43	15,675	25.8	646	18.74	
Resident presence not known	68,687	65	43,556	71.68	2569	74.53	
CRNA status							
CRNA present	43,604	41.27	34,437	56.67	1476	42.82	*<0.001*
CRNA not present	45,338	42.91	19,296	31.76	1928	55.93	
CRNA presence not known	16,724	15.83	7032	11.57	43	1.25	
Board-certification status							
Board-certified anaesthesiologist	58,229	55.11	29,099	47.89	2714	78.74	*<0.001*
Board-certified anaesthesiologist not present	28,822	27.28	14,809	24.37	590	17.12	
Board-certified anaesthesiologist status not known	17,322	16.39	16,856	27.74	137	3.97	
Year							
2010	17,847	16.89	4340	7.14	810	23.5	*<0.001*
2011	20,852	19.73	5607	9.23	887	25.73	
2012	24,387	23.08	10,183	16.76	571	16.57	
2013	23,033	21.8	20,220	33.28	695	20.16	
2014	19,547	18.5	20,415	33.6	484	14.04	

CRNA certified registered nurse anaesthetist

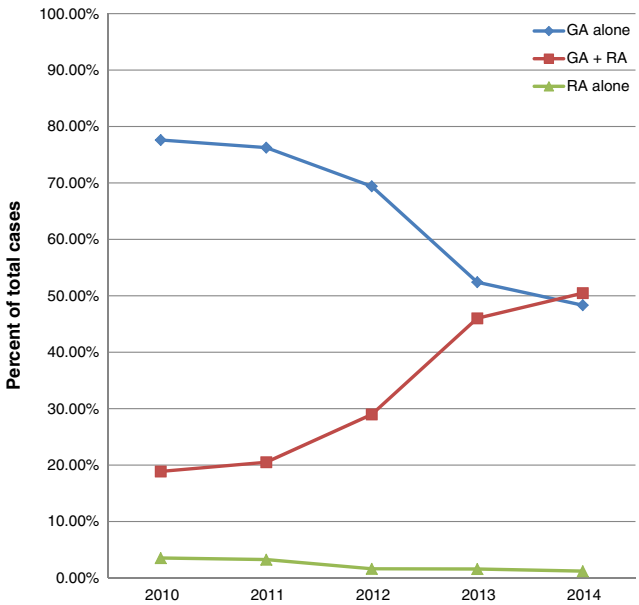

Fig. 1 Changes in anesthetic type distribution

anaesthesiologist and a resident present (OR 2.3 and 2.7, respectively). In the presence of a CRNA, GA+RA was more likely than GA alone (OR 1.86). However, in the presence of a resident, GA alone was more likely than GA+RA.

Case year also contributed to a significant trend. There was an overall decreased OR for RA alone when referenced to the baseline year 2010: from 2012 to 2014, each year was less likely to be associated with RA alone, with a final OR of 0.33. In contrast is the trend of GA+RA becoming much more likely compared with GA alone with each year, culminating with an OR of 4.29 for cases performed in 2014 when compared with 2010. Table 5 reports adverse outcomes data with associated OR. We evaluated data for many widely reported outcome measures and for reference included in the denominator column the total number of cases reporting this type of data. Hemodynamic instability and nausea/vomiting were significantly decreased with RA alone compared with GA alone. There were no cases of arrhythmia, cardiac arrest or death associated with RA alone. GA resulted in reports of some cases of each aforementioned complication (Tables 5), albeit

Table 3 Facility data

	GA alone		GA+RA		RA alone		*P*-value
	n	%	*n*	%	*n*	%	
Total	105,666	62.2	60,765	35.77	3447	2.03	
Facility type							
University Hospital	3000	2.84	824	1.36	220	6.38	*<0.001*
Large Community Hospital	5327	5.04	2696	4.44	188	5.45	
Medium Community Hospital	39,101	37	14,155	23.29	732	21.24	
Small Community Hospital	4784	4.53	3918	6.45	34	0.99	
Other	53,454	50.59	39,172	64.46	2273	65.94	

GA general anaesthesia, *RA* regional anaesthesia

with a much larger denominator.We also compared adverse outcomes for GA alone vs GA+RA; case delay and nausea/vomiting were significantly decreased when RA was performed in addition to GA (Table 6).

Discussion

While there appears to be no shortage of research devoted to determining in detail which anaesthetic choice results in better outcomes for shoulder arthroscopy, there is no data describing current-practice trends in the United States [5, 7–13, 18, 19]. This analysis attempts to fill that data gap.

Our study demonstrates a nationwide trend that strongly favours GA alone or in combination with RA vs RA alone for shoulder arthroscopy. The gradual decline in rates of RA as the sole anaesthetic for these cases since 2010 is surprising given the overall nationwide trend of increasing RA use for orthopaedic [20] and many other procedures [21]. With rising concerns in the medical community over cost-effective care, one could expect a yearly trend to show an increase in the use

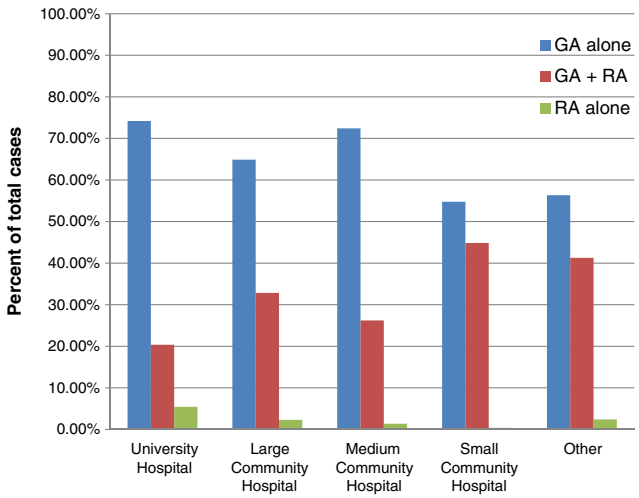

Fig. 2 Distribution of anesthesia type by institution

of RA alone. It has been described that RA alone is an economically efficient strategy for these cases [11] and has the ability to significantly decrease patient transit time and increase throughput through all stages of operative care. There is also a vast body of literature confirming that RA alone, specifically the interscalene nerve block for arthroscopic shoulder surgery, is well tolerated, safe and associated with improved patient satisfaction, post-operative pain control and decreased unplanned hospital admission rates [4–6, 9, 12, 13, 22–25]. Our data on adverse outcomes presented in Tables 5 and 6 reinforce this, as hemodynamic instability and nausea/vomiting had significantly lower incidence with RA alone.

The very significant increase of RA+GA, however, represents an overall increase in the use of RA and likely reflects the recognised role of RA as more than simply a method of post-operative pain control. This combined technique has become increasingly popular over the last 4 years as a means of combining the clear benefits of RA and minimising some drawbacks of GA. It offers advantages such as decreased GA needs and peri-operative opioid use, increased flexibility in intraoperative ventilation choices (since no continuous muscle paralysis is needed) and ability to "control the airway" in a surgical procedure where access to the airway is severely limited. This practice may be appealing as a "best-of-both-worlds" approach, but one could debate that the advantages of avoiding GA could be more significant and represent more aspects of the described superiority of RA alone vs GA [26].

In addition to describing recent trends in RA use, we identified several factors that seem to make RA alone more likely to be performed. As seen in Table 4, RA alone was more highly associated with older patients and an increasing number of comorbidities (ASA class ≥II). This is an expected finding, since older patients are less likely to tolerate GA and opioid-based pain control [27]; a similar trend holds true for patients with increasing ASA classification [28]. Opting for primary RA in patients more likely to have significant cardiopulmonary disease is not a surprising choice, as RA alone has been well reported to be associated with improved haemodynamic stability [29]. Our findings confirm this

Table 4 Logistic regression

Category	Reference value	RA alone vs GA alone	GA+RA vs GA alone
Age group	19–49		
1–18 years		***0.57*** (***0.44–0.75***)	***0.90*** (***0.85–0.95***)
50–64		***1.2*** (***1.11–1.30***)	***1.08*** (***1.05–1.10***)
65–79		***1.28*** (***1.116–1.41***)	0.96 (0.88–1.04)
80+		***1.55*** (***1.21–1.99***)	0.96 (0.88–1.04)
Sex	Female		
Male		1.03 (0.96–1.10)	***0.97*** (***0.95–0.99***)
ASA class	I		
II		***1.47*** (***1.36–1.60***)	***0.93*** (***0.91–0.95***)
≥III		***1.46*** (***1.32–1.61***)	***0.87*** (***0.84–0.89***)
Case duration (min)	0–60		
61–180		***0.66*** (***0.59–0.74***)	***1.42*** (***1.37–1.48***)
>180		***0.68*** (***0.57–0.80***)	***1.32*** (***1.25–1.40***)
Resident	Not present		
Present		***2.7*** (***2.32–3.14***)	***0.65*** (***0.61–0.69***)
CRNA	Not present		
Present		***0.63*** (***0.59–0.68***)	***1.86*** (***1.82–1.90***)
Board-certified	Not certified		
Certified		***2.3*** (***2.1–2.51***)	0.97 (0.95–1.00)
Year	2010		
2011		***0.92*** (***0.83–1.01***)	***1.11*** (***1.06–1.16***)
2012		***0.45*** (***0.41–0.5***)	***1.72*** (***1.65–1.79***)
2013		***0.44*** (***0.4–0.49***)	***3.61*** (***3.47–3.75***)
2014		***0.33*** (***0.3–0.37***)	***4.29*** (***4.13–4.46***)

RA regional anaesthetic, *GA* general anaesthetic, *ASA* American Society of Anesthesiologists, *CRNA* certified registered nurse anaesthesiologist

(Tables 5 and 6). Despite this association in higher-risk patients, raw case numbers still heavily favor GA. Even with the most extreme example of patient age in this data set—80+ years old (Table 1)—only 2.8 % of these patients received RA alone; they were no more likely to receive a nerve block in addition to GA.

There can be several reasons for this apparent resistance to the use of RA as primary anaesthetic. These may include and reflect some anaesthesiologists' relative inexperience with RA, concerns for failed or incomplete blockade, surgeons' lack of familiarity with the benefits of RA, time pressures (particularly for quick turnover cases that include shoulder

Table 5 Adverse outcomes: general (GA) versus regional (RA) anaesthesia

	GA			RA			OR (95 % CI)
	n	Denominator	%	*n*	Denominator	%	
Case delay	609	13,192	4.62 %	0	1064	0.00 %	–
Cardiac arrest	6	27,933	0.02 %	0	951	0.00 %	–
Arrhythmia	12	8934	0.13 %	0	222	0.00 %	–
Death	2	26,312	0.01 %	0	967	0.00 %	–
Extended PACU stay	286	26,954	1.06 %	0	309	0.00 %	–
Hemodynamic instability	1632	7526	21.68 %	6	271	2.21 %	***0.08*** (***0.036–0.18***)
Eye injury	38	25,658	0.15 %	3	948	0.32 %	2.14 (0.66–6.94)
N/V	3046	32,814	9.28 %	15	1105	1.36 %	***0.13*** (***0.08–0.22***)
Unplanned admission	78	31,485	0.25 %	2	375	0.53 %	2.16 (0.53–8.82)

PACU postanaesthesia care unit, *N/V* nausea/vomiting, *OR* odds ratio, *CI* confidence intervals

Table 6 Adverse outcomes: general (GA) versus general plus regional (GA+R) anaesthesia

	GA alone			GA+RA			
	n	Denominator	%	*n*	Denominator	%	OR (95 % CI)
Case delay	598	8344	7.15 %	12	4848	0.25 %	***0.032* (*0.018–0.057*)**
Cardiac arrest	3	24,114	0.01 %	3	3818	0.08 %	***6.32* (*1.28–31.32*)**
Death	2	22,767	0.01 %	0	3544	0.00 %	–
Extended PACU stay	264	24,093	1.10 %	22	2861	0.77 %	0.7 (0.45–1.08)
Hemodynamic instability	1632	7189	22.70 %	0	337	0.00 %	–
N/V	2875	26,036	11.04 %	171	6778	2.52 %	***0.21* (*0.18–0.24*)**
Unplanned admission	70	26,656	0.26 %	8	4829	0.17 %	0.63 (0.30–1.31)

PACU postanaesthesia care unit, *N/V* nausea/vomiting, *OR* odds ratio, *CI* confidence intervals

arthroscopy) and concerns about complications [6, 21]. Several additional patient-, surgeon- and anaesthesiologist-related factors may account for resistance to adopting RA alone as the anaesthetic of choice specifically for these procedures. For patients, the significant discomforts of being awake with the face mostly covered by drapes and surgery proceeding in the immediate vicinity while their head is immobilised can be less appealing. For surgeons, added time pressure and additional considerations required when operating on an awake patient can be seen as detractors. For anaesthesiologists, the lack of airway access and control and the fine balancing act of sedation vs the relative "peace of mind" when using GA may make it a less comfortable choice.

Our data may suggest that anaesthesiologist inexperience and concerns over block quality could possibly play a role in decreased rates of RA use alone. While small (and logically less academic) hospitals and surgery centres perform RA alone the least, they provide the largest percentage of GA+RA in the database (Fig. 2). While the significant increase of GA+RA may be interpreted as evidence of improving penetrance of these techniques, we surmise that it may instead represent a reluctance to trust RA techniques to act as the sole anaesthetic. There may be less perceived risk by anaesthesia providers uncomfortable with RA to perform a nerve block with the knowledge that the patient will receive GA as well, as this could mitigate the downside of a failed block. This middle ground of GA+RA may ultimately prove to trend towards RA alone in order to maximise the benefits of a primary RA once providers gain confidence in their techniques. The trend towards overall increased RA use in smaller hospitals and ambulatory surgery centres likely is explained by the necessity to comfortably discharge patients on the day of surgery, while larger centres may be more likely to admit patients and therefore have less of an institutional need for robust pain control with minimal opioids.

With regard to concerns by anaesthesia providers about complications, there has been no shortage of literature showing how safe RA for shoulder procedures has become [5–7, 12]. Our outcomes data also support this notion, showing very low incidences of adverse cardiac events for RA alone. Notably, however, there was an increased OR of 6.32 for cardiac arrest when RA was performed in addition to GA. Such low incidences provoke a very wide CI (95 % CI 1.28–31.32), casting doubt on the true significance of this finding. Our data does not, however, examine quality of life after or long-term outcomes related to surgery, as these have been reported by others [30, 31].

Our study is the first to evaluate nationwide trends in anaesthetic practice for shoulder arthroscopy. Fleischut and colleagues recently performed a similar analysis in regards to total knee replacement and detailed the benefits and limitations of using this and other databases for detailing national practice patterns [20]. There is also previously published literature evaluating differences in outcomes between board-certified and non–board-certified anaesthesiologists [32] and documenting benefits of specialised care of the elderly [33]. No study until now, however, has examined these variables for shoulder arthroscopy.

Our study is a retrospective, observational data set analysis and therefore has several fundamental limitations. No causal relationship conclusions can be drawn from our analysis, although we speculate as to some possible reasons for these trends in this discussion in an effort to further characterise the state of recent anaesthesia practices. We are reporting associations drawn from a large sample size, but since it is impossible to ascertain the details of the decision-making process of anaesthetic choice, we could not collect or analyze the variables considered by the treating clinicians. Additionally, due to data set limitations, we were unable to stratify arthroscopic procedures by pathology or specific procedure. Therefore, we cannot comment whether there is variation of anaesthetic choice depending on specific type of shoulder arthroscopic procedure. Our use of the NACOR database introduces some further limitations, which have been previously described, and include selection bias, nonrandom retrospective data

collection, outcome bias and possible geographic imbalance in data collection [34]. These, in combination with possible data entry errors and misclassification biases that come with such a large sample collected by independent reporters, need to be taken into account when evaluating these results. Due to a large number of cases and facilities reporting to the NACOR, there is also significant variability in amount and type of data reported, which leads to a noteworthy amount of missing data. While descriptive provider information was relatively uniform in comparison, the most affected data was adverse outcomes variables. Prior authors chose to eliminate reporting outcomes with similar analyses due to this heterogeneity [20]. Although we chose to report adverse anaesthesia-related outcomes for shoulder arthroscopy for the sake of completeness, these data need to be evaluated cautiously, keeping in mind its significant limitations.

Conclusion

Our study is amongst the first to describe nationwide trends in anaesthetic practice with analysis of corresponding patient and provider demographic variables in shoulder arthroscopy. We detected key variables associated with the use of RA as both primary anaesthetic or in combination with GA. RA alone was more highly associated with procedures performed at university hospitals, older patients and patients with higher ASA classification. We were also able to describe just how rarely RA is used as the primary anaesthetic for these procedures across the country and the steadily growing rate of the GA+RA combination. We submit that there is room for improvement given the body of literature expounding the benefits of RA alone for such cases. We also report select adverse outcome data with results that correlate with the already described safety and merits of RA, although outcomes data does have some significant limitations.

Compliance with ethical standards This work attributed to the Department of Anesthesiology, Perioperative and Pain Medicine, Brigham and Women's Hospital, Boston, MA, and the Anesthesia Quality Institute. IRB approval (#2013P002392, titled Analysis of Data reported from the Anesthesia Quality Institute's NACOR database) was obtained from the host institution, Brigham and Women's Hospital

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Conflict of interest The authors declare that they have no conflict of interest

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