Anesthesia in Total Shoulder Arthroplasty

A Systematic Review and Meta-Analysis

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Abstract

» For shoulder arthroplasty, regional anesthesia is safer when compared with general anesthesia. There is insufficient evidence to demonstrate the superiority of regional anesthesia with respect to pulmonary complications and hospital length of stay.

» Infiltration of the shoulder with local anesthetics offers no additional benefits compared with single-shot or continuous brachial plexus blocks for shoulder arthroplasty.

» There is high-quality evidence (Level I) demonstrating lower pain scores and lower perioperative opioid requirements after a continuous peripheral nerve block compared with a single-shot nerve block. However, catheter dislodgment and logistical issues with catheter insertion are impediments to the widespread usage of a continuous nerve block with an indwelling catheter.

» Liposomal bupivacaine is comparable with non-liposomal local anesthetic agents with respect to pain relief, the opioid-sparing effect, and adverse effects in the first 48 hours after total shoulder arthroplasty.

» Perioperative dexamethasone administration improves postoperative pain control, decreases perioperative opioid requirements, and reduces postoperative nausea.

Total shoulder arthroplasty (anatomic total shoulder arthroplasty [aTSA] and reverse total shoulder arthroplasty [rTSA]) is among the fastest growing orthopaedic procedures being performed annually in the United States[1,2]. The combination of increasing indications for rTSA and an increasingly aging population have caused the number of shoulder arthroplasty procedures to rise[1,2].

Reimbursement for shoulder arthroplasty procedures is currently bundled by the Centers for Medicare & Medicaid Services in a push for a more value-based health-care model[3]. Because of this, as well as other factors, there is continued interest to decrease postoperative length of stay (LOS) and to increase the number of shoulder arthroplasties being performed as outpatient procedures[2,4]. The key components to achieving these goals are adequate postoperative pain control and a decrease in systemic side effects from anesthesia. This can be better achieved by determining the ideal anesthesia modality for TSA.

Considerable advancements have been made in anesthesia options for shoulder arthroplasty. TSA can be performed using general anesthesia, regional anesthesia, or a combination of both. Proponents of general anesthesia note the reproducible nature of

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anesthesia and the ability to use paralytics for glenoid exposure. Proponents of regional anesthesia note the improved intraoperative and postoperative pain control, as well as improved safety and decreased systemic side effects compared with general anesthetic agents. There are also multiple adjuvant options for anesthesia in TSA, such as local anesthetic infiltration and parenteral dexamethasone administration.

The purpose of this review article is to critically analyze the literature to identify the best anesthesia modalities for TSA in order to improve postoperative pain control, improve safety, and reduce hospital LOS. Toward this goal, in this review we aimed to (1) compare general anesthesia and different types of available regional anesthesia options for shoulder arthroplasty, (2) explore different anesthetic agents for regional anesthesia and different types of regional anesthesia (e.g., single-shot versus continuous peripheral nerve block), and (3) determine if there is a role for adjuvants like dexamethasone for anesthesia in shoulder arthroplasty surgery.

Materials and Methods

We compared different types of anesthesia and anesthetic agents that are used during shoulder arthroplasty surgery. Specifically, reported differences between general and regional anesthesia were evaluated. In addition, we compared different variations of and considerations for regional anesthesia: local anesthetic infiltration and peripheral nerve block, single-shot and continuous peripheral nerve block, liposomal and non-liposomal preparations of local anesthetic, and the role of adjuvants (e.g., dexamethasone administration).

Search Strategies and Methods

A systematic literature review of the anesthesia modalities that were used during shoulder arthroplasty was conducted in September 2020 and updated in February 2021. This systematic review was performed in full accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines[5]. The literature searches were performed using the following databases: PubMed, Embase, and the Cochrane Central Register of Controlled Trials. The search terms included total shoulder arthroplasty, shoulder arthroplasty, anesthesia, regional anesthesia, interscalene block, dexamethasone, liposomal bupivacaine, clinical, trial, and clinical trials. All of the search terms were grouped by "OR" and subsequently combined by "AND."

Inclusion and Exclusion Criteria

Two broad categories of studies pertaining specifically to shoulder arthroplasty anesthesia were included. The first group included studies comparing general anesthesia with all types of regional anesthesia. Level-I, II, III, and IV studies were included for this strategy, and studies specifically reporting efficacy and complication rates were selected.

The second group investigated differences in the non-general anesthesia modalities. The included studies compared local anesthetic infiltration versus peripheral nerve block, single-shot versus continuous peripheral nerve block, liposomal versus non-liposomal preparations of local anesthetic, and dexamethasone versus non-dexamethasone administration. Only Level-I and II randomized controlled trials (RCTs) were included for all groups except for the general versus regional and dexamethasone subgroups, for which Level-III and IV studies also were included due to the paucity of literature regarding this subgroup.

Outcomes

For the general versus regional anesthesia analysis, the primary outcome measure was the in-hospital overall complication rate, and the secondary outcome was the pulmonary complication rate, based on the results of the available studies. For the non-general anesthesia group, the primary outcomes were visual analog scale (VAS) pain scores and opioid usage on postoperative day 1 (POD 1). The secondary outcome was hospital LOS.

Selection of Studies

The initial search of the databases generated 1,105 articles. Because 711 of the articles were duplicates, the copies were removed, leaving 394 titles and abstracts to be reviewed independently by 2 coauthors. During screening, 2 votes were given to each study based on inclusion and exclusion criteria. Any discrepancies were resolved by discussion and consensus with input from the senior author (M.S.V.). Two coauthors reviewed the full text of 29 studies, and each author voted to include or exclude the studies based on the criteria. Discrepancies were discussed with the senior author and a consensus was reached. Fifteen studies were excluded for the reasons that are provided in the flowchart (Fig. 1). Fourteen studies were included in the final analysis (Table I).

Data Extraction

Two coauthors independently extracted the relevant data from the eligible studies. This included the name of the first author, the year of publication, patient demographics, the type of surgery that was performed, the study design, analgesic methods, VAS pain scores on POD 1, opioid use in morphine milligram equivalents (MMEs) on POD 1, hospital LOS, duration of follow-up, and adverse effects. Attempts were made to obtain unpublished raw data when they were not available in an article.

Data Analysis and Statistical Methods

Standardized mean differences (SMDs) and 95% confidence intervals (CIs) evaluating differences in outcomes between patient groups were recorded or calculated from the data in each study. These outcomes included the VAS pain score and opioid use (in MMEs) on POD 1. For complication rate analysis, odds ratios (ORs) and CIs were used to investigate the differences between general and regional anesthesia. Random-effects meta-analyses were conducted to produce pooled mean differences for each outcome using inverse variance weighting. The I^2 statistic was calculated to assess the proportion of variation that could be caused by heterogeneity and whether that variation was significant. Rather than fixed-effects models, random-effects models

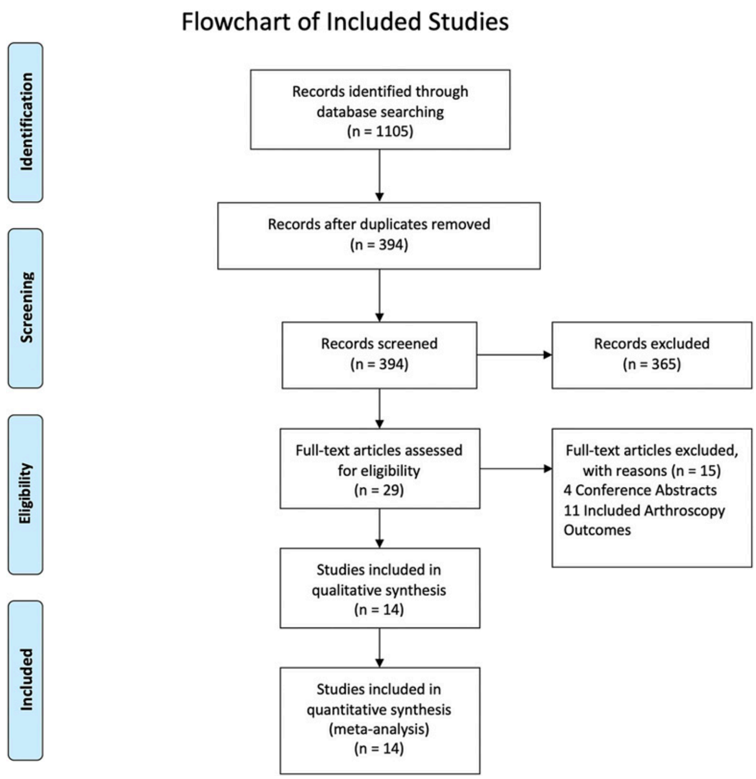

Fig. 1
Flowchart of included studies.

were used for each outcome, whether heterogeneity was present or not, because random-effects models produce more conservative estimations. All of the analyses were performed using Review Manager (RevMan) software (version 5.4; Cochrane Collaboration, 2020).

Results

General Versus Regional Anesthesia

To our knowledge, there are no Level-I or II studies comparing the efficacy and safety of general anesthesia with regional anesthesia for shoulder arthroplasty. Therefore, we included 2 Level-IV studies in our meta-analysis, and both studies reported the primary outcome—in-hospital overall complication rate[6,7]. There was no heterogeneity among the studies (chi-square = 0.80, degrees of freedom [df] = 1, I^2 = 0%, p = 0.37). Data were pooled from the 2 studies for patients who received general anesthesia alone and regional anesthesia alone. There were fewer in-hospital complications in the regional anesthesia group compared with the general anesthesia group (OR, 0.87; 95% CI, 0.77 to 0.99; p = 0.03). There was no difference between the 2 groups with respect to pulmonary complications (OR, 0.79; 95% CI, 0.58 to 0.1.08; p = 0.14) (Fig. 2). Meta-analysis could not be performed on hospital LOS because the studies used different reporting methods. However, the studies did find that the use of regional anesthesia increased the rate of discharge to home and reduced prolonged hospital stays[6,7].

Local Infiltration Versus Regional (Peripheral Nerve Block) Anesthesia

We included 6 Level-I and II studies for the comparison of local infiltration and interscalene block (ISB) anesthesia for TSA[8-13]. All 6 of the studies included in the meta-analysis reported VAS pain scores on POD 1[8-13]. There was significant heterogeneity among the studies (chi-square = 26.37, df = 5, I^2 = 81%, p < 0.0001). There was no difference between the 2 groups with respect to average VAS pain score on POD 1 (SMD, −0.24; 95% CI, −0.64 to 0.17; p = 0.25).

Five of the 6 studies comparing local infiltration of liposomal bupivacaine with ISB reported opioid use on POD 1[8-12]. Again, there was significant heterogeneity among these studies (chi-square = 30.09, df = 4, I^2 = 87%, p < 0.0001). There was no difference between the 2 groups with respect to opioid use on POD 1 after shoulder arthroplasty (SMD, −0.33; 95% CI, −0.87 to 0.21; p = 0.24).

Five of the 6 studies comparing local infiltration of liposomal bupivacaine with ISB reported on hospital LOS[8-10,12,13]. There was significant heterogeneity among the studies (chi-square = 20.99, df = 4, I^2 = 81%, p = 0.0003). There was no difference in the LOS between the groups (SMD, 0.04; 95% CI, −0.38 to 0.46; p = 0.85) (Fig. 3).

Single-Shot Versus Continuous Peripheral Nerve Block

A meta-analysis of data from the RCTs by Panchamia et al. and Hasan et al. was performed[12,14]. Both studies reported VAS pain scores on POD 1, opioid use on POD 1, and LOS. With respect to POD 1 VAS pain scores, the analysis revealed lower pain scores in patients with a continuous ISB compared with those who

TABLE I Included Studies*

Study	LOE	QoE	Potential Conflict of Interest	Interventions	Patients per Group *(no.)*	Procedure Type	Mean Age *(yr)*	Dose of Administered Medication	Follow-up
Hasan et al.[14] (2019)	II	8	No	SSIB, CIB	37, 39	TSA, rTSA, hemiarthroplasty	66.84, 70.18	SSIB: 30 mL of 0.5% ropivacaine CIB: 30 mL of 0.5% ropivacaine + 0.2% ropivacaine at 8 mL/hr for 50 hr	10 days
Panchamia et al.[12] (2019)	I	9	No	SSIB, CIB	42, 41	TSA, rTSA	67.8, 68.1	SSIB: 12-20 mL of 0.5% bupivacaine with 1:200,000 epinephrine CIB: 12-20 mL of 0.2% bupivacaine with 1:200,000 epinephrine + 10 mL bolus of 0.5% bupivacaine in PACU + 0.2% bupivacaine at 8-10 mL/hr for 1 day	1 yr
Abildgaard et al.[8] (2017)	I	8	No	LLB, CIB	37, 46	TSA, rTSA	67.8, 70.1	LLB: 266 mg of LLB + 30 mL of 0.5% bupivacaine as bridge CIB: 0.5% of ropivacaine at 8 mL/hr for 72 hr	3 mo
Hattrup et al.[15] (2021)	I	9	No	SSIB, LBIB	52, 52	TSA, rTSA	69.2, 70.0	SSIB: 25 mL of 0.5% plain bupivacaine LBIB: 133 mg of LB mixed with 7.5 mL of 0.5% and 7.5 mL of 0.25% plain bupivacaine	3 wk
Namdari et al.[10] (2017)	II	8	No	LLB, SSIB	78, 78	TSA, rTSA	68.4, 70.9	LLB: 266 mg SSIB: 30 mL of 0.5% bupivacaine	2 mo
Namdari et al.[17] (2018)	I	9	No	SSIB, SSIB + LLB	39, 39	TSA, rTSA	71.2, 68.6	SSIB: 15 mL of 0.5% ropivacaine SSIB + LLB: 15 mL of 0.5% ropivacaine plexus block + 266 mg of LLB	3 mo
Okoroha et al.[11] (2016)	I	9	No	LLB, SSIB	26, 31	TSA, rTSA	69.4, 67.1	LLB: 266 mg SSIB: 40 mL of 0.5% bupivacaine	4 mo
Sabesan et al.[16] (2017)	I	9	Yes	SSIB + LLB, CIB	34, 36	TSA, rTSA	63, 36	SSIB + LLB: 20 mL of 0.5% bupivacaine plexus block + 266 mg of LLB CIB: 30 mL of 0.5% bupivacaine + 0.125% bupivacaine at 6 mL/hr for maximum of 100 hr	4 mo
Bjørnholdt et al.[9] (2015)	II	8	No	LIA, CIB	30, 31	TSA	65, 66	LIA: 150 mL of 0.2% ropivacaine with a total of 0.5 mg of epinephrine CIB: 7 mL of 0.75% ropivacaine with subsequent 0.2% ropivacaine at 5 mL/hr on demand for 48 hr	3 mo
Sicard et al.[13] (2019)	II	9	No	LIA†, CIB	50, 49	TSA, rTSA	72.2, 71.7	LIA: 110 mL of 0.2% ropivacaine with 30 mg of ketoprofen and 0.5 mg of epinephrine; on postoperative day 1, 10 mL of 0.2% ropivacaine, 30 mg of ketoprofen, and 0.5 mg of epinephrine via catheter CIB: 20 mL of 0.2% ropivacaine + 0.2% ropivacaine at 5 mL/hr for 48 hr	1 mo

continued

TABLE I *(continued)*

Study	LOE	QoE	Potential Conflict of Interest	Interventions	Patients per Group *(no.)*	Procedure Type	Mean Age *(yr)*	Dose of Administered Medication	Follow-up
Klag et al.[18] (2021)	I	9	No	No dexamethasone, dexamethasone	32, 43	TSA, rTSA	66.6, 67.1	No dexamethasone: standardized pain regimen Dexamethasone: standardized pain regiment + 10 mg of intravenous dexamethasone within 90 min prior to surgery	3-18 mo
Routman et al.[19] (2017)	III	8	No	No dexamethasone, dexamethasone	24, 31	TSA, rTSA, hemiarthroplasty	67, 67‡	No dexamethasone: standardized pain regimen Dexamethasone: standardized pain regiment + 8-10 mg of intravenous dexamethasone after incision + LLB	Retrospective study
Ding et al.[6] (2017)	IV	8	No	General anesthesia, regional anesthesia	912, 912	TSA, rTSA	68.4, 68.3	Regional anesthesia: protocol not defined in large database study	Retrospective study
Herrick et al.[7] (2018)	IV	8	No	General anesthesia, regional anesthesia	53,243, 2,062	TSA, rTSA, hemiarthroplasty, revision arthroplasty	Not provided	Regional anesthesia: protocol not defined in large database study	Retrospective study

*LOE = level of evidence, QoE = quality of evidence (Newcastle-Ottawa Scale[28]), SSIB = single-shot interscalene block, CIB = continuous interscalene block, TSA = anatomic total shoulder arthroplasty, rTSA = reverse total shoulder arthroplasty, PACU = post-anesthesia care unit, LLB = local liposomal bupivacaine, LBIB = liposomal bupivacaine interscalene block, LB = liposomal bupivacaine, and LIA = local injection anesthesia. †LIA given locally and via catheter on postoperative day 1. ‡Age given as median.

had a single-shot ISB (SMD, 1.22; 95% CI, 0.65 to 1.79; $p < 0.00001$). There was minimal heterogeneity (chi-square = 0.05, df = 1, $I^2 = 0\%$, p = 0.82) in the 2 studies. Furthermore, there was lower opioid consumption in the continuous ISB group compared with the single-shot ISB group (SMD, 0.47; 95% CI, 0.16 to 0.79; p = 0.003).

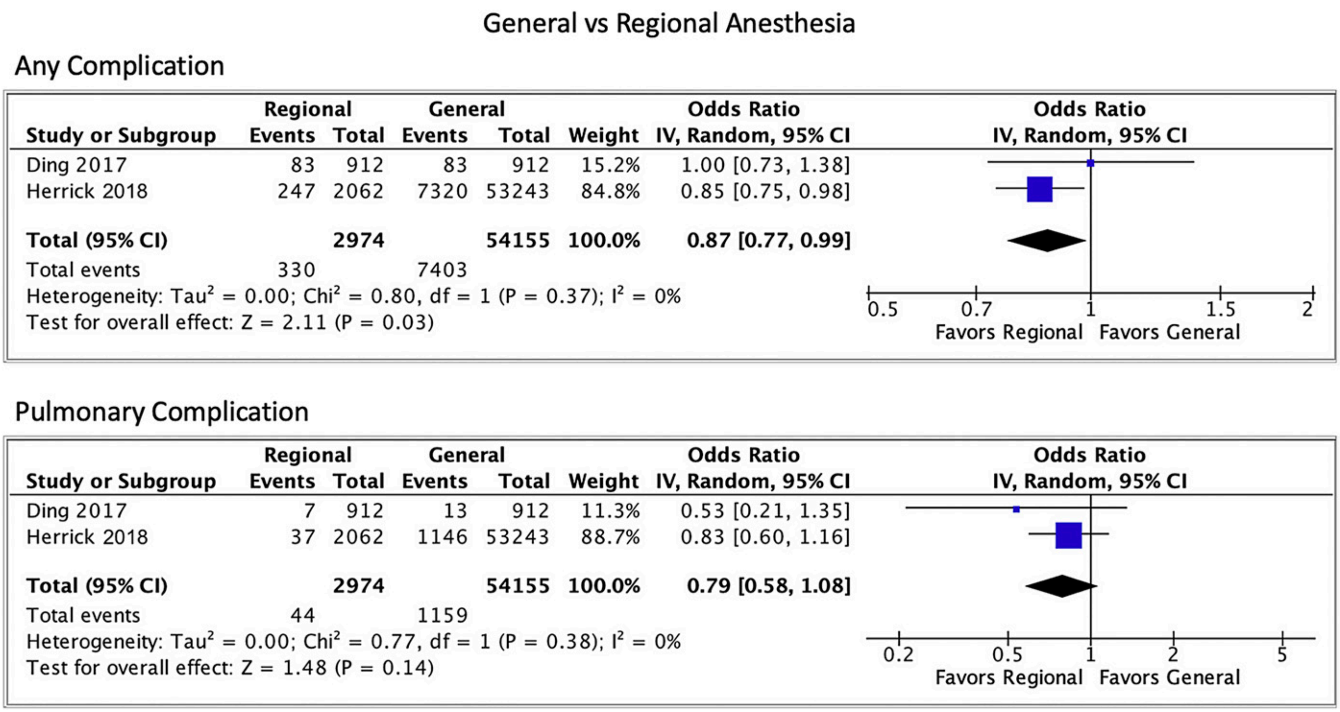

Fig. 2

Forest plots of general versus regional anesthesia. IV = inverse variance.

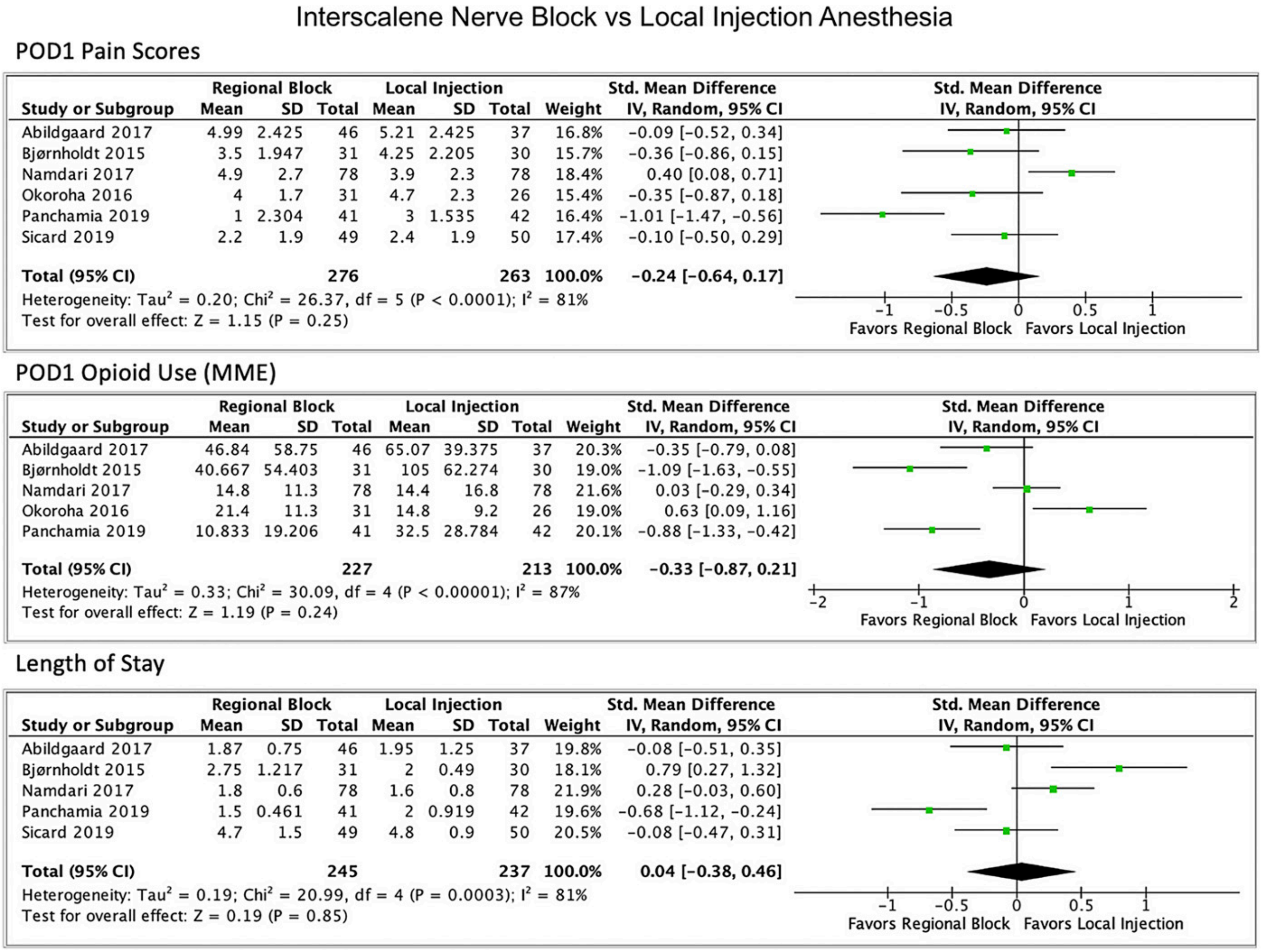

Fig. 3

Forest plots of interscalene nerve block versus local infiltration anesthesia. SD = standard deviation and IV = inverse variance.

With respect to LOS, there was no difference between the 2 groups (SMD, −0.43; 95% CI, −2.10 to 1.24; p = 0.62) (Fig. 4). There was significant heterogeneity for this part of the data in the 2 studies (chi-square = 25.65, df = 1, I^2 = 96%, p < 0.00001).

Liposomal Bupivacaine Versus Non-Liposomal Local Anesthetic

A meta-analysis of data comparing liposomal and non-liposomal local anesthetic agents was performed on 5 RCTs[8,10,11,15,16]. All 5 studies reported pain scores on POD 1, and there was no appreciable difference in pain scores between the 2 groups that underwent shoulder arthroplasty (SMD, 0.06; 95% CI, −0.22 to 0.33; p = 0.70)[8,10,11,15,16]. There was moderate heterogeneity among the studies (chi-square = 8.94, df = 4, I^2 = 55%, p = 0.06) that were included for this analysis.

All 5 of the studies reported opioid use on POD 1[8,10,11,15,17]. There was significant heterogeneity among the studies in this analysis (chi-square = 13.61, df = 4, I^2 = 71%, p = 0.009). The meta-analysis demonstrated that there was no difference in 24-hour opioid usage among the liposomal formulation group versus the non-liposomal preparation group (SMD, −0.02; 95% CI, −0.36 to 0.32; p = 0.90). The theoretical peak activity of liposomal bupivacaine is 24 to 72 hours after drug administration, which may explain why there was no difference in the 24-hour opioid consumption between the groups.

Only 2 studies reported LOS in this analysis[8,10]. There was some heterogeneity among the included studies (chi-square = 1.74, df = 1, I^2 = 42%, p = 0.19). Analysis yielded no differences in LOS between the groups (SMD, 0.13; 95% CI, −0.21 to 0.48; p = 0.45) (Fig. 5).

Dexamethasone Use as an Adjuvant in Shoulder Arthroplasty

Dexamethasone has been used as an adjuvant in anesthesia to improve postoperative pain control as well as minimize postoperative nausea and vomiting[18,19]. We found only 1 RCT

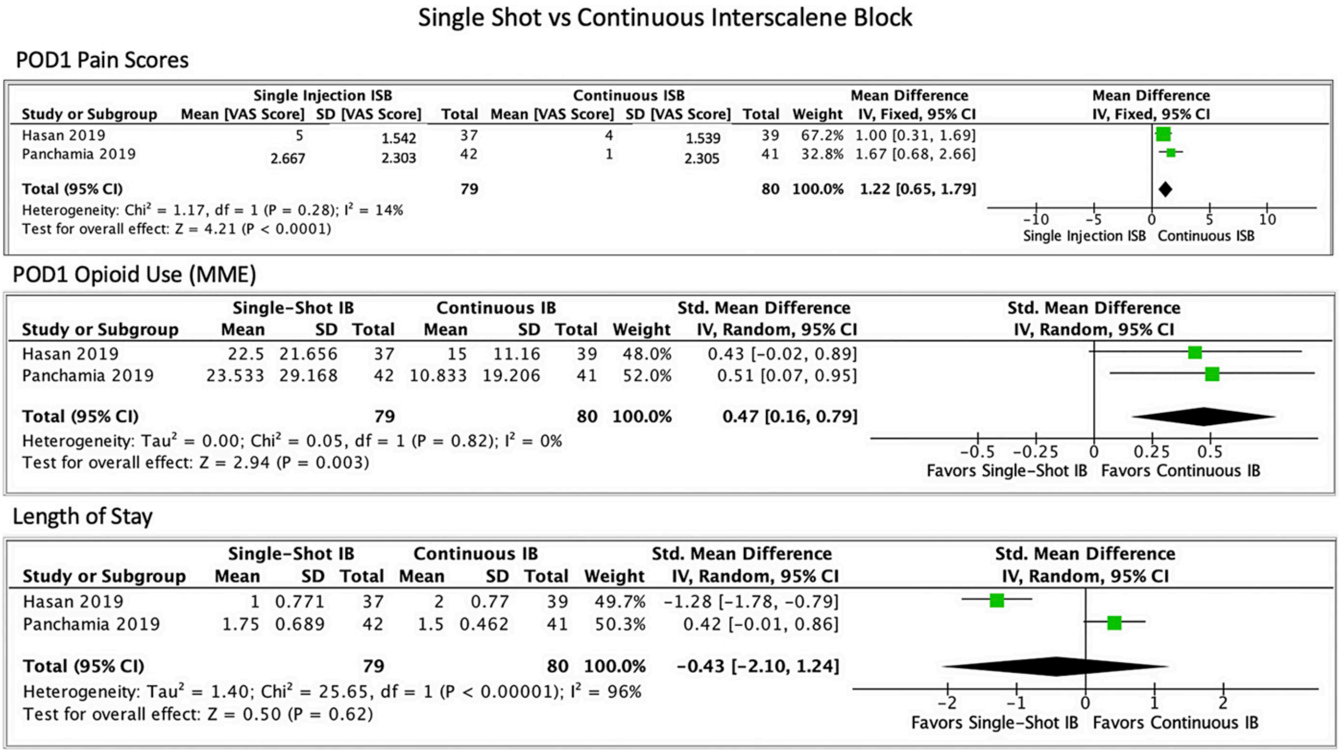

Fig. 4

Forest plots of single-shot versus continuous interscalene block. SD = standard deviation, IV = inverse variance, and IB = interscalene block.

comparing outcomes and complications in patients undergoing shoulder arthroplasty surgery with and without dexamethasone[18]. The dexamethasone group received 10 mg of dexamethasone within 90 minutes of surgery[18]. That group had lower postoperative pain scores ($p < 0.001$), fewer opioid requirements ($p = 0.007$), and fewer antiemetic requirements compared with the group that did not receive dexamethasone. The complication rates were similar between the groups.

Discussion

Considerable advances have been made with respect to anesthesia options for shoulder surgery in the past few decades. The intent of these changes is to improve the safety and efficacy of anesthesia for these procedures. Strategies to prolong the duration of regional anesthesia include using a single-shot peripheral nerve block with longer-acting local anesthetics, a continuous nerve block with use of indwelling catheters, and local infiltration of the shoulder with liposomal preparations of local anesthetics. These strategies have the potential to reduce perioperative pain, reduce opioid consumption, prevent rebound pain, allow for an early start of rehabilitation, and reduce the hospital LOS after shoulder replacement.

The proposed benefits of regional anesthesia compared with general anesthesia include superior intraoperative and postoperative pain control with decreased perioperative opioid consumption, reduced pulmonary complications, and other general-anesthetic-related complications[6,7,20]. The aforementioned benefits of regional anesthesia are likely to decrease the overall hospital LOS[20]. However, peripheral nerve blocks are not without risks. Respiratory and neurologic complications have been reported, including vocal cord paralysis, phrenic nerve palsy, and persistent neurologic pain, even with blocks that have been placed under ultrasound guidance[8-13]. General anesthesia provides improved muscle relaxation for better glenoid exposure, which is one of the key determinants for performing a successful shoulder replacement surgery. Meta-analysis of data from 2 retrospective studies (Level IV) showed fewer inpatient complications in patients who received regional anesthesia but did not show any differences in pulmonary complications and LOS among patients receiving regional versus general anesthesia (grade-C recommendation)[6,7].

Local infiltration of long-acting local anesthetics is another strategy to improve perioperative pain control after shoulder arthroplasty. Furthermore, it can mitigate the issue of rebound pain as seen in situations like a failed peripheral nerve block or an unpredictable short duration of a nerve block, which is seen with up to 20% of ISBs[10,21]. Successful use of high-volume local anesthesia infiltration has been reported with hip and knee arthroplasty to reduce perioperative pain[22,23]. Four RCTs in the present study reported reduced postoperative pain scores and opioid requirement ($p < 0.05$) with ISB compared with

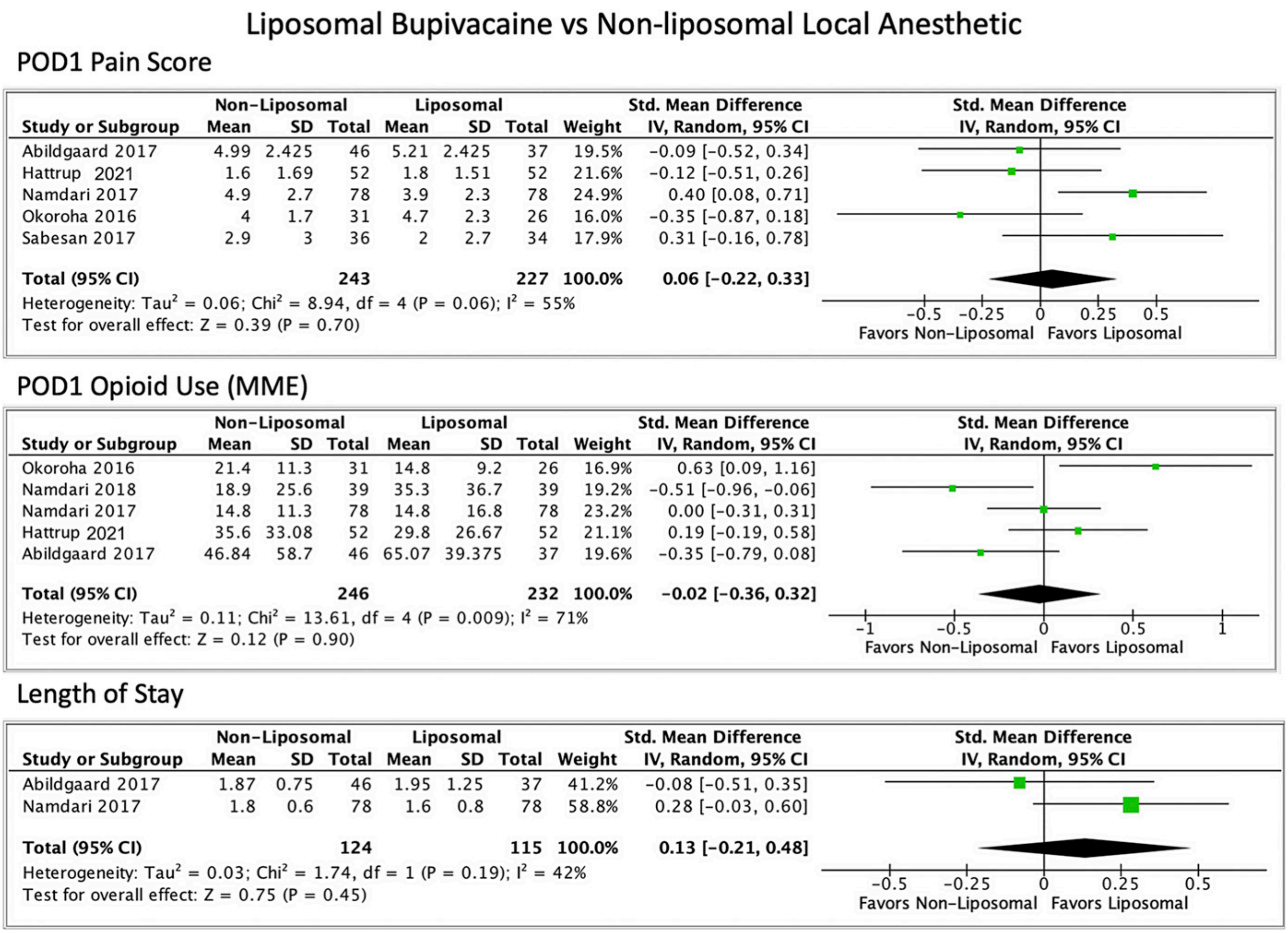

Fig. 5

Forest plots of liposomal bupivacaine versus non-liposomal local anesthetic. SD = standard deviation and IV = inverse variance.

local infiltration of liposomal bupivacaine[8,9,12,13]. In contrast, the RCTs by Namdari et al. and Okoroha et al. reported that although initial pain control was better in the ISB group, pain scores and opioid requirements after 24 hours were higher ($p < 0.05$) in the ISB group compared with the group that received local infiltration of

TABLE II Grades of Recommendation

Anesthesia/Anesthesia Adjuvant	Recommendation	Grade of Recommendation*
General vs. regional	Regional over general anesthesia	Grade C
Single-shot vs. continuous nerve block	Continuous nerve block for improved pain control	Grade A
Liposomal bupivacaine vs. non-liposomal local anesthetic	Liposomal bupivacaine is comparable with non-liposomal preparations	Grade A
Dexamethasone administration	Dexamethasone administration has been shown to improve pain control and postoperative nausea	Grade C
Interscalene block vs. local anesthetic	Favors interscalene block	Grade I

*According to Wright[27], grade A indicates good evidence (Level-I studies with consistent findings) for or against recommending intervention; grade B, fair evidence (Level-II or III studies with consistent findings) for or against recommending intervention; grade C, poor-quality evidence (Level-IV or V studies with consistent findings) for or against recommending intervention; and grade I, insufficient or conflicting evidence not allowing a recommendation for or against intervention.

liposomal bupivacaine[10,11]. Our meta-analysis of data from RCTs (Level-I and II studies) comparing local infiltration with peripheral nerve block demonstrated no differences with respect to VAS pain score, opioid use, and hospital LOS.

Indwelling nerve catheter placement is an attractive strategy to prolong the duration of local anesthetic effect, but concerns remain, including increased procedural time, catheter dislodgment, infection risk, and patient apprehension regarding catheter management[12,14]. In their RCTs, Panchamia et al. and Hasan et al. found that both postoperative pain level and opioid requirements were lower in the continuous ISB group ($p < 0.05$) compared with the single-shot ISB group[12,14]. However, there were adverse events with continuous ISBs, and catheters were dislodged prematurely in 10% of patients, with no difference in hospital LOS between the 2 groups[14]. Our meta-analysis supported a grade-A recommendation for the use of continuous ISBs versus a single-shot block for perioperative pain control in shoulder arthroplasty. However, the pain control benefit must be weighed against the increased complication rate of indwelling catheters. Additionally, patients must be comfortable managing a continuous local anesthesia delivery pump and removing the catheter at home, or home-health services may be required.

Liposomal bupivacaine uses a carrier matrix (DepoFoam technology; Pacira Biosciences) that encapsulates and eventually elutes bupivacaine over time for continuous release of the drug. Liposomal bupivacaine has been approved by the U.S. Food and Drug Administration as an injectable agent for local anesthesia infiltration and for ISB as a means of providing extended pain relief after shoulder surgery. Initial studies demonstrated the safety and efficacy of liposomal bupivacaine compared with a placebo[24,25]. However, more recent studies have demonstrated mixed results when comparing liposomal bupivacaine with non-liposomal preparations of local anesthetics[8,10,15-17]. The meta-analysis of high-quality data in our study demonstrated that liposomal bupivacaine is comparable with non-liposomal anesthetic agents with respect to pain relief, the opioid-sparing effect, and adverse effects in the first 48 hours after TSA (grade-A recommendation).

Dexamethasone works by decreasing the inflammatory response and offers the benefit of diminishing pain in addition to its antinausea and antiemetic properties[26]. In an RCT, Klag et al. demonstrated the aforementioned benefits of dexamethasone in patients who underwent shoulder arthroplasty who received 10 mg of dexamethasone[18]. Similar results were seen in a retrospective study in which patients who underwent shoulder arthroplasty were treated with 2 different multimodal pain regimens, one with dexamethasone and the other without it[19]. Although the findings are consistent, there are limited studies supporting the use of dexamethasone as an adjuvant to anesthesia in shoulder arthroplasty (grade-C recommendation).

There are some limitations to this study that should be taken into consideration when interpreting the results. Even though we included the best available data in our meta-analysis, some of the studies were Level-III or IV studies. Additionally, for certain topics, only 1 RCT was available, which may have limited the final conclusions. For example, we found only 1 RCT that investigated the effects of dexamethasone as an adjuvant to anesthesia[18]. The meta-analysis of RCTs comparing liposomal bupivacaine to non-liposomal preparations of local anesthesia had a small sample size and there was a lack of blinding, which could have led to a potential inherent bias. Furthermore, variation in the methods of opioid administration in these studies could have affected both pain scores and postoperative opioid consumption. However, assigning the grades of recommendation and reporting the level of evidence for the studies that were included in this meta-analysis allow the best interpretation and use of the available information (Table II).

Conclusions

Although there is no ideal anesthesia option for shoulder arthroplasty, regional anesthesia offers improved safety and reduced opioid usage compared with general anesthesia. Strategies to improve the duration of a peripheral nerve block (e.g., continuous nerve blocks, long-acting agents, and liposomal preparations of local anesthetics) should be weighed against the cost-effectiveness of these strategies and the risks and/or complications that are associated with prolonged nerve block. Future innovations focusing on improving the safety and efficacy of anesthetic options will reduce rebound pain and opioid usage, allow for early rehabilitation, and reduce hospital LOS (including same day discharge) after TSA.

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