**Local Infiltration Analgesia versus Interscalene Nerve Block for Pain Control After Shoulder Arthroplasty: A Systematic Review and Meta-Analysis of Randomized Controlled Trials**

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**ABSTRACT:**

**Background:** Shoulder arthroplasty procedures are increasing, requiring effective pain management strategies. Interscalene nerve block (ISB) is widely used but carries potential complications. Local infiltration analgesia (LIA) presents a simpler alternative, but its efficacy compared to ISB remains uncertain. We aimed to compare the effectiveness and safety of local infiltration analgesia versus interscalene nerve block to treat postoperative pain after shoulder arthroplasty.

**Methods:** A systematic review and meta-analysis of randomized controlled trials (RCT) was conducted according to PRISMA and Cochrane guidelines. The databases searched included PubMed, Embase, Cochrane, Scopus, and others. The primary outcome was postoperative opioid consumption (converted to morphine equivalents) within 24 hours. Secondary outcomes included pain scores (VAS) at different time points, chronic pain at two weeks, duration of hospital stay, and complication rates.

**Results:** Twelve RCTs met the inclusion criteria with data from 855 patients. ISB was associated with significantly lower opioid use in 24 hours (mean difference: 7.68 mg of equivalent morphine, 95% CI: 0.96–14.40). Pain scores at 4 and 8 hours favored ISB (mean differences: 1.96 and 1.33, respectively), while no significant differences were observed at 12 and 24 hours or 2 weeks post-op. No differences were found in hospital stay or complications. The certainty of the evidence ranged from high (opioid consumption) to low (hospital stay).

**Conclusions:** ISB provides superior early postoperative analgesia and reduces opioid consumption. However, LIA demonstrates comparable results beyond the immediate postoperative period and may be preferred in resource-limited settings due to lower cost and fewer complications.

**Keywords:** Shoulder arthroplasty; interscalene nerve block; local infiltration analgesia; postoperative pain management; opioid consumption; visual analog scale

# INTRODUCTION

The annual incidence of total shoulder arthroplasty has seen a significant increase, showing a growth rate that exceeds that of total hip or knee arthroplasty (1). This escalation is primarily attributed to the aging population and the introduction of new surgical techniques (2). Considering this trend, establishing effective postoperative pain management protocols has become crucial. Traditional methods, predominantly based on opioids, are associated with several side effects, including respiratory depression, somnolence, and drug dependence (3). Ineffective postoperative pain can lead to reduced patient satisfaction, delayed mobilization, increased healthcare costs, and extended hospital stays (4). Consequently, interscalene nerve block (ISB) has been recognized as a highly effective pain management technique after shoulder arthroplasty, in correlation with shorter hospital stays and reduced opioid consumption (5). However, ISB also carries potential risks of neurological or respiratory complications, such as hemi-diaphragmatic paresis and a nerve blockade failure rate between 10% and 20% (6). Recently, local infiltration at the surgical site has gained popularity, but the efficacy and limitations of this technique need to be fully elucidated (7). Various meta-analyses have been published that compare local infiltration with liposomal bupivacaine and ISB (8), but these often include retrospective trials and focus solely on liposomal bupivacaine.

Therefore, our meta-analysis of randomized controlled trials (RCTs) assessed the efficiency and safety of regional infiltration analgesia compared to interscalene nerve block in managing pain after shoulder arthroplasty.

# METHODS

This systematic review and meta-analysis was structured according to the PRISMA 2020 guidelines (Preferred Reporting Items for Systematic Review and was Meta-analysis) (9) and checked according to the AMSTAR 2 guidelines (evaluating the methodological quality of systematic reviews) (10). The protocol of this study is registered in PROSPERO under the number CRD420251022581.

**Electronics searches:** An extensive electronic search of the relevant literature, with no language restrictions, was performed in March 2025, using the following databases: "Cochrane Library's Controlled Trials Registry and Database of Systematic Review", "United States National Library of Medicine", "National Institutes of Health PubMed/MEDLINE", "Excerpt Medica Database", "Embase", "Scopus", and "Google Scholar". Keywords used for the final search in all databases were "interscalene nerve block", "local infiltration", "total shoulder arthroplasty", "total shoulder replacement", "pain control", "pain management”, and "analgesia". The Boolean operators "OR" and "AND" were used to combine literature searches.  We manually checked the reference list of trials included to identify additional studies. Studies including a patient population of less than 10 patients, case reports, and editorials were not considered.

**Included studies:** All randomized controlled trials (RCTs) reporting a comparison between interscalene nerve plane block and local infiltration analgesia with respect to postoperative analgesia in total shoulder arthroplasty, published in a peer-reviewed journal, were considered for analysis**.** Data from nonrandomized trials, non-comparative studies, editorials, letters to editors, review articles, and case series were excluded from the analysis. RCTs comparing ISB and local infiltration in another type of shoulder surgery were also excluded. The study was excluded if a direct comparison of ISB and local infiltration could not be determined.

**Participants:**adults (aged over 18 years) of any sex undergoing shoulder arthroplasty and receiving local infiltration analgesia or ISB pain control.

**Intervention group:** regional infiltration analgesia group (infiltration group).

**Control group:** interscalene nerve block group (ISB group).

**Primary outcome:** Postoperative intravenous opioid consumption was reported 24 hours after surgery. It was concerted to intravenous milligram equivalents (morEq) (11).

**Secondary outcomes:**

* Acute postoperative pain score at rest at different periods (4 hours (H4), 8 hours (H8), 12 hours (H12), and 24 hours (H24)) using the visual analog scale (VAS) score (0 = no pain and 10 = extreme pain).
* Chronic postoperative pain score (2 weeks postoperative).
* Duration of postoperative hospital stay and complications.

**Study selection: Two** authors (MAD and MAC) independently reviewed all abstracts. All studies, accompanied by the full text that met the inclusion criteria, were retained. Disagreements were resolved by discussion after consulting a third member of the review team (LR).

**Quality assessment of studies and the risk of bias:** All studies that met the selection criteria were independently evaluated. The risk of bias of randomized clinical trials was assessed using the RoB2 (risk of bias) assessment containing the 5-domain noted in the Cochrane Handbook (12).

**Data extraction:** The data extracted from the studies were the author’s name, publication year, age, dosage and type of anesthetic drug, sample size, duration of follow-up, and results. Postoperative pain intensity was measured using a 10-point VAS score (a 100-point VAS was converted to a 10-point VAS). Data in other forms (median, interquartile range, and mean±95% range confidence interval) were converted to mean ± standard deviation by using the Cochrane Handbook guidelines. If the data were not reported numerically, we extracted them from the figures or contacted the corresponding authors for more information.

Each author independently extracted data from each study. Disparities were resolved after discussion with the senior authors (LA).

**Heterogeneity assessment:** To assess heterogeneity, three strategies were used:

1. The Cochrane Chi² test (Q test), Tau2, which is the variance of true effects, and 95% predictive interval (index of dispersion) to estimate the degree of heterogeneity (13). We calculate the predictive interval using a comprehensive meta-analysis prediction interval.
2. Graphical exploration with funnel plots (14).
3. Sensitivity analysis with a subgroup analysis when applicable (15). Subgroup analyzes were carried out, if feasible, to assess potential sources of heterogeneity.

**Assessment of evidence:** Two authors independently assessed the certainty of the evidence. GRADE guidelines were used to assess the quality of evidence. We considered the limitations of the study constancy of effect, imprecision, indirectness, and publication bias. We assessed the certainty of evidence as high, moderate, low, or very low. We considered the following criteria for upgrading the certainty of evidence, if appropriate: large effect, dose-response gradient, and plausible confounding effect. We use the methods and recommendations described in Sections 8.5 and 8.7, and Chapters 11 and 12 of the Cochrane Handbook for systematic reviews of Interventions. GRADEpro GDT software was used to summarize the findings' tables. We explain the reasons for downgrading or upgrading certain included studies using footnotes with comments.

**Evaluation of effect size:**We used the RevMan 5.4 statistical package from the Cochrane Collaboration for meta-analysis (16). We selected the mean difference (MD) as an effective measure for continuous data. Odds ratios (OR) with 95% confidence intervals (95% CI) were calculated for dichotomous variables. The random-effects model was used and the significance threshold was fixed at 0.05. When the mean and standard deviation (SD) were not reported, they were estimated from the range (R) and median according to the formula described by Hozo et *al.* (17).

**RESULTS**

**Literature search results:**We retrieved eight potentially relevant articles **(Figure 1)**. In the initial research, a total of 189 articles were identified from the electronic database. After evaluating the abstracts and titles of these studies, only 12 articles were retained. Five studies were excluded for the following reasons: one study (18) included patients undergoing shoulder arthroscopy surgeries, and four studies were not prospective trials (19–22). **Table 1** summarizes data from 12 clinical studies that compare local infiltration (Group Infiltration) and interscalene block (Group ISB) techniques for postoperative pain management in shoulder surgeries. Studies span from 2015 to 2023 and were carried out primarily in the USA, with additional data from Turkey, Denmark, France and Colombia. The ages ranged from early 50s to the early 70s, with relatively balanced gender distributions. Throughout the studies, various anesthetics were used, commonly liposomal bupivacaine, ropivacaine, and bupivacaine, administered in different volumes and concentrations. The results focused primarily on VAS pain scores and opioid consumption, with follow-up periods ranging from 24 hours to 90 days. The of patients of the group sizes were generally comparable within each study, supporting a balanced analysis of the efficacy between techniques. The risk of bias assessment of these studies is reported in **Table 2**.

**Primary outcome: Postoperative opioid consumption reported up to 24 hours after surgery**

Ten studies evaluated opioid consumption postoperatively, comprising 418 patients in the infiltration group and 437 in the ISB group. The infiltration group demonstrated significantly higher opioid use, with a mean difference of 7.68 mg of equivalent morphine (95% CI: 0.96 to 14.40). The heterogeneity was substantial (Tau² = 93.68), indicating the variability in effect sizes between studies. Despite this, the consistent direction of effect suggests a clinically significant reduction in opioid use with ISB **(Figure 2).**

**Secondary outcomes:**

**Postoperative pain scores at H4, H8, H12 and H24**

VAS scores at 4 hours after the operation were analyzed in ten studies with 410 patients in the infiltration group and 429 in the ISB group. The pooled mean difference favored ISB, with a statistically significant value of 1.96 (95% CI 1.14 to 2.77). The heterogeneity was little (Tau² = 1.45), although the consistent direction of the effect in all studies supports a clear early analgesic advantage for ISB **(Figure 3A).**

Seven studies reported pain outcomes 8 hours following shoulder arthroplasty. According to the studies, 290 patients received infiltration and 298 received ISB. The pooled mean difference was **1.33 points higher in the infiltration group** (95% CI: 0.02 to 2.64), which favors ISB and suggests a **statistically significant reduction in pain** at 8 hours with ISB. However, **heterogeneity was very high** (Tau² = 2.89), indicating substantial variability among the studies **(Figure 3B)**.

At 12 hours postoperatively, ten studies contributed data to the analysis, with a total of 314 patients in the infiltration group and 321 in the ISB group. The pooled mean difference was 0.32 (95% CI: -0.82 to 1.47), again indicating that there were no significant differences in pain scores between the two analgesic approaches. Low heterogeneity was present (Tau² = 2.08), reflecting the variation in pain outcomes across studies **(Figure 3C).**

Finally, nine studies reported VAS pain scores on the first postoperative day, with 418 patients in the infiltration group and 437 in the ISB group. The pooled mean difference was 0.13 (95% CI: -0.84 to 1.10), which does not show significant differences in pain outcomes between groups at this point. The heterogeneity was low, with Tau² = 2.17, reflecting moderate consistency in results across studies **(Figure 3D).**

**Postoperative pain score after two weeks**

Three studies reported VAS pain scores two weeks postoperatively. The infiltration group included 114 patients, while the ISB group included 115 patients. The mean difference between the groups was 0.60 (95% CI: -0.87 to 2.08), indicating that there were no statistically significant differences. However, heterogeneity was low (Tau² = 1.55), suggesting variability among study results and reducing confidence in the pooled estimate. **(Figure 3E)**

**Duration of hospital stay**

Seven studies examined hospital stay, including 368 patients in the infiltration group and 388 in the ISB group. The pooled mean difference was -0.00 days (95% CI -0.13 to 0.12), indicating no significant differences in the duration of hospitalization between the two analgesic approaches. Heterogeneity was low (Tau² = 0.01), suggesting that different hospital discharge practices or patient factors may have influenced results **(Figure 4).**

**Complications**

Six studies evaluated postoperative complications, including 377 patients in the infiltration group and 386 in the ISB group. There were 8 reported events in the infiltration group and 16 in the ISB group. The pooled odds ratio was 0.60 (95% CI: 0.25 to 1.42), indicating that there was no statistically significant difference in the risk between the two interventions **(Figure 5).**

# The certainty of evidence of the effect size

**Table 3** summarizes the findings comparing local infiltration analgesia with ISB for postoperative pain management in shoulder arthroplasty in several outcomes. ISB demonstrated a clear advantage in early pain control, with significantly lower pain scores at 4 and 8 hours after surgery (moderate certainty evidence) and reduced opioid consumption at 24 hours (high certainty evidence). However, 12 and 24-hour post-op, as well as at 2 weeks, pain scores between groups were similar, with no significant differences observed. Complication rates were slightly lower with infiltration, though the difference was not statistically significant (moderate certainty), and both techniques showed comparable results regarding hospital stay duration (low certainty). In general, ISB provides superior immediate analgesia and reduces opioid use, while both methods are equally effective for longer-term pain control and recovery outcomes.

**DISCUSSION**

To our knowledge, this is the first systematic review and meta-analysis comparing local infiltration analgesia with ISB for pain management after shoulder arthroplasty. ISB was more effective in early postoperative pain relief (at 4 and 8 hours) and significantly reduced opioid use within 24 hours. However, there were no significant differences in pain scores at 12 and 24 hours, duration of hospital stay, or complication rates. Although ISB offers better immediate analgesia, LIA is simpler and safer, making it a suitable alternative, especially in resource-limited settings.

Opioids are frequently used as an adjunct therapy for postoperative pain after shoulder arthroplasty. However, their side effects, including nausea, vomiting, respiratory depression, and drug dependence, can impede functional recovery and diminish patient satisfaction (23). Thus, total opioid consumption after surgery is a key indicator of analgesic efficacy. A study by Weller et al. (20) involving 214 arthroplasties reported that average oral morphine equivalent consumption at 24 hours was significantly higher with local infiltration of liposomal bupivacaine compared to the ISB group. Our meta-analysis confirms this difference in total opioid consumption between the two groups up to 24 hours. Beyond opioid consumption, postoperative pain scores were also a critical outcome in our meta-analysis to evaluate the efficacy of analgesics. The aggregated results revealed higher VAS scores at H4 and H8 in the local infiltration group, which then aligned with the ISB group H12 and H24. This initial discrepancy could be explained by the type of local anesthetic used: liposomal bupivacaine in four included RCTs and ropivacaine in others. Liposomal bupivacaine, designed for prolonged release for 72 hours, could account for the higher early postoperative pain scores due to delayed bupivacaine release from lipid stores (24,25). However, the meta-analyses by Liu et al. (26) and Kuang et al. (27) advised against recommending liposomal bupivacaine as a long-acting analgesic in local infiltration, citing no significant differences in postoperative pain scores compared to traditional local anesthetics.

The length of hospital stay did not differ significantly between the two groups, a finding consistent with previous meta-analyses (7,8). Yet, Weller et al. (20) noted that the cost of local infiltration mixtures averaged $289.04 per case, significantly less than $1559.42 for interscalene catheters, inclusive of equipment and anesthesia fees. This cost-effectiveness of local infiltration is also observed in studies of total joint arthroplasty of the lower extremities (28), which positions it as a more economically viable alternative to ISB for pain management after shoulder arthroplasty. Furthermore, the rates of complication, a vital factor in the evaluation of analgesic techniques, were found to be lower in the local infiltration group compared to ISB. However, due to the limited data available, only a general analysis of various complications was feasible. In particular, ISB is associated with a high incidence of hemi-diaphragmatic paresis (29).

Our systematic review and meta-analysis suggest that both local infiltration and interscalene nerve block are effective and safe for postoperative pain management after shoulder arthroplasty. However, considering the higher incidence of hemi-diaphragmatic paresis after ISB and the associated medical expenses, local infiltration appears more suitable, particularly for patients with limited financial resources.

This study has several limitations. First, although 12 RCTs were initially considered, only eight studies with a combined total of 855 patients (418 in the local infiltration group and 437 in the interscalene block group) were included in the primary outcome analysis, which can limit the robustness of the findings and the ability to assess publication bias. Second, there was significant heterogeneity in some outcomes, likely due to differences in anesthetic agents, doses, and study protocols, requiring cautious interpretation. Third, some standard deviations were estimated or extracted from figures rather than directly reported, which could affect the accuracy of the results. Finally, the follow-up periods in most studies were relatively short, with only three reporting outcomes beyond the immediate postoperative period, highlighting the need for more long-term studies to evaluate sustained analgesic effects and recovery.

# CONCLUSIONS

This meta-analysis shows that while ISB provides better early pain control and reduces opioid use within 24 hours after shoulder arthroplasty, local infiltration analgesia offers comparable outcomes beyond that period. Given its lower cost, ease of administration, and similar long-term effectiveness, local infiltration analgesia is a practical alternative to ISB, especially in resource-limited settings. More high-quality studies with longer follow-up are needed to confirm these findings.

**AVAILABILITY OF DATA, CODE, AND OTHER MATERIALS**

All meta-analytic data and all codebooks and analysis scripts are publicly available on the study's associated page on the Open Science Framework (https://osf.io/4sme2/).

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