Comparison of Analgesia Treatment Methods After Arthroscopic Rotator Cuff Repair

A Network Meta-analysis of 42 Randomized Controlled Trials

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Background: The optimal method for postoperative analgesia after arthroscopic rotator cuff repair (ARCR) is still unclear.

Purpose: To compare the efficacy of postoperative analgesic methods after ARCR through network meta-analysis of randomized controlled trials and prospective controlled trials.

Study Design: Systematic review; Level of evidence, 2.

Methods: Following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, we searched PubMed, Embase, and Web of Science from inception until April 12, 2022, for randomized controlled trials and prospective controlled trials evaluating neuraxial analgesia, peripheral nerve block, periarticular local anesthetic infiltration, intravenous patient-controlled analgesia, oral analgesia, or any combination of these methods for pain management after ARCR. Outcomes included pain scores at rest, morphine consumption, and complications (nausea and vomiting). Study quality was assessed using the Cochrane risk-of-bias tool. Network meta-analysis was used to assess the relative efficacy of the methods for postoperative analgesia. The best choice for postoperative analgesia was defined as the one with significant differences in pain scores and morphine consumption compared with placebo, with no significant difference in complications, during the initial 48 hours postoperatively.

Results: Included were 42 studies with 3110 patients. Only suprascapular nerve block (SSNB) was significantly superior to placebo in pain scores (mean difference [MD], –0.93 [95% CI, –1.31 to –0.54] at 6 hours; MD, –2.34 [95% CI, –3.49 to –1.19] at 12 hours) and morphine consumption (MD, –17.70 [95% CI, –32.98 to –2.42] at 24 hours) ($P < .05$ for all), with no difference in complications (odds ratio, 0.96 [95% CI, 0.21 to 4.32]; $P > .05$). Pain scores were significantly lower with interscalene nerve block compared with SSNB (MD, –0.69 [95% CI, –1.17 to –0.20] at 6 hours; MD, –1.44 [95% CI, –2.21 to –0.67] at 12 hours) and with SSNB + axillary nerve block compared with SSNB (MD, –3.09 [95% CI, –4.18 to –1.99] at 6 hours; MD, –0.87 [95% CI, –1.71 to –0.03] at 12 hours) ($P < .05$ for all).

Conclusion: Based on the current evidence, most analgesic methods lowered pain and morphine consumption compared with placebo. There were significant differences in pain scores between interscalene nerve block and SSNB during the first 12 hours postoperatively, and adding axillary nerve block to SSNB enhanced the analgesic effect.

Keywords: arthroscopic rotator cuff repair; analgesia; network meta-analysis

Acute shoulder pain can develop after shoulder surgery. Rotator cuff repair is the most painful surgical procedure,[13] while surgery for restoring shoulder stability is the least painful.[60] Arthroscopic rotator cuff repair (ARCR) has been widely performed for the clinical treatment of rotator cuff injuries. In the United States, there were 98 ARCR procedures performed per 100,000 people in 2006, and the incidence rate increases with age.[48]

The goals of effective postoperative pain management are to decrease pain, limit the adverse effects of these therapies, and decrease the amount of opioid consumption.[15] In the past few years, many postoperative analgesic methods for ARCR have been developed, such as intravenous patient-controlled analgesia (PCA), periarticular local anesthetic infiltration (periarticular analgesia [PA]), epidural analgesia (EA), interscalene nerve block (ISNB), suprascapular nerve block (SSNB), supraclavicular nerve block (SCNB), axillary nerve block (ANB), and lateral pectoral nerve block (LPNB).[62] Combinations of these methods have also been used.

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Our purpose was to assess the relative efficacy of several treatment approaches for postoperative analgesia after ARCR through network meta-analysis (NMA) based on randomized controlled trials and prospective controlled trials. In traditional meta-analysis, only 2 interventions can be compared based on direct evidence. However, in NMA, we can quantitatively compare the effectiveness of ≥3 interventions by pooling the results of direct and indirect comparisons.[12]

METHODS

Search Strategy

This systematic review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[25] We searched PubMed, Embase, and Web of Science between inception and April 12, 2022, using the following search terms: "rotator cuff or shoulder arthroscopy" and "pain or analgesia or analgesias." There were 2 investigators (Y.L., L.Z.) who independently conducted the search process. Any disagreement was resolved by a third author (L.Z.).

Eligibility Criteria

Included were randomized controlled trials or prospective controlled trials with outcome indicators—pain scores, morphine consumption, and complications (nausea and vomiting)—after ARCR using any of the following interventions for pain management:

1. Neuraxial analgesia: EA
2. Peripheral nerve block (single dose or continuous infusion): ISNB, SCNB, SSNB, ANB, LPNB
3. Periarticular local anesthetic infiltration, including subacromial space, intra-articular, subcutaneous, and periarticular infiltration: PA
4. Intravenous PCA
5. Oral analgesia (ORAL)
6. Any combination of the above
7. Placebo control: saline or no intervention

The exclusion criteria were as follows:

1. Nonprospective controlled trials
2. Studies that included revision ARCR or studies in which a proportion of patients did not undergo ARCR
3. Studies that did not report the concerning outcome indicators (pain scores, morphine consumption, and complications)

Reporting Outcomes

The primary outcome indicators were (1) pain scores at rest at 6, 12, 24, and 48 hours postoperatively and (2) morphine-equivalent consumption at 24 hours postoperatively. The secondary outcome indicator was postoperative complications. Data (means and SDs), number of events, and total number of patients were directly extracted from the text and tables or indirectly from graphs by digitizing software (Engauge Digitizer). For continuous data (pain scores and morphine consumption), means and standard deviations were estimated by the method of Hozo et al[24] when the median and range were reported and by the method of Wan et al[65] when the median and interquartile range were reported. Pain scores were always reported using the visual analog scale (VAS), numerical rating scale, or similar scales; these were converted to a standardized 0-to-10 scale for a quantitative evaluation. An online calculator (https://clincalc.com/opioids) was used to convert opioid consumption data into intravenous morphine equivalents. Pain scores, morphine consumption, and complications were compared between analgesic methods using NMA. We defined the optimal analgesic method as the one that had significant differences in pain scores and morphine consumption and had no significant difference in the risk of complications compared with placebo during the initial 48 hours postoperatively.

Risk of Bias

There were 2 authors (L.Z. and P.S.) who independently assessed the risk of various types of bias in each included study using the Cochrane risk-of-bias tool. There are 7 items examined using the Cochrane risk-of-bias tool, including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. The overall risk of bias was rated as "low" if 5 items were judged to be at a low risk. The overall risk of bias was rated as "high" if 1 of 5 items was judged to be at a high risk. Otherwise, the overall risk was rated as "unclear."

Network Geometry

To examine the state of the literature in terms of which analgesics have been compared directly and which treatment comparisons will be dependent on indirect evidence, a trial network was constructed for each outcome. In the

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network, the size of each node indicates the number of patients receiving that treatment, and the thickness of the lines between treatments indicates the number of available studies conducting the comparison between them. Different colors for the connecting lines indicate the risk of bias in the comparison.

Heterogeneity and Consistency

The heterogeneity of direct treatment comparisons was quantified with the I^2 statistic and was interpreted as negligible for $I^2 < 0.25$, reasonable for $0.25 \leq I^2 < 0.50$, high for $0.50 \leq I^2 < 0.75$, and extreme for $I^2 \geq 0.75$. Consistency, which refers to the extent of agreement between direct and indirect evidence, was evaluated using a node-splitting approach to compare the difference between direct and indirect estimates for each treatment comparison.

Sensitivity Analysis

Pain at rest at 24 hours postoperatively was the most often reported outcome and was considered the most important outcome. Sensitivity analysis was conducted by excluding studies with an overall high risk of bias.

Transitivity

Transitivity is an important assumption in NMA. Transitivity refers to the similarity of patients and treatments across the included trials. For comparisons across the network of trials to hold, the patients and treatments should be similar. To evaluate transitivity, the variables of age, body mass index (BMI), surgery performed, anesthesia type, tear size, types and concentrations of local anesthetics, and sex ratio were considered in each study to determine if they were similar in all studies. These variables were chosen, as they were potential effect modifiers and an imbalance between studies would violate the assumption of transitivity.

Treatment Rankings

Treatment rankings are interpreted as cumulative probabilities to be the best treatment. The surface under the cumulative ranking curve (SUCRA) method was used to present the hierarchy of interventions for each outcome. SUCRA values show the percentage of effectiveness that each intervention achieves compared with an optimal intervention. For example, a SUCRA of 0.9 means that the specific intervention achieves 90% of the effectiveness of an optimal intervention.

Statistical Analysis

A heterogeneity test for all outcomes based on NMA was conducted using a random-effects model. If there was obvious heterogeneity ($I^2 > 50\%$), then sensitivity analysis was performed to identify its source.

The frequency method was used to meta-analyze multiple treatments in a random-effects model. Mean differences (MDs) with 95% CIs were adopted for morphine consumption and pain scores, and odds ratios (ORs) with 95% CIs were adopted for postoperative complications. Using a frequentist inconsistency model, a global test for consistency was performed. $P < .1$ was considered as inconsistency. The node-splitting approach tested local differences between direct and indirect comparisons. The cumulative probability to be the best treatment for each outcome was assessed using the SUCRA method.

RESULTS

Characteristics of Included Studies

From an initial search result of 2575 records, 42 studies with 3110 patients were included in this NMA (Figure 1). All of the included studies were published between 2007 and 2021.

Patient age and BMI were similar in all analgesic methods, but the ratio of male to female patients varied (Figure 2). General anesthesia was used in 39 studies,[‖] ISNB in 2 studies,[14,68] and ISNB and sedation in 1 study.[63] The patient characteristics, analgesic methods, anesthesia types, surgery performed, and level of evidence for each included study are shown in the Supplemental Material 1, available separately.

In terms of operative techniques, rotator cuff repair was used in 23 studies[¶]; rotator cuff repair and acromioplasty in 9 studies[7-9,18,21,26,30,31,53]; rotator cuff repair and distal clavicle resection in 2 studies[16,23]; rotator cuff repair and biceps tenotomy or tenodesis in 2 studies[20,34]; rotator cuff repair, biceps tenodesis or tenotomy, and distal clavicle resection in 2 studies[50,56]; rotator cuff repair, acromioplasty, and biceps tenotomy or tenodesis in 3 studies[29,45,51]; and rotator cuff repair, distal clavicle resection, biceps tenotomy or tenodesis, and acromioplasty in 1 study.[55] A full-thickness tear was evaluated in 14 studies[#] and partial- and full-thickness tears in 12 studies,[**] but the tear size was not mentioned in the other 16 studies.[††] The studies were conducted in 9 countries, and the majority of studies (n = 23)[‡‡] were conducted in the Republic of Korea. Blinding methods were described in 34 studies: 24 studies were double blinded,[§§] 4 studies were single blinded,[11,16,37,38] and 6 studies were not blinded.[18,23,29,31,56,68] Pain scores were reported in 39 studies,[‖‖] morphine consumption in $3#20 studies,[¶¶] and complications in 20 studies.[##] Details

[‖] References 2, 3, 5–9, 11, 16, 18, 20, 21, 23, 26, 28–38, 40–42, 44, 45, 50, 51, 53, 55–58, 61, 67.

[¶] References 2, 3, 5, 6, 11, 14, 28, 32, 33, 35–38, 40–42, 44, 57, 58, 61, 63, 67, 68.

[#] References 7, 8, 20, 21, 23, 26, 31, 34, 36, 37, 45, 50, 51, 56.

[**] References 5, 6, 9, 11, 16, 28, 32, 40–42, 55, 67.

[††] References 2, 3, 14, 18, 29, 30, 33, 35, 38, 44, 53, 57, 58, 61, 63, 68.

[‡‡] References 2, 6–9, 21, 28, 31–33, 35–37, 40–42, 44, 45, 50, 57, 58, 67, 68.

[§§] References 2, 3, 5, 9, 14, 21, 26, 28, 30, 32, 34, 35, 40–42, 45, 50, 51, 53, 55, 57, 61, 63, 67.

[‖‖] References 2, 3, 5–9, 11, 14, 16, 20, 21, 23, 26, 28, 29, 31–38, 40–42, 44, 45, 50, 53, 55–58, 61, 63, 67, 68.

[¶¶] References 2, 3, 5, 6, 9, 11, 14, 18, 23, 28, 30, 35, 36, 38, 42, 44, 50, 51, 56, 63.

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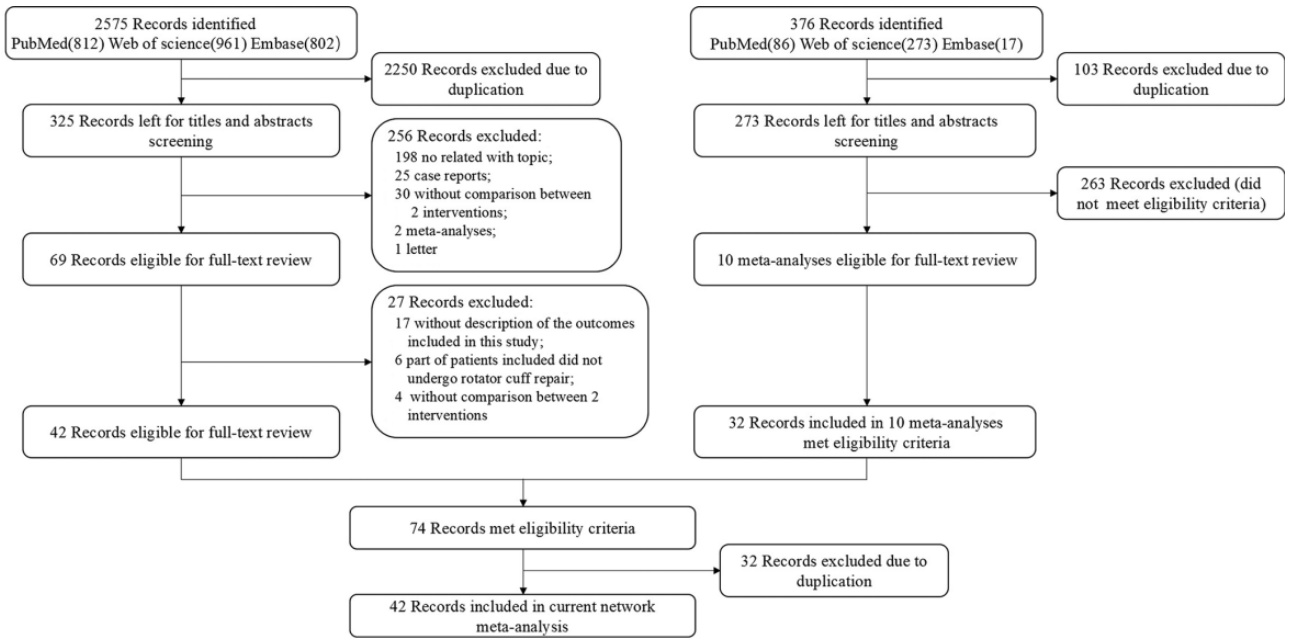

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram of study inclusion.

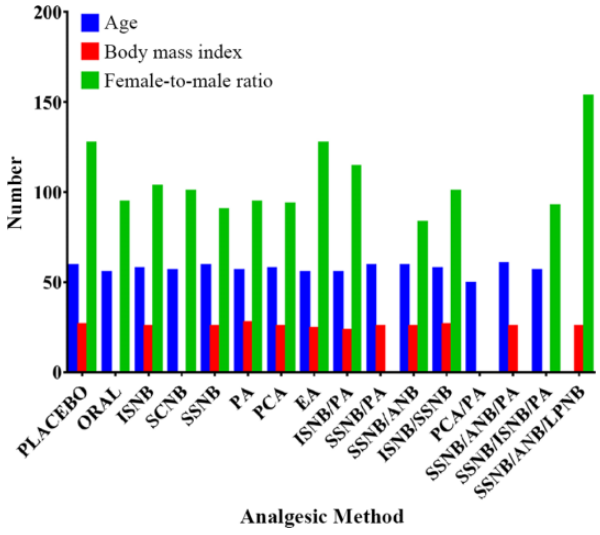

Figure 2. Basic characteristics of all treatments. ANB, axillary nerve block; EA, epidural analgesia; ISNB, interscalene nerve block; LPNB, lateral pectoral nerve block; ORAL, oral anesthesia; PA, periarticular analgesia; PCA, patient-controlled analgesia; SCNB, supraclavicular nerve block; SSNB, suprascapular nerve block.

regarding surgery, tear size, main outcome indicators, blinding methods, publication date, and country are shown in Supplemental Material 2.

Comparison of Outcomes With Placebo

Forest plots of all outcomes after the treatments in comparison with placebo are shown in Figure 3.

Pain Scores. In terms of the pain score at 6 hours, better performance than placebo was seen with SSNB+ANB (MD, –4.01 [95% CI, –5.07 to –2.96]), ISNB+SSNB (MD, –2.51 [95% CI, –3.78 to –1.24]), SSNB+PA (MD, –2.08 [95% CI, –2.50 to –1.66]), ISNB (MD, –1.61 [95% CI, -2.00 to –1.23]), ORAL (MD, –1.60 [95% CI, –2.18 to –1.02]), PCA+PA (MD, –1.01 [95% CI, –2.01 to –0.02]), SSNB (MD, –0.93 [95% CI, –1.31 to –0.54]), and PA (MD, –0.81 [95% CI, –1.58 to –0.04]) ($P < .05$ for all) (Figure 3A).

In terms of the pain score at 12 hours, better performance than placebo was seen with SSNB+ANB+LPNB (MD, –3.67 [95% CI, –4.80 to –2.54]), SSNB (MD, –2.34 [95% CI, –3.49 to –1.19]), ISNB (MD, –1.37 [95% CI, –1.85 to –0.89]), ORAL (MD, –1.30 [95% CI, –1.97 to –0.63]), and SSNB+ANB+PA (MD, –0.80 [95% CI, –1.42 to –0.18]) ($P < .05$ for all) (Figure 3B).

In terms of the pain score at 24 hours, no analgesic methods showed better performance than placebo (Figure 3C). In terms of the pain score at 48 hours, no analgesic methods showed better performance than placebo (Figure 3D).

SSNB+ANB, ISNB+SSNB, SSNB+PA, ISNB, and ORAL showed better performance than placebo at 6 hours postoperatively, and the differences were more than the minimal clinically important difference (MCID) of 1.4 for the VAS pain.[49] SSNB+ANB+LPNB and SSNB at 12 hours postoperatively showed better performance than placebo, and the differences were more than the MCID for the VAS pain. This indicated that the effect of the analgesic methods at 6 and 12 hours postoperatively was of clinical significance. However, no analgesic method showed clinically significant effects at all 4 time points.

Morphine Consumption and Complications. In terms of morphine consumption at 24 hours, better performance than placebo was seen with SSNB (MD, –17.70 [95% CI, –32.98 to –

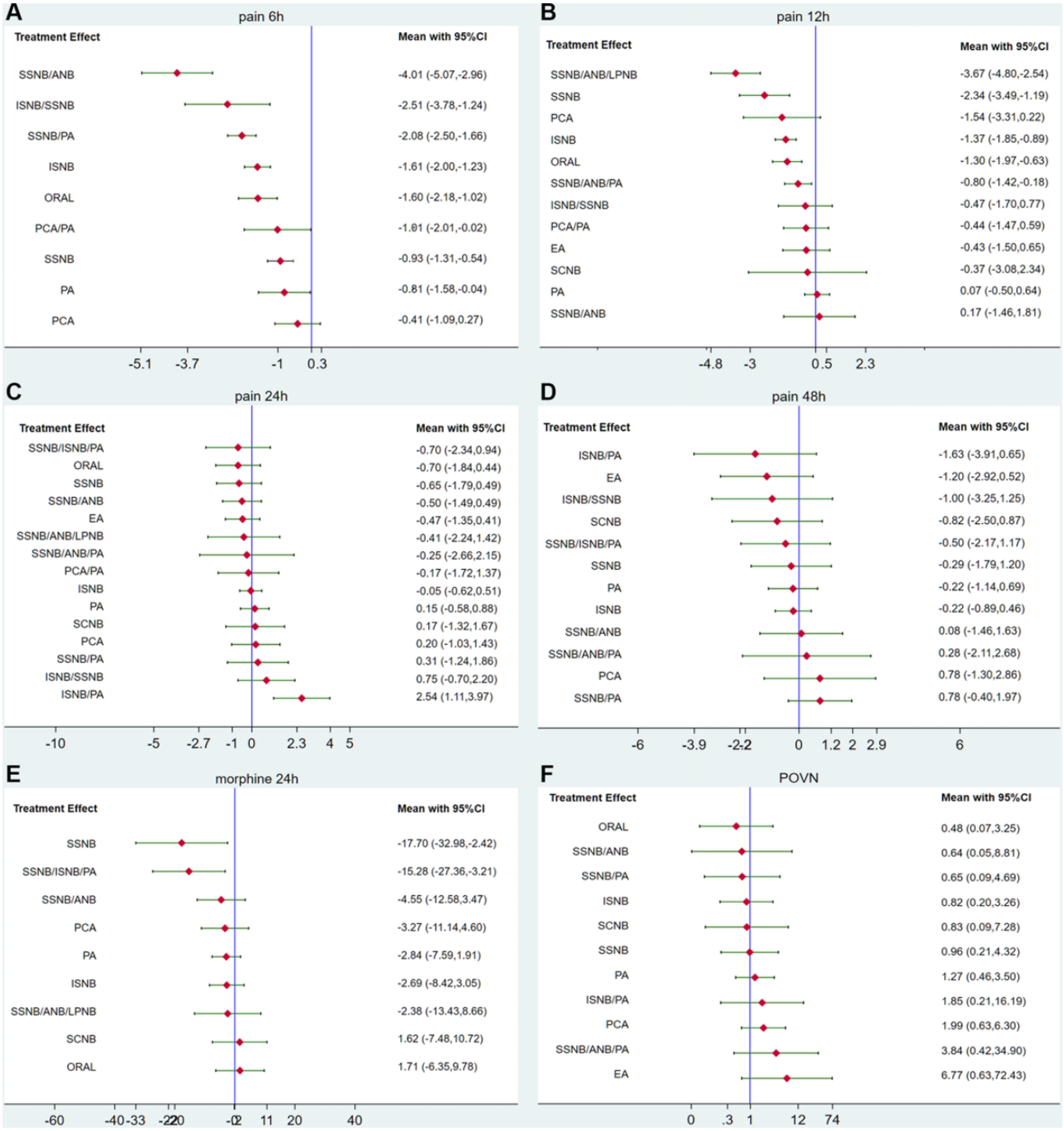

Figure 3. Forest plots of all outcomes. The mean difference or odds ratio with 95% CIs was used to measure the relative efficacy of different treatments compared with placebo. (A-F) The relative efficacy of different treatments compared with placebo for pain scores at 6 hours postoperatively, pain scores at 12 hours postoperatively, pain scores at 24 hours postoperatively, pain scores at 48 hours postoperatively, morphine consumption at 24 hours postoperatively, and postoperative vomiting and nausea (POVN). ANB, axillary nerve block; EA, epidural analgesia; ISNB, interscalene nerve block; LPNB, lateral pectoral nerve block; ORAL, oral anesthesia; PA, periarticular analgesia; PCA, patient-controlled analgesia; SCNB, supraclavicular nerve block; SSNB, suprascapular nerve block.

2.42]) and SSNB+ISNB+PA (MD, –15.28 [95% CI, –27.36 to –3.21]) ($P < .05$ for both). These differences were more than the MCID for intravenous morphine consumption after surgery including ARCR (10 mg[17]) (Figure 3E). In terms of nausea and vomiting, all the treatments showed no significant difference compared with placebo (Figure 3F).

Comparison of Outcomes Between Treatments

Pain scores were significantly lower with ISNB compared with SSNB at 6 hours postoperatively (MD, –0.69 [95% CI, –1.17 to –0.20]; $P < .05$), with no significant differences in morphine consumption (MD, 15.01 [95% CI, –1.31 to 31.33]) or complications (OR, 0.85 [95% CI, 0.19 to 3.74]) ($P > .05$ for both). Pain scores with ISNB were also significantly lower than with SSNB at 12 hours (MD, –1.44 [95% CI, –2.21 to –0.67]; $P < .05$); however, there were no significant differences at 24 hours (MD, –0.20 [95% CI, –1.13 to 0.72]) or 48 hours (MD, –0.01 [95% CI, –1.13 to 1.14]) ($P > .05$ for both).

Compared with SSNB, pain scores were significantly lower with SSNB+ANB at 6 hours (MD, –3.09 [95% CI, –4.18 to –1.99]) and 12 hours (MD, –0.87 [95% CI, –1.71 to –0.03]) ($P < .05$ for both); there were no significant differences in morphine consumption (MD, –13.15 [95% CI, –30.41 to 4.11]) and complications (OR, 1.51 [95% CI, 0.18 to 12.97]) ($P > .05$ for both). Compared with ISNB, pain scores were significantly lower with SSNB+ANB at 6 hours postoperatively (MD, –2.40 [95% CI, –3.38 to –1.42]; $P \leq .05$), with no significant differences in morphine consumption (MD, 1.87 [95% CI, –6.09 to 9.83]) and complications (OR, 1.28 [95% CI, 0.09 to 17.46]) ($P > .05$ for both). All the comparisons between treatments regarding efficacy are shown in Supplemental Material 3.

Risk of Bias

In general, the risk of bias with all the studies was acceptable (Figure 4). The most common cause of the risk of bias was incomplete blinding of participants and personnel and outcome assessment. In this research, 5 studies had incomplete blinding of participants and personnel and outcome assessment. Comparisons with a high risk of bias are shown with red lines in Figure 5.

Network Geometry

The network structure is presented in Figures 5 and 6. PA, SSNB, ISNB, SSNB+ANB, and PCA had the most comparative studies with a high risk of bias.

Heterogeneity and Consistency

The heterogeneity test indicated that the heterogeneity of pain scores at 6 and 12 hours and morphine consumption at 24 hours was high to extreme (Table 1).

The global test for consistency indicated that there was significant inconsistency in pain scores at 12 hours ($P < .0001$) and 24 hours ($P = .0032$). The node-splitting approach indicated that inconsistency between direct and indirect evidence existed in the comparison between placebo and SSNB ($P = .074$) for pain scores at 6 hours; the comparison between placebo and ISNB and between ISNB and SSNB ($P \leq .001$) for pain scores at 12 hours; and the comparison between placebo and PCA ($P = .030$), between ISNB and SSNB ($P = .077$), and between ISNB and PCA ($P \leq .001$) for pain scores at 24 hours. The results of comparisons are shown in Table 2. All the assessments of inconsistency between treatments are shown in Supplemental Material 4.

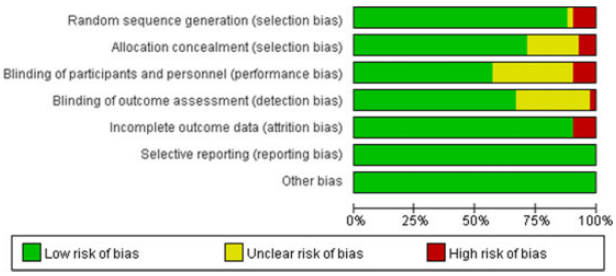

Figure 4. Risk-of-bias graph.

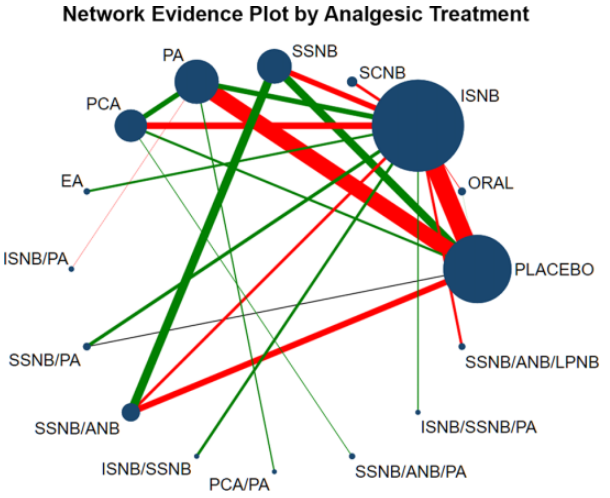

Figure 5. Network plot of all included studies. The size of each node indicates the number of patients receiving that treatment, and the thickness of the lines between treatments indicates the number of available studies conducting the comparison between them. Green lines indicate an overall low risk of bias in the comparison, and red lines indicate a high risk of bias. ANB, axillary nerve block; EA, epidural analgesia; ISNB, interscalene nerve block; LPNB, lateral pectoral nerve block; ORAL, oral anesthesia; PA, periarticular analgesia; PCA, patient-controlled analgesia; SCNB, supraclavicular nerve block; SSNB, suprascapular nerve block.

Sensitivity Analysis

The I^2 value for pain at 24 hours was 0.000. Thus, sensitivity analysis for pain at 12 hours was conducted by excluding studies with a high risk of bias (n = 3); the I^2 value changed from 0.799 to 0.453. Except for risk of bias, the type and concentration of local anesthetics might be a cause of heterogeneity. Because of the limited number of studies included, sensitivity analysis of local anesthetics was not performed in this study.

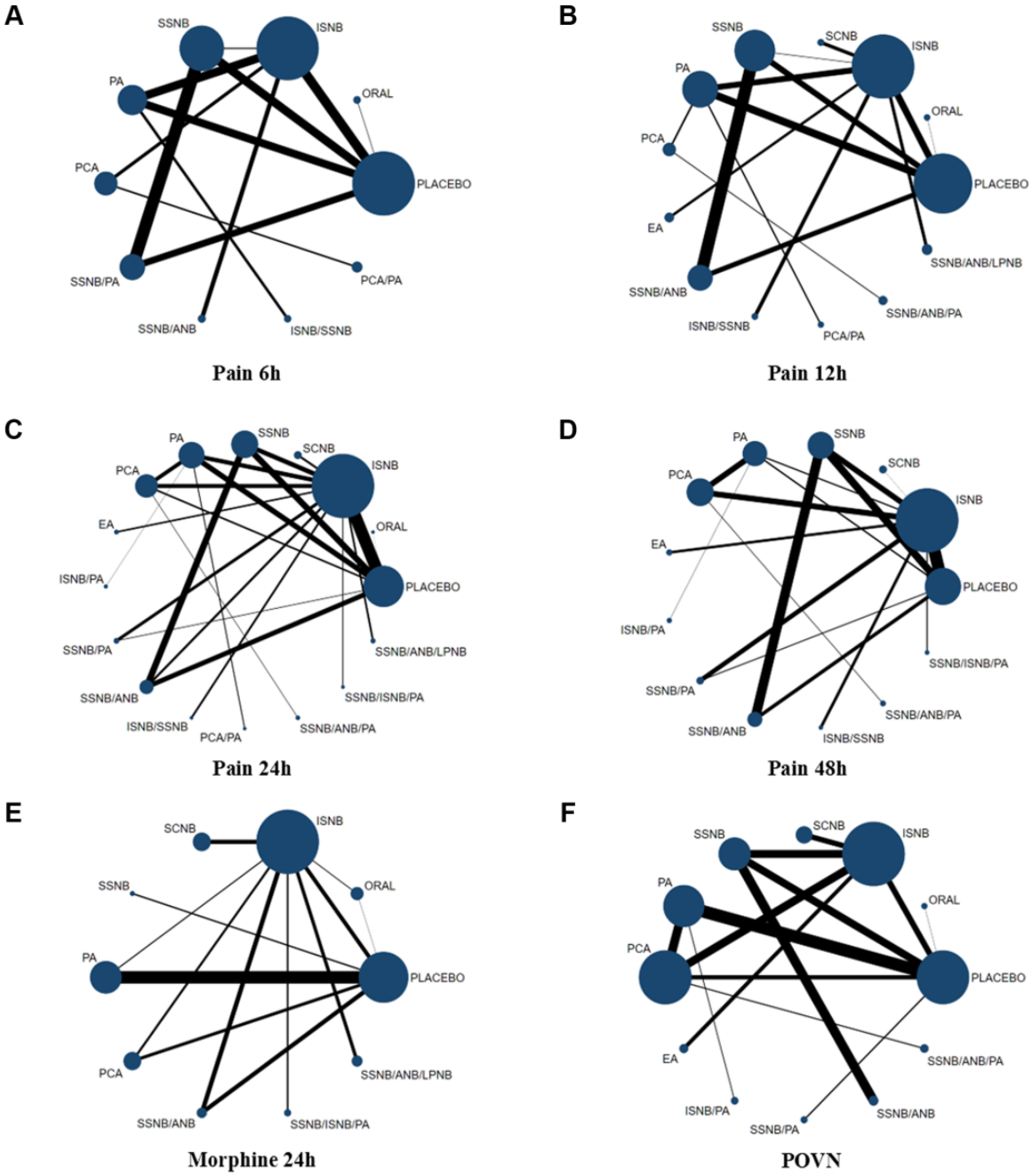

Figure 6. Network structures for all outcomes. (A-F) Pain scores at 6 hours postoperatively, pain scores at 12 hours postoperatively, pain scores at 24 hours postoperatively, pain scores at 48 hours postoperatively, morphine consumption at 24 hours postoperatively, and postoperative vomiting and nausea (POVN). ANB, axillary nerve block; EA, epidural analgesia; ISNB, interscalene nerve block; LPNB, lateral pectoral nerve block; ORAL, oral anesthesia; PA, periarticular analgesia; PCA, patient-controlled analgesia; SCNB, supraclavicular nerve block; SSNB, suprascapular nerve block.

Transitivity

The extent of the validity of NMA relies on the assumption of transitivity. Effect modifiers across direct comparisons are similar other than the intervention, allowing meaningful indirect comparisons of interventions. The effect modifiers that were assessed in this study were age, BMI, sex ratio, surgery performed, anesthesia type, tear size, and types and concentrations of local anesthetics. The details are shown in Figures 7 and 8.

The mean age across all direct comparisons ranged from 50 to 60 years. The BMI ranged from 23 to 30 kg/m^2. The sex ratio across all direct comparisons was inconsistent, but a previous study had proven that sex did not affect acute

postoperative pain levels after ARCR.[51] As for anesthesia type, general anesthesia (39 studies), ISNB (2 studies), and ISNB and sedation (1 study) were used. General anesthesia accounted for the majority. As for tear size, a full-thickness tear was reported in 14 studies, and partial- and full-thickness tears were reported in 12 studies. A previous study proved that tear size did not affect pain after ARCR.[63] As for types and concentrations of local anesthetics, bupivacaine, levobupivacaine, and ropivacaine were used for analgesia. A few studies also have proven that different types and concentrations of local anesthetics would not affect the postoperative pain of patients undergoing knee surgery.[22,52] As for surgery performed, rotator cuff repair with or without acromioplasty constituted the majority. A meta-analysis demonstrated that rotator cuff repair with or without acromioplasty had the same effect on the postoperative pain of patients undergoing ARCR.[54] Generally speaking, no definite effect modifiers broke transitivity.

TABLE 1
Heterogeneity of All Outcomes

Outcomes	I^2
Pain at rest	
6 h	0.532
12 h	0.799
24 h	0.000
48 h	0.000
Morphine consumption at 24 h	0.904
Complications	0.338

Treatment Rankings

The SUCRA was calculated in this NMA to show the ranking of each treatment at each time point (Table 3). The SUCRA value represented the possibility of ranking for each treatment under certain outcomes, with larger values indicating better treatment.

In terms of pain scores at 6 hours, SSNB+ANB showed the highest SUCRA value of 99.6. In terms of pain scores at

TABLE 2
Results of Comparisons Between Direct and Indirect Evidence[a]

Comparison	Direct Evidence	Indirect Evidence	*P*	Inconsistency Between Direct and Indirect Evidence[b]
Pain at 6 h				
Placebo vs SSNB	–0.1000000 ± 0.5594959	–1.5072050 ± 0.5551372	.074	Yes
Pain at 12 h				
Placebo vs ISNB	–1.3899030 ± 0.1942544	0.9094038 ± 0.3948911	≤.001	Yes
ISNB vs SSNB	–0.8999971 ± 0.4472142	1.4665040 ± 0.3803027	≤.001	Yes
Pain at 24 h				
Placebo vs PCA	–0.5000000 ± 0.6244925	1.1498410 ± 0.4309237	.030	Yes
ISNB vs SSNB	–0.4478977 ± 0.4005456	0.6030957 ± 0.4386695	.077	Yes
ISNB vs PCA	2.0979920 ± 0.4381178	–0.3033816 ± 0.3726877	≤.001	Yes

[a]Data are reported as mean ± SE unless otherwise indicated. ISNB, interscalene nerve block; PCA, patient-controlled analgesia; SSNB, suprascapular nerve block.

[b]If there was a significant difference between the value of direct evidence and the value of indirect evidence ($P < .1$), it was considered inconsistent or conflicting.

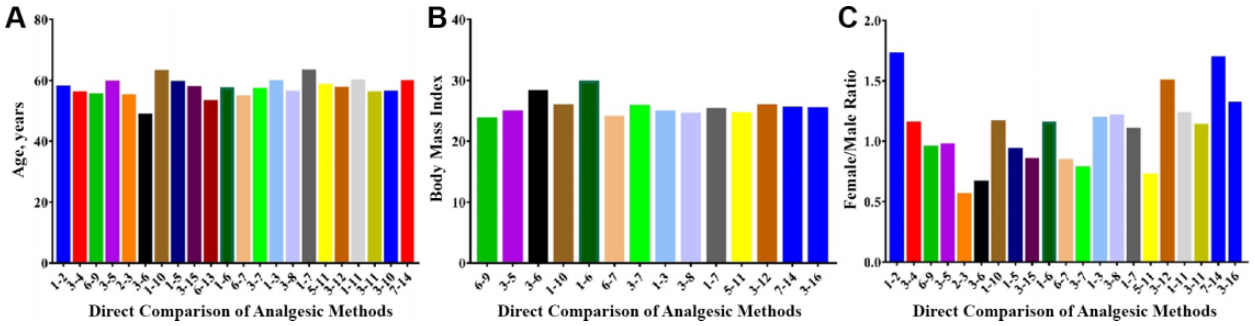

Figure 7. Distribution of (A) age, (B) body mass index, and (C) sex for all direct comparisons based on known data. Key to comparisons: 1 = placebo; 2 = oral analgesia; 3 = ISNB; 4 = SCNB; 5 = SSNB; 6 = PA; 7 = PCA; 8 = EA; 9 = ISNB+PA; 10 = SSNB+PA; 11 = SSNB+ANB; 12 = ISNB+SSNB; 13 = PCA+PA; 14 = SSNB+ANB+PA; 15 = SSNB+ISNB+PA; 16 = SSNB+ANB+LPNB. ANB, axillary nerve block; EA, epidural analgesia; ISNB, interscalene nerve block; LPNB, lateral pectoral nerve block; PA, periarticular analgesia; PCA, patient-controlled analgesia; SCNB, supraclavicular nerve block; SSNB, suprascapular nerve block.

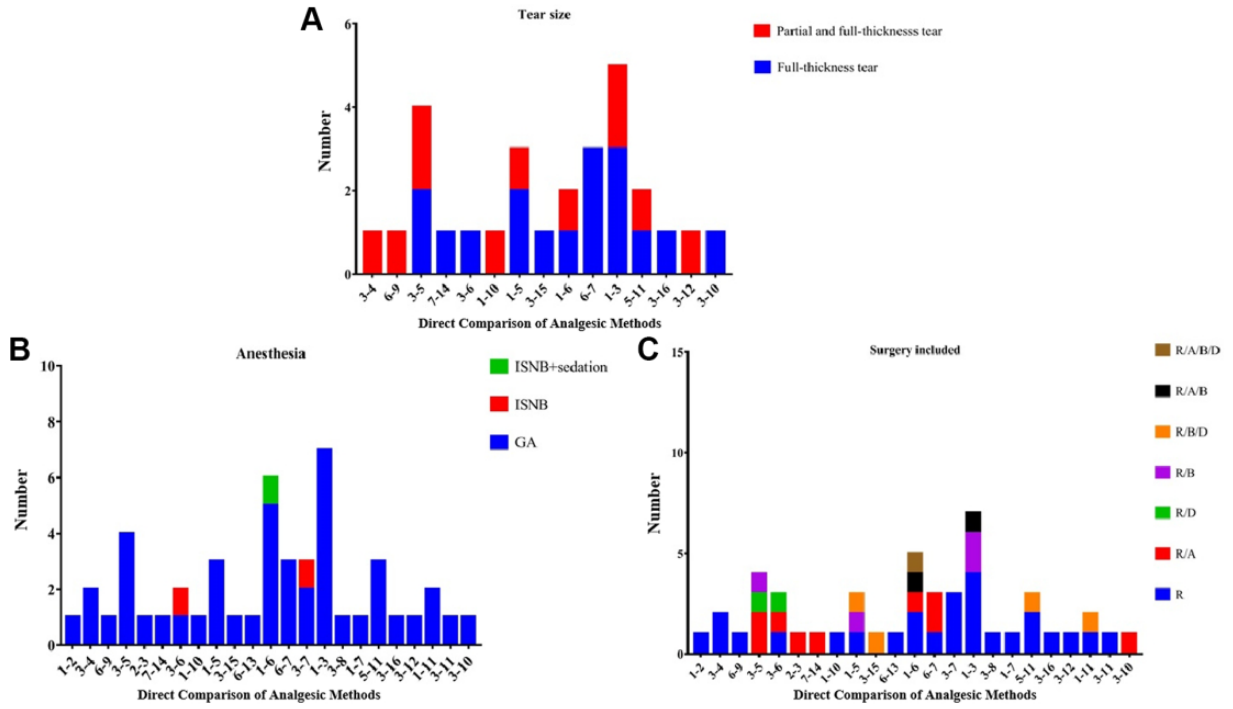

Figure 8. Distribution of (A) tear size, (B) anesthesia type, and (C) surgery performed for all direct comparisons based on known data. Key to comparisons: 1 = placebo; 2 = oral analgesia; 3 = ISNB; 4 = SCNB; 5 = SSNB; 6 = PA; 7 = PCA; 8 = EA; 9 = ISNB+PA; 10 = SSNB+PA; 11 = SSNB+ANB; 12 = ISNB+SSNB; 13 = PCA+PA; 14 = SSNB+ANB+PA; 15 = SSNB+ISNB+PA; 16 = SSNB+ANB+LPNB. ANB, axillary nerve block; EA, epidural analgesia; GA, general anesthesia; ISNB, interscalene nerve block; LPNB, lateral pectoral nerve block; PA, periarticular analgesia; PCA, patient-controlled analgesia; SCNB, supraclavicular nerve block; SSNB, suprascapular nerve block.

12 hours, ISNB+SSNB showed the highest SUCRA value of 99.2. In terms of pain scores at 24 hours, SSNB+ISNB+PA showed the highest SUCRA value of 99.6. In terms of pain scores at 48 hours, SSNB+ISNB+PA showed the highest SUCRA value of 91.7. In terms of morphine consumption at 24 hours, SSNB showed the highest SUCRA value of 92.3, which indicated that SSNB decreased morphine consumption in the first 24 hours. In terms of complications, EA demonstrated the smallest value (SUCRA = 10.7) and ORAL the greatest value (SUCRA = 76.0), indicating that ORAL decreased the likelihood of postoperative nausea and vomiting.

DISCUSSION

In this NMA, most analgesic methods resulted in lower pain scores and decreased morphine consumption compared with placebo; however, differences between methods were small and inconsistent. ISNB exhibited significant differences compared to SSNB in pain scores at 6 hours (MD, –0.69 [95% CI, –1.17 to –0.20]) and 12 hours (MD, –1.44 [95% CI, –2.21 to –0.67]) ($P < .05$ for both). The supplementation of ANB to SSNB was able to enhance the treatment effect. We believe that the premise of the most effective analgesic method is that it is both effective and safe compared with placebo.

ISNB acts very effectively at a central location of the brachial plexus and permits surgery without general anesthesia.[4,19] ISNB provides optimal analgesia for patients who undergo shoulder surgery. It can reduce pain scores and decrease opioid consumption at 12 hours postoperatively.[1] In terms of pain relief with ISNB compared with placebo, Kim et al[32] reported that ISNB relieved pain significantly until 6 hours postoperatively. However, there was significant rebound pain at 12 hours after ARCR.[32] Continuous ISNB was able to relieve pain without rebound pain.[32] Liu et al[45] also reported that pain scores in the ISNB group after ARCR were lower than those in the placebo group on the day of surgery and especially at 6 hours postoperatively. All the researchers above proved that ISNB has a good effect on pain relief. In this research, the pain scores in the ISNB group were significantly lower than those in the placebo group at 6 and 12 hours postoperatively, but morphine consumption and the incidence of postoperative nausea and vomiting in the ISNB group were not significantly different from those in the placebo group. Because of the limited number of studies included, ISNB and continuous ISNB were not examined separately. Previous studies have proven that continuous ISNB provides

TABLE 3
SUCRA Values for All Treatments[a]

Treatment	Pain at 6 h	Pain at 12 h	Pain at 24 h	Pain at 48 h	Morphine at 24 h	Complications
Placebo	1.9	24.2	30.4	31.9	25.6	57.4
ORAL	60.4	70.1	63.0	—	19.9	76.0
ISNB	61.4	73.0	34.4	45.6	48.4	65.4
SCNB	—	40.6	29.1	68.2	19.2	61.7
SSNB	33.3	21.8	25.3	42.1	92.3	57.3
PA	28.9	41.9	54.9	51.7	49.6	48.4
PCA	13.8	24.2	55.8	15.4	50.7	30.3
EA	—	41.7	12.0	33.2	—	10.7
ISNB+PA	—	—	41.0	41.6	—	38.2
SSNB+PA	78.9	—	60.4	51.3	—	67.7
SSNB+ANB	99.6	53.4	53.8	80.8	58.4	66.8
ISNB+SSNB	83.8	99.2	72.8	73.9	—	—
PCA+PA	38.1	57.4	55.6	—	—	—
SSNB+ANB+PA	—	—	41.8	22.4	—	20.0
SSNB+ISNB+PA	—	11.3	99.6	91.7	91.5	—
SSNB+ANB+LPNB	—	91.3	70.3	—	44.3	—

[a]ANB, axillary nerve block; EA, epidural analgesia; ISNB, interscalene nerve block; LPNB, lateral pectoral nerve block; ORAL, oral analgesia; PA, periarticular analgesia; PCA, patient-controlled analgesia; SCNB, supraclavicular nerve block; SSNB, suprascapular nerve block; SUCRA, surface under the cumulative ranking curve.Dashes indicate not available.

better analgesia than ISNB and that less opioid use was needed after ARCR by patients.[32,47]

However, ISNB raises concerns because of the risk of potentially long-term respiratory complications, especially phrenic nerve palsy and unilateral diaphragmatic paralysis .[10,32] Because it targets nerve roots in the neck rather than peripheral nerves, ISNB has a strong potential of leading to nerve injuries.[43,59] SSNB is responsible for motor innervation to the supraspinatus and infraspinatus muscles and 70% of shoulder sensory innervation, while the remaining 30% is managed by the axillary, supraclavicular, subscapular, medial pectoral, and lateral pectoral nerves.[64,66] SSNB is theoretically effective for pain relief because the majority of pain is generated by tissue innervated by the suprascapular nerve.[31] In terms of pain relief with SSNB compared with placebo, Lee et al[42] reported that SSNB did not improve pain after ARCR but that morphine consumption in the SSNB group decreased significantly. Kim et al[31] demonstrated that SSNB significantly improved pain after ARCR. The conclusions above are inconsistent with each other about pain relief with SSNB compared with placebo. In this study, compared with placebo, SSNB reduced pain significantly at 6 and 12 hours postoperatively and decreased morphine consumption significantly at 24 hours postoperatively.

Several randomized controlled trials have compared ISNB with SSNB, but the evidence is conflicting. Choi et al[9] demonstrated that SSNB was more effective than ISNB at 6 and 12 hours postoperatively for analgesia after ARCR and that morphine consumption was comparable between the groups. Desroches et al[16] showed that SSNB was as effective as ISNB for pain control within the first 24 hours and that morphine consumption was comparable between the groups. Kim et al[31] demonstrated that SSNB was not inferior to ISNB for pain control after ARCR and that morphine consumption was comparable between the groups. Kim et al[31] showed that SSNB was more effective than ISNB. The conclusions above are inconsistent with each other about the comparison between ISNB and SSNB. In this study, compared with SSNB, ISNB reduced pain significantly at 6 and 12 hours postoperatively but did not decrease morphine consumption significantly at 24 hours postoperatively.

PA is a simple technique for surgeons and anesthesiologists in which local anesthetics are injected into the joint cavity, into the subacromial space, or around the joint. The mechanism of analgesia is to target the terminal articular branches of the peripheral nerve as well as opioid receptors.[27] Because PA can provide good pain relief and is easy to master by clinicians, it is increasingly popular. In terms of pain relief with PA compared with placebo, Schwartzberg et al[55] reported that there was a significant reduction in pain scores at rest compared with placebo and that there were no differences found between the groups regarding morphine consumption. Verdecchia et al[63] reported no significant reduction in pain scores at rest and morphine consumption. However, Perdreau and Joudet[51] reported that PA after ARCR provided immediate benefits in terms of analgesia and morphine sparing. In this study, compared with placebo, PA reduced pain significantly at 6 hours postoperatively but did not decrease morphine consumption significantly at 24 hours postoperatively. Recently, some researchers[39,46] proved that local anesthetics (ie, bupivacaine, lidocaine, or ropivacaine) can have a detrimental effect on chondrocyte viability in articular cartilage in a dose- and duration-dependent manner, and thus, the choice of intra-articular anesthesia should be made cautiously in clinics.

In addition, there were a few articles concerning SSNB+ANB compared with SSNB. Ko et al[36] reported that SSNB+ANB in ARCR for medium-sized rotator cuff tears provided more improvement in pain scores and greater

patient satisfaction in the first 48 hours postoperatively than SSNB. Lee et al[44] reported that SSNB+ANB in ARCR improved pain scores in the first 24 hours after surgery compared with SSNB alone and that the combination decreased the rebound phenomenon. Park et al[50] reported that SSNB+ANB was a better pain control method than SSNB during the initial 12 hours postoperatively. In this study, compared with SSNB, the supplementation of ANB to SSNB was able to improve pain at 6 and 12 hours postoperatively but did not decrease morphine consumption at 24 hours postoperatively. Generally speaking, the supplementation of ANB to SSNB was beneficial for pain relief after ARCR.

Therefore, a single regional nerve block might not relieve a patient's pain well. A combination of different regional nerve blocks might be an ideal choice. In this study, SSNB+ANB improved pain compared with SSNB or ISNB at 6 hours postoperatively and improved pain compared with SSNB at 12 hours postoperatively. SSNB+ANB+LPNB improved pain compared with SSNB alone or SSNB+ANB at 12 hours post-operatively.

One of the main goals of pain control is to minimize the nausea, vomiting, urinary retention, and pruritus caused by opioids by providing safer alternatives. However, the studies included only reported nausea and vomiting, and thus, only nausea and vomiting were analyzed. In this research, there was no significant difference in the incidence of complications among all analgesic methods. According to the SUCRA method, EA was most likely to induce nausea and vomiting.

Limitations

There are several limitations to this study. First, some included studies had a high risk of bias, which might lead to unreliable conclusions. Second, heterogeneity in direct comparisons and inconsistency in NMA might result in inaccurate conclusions. Third, although no definite effect modifiers were found to break transitivity, anesthesia type, surgery performed, and the use of adjuvant opioids might also affect pain scores and morphine consumption. Fourth, part of the data were not extracted directly from the articles but were converted according to the Cochrane risk-of-bias tool; this might result in errors. Fifth, additional medicine used in the postoperative period might affect pain scores and morphine consumption. In the future, more high-quality and unified randomized controlled studies on anesthesia types and graft selection are needed.

CONCLUSION

Based on the current evidence, most analgesic methods resulted in lower pain scores and morphine consumption compared with placebo; however, differences between methods were small and inconsistent. There seemed to be significant differences between ISNB and SSNB in pain scores during the first 12 hours postoperatively but no significant difference in morphine consumption and complications. The addition of ANB to SSNB enhanced the analgesic effect.

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