Suprascapular and Interscalene Nerve Block for Shoulder Surgery

A Systematic Review and Meta-analysis

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ABSTRACT

Background: Interscalene block provides optimal shoulder surgery analgesia, but concerns over its associated risks have prompted the search for alternatives. Suprascapular block was recently proposed as an interscalene block alternative, but evidence of its comparative analgesic effect is conflicting. This meta-analysis compares the analgesic effect and safety of suprascapular block *versus* interscalene block for shoulder surgery.

Methods: Databases were searched for randomized trials comparing interscalene block with suprascapular block for shoulder surgery. Postoperative 24-h cumulative oral morphine consumption and the difference in the area under curve for pooled rest pain scores were designated as primary outcomes. Analgesic and safety outcomes, particularly block-related and respiratory complications, were evaluated as secondary outcomes. Results were pooled using random-effects modeling.

Results: Data from 16 studies (1,152 patients) were analyzed. Interscalene block and suprascapular block were not different in 24-h morphine consumption. The difference in area under the curve of pain scores for the 24-h interval favored interscalene block by 1.1 cm/h, but this difference was not clinically important. Compared with suprascapular block, interscalene block reduced postoperative pain but not opioid consumption during recovery room stay by a weighted mean difference (95% CI) of 1.5 cm (0.6 to 2.5 cm; $P < 0.0001$). Pain scores were not different at any other time. In contrast, suprascapular block reduced the odds of block-related and respiratory complications.

Conclusions: This review suggests that there are no clinically meaningful analgesic differences between suprascapular block and interscalene block except for interscalene block providing better pain control during recovery room stay; however, suprascapular block has fewer side effects. These findings suggest that suprascapular block may be considered an effective and safe interscalene block alternative for shoulder surgery. **(ANESTHESIOLOGY 2017; 127:998-1013)**

SIGNIFICANT acute postoperative pain is common in adults after shoulder surgery, with approximately 45% reporting severe pain in the immediate postoperative period.[1] With the majority of these procedures being performed in the ambulatory setting, providing effective postoperative analgesia has become paramount in promoting quicker recovery and rehabilitation of these patients.[2]

Interscalene nerve blockade (ISB) provides optimal analgesia for shoulder surgery patients; it reduces pain scores for at least 8 h and decreases opioid consumption for between 8 and 12 h postoperation.[3] However, ISB raises concerns relating to its high risk of transient and potentially long-term respiratory complications, most notably phrenic nerve paresis and unilateral diaphragmatic paralysis.[4–6] By targeting nerve roots in the neck rather than peripheral nerves, ISB also carries a higher risk of nerve damage.[7–9]

Although first described in 1941 by Wertheim and Rovenstine,[10] there has been recent renewed interest in using the suprascapular nerve block (SSNB) for analgesia after shoulder surgery.[11] The suprascapular nerve provides 70% of the sensory input to the glenohumeral joint and also innervates the infraspinatus and supraspinatus muscles.[12,13]

What We Already Know about This Topic

- Shoulder surgery is associated with significant postoperative pain, and interscalene block remains a primary form of perioperative analgesia
- There are conflicting data about the value of suprascapular nerve blocks for shoulder surgery

What This Article Tells Us That Is New

- A meta-analysis of 16 studies demonstrates suprascapular block results in 24-h morphine consumption and pain scores similar to interscalene block
- Pain control may be better with interscalene blocks at 1 h postoperation
- Suprascapular block is associated with fewer complications, in particular those that may limit the use of interscalene blocks in patients with obesity, sleep apnea, or pulmonary disease

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 Anesthesiology 2017; 127:998-1013

<zdoi;10.1097/ALN.0000000000001894>

On this anatomical basis, the SSNB has been proposed to produce sufficient analgesia for shoulder surgery and has consequently been suggested as an ISB alternative.[13] Several randomized controlled trials have compared ISB with SSNB, but the evidence is conflicting. Some have found ISB to be superior,[14,15] whereas others have shown that SSNB provides noninferior analgesia.[1,16] Furthermore, the role of a supplementary axillary nerve block is still not clear[17]; some researchers suggest it as a necessary complement, whereas others dismiss the need for additional blocks.[18–20]

The primary objective of this systematic review and meta-analysis was to compare the analgesic effect, as measured by analgesic consumption and pain severity during the first 24 h postoperation, of SSNB *versus* ISB in adult patients having shoulder surgery. The safety of the two techniques was also compared as a secondary outcome.

Materials and Methods

The authors adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement guidelines in the preparation of this article.[21] Trials that assessed postoperative opioid consumption, pain severity, and other analgesic outcomes in patients undergoing shoulder surgery who were receiving SSNB or ISB were evaluated using a predesigned protocol. The protocol was not registered with the International Prospective Register of Systematic Reviews.

Eligibility Criteria

Randomized or quasirandomized trials that allocated adult patients (18 yr of age or older) to receive either single-shot ISB or SSNB for pain relief after shoulder surgery were considered. We also included trials that administered a supplemental axillary block to SSNB. Studies were considered if blocks were performed for surgical anesthesia or postoperative analgesia. Studies were excluded if the surgery involved areas other than the shoulder joint. Furthermore, trials were excluded if continuous catheter-based nerve block techniques were used, because continuous- and single-injection blocks are considered to be distinct interventions from analgesic and safety perspectives. No language restrictions were placed on inclusion, and non-English articles were translated using online translation. Finally, the corresponding authors of potentially eligible trials were contacted for additional information when needed.

Submitted for publication May 8, 2017. Accepted for publication August 31, 2017. From the Central Michigan University College of Medicine, Mt. Pleasant, Michigan (N.H., G.G., N.R.); Department of Clinical Epidemiology, McMaster University, Hamilton, Ontario, Canada (L.B.); Department of Anesthesia, University of Toronto, Toronto, Ontario, Canada (J.G.L., F.W.A.); Department of Anesthesia and Keenan Research Centre, Li Ka Shing Knowledge Institute, St. Michael's Hospital, Toronto, Ontario, Canada (J.G.L., F.W.A.); Department of Anesthesia, School of Medicine, National University of Ireland, Galway, Ireland (J.G.L.); and Department of Anesthesiology and Pain Medicine and Ottawa Hospital Research Institute, University of Ottawa, Ottawa, Ontario, Canada (F.W.A.).

Search Methods for Identification of Studies

A systematic search strategy was created by an evidence-based medicine librarian (L.B.) for the U.S. National Library of Medicine Database, Excerpta Medica Database, Cochrane Central Register of Controlled Trials, and the Database of Abstracts of Reviews of Effects. The search terms and subject headings contained within each strategy centered around capturing articles related to ISB, SSNB, brachial plexus block, shoulder surgery, and postoperative analgesia. The full search strategy can be viewed in the Supplemental Digital Content (http://links.lww.com/ALN/B544). The bibliographies and citations of all included articles were hand searched to identify additional trials that satisfied inclusion criteria. The following international meetings also had their published abstracts electronically searched for eligible articles: American Society of Anesthesiologists 2011 to 2016, American Society of Regional Anesthesia and Pain Medicine 2013 to 2016, and the European Society of Regional Anesthesia 2014 to 2016.

Selection of Included Studies

Two independent reviewers (N.H. and G.G.) screened the results from the electronic searches of the various databases from inception to February 10, 2017. This initial screening examined the title and abstract only. Subsequently, the full text of all potentially eligible articles were retrieved and evaluated for inclusion. In the case of a disagreement on eligibility, the two reviewers discussed until a consensus was reached. If a consensus still could not be reached, a third reviewer (F.W.A.) assessed the article for eligibility. The initial agreement between the two reviewers for full text eligibility was assessed through the calculation of an unweighted κ.

Data Extraction

A data extraction form was created and piloted by an independent reviewer (N.H.). All of the data were extracted in duplicate by two independent reviewers (N.H. and G.G.). In the case of a discrepancy, the two independent reviewers revisited the source study. If a consensus still could not be reached, a third reviewer (F.W.A.) assessed the data and made the final decision. The data extraction form collected information regarding the age of study participants; year of publication; nature of shoulder surgery performed; nature of local anesthetic used; type of block performed; block localization technique; preoperative, intraoperative, and postoperative analgesic regimens; primary outcome examined; pain scores at all reported follow-up times; interval analgesic consumption at all reported follow-up times; patient satisfaction with pain relief; block discomfort; duration of analgesia; respiratory and functional outcomes; opioid-related and block-related adverse events; and hospital and postanesthesia care unit (PACU) discharge times.

The primary sources of data were numerical data reported in tables of included studies. In cases of graphically reported data, the corresponding authors were contacted

for additional information. If a response was not obtained, data in graphical form were derived from a graph digitizing software (GraphClick, Arizona Software, USA). For abstracts included in the review, the corresponding authors were contacted for additional methodologic and outcome information.

Assessment of Methodologic Quality and Risk of Bias

The Cochrane Collaboration's tool for assessing risk of bias was used to assess the methodologic quality of all included randomized and quasirandomized trials.[22] Questions in this tool relate to randomization sequence generation, allocation concealment, blinding of study personnel and outcome assessors, loss to follow-up, and outcome data reporting.[22] Two independent reviewers (N.H. and G.G.) rated each trial as having a low, unclear, or high risk of bias based on predefined questions related to the study methodology. An unweighted κ was calculated to assess the initial agreement between the two independent reviewers on risk of bias assessment. In the case of disagreement, the two reviewers discussed until a consensus was reached. If an agreement could not be reached, a third reviewer (F.W.A.) evaluated the trial in question.

Primary and Secondary Outcomes

The primary outcomes of this meta-analysis were defined as cumulative postoperative oral morphine consumption (in milligrams) during the first 24-h interval[23] and the difference in the area under the curve of the pooled (weighted) rest pain scores associated with the two interventions examined at four predesignated time points (1 [PACU], 6, 12, and 24 h postoperation). We selected area under the curve analysis to capture the reported variability in analgesic effect of ISB and SSNB over time. Earlier studies suggest that the analgesic effects of ISB and SSNB for postoperative pain control may have opposite trends in the first 24 h after shoulder surgery.[24–26] ISB has been shown to offer better early pain control but is associated with worse pain at 24 h.[3] In contrast, the SSNB seems to be less effective in treating early postoperative pain but is also associated with similarly effective pain control at 24 h.[24–26]

Secondary analgesic outcomes included visual analog scale (VAS; 0 = no pain and 10 = worst pain imaginable) pain scores at 1, 6, 12, 24, and 48 h postoperation; block procedural discomfort (VAS score); cumulative oral morphine consumption in the PACU (in milligrams)[23]; analgesic duration (hours); and patient satisfaction with pain relief (VAS score). Secondary safety outcomes included postoperative respiratory function (peak respiratory flow, in milliliters), incidence of respiratory complications (pneumothorax, dyspnea, or desaturation in the PACU), opioid-related side effects (postoperative nausea and vomiting, pruritus, or sedation), undesirable blockade of nerves or anatomical areas not involved in the surgery (*e.g.*, cervical plexus, recurrent laryngeal, or forearm and hand), and block-related complications (persistent paresthesia, weakness and tingling at 1 day and 1 week after surgery).

Measurement of Outcome Data

Pain severity, one of the primary outcomes of this review, is commonly measured using a 0- to 10-cm or 0- to 100-cm VAS pain scale, with higher scores being associated with greater levels of pain.[27] For the purposes of this meta-analysis, all of the pain scores were converted to an equivalent 0- to 10-point VAS score.[28] All postoperative analgesic medications required were converted to oral morphine equivalents.[23] Patient satisfaction with pain relief and block procedural discomfort could also be measured by a wide variety of tools. When available, data for these outcomes were presented as a VAS score (0 = least satisfied/comfortable, 10 = most satisfied/comfortable).[28] All time-to-event data were presented in hours.

Statistical Analyses

The mean and SD were sought and extracted for continuous outcome data. The median and interquartile range were used to approximate the mean when its value was not provided.[29] In situations where the CI was reported, statistical conversions were made to a SD using the methods described by Wan *et al.*[29] and the Cochrane Collaboration.[22] However, if a SD was not provided, the value was imputed.[30] If permissible, dichotomous outcome data were converted to continuous data to allow for statistical pooling.[31] For dichotomous outcome data related to adverse events (opioid and nerve block related), results were converted to overall incidence numbers.

Assessment of Heterogeneity

An I^2 statistic test was used to assess heterogeneity. We considered an I^2 greater than 50% to be indicative of significant heterogeneity, as suggested by the Cochrane Handbook for Systematic Reviews.[22] If heterogeneity was above our predefined cutoff, meta-regression was performed using mixed modeling to explore whether our primary outcome results were influenced by *a priori* specified clinical predictors of the treatment effect. Meta-regression was performed only if each group within the covariate included two or more trials. The covariates examined were as follows: (1) localization technique (ultrasound *vs.* landmark *vs.* nerve stimulator)[32,33]; (2) surgical anesthesia (general *vs.* regional)[34]; (3) use of intermediate-acting (lidocaine and mepivacaine) *versus* long-acting (bupivacaine, levobupivacaine, and ropivacaine) local anesthetics[35]; (4) postoperative analgesic modality (multimodal = combines opioid and other adjuvants *vs.* unimodal = uses opioids only)[36,37]; (5) addition of adjuvants that can prolong block duration (*e.g.*, epinephrine)[38,39]; and (6) use of a supplemental axillary block, because there is some evidence that axillary block may provide an additive analgesic effect to the SSNB.[17] We resorted to sensitivity analysis when meta-regression could not be performed on a specific covariate (less than two trials).

Assessment of Publication Bias

A funnel plot was created and visually inspected to assess for publication bias in each of the outcomes assessed. In the

absence of bias, the plot should generally take the shape of a symmetrical, inverted funnel.[22] Furthermore, we evaluated publication bias using the Egger's regression test when three or more trials reported a certain outcome.[40]

Meta-analysis

When dichotomous data could be pooled, a meta-analysis was performed using the Mantel–Haenszel random-effects model, because we expected clinical heterogeneity between the included studies. For continuous outcome data, the data were weighted according to the inverse variance method and pooled using a random-effects model.[41] For the primary outcomes, cumulative oral morphine consumption and area under the curve of pain scores during the first 24 h postoperation, the weighted mean difference (WMD) with a 95% CI and the mean difference in the area under the curve of the pooled rest pain scores were calculated, respectively. For continuous secondary outcomes, including VAS pain scores at 1, 6, 12, 24, and 48 h postoperation, block discomfort, patient satisfaction with pain relief, postoperative respiratory and functional outcomes, and analgesic duration, a WMD with a 99% CI was calculated. For dichotomous secondary outcomes, including opioid and block-related complications, an odds ratio (OR) with a 99% CI was calculated. We decided to use the 99% CI for all secondary outcomes to account for the relatively small number of studies and the potential risk of multiple testing bias. For the two primary outcomes of this review, the threshold for significance was set at $P < 0.025$. For the secondary outcomes of this review, $P < 0.01$ was considered significant. All of the tests of significance were two tailed.

To aid in the interpretation of the area under the curve analysis and pooled rest pain severity scores, we evaluated each in relation to the minimal clinically important difference (MCID) of the VAS pain score. The MCID is defined as the smallest change effect that an informed patient would perceive to be beneficial and clinically meaningful.[42] In patients undergoing shoulder arthroplasty, the MCID for postoperative VAS pain scores has been estimated to be 1.4 cm.[43,44] This estimate is in keeping with similar research where pain MCID values of 1.2[45] and 1.3[46,47] have been reported.

Level of Evidence

We assessed the strength of pooled evidence for each individual outcome of interest across the trials, included using Grades of Recommendation, Assessment, Development, and Evaluation guidelines.[48] Based on study quality, consistency, directness, precision, and publication bias, these guidelines classify the strength of evidence into strong, moderate, low, or very low quality.

Data Management

All of the forest and funnel plots were generated using Review Manager Software (RevMan version 5.2; Nordic Cochrane Center, Cochrane Collaboration, United Kingdom). Meta-regression was performed using Comprehensive Meta-Analysis 3.0 (Biostat, USA). Agreement between the reviewers, as assessed through the unweighted κ, was calculated using SPSS software (version 21.0; SPSS Inc., USA).

Results

A total of 708 potentially eligible records were retrieved through the primary literature search. Of these, 688 records were excluded due to various reasons. The flow diagram for study inclusion is depicted in figure 1. A total of 20 articles had their full-text versions retrieved and evaluated for inclusion. Of these, 13 satisfied our eligibility criteria and were included in this review.[1,14–16,24–26,49–54] In addition, the search of conference proceedings identified two recent abstracts that satisfied our eligibility criteria and were included in this review.[55,56] The authors of relevant ongoing trials on www.clinicaltrials.gov were also contacted, and authors of one completed trial provided data that were used in the meta-analysis (NCT02415088).[57] As such, a total of 16 studies were included in this meta-analysis. One of these included trials required electronic translation from Korean to English,[14] and additional unpublished outcome data were available from seven other trials.[1,14,16,24,49,52,57] The unweighted κ for full-text eligibility was calculated to be 0.76 between the two independent reviewers.

Study Characteristics

The characteristics of the included trials and the outcomes assessed are summarized in table 1. The 16 studies included 1,152 patients, of whom 577 received ISB and 575 received SSNB. The primary outcomes of interest were reported in the majority of studies. Analgesic consumption in the first 24 h postoperation was reported by 13 studies,[1,15,16,24–26,49–51,53–55,57] whereas rest pain severity scores in first 24 h postoperation were reported by 15 studies.[1,14–16,24–26,49–55,57]

The nerve block techniques varied between the included trials. The SSNB block techniques and the analgesic regimens used are detailed in table 2. The SSNB involved perineural injection in the suprascapular fossa in 15 studies[1,15,16,24–26,50–52,54–58] and in the supraclavicular fossa in one study.[49] SSNB localization included nerve stimulation in nine studies,[1,14,15,24,25,50,53–55] ultrasound in four,[26,49,56,57] and anatomical landmarks in three.[16,51,52] The timing of SSNB was before general anesthesia induction in 15 studies[1,14–16,24–26,49,50,52–57] and after induction but before surgical incision in one.[51] SSNB was supplemented by an axillary block in eight studies.[24–26,50,54–57] Varying volumes and types of local anesthetic solutions were administered and occasionally included epinephrine.[14,25,53] Twelve studies used low volumes (15 ml or less),[1,14–16,24–26,49,50,54,55,57] three used large volumes (20 ml);[51–53] and volume was not specified in one study.[56] The solution used was a long-acting local anesthetic in 15 trials, including ropivacaine in seven,[16,24,49,52,55–57] bupivacaine in five,[1,15,50,51,53] and levobupivacaine in three[14,25,26]; study 16 used a combination of mepivacaine and ropivacaine.[54] Finally,

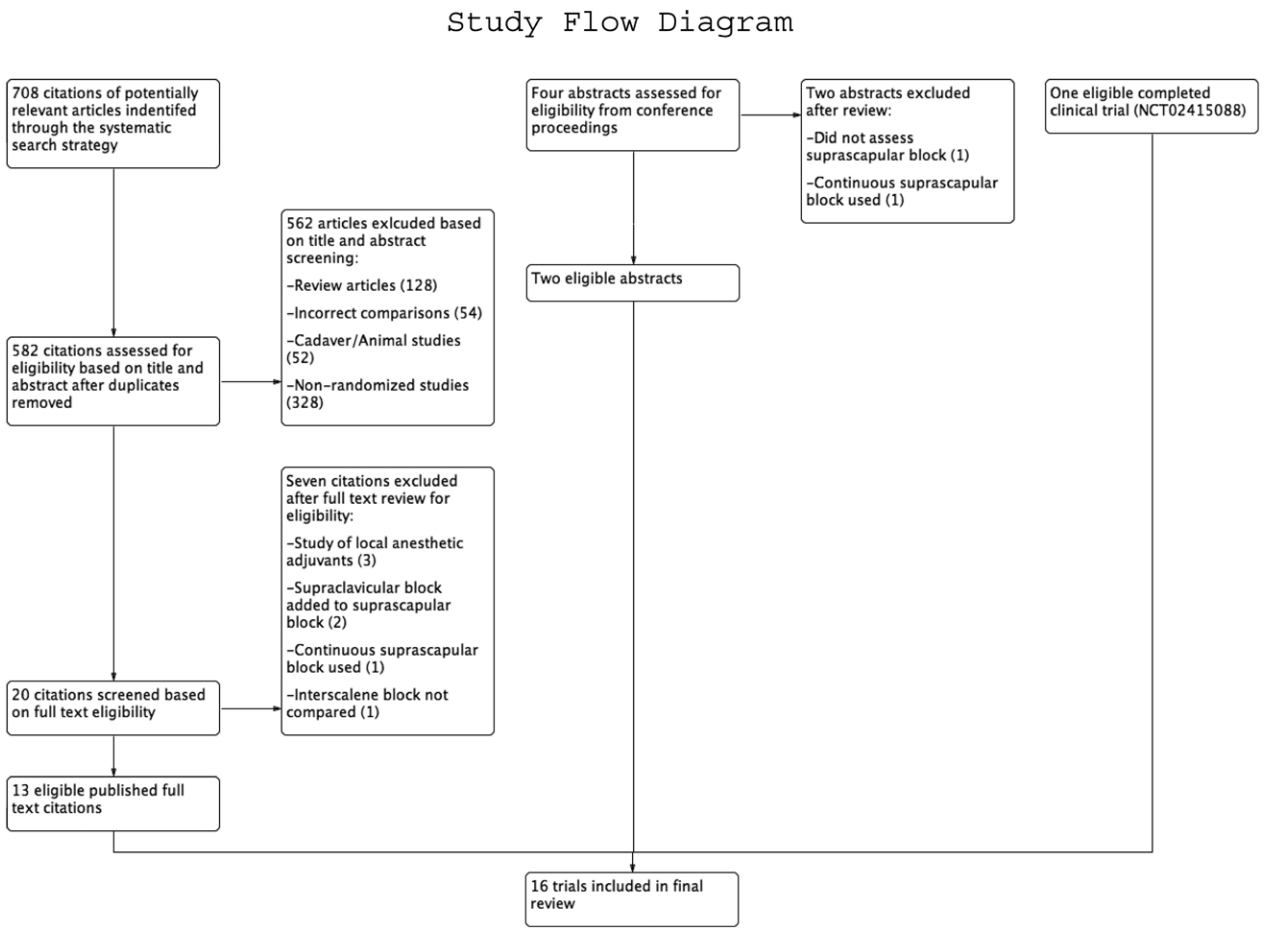

Fig. 1. Preferred reporting items for systematic reviews and meta-analyses flow diagram summarizing retrieved, included, and excluded trials.

patients received a range of postoperative analgesic regimens, including multimodal analgesia in 13 studies[14–16,24–26,49–54,57] and unimodal analgesia (opioids only) in two, and one study did not define the regimen used.[56]

Risk of Bias Assessment

The risk-of-bias rating for the included trials is presented in figure 2. Of the 16 included studies, 13 were randomized controlled trials[1,16,24–26,49–53,55–57] and three were quasirandomized.[14,15,54] Eight trials adequately described the random sequence generation methods,[16,24,25,49,51–53,57] eight adequately described the allocation concealment methods,[16,24,25,49–51,53,57] six explicitly stated that the patients were blinded,[16,24,25,49,53,57] and six explicitly stated that outcome assessors were blinded.[24,25,49,52,53,57] Eleven trials either reported a less than 20% rate of loss to follow-up, adequately reported missing data, or had balanced missing data between the two groups.[15,16,24–26,49–53,57] Four studies were preregistered, and their protocols were available for review.[16,24,49,57] One study described assessment of pain, but results were not presented in the article[25]; thus, its risk of selective reporting bias was high.[25] The unweighted κ for risk of bias assessment between the two independent reviewers was calculated to be 0.7.

Primary Outcomes

Cumulative 24-h Oral Morphine Equivalent. The cumulative 24-h oral morphine equivalent consumption data were available from 12 studies,[1,15,16,25,26,49–51,53–55,57] with 10 trials, including 873 patients (SSNB = 437, ISB = 436), providing numerical or graphical data that permitted statistical pooling.[1,15,26,49–53,55,57] Of these trials, actual morphine consumption was reported in six trials,[16,24–26,50,55] whereas the others reported consumption of different analgesics that were converted to morphine equivalents. Overall, although ISB appeared to reduce 24-h oral morphine consumption by a WMD (95% CI) of 3.4 mg (−1.0 to 7.9; $P = 0.13$; $I^2 = 58\%$), this difference was not statistically significant (fig. 3). The funnel plot and Egger's regression test did not reveal any publication bias ($P = 0.90$). Table 3 summarizes the outcome results and the assigned Grades of Recommendation, Assessment, Development, and Evaluation of evidence for each outcome.

The results of this primary outcome were characterized by high heterogeneity. Meta-regression analysis exploring whether any of the predefined clinical predictors explained this heterogeneity revealed that the WMD of oral morphine consumption was independent of the type of analgesia used (unimodal *vs.* multimodal; $R^2 = -0.03$, $P = 0.38$), block

localization technique (anatomical *vs.* ultrasound *vs.* nerve stimulation; R^2 = 0.50; P = 0.04), and use of a supplemental axillary block (R^2 = 0.17; P = 0.17). For the remaining covariates, meta-regression was not feasible because there were less than two studies in the subgroup examined. Furthermore, sensitivity analysis was also not feasible because the majority of trials included in this review used long-acting local anesthetics, did not use any adjuvants to prolong local anesthesia, and administered preoperative nerve blocks.

Area under the Curve for Pain Severity at Rest. The pooled weighted mean pain scores at 1, 6, 12, and 24 h (four time points) were calculated for patients in both study groups (SSNB and ISB). The analysis for each time point included a different number of patients, with 969 patients (SSNB = 480, ISB = 489), 967 (SSNB = 480, ISB = 487), 224 (SSNB = 108, ISB = 116), and 961 (SSNB = 479, ISB = 482) at 1, 6, 12, and 24 h, respectively. The mean of the differences in area under the curve of the pooled rest pain scores between the ISB and SSNB groups was 1.1 cm/h in favor of the ISB group for the four time points combined (1 to 24 h; fig. 4). However, using an MCID of 1.4 cm on the 0- to 10-cm VAS pain scale[43,44] for each time point, the cumulative area under the curve for the MCID was calculated to be 4.2 cm/h for the four time points combined (1 to 24 h). As such, the cumulative difference in the area under the curve for rest pain severity scores between the ISB and SSNB (1.1 cm/h) did not reach the threshold that is considered clinically important.

Other Analgesic Outcomes

Rest Pain Severity Scores at Individual Time Points. Compared with SSNB, ISB provided significantly better and clinically meaningful[43,44] pain relief by 1.5 cm (95% CI, 0.6 to 2.5; P < 0.0001; I^2 = 97%) at 1 h only (during PACU stay), but there were no differences in rest pain severity at any of the other time points (*i.e.*, at 6, 12, 24, and 48 h; table 3). A funnel plot was created to evaluate the potential for publication bias at all of the time points except at 48 h, where only two studies reported pain scores. The Egger's regression test for the degree asymmetry yielded P values equivalent to 0.08, 0.12, 0.52, and 0.86, at 1, 6, 12, and 24 h, respectively, suggesting the absence of publication bias.

Oral Morphine Consumption in the PACU. Postoperative morphine consumption in the PACU was assessed by seven studies,[16,24,25,49,53,55,57] with four studies including 547 patients (SSNB = 274, ISB = 273) providing data that permitted statistical pooling.[24,49,53,55] ISB seemed to reduce postoperative oral morphine consumption in the PACU, but the difference was not statistically significant (table 3). The funnel plot and Egger's regression test did not reveal any publication bias (P = 0.08).

Analgesic Duration. The duration of analgesia was assessed by three studies,[1,25,50] inclusive of 178 patients (SSNB = 89, ISB = 89). ISB seemed to prolong the duration of analgesia, but the difference did not reach statistical significance (table 3). The funnel plot and Egger's regression test did not reveal any publication bias (P = 0.82).

Block Procedural Discomfort. Block discomfort was assessed by a total of three studies including 207 patients (SSNB = 102, ISB = 105).[15,25,57] Patients receiving ISB seemed to experience more procedural discomfort (measured on a VAS scale) in comparison with patients receiving SSNB, but the difference did not reach statistical significance (table 3). The funnel plot and Egger's regression test did not reveal any publication bias (P = 0.74).

Safety Outcomes

Respiratory Function and Complications. Only one study assessed respiratory function (peak expiratory flow rate)[55] and found no significant difference between the ISB and SSNB groups. Respiratory complications were assessed by eight trials.[14,16,25,26,49,50,55,57] In total, the number of patients who reported having respiratory complications was 34 of 373 in the ISB group and 8 of 379 in the SSNB group.[16,25,26,49,50,55,57] SSNB reduced the odds of having respiratory complications by 70% or an OR of 0.3 (95% CI, 0.1 to 0.9; P = 0.005; I^2 = 9%; table 3). Postoperative dyspnea was the primary respiratory complication reported, except for one patient, who developed pneumothorax after receiving ISB.[16] The funnel plot and Egger's regression test did not reveal any publication bias (P = 0.28).

Opioid-related Side Effects. In total, the number of patients who reported opioid-related side effects, including nausea, vomiting, and sedation, was 28 of 164 in the ISB group and 26 of 169 in the SSNB group.[24–26,50,51,53] The OR of the difference in the risk of side effects for the two blocks was not statistically significant (table 3). The funnel plot and Egger's regression test did not reveal any publication bias (P = 0.51).

Undesirable Blocks. Reported undesirable nerve blocks affected the cervical sympathetic chain (Horner's syndrome) and recurrent laryngeal nerve (hoarseness). These were reported in 55 of 299 patients in the ISB group and 11 of 304 patients in the SSNB group at 24 h.[25,26,49,50,55] SSNB reduced the odds of having these complications at 24 h by 90% or an OR of 0.1 (95% CI, 0.0 to 1.0; P = 0.008; I^2 = 63%; table 3). The funnel plot and Egger's regression test did not reveal any publication bias (P = 0.1).

Undesirable blocks in the forearm and hand were reported in two studies only.[15,49] Both reported that a greater proportion of patients receiving ISB had impaired grip strength postoperation up to 24 h.[15,49]

Block-related Complications. Block-related complications, including paresthesia, weakness, and tingling, were reported in 39 of 134 patients in the ISB group and 6 of 139 patients in the SSNB group at 24 h.[24–26,50,51] SSNB reduced the odds of having these complications at 24 h by 90% or an OR of 0.1 (95% CI, 0.0 to 0.7; P = 0.002; I^2 = 39%; table 3). The funnel plot and Egger's regression test did not reveal any publication bias (P = 0.07).

Only one study[24] assessed the incidence of weakness and tingling at one week and reported that 4 of 19 patients who

Table 1. Study Characteristics and Outcomes of Interest Assessed in Included Studies

First Author/Year	Surgery	N	Groups (n)	Anesthesia	Primary Outcome	Rest Pain Scores		Dynamic Pain Scores		Opioid Consumption	
						Early	Late	Early	Late	Early	Late
SSNB *vs*. ISB											
Desroches 2016[16]	Arthroscopic rotator cuff repair	59	1. SSNB (31) 2. ISB (28)	GA	Pain at 24-h follow-up	•	•			•	•
Ikemoto 2010[52]	Arthroscopic rotator cuff repair	45	1. SSNB (15) 2. ISB (15) 3. GA alone (15)	GA	N/D	•	•				•
Konradsen 2009[15]	Arthroscopic acromioplasty	48	1. SSNB (24) 2. ISB (24)	GA	Pain at rest	•		•		•	
Kumara 2016[1]	Arthroscopic shoulder surgery	60	1. SSNB (30) 2. ISB (30)	GA	N/D	•		•		•	
Ovesen 2014[51]	Arthroscopic acromioplasty	91	1. SSNB (23) 2. ISB (22) 3. Subacromial bursae block (22) 4. GA alone (24)	GA	N/D	•				•	
Shin 2010[14]	Arthroscopic shoulder surgery	58	1. SSNB (20) 2. ISB (20) 3. GA alone (18)	GA	N/D	•					
Singelyn 2004[53]	Arthroscopic acromioplasty	120	1. SSNB (30) 2. ISB (30) 3. Intraarticular local anesthetic (30) 4. GA alone (30)	GA	Pain at rest	•		•		•	
Wiegel 2017[49]	Arthroscopic shoulder surgery	329	1. SSNB (164) 2. ISB (165)	GA	Pain at rest and Grip strength	•	•			•	
Neuts[57]	Arthroscopic shoulder surgery	48	1. Subomohyoidale SSNB (25) 2. ISB (24)	GA	Respiratory Function						
SSNB + AXB *vs*. ISB											
Dhir 2016[24]	Arthroscopic shoulder surgery	60	1. SSNB + AXB (30) 2. ISB (30)	GA	Pain in PACU	•		•		•	
Lee 2012[54]	Arthroscopic rotator cuff repair	61	1. SSNB + AXB + PCA (18) 2. ISB + PCA (26) 3. PCA alone (17)	GA	N/D	•				•	
Pitombo 2013[25]	Arthroscopic shoulder surgery	68	1. SSNB + AXB (34) 2. ISB (34)	GA	Pain at 24-h follow-up	•				•	
Waleed 2016[26]	Arthroscopic shoulder surgery	60	1. SSNB + AXB (30) 2. ISB (30)	GA	N/D	•				•	
Zanfaly 2016[50]	Arthroscopic shoulder surgery	50	1. SSNB + AXB (25) 2. ISB (25)	GA	N/D	•		•		•	
Price 2012[55]	Total shoulder arthroplasty	98	1. SSNB + AXB (51) 2. ISB (48)	GA	N/D					•	
Mayorga-Buiza 2014[56]	Arthroscopic shoulder surgery		1. SSNB + AXB 2. ISB	GA	N/D						

Early is 24 h or less and late is more than 24 h.

AXB = axillary nerve block; CISB = continuous interscalene block; CSCNB = continuous supraclavicular nerve block; CSSNB = continuous suprascapular nerve block; GA = general anesthesia; ISB = interscalene block; N/D = not defined; PACU, post-anesthesia care unit; PCA = patient-controlled analgesia; SSNB = suprascapular nerve block.

Time to First Analgesic Request	Opioid-related Adverse Effects	Block-related Complications	Patient Satisfaction	PACU Discharge Time	Hospital Discharge Time	Functional Outcomes	Respiratory Outcomes	Comments
		•						
						•		
•								
	•	•						
		•						
	•	•	•					
						•		
		•	•					
	•	•	•	•				
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	•	•	•					
		•	•				•	

Table 2. Details of Block Characteristics and Analgesic Regimens in Included Studies

				SSNB				
First Author/Year	Preincisional Analgesia	Surgical Analgesia	Supplemental Postoperative Analgesia	Block Timing	Block Technique	Localization	Assessment of Block Success	SSNB Bolus
Wiegel 2017[49]	IV sufentanil	IV sufentanil	Oral ibuprofen, IV Piritramid	Preoperative	Perineural, supraclavicular fossa	Ultrasound	Y	10 ml 1.0% ropivacaine
Desroches 2016[16]	N/A	IV sufentanil	IV acetaminophen, IV ketoprofen, IV tramadol, then IV morphine	Preoperative	Perineural, suprascapular fossa	Anatomical	N	10 ml 0.75% ropivacaine
Dhir 2016[24]	IV fentanyl	IV fentanyl	Oral ketorolac, Oral acetaminophen, then IV morphine	Preoperative	Perineural, suprascapular fossa	N-Stim	Y	15 ml 0.5% ropivacaine
Kumara 2016[1]	N/A	IV fentanyl	IV diclofenac sodium	Preoperative	Perineural, suprascapular fossa	N-Stim	N	15 ml 0.5% bupivacaine + clonidine
Waleed 2016[26]	N/A	IV fentanyl	IV ketorolac then IM morphine	Preoperative	Perineural, suprascapular fossa	Ultrasound	N	10 ml 0.25% levobupivacaine
Zanfaly 2016[50]	N/A	IV fentanyl	IM diclofenac sodium then IM morphine	Preoperative	Perineural, suprascapular fossa	N-Stim	Y	7–10 ml 0.5% bupivacaine
Neuts[57]	N/A	N/D	N/D	Preoperative	Perineural, suprascapular fossa	N/D	N/D	10 ml 0.2% ropivacaine
Mayorga-Buiza 2014[56]	N/A	IV fentanyl	N/D	Preoperative	Perineural, suprascapular fossa	Ultrasound	N/D	0.5% ropivacaine
Ovesen 2014[51]	IV remifentanil	SSNB *vs.* IV remifentanil	Oral paracetamol, oral ibrufen, then IV nicomorphinhydrochlorid and oral ketomebidon, oral dimethylaminphren	Preoperative	Perineural, suprascapular fossa	Anatomical	N	20 ml 5 mg/mL^{-1} bupivacaine
Pitombo 2013[25]	IV fentanyl	SSNB *vs.* IV fentanyl	IV dipyrone then IV morphine	Preoperative	Perineural, suprascapular fossa	N-Stim	Y	15 ml 0.33% levobupivacaine + Epi
Price 2012[55]	N/A	N/D	IV morphine, oral oxycodone	Preoperative	Perineural, suprascapular fossa	N-Stim	N/D	15 ml 0.75% ropivacaine
Lee 2012[54]	N/A	IV fentanyl	IV PCA with fentanyl and ketorolac	Preoperative	Perineural, suprascapular fossa	N-Stim	Y	15 ml of 2% mepivacaine + 0.75% ropivacaine
Ikemoto 2010[52]	N/A	IV alfentanil	IM diclofenac, IV tramadol, IV dipyrone, IV tenoxican	Preoperative	Perineural, suprascapular fossa	Anatomical	N	2/3 of 2 mg/kg^{-1} 0.5% ropivacaine
Shin 2010[14]	N/A	IV remifentanil	IV PCA with alfentanil and ketorolac	Preoperative	Perineural, suprascapular fossa	N-Stim	N	10 ml 0.5% levobupivacaine + Epi
Singelyn 2004[53]	N/A	IV sufentanil	IV acetaminophen, subcutaneous morphine	Preoperative	Perineural, suprascapular fossa	N-Stim	Y	20 ml 0.25% bupivacaine + Epi
Konradsen 2000[15]	N/A	IV fentanyl	Oral paracetamol, oral ibumetin, oral tramadol, then IV morphine	Preoperative	Perineural, suprascapular fossa	N-Stim	N	10 ml 0.25% bupivacaine

Epi = epinephrine; IM = intramuscular; IV = intravenous; N = no; N/A = not applicable; N/D = not defined; N-Stim = nerve stimulator; PCA = patient-controlled analgesia; SSNB = suprascapular nerve block; Y = yes.

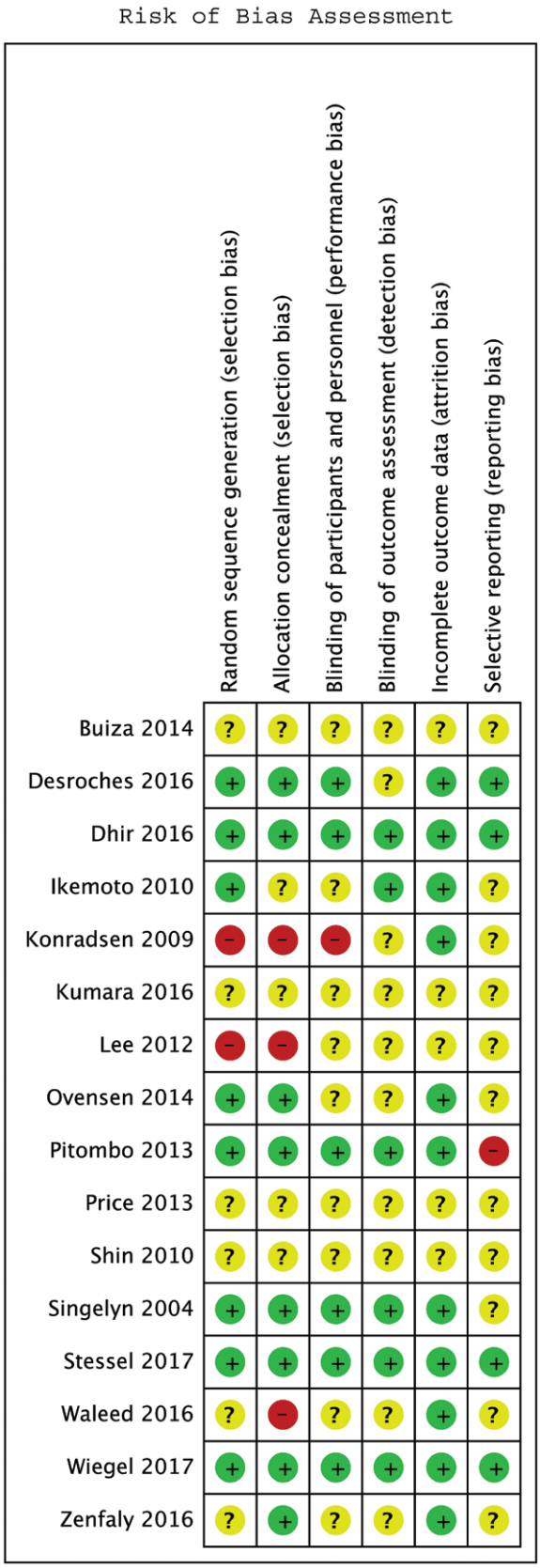

Fig. 2. Risk of bias assessment of included studies using the Cochrane risk of bias tool. ? = unclear risk; – = high risk; + = low risk.

received ISB had residual weakness compared with 0 of 13 in the SSNB group.

Discussion

Our systemic review and meta-analysis challenges the purported superiority of ISB over SSNB for shoulder surgery.[14,24,51,53] There is high-level evidence suggesting that the blocks are not different for two important analgesic measures, namely postoperative oral morphine consumption at 24 h and the cumulative difference between the ISB and SSNB in the area under the curve for rest pain during the first 24-h interval. Furthermore, analysis of postoperative pain at the individual time points suggested that ISB may provide superior pain control that is limited to the 1-h time point, corresponding with PACU stay, and that the ISB was not different from SSNB for pain control beyond that, that is, at 6, 12, 24, and 48 h postoperation. Likewise, the results for the remaining analgesic outcomes, such as opioid-related side effects, analgesic duration, PACU analgesic consumption, and procedural discomfort, were consistently not different between the two groups. In contrast, ISB was associated with more respiratory complications, undesirable blockades, and block-related complications. However, it seems that the impact of ISB on patients with intact respiratory function may be subclinical only.[55] Furthermore, although undesirable blockade of the cervical plexus, recurrent laryngeal nerve, and weakness in the forearm and hand are common with ISB,[15,49] the clinical importance of these blocks may be questionable, particularly the upper extremity weakness, because the operative arm is usually supported in a sling postoperation.

Our findings may have impact on both research and clinical practice. For researchers, the lack of clinically important differences emphasizes the need to consider equivalence or noninferiority designs for future comparisons. For practitioners, the minor analgesic advantages that the ISB offers compared with the SSNB seem to be transient and limited to the immediate postoperative period (PACU stay). However, improved pain control in the PACU *per se* may facilitate discharge and can thus be desirable in outpatient shoulder surgery, because most PACU discharge criteria may require a certain pain severity score threshold value, in addition to independence from systemic analgesics, to determine discharge readiness.[59–61] In contrast, the risk of respiratory and block-related complications associated with ISB may outweigh its benefits in certain settings and/or patient populations,[62] especially when SSNB can offer a safe and effective alternative. Indeed, although determining the exact role of SSNB in shoulder surgery clinical pathways requires additional research, patients with morbid obesity,[63] obstructive sleep apnea,[64] and severe chronic obstructive pulmonary disease[65,66] may be good candidates for the SSNB.

Current estimates suggest that 82% and 42% of patients undergoing any type of shoulder surgery and total shoulder arthroplasty in particular, respectively, receive an ISB, with

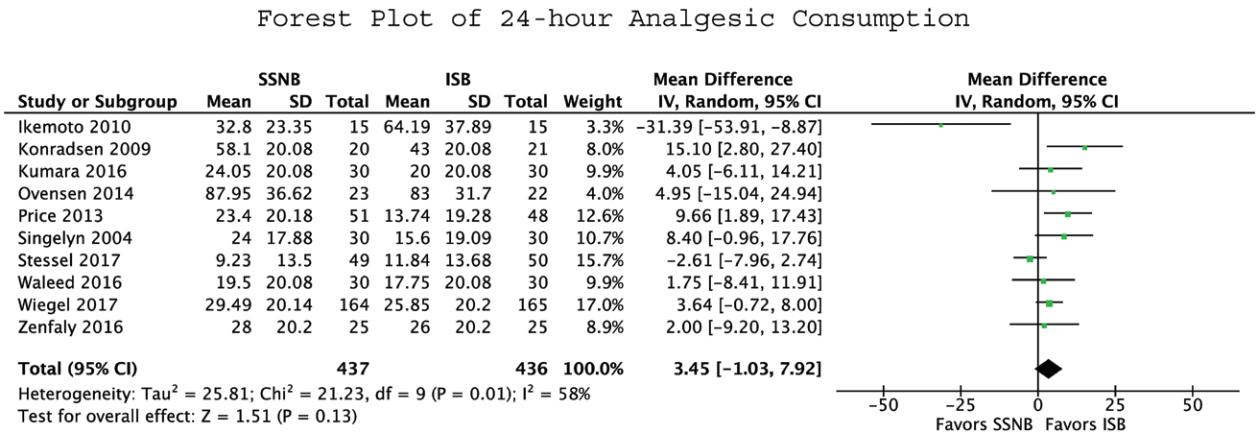

Fig. 3. Forest plot of cumulative oral morphine equivalent consumption at 24 h. The pooled estimates of the weighted mean difference are shown with 95% CIs. The pooled estimates are represented as *diamonds* and the *lines* represent the 95% CIs. ISB = interscalene nerve blockade; SSNB = suprascapular nerve block.

this rate increasing every year.[67,68] Although ISB continues to be the care standard, the interest in ISB alternatives is driven by several factors. As shown by Abdallah *et al.*,[3] the duration of analgesia provided by the ISB, as measured by pain relief and opioid consumption, is limited to 8 and 12 h postoperation, respectively,[3] but it is associated with rebound pain and a high incidence of undesirable adverse events.[3,24] Importantly, the proximity of the ISB location to the neuraxis and other structures in the neck has resulted in a concerning risk profile. For example, the incidence of transient neurologic complications after ISB has been reported to be as high as 16%, approximately three times the risk of all other peripheral nerve blocks combined.[69–71] Furthermore, catastrophic neurologic complications, such as acute[72,73] and permanent[74] quadriplegia, have also been reported when ISB is performed after induction of general anesthesia. The underlying mechanism may be related to a combination of needle trauma to the upper limb C8-T1 nerve roots,[75] rostral spread of local anesthetics,[17] low proportion of connective tissue in these nerve roots relative to other peripheral nerve block locations,[76] and ambiguity[77,78] and/or difficulty[79,80] in identifying what constitutes intraneural *versus* perineural at the interscalene level of the brachial plexus. Also, ISB is associated with phrenic nerve injury and hemidiaphragmatic paralysis,[81,82] which may be attributed to any or a combination of needle injury, underlying predisposition,[4] or local anesthetic-associated myotoxicity.[83] Delayed-onset phrenic nerve damage or even permanent hemidiaphragmatic paralysis[4,81] is also a concern. Moreover, we have not been able to identify the ISB local anesthetic volume[84] and technique that preserves the phrenic nerve and dorsal scapular and long thoracic nerves, respectively.[85] Finally, severe hypotension[86,87] and cardiac asystole[88–90] due to the predominance of vagal tone in patients undergoing shoulder surgery in the beach-chair position are also concerns surrounding ISB use, because the blockade of the cervical sympathetic chain[91] may aggravate hemodynamic instability. Clearly, the need for a more distal and safer ISB alternative has prompted researchers to examine several options, including but not limited to the combination of infraclavicular and suprascapular block,[92] subacromial bursa block,[93,94] superior trunk block,[95] periarticular local anesthesia infiltration,[96] and novel brachial plexus blocks, such as the retroclavicular[97,98] and costoclavicular blocks.[99,100]

From an anatomical perspective, the shoulder joint is innervated anteriorly by the suprascapular, axillary, and lateral pectoral nerves and posteriorly by the suprascapular and branches of the axillary nerves.[101] The suprascapular nerve also provides sensory branches to the glenohumeral joint, acromioclavicular joint, subacromial bursa, and coracoclavicular ligament.[13,101] Thus, the suprascapular nerve is proposed to provide approximately 70% of the sensory innervation to the shoulder joint.[12,13] The remaining 30% of sensory input to the shoulder is provided by the axillary, supraclavicular, subscapular, and pectoral nerves.[12,13] Therefore, blocking the suprascapular nerve spares the functional capacity of the forearm and hand, while providing partial postsurgical pain relief. This contrasts with ISB, which targets the most proximal level of the brachial plexus trunks (roots), thereby leading to complete motor and sensory analgesia in multiple dermatomes,[17] including the forearm and hand. Plausibly, the modest contribution of the axillary nerve to the innervation of the shoulder may confer additional analgesic benefits if the axillary nerve block is blocked,[102] although this was not evident in our findings.

Limitations

Our systematic review and meta-analysis has limitations that should be acknowledged. First, our primary and secondary outcome analyses were associated with high levels of heterogeneity, which were unresolved through meta-regression analysis. This could have been due to the lack of standardization in anesthetic and analgesic management across the included studies and the diversity of shoulder

Table 3. Summary of Results and GRADE of Evidence

Outcome	Studies Included	Suprascapular Block, Mean or n/N	Interscalene Block, Mean or n/N	Mean Difference or Odds Ratio (99% CI)	*P* Value for Statistical Significance	*P* Value for Heterogeneity	I^2 Test for Heterogeneity	Quality of Evidence (GRADE)
Cumulative 24-h oral morphine equivalent, mg	10	29.6	26.3	3.4 (–1.0 to 7.9)*	0.130	0.01	58%	⊕⊕⊕⊕, high
Area under the curve for pain severity at rest, cm/h	13	N/A	N/A	1.1 (N/A)	N/A	N/A	N/A	⊕⊕⊕⊕, high
Rest pain at 1 h (PACU), VAS, cm	13	2.4	1.4 (1.7)	1.5 (0.6–2.5)	0.001	< 0.00001	97%	⊕⊕⊕⊕, high
Rest pain at 6 h, VAS, cm	13	2.6	2.2 (2.0)	0.7 (–0.1 to 1.6)	0.020	< 0.00001	96%	⊕⊕⊕⊕, high
Rest pain at 12 h, VAS, cm	5	4.0	3.7 (3.2)	0.4 (–1.5 to 2.4)	0.560	< 0.00001	93%	⊕⊕⊕⊖, moderate
Rest pain at 24 h, VAS, cm	13	3.1	3.1 (3.3)	0.2 (–0.3 to 0.7)	0.320	< 0.00001	84%	⊕⊕⊕⊕, high
Rest pain at 48 h, VAS, cm	2	3.6	3.8 (1.5)	–0.3 (–1.8 to 1.2)	0.620	0.09	65%	⊕⊖⊖⊖, very low
Oral morphine consumption in PACU, mg	4	8.4	4.0	7.2 (–2.3 to 16.8)	0.050	< 0.00001	96%	⊕⊕⊕⊖, moderate
Analgesic duration, h	3	13.5	12.9	0.4 (–5.6 to 6.5)	0.850	0.0003	88%	⊕⊕⊖⊖, low
Block discomfort, VAS, cm	3	3.1	4.2	–1.4 (–3.4 to 0.7)	0.080	< 0.00001	91%	⊕⊕⊖⊖, low
Respiratory complications, 0–24 h	8	8/379	34/373	0.3 (0.1–0.9)	0.005	0.36	9%	⊕⊕⊕⊖, moderate
Opioid-related side effects	6	26/169	28/164	0.9 (0.3–2.5)	0.750	0.21	30%	⊕⊕⊕⊖, moderate
Undesirable blocks, 0–24 h	5	11/304	55/299	0.1 (0.0–1.0)	0.008	0.05	63%	⊕⊕⊕⊖, moderate
Block-related complications at 24 h	5	6/134	39/134	0.1 (0.0–0.7)	0.002	0.18	39%	⊕⊕⊕⊖, moderate
Block-related complications at 7 days	1	0/13	4/19	N/A	0.128	N/A	N/A	⊕⊖⊖⊖, very low

*Data include 95% CI.

GRADE = Grades of Recommendation, Assessment, Development, and Evaluation; N/A = not applicable; PACU = postanesthesia care unit; VAS = visual analog scale.

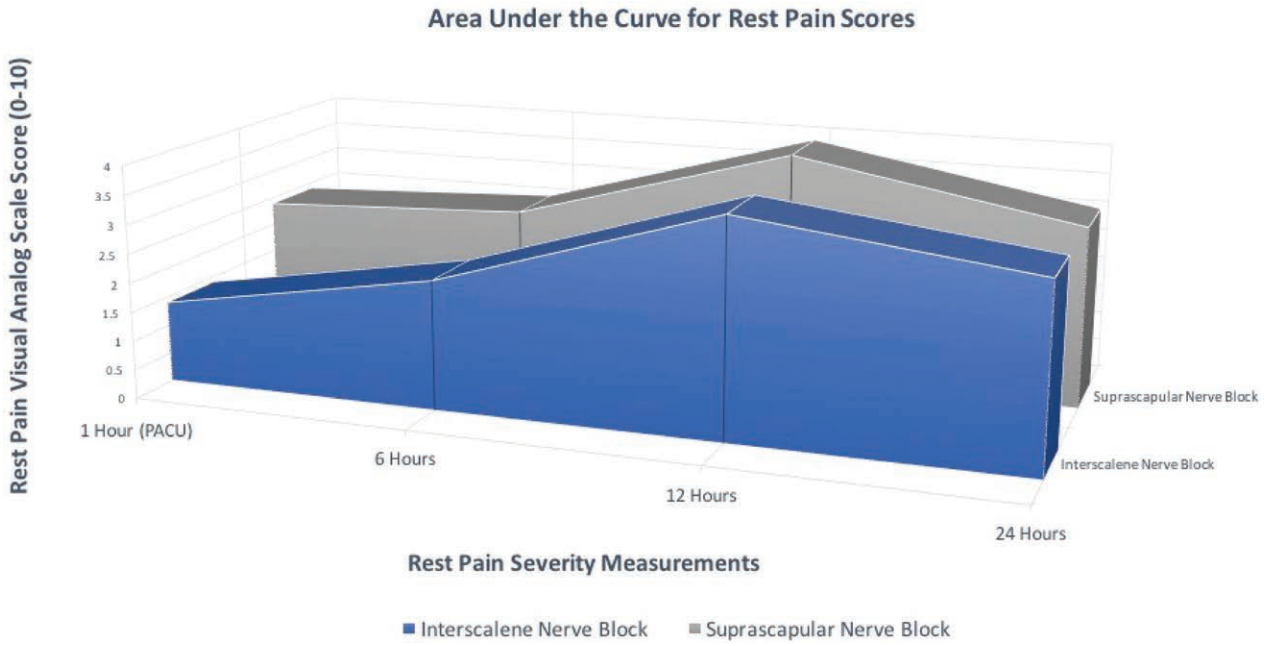

Fig. 4. Graphical representation of the cumulative area under the curve of the pooled (weighted) mean pain scores at rest, as measured by the visual analog scale (0 to 10 cm) over time (four time points). The pooled rest pain scores from 969 patients (13 trials) were used to calculate the mean difference in rest pain between the suprascapular and interscalene blocks over the first 24 h after shoulder surgery. PACU = postanesthesia care unit.

surgeries performed. Second, most studies included in this review had smaller sample sizes, which decreases the strength of their effect and limits external validity. This is particularly important because meta-analyses of small trials tend to overestimate the treatment effect[103] of the intervention examined, underscoring the role of larger-sized confirmatory trials. Third, although we attempted to control for multiple testing bias in our secondary outcomes by calculating a 99% CI and using a corrected threshold of statistical significance ($P = 0.01$), we cannot exclude the possibility of residual bias in the pooled secondary outcomes estimates. Indeed, bias continues to be a concern, because the majority of source trials were characterized by an unclear risk of bias. Fourth, we excluded studies that evaluated continuous blocks for shoulder surgery, although these are part of the care standard in numerous centers. Fifth, none of the included trials reported long-term complications, whereas reporting of other safety outcomes was infrequent and inconsistent. Sixth, the lack of difference in pain scores at most time points theoretically suggests that neither of the two blocks prevents rebound pain,[3] but the comparison herein lacked a control group, precluding a meaningful evaluation of rebound pain. Lastly, because most findings in the study pointed to a lack of difference between the two interventions compared, the possibility of a type II error should not be discounted.

In contrast, our review also comes with several strengths. In addition to our exhaustive literature search, we incorporated non-English studies in this review. We also successfully obtained additional unpublished data for several of the included studies. This allowed us to provide a larger estimate of effects and more generalizable results. Finally, although our results had a high level of heterogeneity, the results were robust to meta-regression analysis based on our predefined confounders.

Conclusions

In conclusion, high-level evidence indicates that SSNB is not different from ISB with respect to postoperative opioid consumption and total pain severity during the first 24 h after shoulder surgery. It is also not different from ISB with respect to opioid-related side effects, analgesic duration, PACU analgesic consumption, and procedural discomfort. Nonetheless, ISB seems to offer minor analgesic advantages that are transient and limited to the immediate postoperative period (PACU stay). In contrast, SSNB does appear to reduce the risk of respiratory complications, undesirable nerve blocks, and block-related complications. Pending future research defining the specific role of SSNB, these findings suggest that SSNB may be considered an effective and safe analgesic alternative to ISB in shoulder surgery.

Research Support

Supported by the Merit Award Program, Department of Anesthesia, University of Toronto (Toronto, Ontario, Canada; to Drs. Abdallah and Laffey).

Competing Interests

The authors declare no competing interests.

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