Systematic Review

Comparative Effectiveness of Suprascapular Nerve Block in the Relief of Acute Post-Operative Shoulder Pain: A Systematic Review and Meta-analysis

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Background: The suprascapular nerve accounts for 70% of shoulder sensory innervations, and suprascapular nerve block (SSNB) has been shown to be effective in the relief of chronic shoulder pain including rotator cuff tendinitis, subdeltoid impingement syndrome, and adhesive capsulitis. However, this remains inconclusive for patients undergoing surgery. The present meta-analysis aimed to explore the effectiveness of SSNB for relieving acute post-operative shoulder pain.

Objective: To explore the effectiveness of SSNB for relieving acute post-operative shoulder pain.

Study Design: A systematic review and meta-analysis.

Setting: Services of general surgery, orthopaedics, and anaesthesiology.

Methods: A systematic search of studies on SSNB for post-operative shoulder pain was conducted mainly in PubMed and Scopus. The standardized mean difference (SMD) of post-operative pain scales of SSNB versus placebo was treated as the primary outcome, whereas the odds ratio of nausea of SSNB versus placebo comprised the secondary outcome.

Results: The meta-analysis included 7 randomized controlled trials and 2 comparative studies comprising 681 participants in total. The quantitative analysis showed a significantly lower pain level of SSNB versus placebo in the shoulder surgery patient group (SMD: -0.33; 95% confidence level [CI]: -0.51 to -0.15), but not in the non-shoulder surgery group (SMD: 0.28; 95% CI: -0.37 to 1.93). The pooled odds ratio of nausea in the SSNB arm compared with the placebo arm was 0.20 (95% CI: 0.09 to 0.45), indicating a reduction in the incidence of nausea following SSNB.

Limitations: Heterogeneity of included trials.

Conclusions: SSNB significantly reduced acute post-operative shoulder pain in the shoulder surgery group but not in patients undergoing laparoscopic surgery or thoracotomy. This suggests that SSNB can be used as a method of polymodal analgesia for patients undergoing shoulder surgery; however, it is not recommended for the non-shoulder surgery patient population.

Key words: Suprascapular nerve, shoulder surgery, thoracotomy, laparoscopic surgery

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The suprascapular nerve accounts for motor innervations to the supraspinatus and infraspinatus muscles and 70% of shoulder sensory innervations, while the remaining 30% is managed by the axillary, supraclavicular, subscapular, medial pectoral, and lateral pectoral nerves (1,2). Therefore, suprascapular nerve block (SSNB) is widely utilized in cases of recalcitrant shoulder pain, and its effectiveness at relieving chronic painful shoulders, including rotator cuff tendinitis, subdeltoid impingement syndrome, and adhesive capsulitis, has been demonstrated (3). The potential mechanism behind this pathology may be the amelioration of the neuropathic pain component or hydrodissection of an entrapped nerve (4,5). However, although SSNB is an effective procedure for treating long-term shoulder pain, evidence relating to the relief of acute post-operative shoulder pain is lacking.

Acute post-operative shoulder pain can develop after shoulder surgery or after operations in non-shoulder regions. With the introduction of arthroscopic techniques, shoulder surgery has become less traumatic and painful. However, the magnitude of pain depends on surgical types. The most painful surgery is rotator cuff repair, whereas the shoulder instability restoration procedure is the least painful (6). Use of SSNB before and during shoulder surgery is theoretically effective for pain relief because the majority of pain generated is innervated by the suprascapular nerve. In contrast, surgeries such as laparoscopic surgery or thoracotomy can result in shoulder tip pain without direct influence on the shoulder joint. Irritation of the phrenic nerve due to pneumo-peritoneum and exploration of the pericardium or pleural surface is the most plausible mechanism (7,8). The convergence-projection theory implies a potential effect of SSNB at reducing post-operative shoulder pain through a shared pathway of the suprascapular and phrenic nerves above the cervical root level (9). However, the efficacy of SSNB in the non-shoulder surgery patient population remains inconclusive. Therefore, the present meta-analysis aimed to explore the effectiveness of SSNB in the relief of post-operative shoulder pain and to examine whether its effect differs between various surgical types.

Methods

Search Strategy and Inclusion Criteria

PubMed, Scopus, Cochrane Collaboration Central Register of Controlled Clinical Trials, Cochrane Systematic Reviews, and ClinicalTrials.gov were searched for studies on the use of SSNB for post-operative shoulder pain relief, from the earliest record to January 2016 (3,10,11). The bibliographies of included trials and related review articles were manually reviewed for relevant references. Literature not written in English or not available in full texts were excluded. We investigated studies employing SSNB for the relief of shoulder pain in patients receiving any type of surgery. The search strategy comprised the following keywords variably combined with SSNB: shoulder pain, post-operative pain, arthroscopy, surgery, and thoracotomy.

Regarding the types of included studies, we enrolled randomized controlled trials (RCTs) or comparative experimental trials, and excluded single-armed follow-up studies, case series, and case reports. All retrieved studies were required to comprise at least 2 treatment arms, one of which was SSNB and the other of which was placebo injection or no block. Since the present meta-analysis aimed to compare SSNB with placebo, the treatment arms using interscalene block or subacrominal infiltration or intra-articular injection of analgesics were not included in the quantitative analysis. The target population comprised patients who were at risk of developing post-operative shoulder tip pain, and the surgical region was not restricted to the shoulders. Post-operative shoulder pain was defined as shoulder pain within 72 hours after operations. The SSNB procedure could be conducted by using a single injection or continuous administration of local anaesthetics before or during the operation. Studies that explored the efficacy of SSNB for chronic shoulder pain or shoulder pain after stroke were beyond the scope of the present meta-analysis.

Data Extraction and Quality Assessment

Two reviewers examined all of the retrieved articles and extracted data using a predetermined form. We recorded the first author, year, sample size, number and type of treatment arms, participant characteristics, details of SSNB, comparative arm regimens, and summary of the general anaesthesia protocol. The methodological quality of enrolled studies was evaluated by 2 reviewers independently using Jadad scoring for the RCTs and the Newcastle-Ottawa Quality Assessment Scale for the comparative experimental trials. Jadad score evaluates the methodology of RCTs according to 3 aspects: randomization (2 points), blinding (2 points), and an account of all patients (1 point). The range of potential scores is 0 to 5; a higher score indicates better methodological quality (3). The Newcastle-Ottawa Quality Assessment Scale contains 9 items in 3 categories: participant selection (4 items), comparability (4 items), and exposure (3 items) (12). A study can be scored a maximum of one point for items in the Selection and Exposure domains and a maximum of 2 points for the Comparability domain. Between-reviewer discrepancies were solved through discussions under the supervision of the corresponding author.

Data Synthesis and Analysis

The standardized mean differences (SMDs) of post-operative shoulder pain between the SSNB and reference groups comprised the primary outcome (3). Data were extracted from the visual analogue scales evaluated at the rest position at the point closest to 24 hours post-surgery. A negative SMD value indicated SSNB to be a favorable treatment option. The odds ratios (ORs) of post-operative nausea in the SSNB group compared with the control comprised the secondary outcome (13). A random effects model was employed to pool individual SMDs and ORs; all analyses were performed using Stata 11.0 software (StataCorp, Texas, USA). Between-trial heterogeneity was determined by using I2 tests; values > 50% were regarded as considerable heterogeneity (13). Funnel plots and Egger's test were used to examine potential publication bias (3,13). Statistical significance was defined as *P*-values < 0.05, except for the determination of publication bias which employed *P* < 0.10.

Results

Study Search and Characteristics of Included Patients

We retrieved 245 non-duplicate citations for a review of their titles and abstracts, and included 16

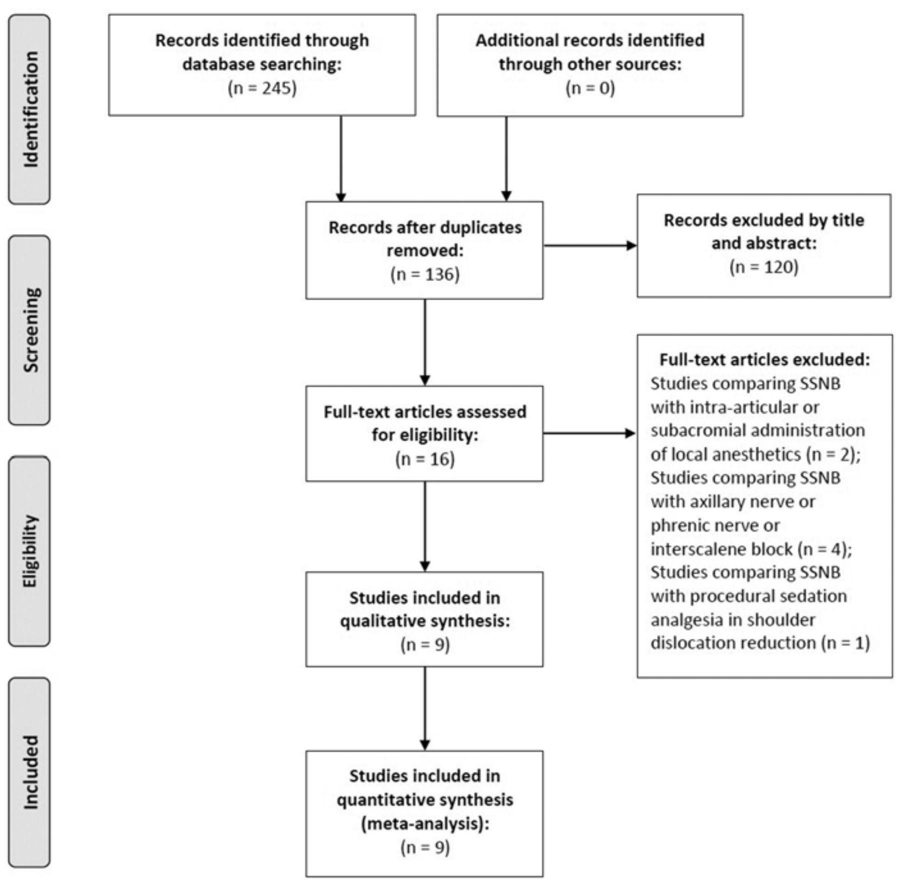

Fig. 1. *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for the searching and identification of included studies.*

articles for meticulous evaluation after eliminating references violating the inclusion criteria (Fig. 1). We excluded 2 studies comparing SSNB with intra-articular or subacromial administration of local anaesthetics (14,15), 4 studies comparing SSNB with axillary nerve or phrenic nerve or interscalene block (16-19), and one study comparing SSNB with procedural sedation analgesia in shoulder dislocation reduction (20). Therefore, the meta-analysis included 4 two-armed RCTs (21-24), 2 three-armed RCTs (25,26), one four-armed RCTs (14), and 2 two-armed quasi-experimental studies (27,28). In terms of the patient population, 6 trials targeted groups receiving shoulder surgeries (14,21,23-25,28), 2 focused on participants undergoing thoracotomy (22,27), and one investigated SSNB for shoulder tip pain after laproscopic surgery (26).

The final quantitative analysis included 681 participants. Two treatment arms in a four-armed RCT (14) and 2 treatment arms in 2 three-armed RCTs were not used for meta-analysis (25,26). Patient age range was 24 to 72.6 years in the shoulder surgery group and 26.6 to 79 years in the non-shoulder surgery group. Diagnosis in the shoulder surgery group comprised subdeltoid impingement syndrome, rotator cuff tears, calcific tendinitis, and adhesive capsulitis. Regarding the non-shoulder surgery group, one trial recruited lung cancer patients for thoracotomy (27), while the remaining 2 did not specify the constitution of their patient population (22,26). Patient characteristics, study methodology, and quality assessment of included trials are listed in Table 1, while Table 2 summarizes the SSNB procedures and general anaesthesia.

SMDs of Post-operative Pain and Pooled Odds Ratio of Nausea

The overall SMD of SSNB versus placebo regarding post-operative pain was -0.10 (95% confidence interval [CI]: -0.53 to 0.32). The subgroup analysis showed a significantly lower pain level of SSNB versus placebo in the shoulder surgery group (SMD: -0.33; 95% CI: -0.51 to -0.15), but not in the non-shoulder surgery group (SMD: 0.28; 95% CI: -0.37 to 1.93). Regarding SMD heterogeneity, the I2 was less than 0.01% in the shoulder surgery group and 93.5% in the non-shoulder surgery group (Fig. 2). The subgroup analysis based on different study designs and guiding techniques was listed in Table 3.

The pooled odds ratio of nausea in the SSNB arm compared with the placebo arm was 0.20 (95% CI: 0.09 – 0.45), indicating a reduced incidence of nausea following SSNB. After removing a trial in the non-shoulder surgery group, the benefit of SSNB remained with a pooled odds ratio of 0.19 (95% CI: 0.08 – 0.45) (Fig. 3). Regarding the heterogeneity of odds ratio, the I2 was less than 0.01% in both the overall included studies and the shoulder surgery group. The Egger's test revealed the existence of significant publication bias (P = 0.089) regarding the overall SMD; however, the statistical significance reduced after being divided into both subgroups (P = 0.168 in the shoulder surgery group and P = 0.793 in the non-shoulder surgery group). There was no publication bias detected in the overall odds ratio of nausea (P = 0.255). The funnel plots for SMD of post-operative pain and log odds ratio of post-operative nausea are shown in Figs. 4 and 5, respectively.

Discussion

The present meta-analysis focused on the use of SSNB for the relief of post-operative acute shoulder pain and nausea. It included 6 studies related to shoulder operations and 3 studies that recruited patients receiving thoracotomy or laparoscopic surgery. Compared with placebo, patients following SSNB presented with less shoulder pain in the shoulder surgery group, but the benefit was not significant in the non-shoulder surgery group. Similarly, there was a lower incidence of nausea after SSNB in the shoulder surgery group, although this beneficial effect was unclear in the non-shoulder surgery group due to the limited number of enrolled trials.

SSNB has been widely used in management of shoulder pain in miscellaneous conditions and there have been several systematic reviews and meta-analysis investigating this treatment. In a narrative review in 2011, Chan et al (29) investigated the anatomy of the suprascapular nerve, indications and techniques of SSNB, and outcomes of SSNB in the management of acute and chronic shoulder pain. This review found that SSNB may be beneficial for the control of post-operative pain after open and arthroscopic shoulder surgery, and reduces analgesic dosage and demand. However, conflicting results exist regarding the effectiveness of SSNB for shoulder pain management following thoracotomy. The most recent quantitative analysis of available trials regarding SSNB was published in 2015 (3). The article demonstrated the superiority of SSNB to placebo and physical therapy for relieving chronic shoulder pain; however, the patient population was out of the scope of our meta-analysis. Since post-operative shoulder pain drastically influences patient recovery and quality of life, it is of clinical importance to collect solid evi-

Table 1. *Summary of the retrieved trials investigating suprascapular nerve block on patients with acute post-surgical shoulder pain.*

Author, year	Patients' diagnosis	Surgery	Study design	Enrolled sample number, (Male/ Female)	Average age, years	Double-blind	Intention-to-treat	Outcome measurement	Quality assessment
Shoulder surgery									
Ritchie et al, 1997	Not mentioned	Arthroscopic shoulder surgery	RCT	SSNB: 25 (20/5); subcutaneous normal saline: 25 (22/3)	SSNB: 42 ± 14; subcutaneous normal saline: 39 ± 15	Yes	Not mentioned	VAS, VPS, MPQ, incidence of nausea and vomiting, using of other analgesic	5#
Neal et al, 2003	Not mentioned	Non-arthroscopic Shoulder Surgery (acromioplasty, rotator cuff repair, or combination)	RCT	SSNB: 25 (16/9); subcutaneous normal saline: 25 (13/12)	SSNB: 55 ± 13; subcutaneous normal saline: 61 ± 11	Yes	Not mentioned	Static and dynamic VPS, incidence of nausea, patient satisfaction, activity level, sleep quality	4#
Singelyn et al, 2004	Not mentioned	Arthroscopic shoulder acromioplasty	RCT	SSNB: 30 (15/15); IA: 30 (12/18); ISB: 30 (11/19); control: 30 (12/18)	SSNB: 52 ± 14; IA: 54 ± 15; ISB: 50 ± 14; control: 53 ± 17	Yes	Not mentioned	Static and dynamic VAS, incidence of nausea and vomiting	4#
Jerosch et al, 2008	Not mentioned	Arthroscopic shoulder surgery (rotator cuff repair, subacromial decompression, acromioclavicular resection, removal of calcific tendinitis, reconstruction of instability capsular release, shoulder replacement)	Quasi-experimental study	SSNB: 130 (59/71); no treatment: 130 (61/69)	SSNB: 56.2 ± 6.86; no block: 54.5 ± 7.06	No	Not mentioned	VAS	8*
Jeske et al, 2011	Shoulder impingement	Arthroscopic subacromial decompression	RCT	SSNB: 15 (9/6); subacromial infiltration: 15 (7/8); normal saline injection to SSN: 15 (8/7)	SSNB: 59.1 ± 6.1; subacromial infiltration: 62.9 ± 6.9; normal saline injection to SSN: 63.6 ± 9.0	Yes	Not mentioned	Static and dynamic VAS, CMS, patient satisfaction, incidence of nausea and vomiting	4#
Lee et al, 2015	Rotator cuff tear	Arthroscopic rotator cuff repair	RCT	SSNB: 15 (11/4); SSNB with normal saline: 15 (10/5)	SSNB: 48.9 ± 11.7; SSNB with normal saline 51.6 ± 10.6	Yes	Not mentioned	VAS, incidence of nausea	5#

Table 1 (cont). *Summary of the retrieved trials investigating suprascapular nerve block on patients with acute post-surgical shoulder pain.*

Author, year	Patients' diagnosis	Surgery	Study design	Enrolled sample number, (Male/ Female)	Average age, years	Double-blind	Intention-to-treat	Outcome measurement	Quality assessment
Non-shoulder surgery									
Tan et al, 2002	Not mentioned	Thoracotomy	RCT	SSNB: 15 (9/6); normal saline: 15 (10/5)	SSNB: 66 (55-78); SSNB with normal saline: 66 (33-79)	Yes	Not mentioned	VAS, 5-point VRS	5#
Hong et al, 2003	Infertility	Diagnostic laparoscopy	RCT	SSNB: 20; piroxicam patch: 20; no block: 20 (all females)	SSNB: 31.8 ± 3.4; piroxicam patch: 31.0 ± 4.4; no treatment: 32.3 ± 3.8	No	Not mentioned	VAS, incidence of nausea, dizziness and epigastria discomfort	2#
Ozyuvaci et al, 2013	Lung cancer	Thoracotomy	Quasi-experimental study	SSNB: 18 (13/5); no block: 18 (14/4)	SSNB: 61.83 ± 8.69; no block: 57.5 ± 8.21	Yes	Not mentioned	VAS, VAS at coughing	8*

Note: SSNB: suprascapular block; IA: intra-articular injection; ISB: interscalene block; RCT: randomized controlled trial; CMS, Constant-Murley score; VAS: visual analog scale; MPQ: McGill Pain Questionnaire; VPS: verbal pain scale; VRS: verbal ranking score. *# indicated that the study was evaluated by Jadad's scale.* * indicated that the study was assessed by *the* Newcastle-*Ottawa Scale.*

Table 2. *Summary of the intervention details of suprascapular nerve block (SSNB) in the retrieved trials.*

Author, year	Treating arm and regimen	Injection Volume	Guidance for SSNB	General anesthesia method	Regional anesthesia method	Post-operative analgesia	Follow-up timing	Opioid usage
Shoulder surgery								
Ritchie et al, 1997	SSNB with 0.5% bupivacaine + epinephrine (1: 200,000)	10 mL	Surface landmark and electric stimulation	Alfentanil 15 µg /kg and propofol 2-2.5 mg/kg. Maintained with 60% nitrous oxide in oxygen and end-tidal isoflurane 0.5%-2%	Not mentioned	Analgesia by PCA morphine after surgery in 2-mg increments with a 5-min lockout time up to a total of 8 mg. If VAS >4 cm after 8 mg of morphine, 2-mg increments until VAS <4 cm	VPS: before surgery, awake, 15,30,45,60, 90, 120, 180, 240 min after surgery. MPQ: before surgery, 60 min, 120 min after surgery	Morphine consumption: 8.4±5.0 mg
	Subcutaneous normal saline	5 mL						Morphine consumption: 12.2±4.6 mg
Neal et al, 2003	SSNB with 0.25% bupivacaine + epinephrine 5 µg/ mL	10 mL	Surface landmark	Intravenous with ketorolac 30 mg and with a maximum of 2µg/kg of fentanyl up to 3.5 µg/kg, 0.03 mg/kg of midazolam up to 5 mg, or both	ISB with 30 mL of mepivacaine 1.25% with epinephrine 2.5 µg/mL	Infiltrated the wound with 10 ml of subcutaneous 0.25% bupivacaine after surgery. 5 mg oxycodone and 500 mg acetaminophen using for pain control	Static VAS on admission to Phase 1 and every 30 min until discharge. Static and dynamic VAS before discharge. Standardized telephone interview on 24 h after discharge	Fentanyl (µg/kg) : 7± 22; Oxycodone caplets: 0.6±0.7
	Subcutaneous normal saline	5 mL						Fentanyl (µg /kg) : 3±11 Oxycodone caplets: 0.6±0.7

Table 2 (cont). *Summary of the intervention details of suprascapular nerve block (SSNB) in the retrieved trials.*

Author, year	Treating arm and regimen	Injection Volume	Guidance for SSNB	General anesthesia method	Regional anesthesia method	Post-operative analgesia	Follow-up timing	Opioid usage
Singelyn et al, 2004	SSNB with 0.25% bupivacaine + epinephrine (1: 200,000)	10 mL	Surface landmark	Induction: sufentanil 0.3 µg/kg IV, propofol 2–2.5 mg/kg, and atracurium 0.5 mg/kg. Maintenance with mixture of nitrous oxide (66%) and desflurane (3%–5%) in oxygen	Not mentioned	If VAS >30, received 2 g of IV propacetamol followed by 5 mg (weight <60 kg) or 10 mg (weight >60 kg) of subcutaneous morphine if VAS remained unchanged after 30 min	Static and dynamic VAS in the PACU 4 and 24 h after surgery	Total morphine (mg/24 h) : 6 ±8
	IA injection with 0.25% bupivacaine + epinephrine (1: 200,000)	20 mL	Surface landmark					Total morphine (mg/24 h) : 8±9
	ISB with 0.25% bupivacaine + epinephrine (1: 200,000)	20 mL	peripheral nerve stimulator					Total morphine (mg/24 h) : 3± 8
	Control group without block	-	-					Total morphine (mg/24 h) :13 ± 14
Jerosch et al, 2008	SSNB with 0.5% bupivacaine	10 mL	Surface landmark	Not mentioned	Not mentioned	Not mentioned	VAS before surgery; VAS in 1st, 2nd, and 3rd day after surgery	Not mentioned
	Control group without block	-	-					
Jeske et al, 2011	SSNB with 1% ropivacaine	10 mL	Surface landmark and peripheral nerve stimulator	Not mentioned except fentanyl 0.2 mg during anesthesia	Not mentioned	Intravenous 75 mg diclofenac 4h after surgery. Twice a day using for at least 48 h	Static and dynamic VAS in 6h, 24h, 48h; doses of analgesics needed for first 24 hr and 0-48 h after surgery; patient satisfaction at 48h, 14d, 6 wk; nausea/ vomiting in first 48h; CMS, pain, ADL, ROM, power at 48 h, 6 wk	Morphine for the 1st day (mg/24 h): 6.3 ± 7.5
	Subacromial infiltration with 1% ropivacaine	20 mL						Morphine for the 1st day (mg/24 h): 13.0 ± 13.7
	SSNB with 0.9% saline	10 mL						Morphine for the 1st day (mg/24 h):: 13.4 ± 8.9
Lee et al, 2015	SSNB with 0.5% ropivacaine + epinephrine (1: 200,000)	10 mL	Arthroscopy	Intravenous propofol (2 mg/kg). Rocuronium (0.7 mg/kg) for muscle relaxation and tracheal intubation. Maintenance with 50 % nitrous oxide in oxygen and 2–2.5 % sevoflurane	Not mentioned	PCA intravenous pump to deliver a 1 µg/ kg bolus of fentanyl after surgery. The lockout time was 1 h, and the maximum dose was 700 µg	VAS in 1, 3, 6, 12, 18, 24 h after surgery	Total fentanyl(µg): 137.8 ± 212.4
	SSNB with 0.9% saline	10 mL						Total fentanyl(µg): 315.1 ± 110.4

Table 2 (cont). *Summary of the intervention details of suprascapular nerve block (SSNB) in the retrieved trials.*

Author, year	Treating arm and regimen	Injection Volume	Guidance for SSNB	General anesthesia method	Regional anesthesia method	Post-operative analgesia	Follow-up timing	Opioid usage
Non-shoulder surgery								
Tan et al, 2002	SSNB with 0.5% bupivacaine	10 mL	Surface landmark and electric stimulation	Propofol 2–3 mg/kg and fentanyl 1µg/kg. Ventilated with 1%–2% isoflurane in an oxygen/ air mixture	A bolus of 0.1 mL/kg of epidural solution (0.1% bupivacaine and fentanyl 5µg/mL) before surgery. Epidural solution was infused at 0.1 mL/kg/h intraoperatively	Epidural solution (0.1% bupivacaine and fentanyl 5µg/ mL) was provided after surgery	VAS and 5-point VRS before nerve block, 0.5,1,2,3,4,6 h after surgery	Total epidural fentanyl (µg/kg): 5.3 (2.8-7.4)
	SSNB with normal saline	10 mL						Total epidural fentanyl (µg/kg): 4.4 (3.1-6.2)
Hong et al, 2003	SSNB with 0.5% bupivacaine + epinephrine (1: 200,000)	5 mL	Surface landmark	Intravenous with fentanyl 1 µ g/kg, vecuronium 0.05-0.1 mg/kg, and target concentration of propofol 4-8µ g/ml	Not mentioned	Intravenous with nalbuphine of 10 mg or ketorolac 30 mg	VAS at 1,3,6,12, 24 h after surgery	Not mentioned
	Piroxicam (48 mg) patch	-						
	Control group without block	-						
Ozyuvaci et al, 2013	SSNB with 0.5% levobupivacaine	10 mL	Ultrasound	Propofol 2.5 mg/kg and fentanyl 1 µ g/kg, and vecuronium 0.1mg/ kg. Maintenance with vecuronium 0.01mg/kg/h	Epidural block with 10 ml 0.5% levobupivacaine and fentanyl 2.5µ g/ml, maintained with 5 ml/h infusion and 10 ml bolus per 45 min during surgery	Epidural analgesia infusion of 0.5% levobupivacaine and fentanyl 2.5µ g/ml, with baseline infusion of 5 ml/h, incremental dose of 8 ml, lockout period of 20 min	VAS in 0, 1, 3, 6, 12, 24, 36, 48, 72 h after surgery. VAS at coughing in 12, 24, 36, 48, 72 h after surgery	Fentanyl (µg /kg): 4.1± 1.3
	Epidural analgesia only	-						Fentanyl (µg/kg): 5.36± 0.95

Note: SSNB: suprascapular block; IA: intra-articular injection; ISB: interscalene block; RCT: randomized controlled trial; CMS, Constant-Murley score; VAS: visual analog scale; MPQ: McGill Pain Questionnaire; VPS: verbal pain scale; VRS= verbal ranking score; PACU: post anesthesia care unit; ISB: interscalene brachial plexus block; wk: week; d: day; h: hour; min: minute.

dence based on common statistical measures in terms of SSNB for shoulder pain relief after surgery.

The origin and mechanism of post-operative shoulder pain differs from that in chronic shoulder pain. In the shoulder surgery group, the magnitude of shoulder pain is related to the operative procedure (open versus arthroscopic surgery, type of surgery [rotator cuff versus non-rotator cuff], and causative factors of shoulder disorders [work-related accidents, occupational overuse syndrome, or trauma or degenerative pathology]) (6,30). The most painful period usually occurs on post-operative day 1, when the effect of general anaesthesia gradually wears off and the tissues start to become swollen and edematous (6). Our results indicated that the use of SSNB resulted in a significantly less painful status in the shoulder surgery group compared with placebo. Since SSNB in most of the included studies was administered before or during surgery, its effect on post-operative day 1 was unlikely to be derived from the persistent action of local anaesthetics. We believe that the pre-operative and intra-operative implementation of SSNB could effectively reduce neurogenic inflammation, a neurally elicited local inflammatory response mediated by neuropeptides such as substance P and calcitonin gene-related peptide (31). The benefit of SSNB was also reflected in the lower incidence of nausea, a common adverse symptom due to post-operative pain and use of opioid analgesics.

The cause of post-thoracotomy and laparoscopic surgery shoulder pain is presumed to differ from that after shoulder surgery. Irritation of phrenic nerves due to peritoneal stretching or exploration of the mediastinum and pericardium is a widely accepted mechanism (18). Since the suprascapular and phrenic nerves share the same origin (C5) in the root, SSNB may play a role in reducing shoulder-tip pain after operations. However, in the meta-analysis, there appeared to be inconsistent outcomes between trials; one of which showed a favorable result of SSNB, but 2 had an opposite effect, leading to a pooled SMD covering the zero value. One RCT indicated lower shoulder pain intensity after phrenic nerve infiltration than SSNB for post-thoracotomy pain (18). Therefore, direct targeting of the phrenic nerve may be a better solution for post-thoracotomy and -laparoscopy shoulder pain, and SSNB may not be a preferable pre-emptive analgesic procedure for non-shoulder surgeries.

Our subgroup analysis revealed that different study designs or guiding techniques did not result in discrepancy of treatment

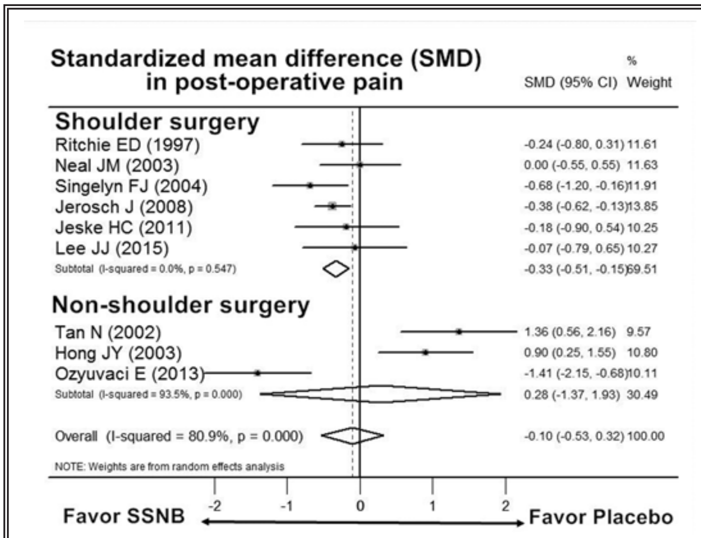

Fig. 2. *Forest plot of standardized mean difference of post-operative pain in the suprascapular nerve block (SSNB) group versus the placebo group.*

Table 3. *Subgroup analysis of standardized mean differences based on study designs and guiding techniques for suprascapular nerve block*

Subgroup	Standardized mean difference	95% confidence interval
Study design		
Shoulder surgery group		
Randomized controlled trials	-0.27	-0.54 to -0.00
Quasi-experimental studies	-0.38	-0.62 to -0.13
Non-shoulder surgery group		
Randomized controlled trials	1.09	0.58 to 1.59
Quasi-experimental studies	-1.41	-2.15 to -0.68
Guiding technique		
Shoulder surgery group		
Surface landmark	-0.35	-0.53 to -0.16
Arthroscopy	-0.07	-0.79 to 0.65
Non-shoulder surgery group		
Surface landmark	1.09	0.58 to 1.59
Ultrasound	-1.41	-2.15 to -0.68

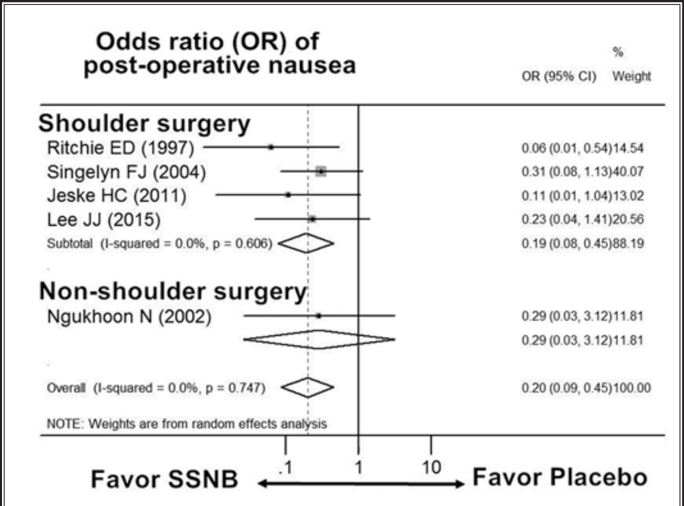

Fig. 3. *Forest plot of odds ratio of post-operative nausea in the suprascapular nerve block (SSNB) group versus the placebo group.*

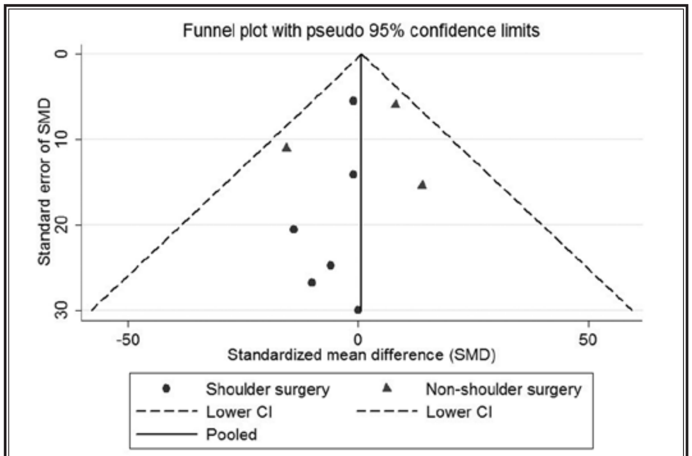

Fig. 4. *Funnel plot of the standardized mean difference (SMD) of post-operative pain.*

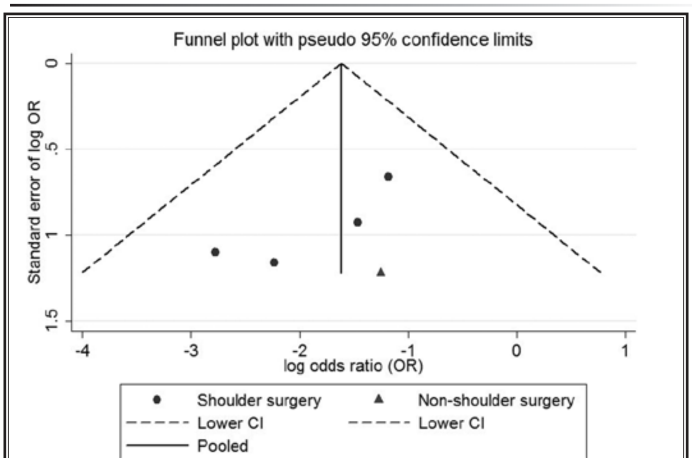

Fig. 5. *Funnel plot of log odds ratio (OR) of post-operative nausea.*

effectiveness in the shoulder surgery group but led to a significant difference in the non-shoulder surgery group (Table 3). However, since only 3 studies were enrolled in the non-shoulder surgery group, the sample size was too small to claim that heterogeneity of effectiveness was derived from variations in study designs or guiding techniques.

There are several limitations of the present meta-analysis. First, the primary outcome was post-operative pain condition, not the change of visual analog scales pre- and post-operatively. The main reason for this was that only a minority of included trials recorded pre-operative pain status. Second, we did not serially investigate pain status; instead, we used the visual analog scale on the post-operative day 1. This was because this time point was the most commonly documented in the results of the retrieved studies, especially in the shoulder surgery patient group. Another reason was based on a previous report stating that the patients felt the most pain 24 hours after arthroscopic shoulder surgery. Third, the outcome of post-operative pain can be modified by different analgesic regimens following surgery. Therefore, we also analyzed the odds ratio of the most prevalent adverse symptom, nausea, to examine whether there was inconsistency between both outcomes. Fourth, since SMD is derived from the between-group mean difference divided by the standard deviation, the value of SMD may be overestimated if the variability of the recruited population is artificially or accidentally reduced. In contrast, if the variability is increased, the SMD will be underestimated. Therefore, the researchers should consider the influence of measurement precision when reporting the treatment effectiveness by using the SMD. Finally, based on the above mentioned limitations, we suggest that future similar trials should document serial changes in post-operative shoulder pain and functional status as well as their pre-operative condition.

Conclusions

The present meta-analysis revealed that SSNB can lead to less painful shoulders for participants following shoulder surgery; however, its effectiveness is uncertain in patients receiving thoracotomy and laparoscopic surgery. SSNB also reduced the incidence of post-operative nausea. Therefore, our meta-analysis suggests that SSNB can be used as a method of polymodal analgesia for patients undergoing shoulder surgery, but is not recommended for patients undergoing non-shoulder surgery.

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