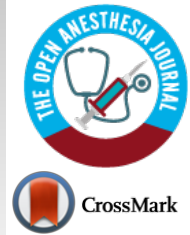




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SYSTEMATIC REVIEW

Regional Anesthesia for Clavicle Fracture Surgery- What is the Current Evidence: A Systematic Review

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Abstract:

Introduction:

The sensory innervation of the clavicle remains controversial. It might come from both the cervical plexus and brachial plexus. Peripheral nerve blocks used to anesthetize the clavicle include cervical plexus blocks, brachial plexus blocks, and combined cervical and brachial plexus blocks.

Objectives:

The review was to determine whether there is a difference in pain scores and pain medication consumption intraoperatively and postoperatively among these blocks. Secondary endpoints were block success and serious adverse events.

Methods:

A comprehensive literature search of PubMed and Web of Science was performed. Only English-written randomized controlled studies were included.

Results:

Compared with patients with general anesthesia, patients with combined ultrasound-guided superficial cervical and interscalene brachial plexus block spent a shorter time in PACU (35.60 ± 5.59 min vs. 53.13 ± 6.95 min, $P < 0.001$), had a more extended pain-free period (324.67 ± 41.82 min vs. 185.27 ± 40.04 min, $P < 0.001$), and received less opioid consumption (Tramadol 213.33 ± 57.13 mg vs. 386.67 ± 34.57 mg, $P < 0.001$) in first 24 h postoperatively. Compared with patients with ultrasound-guided superficial cervical and interscalene brachial plexus block, patients with ultrasound-guided intermediate cervical and interscalene brachial plexus block had a higher success rate (100% vs. 80%) and longer duration of post-operative analgesia (7.5 ± 0.8 h vs. 5.7 ± 0.4 h, $P < 0.001$). Without ultrasound guidance, patients with combined superficial, deep cervical, and interscalene brachial plexus block had a higher success rate (96% vs. 60%), lower pain score at two h postoperatively (1.96 ± 0.17 vs. 3.22 ± 0.88 , $p = 0.000$), and a more extended pain-free period (1h vs 6h) compared to combined superficial cervical and interscalene brachial plexus block. There were no regional anesthesia-related complications reported in all studies.

Conclusion:

Patients with regional anesthesia have a more significant pain-free period and less intraoperative and postoperative opioid consumption than patients with general anesthesia. Combined intermediate or deep cervical plexus and Interscalene brachial plexus blocks provide better analgesia than combined superficial cervical plexus and Interscalene brachial plexus blocks. Ultrasound guidance improved the success rate of regional anesthesia. Combined cervical plexus and brachial plexus block can be used as sole anesthesia for clavicle fracture surgery.

Keywords: Clavicle fracture, Regional anesthesia, Superficial cervical plexus block, Intermediate cervical plexus block, Deep cervical plexus block, Brachial plexus block.

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1. INTRODUCTION

The clavicle is the bone that connects the sternum to the scapula. Any severe force on the shoulder, such as falling directly onto the shoulder or falling on an outstretched arm, transfers force to the clavicle. As a result, the clavicle is one of

the most commonly broken bones in the body. It accounts for about 5 percent of all adult fractures and occurs in people of all ages [1].

Clavicle fractures are basically classified into three types based upon location [2]. The most common clavicle fractures are in the middle of the shaft of the bone, approximately halfway between the sternum and the acromioclavicular joint. The least common fractures are near the sternum. Fractures

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near the acromioclavicular joint are the second most common and can come in many different patterns.

Non-displaced clavicle fractures can be treated by conservative or nonsurgical treatment such as immobilization with a sling, pain control, and physical therapy [3]. However, surgery may be needed for more complicated fractures such as open fractures, displaced fractures with skin tenting, clavicle fractures, concomitant vascular injury, and nerve injuries [4].

The sensory innervation of the clavicle remains controversial. It might come from both the cervical plexus and brachial plexus [5]. The cervical plexus is composed of C1-C4. It has four branches: greater auricular, lesser occipital, supraclavicular, and transverse cervical nerves. Among these branches, the supraclavicular nerve is the one that provides the most innervation to the clavicle. It arises from C3 – C4 and has three branches. The medial branch innervates the skin and clavicle from the sternoclavicular joint to the mid clavicle; intermediate branch innervates clavicle and skin from the superior aspect of the pectoralis major to the anterior deltoid; and lateral branch innervates the distal clavicle and skin supplying the superior and posterior aspect of the deltoid [6]. The brachial plexus provides innervation for the entire upper extremity, both sensory and motor, specifically the skin over the deltoid muscle. The supraclavicular, subclavian, and long thoracic/suprascapular nerves, alone or together, may be responsible for pain transmission after clavicular fracture and surgery [5].

Since the clavicle is probably innervated by both the cervical plexus and brachial plexus, peripheral nerve blocks are used to anesthetize the clavicle including cervical plexus block, and brachial plexus block, and combined cervical and brachial plexus blocks.

This review aims to evaluate the primary outcome data from available research trials on intraoperative and post-operative analgesic efficacy and secondary outcomes such as complications and adverse events compared to different regional anesthesia methods for clavicle fracture surgery.

2. METHODS

2.1. Search Strategy and Selection Criteria

The literature search for this review was conducted using PubMed and embase databases. The following keywords were searched: "regional anesthesia," "cervical plexus block,"

"superficial cervical plexus block," "intermediate cervical plexus block," "deep cervical plexus block," "brachial plexus block," "Clavicle fracture," and "clavicle nerve innervation." Only randomized controlled trials were included in this review.

3. RESULTS

Our comprehensive search strategy identified 36 studies from PubMed and no studies from embase databases. After screening the titles and abstracts of all 36 studies, four randomized controlled studies were identified. One of the studies was excluded because it is a non-English written study. Three randomized studies were included in this review.

One randomized study compared Ultrasound-guided superficial cervical plexus block (SCB) and interscalene brachial plexus block (ISB) with general anesthesia in patients undergoing clavicular surgery [7]. One randomized study compared ultrasound-guided ISB and intermediate cervical plexus block (ICB) with Ultrasound guided ISB-SCB in patients undergoing clavicular surgery [8]. Another randomized study compared combined ISB-SCB-deep cervical plexus block (DCB) with SCB-ISB without ultrasound guidance in patients undergoing clavicular surgery [9].

The personal characteristics of the participants of the included studies are summarized in Table 1.

All patients in the study were comparable in terms of demographic data expressed regarding age and weight. Two studies included ASA I and II patients [7, 8], the other study only included ASA I patients [9] (Table 1).

In two studies, cervical plexus and brachial plexus blocks were performed under ultrasound guidance [7, 8]. Sixteen ml of local anesthetic consisting of 8 ml of 2% lignocaine with adrenaline along with 8 ml of 0.5% bupivacaine was used for ultrasound-guided ISB, and 10 ml of local anesthetic mixture consisting of 5 mL of lignocaine with adrenaline and 5 ml of 0.5% bupivacaine was administered for SCB in one of the studies [7]. In the other study, 10 ml of 0.5% bupivacaine was used for both ISB and cervical plexus block [8]. The block and injection techniques are similar in these two studies (Table 2).

One study performed SCB, DCB, and ISB with nerve stimulator guidance. Each patient received 40 ml of a local anesthetic solution consisting of 20ml of 0.25% Bupivacaine and 20 ml of 1% Lignocaine with 1 in 200000 adrenaline mixture divided into two/three blocks [9].

Table 1. The personal characteristics of the participants of the included studies.

Study(year)	Anesthesia	Number	Age	Weight	Gender Male/Female	ASA I/II/III
Banerjee <i>et al</i> (2019)	General	30	36.10±11.09	54.60±4.98	16/15	18/17/0
	ISB+SCB	30	37.23±11.59	55.53±6.04	14/15	12/13/0
Arjun <i>et al</i> (2020)	ISB+ICB	25	38±14.9	BMI(22.9±0.9)	20/5	14/11/0
	ISB+SCB	25	37±12.8	BMI(22.9±0.9)	18/7	15/10/0
Basu <i>et al</i> (2019)	ISB+SCB	25	20-50	50-70	N/A	50/0/0
	ISB+SCB+DCB	25				

Table 2. The study characteristics and outcome measures of the selected studies.

Study (year)	Anesthesia	Success Rate	Total Opioid Consumption in 24 h	First Postoperative Analgesia(h)	VAS (2h)	VAS (4h)	Complications
Banerjee <i>et al</i> (2019)	General	N/A	386.67±34.57 mg (T)	5.4±0.7	3.3	4.6	N/A
	ISB+SCB	N/A	213.33±57.13 mg (T)	3.1±0.6	1.6	2.7	no
Arjun <i>et al</i> (2020)	ISB+ICB	100% (25/25)	N/A	7.5 ± 0.8	N/A	N/A	no
	ISB+SCB	80% (20/25)	N/A	5.7 ± 0.4	N/A	N/A	no
Basu <i>et al</i> (2019)	ISB+SCB	60%	N/A	1	3.22±0.88	2.27±0.45	no
	ISB+SCB+DCB	96%	N/A	6	1.96±0.17	1.10±0.52	no

3.1. Block Success Rate

Two studies [10 - 16] documented block success rates. One study defined a successful block as one in which surgery was solely under the block and there was no additional analgesic requirement [16]. Ultrasound-guided ISB-ICB achieved a 100% successful rate. In contrast, ultrasound-guided ISB-SCB achieved an 80% success rate. In another study, a successful block was defined as one which did not necessitate conversion to general anesthesia [9]. The patients with combined ISB-SCB-DCB had fewer patients (1/25 vs. 10/25) who converted to general anesthesia compared with patients with combined ISB-SCB.

3.2. Hemodynamic Parameters

Heart rate, mean arterial pressure, and peripheral arterial saturation were recorded in all three studies. The heart rate increases significantly in the general anesthesia group compared to the group with regional anesthesia [7]. There was no difference between the groups with ultrasound-guided regional anesthesia groups with respect to the effects on heart rate and mean arterial pressure [8]. There was a significant difference in MAP and heart rate between the groups with nerve stimulator-guided nerve blocks during stripping of the periosteum, screw and plate fixation, skin suturing, and till two hours postoperatively [9].

3.3. The Mean Duration of Post-operative Analgesia

Time of the first post-op analgesic was recorded in all three studies. The time of the first occurrence of pain after complete closure was significantly longer in the group with combined ISB-SCB (324.67 ± 41.82 min) than in the group with general anesthesia (185.27 ± 40.04 min)(P < 0.001) [7]. The mean duration of postoperative analgesia was longer in the group with combined ultrasound-guided ISB-ICB (7.5±0.8 h) compared with the Group with Ultrasound-guided combined ISB-SCB (5.7±0.4 h) [8]. In the group with nerve stimulator guided ISB-SCB-DCB, pain medication was required only when the block wore off after 6 hours of the block postoperatively. In contrast, Patients of Group with nerve stimulator guided ISB-SCB had to be supplemented immediately with Diclofenac in the post-op period [9].

3.4. Visual Analog Scale (VAS) Score

Two studies compared the VAS score among the study groups at specified points of time during surgery [7, 9]. The mean pain score was comparatively lower in the group with combined Ultrasound-guided ISB-SCB than in the group with

general anesthesia [7]. The group with combined ISB-SCB-DCB has lower VAS intraoperatively and postoperatively compared to the group with combined ISB-SCB [9].

3.5. Complications

There were no block-related complications reported in all studies.

3.6. Grade

Based on the inconsistency in the result and the risk of publication bias, we assigned the GRADE level of “low quality” to our primary and secondary outcomes.

4. DISCUSSION

General anesthesia is usually preferred in clavicular surgery in anesthesia practice because clavicle surgery is generally performed in a sitting position, airway access is difficult during surgery, and clavicle surgery also requires deep and efficient anesthesia to cover the entire clavicle bone and its sternal extremity. Regional anesthesia (RA) is usually not sufficient to cover. However, regional anesthesia for upper limb surgery represents several advantages over general anesthesia, including more hemodynamic stability, less nausea and vomiting, better intraoperative and postoperative analgesia, fewer side effects, shorter hospital stay, and improved patient satisfaction [10]. So far there is only one randomized study that compared ultrasound-guided ISB-SCB with general anesthesia in patients undergoing clavicular surgery [7]. Their results showed the patients with ultrasound-*ISB-SCB* had less postoperative opioid consumption, lower pain scores, and spent a shorter time in PACU. Similar to their study, one matched case-controlled study [8] also showed ultrasound-guided *ISB* provides adequate analgesia for middle and lateral clavicle fracture surgery compared to general anesthesia.

Regional anesthesia used for clavicle fracture surgery includes cervical plexus block, brachial plexus block, and combined cervical and brachial plexus blocks. It could be a different combination depending on the location of the cervical and brachial plexus block. In the literature, the proposed interventional strategies for clavicular fractures include *SCB* [11], *ISB* [12], combined *SCB-DCB* [13], combined *SCB-ISB* [7, 9, 14 - 17], combined *ICB-ISB* [8], combined *SCB-DCB-ISB* [9], combined *SCB-supraclavicular brachial plexus blocks* [10], and *clavipectoral fascial plane block* [18]. These techniques are usually used for the analgesia of the clavicle.

Our literature review showed that combined cervical

plexus and brachial plexus block could be used as sole anesthesia for clavicle fracture surgery. Cervical plexus block can be performed in different locations. The superficial cervical plexus block consists of subcutaneous injection of the local anesthetic agent along the posterior border of the sternocleidomastoid muscle. An intermediate cervical plexus block delivers local anesthetic deeper to the sternocleidomastoid muscle, under the investing fascia of the neck. The Deep cervical plexus block involves the deposition of a local anesthetic beneath the deep cervical fascia, close to the transverse processes of the cervical vertebrae. Therefore, the intermediate or deep cervical plexus block is supposed to result in denser and more reliable analgesia compared to the superficial cervical plexus block. Some studies [18, 19] found no difference between a superficial or intermediate or combined cervical plexus block (Superficial plus deep) for carotid endarterectomy surgery. However, our review showed that intermediate cervical plexus or combined cervical plexus blocks provided more effective analgesia and had a higher success rate compared to superficial cervical plexus blocks. It could be due to clavicle surgery requiring denser analgesia compared to carotid endarterectomy surgery.

We found out that brachial plexus and cervical plexus blocks performed under ultrasound guidance had a higher success rate and less local anesthetic requirements. In the study on ultrasound-guided ISB-SCB [8], 20 ml of 0.5% bupivacaine was used and achieved an 80% success rate. In the other study [9] without ultrasound guidance, 40 ml of local anesthetic solution was used and only achieved a 60% success rate. The two studies are comparable in terms of demographics.

The cervical plexus block and brachial plexus block have some potential complications. Local anesthetic or systemic toxicity from the inadvertent intravascular injection is possible. Cervical plexus block can cause dysfunction/blockade of the recurrent laryngeal nerve, deep cervical plexus, and brachial plexus with an inadvertent deep injection or excessive local anesthetic volume [20]. Accidentally blocking the accessory nerve can cause sternocleidomastoid and trapezius muscle weakness. Puncture of the internal jugular vein and carotid artery is also possible [21]. Possible complications of the interscalene nerve block include infection, bleeding/hematoma, epidural or subarachnoid injection, permanent nerve injury, horner syndrome [22] hemiparalysis of the diaphragm [23] and pneumothorax. None of the studies included in this review reported nerve block-related complications.

In addition to cervical plexus and brachial plexus block, the clavipectoral fascial plane block is a novel regional anesthesia technique that has been used for clavicular fracture surgery since the terminal branches of some sensory nerves like subclavian, lateral pectoral, long thoracic, and suprascapular nerves pass through the plane between the clavipectoral fascia and the clavicle itself [24]. The clavipectoral fascial plane block has proved to be an attractive alternative to the cervical plexus and brachial plexus block given its singular injection, ease of performance, and advanced safety profile, especially for patients with respiratory disease.²⁵ However, randomized controlled studies need to be done to prove its efficacy.

We acknowledge a few limitations of this study. The literature search only generated three randomized controlled trials with mixed quality and bias risks. One study did not report postoperative opioid consumption. In addition, there is significant clinical heterogeneity regarding the drugs, volume, and concentration used for cervical and brachial plexus block.

CONCLUSION

Patients with regional anesthesia have a more significant pain-free period, less intraoperative and postoperative opioid consumption than patients with general anesthesia. Combined intermediate or deep cervical plexus and Interscalene brachial plexus blocks provide better analgesia than combined superficial cervical plexus and Interscalene brachial plexus blocks. Ultrasound guidance improved the success rate of regional anesthesia. Combined cervical plexus and brachial plexus block can be used as a sole anesthesia for clavicle fracture surgery.

LIST OF ABBREVIATIONS

SCB	=	Superficial Cervical Plexus Block
ICB	=	Intermediate Cervical Plexus Block
DCB	=	Deep Cervical Plexus Block
RA	=	Regional Anesthesia

CONSENT FOR PUBLICATION

Not applicable.

STANDARDS OF REPORTING

PRISMA guidelines are followed.

FUNDING

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CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

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SUPPLEMENTARY MATERIAL

PRISMA checklist is available as supplementary material on the publisher's website along with the published article.

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