Current Concepts in Regional Analgesia Techniques for Postoperative Pain Management after Total Shoulder Arthroplasty: A Narrative Review

Prasanna Khare1, Rijuta Kashyap1, Manjiri Ranade1
1Department of Anaesthesiology, Deenanath Mangeshkar Hospital & Research Centre, Pune, Maharashtra, India.

Abstract
Postoperative pain management after total shoulder arthroplasty (TSA) can be challenging. Interscalene brachial plexus block (ISB), which is administered either as single shot injection (ssISB) or with continuous catheter (ccISB) technique, is the gold standard. Ultrasonography (USG) guidance facilitates a faster, more accurate block with a lower local anaesthetic volume in ssISB. USG also helps for accurate catheter placement in ccISB. Hemi-diaphragmatic palsy is a common complication of ISB. This can be a major concern for patients with a respiratory compromise so it necessitates the administration of diaphragm-sparing nerve blocks. Phrenic nerve sparing block like suprascapular nerve block (SSNB) singly or along with axillary nerve block, subomohyoid anterior suprascapular block, superior trunk block, erector spinae plane block, individually, provide perioperative analgesia non-inferior to ISB. Subacromial or intraarticular infiltration of local anaesthesia (SAIA) is not recommended due to its limited clinical efficacy. Extended analgesic effects have been observed with the continuous catheter (ccISB) technique and liposomal bupivacaine when used as a field block. This article provides an overview of regional anaesthesia techniques for postoperative analgesia following Total shoulder arthroplasty (TSA).

Keywords: Shoulder arthroplasty, Pain management, Regional anaesthesia, Interscalene brachial plexus block

Introduction
Glenohumeral osteoarthritis affects up to 30% of patients aged 60 years. It causes significant functional limitation and disability [1]. The incidence of total shoulder arthroplasty (TSA), an effective lifestyle modification surgery for this painful condition, has increased significantly over the past two decades [2]. This surgery provides long-term clinical results and lasting pain relief [3]. Adequate early postoperative pain control improves the outcome by facilitating early rehabilitation of these elderly patients with associated comorbidities.

Opioids are commonly prescribed to reduce short-term postsurgical pain but their side effects such as nausea, constipation, and respiratory depression are distressing to patients [4]. Enhanced recovery after surgery (ERAS) protocol for shoulder arthroplasty features multidisciplinary collaboration and multimodal analgesia with a mainstay on regional anaesthesia. ERAS has reduced the length of hospital stay and complications, simultaneously improving patient outcomes [5].

In this article, we will provide an overview of regional anaesthesia techniques used to manage postoperative pain following total shoulder arthroplasty.

Anatomy
The shoulder receives sensory innervation from the cervical (C3, 4) and brachial plexuses (CS, 6). The major motor and sensory innervation to the shoulder is from the suprascapular nerve (upper trunk of the brachial plexus) and axillary nerve (posterior cord of the
The cutaneous supply to the cape of the shoulder, upper thoracic region and a sensory contribution to the acromioclavicular and sternoclavicular joints are from the supraclavicular nerves. (Descending branches of superficial cervical plexus; C3, 4) [6].

**Surgery**

The standard surgical approach for total shoulder arthroplasty is an anterior skin incision running from the coracoid process along the deltopectoral line towards the deltoid tuberosity of the humerus [7].

**Types of Regional Anaesthesia**

**Interscalene Brachial Plexus Block (ISB)**

Interscalene block, the gold standard regional anaesthetic technique for shoulder procedures, is commonly used for all shoulder arthroplasty cases [8]. ISB is administered at the upper border of the cricoid cartilage (the transverse process of C6) in the interscalene groove. Successful blockade achieves analgesia at the lateral two-thirds of the clavicle, the proximal humerus, and the glenohumeral joint [9].

Historically paraesthesia or the peripheral nerve stimulation (PNS) technique has been used to locate and identify the brachial plexus anatomy. In Ultrasonography (USG) guided ISB, using the same landmarks C5 and C6 nerve roots are identified and local anaesthetics is injected (Figure 1).

Use of USG has facilitated accurate identification of the brachial plexus and its branches, blocks performed using USG guidance were more likely to be successful, took less time to perform, had faster onset than those performed with PNS guidance. USG guidance also decreased the risk of a vascular puncture during block performance [10].

Winnie had recommended the use of 40 ml of local anaesthetic for a successful brachial plexus block [9]. However, USG guided block helps to visualize the spread pattern of local anaesthetic in real-time; improves the success rate with a lower local anaesthetic dose than the conventional volume. One study reported that the minimum effective anaesthetic volume (MEAV) required for successful surgical anaesthesia is 5 ml but possibility of a 25% failure rate [11]. ISB may be performed as either a single injection (ssISB) or with a continuous catheter (ccISB). Single shot ISB can provide effective analgesia up to 6 hours on movement and 8 hours at rest after shoulder surgery, with no demonstrable benefits thereafter. Patients who receive an ISB can suffer rebound pain at 24 hrs(54,269),(794,305).[12].

**Local anaesthetic adjuvants**

Various agents such as Clonidine, Dexmedetomidine, Buprenorphine and Dexamethasone have been used as adjuvants with peripheral nerve blocks to increase the duration of analgesia following surgery [13]. Cochrane review has concluded that the addition of Dexamethasone to a peripheral nerve block, prolongs analgesia up to 6-14 hours in upper limb surgery, with similar or better pain relief and lesser narcotic use than plain local anaesthetic [14]. Most adjuncts are safe to use with little or no neurotoxicity and tissue damage [15]. Although extensively used in clinical practice their use as adjuncts is off-label. The assessment of risk and potential benefit must be done while using such an agent [13].

**Continuous catheter ISB (ccISB)**

To extend the duration of postoperative pain relief after single-shot Interscalene block (ssISB), continuous local anaesthetic infusion into the interscalene groove via a perineural catheter connected to a portable infusion device has been used. Interscalene catheter placement is an advanced technique requiring a skilled operator for block placement. A meta-analysis concluded that, compared with
ssISB, ccISB reduced 24 and 48 hour oral morphine consumption, provided superior rest and dynamic pain control beyond 48 hours, prolonged time-to-first analgesic, enhanced satisfaction, and reduced postoperative nausea and vomiting without complications [16].

USG-guided catheter insertion may be performed either in-plane or out-of-plane according to operator preference. In the out-of-plane technique, the needle tip is adjusted to lie immediately lateral to the two most superficial brachial plexus roots/trunks. For in-plane needle advancement, the needle is inserted lateral to medial and advanced directly towards the brachial plexus. Needle tip position is determined by injection of local anaesthetic and view of injectate spread directly posterior and lateral to the target roots/trunks [17] (Figure 2).

The catheter tip position must be verified with ultrasound and a test bolus of local anaesthetic should be administered under clinical supervision. If the catheter and tip is difficult to visualise, small ‘boluses of fluid’ can be detected using Doppler mode ultrasound. Injection of a tiny volume of air or manual ‘wiggling’ of the catheter can also help confirm the position [18].

Secure fixation is essential but practically difficult because of shoulder mobility and the proximity of the surgical field to the catheter entry site. Several methods including skin glue, specialist anchor dressings, epidural catheter securing device (Lockit-Plus, Portex) (Figure 3) and tunnelling have all been described to prevent dislodgement with variable success rates [18].

**Complications of ISB**

Potential complications of ISB are central block with paralysis, brachial plexopathy, phrenic nerve palsy (hemidiaphragmatic paresis), recurrent laryngeal nerve palsy (hoarseness), Horner syndrome, pneumothorax, and cardiac arrhythmias [19].

Phrenic nerve palsy is observed in up to 100% of patients with 20 ml or more local anaesthetic volume and up to 45% with 5-10 ml volume [20]. Hemi-diaphragmatic paresis (HDP), though well tolerated by healthy adults, can cause respiratory compromise due to reduced pulmonary reserve, especially in patients with severe chronic obstructive pulmonary disease, obstructive sleep apnoea and morbid obesity.

Although overall complication rates are low with ccISB, there are concerns regarding the need for additional infrastructure to monitor and troubleshoot the infusion pumps, increased monitoring, risk of catheter migration/pull-out (15%), additional costs and improper placement [17]. Increased adverse effects are seen in ccISB group such as syncope, oversedation, bradycardia, shortness of breath and hypotension compared with ssISB [21].

Considering hemi-diaphragmatic paresis as a major occurrence, phrenic sparing blocks have been described.

**Diaphragm Sparing Nerve Blocks**

**Isolated Suprascapular Nerve Block (SSNB)**

The suprascapular nerve (SSN) is a branch of the brachial plexus, which receives contributions mostly from the C5, C6. The motor branch of the SSN supplies the supraspinatus and infraspinatus muscles. SSN provides 70% sensation to the shoulder joint, acromioclavicular joint, coracohumeral ligament, coracoclavicular ligaments, and subacromial bursa [22].

Contrary to the earlier belief [22], recent anatomical studies indicated that SSNs contribution is modest and confined to the posterior superior quadrant of the joint. The subscapular nerve contributes to the anterior superior quadrant, and the inferior half of the joint is innervated by the axillary nerve [23].

The suprascapular nerve branches off the superior trunk of the brachial plexus, close to the anterior and posterior divisions, and runs through the supracoacicular fossa under the inferior belly of the omohyoid and trapezius muscles. It enters the supraspinous fossa under the superior transverse scapular ligament.

USG-guided SSNB via a posterior approach at the suprascapular notch where the suprascapular nerve enters the supraspinous fossa has limited success due to the nerve’s depth and inconsistent anatomic variation at the origin of the sensory branches [24].

**Axillary nerve block**

The axillary nerve may be blocked by imaging the posterior surface of the humerus just distal to the humeral head. The posterior circumflex humeral artery and axillary nerve may be seen at this point, and local anaesthetic is injected deep to...
the deltoid muscle. A volume of 5-7 ml may be sufficient to travel proximally through the quadrilateral space to block the axillary articular supply to the shoulder [25]. The axillary nerve may also be blocked by an infraclavicular approach also aiming to block the subscapular, musculocutaneous, and lateral pectoral nerves and thus achieve complete shoulder analgesia with a low incidence of phrenic nerve palsy.

A combination of the posterior suprascapular block and axillary nerve block has been found non-inferior to interscalene block for postoperative analgesia for shoulder surgery. It could be an efficient alternative for interscalene block with the additional benefit of avoiding phrenic nerve involvement [26].

Subomohyoid Anterior Suprascapular block

Suprascapular block in the supraclavicular fossa is better than the posterior suprascapular approach owing to its proximity to the superior trunk. This helps in accurate visualization of the suprascapular nerve [27]. In the supraclavicular region before the suprascapular nerve travels through the suprascapular notch, the nerve can be identified more proximally and superficially under the omohyoid muscle (which serves as a landmark) [27]. USG-guided, in-plane needle insertion, and local anaesthetic solution injection in 5 ml incremental doses ensure its spread around the neurovascular bundle. A multicentric double-blind noninferiority randomized trial concluded that the Subomohyoid anterior Suprascapular block was non-inferior to interscalene block with respect to improvement of postoperative pain control [28].

Superior Trunk Block

Low volume interscalene block was not effective in reducing the incidence of hemidiaphragmatic paralysis [29]. Reductions in the local anaesthetic dose and volume as well as injections away from the C5, and C6 nerve roots have been in focus for minimizing hemidiaphragmatic paralysis associated with interscalene block [30]. It has been observed that contrary to the misconception of its proximity to the anterior division, the suprascapular nerve is nearer to the posterior division of the superior trunk. This facilitates the spread of a small volume of local anaesthetic deposited proximal to the origin of the suprascapular nerve, to the posterior division of the superior trunk blocking its branches namely, the axillary and subscapular nerves [31]. This results in less spread to the phrenic nerve, inferior trunks of brachial plexus as well as the recurrent laryngeal nerve. So, side effects of ISB like breathing difficulty, hand immobility and hoarseness are reduced [32].

After identifying the cervical roots and scalene muscles with ultrasonography guidance, the probe is moved distally till the suprascapular nerve can be seen branching from the superior trunk. The needle path should avoid the transverse cervical and dorsal scapular arteries which traverse across the brachial plexus and can lie over the superior trunk (Figure 4).

With lateral to medial in-plane needle insertion 10 ml of 0.2% Ropivacaine is injected in the vicinity of SSN. Additional 5 ml is injected anteriorly after directing the needle anterior/superior to the trunk, continuing to be lateral to the trunk [31]. Local anaesthetic injection at the confluence of C5 and C6 ensures adequate blockade of suprascapular nerve, which has a variable origin from the superior trunk. Superior trunk block causes significantly less hemidiaphragmatic paresis and provides noninferior analgesia in comparison to interscalene block for initial 24 hours [32].

Erector Spinae Plane Block (ESPB)

The use of erector spinae plane block (ESPB) for chronic shoulder pain aroused interest to use it for shoulder surgery anaesthesia and analgesia [33].

In a case series of five patients undergoing proximal humerus fixation, cervical ESPB was administered with satisfactory pain relief. The spread of drug injected was studied by contrast-enhanced computed tomography. The contrast spread was seen deep to the erector spinae muscle, medially in the retro-laminar region and in the cervical paravertebral space up to C3, and C4 cervical nerve roots. The contrast in the erector spinae plane was also seen to spread along the dorsal rami in a retrograde fashion. The phrenic nerve was spared in these patients. Postoperative analgesia for shoulder surgeries can be an additional indication of cervical ESPB [34].

In a randomized prospective double-blind study for patients undergoing arthroscopic shoulder surgery, it was found that high thoracic ESPB had superior postoperative pain control for the first 48 hours and the VAS score, opioid consumption and rescue analgesia requirement were significantly less.
compared with a sham block (NS). The ESPB was administered at T2-3 level under USG guidance. In-plane needle insertion was done in the caudal-cranial direction. A single injection of 30 ml local anaesthetic has been observed to be effective up to C3-5. Insertion of 20G epidural catheter along with local anaesthetic infusion has been found to produce excellent analgesia for up to 48 hours [35]. There was no respiratory depression following this high thoracic, high-volume, single-injection ESPB [35]. Cadaveric injection at the level of T1 resulted in the injectate spread in the dorsal rami path between the medial and lateral erector spinae muscle reaching dorsal to ventral rami [36].

Subacromial or Intraarticular Infiltration of Local Anesthesia (SAIA)

Injection of local anaesthetics into the subacromial or intraarticular (SAIA) space has been well described and can be performed by the surgeon at the end of a case in high volumes of 50 ml to 120 ml, with or without a catheter. However, the literature has failed to demonstrate better pain relief than ISB [37, 38]. Although the implications of chondrolysis may be less relevant in arthroplasty, this modality is not recommended given the limited clinical efficacy [37, 39].

Liposomal bupivacaine (LB)

Liposome bupivacaine (LB) is a novel local anaesthetic which uses DepoFoam® as a delivery platform that encapsulates bupivacaine that enables the extended-release of bupivacaine for over 72 hours into surgical sites to extend analgesic effects. In a recent meta-analysis, liposomal bupivacaine was found to be comparable to non-liposomal local anaesthetic agents with respect to pain relief, the opioid-sparing effect, and adverse effects in the first 48 hours after arthroscopic rotator cuff repair and total shoulder arthroplasty [40, 41]. LB costs 10-100 times more than a standard local anaesthetic agent. The literature suggests the use of LB as a field block rather than periarticular use, in the preoperative setting in conjunction with a standard ISB [42].

| Table 1: Summary of available modalities for postoperative pain management after TSA. |
|--------------------------------------|------------------------------------------|------------------------------------------|
| Modality                             | Advantages                               | Limitations                              |
| Continuous catheter Interscalene nerve block | Lower pain scores and lower perioperative opioid requirements, longer pain relief (24-48 hours) | Advanced block, risk of catheter dislodgement and logistic issues. |
| Suprascapular/ Superior trunk        | Diaphragm sparing                         | Need for supplementary axillary Nerve block |
| Erector spinae                       | Diaphragm sparing                         | Advanced block, need more evidence       |
| Liposomal bupivacaine                | Comparable pain relief, the opioid-sparing effect, and less adverse effects in the first 48 hours | High Cost, insufficient evidence. |
| Infiltration of the shoulder with local anaesthetic | No additional benefits compared with single-shot or continuous brachial plexus blocks | No proven efficacy |

Comparative studies

Intraoperative pain management options were compared with each other in a few studies. A study comparing ssISB, ccISB, and SAIA in shoulder arthroplasty patients reported significantly lower pain up to 12 hours and lower narcotic consumption in the ccISB group compared with ssISB alone and SAIA. ISB alone outperformed SAIA [43]. Comparing ssISB, SSNB, and SCB in arthroscopic surgery and ccISB, SSNB, and SCB in arthroplasty resulted in no statistically significant differences in terms of pain scores and oxycodone consumption at 24 hours; however, the authors reported a significantly higher incidence of Horner syndrome, hoarseness, and affected vital capacity in the ISB-only group [44, 45].

Institutional experience

At Deenanath Mangeshkar Hospital, Pune approximately 100-120 total shoulder arthroplasty are performed in a year. We were using ssISB 30 cc of 0.5% Bupivacaine followed by Fentanyl Patch 25 mcg/hr for postoperative analgesia. But we have faced problems of PONV, unilateral diaphragmatic palsy and severe pain after 12 hours. For the last few years, we are using ccISB using 20 ml of 0.5% Levobupivacaine + Dexamethasone 8 mg, followed up by 12 hourly top-up using 10 ml of 0.2% Ropivacaine for the next 48 hours with better pain relief and fewer side effects. With the use of a catheter fixation device, the rate of dislodgement of catheters has been reduced. We are planning to shift towards the use of diaphragm sparing blocks in near future.
Conclusion
Although ISB continues to be the gold standard for postoperative pain relief after TSA, interest in ssISB alternatives is driven by limited duration of analgesia, associated rebound pain and a high incidence of adverse events especially hemidiaphragmatic paraly.

Several options have been evaluated for safer alternatives to ISB, including a combination of suprascapular block and axillary block, Superior trunk block, Erector spinae plane block, Periarticular local anaesthesia infiltration and Liposomal bupivacaine with promising results.

References
Declarations of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his/her consent for his/her images and other clinical information to be reported in the Journal. The patient understands that his/her name and initials will not be published, and due efforts will be made to conceal his/her identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil Source of support: None