Postoperative analgesia for shoulder surgery

ABSTRACT

Both arthroscopic and open surgery of the shoulder are associated with significant postoperative pain. Use of opioids can result in adverse systemic effects, so a multi-modal analgesic approach and complementary analgesic techniques should be considered to minimize the postoperative opioid requirement. Single shot interscalene block provides effective pain control of early and limited duration which can be extended with a catheter. Continuous interscalene block should be considered for more invasive shoulder procedures. However, interscalene block is associated with hemidiaphragmatic paresis which is a substantial risk in patients with serious pulmonary pathology who could otherwise benefit most from a regional technique and the avoidance of opioids. Local infiltration analgesia, and suprascapular nerve block with or without axillary nerve block, have not been consistently shown to be superior to or as effective as interscalene block and there is insufficient evidence to support the use of supraclavicular block over interscalene block.

Surgery of the shoulder is associated with significant postoperative pain which may result in the need for opioid use for several days (Ilfeld et al, 2003; Wilson et al, 2004). Even though minimally invasive arthroscopic techniques can reduce postoperative pain, this is usually only seen after the first few days (Fredrickson et al, 2010a). Open and arthroscopic shoulder surgery therefore have a similar analgesic requirement in the first 24–48 hours. Patients reported higher worst dynamic pain scores after acromioclavicular resection, biceps tenotomy or tenodesis, rotator cuff repair and total shoulder arthroplasty than following revision arthroplasty of the hip and knee in a survey (Lindberg et al, 2013).

Use of opioids as the sole analgesic in shoulder surgery is linked to adverse effects including constipation, nausea and vomiting, pruritus and sleep disturbance (Ilfeld et al, 2003). Opioid requirement can be decreased with a multi-modal analgesic approach, which includes the use of paracetamol, non-steroidal anti-inflammatory drugs and tramadol, but the need for opioids is still significant (Ilfeld et al, 2006; Coghlan et al, 2009). Uncontrolled postoperative pain and acute postoperative opioid use can lead to nociception-induced central sensitization (Kehlet et al, 2006) and opioid-induced secondary hyperalgesia (Angst and Clark, 2006). In view of this, alternative opioid-sparing analgesic approaches such as local infiltration and regional techniques have been explored and evaluated, as discussed in this review.

Nerve innervation of the shoulder

Branches of the brachial plexus, a network of nerves that begins as spinal nerve roots (C5–8), innervate most of the shoulder (*Figure 1*). The anterior aspect of the shoulder joint is innervated by the axillary, lateral pectoral and subscapular nerves, all of which are branches of the posterior (axillary and subscapular nerves) and medial (lateral pectoral nerve) cords of the brachial plexus (Aszmann et al, 1996). Of particular importance is the suprascapular nerve (C5–6) which branches from the superior trunk of the brachial plexus and provides sensory innervation to the posterior and superior 70% of the shoulder joint (along with the axillary nerve), the acromioclavicular joint and to the anterior axilla in about 10% of patients (Neal et al, 2008).

In addition to the shoulder joint itself, adjacent soft tissues structures also receive innervation from the brachial plexus (Gardner, 1948; Aszmann et al, 1996):

- Rotator cuff (suprascapular and subscapular nerves)
- Subacromial bursa (lateral pectoral and suprascapular nerves)
- Subcoracoid bursa (subscapular nerve)
- Coracoclavicular ligament (lateral pectoral nerve)

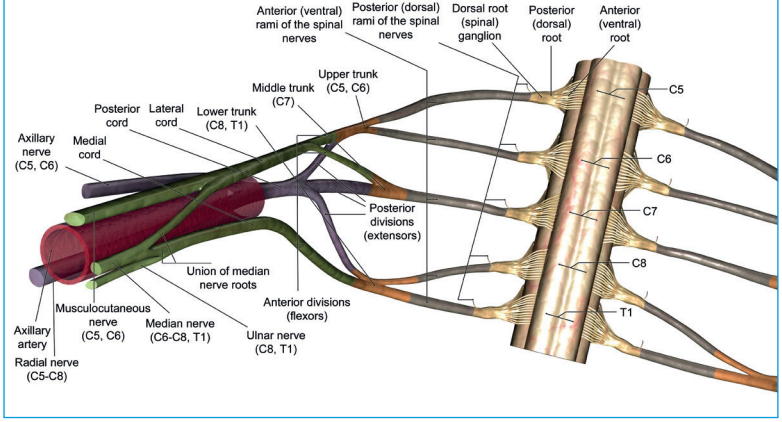

Figure 1. Anterolateral view of the cervical spinal cord and brachial plexus. The brachial plexus is formed from the five ventral rami of C5-8 and T1 spinal nerves. C5 and C6 rami unite to form the superior trunk, the C7 ramus continues as the middle trunk and the C8 and T1 rami unite to form the inferior trunk. Each trunk bifurcates into an anterior (flexor) and posterior (extensor) division. Divisions then reunite into the medial, lateral and posterior cords which give rise to the five terminal branches of the plexus (axillary, median, musculocutaneous, radial and ulnar nerves).

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- Coracoacromial and coracohumeral ligaments (suprascapular nerve).

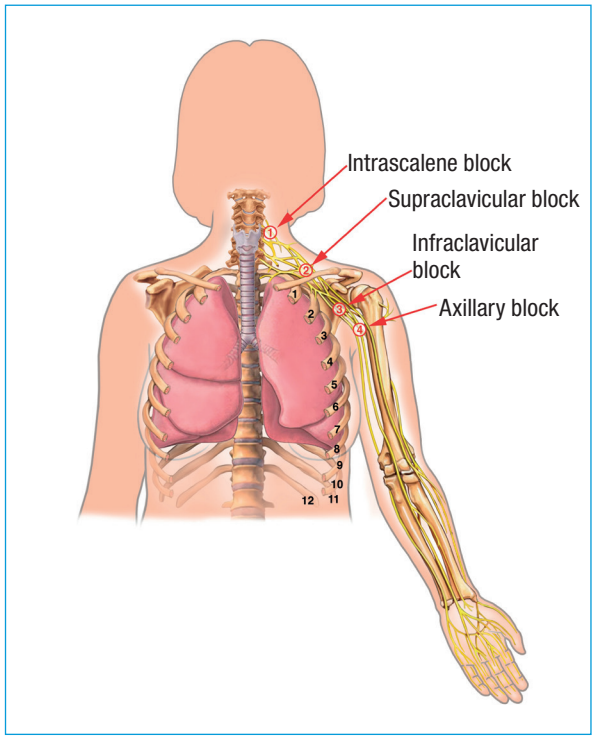
Of note, the cape of the shoulder is not supplied by the brachial plexus but by the supraclavicular nerves, branches of the superficial cervical plexus (C3–4).

Local infiltration analgesia

Local anaesthetic infiltration into the intra-articular or subacromial bursa is usually performed at the end of the shoulder procedure just before wound closure. It can consist of a single injection and/or a continuous infusion.

Earlier studies of continuous subacromial bursa block demonstrated a clinically significant reduction in pain compared to controls but this effect could not be found in later studies of single injection or continuous subacromial bursa block (Fredrickson et al, 2010b). This could be explained by the nature of the surgical procedures included in each study. Simple, arthroscopic and non-rotator cuff procedures tended to be included in the earlier studies while open or rotator cuff procedures were included in the later studies. It appears therefore that at best subacromial bursa block is only effective for arthroscopic and non-rotator cuff procedures. Moreover, concerns have been raised that intra-articular local anaesthetic can be associated with iatrogenic chondrolysis, particularly in the setting of high and prolonged doses of bupivacaine (Bailie and Ellenbecker, 2009).

Figure 2. Different approaches which can be used to block the brachial plexus.



Single shot interscalene block

Single shot interscalene block has been considered the gold standard for analgesia after shoulder surgery (*Figure 2*). It consists of an injection of local anaesthetic at the nerve root level of the brachial plexus to block C5–7 between the anterior and middle scalene muscles. C5 and C6 unite to form the superior trunk and C7 becomes the middle trunk of the brachial plexus. Single shot interscalene block tends to spread and consistently include the non-brachial plexus supraclavicular nerve (Urmey et al, 1996).

Some studies have suggested that single shot interscalene block can provide clinically important analgesia and opioid-sparing effects lasting for 12 hours (Wurm et al, 2003; Nisar et al, 2008) and even 24 hours (Singelyn et al, 2004; Fontana et al, 2009). Subsequent meta-analysis demonstrated the early benefits of single shot interscalene block in shoulder surgery but did not find that the analgesic effects were as prolonged as traditionally described (Abdallah et al, 2015). Pain control was effective for up to 6 hours with motion and 8 hours at rest and an opioid-sparing effect lasted up to 12 hours. Crucially, patients experienced more pain between 16 and 24 hours postoperatively after single shot interscalene block than those without single shot interscalene block. Rebound pain has also been reported after femoral block for knee replacement (Maheshwari et al, 2009) and popliteal block for ankle surgery (Goldstein et al, 2012). It is a concern for clinicians and patients alike and, because of this, patients receiving regional blocks should start taking oral analgesics well before the nerve block wears off.

Single shot interscalene block is not without risk and one of the most common adverse effects is ipsilateral phrenic nerve block as a result of the proximity of the phrenic nerve and its originating cervical nerve roots (C3–5) to the brachial plexus. It has been shown that single shot interscalene block results in a 100% incidence of hemidiaphragmatic paralysis (Urmey et al, 1991) and patients can experience a 25–32% reduction in spirometric measures of pulmonary function (Urmey and McDonald, 1992). Although well tolerated by healthy patients, the risk of hemidiaphragmatic paralysis can contraindicate single shot interscalene block in patients with serious pulmonary pathology who could otherwise benefit most from a regional technique and the avoidance of opioids. Because of this, various other approaches have been studied, such as ultrasound-guided single shot interscalene block with small volumes (5 ml), dilute local anaesthetic concentrations and local anaesthetic injection 4 mm lateral to the sheath of the brachial plexus, all of which reduce the incidence of hemidiaphragmatic paralysis but not to below 20% (Tran et al, 2017).

Single shot interscalene block can result in other complications and these include epidural or subarachnoid injection, Horner's syndrome, intravascular injection, muscle or vascular injury, pneumothorax, recurrent laryngeal nerve block and hypotensive and/or bradycardic events (Neal et al, 2008). Notably, compared with other nerve blocks, single shot interscalene block has been associated with a higher risk of transient (Fredrickson and Kilfoyle, 2009) and long-term neurological complications (Sites et al, 2012).

Continuous interscalene block

In continuous interscalene block, the tip of the catheter is directed towards the C5–6 nerve roots or the superior trunk of the brachial plexus. It can be challenging to perform and insert (Coleman and Chan, 1999), one factor which explains the more gradual uptake of this approach.

Continuous interscalene block provides superior analgesia than single shot interscalene block in multiple subsets of patients, including those undergoing acromioplasty, minor arthroscopic and rotator cuff surgery (Borgeat et al, 1997; Lehtipalo et al, 1999; Fredrickson et al, 2010b). Discharge after arthroscopic shoulder surgery with single shot interscalene block results in 17% of patients reporting severe pain during the first postoperative night (Fredrickson and Stewart, 2008) and continuous interscalene block in this context extends the analgesic benefits of single shot interscalene block. Safe and effective application of continuous interscalene block in the ambulatory environment has been demonstrated (Fredrickson et al, 2008) but management of continuous interscalene block requires careful patient selection, substantial preoperative education and close postoperative supervision.

On the other hand, some have concluded that the complexity and costs of continuous interscalene block may not be justified for intermediate shoulder surgery. In a study which evaluated the analgesic requirements after single shot interscalene block for arthroscopic shoulder surgery, 97% of patients were satisfied with their postoperative oral analgesia despite 15% experiencing severe pain at some time over the first three postoperative days (Trompeter et al, 2010). Routine use of catheters for less invasive shoulder surgery has been described as impractical (Rawal, 2012) and is not welcomed by most shoulder surgeons (Moore et al, 2013). Side effects are similar to those of single shot interscalene block but those which are dose and/or volume related should be less frequent with a lower initial local anaesthetic injection as is often used with continuous interscalene block.

Suprascapular nerve block with or without axillary nerve block

Suprascapular nerve block can offer better postoperative analgesia than intra-articular or subacromial space local anaesthetic infiltration but is not as good as single shot interscalene block (Singelyn et al, 2004). However, suprascapular nerve block can be combined with axillary nerve block to result in lower pain scores until 24 hours and less rebound pain than suprascapular nerve block alone (Lee et al, 2014).

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Price (2007), who can be credited with the idea of combining suprascapular nerve block with axillary nerve block for shoulder surgery, cautioned that axillary nerve block-suprascapular nerve block should be reserved for minor arthroscopic surgery because it does not provide complete coverage of the shoulder joint. Nonetheless, axillary nerve block-suprascapular nerve block was subsequently compared to single shot interscalene block in arthroscopic, mainly rotator cuff, shoulder surgery. Axillary nerve block-suprascapular nerve block was associated with increased pain and opioid requirement in the postanaesthesia care unit and decreased patient satisfaction at 6 hours. However, with axillary nerve block-suprascapular nerve block, analgesic duration was longer and pain scores were lower at 24 hours which could be explained by rebound pain in those who had undergone single shot interscalene block (Pitombo et al, 2013; Dhir et al, 2016).

Compared to single shot interscalene block, motor block associated with axillary nerve block-suprascapular nerve block is less dense and confined to the infraspinatus, teres minor and supraspinatus muscles. It therefore conserves the patient's functional capacity. Axillary nerve block-suprascapular nerve block can result in the same complications as for any peripheral nerve block, pneumothorax in the case of suprascapular nerve block and has a lower incidence of hemidiaphragmatic paralysis than single shot interscalene block.

Superficial cervical plexus block

Superficial cervical plexus block can be achieved by infiltration of local anaesthetic along the posterior border of sternocleidomastoid. Its sole use has been reported for surgery of the clavicle (Choi et al, 2005) and, in view of its limited and cutaneous innervation of the shoulder, it has not been extensively used as an isolated regional technique nor been compared to single shot interscalene block in studies for shoulder surgery. It is thought to be more valuable as an adjunct to other techniques and, in fact, local anaesthetic tends to spread and consistently include the supraclavicular nerve in single shot interscalene block (Urmey et al, 1996).

Supraclavicular block

Supraclavicular block is performed lateral and posterior to the subclavian artery at the level of the trunks and proximal anterior and posterior divisions of the brachial plexus as

KEY POINTS

- Surgery of the shoulder is associated with significant postoperative pain but use of opioids can result in adverse systemic effects.
- A multi-modal analgesic approach and complementary analgesic techniques should be considered to minimize the postoperative opioid requirement.
- Single shot interscalene block provides effective pain control of early and limited duration which can be extended with a catheter.
- Rebound pain can occur after single shot interscalene block, so patients should start taking oral analgesics well before the nerve block wears off.
- Continuous interscalene block should be considered for more invasive shoulder procedures. However, interscalene block is associated with hemidiaphragmatic paresis which is a substantial risk in patients with serious pulmonary pathology who could otherwise benefit most from a regional technique and the avoidance of opioids.
- Local infiltration analgesia, suprascapular nerve block with or without axillary nerve block and supraclavicular nerve block have not been consistently shown to be superior or as effective as interscalene block and there is insufficient evidence to support supraclavicular block over interscalene block.
- Suprascapular nerve block with or without axillary nerve block and supraclavicular nerve block results in a lower incidence of hemidiaphragmatic paresis compared to interscalene block which should be considered when selecting the most appropriate technique.

it courses below the clavicle and above the first rib. It has previously been uncommonly used for shoulder surgery because of concern that the block site is too distal from the cervical nerve roots. After supraclavicular block, however, local anaesthetic has been found to spread cephalad between the anterior and middle scalene muscles and thus it can function as a more caudad approach to single shot interscalene block (Cornish, 2009).

Efficacy of supraclavicular block for arthroscopic shoulder anaesthesia was established by Liu et al (2010) who demonstrated a success rate of 99.4%. Compared to single shot interscalene block, supraclavicular block resulted in comparable pain scores, duration of postoperative analgesia and patient satisfaction but a lower incidence of hemidiaphragmatic paralysis (Kim et al, 2017). More studies are needed to compare supraclavicular block to single shot interscalene block for shoulder surgery. Supraclavicular block is associated with similar adverse effects to single shot interscalene block and the reported rate of pneumothorax has declined as classical approaches have been superseded by ultrasound-guided techniques.

Conclusions

Single shot interscalene block is associated with effective pain control of early and limited duration and can result in subsequent rebound pain. Continuous interscalene block could extend these benefits but the routine use of catheters for less invasive shoulder surgery has not been seen as being practical or realistic. None of the other discussed analgesic techniques have been consistently shown to be superior to or as effective as single shot interscalene block and there is insufficient evidence to support supraclavicular block over single shot interscalene block although results from early studies are encouraging. Single shot interscalene block remains the current criterion standard for shoulder surgery as part of a multimodal approach but continuous interscalene block should be considered for more invasive procedures. Hemidiaphragmatic paralysis can be a concern with these regional techniques, more so with single shot interscalene block and continuous interscalene block than the others, and a more novel approach could comprise a combined infraclavicular approach, to anaesthetize the axillary, lateral pectoral and subscapular nerves in the posterior and lateral cords of the brachial plexus, with suprascapular nerve block. **BJHM**

Conflict of interest: none.

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