

## Pain relief following thoracic surgical procedures: A literature review of the uncommon techniques

### ABSTRACT

Thoracic surgical procedures can be either thoracotomy or thoracoscopy. In thoracotomy, the incision could be either muscle-cutting or muscle-sparing incision. The posterolateral thoracotomy incision is used for most general thoracic surgical procedures. This incision, which involves division of the latissimus dorsi and serratus anterior muscles, affords excellent exposure of the thoracic cavity. However, it is associated with significant morbidity, including impaired pulmonary function, postoperative chest pain, and restricted arm and shoulder movement. Various muscle-sparing incisions have been proposed to decrease the morbidity. Postthoracotomy pain originates from pleural and muscular damage, costovertebral joint disruption, and intercostal nerve damage during surgery. Inadequate pain relief after surgery affects the quality of patient's recovery and exposes the patients to postoperative morbidities. There is a tendency nowadays among thoracic surgeons and anesthesiologists toward the area of enhanced recovery after thoracic surgery which requires careful titration of the anesthetic drugs in awake patients undergoing thoracoscopic procedures. There is a common feeling among thoracic anesthesiologists that postthoracotomy procedures produce less pain intensity versus thoracotomy which is partially true. However, effective management of acute pain following either thoracotomy/thoracoscopy is needed and may prevent these complications and reduce the likelihood of developing chronic pain. In this report, we are going to review the newly introduced postthoracotomy/thoracoscopy pain relief modalities with special reference to the new tendency of awake thoracic surgical procedures and its impact on enhanced recovery after surgery.

**Key words:** Intercostal nerve block; thoracic epidural analgesia; thoracic paravertebral nerve block

### Introduction

Thoracic surgical procedures can be either thoracotomy or thoracoscopy. In thoracotomy, the incision could be either muscle-cutting or muscle-sparing incision. The posterolateral thoracotomy incision is used for most general thoracic surgical procedures. This incision, which involves division of the latissimus dorsi and serratus anterior muscles, affords excellent exposure of the thoracic cavity. However, it is associated with significant morbidity, including impaired pulmonary function, postoperative chest

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anesthetic drugs in awake patients undergoing thoracoscopic procedures. There is a common feeling among thoracic anesthesiologists that postthoracoscopy procedures produce less pain intensity versus thoracotomy which is partially true. However, effective management of acute pain following either thoracotomy/thoracoscopy is needed and may prevent these complications and reduce the likelihood of developing chronic pain. Adequate pain relief leads to early mobilization, improves respiratory functions, and decreases global stress response. Thus, good perioperative pain management significantly reduces postoperative complications. Currently, numerous analgesic methods are available for the management of acute postthoracotomy/thoracoscopy pain including patient controlled analgesia, infiltration with local anesthetic (LA), intrapleural or intercostal nerve blockades, and neuraxial blocks. In this report, we review the newly introduced postthoracotomy/thoracoscopy pain relief modalities with special reference to the new tendency of awake thoracic surgical procedures and its impact on enhanced recovery after surgery.

### Thoracic Paravertebral Nerve Block

Thoracic epidural analgesia (TEA) is usually considered the gold standard technique of choice for postthoracotomy pain relief.<sup>[1]</sup> TEA provided better analgesia than conventional analgesia techniques in postthoracotomy pain.<sup>[2]</sup> However, there are limitations for this method which is not suitable for all patients and is associated with many risks such as dural perforation, spinal cord damage hematoma, infection and abscess, hypotension, and urinary retention. The introduction of ultrasound technology has allowed anesthesiologists to perform many nerve block techniques with great efficiency. Thoracic paravertebral nerve block (PVB) is one of the techniques with proven efficient in postthoracotomy/thoracoscopy procedures. The thoracic paravertebral space in transverse section is triangular in shape. The base is formed by the posterolateral aspect of the vertebral body, intervertebral discs, intervertebral foramina, and articular processes; anterolateral border by the parietal pleura and the posterior border by the superior costotransverse ligament. This space communicates with the intercostal space laterally, and caudally, it extends up to L1 at the origin of psoas muscle. Medially, it communicates with the epidural space through the intervertebral foramen. It contains fatty tissue, thoracic spinal nerves, intercostal vessels, and the sympathetic chain. It produces unilateral analgesia over several thoracic segments and has been shown to provide effective postthoracotomy pain control.<sup>[3]</sup> PVB is as effective as TEA in controlling postthoracotomy pain and associated with less hemodynamic side-effects. Recent evidence from two meta-analyses and systematic reviews comparing the analgesic efficacy and side

effects of epidural versus PVB for thoracotomy pain control concluded that although the analgesia was comparable, PVB had a better short-term side effect profile, including urinary retention, hypotension, nausea and vomiting, and pulmonary complications.<sup>[4,5]</sup> Despite the evidence, previous surveys of clinical practice have consistently demonstrated that thoracic epidural remained the most popular choice. A survey of Australian thoracic anesthetists in 1997 revealed that 79% regarded TEA as the method of choice for analgesia in thoracotomy.<sup>[6]</sup> Similar results were found in the UK with 80% of anesthetists considered TEA as the best mode of pain relief for upper abdominal surgery.<sup>[7]</sup> A 2011 survey of 39 thoracic units in the UK that was carried out by the Association of Cardiothoracic Anesthetists reported that the majority of thoracic anesthetists (2/3 units) prefer TEA to PVB, which suggests that most thoracic anesthetists have yet to be convinced by the evidence available.<sup>[8]</sup> We had carried a survey among Middle Eastern thoracic anesthetists with the aim of describing the current practice of thoracic anesthesia in the region. In terms of postthoracotomy analgesia, the results showed that TEA is favored by the majority of respondents. Fifty-eight percent of respondents reported that they establish the epidural block before induction of general anesthesia. Bupivacaine was reported as the drug of choice for TEA in the majority of cases (89.7%), most commonly with fentanyl as an additive (96.2%). Only 9.1% reported the use of PVB as the preferred analgesic modality.<sup>[9]</sup> In 2005, in a multicenter UK audit of 365 pneumonectomies, PVB was associated with significantly lower major postoperative complications (23% vs. 35%) and lower unexpected Intensive Care Unit admissions (8% vs. 18%) compared with TEA. The benefits seen with PVB can be explained by the blocking of unilateral intercostals nerves only, with preservation of respiratory and sympathetic function on the contralateral side.<sup>[10]</sup> The most recent Cochrane Review comparing PVB and TEA in adults undergoing thoracotomy found no difference between PVB and TEA in 30-day mortality following surgery. PVB was associated with a lower incidence of pneumonia and delirium when compared with TEA. No significant difference between PVB and TEA was found in critical care admission and there were insufficient data to compare the two techniques in terms of cardiovascular complications or the need for further surgery. In terms of analgesic efficacy, PVB was comparable to TEA and was found to be superior at 24 h postoperatively. PVB also had a better minor complication profile with lower incidence of hypotension, nausea and vomiting, pruritus, and urinary retention. No difference between PVB and TEA was found in excessive sedation and length of hospital stay. There were insufficient data to compare PVB and TEA in terms of assessing chronic postthoracotomy pain (CPTP) and health costs. The review also concluded that a well-conducted randomized controlled trial comparing PVB and TEA in

thoracotomy is needed. Areas that require further research include 30-day mortality, major complications, chronic pain, and health costs.<sup>[11]</sup> The limitations of TEA can be overcome easily by simple measures such as maintaining preload and using the synergistic effects of LA and opioids. A major added advantage of TEA is its effectiveness in reducing (CPTP), a critical endpoint for thoracotomy patients. TEA therefore remains superior for postthoracotomy pain control as compared with PVB. Ultimately, the choice of technique will be patient and clinician dependent.<sup>[12]</sup> In another report, the authors were pro PVB versus TEA. They concluded that TEA was not superior to PVB for open thoracic operations. Although both techniques provided adequate analgesia in open thoracic procedures the decreased incidence of untoward consequences encountered with the nonneuraxial technique elevate its place in providing overall improved patient care. Also given that the use of newer more potent anticoagulants for thromboprophylaxis has increased the PVB offers lower risk of potentially devastating hemorrhagic complications such as spinal hematoma as compared to TEA. Thus, not only is the thoracic PVB noninferior to similar level epidural analgesia, but also the bulk of evidence supports the opposite view-thoracic PVB seems to be superior to TEA for open thoracic procedures.<sup>[13]</sup> Recently, most of thoracic surgical procedures are performed thoracoscopically which led TEA to be used less frequently or even not to be used in such cases because due to lack of genuine indication. Thoracoscopy has brought the use of PVB to the surface again and now it's widely used in thoracoscopic operations. In one study on pain relief following video-assisted thoracoscopy (VATS), the systematic review of PubMed, the Cochrane Library, and Embase databases yielded 1542 unique abstracts; 17 articles were included for qualitative assessment, of which three were studies on VATS lobectomy. The analgesic techniques included TEA, multilevel and single PVB, paravertebral catheter, intercostal catheter, interpleural infusion, and long thoracic nerve block. Overall, the studies were heterogeneous with small numbers of participants. In comparative studies, TEA and especially PVB showed some effect on pain scores but were often compared with an inferior analgesic treatment. Other techniques showed no unequivocal results. No clear gold standard for regional analgesia for VATS could be demonstrated, but a guide of factors to include in future studies on regional analgesia for VATS was presented.<sup>[14]</sup>

### Intrapleural Analgesia

One of the advantages of VATS procedures compared with thoracotomy is a reduction in postoperative pain. However, VATS, in particularly VATS lobectomy, is still associated with moderate acute postoperative pain. With the increasing

popularity of the procedure, there is a growing demand from both anesthesiologists and surgeons for an evidence-based approach to pain management for VATS. In our practice, we use intrapleural analgesia (IPA) with bupivacaine combined with oral non steroid anti-inflammatory drugs to control postthoracoscopy pain namely in thoracoscopic sympathectomy. In our setting, the first report published on the use of intrapleural catheter was for a case in which long-lasting relief of upper abdominal cancer pain was achieved by injections of LA through the interpleural approach. This technique may be a good alternative to coeliac plexus block in selected cases. Furthermore, if pain relief in such a case proves to be only transient, injections of dilute phenol might provide permanent relief.<sup>[15]</sup> Also successfully in an old clinical study in open cholecystectomy, we have used LPA for postoperative pain management.<sup>[16]</sup> Earlier on in our center we have conducted a randomized controlled trial on pain relief following thoracoscopic sympathectomy for palmar hyperhidrosis and we concluded that the combination of IPA with bupivacaine and I.M ketoprofen provided superior analgesia when compared to each modality alone.<sup>[17]</sup> Nowadays, there is renewed interest in using IPA in VATS for pain management. In one study, it was found that IPA using ropivacaine, compared to conventional analgesia, reduced pain in the late postoperative period of patients underwent thoracic sympathectomy, and when used in its higher concentration, it produced better global analgesic results and less alteration in ventilatory mechanics, thus producing a better respiratory outcome.<sup>[18,19]</sup> It is well known that VATS has reduced the invasiveness of a considerable number of thoracic operations although optimal postoperative thoracic analgesia remains an open issue. Among commonly used methods, continuous intravenous infusion of analgesics, including opioids and nonsteroidal anti-inflammatory drugs, has shown promise but is not always satisfactory and can have some adverse effects. A new technique of continuous intercostal-intrapleural analgesia (CIIA) in VATS lung resections was described, which is based on a double-catheter pain relief system with encouraging results. The authors concluded that in patients having thoracoscopic lung resection, CIIA proved easy, safe, and effective in ensuring adequate thoracic analgesia. Moreover, comparison with continuous intercostal analgesia results revealed that CIIA proved somewhat better in terms of VAS, interleukin-6 production at 24 h, nursing-care calls at 48 h, and duration of hospitalization.<sup>[20]</sup>

### Serratus Anterior Plane Block

The serratus anterior plane (SAP) block is a recently described regional block, designed to block the thoracic intercostal nerves along with the thoracodorsal and the long thoracic

nerves.<sup>[12]</sup> It aims to provide analgesia to the anterolateral and part of the posterior side of the chest wall as an alternative to epidural and paravertebral blocks. SAP block was described in healthy volunteers without clinical validation. The sensory paresthesia was described in dermatomes from T2 to T9. In this block, the injectate is administered either superficial or deep to the serratus anterior muscle, and the difference is only the duration of the block. Duration of the block was found to be doubled if the LA solution was injected superficial to the SA muscle. Serratus plane block is a variation of Pecs-2; only the needle is placed in more caudally and posteriorly compared to Pecs-2 block.<sup>[21]</sup> The needle is advanced “in plane” from caudal to cranial approach at the level of mid-axillary line. Ultrasound-guided SAP block is a novel interfacial plane block technique that may be considered the transversus abdominis plane block of the chest wall. The lateral cutaneous branches of the intercostal nerves are blocked as they pass through, before dividing into anterior and posterior branches to supply sensation to most of the chest wall. The first description of SAP block demonstrated its effectiveness in blocking the lateral branches of intercostal nerves T2 to T9 in healthy volunteers. It produced a prolonged block (750–840 min) with a dose of 0.4 mL/kg of 0.125% levobupivacaine. Blanco *et al.* proposed a reliable and widespread block while the LA solution is injected into a plane with relatively low vascularity and consequently less absorption and decreased LA toxicity.<sup>[22]</sup> The block might miss the posterior primary rami (posteriorly), the anterior cutaneous branches of the intercostal nerve (close to the sternum), and the supraclavicular nerves (immediately below the clavicle). In addition, autonomic block that accompanies paravertebral and epidural blocks is not present in SAP block, which is why it was associated with the hemodynamic stability that was demonstrated in the study presented here.<sup>[23]</sup> SAP block currently is the subject of a number of future clinical trials in thoracic surgery that have not been published yet. In one study, it was concluded that SAP block appeared to be a good safe for and maintained hemodynamic stability compared with TEA and provided low pain scores and less total morphine consumption in the early postoperative period after thoracotomy without noteworthy complications.<sup>[24]</sup> SAP block produces analgesia of the hemi-thorax. A few clinical reports are available about its efficacy for postoperative analgesia.

### Intercostal Nerve Block

The intercostal nerves arise from the ventral rami of the thoracic spinal nerve. They are mixed nerves containing both sensory and motor fibers. The collateral branch of the intercostal nerve runs along the upper border of the rib below. It gives motor innervations to the intercostal muscles,

latissimus dorsi, serratus anterior and abdominal wall muscles and sensory innervations to the pleura, peritoneum, anterior and lateral chest and abdominal walls. Intercostal block produces stretch of band-like anesthesia along the chosen plane.<sup>[25]</sup> A high-frequency linear array transducer is used. The ribs are identified by their curved hyper-echogenic surface outline and the acoustic shadow underneath them in a parasagittal view (between adjacent ribs, the intercostal muscles and pleura is identified (hyperechoic line in gliding motion during respiration). Initial scanning is performed in the transverse plane of the rib to identify the level. The level of the block is marked by counting the ribs from above downward starting from the 2<sup>nd</sup> rib or in opposite direction starting from the 12<sup>th</sup> rib. Another landmark used is T7 at the level of tip of scapula.<sup>[26]</sup> The ideal point to block the nerve is at the angle of the rib (6–7 cm lateral to the spinous process) before the nerves branches out. The neurovascular bundle lies between the internal intercostal and the innermost intercostal muscles. In-plane or out-of-plane approach can be used. It is very important to identify the plane by hydro-dissection at every level to prevent damage to the pleura or the vascular bundle lying in proximity to the nerve. It is prudent to check for pneumothorax by seeing the gliding movement of the pleura and the comet tail appearance underneath (they both disappear in case of pneumothorax. Once the correct plane is reached, 3–5 mL of LA solution should be injected after careful aspiration.<sup>[26,27]</sup> The needle is introduced usually from the superior border of the rib below. It is used for providing surgical anesthesia for thoracic and upper abdominal procedures and analgesia in case of chest trauma, flail chest, and intercostal drain placement. This block is also given for chronic pain management in cases of postherpetic neuralgia.<sup>[28-30]</sup> Continuous intercostal nerve block (IB) was shown to provide adequate pain control following thoracotomy, but requires continuous infusion of the LA through indwelling catheter introduced percutaneously and guided by the surgeon to a subpleural tunnel just before closing the chest. It requires intact parietal pleura, can be somewhat cumbersome to insert, and offers potential opportunity for introducing infection. A recent randomized controlled study suggested that subpleural continuous IB may be less effective than TEA.<sup>[31]</sup> IB administered percutaneously at the start of the procedure or injected by the thoracic surgeon under direct vision from within the pleural cavity before thoracotomy closure have been shown effective in providing better pain relief and better preservation of pulmonary function than narcotics alone.<sup>[32]</sup> The recent introduction of extended release bupivacaine liposome (Exparel, Pacira Pharmaceuticals Inc., Parsippany, NJ, USA) provided prolonged duration of action up to 72 h which provided renewed interest in the role of single-shot, intraoperative IB administered by the thoracic surgeon for the prolonged relief of postthoracotomy pain.<sup>[33]</sup>

In conclusion, we believe that TEA will remain the gold standard for thoracotomy. PVB is growing and gradually has become a standard practice for managing potthoracoscopy procedures; however, it needs skillful anesthesiologists dealing with ultrasound sonoanatomy. The same will apply on the use of SAP block. IB seems easy to perform but still infrequently practiced. We hope by time there will be growing tendency on the use of those uncommon nerve blocks in thoracoscopy procedures with special reference to the new era of awake thoracic surgery and enhanced recovery protocols.

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### Conflicts of interest

There are no conflicts of interest.

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