Update on the role of paravertebral blocks for thoracic surgery: are they worth it?

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Current Opinion in Anaesthesiology 2009, 22:38–43

Purpose of review
To consider optimal analgesic strategies for thoracic surgical patients.

Recent findings
Recent studies have consistently suggested analgesic equivalence between paravertebral and thoracic epidural analgesia. Complications appear to be significantly less common with paravertebral analgesia.

Summary
There is good evidence that paravertebral block can provide acceptable pain relief compared with thoracic epidural analgesia for thoracotomy. Important side-effects such as hypotension, urinary retention, nausea, and vomiting appear to be less frequent with paravertebral block than with thoracic epidural analgesia. Paravertebral block is associated with better pulmonary function and fewer pulmonary complications than thoracic epidural analgesia. Importantly, contraindications to thoracic epidural analgesia do not preclude paravertebral block, which can also be safely performed in anesthetized patients without an apparent increased risk of neurological injury. The place of paravertebral block in video-assisted thoracoscopic surgery is less clear.

Keywords
complications, paravertebral block, postoperative pain, thoracic epidural, thoracotomy, video-assisted thoracoscopic surgery

Curr Opin Anaesthesiol 22:38–43

0952-7907

Introduction

Respiratory complications are amongst the most common and serious problems after thoracic surgery [1]. The patients' underlying lung disease, surgical trauma, the subsequent inflammatory response and fluid shifts, and postoperative pain lead to impaired sputum clearance and ventilatory capacity [2,3]. Thoracic surgery is associated with a 30% reduction in functional residual capacity and 50% reduction in vital capacity, for which uncontrolled postoperative pain is a major contributor [4,5]. A sizeable proportion of thoracic surgical patients, including those undergoing video-assisted thoracoscopic surgery (VATS), have ongoing chronic pain for months or years after surgery [6–8].

Acute pain and the subsequent impaired respiratory function demand effective pain relief, for which 'opioid-sparing' multimodal techniques have become a recommended approach for thoracic and other major surgeries [9]. Opioids are central nervous system depressants that can also cause respiratory depression. Thoracic epidural analgesia (TEA) provides near-complete pain relief but is associated with hypotension and, in some cases, muscle weakness. Epidural abscess or hematoma are rare but serious complications of TEA and can lead to paraplegia [10]. For these reasons there has been increased interest in the use of paravertebral block (PVB) for thoracotomy, VATS, and other unilateral chest wall and abdominal surgeries. The intercostal nerves are relatively devoid of covering fascia as they traverse the paravertebral space, making it an ideal location for local anesthetic blockade [11].

The traditional PVB technique is via a posterior approach using loss of resistance as the superior costotransverse ligament is traversed [12]. Recent modifications to this technique include use of a nerve stimulator [13,14] and ultrasound [14]. Alternatively, catheters can be placed in the paravertebral space intraoperatively under direct vision by the surgeon [15] or anesthesiologists prior to chest closure [16].

Figure 1 shows the author placing a PVB between the T4 and T5 transverse processes for a young patient undergoing a VATS pleurodesis. Note the position of the index fingers to control depth of needle insertion beyond the transverse process. Figure 2 is a thoracoscopic image of the paravertebral gutter following injection of 20 ml of local anesthetic solution stained with methylene blue.

Figure 1 A paravertebral block being placed between the T4 and T5 transverse processes for a young patient undergoing a video-assisted thoracoscopic surgery pleurodesis

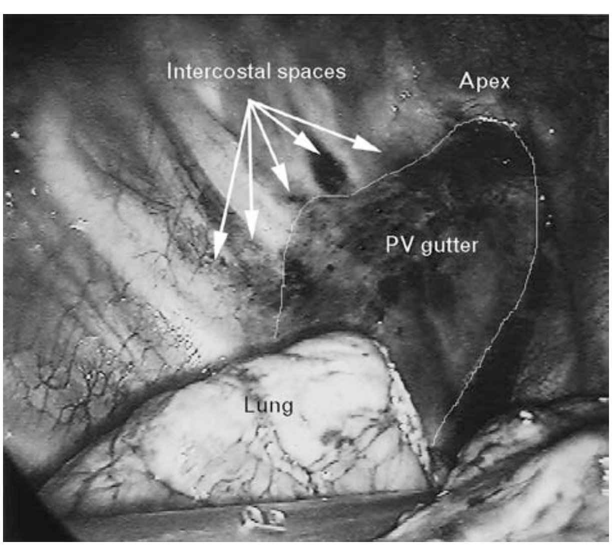
Note the position of the index fingers to control depth of needle insertion beyond the transverse process.

The catheter was inserted 5 cm into the paravertebral space. Note the spread of solution to the apex of the lung and tracking along the intercostal spaces.

Does paravertebral block provide comparable analgesia to thoracic epidural analgesia after thoracotomy?

The gold standard analgesic technique for thoracotomy is generally regarded to be TEA with a local anesthetic and opioid combination [4,17–19]. Even so, the optimal drug and concentration for TEA has not been established, and to date there is a paucity of high-quality trial data comparing TEA with PVB when used in combination with other adjunctive analgesic techniques.

Figure 2 A thoracoscopic image of the paravertebral gutter following injection of 20 ml of local anesthetic solution stained with methylene blue



The catheter was inserted 5 cm into the paravertebral space. Note the spread of solution to the apex of the lung and tracking along the intercostal spaces.

A recent review [20••] evaluated the risks and benefits of TEA compared with PVB for patients undergoing thoracotomy. The authors of the review concluded that unless TEA is proven to reduce the incidence of chronic pain significantly more than PVB, then the balance of evidence suggests that PVB should replace TEA for thoracotomy patients.

The nociceptive pathways involved in pain following thoracic surgery are complex and incompletely understood. Chest wall pain is caused by retraction, resection, rib fracture, costovertebral joint disruption, and intercostal nerve damage. Intercostal nerve damage appears to be caused by rib retraction, trocar insertion, and suture placement. The afferent input from these structures, as well as most of the parietal pleura, is via the intercostal nerves. Afferent pain signals from the diaphragmatic pleura travel in the phrenic nerve. Afferent phrenic nerve nociceptive signals are most probably the cause of ipsilateral shoulder pain seen after thoracotomy. The incidence of shoulder pain can be reduced by infiltration of lidocaine into the fat pad surrounding the phrenic nerve at the diaphragm but not by TEA or PVB [21]. Afferent nociceptive signals from the lung, mediastinal pleura, and pericardium travel with the vagus nerve. At this time we do not understand the role of the sympathetic afferents and efferents in pain transmission after thoracic surgery.

A systematic review and meta-analysis [22] established analgesic equivalence between TEA and PVB with respect to visual analog scale (VAS) pain scores and morphine consumption. This meta-analysis included only 520 patients, with each trial rated according to its quality of bias minimization according to the Jadad score [23]: 0 (high bias) to 5 (low bias). Four of the trials had a Jadad score of 3, whereas the remaining six trials had a Jadad score of 2, with the commonest issue being a lack of blinding. About half of the studies did not include an opioid with the local anesthetic in the TEA group. Thoracic anesthesiologists committed to major regional block for thoracotomy must decide whether to offer their patients TEA with local anesthetic/opioid solution, or PVB with local anesthesia alone or in combination with opioid, and with or without adjunctive analgesics such as nonsteroidal anti-inflammatory drugs and acetaminophen. Because of the small number of patients who received local anesthesia/opioid epidural infusions in the above meta-analysis it is difficult to generalize the results to routine clinical practice. It may be that if all epidural patients had received a 'gold standard' epidural block (i.e. local anesthetic/opioid) then TEA could have provided superior analgesia.

Closer inspection of two of the included trials [24,25] in the meta-analysis reported an incidence of failed PVB of 0/17 and 0/46, and failed epidural block of 2/19 and 5/54. In these two studies morphine requirements (rescue analgesia) were high in both groups – over 80 mg at 48 h – indicating that additional analgesia is required for many thoracic surgical patients.

All nerve block techniques can fail to provide adequate postoperative analgesia from time to time. The commonest causes of analgesia failure with TEA and PVB are failure to place the catheter in the correct anatomical location and nocioceptive pathways that are not captured by the block technique employed. In the case of PVB it is often difficult to feed the catheter into the paravertebral space despite successful needle placement within the space. PVB can also fail if the catheter is placed within the paravertebral space ventral to the endothoracic fascia.

Recently Casati *et al.* [26] reported on a small clinical trial ($n = 42$) comparing thoracotomy patients having either TEA or PVB with a continuous infusion of 0.2% ropivacaine; however, no patients received co-administration of epidural opioid. They found no significant differences in pain scores at rest ($P = 0.56$) or following cough ($P = 0.29$), and so they concluded that PVB was as effective as TEA in controlling postthoracotomy pain.

Modifying features: the risks and benefits

The choice of analgesic technique is not based only on the relative efficacy of each technique. Clinicians must balance many issues in providing optimal postoperative analgesia. Simplicity, speed of onset, safety, durability, access to an acute pain service, and side-effect profile are each important when confronted with a long list of thoracic surgical procedures in an operating session. Proponents of PVB argue that the incidence of paraplegia after TEA and the greatly reduced occurrence of hypotension, urinary retention, pruritus, postoperative nausea and vomiting (PONV), and respiratory complications with PVB favor PVB as the regional analgesia technique of choice for thoracic surgery.

Although not a primary consideration, PVB is associated with greater flexibility during a busy thoracic list. TEA is generally performed in the patient who is awake prior to surgery to ensure maximum safety. PVB can be performed either before or after induction of anesthesia and before, during, or after surgery. The ability to change analgesia plan during the surgical procedure has great utility in thoracic surgery in which bleeding or inadequate exposure might necessitate the surgeon performing thoracotomy when VATS was originally planned.

Contraindications

Some of the absolute contraindications to TEA are not such a problem with PVB. Many patients present to hospital taking antiplatelet agents such as the thienopyridines (clopidogrel, ticlopidine) and/or aspirin. Often such patients may have undergone a percutaneous coronary intervention; premature discontinuation of dual antiplatelet therapy markedly increases the risk of catastrophic stent thrombosis and death or myocardial infarction [27]. Current guidelines advise that dual antiplatelet agents should not be stopped within 30–45 days of bare-metal stent deployment and within 1 year of drug-eluting stent deployment [28]. The margin of safety in such situations is much higher with PVB than TEA. Furthermore, the surgeon, using direct vision during thoracotomy, can place a PVB catheter. In the postoperative period the requirement for thromboprophylaxis and the potential for accumulation of low-molecular-weight heparins in patients with preexisting or perioperative renal impairment can introduce significant risk at the time of removal of an epidural catheter. Well resourced acute pain management teams are required to coordinate the removal of epidural catheters at times of lowest risk. Nonetheless a substantial proportion of epidural catheters are inadvertently removed at times that are less than optimal in the setting of postoperative or posttrauma thromboprophylaxis.

Complications

Side-effects of TEA are common and well known to all anesthesiologists, and are usually considered significant by patients. Two serious complications of epidural analgesia, epidural abscess and epidural hematoma, may result in devastating neurological complications.

A recent review of neurological complications after regional anesthesia has estimated a rate of permanent neurological injury after epidural anesthesia to be 0–7.6 : 10 000 [29••]. Horlocker and Wedel [30] have estimated that the incidence of epidural hematoma after epidural analgesia in association with the use of low-molecular-weight heparin is between 1 : 1000 and 1 : 10 000. Wang *et al.* [10] have focused on epidural abscess and found an incidence of 1 : 1930 in a study population of 17 342. Of relevance to a thoracic surgical population the majority of the patients with epidural abscess were immunocompromised by one or more complicating disease. Many thoracic surgery patients are elderly and have significant comorbidities associated with impaired immune function.

Estimates of the incidence of these catastrophic complications vary widely; not so many years ago anesthesiologists considered the risk of serious bleeding after epidural analgesia to be in the order of 1 : 200 000 [30]. It is

Table 1 Summary of findings from a systematic review and meta-analysis of trials comparing paravertebral block with epidural analgesia on side-effects associated with analgesic therapy

Outcome	OR (fixed) 95% CI
Pulmonary complications	0.36 (0.14–0.92)
Urinary retention	0.23 (0.10–0.51)
Nausea or vomiting	0.47 (0.24–0.93)
Hypotension	0.12 (0.04–0.34)

All odds ratios (OR) favor paravertebral block (PVB) ($P < 0.05$). CI, confidence interval. Data from [22].

uncertain whether earlier estimates were simply too optimistic, or perhaps we have moved into an anticoagulant-driven era of epidural complications.

Anesthesiologists must allow their clinical approach to evolve in response to changing issues in our patient populations. Antiplatelet agents and anticoagulants used for thromboprophylaxis are a serious issue perhaps demanding a paradigm shift in anesthesia practice. Should we move away from centrally acting blocks in favor of peripheral blocks? Persistence with central blocks will have consequences for our patients: stopping or reducing antiplatelet agents preoperatively will have a cost in terms of perioperative cardiac morbidity; suboptimal postoperative thromboprophylaxis will result in increased morbidity from pulmonary embolism. If a peripheral block is feasible and has reasonable efficacy then perhaps this is in the patient's best interest?

Primum non-nocere?

The meta-analysis of Davies *et al.* [22] reported a better side-effect profile and reduction in pulmonary complications in patients with PVB compared with TEA (Table 1).

The odds of hypotension occurring during TEA are almost 10 times greater than during PVB. Routine monitoring of patients with TEA is more complex and time consuming than the monitoring required for PVB. Hypotensive patients often receive excessive intravenous fluids and it is possible that this contributes to problems with postoperative respiratory function and acute lung injury.

Respiratory function was improved at both 24 and 48 h with PVB but only significantly improved at 24 h, weighted mean difference (WMD) 6% [3,9], 8% (−1, 17), respectively. There was no significant difference in duration of hospital stay.

Video-assisted thoracoscopic surgery: is single-shot paravertebral block worthwhile?

VATS has become increasingly popular over the past 20 years with the advent of high-quality fiberoptic imaging systems and improved surgical instruments. Early published data suggest that when compared with open thoracotomy, patients undergoing VATS experience a shorter postoperative hospital stay, lower opioid requirements, and reduced shoulder dysfunction [31]. Patients undergoing VATS for lobectomy report less postoperative pain, decreased time to return to usual activities, and higher satisfaction with surgery than patients having thoracotomy [32]. As a result many thoracic anesthesiologists have considered that TEA is probably not warranted for less invasive VATS cases. Sometimes, the extent of surgery is unclear until histopathology results are obtained or a VATS procedure is complicated by bleeding or poor surgical exposure and so an open thoracotomy is performed. In these circumstances a paravertebral catheter can be placed surgically or percutaneously at the end of surgery without the concerns that exist regarding epidural block under anesthesia.

Postoperative pain after VATS, however, is significant, especially early after surgery [33,34]. Surprisingly, VATS is associated with an incidence of chronic pain similar to that of thoracotomy, with rates of pain ranging from 22 [6] to 63% [7]. Chronic pain is thought to relate to intercostal nerve and muscle damage with trocar insertion.

Vogt *et al.* [33] reported on a double-blind randomized trial in 40 patients investigating the benefits of a single-shot PVB using 0.375% bupivacaine with epinephrine. They found a significant difference in VAS scores both at rest and with coughing that persisted for 48 h. Of interest, they found no difference in patient-controlled analgesia (PCA) morphine administration at 30 min, 3 h, and 48 h postoperatively. This study was accompanied by an editorial [35] discussing the concept of preemptive analgesia with PVB, noting that the postoperative analgesic effect substantially outlasted the expected duration of action of the local anesthetic solution used.

In contrast, Hill *et al.* [36] published a double-blind randomized trial ($n = 80$) of preoperative multilevel single-dose PVB with 0.5% bupivacaine/epinephrine. They found that patients undergoing PVB had a 31% reduction in cumulative PCA morphine ($P = 0.03$) in the 6 h after block placement, as well as lower pain scores ($P = 0.02$); however, a longer lasting benefit group was not seen.

Kaya *et al.* [37] reported the findings of a double-blinded randomized trial in 47 patients, and found that preoperative multilevel single-dose PVB with 0.5% bupivacaine/epinephrine led to lower pain scores at 1, 2, and 4 h after surgery ($P < 0.05$). There were no significant differences in pain scores thereafter out to 48 h. Cumulative PCA morphine requirements were significantly lower in the PVB group throughout the study period ($P < 0.01$), except at the 12 h datum point ($P < 0.05$).

Table 2 Key differences in the studies of Hill *et al.* and Kaya *et al.* that might account for the observed outcomes

	Hill *et al.* [36]	Kaya *et al.* [37]
Study location	Boston	Turkey
Female patients	31/80 (39%)	9/47 (19%)
Surgical time (mean)	144 min	60 min
Morphine PCA dose	20 μg/kg	30 μg/kg
PCA lock-out	8 min	10 min
NSAID administration	Ketorolac 75 mg/24 h	None

NSAID, nonsteroidal anti-inflammatory drug; PCA, patient-controlled analgesia. Data from [36,37].

It is interesting to speculate as to why the patients in Kaya *et al.*'s study demonstrated a reduced morphine usage out to 48 h and those in the study of Hill *et al.* did not. There appear to be key differences in the demographic characteristics of the two trials (Table 2). Female and male patients are known to differ in their responses to pain and opioids [38]. Intercostal nerve injury is likely to be more severe with increased compression time by VATS ports. The increased operative time seen in the study by Hill *et al.* might reflect more extensive VATS procedures with a greater number of port insertions (affecting more intercostal nerves) and an access incision for insertion of surgical instruments [39]. VATS lung resection could imply a greater degree of vagally mediated pain. There may also be cultural differences in patient responses to postoperative pain and PCA usage. Non-steroidal anti-inflammatory drugs (NSAIDs) are effective in treatment of pain following thoracotomy and VATS. The component of pain that is believed to be transmitted via the phrenic nerve is typically poorly treated with TEA, PVB, and opioids [21]. NSAIDs have demonstrated efficacy in treating this component of postoperative pain.

The take-home message seems to be that single-shot multilevel PVB has a place in simple VATS procedures. Longer and more complex procedures are well suited to PVB catheter insertion and infusion of local anesthetic. Slow release, encapsulated local anesthetics might prove to be a useful alternative to PVB infusion in this patient group [40].

Conclusion

Over the past decade enthusiasm for PVB in patients undergoing thoracic surgery has increased. There is good evidence that PVB can provide acceptable pain relief compared with that provided by TEA for thoracotomy [22,26].

Important side-effects such as hypotension, urinary retention, nausea and vomiting are less frequent with PVB than with TEA. PVB is associated with better pulmonary function and fewer pulmonary complications than TEA. Importantly, contraindications to TEA do not preclude PVB, which can also be safely performed in anesthetized patients without an apparent increased risk of neurological injury. The place of PVB in VATS surgery is less clear. There are clear analgesic benefits seen in the first few hours after VATS, but whether there is an important preemptive analgesia component that can reduce long-term adverse pain outcomes remains controversial. This is an appealing area for a well planned large, prospective randomized trial.

Acknowledgement

Professor Myles is supported by an Australian National Health and Medical Research Council Practitioner Fellowship.

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Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 131–132).

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