Postthoracotomy Paravertebral Analgesia: Will It Replace Epidural Analgesia?

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The pain associated with thoracic surgery is notable for both its severity and its duration. Thoracic epidural analgesia has long been considered the reference standard for management of postthoracotomy pain. Paravertebral block, which was first performed in 1905 to produce abdominal analgesia [1], is an alternative technique. The classic approach uses loss of resistance to air or saline as the superior costotransverse ligament is traversed [2]. Injection of local anesthetic into the paravertebral space (Fig. 1), by blocking the intercostal nerve, its dorsal ramus, the rami communicantes, and the sympathetic chain, produces a dense sensory and sympathetic block (see Fig. 1) [2].

Although there is universal agreement that for patients undergoing thoracotomy a combined regional and general anesthesia technique confers greater benefits than general anesthesia alone, there recently has been much debate about whether thoracic epidural or paravertebral anesthesia is the best regional technique. When reflecting on the question “Postthoracotomy paravertebral analgesia: will it replace epidural analgesia?,” consideration must be given to the limitations of available evidence. There are no double-blind clinical trials comparing paravertebral and epidural techniques. Indeed, there are no large randomized trials comparing the two techniques, and a recent meta-analysis of 10 studies included a total of only 520 patients [3].

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Within the restrictions of the available evidence, comparison of the two techniques from the point of view of analgesic efficacy, complications, side effects, contraindications, and development of chronic pain will help elucidate the issue.

**Analgesic efficacy**

The nociceptive pathways responsible for postthoracotomy pain remain poorly understood, but the intercostal, phrenic, and vagus nerves have been implicated [4]. Afferent input from the structures of the chest wall and most of the pleura is via the intercostal nerves; input from the diaphragmatic pleura is via the phrenic nerve; and input from the lung and mediastinum (including the mediastinal pleura) is via the vagus nerve [5]. Intercostal nerve stimulation results from a combination of surgical incision, rib retraction, trocar insertion, and suture placement [6]. Phrenic nerve stimulation is believed to be the source of the shoulder tip pain that frequently occurs after thoracic surgery and that is not blocked despite effective thoracic epidural analgesia. This mechanism was demonstrated in a randomized, controlled trial of 48 patients, which showed an incidence of shoulder pain after lung resection of 33% when 10 mL of 1% lidocaine was infiltrated into the periphrenic fat pad at the level of the diaphragm and an incidence of 85% after infiltration of 10 mL of 0.9% saline ($P < .008$) [7].

When comparing postthoracotomy paravertebral analgesia and epidural analgesia, a primary consideration is analgesic efficacy. Adequate pain control in the immediate postoperative period is important for patient satisfaction and also reducing postoperative pulmonary complications. Poorly

Fig. 1. Cervical vertebra. The drawing illustrates the paravertebral space with a spinal nerve coursing through it.
controlled pain can result in inadequate coughing and secretion clearance with atelectasis and progression to pneumonia and is considered an independent risk factor for postthoracotomy morbidity and mortality [8]. Unrelieved acute pain also may contribute to the development of postthoracotomy pain syndrome [9]. Multiple studies have examined paravertebral blockade with patient-controlled analgesia, demonstrating improved analgesia for variable periods of time postoperatively [10]. It perhaps is more important, however, to examine paravertebral and epidural analgesia after thoracic surgery. A recently published systematic review and meta-analysis of randomized trials directly compares the analgesic efficacy of paravertebral versus epidural blockade for thoracotomy [3]. All the included studies used a paravertebral catheter technique. Ten studies published between 1989 and 2005 and including 520 adult patients who underwent thoracotomy were included in the meta-analysis. The included studies were noted to be of moderate quality, mainly because none were blinded. The variables compared between studies included pain scores at 4 to 8 hours, 24 hours, and 48 hours; mean dose of opioids at 24 and 48 hours; and number of patients requiring supplemental analgesia. There was no significant difference in pain scores between the paravertebral block and epidural groups at any of the three time-points (Fig. 2). There also was no difference in morphine consumption at 24 hours or 24 to 48 hours and no difference in the use of supplemental analgesia. Interestingly, there was a significantly lower incidence of pulmonary complications, defined as clinical evidence of pneumonia and atelectasis, in the paravertebral group (odds ratio [OR], 0.36; 95% confidence interval [CI], 0.14–0.92), (Fig. 3). Respiratory function, which was recorded as the percentage change from baseline of either peak expiratory flow rate or forced expiratory volume in 1 second, also was improved significantly at 24 hours in the paravertebral group [3].

![Fig. 2. A meta-analysis of trials comparing paravertebral block (PVB) with epidural analgesia on pain visual analogue scale (VAS) scores 24 hours postoperatively. WMD, weighted mean difference. (Modified from Davies RG, Myles PS, Graham JM. A comparison of the analgesic efficacy and side-effects of paravertebral vs epidural blockade for thoracotomy—a systematic review and meta-analysis of randomized trials. Br J Anaesth 2006;96:422; with permission.)](image)
improvement probably results from the unilateral nature of a paravertebral block, with preservation of respiratory effort on the contralateral side.

The available evidence indicates that paravertebral block and epidural analgesia provide comparable pain relief after thoracic surgery, but paravertebral block is associated with a lower incidence of pulmonary complications.

Complications

Although it has been reported that a blood vessel is punctured in 2.8% to 11.5% of epidural insertions, usually without any sequelae [11], instrumentation of the epidural space potentially can result in epidural hematoma and paraplegia. The exact incidence of permanent neurologic damage after thoracic epidural catheterization is unknown, but a meta-analysis in 1995 that included both thoracic and lumbar epidural catheterization estimated the incidence of major spinal hematoma at 0.0007% [12]. A review that included studies published between 1995 and 2005 with primary intent of investigating neurologic complications of regional anesthesia estimated the rate of paraplegia after epidural placement at 0.0009% and the rate of cauda equine syndrome at 0.0023% [13]. The incidence of blood vessel puncture is reported to be significantly greater during lumbar epidural placement than during thoracic epidural placement, so the risk for thoracic epidural placement alone may be lower than the combined incidence [14]. This risk is increased if the patient has a coagulation disorder or has received any anticoagulant medications [15,16]. Epidural abscess can cause spinal cord compression and requires emergency decompression to avoid permanent neurologic damage [17].

Accidental dural puncture, with an incidence of 1% to 5% [18], is a common complication of thoracic epidural catheterization. A higher incidence has been reported in the lumbar (1.16%) and lower thoracic regions

Fig. 3. A meta-analysis of trials comparing postoperative pulmonary complications with paravertebral block (PVB) or epidural analgesia. CI, confidence interval; OR, odds ratio. WMD, weighted mean difference. (From Davies RG, Myles PS, Graham JM. A comparison of the analgesic efficacy and side-effects of paravertebral vs epidural blockade for thoracotomy—a systematic review and meta-analysis of randomized trials. Br J Anaesth 2006;96:418–26; with permission.)
than in the upper thoracic region (0.20%–0.29%) [14]. The regional variation probably can be explained by the more frequent use of the para-
median approach in the upper thoracic region. Although postdural puncture headaches occur in up to 70% of patients after accidental dural puncture, persistent neurologic sequelae are extremely rare [18]. Other infrequent neurologic complications of epidural placement include radiculopathies and peripheral neuropathies, with an incidence of 0.0219% [13]. Almost all are transient and do not require treatment [19].

Paravertebral blocks also have been associated with neurologic complications. The literature reports only four cases that resulted in significant morbidity. Three cases of myelopathy after paravertebral injection of eilocaine were reported in 1931, and a single case of Brown Sequard syndrome after paravertebral injection of alcohol was reported in 1954 [1]. Extradural injection, intrathecal injection with total spinal anesthesia, and postural headache with presumed meningeal penetration have been reported on rare occasions [2]. Segmental thoracic pain that lasted for 3 months after surgery, presumably secondary to intercostal nerve trauma, also has been reported in a patient after cholecystectomy [20]. Paravertebral blocks also are associated with inadvertent pleural puncture, with an incidence of 1.1%; the frequency of pneumothorax development is 0.5% [21].

As described, complications can arise from both epidural and paravertebral block techniques. Most are minor and self-limiting. The exception is spinal cord injury, a rare but catastrophic complication, which can result from instrumentation of the epidural space. Paravertebral block does not carry this risk and therefore may be a better option for anesthesiologists and patients alike.

Side effects

Many of the unwanted side effects of regional analgesia techniques are secondary to the associated sympathetic, sensory, and motor blockade or the addition of opioids to the local anesthetic solution. Both hypotension and urinary retention are commonly reported sequelae of thoracic epidural and paravertebral analgesia techniques. The perils of hypotension in the thoracic patient can lie as much in the treatment as in the occurrence: excessive fluid administration, especially during pneumonectomy, can lead to elevated pulmonary artery pressures and pulmonary edema [22]. It would be reasonable to expect a higher incidence of these complications with an epidural technique, because of the bilateral nature of the associated sympathetic and sensory block, in contrast to a unilateral paravertebral block. Richardson and colleagues [23], in a prospective, randomized comparison of epidural versus paravertebral bupivacaine in 95 patients, found a significantly higher incidence of both urinary retention, defined as the requirement for catheterization, and hypotension, defined as a decrease in preoperative systolic or diastolic blood pressure of 20% or more, in the epidural group.
In fact, no patient in the paravertebral group experienced hypotension [23]. The meta-analysis by Davies and colleagues [3] reinforced these findings. They showed a significant reduction in hypotension (OR, 0.12; 95% CI, 0.04–0.34) and urinary retention (OR, 0.23; 95% CI, 0.10–0.51) in the paravertebral group.

Another frequently reported and troublesome side effect is nausea and vomiting. Although this side effect may be attributed in part to hypotension, several other factors may play a role. The solution administered and whether it contains local anesthetic alone or is combined with an opioid, with the attendant increased risk of nausea and vomiting, is an important consideration. Paravertebral infusion solutions are more likely to contain local anesthetic without opioids; epidural infusions generally contain a combination. For the same reason, block efficacy is important, because it reduces the requirement for opioid rescue analgesia. It is difficult to dissect out the relative contributions of these factors in the meta-analysis by Davies and colleagues [3], because the included studies showed varied incidences of hypotension, administered several different solutions, and used a variety of rescue analgesia regimens. The combination, however, did show a significantly lower incidence of nausea and vomiting in the paravertebral group (OR, 0.47; 95% CI, 0.24–0.93).

The most serious side effect of epidural opioids is respiratory depression, with an incidence following conventional dosing regimens of approximately 1%, similar to the incidence following conventional dosing of intravenous or intramuscular opioids [24]. Respiratory depression may occur from minutes to hours after epidural opioid injection. Early respiratory depression (< 2 hours of injection) is associated most commonly with epidural fentanyl [25] or sufentanil [26], whereas epidural morphine [27] and hydromorphone are more likely to be responsible for late respiratory depression (> 2 hours after injection). Although certain factors such as advanced age and coexisting disease are associated with increased risk of respiratory depression with epidural opioids [24], its occurrence is largely unpredictable, and patients generally need closer monitoring in the postoperative setting than patients who have paravertebral catheters and who are receiving local anesthetic alone [28].

The most common side effect of epidural opioids is pruritus, which can be generalized but more commonly is localized to the face, neck, or upper chest [29]. The incidence is related to the type of opioid used, with epidural morphine being implicated more frequently than fentanyl or hydromorphone [30], and the concentration. A study of epidural pain relief in labor [31] showed a significantly increased incidence of pruritus with bupivacaine plus 4 ug/mL of fentanyl than with plain bupivacaine (P = .0015). A study comparing different doses of epidural fentanyl, however, concluded that epidural opioids are associated with concentration-dependent pruritus, with the incidence of pruritus increasing from 17% at 10 ug/mL to 36% at 20 ug/mL [32].
Perhaps the ultimate side effect is block failure. The reported failure rate of paravertebral block varies from 6.8% to 10% [1]. In the meta-analysis by Davies and colleagues [3], the epidural failure rate was significantly higher (OR, 0.28; CI, 0.12–0.64).

An epidural analgesic technique seems to have a higher failure rate and, with a bilateral sympathosensory block and the addition of an opioid to the infusate, is associated with significantly higher adverse effects than a paravertebral technique.

Contraindications

Some of the absolute contraindications to epidural insertion do not exclude the use of a paravertebral technique. In the setting of a coagulopathy, when an epidural technique carries the risk of epidural hematoma and subsequent cord compression, the margin of safety is much higher with a paravertebral block and the more distensible paravertebral space. Thus, a coagulopathy is a relative rather than an absolute contraindication to a paravertebral technique, and regional analgesia with all its attendant advantages still can be provided to the patient.

Pre-existing neurologic disease such as raised intracranial pressure also may contraindicate the use of an epidural technique. A paravertebral technique still can be used safely in this setting. A case report has described the use of a thoracic paravertebral block to manage pain associated with multiple rib fractures in the presence of a lumbar spine injury requiring continuous neurologic assessment [33].

Difficult thoracic spinal anatomy is a relative contraindication to an epidural technique because it makes the technique more difficult and more likely to be associated with complications. In this situation, a paravertebral technique also may be difficult and more likely to result in pleural puncture, but in challenging anatomy it has the added advantage that it can be placed under direct vision by the surgeon before the end of the surgical procedure [34]. If, after a patient is anesthetized, a decision is made to extend the original procedure because of pathology findings, complications, or poor surgical exposure, a paravertebral catheter still can be placed safely without fear of neurologic sequelae. In contrast, most anesthesiologists are uncomfortable with epidural placement in anesthetized patients, although some case series suggest that the practice is not unsafe [35]. Local or systemic sepsis and allergy to local anesthetic drugs contraindicate both epidural and paravertebral block.

Chronic pain

Postthoracotomy pain syndrome is defined as pain that recurs or persists along a thoracotomy incision for at least 2 months following the surgical procedure [36]. The frequency of occurrence makes it a significant issue after thoracotomy: a recent study reported an incidence of 52%, with 32%
described as mild, 16% as moderate, and 3% as severe [37]. Other groups have reported an incidence as high as 80% [38]. The exact mechanism for the pathogenesis of postthoracotomy pain syndrome remains unclear, but it is likely that both myofascial and neuropathic pathways are involved. Whereas tissue damage (such as muscle damage from trocar placement) typically leads to peripheral inflammation, progression to a chronic neuropathic pain syndrome probably is secondary to damage to neural structures [39], and rib retraction with resultant intercostal nerve damage has been implicated. This situation has been characterized in a rat study that compared a thoracotomy incision with rib retraction for 5, 30, and 60 minutes with a control group with thoracotomy incision down to the pleura but without rib retraction [40]. At 2 weeks after surgery, allodynia had developed in 50% of the rats that had undergone 60-minute retraction, in 11% and 10% of the rats that had gone 5- and 30-minute retraction, respectively, and in none of the control group. Histologically, the allodynic rats showed extensive axon loss in the intercostal nerves of the retracted ribs [40]. Modifications in surgical technique with a reduction in intercostal nerve damage, including muscle-sparing thoracotomy and intracostal placement of sutures, have been shown variably to result in a reduction in postthoracotomy pain. Benedetti and colleagues [6] compared the degree of intercostal nerve impairment at 1 month after surgery in 24 patients who underwent a standard posterolateral thoracotomy versus a muscle-sparing thoracotomy. Intercostal nerve impairment, measured by amplitude of superficial abdominal reflexes, amplitude of somatosensory-evoked potentials in the incisional area, and sensory thresholds for pain, was significantly greater in the posterolateral thoracotomy group. These findings also correlated with the clinical incidence of pain at 1 month after surgery [6]. Ochroch and colleagues [41], however, failed to replicate these results when they measured postthoracotomy pain during hospitalization and up to 48 weeks postoperatively in 82 patients who underwent muscle-sparing thoracotomy and 38 patients who underwent posterolateral thoracotomy. Incision type predicted neither postoperative pain nor pain after discharge. Cerfolio and colleagues [42], in a study of 280 patients undergoing elective thoracotomy, compared postoperative pain scores in a group of patients who had the chest closed with intracostal sutures and in a group who had the chest closed with the traditional pericostal sutures. Pericostal sutures are placed on top of the fifth and seventh rib, and this placement was hypothesized to contribute to intercostal nerve damage. For intracostal sutures, the lower suture is placed through a hole drilled in the sixth rib. Pain scores were significantly lower in the intracostal group ($P = .004$, $P = .0001$, $P < .0001$, and $P < .0001$ at 2 weeks, 1 month, 2 months, and 3 months postoperatively, respectively). A concurrently administered McGill pain questionnaire revealed that pain in the pericostal group was much more likely to be described as “burning” or “shooting” [42]. Interestingly, video-assisted thoracic surgery is not associated with a reduction in the incidence of chronic pain after surgery, with
rates of chronic pain variably reported from 22% [43] to 63% [44]. This pain can be explained by the disruption of the intercostal nerve and the muscle damage associated with trocar insertion.

When choosing an analgesic strategy for patients undergoing thoracotomy, prevention of chronic pain is as important a consideration as immediate postoperative analgesic efficacy. A randomized, controlled trial compared the effect of three different analgesia techniques (preoperative thoracic epidural analgesia, postoperative thoracic epidural analgesia, and patient-controlled morphine analgesia) on postthoracotomy pain in 69 patients [45]. The incidence of pain was significantly lower at 2 months ($P = .0106$) and 6 months ($P = .0233$) in the group receiving preoperative epidural analgesia than in the group receiving patient-controlled analgesia; there was no difference between the groups receiving postoperative epidural anesthesia or patient-controlled analgesia (Table 1). This study concludes that epidural analgesia significantly reduces the incidence of chronic postthoracotomy pain, but only when instituted pre-emptively [45], and reinforces the concept that acute pain after thoracic surgery predicts chronic postthoracotomy pain [9,46].

In studies of acute pain, paravertebral blocks have been shown to be as effective as thoracic epidural analgesia for postoperative pain control [1], but the authors could find no trials that looked at the effect of paravertebral blocks on chronic postthoracotomy pain. They also found no randomized, controlled trial comparing the efficacy of thoracic epidural analgesia and paravertebral block with regard to chronic pain. The available evidence indicates that thoracic epidural analgesia used pre- and postoperatively is the optimal regimen to minimize the incidence of chronic postthoracotomy pain.

**Summary**

Paravertebral blocks are easy to perform and have a high success rate. There seems to be no difference in analgesic efficacy between paravertebral techniques and epidural techniques, but paravertebral techniques are

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**Table 1**

Comparison of pain at 6 months and lasting more than 2 months between presurgical thoracic epidural analgesia, postsurgical thoracic epidural analgesia, and patient-controlled analgesia

<table>
<thead>
<tr>
<th>Results</th>
<th>All patients (n = 69)</th>
<th>Pre-TEA group (n = 22)</th>
<th>Post-TEA group (n = 24)</th>
<th>IV-PCA group (n = 23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain at 6 months</td>
<td>43 (62%)</td>
<td>10 (45%)</td>
<td>15 (63%)</td>
<td>18 (78%)</td>
</tr>
<tr>
<td>Pain lasting at least 2 months</td>
<td>47 (68%)</td>
<td>11 (50%)</td>
<td>16 (67%)</td>
<td>20 (87%)</td>
</tr>
<tr>
<td>Numeric rating scale</td>
<td>1 ± 1.0 (0–4)</td>
<td>0.6 ± 0.8 (0–3)</td>
<td>0.9 ± 0.9 (0–3)</td>
<td>1.4 ± 1.2 (0–4)</td>
</tr>
<tr>
<td>Pain affecting daily life</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Abbreviations: IV, intravenous; PCA, patient-controlled analgesia; TEA, thoracic epidural analgesia.*

associated with better postoperative respiratory function and a significant reduction in side effects. Unlike epidural catheterization, paravertebral blocks are not associated with serious neurologic complications, and a paravertebral technique may be particularly useful when epidural insertion is contraindicated.

Chronic postthoracotomy pain, which occurs in up to 80% of patients, is a significant issue in thoracic surgery. Acute postoperative pain is a good predictor of the development of chronic pain. One small study has suggested that preoperative initiation of epidural analgesia can reduce the incidence of chronic pain significantly. The effect of paravertebral blockade on chronic postthoracotomy pain has not been studied.

Returning to the question whether postthoracotomy paravertebral analgesia will replace epidural analgesia, the answer is, “Probably.” The only hope for the traditionalists and the thoracic epidural is on the issue of chronic postthoracotomy pain. Unless epidural analgesia is proven to reduce the incidence of chronic pain significantly more than paravertebral analgesia, the evidence argues for the paravertebral technique.

References


