PAIN AFTER thoracotomy and thoracoscopic surgery can cause patient distress, impair respiratory function, and delay recovery.\textsuperscript{1,2} Epidural analgesia is generally regarded as a standard of care for patients undergoing thoracotomy, but epidural block is probably not warranted for less invasive thoracic surgery. Sometimes, however, the extent of surgery is unclear until histopathology results are obtained during surgery or a thoracoscopic procedure is complicated by bleeding or inadequate surgical exposure, and so an open thoracotomy is performed. In addition, epidural block is contraindicated in patients with coagulopathy or local sepsis,\textsuperscript{4} and some patients refuse neuraxial block because of concern regarding spinal cord injury and permanent paraplegia.

Thoracic paravertebral block (PVB) is an alternative analgesic technique, particularly for unilateral surgical procedures of the chest and abdomen.\textsuperscript{5,6} It is relatively simple to perform and has a low incidence of side effects.\textsuperscript{5-8} Thoracic PVB was first described in 1905 to produce abdominal analgesia by injection of small volumes of procaine at different spinal levels.\textsuperscript{5,6} PVB has since been used in open thoracic surgery,\textsuperscript{4,9-11} thoracoabdominal surgery,\textsuperscript{12} video-assisted thoracoscopic surgery,\textsuperscript{13} laparotomy,\textsuperscript{13} breast surgery,\textsuperscript{14} after traumatic rib fracture,\textsuperscript{15} and in other chronic pain states. The block may be achieved by multiple small-volume (3-4 mL) injections\textsuperscript{5,6} or a single larger-volume (15-20 mL) injection\textsuperscript{14} and can be maintained by infusion via a paravertebral catheter of a low-concentration local anesthetic solution.\textsuperscript{5,6}

When compared with thoracic epidural block, PVB is more likely to preserve bladder and lower-limb motor function, thereby assisting early mobilization after surgery. The hemodynamic instability following the cardiovascular effects of epidural block is avoided.\textsuperscript{16} Importantly, paravertebral injections and catheter insertion can be performed in sedated and ventilated patients with less risk of neuraxial injury. The catheters can also be safely and accurately placed under direct vision during thoracotomy.\textsuperscript{10,11,17,18}

The thoracic paravertebral space is a wedge-shaped space that lies on either side of the vertebral column, is in communication with the epidural space (medially through the spinal foramina), and is bounded laterally and anteriorly by the parietal pleura. The space contains fatty tissue, nerves (intercostal/spinal, dorsal rami, rami communicantes, and the sympathetic chain), and the intercostal vessels. The sitting position allows easy identification of the landmarks; however, the block may be performed in the lateral or prone position. A 10-cm 18- to 22-G needle is inserted perpendicular to the skin 2.5 cm lateral to the tip of the spinous process to contact the transverse process at a depth of 2 to 4 cm. The needle is then “walked” off the superior or inferior aspect of the transverse process (either a fixed distance [1-2 cm] or until a loss of resistance to air or saline is encountered as the needle passes through the costotransverse ligament into the paravertebral space). The needle should not pass deeper than 2 cm beyond the transverse process to minimize the risk of pleural puncture.\textsuperscript{5,6} The use of a nerve stimulator to elicit a motor response in the corresponding intercostal muscle may allow for more reliable percutaneous identification of the paravertebral space.\textsuperscript{19} A Tuohy needle is used if catheter insertion is planned, and normally, in contrast to epidural insertion, the catheter is difficult to feed. Absence of resistance at this point may suggest that the catheter is interpleural. Significant resistance to catheter insertion can be reduced by injection of 5 to 10 mL of saline before catheter insertion, at the point of loss of resistance.

Sabanathan et al,\textsuperscript{10} Berrisford and Sabanathan,\textsuperscript{20} and Eng and Sabanathan\textsuperscript{21} originally described a technique whereby the surgeon places a catheter via a 16-G Tuohy needle immediately before wound closure. A cavity is created for
This technique can be modified by careful positioning of the needle immediately deep to the parietal pleura and injection of saline to give a characteristic “sausage” shape as the paravertebral space fills and feeding of the catheter under direct vision before thoracotomy or thoracoscopy closure. This latter technique can be done by the surgeon or anesthesiologist21 (Table 1). This should maximize analgesic efficacy and minimize complications.

Unfortunately, most anesthesiologists have had little or no training in PVB techniques. Positive studies have encouraged interest from established anesthesiologists and highlighted the need for structured residency training in PVB techniques. Also, further studies are needed to investigate the most suitable local anesthetic agent (type, concentration, and volume of injection), relative merits of single or multilevel injection, and catheter placement (anesthesiologist or surgeon). Concern about block failure is understandable in view of the limited training and experience of most anesthesiologists, but failed PVB occurs less often when compared with epidural block.22

Thus, PVB is not a difficult technique to learn and its placement takes little time, so it can be done, but should it be done (and when)? What evidence is available in the literature? Some authors have reported extensive experience with PVB, with very good results.5-7,10,11,23 There are no large randomized trials comparing PVB with epidural block, but a recent meta-analysis of 10 small trials found that PVB provided comparable analgesia with epidural blockade but had a better side effect profile.22 PVB was associated with less urinary retention, less postoperative nausea and vomiting, less hypotension, and a reduction in pulmonary complications. This latter endpoint is particularly important; when compared with epidural block, PVB significantly reduces the risk of pulmonary complications by 64% (95% confidence interval, 8%-86%)22 (Fig 1).

Three articles in this issue of the journal address some of the technical aspects relating to PVB.24-26 Kaya et al24 have investigated the analgesic effects of a multilevel series of single injections into the paravertebral space immediately before thoracotomy/ thoracoscopy. Others have reported success with this technique in other settings.13,27 Kaya et al24 showed superior postoperative pain control and reduced analgesic requirements with this multilevel PVB. Nevertheless, 2 of the 27 blocks were deemed by the authors to be inadequate, a rate similar to that

Table 1. Intraoperative Paravertebral Block by the Anesthesiologist

<table>
<thead>
<tr>
<th>Study</th>
<th>PVB nN</th>
<th>Epidural nN</th>
<th>OR (fixed) % 95% CI</th>
<th>Weight</th>
<th>OR (fixed) % 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaiser</td>
<td>0/13</td>
<td>2/13</td>
<td>15.46 0.17 (0.01, 3.92)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Binston</td>
<td>4/30</td>
<td>3/28</td>
<td>20.01 0.07 (0.17, 4.39)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Richardson</td>
<td>1/46</td>
<td>8/49</td>
<td>48.61 0.11 (0.01, 0.96)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaver</td>
<td>2/14</td>
<td>9/16</td>
<td>16.92 0.67 (0.09, 4.73)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>7/103</td>
<td>16/97</td>
<td>100.00 0.36 (0.14, 0.92)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total events: 7 (PVB), 18 (Epidural)
Test for heterogeneity: Chi² = 2.87, df = 3 (P = 0.41), P = 0%
Test for overall effect: Χ² = 2.13 (P = 0.03)

Fig 1. A meta-analysis of 4 randomized trials comparing PVB with epidural block in thoracic surgery, showing a reduction in postoperative pulmonary complications with PVB. n, number of adverse events; N, number of blocks. (Reprinted with permission.22)
reported by others.28 Once again, the importance of skill and experience are crucial if PVB techniques are to provide reliable postoperative analgesia. The alternative strategy, as outlined previously, is for the surgeon or anesthesiologist to insert a paravertebral catheter under direct vision at the time of wound closure.

Navlet et al25 compared 2 local anesthetic solutions at equipotent concentrations (ropivacaine 0.30% and bupivacaine 0.25%) after thoracotomy and found that they provided comparable analgesia. Some of their patients had unacceptably high pain scores with coughing on postoperative day 1, and so they suggested that higher concentrations would improve pain control and enhance respiratory function. They recommended bupivacaine 0.375%, at least for the first 24 hours after surgery.

Garutti et al26 measured the hemodynamic effects of PVB by using a bolus dose of 5 mg/kg (about 15 mL) of lidocaine. They found no significant cardiovascular effects other than a small, transient effect on heart rate and blood pressure, which they attributed to systemic absorption of local anesthetic from the paravertebral space. This highlights one of the great benefits of PVB, avoidance of block-induced hypotension. This reduces the need for fluid boluses and may reduce fluid overload, pulmonary edema, and impaired gas exchange. Optimization of respiratory function is a primary goal after thoracic surgery; like epidural block, PVB can provide excellent pain relief, but it can be achieved without a need for additional fluid therapy. Although the role of fluid restriction in major pulmonary resections remains controversial,28 most clinicians aim to avoid excess fluid administration.

Given that there appears to be no substantial difference in analgesia with PVB techniques when compared with epidural regimens and that PVB is associated with improvements in respiratory function and a reduction in complications,22 PVB should be considered for patients undergoing many types of thoracic surgery. PVB is a particularly useful option in patients in whom epidural analgesia is contraindicated (local sepsis, coagulopathy, and pre-existing neurologic disease) or for use during anesthesia if unexpectedly more extensive surgery is undertaken. PVB may be more appealing to anesthesiologists and their patients who have great concern for spinal cord injury. There is widespread underutilization of PVB in thoracic surgery; PVB can be and should be performed more often.

**REFERENCES**

22. Davies RG, Myles PS, Graham JM: A comparison of the analgesic efficacy and side effects of paravertebral versus epidural block-


