Chapter 18

Thoracic Paravertebral Block

- Single-Injection and Continuous Thoracic Paravertebral Blocks




SINGLE-INJECTION AND CONTINUOUS THORACIC PARAVERTEBRAL BLOCKS

Introduction

The indications for thoracic paravertebral block for orthopedic surgery are relatively few, but include multiple rib fractures and flail chest. Other, nonorthopedic indications include unilateral mastectomy, unilateral thoracotomy, and unilateral laparotomy or retroperitoneal surgery.

The three potential problems with this block are intrapleural catheter placement with or without pneumothorax formation, and epidural or subarachnoid injection. Pneumothorax is not always a consequence of intrapleural needle or catheter placement and is a rare complication. Pneumothorax follows only if the visceral pleura is penetrated.

As is the case with all paravertebral blocks (cervical, thoracic, lumbar, and sacral), two principles apply with this block:

1. Because the nerve roots are covered with dura, sharp or thin needles should not be used for thoracic paravertebral or any other paravertebral block. Even a 22-gauge B-bevel needle is not advisable because of the danger of dural (or pleural) penetration and large-volume subarachnoid injection. As a general principle, large-bore Tuohy needles (16- to 18-gauge) are the best choice. Because of their design, these needles are the least likely to penetrate the dura or the pleura.
2. The indication for this block should be carefully selected and weighed against the possibility of doing a thoracic epidural block.

Figure 18-1, a postmortem photograph in a pig, the catheter can be seen coiled up in the paravertebral space.

When 1 mL of India ink is injected through a thoracic paravertebral catheter, spread is mainly localized (Fig. 18-2).

After a 10-mL India ink injection, however, it is clear that the spread is largely local but also

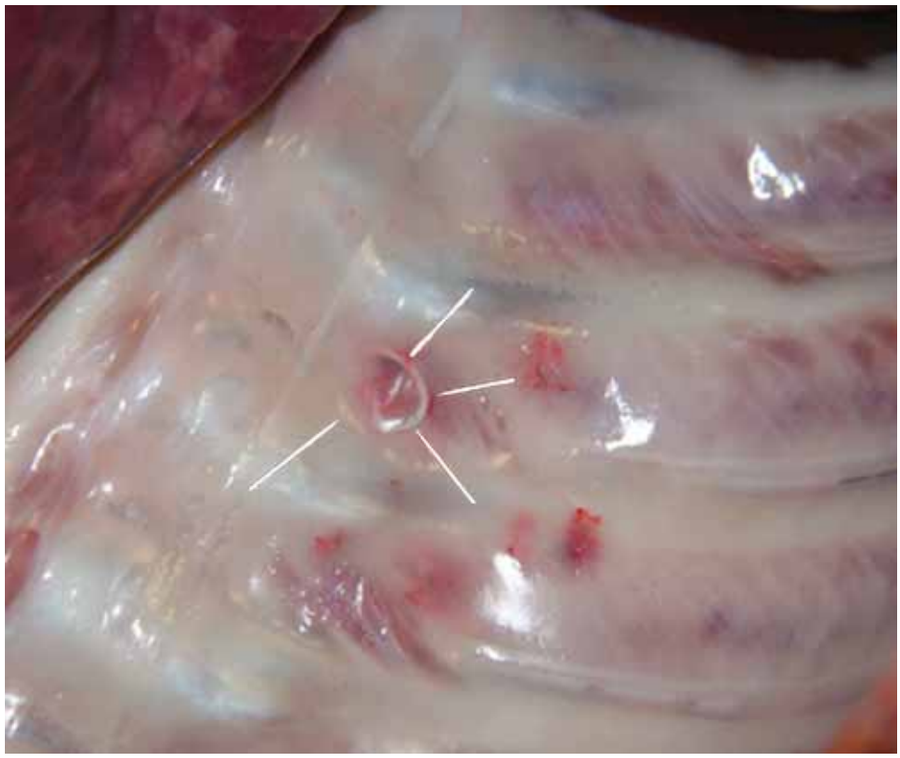


FIGURE 18-1 Postmortem dissection. The *arrows* indicate the coiling of a thoracic paravertebral catheter placed in an anesthetized pig. (Photographs courtesy Alex Fraser, MD.)

FIGURE 18-2 One milliliter of India ink is injected through the catheter.

FIGURE 18-3 Ten milliliters of India ink is injected through the catheter.

cephalic and caudal (Fig. 18-3). Spread is also along the intercostal nerve. If the pleura were injured, as in the case with rib fractures, spread will also be intrapleural.

The noncontinuous block techniques using multiple-level injection sites have been the subject of controversy and contradictory research findings. Cheema and colleagues demonstrated a spread of approximately 4.6 segments after a 15-mL, one-level injection, whereas Naja and colleagues recently demonstrated that multiple-level injections provide wider and more reliable spread.A continuous thoracic paravertebral block placed at one level has the obvious advantage of

long-term analgesia into the postoperative period, yet it may block insufficient levels to function as the sole anesthetic for major breast and other unilateral thoracic and upper abdominal surgery.

Specific Anatomic Considerations

The thoracic paravertebral space is wedge-shaped and bounded above and below by the heads and necks, respectively, of adjoining ribs (Fig. 18-4). The posterior wall is formed by the superior costotransverse ligament, which runs from the lower border of the transverse process above, to the upper border of the rib below. The posterolateral aspect of the vertebral body and the intervertebral foramen and its contents forms the base of this wedge. Anterolaterally, the space is limited by the parietal pleura.

Medially, the space communicates with the epidural space through the intervertebral foramen and, lateral to the tips of the transverse processes, it is continuous with the intercostal space.

Technique

The patient is placed in the lateral decubitus or sitting position (Fig. 18-5). Needle entry is approximately 3–4 cm lateral of the midpoint of the most appropriate thoracic vertebral dorsal spine—the fourth thoracic vertebra (T4) in the case of major breast surgery.

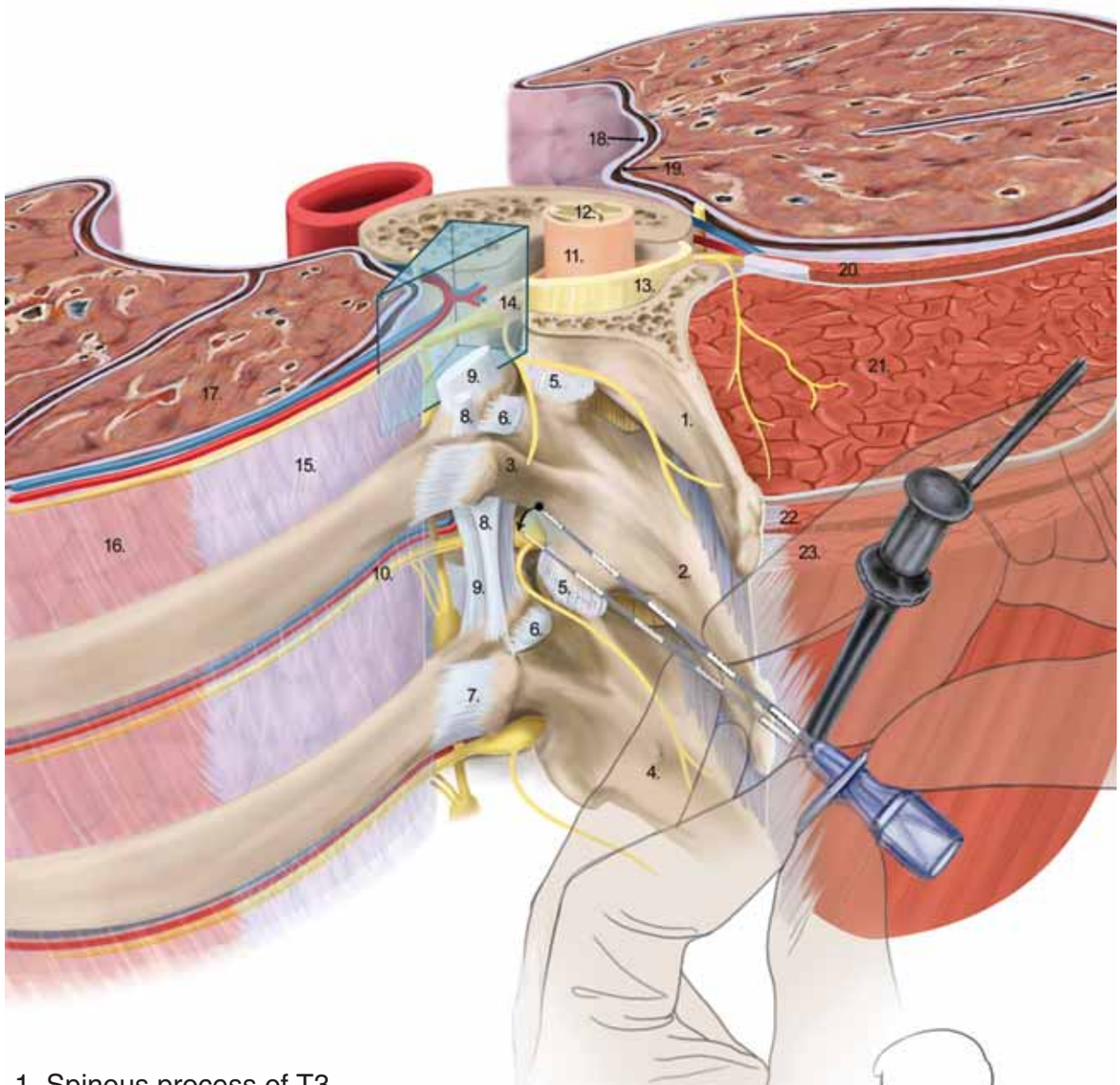
After thorough local anesthetic agent infiltration of the skin and subcutaneous tissue, a 17- or 18-gauge insulated Tuohy needle is advanced directly perpendicular to the skin until contact with the pars intervertebralis, articular column, or transverse process of the particular vertebra is established. This is typically at a depth of 4 to 6 cm from the skin surface (Fig. 18-6).

A nerve stimulator and loss-of-resistance-to-air syringe is attached to the needle and, while continuously testing for loss of resistance to air or 5% dextrose in water (D_5W), the needle is walked off the bony structure in an inferolateral (lateral and caudal) direction and advanced approximately 1 cm (but no more than 1.5 cm), ensuring that the bevel of the needle points laterally, away from the medial structures (Fig. 18-7). As the costotransverse ligament is penetrated, a "pop" can usually be felt, and there is loss of resistance to air or D_5W simultaneously with an intercostal muscle motor response. The "pop," however, is not consistently reliable. If saline is used to test for loss of resistance, the capacity for nerve stimulation is lost; D_5W is likely the better choice because it does not conduct electricity and hence preserves the ability to perform nerve stimulation. In theory, D_5W should provide a more distinct loss of resistance.

The nerve stimulator is set to a current output of 1 to 3 mA, a frequency of 2 to 5 Hz, and a pulse width of 200 to 300 μsec. Because the nerve roots are covered by dura, the paravertebral block is in essence an extradural or epidural block, and all the precautions used for epidural needle and catheter placement should be applied. Similarly, as for all the paravertebral blocks, relatively fine and sharp needles, such as 21-G needles should probably not be used because these are more likely to puncture the dura or pleura. A 17- or 18-G Tuohy needle is ideal for this application because they are designed to preclude dural puncture. When the tip of the needle nears the roots of an intercostal nerve, as indicated by loss of resistance, a "pop" as it penetrates the superior costotransverse ligament, and an intercostal muscle motor response, the needle is held steady while the syringe is removed. If a continuous nerve block is not required, the local anesthetic agent can now be injected through the needle.

When placing a T4 thoracic paravertebral block for breast surgery, it is helpful to ask an assistant to place his or her hand in the patient's ipsilateral axilla to detect the intercostal muscle motor response, which is obvious and easy to feel. The patient will also report the sensation of a pulsating electrical stimulus in the nipple.

The nerve stimulator lead is now attached to the proximal end of a 19- or 20-G stimulating catheter and its distal end inserted into the needle shaft (Fig. 18-8). With the nerve stimulator output kept constant at a current output that provides brisk twitching of the intercostal muscle, the catheter tip is advanced beyond the tip of the needle. If the muscle twitches stop or decrease during catheter advancement, the catheter tip has moved away from the nerves. The catheter is then carefully withdrawn so that its distal end is once again inside the needle shaft. A small adjustment is made to the needle (e.g., the needle is turned 45 degrees clockwise



1. Spinous process of T3
2. Spinous process of T4
3. Transverse process of T4
4. Spinous process of T5
5. Zygapophyseal joint capsule
6. Costotranverse ligament
7. Lateral costotransverse ligament
8. Intertransverse ligament
9. Superior costotransverse ligament
10. Intercostal vein, artery and nerve
11. Dura mater
12. Spinal cord
13. Ligamentum flavum
14. Nerve root
15. Internal intercostal membrane
16. Internal intercostal muscle
17. Left lung
18. Partietal pleura
19. Visceral pleura
20. Internal intercostal muscle
21. Erector spinae muscle
22. Rhomboid major muscle
23. Trapezius muscle

FIGURE 18-4 Anatomy of the thoracic paravertebral space.

FIGURE 18-5 Surface anatomy for the thoracic paravertebral block. The *circle* indicates the dorsal spine of the seventh thoracic vertebra.

FIGURE 18-6 Needle entry is 3 cm lateral to the midpoint of the dorsal spine of T7 for a T7 thoracic paravertebral block (T4 is used for breast surgery). The skin and subcutaneous tissues are anesthetized all the way down to the transverse process or articular column of the vertebra.

FIGURE 18-7 An insulated, 17- or 18-gauge Tuohy needle attached to a nerve stimulator and a loss–of–resistance-to-air syringe is advanced until contact is made with the transverse process or articular column of the vertebra. The needle is walked off the bony path in a caudal and lateral direction.

or counterclockwise, or moved 1 mm outward or inward), and the catheter is readvanced while the appropriate nerve stimulation is monitored. These maneuvers may be repeated until the intercostal muscles twitch briskly throughout catheter advancement. The advisability of withdrawing and readvancing the catheter is unclear and controversial, but the benefits of doing this outweigh the potential risk of catheter shearing. If it proves difficult to withdraw the catheter carefully, the needle should be removed with the catheter and the process restarted.

Too easy advancement of the catheter may suggest that the catheter does not lie within

FIGURE 18-8 Once contact with the nerve root is made, a clear intercostal muscle motor response can usually be seen. Loss of resistance to air is also demonstrated. A stimulating catheter attached to a nerve stimulator is advanced through the needle while the operator continues to observe the intercostal motor response.

FIGURE 18-9 The needle is removed and the catheter is placed in a fixation device attached to the patient in an appropriate and comfortable position.

the paravertebral space. Advancement in the paravertebral space seems to be associated with more resistance than anesthesiologists are used to in the epidural space. Although this observation has never been quantified or scientifically confirmed, easy advancement may imply that the catheter is situated intrapleurally, epidurally, or intrathecally. If, during nerve stimulation, the motor response is lost, intrapleural placement is likely. If the motor response becomes bilateral or bizarre, the anesthesiologist should be suspect intrathecal or epidural catheter placement. A normal unilateral intercostal muscle motor response is strongly indicative of pure paravertebral catheter placement. The catheter is typically advanced 2 to 3 cm beyond the tip of the needle against some resistance, which invariably causes the catheter to coil up in the paravertebral space (see Fig. 18-1). Spread of injectant is first local (see Fig. 18-2), and then along the intercostal nerve (see Fig. 18-3). Finally, the injectant spreads up and down the paravertebral "gutter" (see Fig. 18-3).

To prevent dislodgement, the catheter may be tunneled subcutaneously to a convenient and stable position, although in the thoracic area this usually is not required. Leaving a small, 1- to 3-mm skin bridge after tunneling, as described previously (see Chapter 12), may make catheter removal easier.

After tunneling and securing the catheter, the Luer lock attachment device with a stimulator lead attachment may be attached to the catheter, and the nerve stimulator attached to the fixation device, which in turn is attached to a convenient position (Fig. 18-9).

While stimulating the nerve with the minimum current that produces appropriate muscle twitches, a test dose of 2 mL short-acting local anesthetic agent such as lidocaine 2% with epinephrine 1/200,000 is injected through the catheter. This should cause the muscle twitches

to stop immediately, which is a further indicator of the proximity of the catheter to the nerve root. Inadvertent intrathecal injection should present with subarachnoid block, whereas intravascular injection should present with tachycardia. Because paravertebral block is essentially an epidural block, all the precautions for epidural block, including test dosing as described previously, should be used. There is no known low-dose test to distinguish true epidural block from paravertebral block. The main bolus dose should therefore be injected in 5-mL increments, followed by hemodynamic evaluation after each increment.

Local Anesthetic Agent Choice

Many local anesthetic combinations and dosages have been used for this block. The author prefers to use 20 mL of ropivacaine 0.5% to 0.75% or bupivacaine 0.5% as 5-mL incremental injections for intraoperative and postoperative analgesia if the block is combined with general anesthesia. Naja and colleagues proposed 0.26 mL/kg, but a dose per kilogram is probably not appropriate because body mass may not necessarily relate to paravertebral space size and longitudinal spread. Because Cheema and colleagues demonstrated a spread of approximately 4.6 segments after an injection of 15 mL, which is equivalent to a spread of approximately 1 segment per 2.5 to 3 mL, 20 mL should provide a spread of approximately 6 to 8 segments. However, segmental spread per volume injected is not consistent. Therefore, if it used as the sole anesthetic, larger volumes of up to 30 mL of the 0.5% solution may be required. If after 30 minutes the dermatomal spread of the bock is insufficient to cover the surgical area, a single-injection block can be done a few segments cephalic or caudal from the catheter as appropriate for the clinical situation.

Catheter placement and bolus injection is typically followed by a continuous infusion of bupivacaine 0.25% or ropivacaine 0.2% at an infusion rate of 5 mL/hour. Slow, incremental injection is strongly encouraged.

Although there is controversy about performing blocks in heavily sedated or anesthetized patients, and the literature is unclear on the relative or absolute risks of injury, blocks in awake patients may be preferable. When appropriate, this block may safely be placed under light sedation with midazolam in adult patients. General anesthesia may facilitate block placement in selected settings, such as in children, very anxious patients, or very painful preexisting conditions. A potent analgesic agent such as remifentanil 0.3 to 0.5 μg/kg, with careful respiratory monitoring, is sometimes indicated if painful conditions such as fractured ribs are present.

(See thoracic paravertebral block movie on DVD.)

SUGGESTED READINGS

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