Epidural Analgesia

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CASE REPORT

A 64-year-old retired railway worker was admitted to the hospital following a motor vehicle accident in which he sustained 6 fractured ribs on the right (4 through 9 inclusive) and 4 fractured ribs on the left (8 through 11 inclusive). He had a thirty-year history of smoking twenty cigarettes a day and had been admitted to the hospital twice in the last eight months with bronchopneumonia, which he had developed from acute exacerbations of his chronic bronchitis.

On admission he was in severe pain, had grunting respirations, and was unable to cough effectively. A chest x-ray showed evidence of bilateral basal collapse and moderate pulmonary contusion in the right mid zone. Arterial blood gas values taken while the patient was breathing 28 percent oxygen were \( \text{PO}_2 \) 52 mm Hg, \( \text{PCO}_2 \) 58 mm Hg, pH 7.32. An intramuscular injection of pethidine, 75 mg, was given and a pethidine infusion at 25 mg/hour was commenced. After 1 hour the patient seemed moderately comfortable, although he still had some evidence of labored respiration. However, the patient was unable to cough even with an inhalation of a 50:50 mixture of nitrous oxide and oxygen, and 8 hours after admission the arterial gas results breathing 28 percent oxygen showed \( \text{PO}_2 \) 46 mm Hg, \( \text{PCO}_2 \) 68 mm Hg, pH 7.22.

At this stage it was deemed that a thoracic epidural should be tried. Using the lateral approach a catheter was inserted between the eighth and ninth thoracic vertebrae and 5 ml of 0.5 percent bupivacaine with epinephrine 1:200,000 hourly as required, with the first top-up dose being delayed at least 2 hours after the initial dose. During the next three days the chest x-ray opacifications slowly cleared, and six days after admission the epidural cannula was removed and the patient was able to manage with intermittent intramuscular injections of pethidine 75 mg q 4h. On discharge 14 days after his accident his arterial gas analysis while breathing air revealed \( \text{PO}_2 \) 60 mm Hg, \( \text{PCO}_2 \) 45 mm Hg, pH 7.45, and his chest x-ray showed a small area of subsegmental atelectasis in the right lower zone, healing rib fractures, and a small right pleural effusion. One month after his accident he felt no pain and regarded himself clinically normal.

Comment

This patient with chronic chest disease developed acute respiratory failure after multiple fractures of his ribs that resulted in a flail anterior segment of his chest.

Conventional analgesic techniques were initially tried but failed for a variety of reasons, including inadequate resulting analgesia and narcotic depression of cough and conscious state.

Thoracic segmental epidural analgesia allowed reversal of factors causing acute respiratory failure and the use of artificial ventilation was avoided.

Pain functions to reduce the movement of injured tissue, minimizing further injury and allowing tissue to heal. However, the immobilization may also reduce ventilation, decrease

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skeletal muscle protein synthesis,\textsuperscript{2,3} and allow other aspects of the metabolic stress response to continue protein catabolism.\textsuperscript{4} The control of pain therefore is indicated not only to relieve suffering but also to minimize the respiratory and metabolic effects of excessive immobilization.\textsuperscript{5}

In the intensive care unit a common indication for pain therapy is to reduce the respiratory restriction caused by postoperative or post-traumatic thoracic or abdominal injury.\textsuperscript{6-8} Therapy, however, is often chosen because of ease of administration or absence of numerous side effects rather than for its efficacy in relieving pain; therefore, treatment with opiates, antipyretic analgesics, or nitrous oxide inhalation, singly or in combination, may not achieve the desired effect on respiration. Some patients may require complete pain relief to breathe and cough effectively.

Epidural analgesia with local anesthetic agents abolishes rather than relieves pain and therefore adds a new dimension to the treatment of pain. The technique of epidural cannulation is complex. It requires skilled personnel to administer the block, monitor its effects, and treat any side effects. Thus, simpler measures for pain relief should be tried first.

In learning the technique of epidural blockade the operator should first have a comprehensive knowledge of the anatomy of the spine and also be adept at the midline approach before trying the more difficult lateral approach. Furthermore, before the block is attempted in a patient the skill of epidural cannulation should be tested in the autopsy room.

### ANATOMY OF THE EPIDURAL SPACE

The superior and inferior boundaries of the epidural space extend respectively from the base of the skull, where the periosteum of the spinal canal and the spinal dura fuse to the foramen magnum, to the sacrococcygeal membrane. The posterior longitudinal ligament lies anteriorly, the ligamentum flavum posteriorly, and the pedicle and intervertebral foramina lie laterally. The spinal nerves pass through the latter. The epidural space extends from the spinal dura to the spinal periosteum and contains fat, veins, and lymphatics and is traversed by the spinal nerves with their dural prolongations (Fig. 1). The spinal branches of the subclavian, aortic and iliac arteries cross the epidural space and enter the subarachnoid space in the region of the dural cuff. There are important differences between lumbar and thoracic vertebra (Table 1, Fig. 2).

### TECHNIQUE

Pain may limit respiratory movement if it occurs in the area supplied by the T1–L1 spinal nerves. Since the upper thoracic area of T1–T4 moves little with respiration, and epidural blockade above T4 can be associated with severe hypotension, the block is usually attempted below T4.\textsuperscript{9} A Tuohy 16-gauge needle with a closely fitting stylet is used if a catheter is to be inserted into the epidural space and intermittent injections administered. The dermatome landmarks, nipple T4–T5, xiphoid process T7, umbilicus T10, and inguinal ligament T12 are

![Figure 1. Anatomic localization of epidural space. (From Baker, AS, et al\textsuperscript{31})](image)
often used to aid the correct placement of the needle by delineating the extent of pain and the intervertebral space midway between the upper and low boundaries of pain. Insertion of the needle below T9 may be performed using the midline approach; however, the placement of the needle above this level is usually performed using a lateral approach (Fig. 3). In the elderly the interspinous ligament may be calcified, necessitating a lateral approach at all levels. Conversely, in the young, because of their suppleness and wide interspinous spaces, a midline approach may be successfully used at all levels. If both techniques are performed above the lower border of L2, both are associated with the risk of spinal cord trauma; although the angle

| Vertebral Foramen       | Lumbar              | Thoracic                        |
|-------------------------|---------------------|---------------------------------|
| Body                    | Large and triangular| Small and circular (no larger than the tip of the ring finger) |
| Articular Processes     | Allow flexion and extension of the spine, which widens and narrows the interlaminar space | Allows the rotation of the spine with minimal flexion and extension, thus minimal change in the interlaminar space |
| Interlamina Space       | Wide                | Small, narrow                   |
| Spinous Process         | Quadrangular, extending horizontally backward | Triangular, extending downwards |
| Ligamentum Flavum       | Thick, elastic      | Thin, filamentous               |
| Interspinous Ligament   | Thick, fibrous      | Thin, narrow                    |

Table 1. Differences Between the Lumbar and Thoracic Vertebrae

Figure 2. Superior and lateral view of thoracic and lumbar vertebrae. (Modified from Lockhart RD, Hamilton GF, Fyfe FW (eds): Anatomy of the Human Body. London: Faber and Faber, 1959, p 62)
involved in the lateral approach above T9 allows a greater penetration of the epidural space before the dura or spinal cord may be pierced.¹⁰

When epidural analgesia is contemplated the suitability of the patient is first evaluated. The technique is not used if the patient has pre-existing neurologic disease, fractured vertebra, a coagulation disorder, infection overlying the area of insertion, or if the patient is unconscious, uncooperative, or refuses to be treated by this technique. If the patient is deemed suitable the site of insertion is decided upon and an intravenous infusion begun. The patient is then turned with the painful side uppermost and places his arms around a pillow for added comfort.

**MIDLINE APPROACH**

A line drawn between the highest points of the two iliac crests passes through the spinous process of L4; the interspinous space above this lies between the L3–L4 vertebra. Interspinous spaces can then be counted from this space to determine the space desired. This may then be confirmed by counting from other landmarks, that is, vertebra prominens (spine of C7), inferior angle of the scapula (spine of T7), and root of the spine of the scapula (spine of T3). The correct space is identified and a small mark is placed in the skin. We prefer a 1-cm skin scratch mark drawn with the tip of a needle, as it won't be removed by the sterile preparation solution.

**Figure 3.** Vertebral column: epidural approach. (From Grant JCB (ed): Grant's Atlas of Anatomy, Baltimore: Williams & Wilkins, 1962, p 363)

**Figure 4.** Midline and lateral approach to epidural space.
The site is then prepared as a sterile area. The operator uses sterile gown, gloves, and mask, and solutions of iodine and sterile towels to complete the preparation. Using a 23-gauge needle and a 2-cc glass syringe with a freely moving, snugly fitting plunger filled with 1 percent lignocaine a small weal is raised to anesthetize the skin site for insertion of the Tuohy needle. The subcutaneous area overlying the supraspinous ligament is anesthetized with the remainder of the local anesthetic. To reduce resistance to the insertion of the Tuohy needle, a small cut is made in the skin with the tip of a scalpel blade. The Tuohy needle is then inserted with its tip angled cephaloid, at right angles to the skin and with a slight 5 to 10° tilt upward. Once the tip engages the supraspinous ligament the stylet is removed and the 2-cc glass syringe containing air is placed onto the hub of the needle. The needle is advanced farther through the interspinous ligament and the ligamentum flavum. The latter is often penetrated with a sudden loss of resistance. The plunger is continually “tapped” with the index finger during this procedure to detect the loss of resistance indicating that the tip of the needle has reached the epidural space. This usually occurs 4 to 6 cm from the skin surface. Once the space has been identified the catheter is inserted 2 to 3 cm past the needle tip. The needle is then withdrawn over the catheter and a 2-0 silk stitch secures the catheter to the skin entry site. The Tuohy needle is withdrawn over the remainder of the catheter and a 23-gauge needle with its cover is attached to the end of the catheter with a Luer lock micropore filter (Fig. 5). While the filter is not thought of as a substitute for strict asepsis, it is used to prevent foreign material and bacteria from gaining access to the epidural space. A 5-cc Luer lock syringe with the local anesthetic is then attached to the filter, the catheter is placed over the shoulder and strapped down, and the syringe, filter, and end of the catheter are strapped to the front of the chest overlying the sternum. The patient then remains supine while the local anesthetic is injected.

**LATERAL APPROACH (T4-T9) (Fig. 4)**

The site is chosen and marked as described for the midline approach. The weal, however, is raised 1 cm lateral to the chosen interspinous space. The local anesthetic is then infiltrated at right angles to the skin down to the lamina of the lower vertebra. The needle is withdrawn 2 cm and redirected at 30° to the skin toward the midline and 30° upward, infiltrating the subcutaneous tissue for 3 to 4 cm. The Tuohy needle is introduced 1 cm lateral to the interspinous space and at right angles to the skin down to the lamina of the lower vertebra to gauge the depth of the interlamina space. The needle is then withdrawn 1 cm and angled into the midline 30° and cephaloid 30° and advanced a further 1 to 2 cm until it fits snugly between the bases of the spines of both vertebrae, just before it enters the interlamina space. The stylet is then withdrawn and the 2-cc air-filled glass syringe is placed onto the hub of the needle. The needles advanced farther using the loss of resistance technique previously described to detect the entry of the tip of the needle into the epidural space. When loss of resistance is detected, the palm of the hand is placed just above the needle and 2 cc of air are injected. If crepitus is felt the needle tip lies subcutaneously and not in the epidural space. If no crepitus is felt the catheter is inserted 2 to 3 cm and secured as before.

As the lateral approach requires a highly trained feel for the correct angle and direction of the needle, as well as an accurate interpretation for the correct loss of resistance, it requires much more practice than the midline approach before the operator is completely skilled in its use.

**INSERTION DIFFICULTIES**

If bone or periosteum is encountered before there is loss of resistance, the needle is withdrawn, the stylet reintroduced, and the needle reinserted at a slight angle.

If a subdural tap occurs the needle is withdrawn and may be inserted one space higher.

If the patient complains of a sudden sharp “electric” pain around the chest or abdomen, the needle may have pierced a nerve root. If the
pain shoots down both legs, the needle tip may have irritated the posterior columns of the spinal cord. On both occasions the needle is withdrawn and the technique of insertion is carefully reappraised.

If there is free flow of blood back through the needle, an epidural vein may have been pierced. The needle is withdrawn and may be reinserted one space higher.

If the catheter won't thread into the epidural space, the catheter and needle should be withdrawn together and the needle reinserted at the same or a different site, and another attempt is made to thread the catheter.

**TOP-UP TECHNIQUE**

While some centers make a practice of infusing local anesthetics continuously to achieve uninterrupted pain relief, others have found it less satisfactory than the top-up technique to relieve pain. We prefer to use the top-up technique to allow an assessment of the block as well as a regular assessment of the need for local analgesia. The presence of continuous analgesia may also be the first sign of infection in the epidural space.

The top-up technique calls for the administration of the drug when the patient complains of returning pain, or at predetermined intervals appropriate to the effective duration of the action of the drug used. The latter is often used to diminish the problem of tachyphylaxis and to spare the patient episodes of severe pain between doses.

**A CHOICE AND ADMINISTRATION OF LOCAL ANESTHETIC AGENT**

For pain relief that may be required for some days, a long-acting local anesthetic agent is chosen. Of the two agents commonly available, bupivacaine rather than etidocaine is used because of its greater sensory selectivity. Epinephrine 1:200,000 is also added to enhance the quality and length of the sensory block, to lessen the effect of tachyphylaxis, and to lower peak blood levels of the drug.

The patient is placed supine. A standard dose of 5 ml of 0.5 percent bupivacaine with 1:200,000 epinephrine, with an extra amount added to fill the dead space of the filter, is often used as the initial test dose. However, if the patient is older than 70, or if less than 5 segments need to be blocked, using the approximation that 1 ml of local anesthetic is needed to block one segment, only 2 to 3 ml may be required.

The local anesthetic is administered in a 5-cc Luer lock syringe, which remains in place until the next dose is required. While the patient remains supine his blood pressure and pulse are measured every 5 minutes for the next 30 minutes. The lung vital capacity is also measured both before the dose and 30 minutes later. The extent of the block may be assessed by pinprick; however, of greater clinical importance is the ability of the patient to breathe freely and cough effectively at the time of the maximum effect of the block. If the improvement in respiratory function is judged adequate, no further extension of the block is needed. If further pain relief is required, the next dose is increased by 1 ml, if the drop in blood pressure produced by the first dose is not severe. Thereafter, to determine the optimal dose, pain relief is titrated against the hypotensive effect of the drug.

The second top-up dose is given no sooner than 2 hours after the first. Thereafter, rather than the standard recommendation of the 2 hours between top-up doses, we prescribe doses every hour as required. With this regimen we have administered, in one patient, 10 ml of 0.5 percent bupivacaine with epinephrine 1:200,000 hourly for 3 consecutive days with no adverse effects.

**EPIDURAL OPIATES**

There has been much enthusiasm for the use of small doses of morphine (2–5 mg) and pethidine (10–30 mg) in the epidural space to relieve pain. The advantages are that pain relief is prolonged and not associated with somatic motor of sympathetic blockade, which are often seen with conventional local anesthetic agents. However, the side effects of respiratory depression, pruritus, hallucinations, and catatonia indicate that it is not without hazard. Furthermore, the pain relief obtained by epidural opiates is not as complete as that seen with conventional local anesthetic agents, and this has discouraged our use of these agents. In summary, one group concluded that "epidural narcotics in adequate dosage are an effective means for production of prolonged and segmental analgesia," although "satisfactory segmental epidural block with local anesthetic resulted in the most mobile and alert patients, who performed deep breathing and leg exercises effectively and without complaint."

**SIDE EFFECTS AND COMPLICATIONS**

These may be related to the technique of epidural cannulation, local anesthetic agent used, or sympathetic or somatic block (Table 2).
Problems related to the technique

- Infection, epidural abscess, meningitis, anachroiditis osteomyelitis
- Epidural hematoma, vascular puncture or damage
- Catheter knotting, misplacement, particulate matter
- Dural puncture, spinal cord and nerve damage.

Nerve Blockade

**Sympathetic:**
- Hypotension, bradycardia, cardiac arrest
- Horner's syndrome
- Urinary retention
- Shivering
- Intercostal nerve block with paradox respiration and reduced ability to cough

**Somatic:**
- L2-T1

Local Anesthetic Agent

- Hypotension, convulsions
- Hypersensitivity
- Allergic reaction

**PROBLEMS RELATED TO THE TECHNIQUE**

In our practice of using epidural analgesia to relieve pain in patients with respiratory restriction we have had 1 epidural infection in over 250 cases. The infection was *Staphylococcus aureus* and had been transmitted from the external nares of one of the specialists performing the procedure, highlighting once again the necessity for absolute sterility. The presentation of this case had been different from that described for spontaneous epidural abscesses. Two days after an epidural catheter was inserted the patient developed a high swinging fever. The band of analgesia provided by the block did not wear off, yet unlike the classic picture of a spontaneous epidural abscess, there was no pain overlying the abscess site. The pathogen was grown from the tip of the catheter, and following laminectomy with drainage of the epidural space and intravenous administration of cloxacillin, the patient recovered with only minimal residual depression of sensation in the upper thoracic dermatomes.

**NEURAL BLOCKADE**

With the currently available local anesthetic agents epidural blockade involves sympathetic as well as somatic sensory and motor blockade. To relieve pain it is somatic sensory blockade which is desired; the sympathetic and motor blockades are often undesirable side effects.

The sympathetic block is usually manifested clinically by the cardiovascular effects, which are related to the level of the block (Table 3). The blood pressure drop with the initial dose may also be related to the sudden relief of pain and loss of its associated sympathetic component. These effects, however, may be modified by the presence of epinephrine. Furthermore, with the passage of time the ability of the precapillary sphincters to achieve auto-regulation means that even with cessation of neural activity the blood pressure drop often becomes less and less with each top-up dose.

In summary, the cardiovascular effects of the epidural block will be determined by the level of the block, presence or absence of epinephrine, blood levels of circulating local anesthetic agents, blood volume of the patient, prior cardiovascular status of the patient and previous drug therapy.

**TREATMENT OF HYPOTENSION**

With sympathetic blockade and severe hypotension one must be able to assume control of the cardiovascular system. Initially oxygen is administered and venous return improved by elevating the patient’s legs and rapidly infusing

| Level | Effect | Response |
|-------|--------|----------|
| L2–T10 | Low Peripheral Sympathetic Block | Venous and arterial dilation of lower limbs with slight drop in blood pressure |
| L1–T5 | Adrenal Medullary Sympathetic Block | Venous and arterial dilation of lower limb and splanchnic vessels. Block to sympathetic outflow to adrenal medulla, thus diminished level of circulating catecholamines. Moderate in drop blood pressure |
| L2–T1 | Peripheral and Central Sympathetic Blockade | Generalized venous and arterial vasodilation with blockade to cardiac sympathetics. Severe drop in blood pressure |
500–1000 ml of crystalloid or colloid.\(^4\) If bradycardia is present atropine 0.6 mg is given.\(^4\) If these simple measures don’t produce the desired result, pressor agents are required.

We infuse epinephrine 2–8 \(\mu\mu\) min to emulate the body’s adrenal medullary response\(^4,2,43\) and titrate against the pulse blood pressure and tissue perfusion. Some prefer ephedrine 5–10 mg in I.V. increments.\(^4,44,45\) Metaraminol, phenylephrine, and methoxamine may produce a further decrease in cardiac output and are therefore not recommended.\(^46\) If the hypotensive response is unexpected, particularly after a long period of cardiovascular stability, hidden blood or fluid loss must be suspected, in particular, hemothorax or ruptured spleen in patients with trauma.

**URINARY RETENTION**

A block extending to T12–L1 may increase bladder sphincter tone and lead to acute urinary retention. This should be treated with catheterization, since sitting and straining on a commode may exacerbate the effects of hypotension. Bladder atonia following a block to S2–S4 should not occur unless an overdose of local anesthetic has been given.

**SOMATIC MOTOR BLOCKADE**

This may decrease the patient’s ability to cough owing to intercostal nerve blockade and muscle paralysis.\(^47,49\) If respiratory paradox is evident, the concentration of bupivacaine should be reduced from 0.5 to 0.25 percent and the same volume is used as before.

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