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Epidural Analgesia for Perioperative Upper Abdominal Surgery

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1. Introduction

Uncontrolled postoperative pain and the pathophysiologic response to surgery following upper abdominal surgery may cause significant complications of many organ systems. Perioperative thoracic epidural analgesia (TEA), especially with a local anesthetic-based analgesic solution, can decrease the incidence of postoperative morbidity and mortality. In the case of the cardiovascular system, TEA may decrease the incidence of postoperative myocardial infarction by providing a favorable redistribution of coronary blood flow, attenuating the stress response, hypercoagulability and postoperative pain. As for the respiratory system, TEA provides superior analgesia, allowing patients to do deep breathing exercises and early ambulation. In a recent cohort study of 541 patients with chronic obstructive pulmonary disease, it was reported that TEA offered a preventive effect for postoperative pneumonia and a decrease in 30-day mortality. Stress-induced sympathetic outflow causes ileus and prolonged hospital stay. (van Lier et al., 2011) TEA can facilitate the return of gastrointestinal motility without contributing to anastomotic bowel dehiscence. Finally, TEA improves postoperative analgesia, resulting in increased patient satisfaction. (Hurley & Wu, 2009)

Although TEA provides many benefits, this technique has significant risks, including medication-related complications, epidural catheter-related complications and other complications associated with continuous epidural analgesia. This chapter will cover the practical aspects of thoracic epidural analgesia for perioperative upper abdominal surgery, including the anatomy of the thoracic epidural space, the technique of epidural block, drugs used for intraoperative and postoperative analgesia, and intraoperative and postoperative complications.

2. Approaches to the epidural space

Patients undergoing upper abdominal operations (cholecystectomy, esophagectomy, gastrectomy, hepatectomy and Whipple's operation) that involve large surgical incisions are suited for thoracic epidural anesthesia and analgesia. The recommended sites for epidural needle and catheter placement are at T6-8 levels. Catheter-incision-congruent epidural analgesia provides effective analgesia and minimizes side effects.

Standard monitors, including non-invasive blood pressure, pulse oximetry and electrocardiogram, should be applied before or after the positioning. Either the sitting or lateral decubitus position can be used. Exaggerated spinal flexion serves little benefit because thoracic facet joints primarily allow axial rotation. (Neal, 2004) Intravenous sedation (small doses of midazolam and fentanyl) for alleviating anxiety and supplemental oxygen should be given. The assistant should help the patient to hold the position during the entire procedure.

Identification of a specific vertebral interspace is generally based on palpitation at the surface landmarks of the spine. A line drawn between the inferior angles of the scapulae identifies the T7 spinous process (Fig. 1). The interspace can also be located by ultrasound imaging. This new technique has been reported useful for guiding neuraxial anesthetics in patients with prior instrumentation, and in obese and elderly patients. (Grey, 2010)

Since the midthoracic spinous processes are acutely angulated and the laminae become more vertically oriented as one progresses caudally (Fig 2), performing a paramedian approach is easier than a midline approach. The needle entry point is marked just off midline to avoid the process (Fig 1). The epidural space is commonly identified using a loss of resistance to air or the saline technique. An epidural catheter is advanced through the needle and 3 to 5 cm into the epidural space.

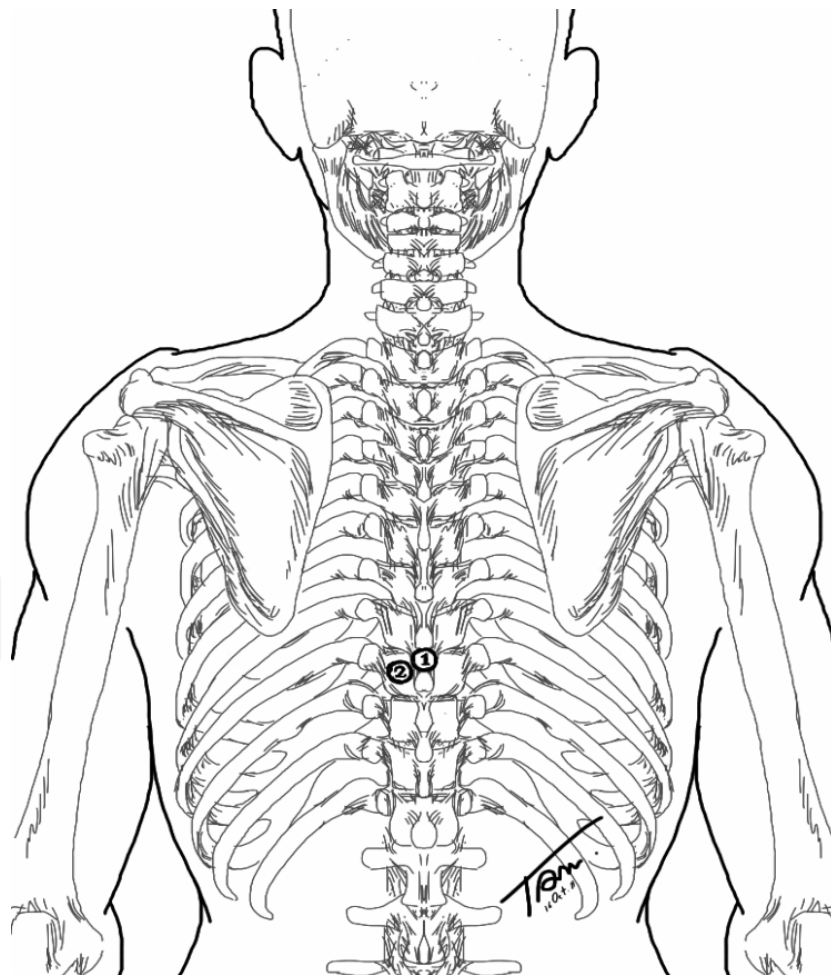


Fig. 1. Puncture sites at the surface landmark of the T7 level are at the line drawn between inferior angles of the scapulae: (1) median approach and (2) paramedian approach.

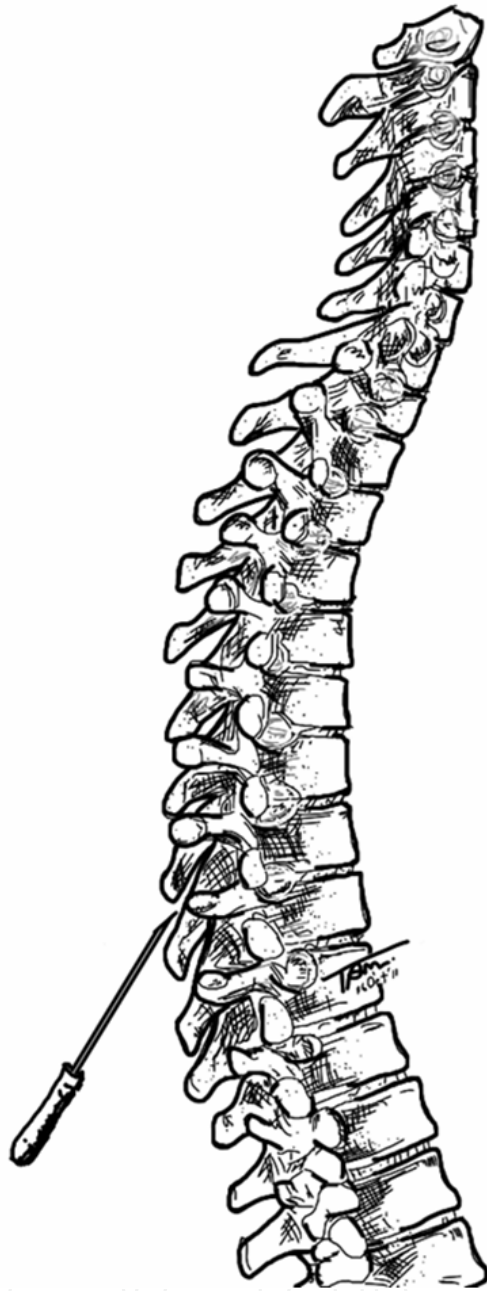


Fig. 2. Anatomy of thoracic spine: the spinous processes of the midthoracic spine have a very caudal angle. The acute insertion in the T7 level should be noted.

3. Epidural test dose

Once the catheter is placed, it is aspirated for the presence of blood or cerebrospinal fluid (CSF). A test dose of 60 mg of lidocaine and 1:200,000 of epinephrine is used to detect misplacement in the intrathecal or intravascular space. An intravenous injection of 15 μ g of epinephrine typically produces an average heart rate increase of 30 beats per minute between 20 and 40 seconds after its administration. (Moore & Batra, 1981) A survey of academic medical centers in the United States found that 83% of the respondents indicated they use a test dose, whereas 6% do not. (Minzter et al., 2002)

4. Drugs used for intraoperative and postoperative analgesia

Several analgesics have been successfully used to provide optimal pain control via the thoracic epidural route. Because of their synergistic effects, combinations of low concentration local anesthetics (LA) with opioids are now standard (Conacher &Slinger, 2003) The choice of LA for continuous epidural infusion varies. Lidocaine is the prototypical LA and is used epidurally in 1.5% to 2% concentrations. However, continuous infusion of lidocaine produces a tachyphylaxis phenomenon and increases the risk of LA toxicity. Bupivacaine remains the most commonly used LA and is commercially available as a racemic mixture of S(-) and R(+) enantiomers, but evidence suggests the R(+) enantiomer has greater cardiotoxicity. Pure S(-) enantiomer levobupivacaine has been developed for a potentially lower cardiotoxic profile. Both drugs provide comparable sensory block features, intraoperative hemodynamics and postoperative analgesia. (Cok et al., 2011) Commercial preparations of levobupivacaine have a 0.563% concentration of the molecule versus 0.5% in bupivacaine. Ropivacaine is another pure S(-) enantiomer that has been shown to be less cardiotoxic than bupivacaine.

Local Anesthetics	Concentration	Two-dermatome regression(min)
Lidocaine	1.5 – 2%	60 - 100
Bupivacaine	0.5 – 0.7%	120 - 240
Levobupivacaine	0.5 – 0.75%	105 - 290
Ropivacaine	0.5 – 1%	90 -180

Table 1. Duration of sensory block for commonly used local anesthetics for epidural Anesthesia

4.1 Opioids

There is no single “best opioid” for epidural analgesia. Each opioid has a different set of pharmacologic properties that determine its effectiveness in a given clinical situation. One of the major properties of the opioids that affects their application for neuraxial analgesia is their lipid solubility (Figure 3). Lipophilic opioids such as sufentanil and fentanyl remain longer within the epidural space by partitioning into epidural fat and thus are found in lower concentrations in CSF than hydrophilic opioids such as morphine. Close titration of epidural local anesthetic and opioids concentrations must be performed to attain a balance between providing optimal analgesia and avoiding unwanted side effects.

5. Methods of drug delivery

Opioids or opioid-local anesthetic combinations can be administered in various methods. Patient-controlled epidural analgesia (PCEA) with a background infusion theoretically offers several advantages over continuous infusion or intermittent bolus methods. Background infusion provides fewer fluctuations in concentration of the analgesic drug, and the patient-controlled mode allows patients to control their analgesia on demand. Nevertheless, methods of drugs delivery also depend on an availability of equipment and the need for careful and repeated assessment by experienced staff. Common epidural regimens for PCEA or continuous infusion are listed in table 3.

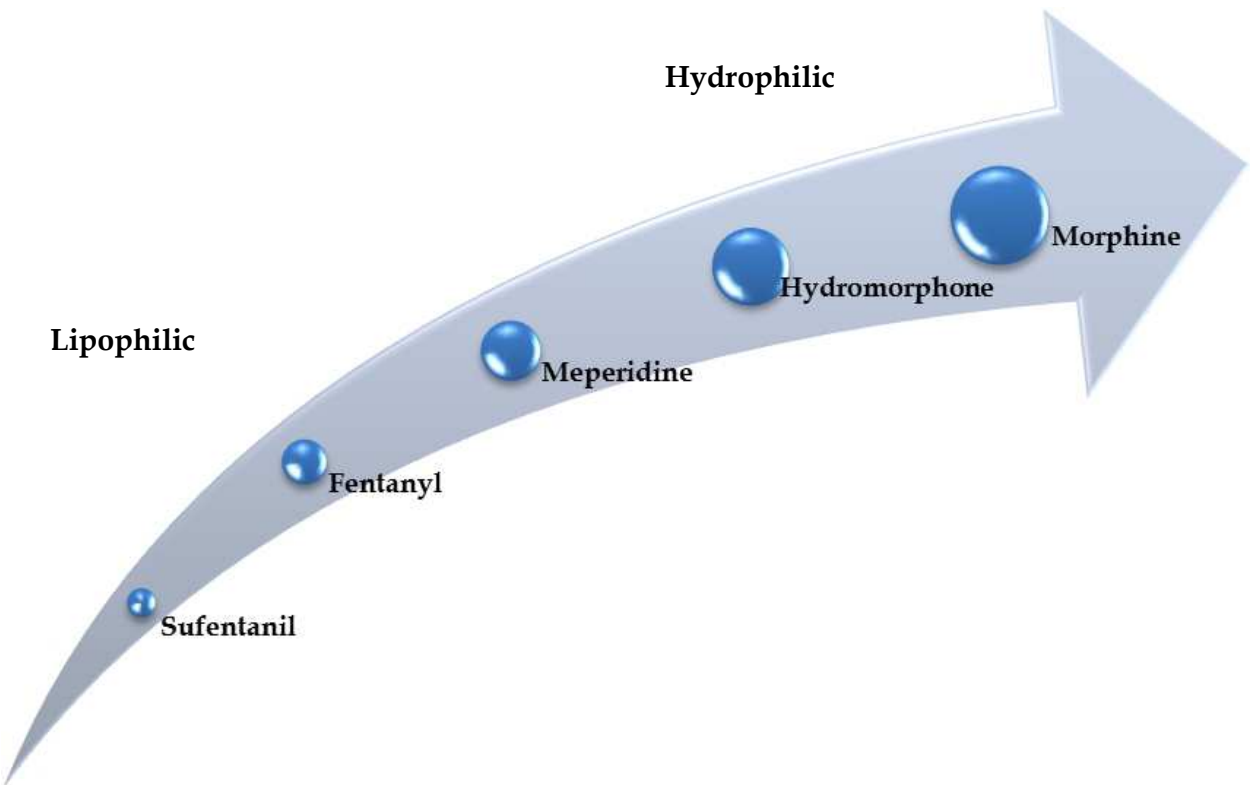


Fig. 3. The lipid solubility of the neuraxial opioids

Agent	Single bolus or intermittent injection		
	Dose	Onset (minutes)	Duration (hours)
Morphine	1-3 mg	20-60	8-24
Fentanyl	25-100 µg	4-10	4-6
Hydromorphone	0.1-0.3 mg	10-15	10-12

Table 2. Commonly used epidural opioids for single bolus or intermittent injection

Regimen	Continuous infusion	PCEA	
	Range (mL/ hour)	PCEA dose (mL.)	Lockout interval (minutes)
0.0625% bupivacaine + morphine 25-50 µg/ mL	5-15 mL/h	1	10
0.0625% bupivacaine + fentanyl 1-10 µg/ mL	5-15 mL/h	1	20
0.0625% bupivacaine + hydromorphone 3-12 µg/ mL	5-15 mL/h	1	20

Table 3. Common epidural regimens

6. Adjuvant drugs

In addition to local anesthetics and opioids, other categories of agents have been investigated for epidural analgesia. All of the following drugs are not part of treatment in routine clinical practice. These include ketamine, clonidine, dexmedetomidine, midazolam, neosigmine and adrenaline. Details of adjuvant drugs are presented in table 4.

Reference	Adjuvant drugs	Dose or concentration	Type of surgery	Results
9	Ketamine	0.4 mg/ mL	Major surgery	Adding Ketamine to routine PCEA regimen provided lower pain score and reduced analgesic consumption.
10	Clonidine	20 µg/ hr	Gynecologic surgery	Improved analgesia during coughing, but was associated with hypotension and bradycardia.
11	Adrenaline	2 µg/ mL	Major surgery	Decrease pain while coughing.
12	Dexmedetomidine (single dose)	1.5 µg/ kg	Vaginal hysterectomy	Provide early onset of sensory analgesia, adequate sedation and prolonged postoperative analgesia when compared to clonidine.
13	Neostigmine	4 µg/ mL	Painless labor	Reduced the hourly bupivacaine requirement.
14	Midazolam (intermittent)	3 mg every 2 hours	Gastrectomy or cholecystectomy	Provide better analgesia, amnesia and sedation than bupivacaine alone.

Table 4. Types and results of adjuvant drugs on epidural analgesia

7. Complications associated with thoracic epidural analgesia

Most complications of TEA are not limited to the thoracic approach. Undesirable effects can occur during either the intraoperative or postoperative periods. In this chapter, complications are categorized into medication-related complications and risks of the thoracic epidural approach.

7.1 Medication-related complications

7.1.1 Complications associated with epidural opioids

Postoperative nausea and vomiting (PONV)

PONV is common, ranging from 3 to 60%. The first factor affecting this unpleasant effect of opioids is the type of opioid as the use of fentanyl is associated with a lower incidence of

PONV than the use of morphine. Secondly, PONV appears to be dose dependent, with lower doses related to lower incidences. Others risk factors of PONV are the female gender, a nonsmoker and a history of PONV. If patients have a high risk of PONV, 4 mg of dexamethasone and an additional antiemetic (12.5 to 25 mg of promethazine, 31.25 to 62.5 mg of dimenhydrinate, or 25 to 50 mg of metoclopramide) are recommended.

Pruritus

The incidence of pruritus ranges from 2 to 38%. Agents that have been used for the prevention and treatment of neuraxial opioid-induced pruritus are opioid antagonists, droperidol, propofol and serotonin receptor antagonists. (Richman & Wu, 2007)

Respiratory effects

Two types of desaturation usually occur after upper abdominal surgery. Constant desaturation has been attributed mainly to a decrease in functional residual capacity by atelectasis, reduction of the diaphragm and intercostal muscle activity, residual anesthetic drugs, and postoperative pain. Episodic desaturation may be related to a disruption of the normal sleep pattern induced by stress from the surgery and anesthesia. Both conditions frequently occur on the second postoperative day and may last longer than a week. A prospective study designed to determine the incidence of desaturation after upper abdominal surgery during the first 48 hours showed that desaturation occurred in 65 out of 171 patients (38%), and risk factors were obesity, epidural analgesia and subcostal incision. Based on the findings, it is reasonable that supplemental oxygen be given to patients undergoing upper abdominal surgery and that neuraxial opioids be administered for at least 48 hours postoperatively. (Siriussawakul et al., 2010)

7.2 Complications associated with local anesthetics

Hypotension

Hypotension from TEA is due to the local anesthetic induced sympathetic blockade, which causes a decrease in systemic vascular resistance and also attenuates the normal cardiac compensatory mechanism. Other causes of hypotension, such as low intravascular volume, bleeding and low cardiac output, must be considered when hypotension occurs. Volume loading (≥ 500 ml.) is frequently utilized prior to performing TEA. Atropine and vasopressor should be used to keep the patient's blood pressure at baseline.

Motor block

The use of local anesthetics for epidural analgesia may result in a lower extremity motor block, and this may lead to the development of pressure sores in the heel. A lower concentration of local anesthetics and TEA may decrease the incidence of motor block. A persistent or increasing motor block should be evaluated promptly if the motor block does not resolve after stopping the epidural infusion for approximately 2 hours.

Local anesthetic systemic toxicity

Local anesthetic systemic toxicity (LAST) results from an unintentional intravascular injection or the rapid absorption of the drugs into the circulation. The target of toxicity is the central nervous system (CNS) and the cardiovascular system (CVS). The CNS is more

sensitive to LAST than the CVS. The clinical feature of intoxication has two stages: excitation and inhibition. CNS toxicity symptoms begin with a numbness of the tongue or circumoral structures, light-headedness, tinnitus, slurring of the speech, muscle twitching or tonic-clonic seizure, followed by drowsiness, a loss of consciousness and apnea. CVS intoxication symptoms are brief tachycardia and hypertension, followed by bradycardia and cardiovascular collapse. The recommendations to minimize the risk of LAST are using a test dose, administering the lowest drug concentration, and close monitoring for signs and symptoms during slow drug injection.

Urinary retention

Urinary retention may be associated with both local anesthetics and opioids interfering with detrusor muscle contraction and decreasing the sensation of urgency. Bladder function impairment will resolve when the block has regressed to the third sacral segment. Use of TEA, a low infusion rate and a low concentration of continuous epidural analgesia may result in a low incidence of urinary retention and diminish the need for bladder catheterization.

7.3 Risks of thoracic epidural approaches

Close proximity of the spinal cord, a narrower epidural space and a thinner ligamentum flavum make TEA more intimidating than via lumbar epidural approaches. Nevertheless, the placement of thoracic epidural catheters is relatively safe. There is no evidence of a higher incidence of neurologic complication compared to the placement of lumbar epidural catheters. Giebler et al report complications related to thoracic epidural catheterization in 4,185 patients. The overall incidence in this study was 3.1%. Adverse events included unsuccessful catheter placement, inadvertent dural puncture, postoperative radicular pain and peripheral nerve lesions (peroneal nerve palsy probably related to surgical position). There was no report of epidural hematoma or permanent sensory or motor defects. (Giebler et al, 1997) There were a few reports of an accidental intrapleural catheter placement and pneumothorax. (Cordone et al., 2007)

8. Conclusion

Epidural analgesia provides favorable outcomes after upper abdominal surgery. The success and safety of the procedure rely on expertise in the procedural, pharmacologic and physiologic aspects of epidural technique.

9. Appendix: Postoperative order for TEA

Thoracic Epidural Analgesia Order (Adult)
Name: Date:
Diagnosis: Age: Weight:
Site of catheter insertion:

Access:

☐ Median

☐ Paramedian

Injection level: T.....

Catheter length in space:cm. Mark at skin:cm

Method of drug delivery:

☐ Single shot

Opioid:

☐ Morphine

☐ Fentanyl

☐ Other

Local anesthetic:

☐ Bupivacaine

☐ Levobupivacaine

☐ Ropivacaine

☐ Other

Concentration% Loading dose ml Loading time

☐ Intermittent

	First dose	Second dose	Third dose	Forth dose
Time				
Opioids <div>- Type</div> <div>- Dose</div>				
Local anesthetics <div>- Concentration (%)</div> <div>- Loading dose (mL)</div>				
Signature				

☐ Continuous epidural

☐ Local anesthetic:%mL

☐ Addition:

☐ Morphine..... mg./ mL

☐ Fentanylµg/ mL

☐ Other.....

Infusion rate: mL/ hr

☐ Patient control epidural analgesia (PCEA)

Opioid :

☐ Morphine

☐ Fentanyl

☐ Other.....

Local anesthetic:

☐ Bupivacaine

☐ Levobupivacaine

☐ Ropivacaine

☐ Other.....

Concentration Loading dose mL.

Loading timeBasal ratemL/ hr PCEA ratemL/ hr

Lockout interval.....minutes 4 hour limit.....mL

Orders for monitoring and management of adverse effects
Respiratory monitoring <ul style="list-style-type: none">- Record respiratory rate every hour for the first 12 h, every 2 h for the next 12 h, then every 4 hours until discontinue treatment.- Notify acute pain service immediately, for respiratory rate less than 6/ minute, place supplemental oxygen 8- 10 LPM via oxygen mask with bag and administer naloxone 0.2 mg IV repeat dose every 5 minute if respiratory rate less than 6/ minute
Inadequate analgesia (Numerical rating scale ≥ 4) <input type="checkbox"/> Pethidine 20 mg IV prn q 2h <input type="checkbox"/> Other <input type="checkbox"/> Notify acute pain service
Nausea and vomiting <input type="checkbox"/> Ondansetron <input type="checkbox"/> 4 mg <input type="checkbox"/> 8 mg IV prn q 8h <input type="checkbox"/> Metoclopramide mg IV prn q 6h <input type="checkbox"/> Other
Pruritus <input type="checkbox"/> Diphenhydramine (25 mg/ 10 ml or cap) <input type="checkbox"/> Syrup 10 mL <input type="checkbox"/> 1 cap oral prn q 6h <input type="checkbox"/> Chlorpheniramine 10 mg IV prn q 6h <input type="checkbox"/> Other
Urinary retention <input type="checkbox"/> Keep indwelling urinary catheter in place until discontinuation of epidural analgesia <input type="checkbox"/> Other.....

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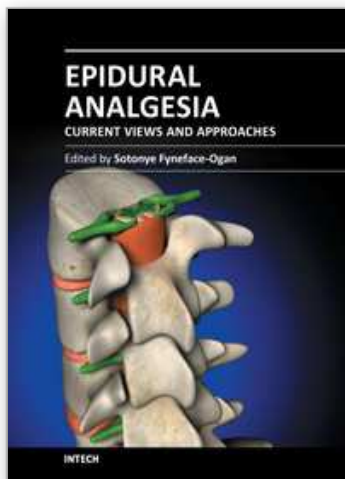
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Epidural analgesia is a form of pain relief administered through the space surrounding the dural sheath either by direct injection or via catheter. The agent, when administered, can cause both a loss of sensation (anesthesia) and a loss of pain (analgesia), by reversibly interrupting the transmission of signals through nerves in or near the spinal cord. This form of pain relief has been found useful in many clinical situations. This book intends to provide an in-depth review of the current knowledge on epidural analgesia. The use of this form of analgesia is explored by contributors from different perspectives, including labor and delivery, postoperative analgesia in both pediatric and geriatric patients, and its role during anesthesia and surgery. In order to provide a balanced medical view this book was edited by an obstetric anesthesiologist.

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