Section 3: Neuraxial Anesthesia

A. General Information
B. Spinal Anesthesia
C. Epidural and Caudal Anesthesia
D. Assessing level of blockade
E. Complications

Section 3: General Information - Indications

Neuraxial anesthesia is the name used for spinal, epidural and caudal blocks.

Each of these different blocks can be achieved either with a single injection or through intermittent boluses or constant infusions delivered through a catheter.

Indications for neuraxial blockade include:

1) Surgery of lower abdominal, inguinal, urogenital, gynecologic and rectal regions and the lower extremity including orthopedic and vascular procedures
2) Obstetrics
    - Labor analgesia
    - Surgical anesthesia for c-sections
3) Post-operative pain control
    - Thoracic surgery
    - Major abdominal surgery
    - Orthopedic surgery (hip, knee)
4) Pain Control
    - Rib fractures

General Information - Contraindications

- Absolute:
  - -patient refusal
  - -bleeding diathesis
  - -infection at the proposed site of injection
  - -severe hypovolemia
  - -elevated intracranial pressure
- Relative:
  - -sepsis
  - -uncooperative patient
  - -severe spinal deformity
  - -demyelinating lesion
  - -severe stenotic heart valvular disease or ventricular outflow obstruction
- Controversial:
  - -prior back surgery at injection site
  - -prolonged and complicated operation with severe blood loss

General Information - Sites of Action

The main site of action for neuraxial blockade is the nerve root.

In *spinal blocks*, LA is injected around the nerve root in the *subarachnoid space.* Direct injection into the CSF allows a relatively small dose and volume to achieve a dense sensory and motor blockade.

In *epidural and caudal blocks*, LA is injected into the *epidural space* to bathe the nerve root. In contrast to spinal blocks, a higher volume and dose of LA is needed to achieve the same concentration of LA.

General Information - Mechanism of Action

Conduction blockade of posterior nerve roots interrupts somatic and visceral sensation whereas blockade of anterior nerve root fibers prevents efferent motor and autonomic transmission.

<u>Somatic and Motor Blockade</u>

Blocking painful stimuli and abolishing skeletal muscle tone is ideal for surgical procedures, providing analgesia and muscle relaxation.

The mechanism of action of LAs and differences in nerve fiber type has been discussed in previous sections. Briefly, smaller and myelinated fibers are blocked before larger, unmyelinated fibers. This and the fact that the concentration of LA decreases with increasing distance from the site of injection leads to the phenomenon of differential blockade:

-sympathetic blockade (tested by temperature) occurs two levels above . . .

-sensory blockade (tested by pin prick or light touch) occurring two levels above . . .

-motor blockade

<u>Autonomic Blockade</u>

Interruption of efferent autonomic transmission at spinal nerve roots produces sympathetic and some parasympathetic blockade. Sympathetic nerve fibers exit from T1-L2 (thoracolumbar) while parasympathetics exit with cranial and sacral nerves (craniosacral).

Neuraxial anesthesia does not block the Vagus nerve.

What results from blockade is either decreased sympathetic tone or unopposed parasympathetic tone.

General Information - Organ System Effects

Cardiovascular

Due to sympathetic blockade, neuraxial blocks produce varying degrees of decreased blood pressure, heart rate and cardiac contractility depending on the level of sympathectomy.

Vascular tone is determined mainly by sympathetic fibers arising from levels T5-L1 which innervate vascular smooth muscle. Blockade of these fibers results in venous vasodilation, pooling of blood, and decreased venous return to the heart. Compensatory vasoconstriction at levels above the block may compensate for this vasodilation.

Blockade of higher levels (T1-T4) prevents compensatory vasoconstriction and interrupts sympathetic fibers leading to compensatory tachycardia. The resulting hypotension and bradycardia (unopposed vagal or parasympathetic tone) can result in the sudden cardiac arrest sometimes seen with spinal anesthesia.

Clinical Pearl: To avoid hypotension and bradycardia, volume load, place patient in supine position, and if a gravid uterus is present place patient in lateral decubitus to avoid obstruction of venous return.

Pulmonary

Pulmonary manifestations are generally minimal in healthy patients as the diaphragm is innervated by C3-C5. In patients with little pulmonary reserve, however, who depend on accessory muscles for respiration, higher blockade will impair these muscles. Coughing and clearing secretions also depends on these muscles for expiration.

Neuraxial Blocks - Organ System Effects

Gastrointestinal

Unopposed vagal tone via sympathetic blockade from T5-L1 results in a contracted gut with active peristalsis. This is a helpful adjunct to general anesthesia in laparoscopic surgery.

Urinary Tract

Neuraxial anesthesia at the lumbar and sacral levels blocks both sympathetic and parasympathetic outflow to the bladder. This results in urinary retention until the block wears off.

Metabolic and Neuroendocrine

Surgical manipulation evokes the stress response leading to an increase in ACTH, cortisol, epinephrine, norepinephrine, and ADH levels as well as the activation of the renin-angiotensin-aldosterone system. This leads to intra- and post-operative hypertension, tachycardia, hyperglycemia, protein catabolism, suppressed immune responses and altered renal function. Neuraxial anesthetic techniques can wholly or partially block this response if initiated before and continued after surgery.

Section 3B: Spinal Anesthesia - Technique

Spinal anesthesia blocks nerve roots as they course through the subarachnoid space which runs from the foramen magnum to S2 in adults. Insertion of the needle below L1 avoids direct trauma to the spinal cord.

<u>Spinal Needles</u>

Spinal needles come in a variety of sizes (gauge and length) as well as bevel and tip designs.

Cutting needles:

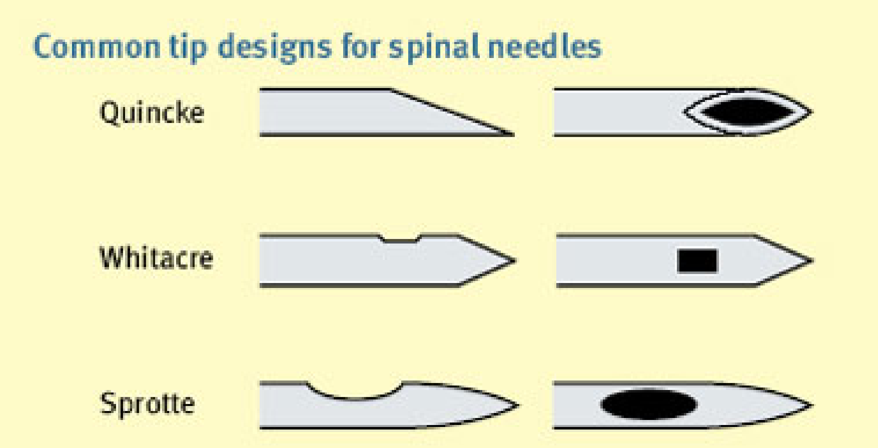
The Quincke is a cutting needle with end injection.

Blunt-tipped needles:

The Whitacre has a rounded point with side injection.

The Sprotte is also side injection with a longer opening.

Blunt tipped needles are believed to carry less of a risk of spinal headache. Smaller gauge needles also lower the risk.



http://www.anaesthesiauk.com/images/lumbar-fig1.jpg

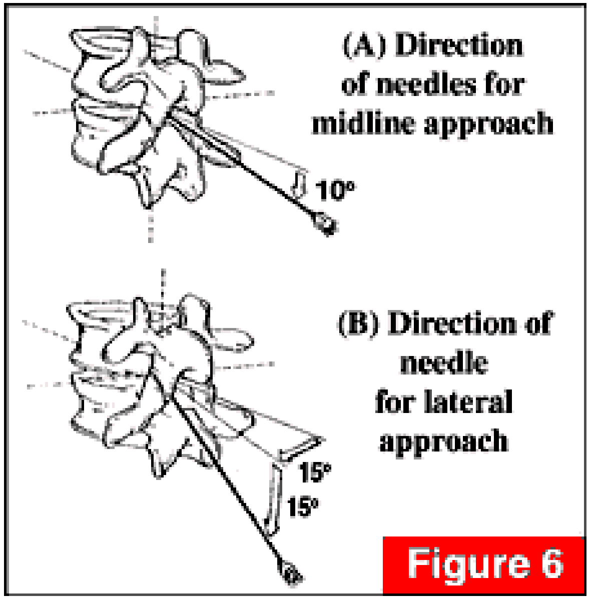
Spinal Block - Technique

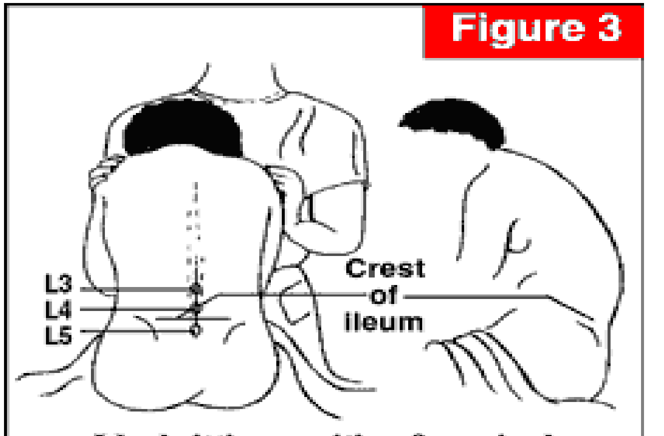
Midline, paramedian, and prone approaches can all be used.

After positioning, draping and preparing patient using sterile techniques, local anesthetic is applied subcutaneously.

The needle is advanced until two “pops” are felt, one as the needle penetrates the ligamentum flavum and one as it penetrates the dura mater.

Successful puncture is confirmed by withdrawing the stylet and getting the free flow of CSF.





Ideal sitting position for spinal anaesthesia

http://www.nda.ox.ac.uk/wfsa/html/u03/u03_005.htm

Spinal Anesthesia - Factors affecting level of the block

Baricity

Baricity of a LA solution is its specific gravity relative to that of CSF. A hyperbaric solution is more dense than CSF while a hypobaric solution is less dense.

In general, the higher the level of injection, the higher the level of the block.   However, when a hyperbaric solution is injected into a patient in the head down position, it will migrate cephalad, and vice versa. Likewise, a hypobaric solution will move caudad.

The same holds true when a patient is in the lateral decubitus postion-a hyperbaric solution will move towards the dependent side while the hypobaric solution to the non-dependent.

With normal spinal anatomy, the apex of the thoracolumbar curvature is T4 (*link to prior slide*). When the patient is in the supine position, this should limit a hyperbaric solution spread and level of block to T4 or below.

Positioning

As described above level of anesthesia is dependent on patient positioning. If the patient is seated for 3-5 minutes after injection of a hyperbaric solution into the lumbar region, only the lumbar and sacral nerves are blocked.

Moving the patient from seated to supine immediately following injection moves the solution more cephalad.

A patient can also be placed in the lateral decubitus position if unilateral block is desired (the hyperbaric solution will move to the operative side if the patient is appropriately positioned.)

Spinal Anesthesia - Factors affecting level of the block

<u>Local Anesthetic and dosage</u>

In general, the higher the dosage, the higher the level of the block.

Hyperbaric bupivacaine and tetracaine are two of the most commonly used agents.

Both are relatively slow in onset (5–10 min) and have a prolonged duration (90–120 min).

Tetracaine generally produces more motor blockade than the equivalent dose of bupivacaine.

Addition of epinephrine to spinal bupivacaine prolongs its duration only modestly.

In contrast, epinephrine can prolong the duration of tetracaine anesthesia by more than 50%.

<u>Other factors potentially affecting level of block</u>

Age

CSF volume

Curvature of spine

Drug volume

Intraabdominal pressure

Needle direction

Patient height

Pregnancy

Commonly Used LAs for Spinal Anesthesia

Drug	Preparation	Duration (min)	Duration with Epinephrine (min)
Procaine	10%	45	60
Bupivacaine	0.75% in 8.25% dextrose	90-120	100-150
Tetracaine	1% solution in 10% glucose	90-120	120-240
Lidocaine	5% in 7.5% glucose	60-75	60-90
Ropivicaine	0.2%-1.0% solution	90-120	90-120

Adapted from Morgan and Mikhail’s Clinical Anesthesiology, 4th edition.

Section 3C: Epidural Anesthesia - Technique

Epidural anesthesia blocks nerve roots as they travel in the epidural space surrounding the dura mater posteriorly, anteriorly and laterally.

It can be used as a single injection technique as with spinal anesthesia, and can also be performed with catheter placement allowing intermittent bolusing or continuous infusion.

An epidural block can be performed at any level of the spinal cord or below.

- Lumbar spine-Used for any procedure below the diaphragm.
- Thoracic spine-More difficult than lumbar blocks due to greater angulation and overlapping of spinous processes. Risk of dural puncture is also greater. Technique is used for intra- and pos-operative analgesia and can involve single injection or catheter dosing. *Often used for chest surgery.
- Cervical spine-This technique is mostly used for chronic pain management.

Compared to spinal blocks, epidural blocks are slower in onset and may be less dense leading to the clinically useful phenomenon of differential blockade.

Clinical Pearl: Combining a dilute LA with an opioid can block the smaller sympathetic and sensory fibers and spare the larger motor fibers resulting in pain relief without muscle paralysis. This is particularly useful in labor and postoperative analgesia.

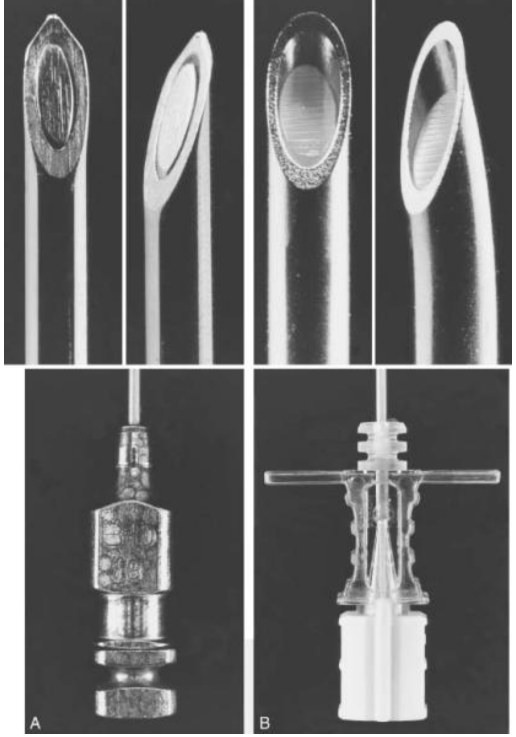
As the epidural space is more restricted than the subarachnoid space (a true potential space), CSF does not spread the LA as much thereby creating a segmental block in which the nerve roots above and below are not blocked.

Epidural Needles

The epidural needle is typically 16-18G, 8cm long with surface markings at 1cm intervals. Shown here are two types of epidural needles.

At left, the Crawford with a straight needle allowing slightly easier insertion of catheter but with a greater risk of dural puncture.

At right, the more commonly used Tuohy needle whose curved end pushes the dura away after penetrating the ligamentum flavum.



From Miller: Miller's Anesthesia, 6th ed.

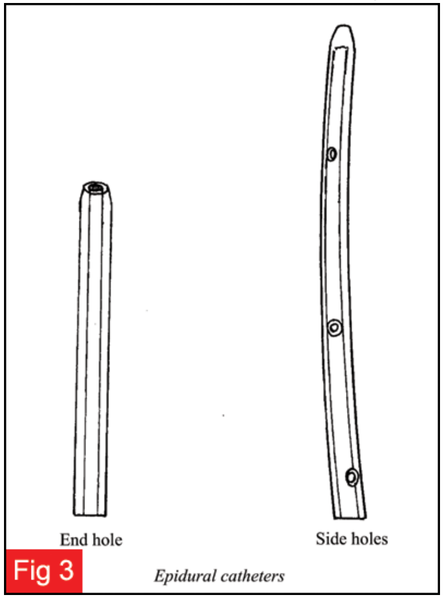
Epidural Catheters

Epidural catheters are used for intra-operative anesthesia or postoperative analgesia.

Epidural catheters are designed to pass through the lumen of the needle, are generally 25 gauge, and have either a single end-hole or a number of side holes at the distal end.

After advancing the catheter through the needle to the desired depth, the needle is removed leaving the catheter in place.

The catheter is then secured along the back with tape.



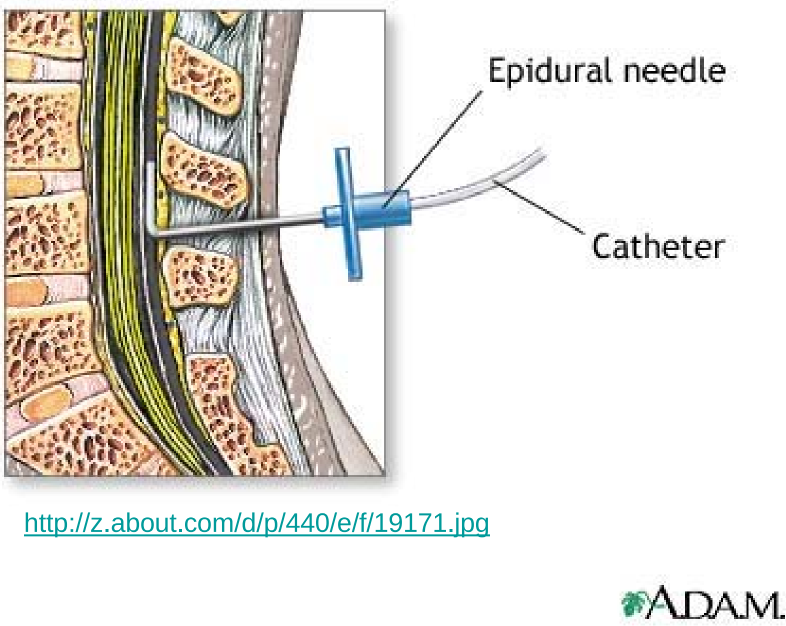
http://www.nda.ox.ac.uk/wfsa/html/u13/u1311_02.htm

Epidural Anesthesia - Technique

As with spinal anesthesia, the patient is properly positioned and sterilely prepared while identifying the level desired using anatomic landmarks.

The needle is then passed through the same layers as with spinal anesthesia, but stopped short of entering the dura.

To ensure the dura has not been penetrated, one commonly used technique is “loss of resistance:”



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Loss of Resistance technique:

1) The needle is advanced with stylet in place until increased tissue resistance indicates that the interspinous ligament is entered.

2) The stylet is removed and replaced with a glass syringe containing about 2 mL of fluid or air.

3) If needle tip is in ligament, gentle pressure on syringe is met by resistance. Then the needle is slowly advanced until the tip of the needle just enters the epidral space and there is a loss of resistance to gentle pressure on the syring and injection is easy.

Activating an Epidural

The volume and concentration of LA needed for an epidural are much larger compared with spinal anesthesia.

As a result, significant systemic toxicity can result if it is injected intrathecally or intravascularly.

The Test Dose

This is designed to detect both subarachnoid and intravascular injection.

The test dose combines a LA, typically Lidocaine, with epinephrine. When injected, this should produce spinal anesthesia that is rapidly felt if injected in the subarachnoid space.

If intravascular injection occurs, the epinephrine should produce a 20% or greater increase in heart rate with or without hypertension within 30 seconds.

Clinical Pearl: Patients on beta-blockers may have minimal to no increase in heart rate increase with epinephrine.

Other Safety Measures

Aspiration prior to injection is commonly used, though not fool-proof. In addition, incremental dosing is also an effective method of avoiding serious complications caused by systemic vascular injection or intrathecal injection.

Section 3B: Caudal Technique

A caudal block follows the same principles as epidural anesthesia in that the caudal space is the epidural space in the sacral portion of the spinal canal.

It is the most commonly used technique in pediatric patients and, in adults, is used for anorectal surgery.

Please review slide on anatomy of this region and techniques for locating the sacral hiatus. (*link to prior slide).*

<u>Technique</u>

1) Children are most often placed prone in lateral decubitus position and adults in operative jack-knife position allowing easier palpation of the sacral hiatus.

2) After sterile skin preparation, a needle is inserted at a 45-90 degree angle cephalad until a "pop" is felt as the sacrococcygeal ligament is pierced (this is a continuation of the ligamentum flavum.

   Clinical Pearl: In the elderly, this ligament can be so calcified as to make the procedure impossible to perform safely.

3) The needle angle is then flattened and advanced.

4) Aspiration for blood and CSF is performed, and if negative, injection is performed.

It should be noted again that, in children, the dural sac extends to S3 whereas in adults only to S1.

Factors Affecting Level of Blockade

These are not so clear-cut as in spinal anesthesia.

Dosage of LA-One acceptable guideline is 1-2 mL of LA per segment to be blocked, in adults.

For example, if injecting at L4-L5 and desiring sensory blockade to T4, 12-24 mL would be injected.

It is optimal to place the epidural at the level that correlates with the dermatomal level of the incision, e.g., an umbilical incision would be well-served by a T10-11 epidural.

Age-The dose required decreases with age. This is likely due to decreases in compliance or size of the epidural space.

Patient height-It has been observed that shorter patients may require less LA (1 mL per level as opposed to 2mL) than taller patients due to the extent of cephalad spread.

Gravity-Though less than with spinals, patient position can affect spread of LA.

Additives-Addition of epinephrine improves the duration and quality of block, more with lidocaine, mepivicaine, and chloroprocaine than with bupivacaine, etidocaine and ropivacaine.

In addition, epinephrine decreases vascular absorption and peak blood levels of LAs.

Commonly Used LAs for Epidural Anesthesia

Agent	Concentration	Onset	Sensory Block	Motor Block
Chloroprocaine	2% 3%	Fast Fast	Analgesic Dense	Mild to Moderate Dense
Lidocaine	</=1% 1.5% 2%	Intermediate Intermediate Intermediate	Analgesic Dense Dense	Minimal Mild to Moderate Dense
Mepivacaine	1% 2-3%	Intermediate Intermediate	Analgesic Dense	Minimal Mild to Moderate
Bupivacaine	</=0.25% 0.5% 0.75%	Slow Slow Slow	Analgesic Dense Dense	Minimal Mild to Moderate Moderate to Dense
Ropivacaine	0.2% 0.5% 0.75-1.0%	Slow Slow Slow	Analgesic Dense Dense	Minimal Mild to Moderate Moderate to Dense

Section 3D: Assessing Level of Blockade

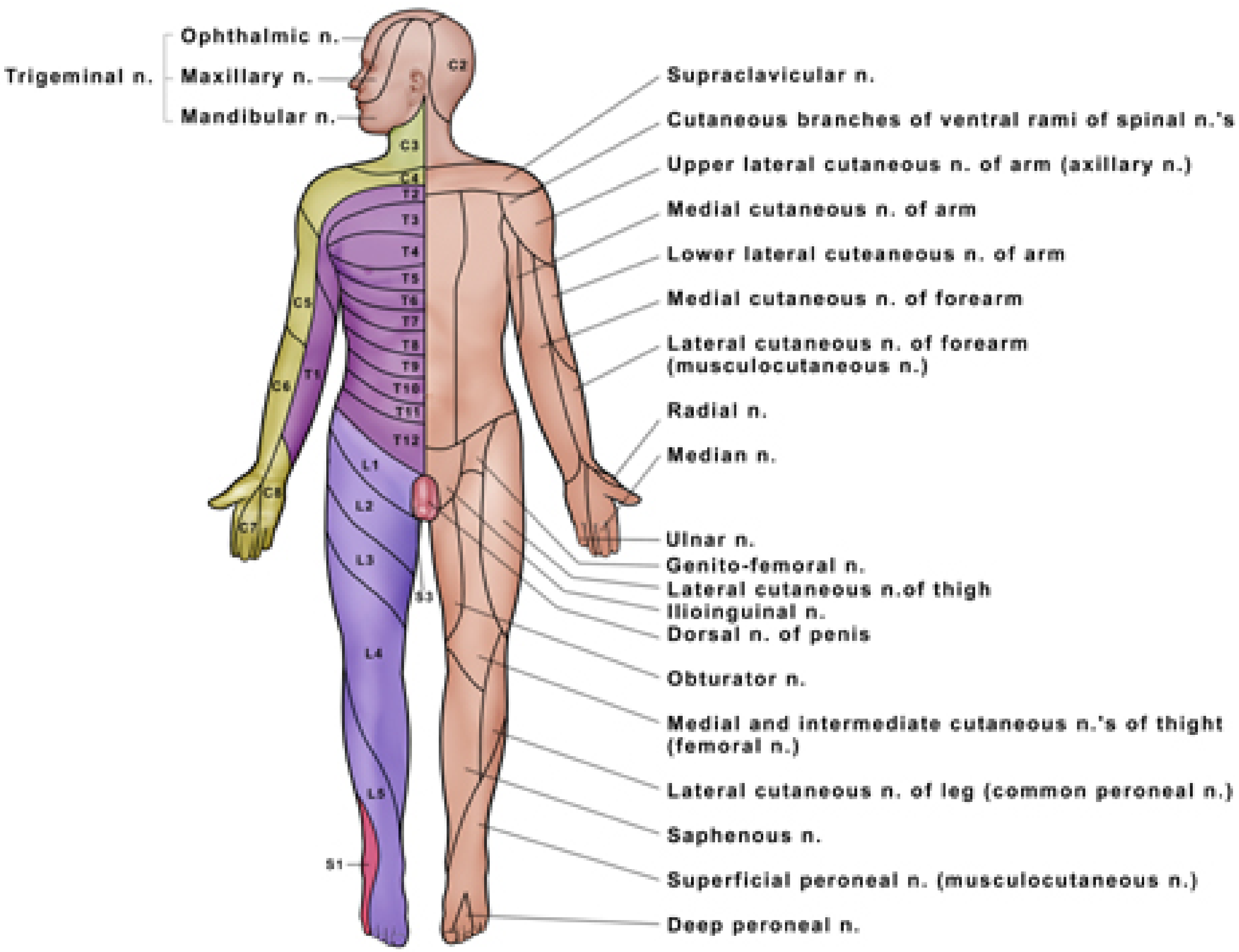
With knowledge of the sensory dermatomes one can test sensory level achieved by the block using pinprick, and somatic level by assessing skin temperature sensation.

Clinical Pearl: Keeping a supply of tongue depressors to break provides one with a sharp device to test pain sensation. A glove filled with ice can be used to test temperature sensation.

Section 3E: Complications of Neuraxial Blocks

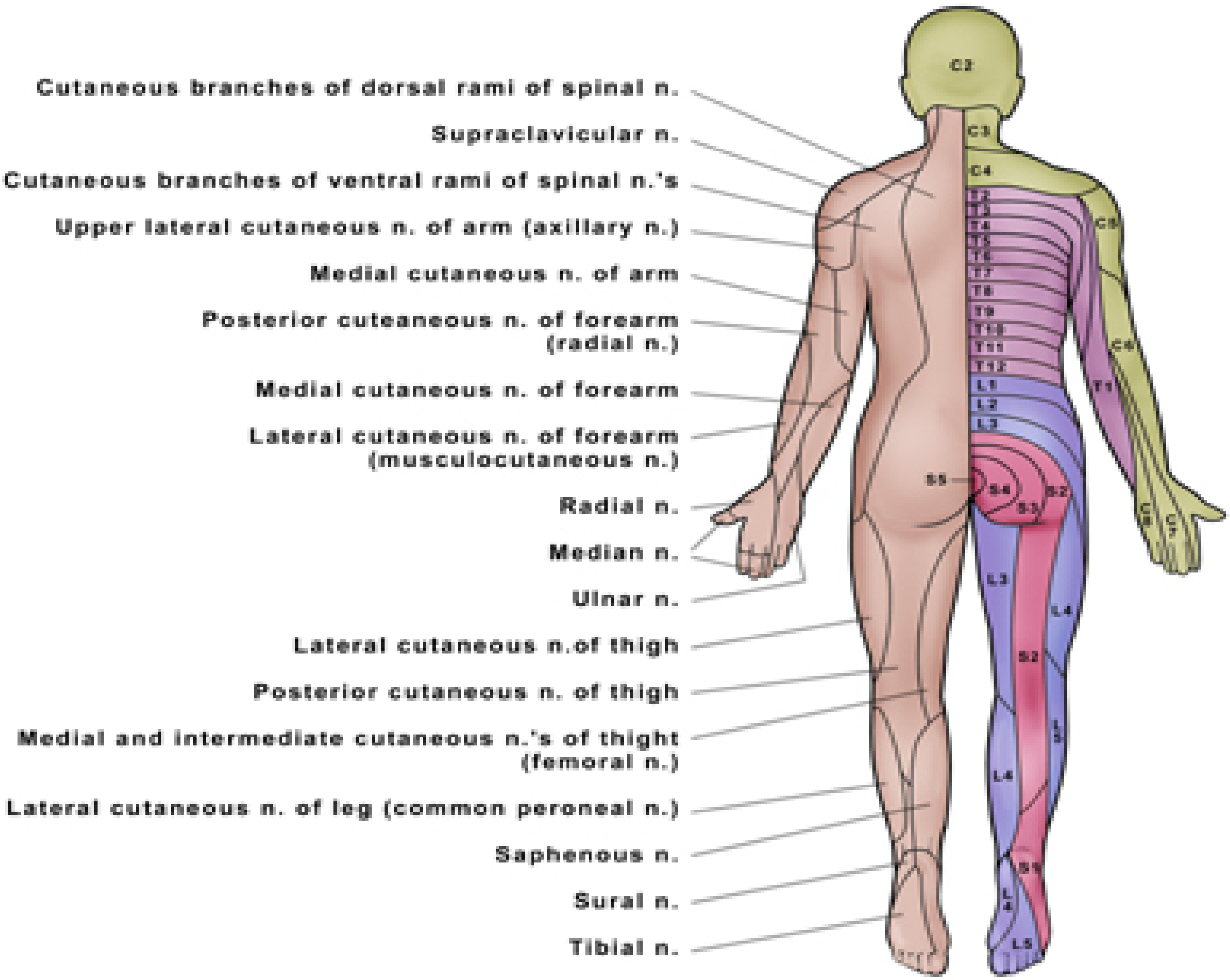
Adverse or Exaggerated Physiologic Responses	
Urinary Retention	Cardiac Arrest
High block	Anterior spinal artery syndrome
Total spinal anesthesia	Horner's syndrome
Complications Related to Needle/Catheter Placement	
Trauma	Misplacement
Backache	No effect/inadequate anesthesia
Dural puncture/leak	Subdural block
Postdural puncture headache	Inadvertent subarachnoid block
Diplopia	Catheter Shearing/Retention
Tinnitus	Inflammation
Neural Injury	Arachnoiditis
Nerve root damage	Infection
Spinal cord damage	Meningitis
Cauda equina syndrome	Epidural abscess
Bleeding	
Intraspinal/epidural hemorrhage	
Drug Toxicity	
Systemic local anesthetic toxicity	
Transient neurologic symptoms	
Cauda Equina Syndrome	

Dermatomes and peripheral nerves-anterior view



http://www.regionalabc.org/images/med-illustartion/ant-dermatome.jpg

Dermatomes and peripheral nerves-posterior view



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