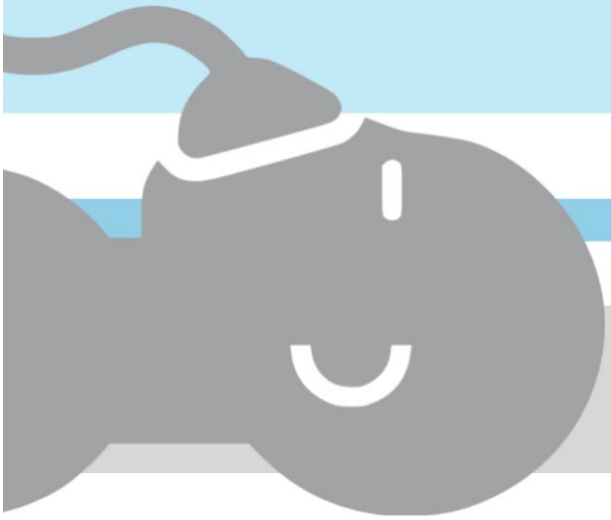

ANESTHESIA

(10) Regional Anesthesia

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Doctor's note Team's note Not important Important 431 teamwork

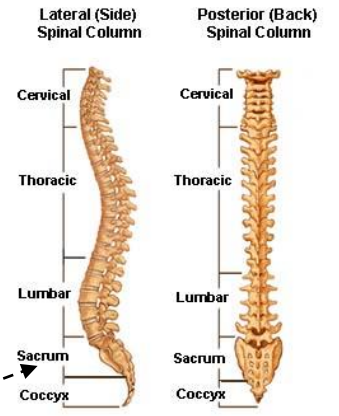
(431 teamwork do not highlight it in yellow, but put it in a yellow "box")

The doctor refused to give his slides however; all notes are written in this document.

I would recommend reading the topic from the anesthesia book first then going through the team work.

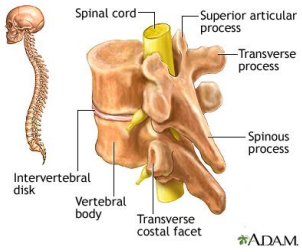
Special thanks to Lama Alfraidi and Norah Alneghemish for helping me with their notes. <3

Regional Anesthesia

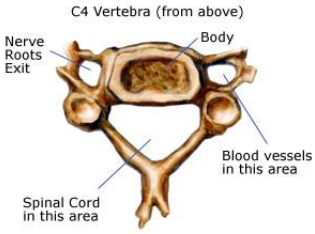


- **Vertebral column** surrounds the spinal cord and **is formed by**:
  - 7 Cervical vertebrae (lordosis)
  - 12 Thoracic (kyphosis)
  - 5 Lumbar (lordosis)
  - 5 fused sacral vertebrae
  - Coccyx

- **Neuroaxial anesthesia includes:** spinal anesthesia (SA), epidural anesthesia (EA), combined spinal and epidural and caudal block.
- More than 95% of the neuroaxial anesthesia happens here
- First palpable vertebra is C2.



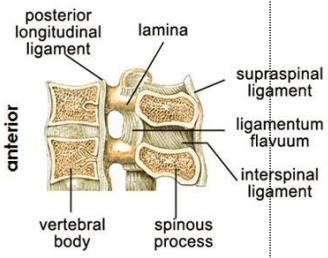
- **The most prominent vertebra in the neck is** C7. It intersects with the tip of scapula.
- Blade of the scapula intersects with T3 vertebra.
- Spinous processes are the protruded bony structures that are felt on palpation of the spine.
- Spinal nerves exit from intervertebral formina .
- The patient should flex their back during the procedure to convert lordosis into kyphosis giving a wider interlaminal space for needle insertion.
- Lumbar lordosis increases in pregnancy.
- **We have four articular processes**: 2 superior and 2 inferior, they articulate to form facet joints.
- Lamina is the part that connects transverse processes with spinous processes. Pedicles connect between transverse process and vertebral body.



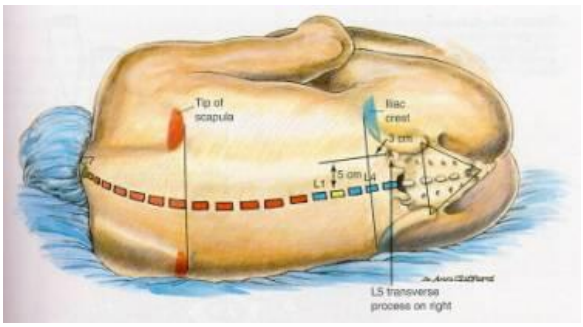
- Cervical vertebrae (from C1-C6) have bifid spinous and transverse processes.
- C1-C6 have a unique bony canal through which vertebral arteries pass. It serves in the protection of vertebral arteries in the neck.
- Spinous processes lie horizontal in lumbar spine but are slanted caudally in thoracic spine. This prompts changing the angle of the needle upon insertion.
- The widest interlaminal space is located between L5 and S1.
- Ventral root of the spinal cord gives motor nerves (efferent) while the dorsal root gives sensory nerves (afferent).
- Sympathetic fibers come out of the lateral horn then exit through the ventral root along with motor fibers.
- **T1-L2** → sympathetic outflow (Thoracolumbar).
- **C3, C7, C9, C10, S2, S3, S4** → parasympathetic outflow (craniosacral).

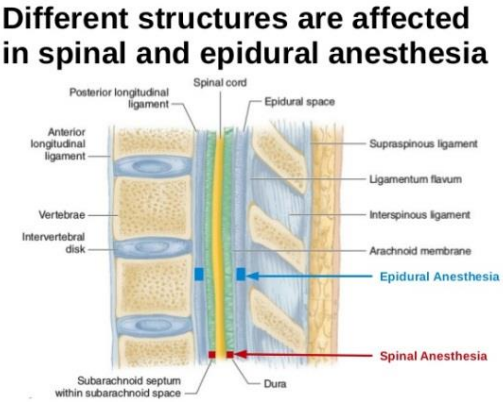
- **Superior posterior iliac spines**: an extremely important bony landmark that appears as two depressions at the back. If you draw a line from left to right superior posterior iliac spines, it will bisect **S2** → *Where the dura ends*.
- **Ligamentum nuchi** → above C7.
- **Supraspinous ligament** starts from C7 and down to L5.
- Supraspinous ligament is continuous while interspinous and ligamentum flavum are interrupted.
- Ligamentum flavum stops before S5. → not penetrated in caudal anesthesia.
- **Interspinous ligament** connects spinous processes above and below.
- **Ligamentum flavum** conncets lamina above and below.
- **Layers:**

  Skin → subcutaneous tissue → supraspinous ligament →interspinous →ligamentum flavum → epidural space → dura →arachnoid membrane → subarachnoid space (Intrathecal/spinal) → Pia matter → spinal cord.



- Anterior and posterior longitudinal ligaments support the spine.
  Disc herniates laterally because it cannot push posteriorly or anteriorly against these ligaments.
- **Spinal cord** ends at **L3** in children but at **L1-L2 in adults.**
- There are only **four** spaces for spinal anesthesia: L2/L3 – L3/L4 – L4/5 – L5/S1 → Spinal anesthesia is **not performed above L2.**
- **Filum terminalie** is an extension of pia matter that ends in coccyx.
- **Conus medullaris** is the lower end of spinal cord at L1. **Cauda equina** comes after it.
- MCQ: **Tuffier's line (intercrestal line)** → If I draw a line connecting iliac crests it is going to cross **L4**.





Caudal Anesthesia:

- Caudal space is located at **S5** where lamina fail to fuse. It is covered by skin and subcutaneous tissue. Mainly used in pediatrics.
- **Layers:**

  Skin → subcutaneous tissue → Sacrococcygeal membrane (Sacral hiatus): an extension of ligementum flavum that covers caudal space → Epidural space.
- Sacrococcygeal membrane covers the caudal space and is an extention of ligementum flavum but not a parts of it.

- Caudal anesthesia is difficult to be performed on women because 99% of females have a fatty hump on top of S5.
- **Caudal anesthesia** is considered a very low level epidural anesthesia **NOT** spinal.

Spinal and Epidural Anesthesia:

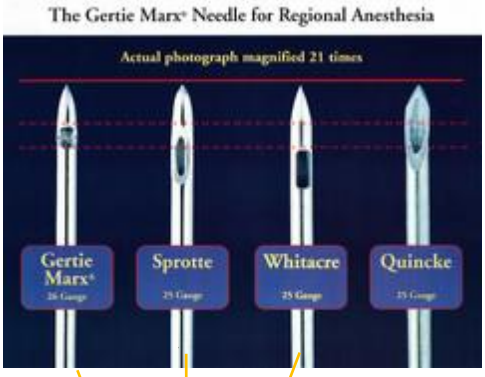
- Subarachnoid space is a continuous space that contains CSF, spinal cord and nerves.
- CSF is a clear fluid that fills subarachnoid space.
  - Total volume is ~ 100 -150 ml = 2 ml/kg
  - In pediatrics ~ 4ml/kg
  - Roughly half of it is in the brain and the other half in the spinal cord.
  - Continually produced at a rate of 450 ml/24 hrs
  - Reabsorbed into the blood stream by subarachnoid villi.
  - **Specific gravity (density, baricity)** = 1.003 – 1.007.
    Baricity plays a crucial role in choosing the local anesthetic agent for spinal anesthesia.
  - CSF volume contributes to the variability in response to spinal anesthesia.
- **Body weight** is the only measurement that correlates with CSF volume. → Obese and pregnant women have less volume of CSF. Thus, the anesthetic dose should be reduced.
- **Epidural veins** are connected to body venous system. In case of increased intra-abdominal pressure (ascites, mass, or pregnancy), abdominal veins will be compressed → epidural veins will become engorged creating a smaller space.
- **In pregnant women**, the epidural space is narrowed because of the engorged veins.
- **Progesterone** increases local anesthetic sensitivity. For this reason, the dose of anesthetic agent is reduced to almost half in pregnant women.
- **Pia matter** is highly vascular and directly covers the spinal cord. It is attached the periosteum of the coccyx as filum terminalis. It is irrelevant in regional anesthesia because it cannot be accessed.
- **Dura matter** extends from foramen magnum to S2 (superior posterior iliac spine).
- **Epidural space** extends from foramen magnum to sacral hiatus.
- **Contents of epidural space**: Nerve, fat, lymphatics, vessels including batson venous plexus.
- **Epidural space** has a negative pressure because epidural veins are valveless and are connected to systemic veins (such as azygous, thoracic veins) which transmit negative pressure .
- If you penetrate ligamentum flavum you enter the epidural space. If you continue and penetrate the dura you will get CSF leakage which is spinal.
- **Indications:**
  Pelvic, gynecological, hernia repair, urological, orthopedic, any operations involving perineum or genitalia.

- **Absolute contraindications:**
  - Patient's refusal,
  - Infection at injection site → seen in immobilized patients who develop bed sores.
  - Coagulopathy & anticoagulants use (warfarin, heparin, clexane) *aspirin use is not a contraindication for spinal anesthesia according to guidelines.
  - Severe hypovolemia → because spinal/epidural anesthesia cause hypotension as a side effect and thereby worsen the condition in case of hypovolemia.
  - Increased ICP.
  - Severe aortic/mitral stenosis → because these patients cannot tolerate hypotension.
- **Relative contraindications**: (use your best judgment.)
  - For example: A patient who has done a previous spinal orthopedic surgery or a patient with scoliosis → all have distorted anatomy → high risk of error during the procedure. → better not to use regional anesthesia.
- **Positions**: lateral decubitus, sitting or jackknife.
- **Techniques**:
  - **Paramedian**:
    Skin – subcutaneous tissue – ligamentum flavum – epidural space – dura – subarachnoid (no supra and intraspinous ligaments). Used in thoracic epidural anesthesia because the thoracic spinous processes are inclined downwards giving narrower interlaminal space for injection.
  - **Midline:**
    Skin – subcutaneous tissue – supraspinous ligament, intraspinous ligament - ligamentum flavum - epidural space – dura - subarachnoid → most commonly used technique. If you encounter difficulty in medline technique, you can try paramedian.

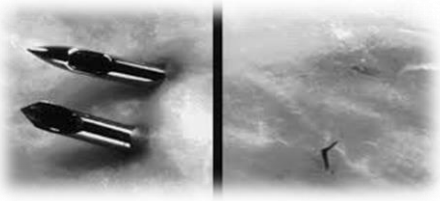
- **Epidural anesthesia**:
  Injection of high volume (up to 20 ml) of local anesthetic into epidural space.

- **Spinal anesthesia (SA):**
  - Injection of small volume (2-3 ml) of local anesthetic into the CSF at levels below L2 (where the spinal cord ends).
  - Anesthesia of the lower body parts, below the umbilicus is achieved by SA.
  - It is a single shot technique.
- **Onset of action** is very rapid in SA (3-5 mins) but slower in EA (up to 30 mins).
- **Duration of action** is shorter in SA (3-4 hrs) than in EA.
- **Needles in SA:**

1. Quinke: short cutting bevel → cuts the dura. **(used previously)**
2. **Pencil point**: Blind end with an opening on the side. → Spreads the dura, does not cut!



These 3 are considered pencil point



Size of cut from of pencil point needle vs. Quincke needle on dura (magnified)

MCQ Post Dural Puncture Headache (PDPH):

A complication of spinal anesthesia which develops about 12 - 24 hours post SA, due to leakage of CSF from the site of puncture in the dura. Mostly occurs in young females (age of pregnancy). Headache is bilateral, improves when lying supine and worsens in recumbent position.

- **Mechanism of PDPH:**
  - Persistent leakage of CSF → decrease in CSF volume → Shift of intracranial contents → stretching of meninges.
  - Intracranial volumes are fixed → the decrease in CSF volume is compensated by an increase in blood volume by cerebral vasodilatation. → headache.
- **The risk of PDPH is determined by:**
  - The gauge of the needle (the smaller the needle the smaller the cut),
  - Design of the needle tip determines the size of the cut to the dura. → The bigger the cut, the greater the leakage of CSF.
- You have to make sure that it's actually PDPH, because some patients have preexisting migraine or when they haven't drank their coffee. → Enquire about the features of the headache.
- **DDx:**
  Contamination of the needle causing meningitis, sinusitis, preexisting migraine, pregnancy related hypertension, pneumocephalus, intracranial pathology, dural venous thrombosis.
- This complication does not occur in epidural anesthesia because the dura should not penetrated, unless it is mistakenly punctured!
- 27 gauge pencil point needle for SA is the most commonly used needle nowadays. → PDPH incidence is approaching zero ~ 0.2%
- **Treatment:**
  - **Conservative:** Paracetamol, caffeine, abdominal binders and bed rest.
  - **Severe headache:** Blood patch: withdrawing 20 ml of blood from the patient and injecting it into the epidural space (autologous) under a fully sterile technique. A clot will be formed into the puncture site and will occlude the opening to prevent further CSF leakage.

- **Level of block depends on:**
  - Anesthetic baricity
  - Patient's position (during and immediately after injection. Do not move the patient for 5 minutes after epidural injection to prevent the drug from going up)
  - Dose of the anesthetic
  - Level of injection
  - Age, height, pregnancy, intraabdominal pressure, blood volume.
- **A unique feature to spinal anesthesia is baricity of medications used**: fluid is injected into another fluid i.e. local anesthetic drug and CSF → fluid physics must be respected.
  - **Example:** if I pour oil on water, the oil droplets will float, even if I flip the glass over. Because the density (baricity) of oil is lower than that of water → same concept is applied to spinal anesthesia.
  - **Hyperbaric:** Descends in the intrathecal space.
    Most commonly used type because it is predictable.
    Prepared by mixing the local anesthetic with dextrose.
    Example: Bupivacaine (trade name: heavy Marcaine).
  - **Isobaric:** Stays at the same level. Used in epidural anesthesia.
  - **Hypobaric:** floats on CSF.

- **Classification of nerve fibers:**
  - **Myelinated:**
    - Aα: Motor
    - Aβ: Sensory. Transmits touch sensation.
    - A delta: Sensory. Transmits fast pain sensation.
    - B: Preganglionic autonomic. It is the most sensitive to local anesthesia → So first effect you see is sympathetic blockade causing vasodilation and subsequent hypotension.
  - **Unmylinated:**
    - C fibers: Postganglionic. Slow transmission.
- **Order of block:** B > C > A delta > Aβ > last thing is Aα (motor).
- **To determine sensory level:** (an ice cube is passed over the patient's dermatomes)
  - T4 is marked by nipples
  - T7 is marked by xyphoid process
  - T10 is marked by umbilicus
  - L1 is inguinal area
- **Examples for sensory level that must be achieved in types operations:**
  - S2 – S5 "Saddle block" → perineal surgery. In this case block does not involove any lumbar segments which means there will no sympathetic block → no hypotension.
  - T10 → vaginal delivery, transurethral resection of prostate.
  - T8 → abdominal surgery.
  - T6 → C section because the gravid uterus is distended and reaches high in the abdomen.

- L2, L3 → foot surgery

- Autonomic and motor block level cannot be determined by physical examination. So after determining the sensory level we assume that autonomic block is two segments above the sensory level and motor block is two segments blow the sensory level.
  For example:
  If sensory level T10 dermatome → autonomic block is at T8, motor block is up to T12.
- The motor component is the last to be blocked and the first to return.
- The autonomic component is the first to be blocked and the last to return.

- **Complications:**
  1. Back pain.
  2. Total spinal block.
  3. PDPH.
  4. Epidural hematoma: likelihood increase with bigger needle size, especially in anticoagulated/coagulopathy.
  5. Epidural infection or meningitis when using unsterile technique or in immunocompromised patients or if we leave the catheter in for 7-10 days.
  6. Cauda equina syndrome: if local anesthetic is injected into the nerve itself.
  7. Transient neurological symptoms: burning sensation which may stay for 3-4 hours and resolves on its own.
  8. Hypotension: if treatments is delayed, bradychardia and cardiac arrest occur.
- MCQ: Hypotension is due to sympathetic blockade.
- A patient was given local anesthesia, after 10 minutes her blood pressure dropped to 80/40. What is most likely the cause of her hypotension? Sympathetic block.
- The higher the sensory level the greater the degree of hypotension.
- Severe hypotension is prevented by preloading the patient with a minimum of 1 L of crystalloid IV fluids.
- **First step in the management of hypotension is** IV fluids.
- **The best pharmacological treatment is** ephedrine (aliquots of 5-10 mg).
- In case of pregnant patient with hypotension after regional anesthesia , the cause is most likely caval compression by gravid uterus (supine hypotension) → First change position to left lateral rather than supine to relieve the compression. Next, give fluids then administer ephedrine if no improvement.

- To confirm that the needle is in the right place:
  - EA: Loss of resistance using a syringe: the sensation felt by the anaesthesiologist from the syringe plunger with loss of resistance.
  - SA: CSF leakage.
- When performing epidural anesthesia, the anesthesiologist will be able to tell when the needle is passed through ligamentum flavum because it is the densest.
- Loss of resistance can be done using saline or air in the syringe:

- Universally most people use saline to confirm loss of resistance: How to differentiate between saline and CSF in the syringe?
  - CSF is warmer than saline.
  - Glucose reagent strip → CSF will be positive for glucose.

- Air may be preferred because in case any fluid comes out, it is definitely CSF.

- When using air in loss of resistance syringe, pneumocephalus may be caused if intrathecal space is entered by mistake, resulting in headache.

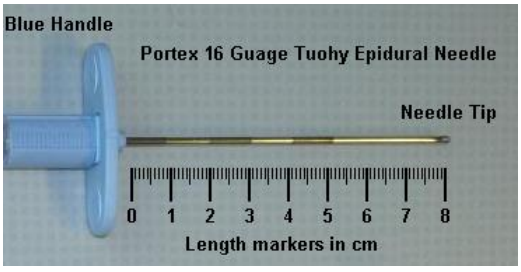
- In EA change in position does not affect the level of block. It is the dose of the drug that changes the level of block. (In spinal, we can tilt the patient to change the level of block)
- **Agent in EA: Isobaric bupvacaine.**
- **Type of needle in EA:** Touhey needle.

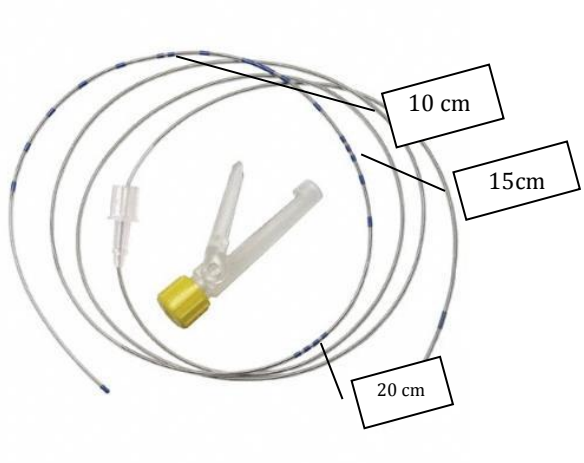
- Epidural catheter has series of special markings to guide the anesthetist on the length inserted into epidural space. → 2 dashes = 10 cm / 3 dashes = 15 cm / 4 dashes = 20cm.

- Skin to epidural space distance must be documented: 80-90% of people have 4-6 cm distance.

- The catheter should be advanced 3-5 cm in addition to skin to epidural space distance. For example skin to epidural space = 5 cm, catheter should be inserted = 8-10 cm.

- If the catheter is advanced more than 5 cm or less than 3 cm there will be risk of migration.





- **Systemic local anesthetic toxicity happens in two cases:**
  1. If the maximum safe dose is exceeded.
  2. If the agent is mistakenly injected into one of the blood vessels in epidural space (can lead to cardiac arrest).

- **To avoid systemic local anesthetic toxicity we can inject a "Test dose":**
  - A small dose (2-3 ml) of local anesthetic agent is injected before injecting the actual full dose. In case the needle is inserted mistakenly into a blood vessel or intrathecal space, it will not do much harm. (Test dose is unique for EA NOT done in SA).
  - 3 ml lidocaine 1.5% + epinephrine 15 micrograms = 5 micrograms epinephrine / 1 ml lidocaine

- If the anesthetic dose used in EA (high dose) is injected by mistake into intrathecal space, total spinal anesthesia develops.

- When the epidural catheter is inserted, it should be aspirated to test for the presence of blood or CSF. Test dose is injected even if no blood or CSF appear after aspiration. Then ask the patient to move their leg after 5 mins → if they're unable to move, it means the catheter is placed intrathecally and the drug is injected as spinal (fast onset). If tachycardia within 2-3 mins →it means it went into a blood vessel.

- After confirming that epidural catheter is in the right place and giving the test dose, you can go ahead and inject the drug but <u>fractionate the dose!</u> (5ml then 5 ml then 5 ml the the last 5 ml).

- **Lidocaine is chosen over Marcaine for test dose because:**
  - Lidocaine has a fast onest compared to Marcaine → because it is less lipophilic.
  - The more lipophilic the drug, the slower the onset, the longer the action, the more potent, the more toxic it is.

Local anesthetics:

- Cocaine is the first local anesthetic to be discovered. (ester family)
- Two main families: ester & amide → amides are more common in use.
- **All local anesthetics consist of** an aromatic ring (giving the lipophilic property) + intermediate chain + amine group (giving hydrophilic property).
- Ester local anesthetics are readily hydrolyzed by acetylcholine esterase in the plasma. This means that they rarely accumulate and cause toxicity.
- Esters are metabolized to para-amino benzoic acid which may cause allergies.
- Amides are metabolized by CYT P450 in the liver → slower metabolism than esters.
- Toxicity can occur in case hepatic metabolism is slowed down or inhibited.
- Grapefruit can inhibit CYT p450 which can result in local anesthetic toxicity.
- **Most commonly used local anesthetics are:**
  lidocaine and bupivacaine. (amide family)
- **Mechanism of action:** Unionized local anesthetic enters cell membrane (acidic environment) → becomes water soluble → blocks voltage gated sodium channel from inside the cell.
- **Duration of action depends on** degree of lipid solubility and protein binding.

- **Local Anesthetic Systemic Toxicity (LAST):** (when the maximum dose is exceeded)

  - Safe dose of bupivacaine: 2 mg/kg
  - Safe dose of lidocaine: 5 mg/kg
  - **Effect ranges from** mild CNS toxicity **to** serious cardiovascular toxicity.

  - **Clinical features:** perioral numbness, facial tingling (mild CNS toxicity) → loss of consciousness, tonic-clonic seizure (severe CNS toxicity) → wide QRS complex, ventricular tachycardia then cardiac arrest (cardiac toxicity).
  - CNS toxicity precedes CVS toxicity.
  - Cardiovascular effects occurs at higher serum concentrations of local anesthesia.
  - **CVS toxicity consists of two phases:**
    - Activation phase: tachycardia, hypertension
    - Depression phase: hypotension, wide QRS, cardiac arrest
  - **Treatment:** A B C + lipid emulsion therapy.
  - **Generally,** all lipid soluble drugs can be chelated with lipid emulsion in case of toxicity.

Summary

	Epidural	Spinal
Site	Epidural space	Subarachnoid space
Level	Anywhere in the spine	Only below L2
Technique	Catheter	Single shot
Duration of action	Long	Short
Onset of action	Slow up to 30 mins	Rapid within 2-4 mins
Type of needle	Tuohy	Pencil point
Dose	Large	Small
Technique	Catheter	Single shot
Baricity	Only isobaric drugs are used.	Baricity of the drug is taken into consideration.
Confirming the correct site by	Loss of resistance technique	CSF leakage
Test dose	Required	Not required

For mistakes or feedback

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