Spinal Anesthesia

Spinal anesthesia involves the use of small amounts of local anesthetic injected into the subarachnoid space to produce a reversible loss of sensation and motor function. The anesthesia provider places the needle below L2 in the adult patient to avoid trauma to the spinal cord. Spinal anesthesia provides excellent operating conditions for:

- ✓ surgical procedures below the umbilicus
- ✓ obstetric/gynecologic procedures of the uterus and perineum
- ✓ hernia repairs
- ✓ genitourinary procedures
- ✓ orthopedic procedures from the hip down.

In addition, it is an excellent technique to use in the elderly patient that may not tolerate a general anesthetic. It is important not to use a spinal anesthetic in patients who are hypovolemic or severely dehydrated. Patients receiving a spinal anesthetic should be preloaded with 1-1.5 liters of a crystalloid solution, such as ringers lactate, immediately prior to the block.

Advantages of Spinal Anesthesia

Several advantages of neuraxial blockade (including spinal anesthesia) were listed in the Introduction to Neuraxial Blockade section of this manual. There are additional advantages specific to spinal anesthesia.

- Easy to perform
- Reliable
- Provides excellent operating conditions for the surgeon
- Less costly than general anesthesia
- Normal gastrointestinal function returns faster with spinal anesthesia compared to general anesthesia
- Patient maintains a patent airway
- A decrease in pulmonary complications compared to general anesthesia
- Decreased incidence of deep vein thrombosis and pulmonary emboli formation compared to general anesthesia

Disadvantages of Spinal Anesthesia

Disadvantages include the following:

- Risk of failure even in skilled hands. Always be prepared to induce general anesthesia.
- Normal alteration in the patient's hemodynamics. It is essential to place the spinal block in the operating room, while monitoring the patient's ECG, blood pressure, and pulse oximetry. Resuscitation medications should be available.
- The operation could outlast the spinal anesthetic. Alternative plans (i.e. general anesthesia) should be prepared in advance.
- Risk of complications as outlined in the complications of neuraxial blockade chapter.

Contraindications

Please review Chapter 2 for contraindications.

Mechanism of Action

Local anesthetics administered in the subarachnoid space block sensory, autonomic, and motor impulses as the anterior and posterior nerve roots pass through the CSF. The site of action includes the spinal nerve roots and dorsal root ganglion.

Uptake & Elimination of Spinal Anesthetics

Four factors affect the uptake of local anesthetics in the subarachnoid space:

- Concentration of local anesthetic
- Surface area of neuronal tissue exposed
- Lipid content of the neuronal tissue
- Blood flow to the tissue

Local anesthetic concentration is highest at the site of injection. Spinal nerve roots lack an epineurium and are easily blocked. The surface area of the exposed nerves allow for absorption of the local anesthetic. As the local anesthetic travels away from the initial site of injection, its concentration decreases secondary to absorption into neural tissue and dilution by the CSF. Spinal cord tissue absorbs local anesthetics through the pia mater and the spaces of Virchow-Robin, which are extensions of the subarachnoid space. However, the site of action is not the spinal cord, but the spinal nerves and dorsal root ganglia.

Elimination occurs through vascular absorption in the subarachnoid and epidural space. Initial vascular uptake occurs through blood vessels in the pia mater and spinal cord. The rate of absorption is related to the vascular surface area that the local anesthetic comes into contact with. Lipid solubility of the local anesthetic solution enhances uptake into the tissue, further diluting the concentration. Local anesthetics also diffuse into the epidural space along a concentration gradient. Once in the epidural space, diffusion into the epidural vasculature occurs.

Factors Determining Distribution of Spinal Anesthetics

Several factors impact the distribution of local anesthetics within the subarachnoid space and subsequent height. Some factors play a major role while others play a minor/negligible role. These factors can be divided into 4 main categories:

- Characteristics of the local anesthetic medication
- Patient characteristics
- Technique of injection
- Characteristics of spinal fluid

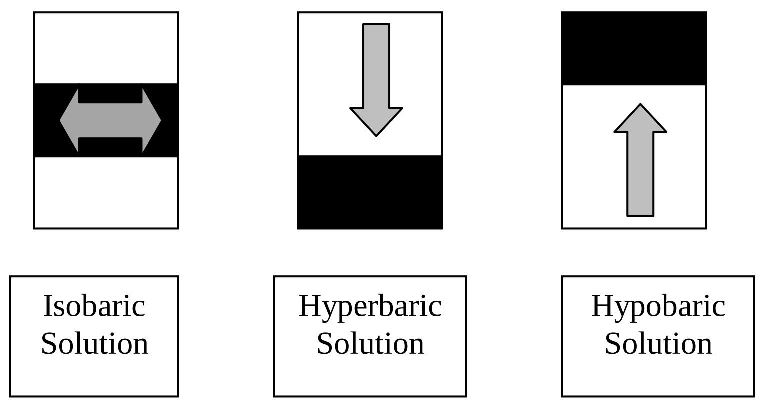
Characteristics of the Local Anesthetic Solution

Multiple characteristics of local anesthetic solution affect its spread within the subarachnoid space. These include density, dose, concentration, temperature, and volume.

Density- weight of 1 ml of solution in grams at a standard temperature.
Specific Gravity- density of a solution in a ratio, compared to the density of water.
Baracity- the ratio comparing the density of one solution to another.

- **Density/baracity**- the density or baracity of the local anesthetic exerts one of the greatest effects on subsequent height of the block. Local anesthetic movement within CSF is dependent on its specific gravity in relation to CSF, which at 37 degrees C is 1.003-1.008. A local anesthetic solution can be hyperbaric, hypobaric, or isobaric. Hyperbaric means that the solution is heavier than CSF. Dextrose is added to the local anesthetic solution to make it hyperbaric. Hypobaric means that the solution is lighter than CSF. This will allow it to move in a cephalad direction. Hypobaric solutions are created by adding sterile water to the solution. Isobaric solutions have the same specific gravity as CSF. Local anesthetic agents mixed in a 1:1 ratio with CSF create an isobaric solution. Alternatively, sterile distilled water may be used to achieve a baracity < 0.9990.

Diagram of Gravities Influence on Baricity



Common Local Anesthetics and Specific Gravity

Local Anesthetic	Specific Gravity
Bupivacaine 0.5% in 8.25% Dextrose	1.0227-1.0278
Bupivacaine 0.5% plain	0.9990-1.0058
Lidocaine 2% plain	1.0004-1.0066
Lidocaine 5% in 7.25% Dextrose	1.0262-1.0333
Procaine 10% plain	1.0104
Procaine 2.5% in water	0.9983
Tetracaine 0.5% in water	0.9977-0.9997
Tetracaine 0.5% in D5W	1.0133-1.0203

Examples of baricities impact on the spread of local anesthetic solutions and patient position are described below.

- Head down position- a hyperbaric solution will spread cephalad; a hypobaric solution will spread caudad.
- Head up position- a hyperbaric solution will spread caudad; a hypobaric solution will spread cephalad.
- Lateral position- a hyperbaric solution will spread towards the dependent area; a hypobaric solution will spread to the non-dependent area.
- Any position with isobaric solution- will stay within the general area of injection.

Hyperbaric solutions move toward dependent areas. When the patient is supine, after injecting a hyperbaric solution, the local anesthetic will move toward the T4-T8 area. The apex, following the normal curvature of the spine, is T4.

Additional characteristics of local anesthetic solutions include the following:

- **Dose**- the larger the dose, the higher the block.
- **Concentration**- the higher the concentration, the higher the block.
- **Temperature-** if the solution is cold it becomes viscous. This limits its spread within the CSF. The warmer the solution, the greater the spread. Temperature is a minor consideration.
- **Volume**- the greater the volume, the greater the spread.

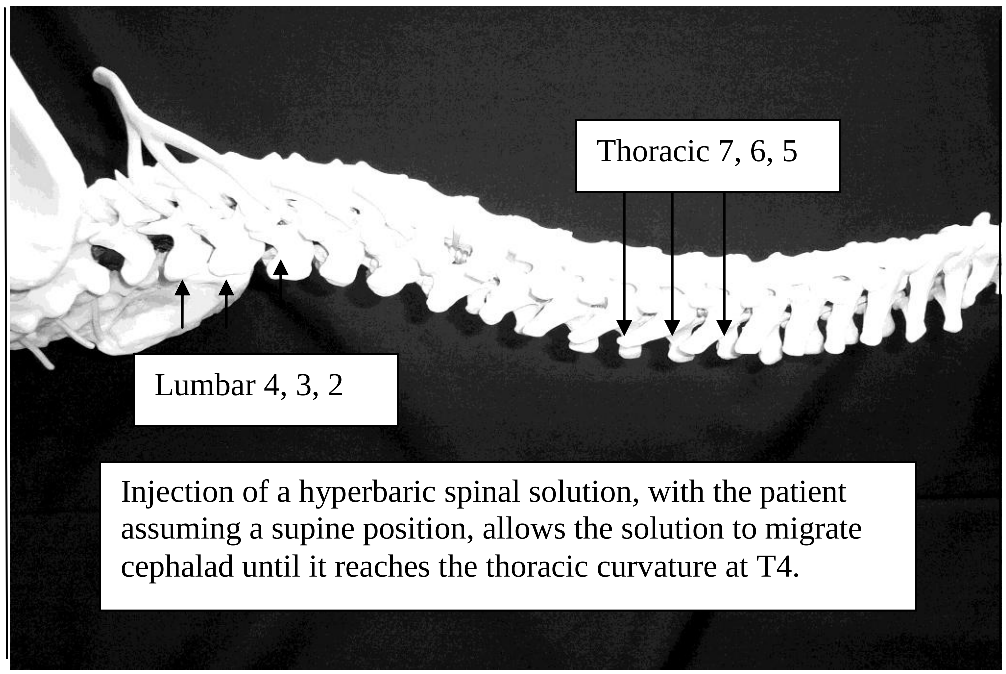
Baracity and dose of local anesthetic (along with patient position) are the most important factors that impact eventual block height.

Patient Characteristics

Patient characteristics include age, height, intra-abdominal pressure, anatomic configuration of the spinal cord, and patient position during and immediately after injection.

- **Age-** plays a negligible role in block height. As we age there are anatomical changes in the subarachnoid area which may increase block height- not very predictive.

- **Height-** plays a minor role. However, for the very short the dose of local anesthetic should be decreased, and for the very tall it may need to be increased-not overly predictive.
- **Intra-abdominal pressure**- plays a role in relation to engorgement of epidural veins, decreasing CSF volume, resulting in a higher subarachnoid block. Conditions that increase intra-abdominal pressure include: pregnancy, obesity, ascites, large abdominal tumors, etc.
- **Anatomic configuration of the spinal cord**- natural lardosis and thoracic kyphosis influences spread of the local anesthetic solution. Medications injected above L3, with the patient in a supine position after injection, will spread cephalad reaching the thoracic curvature at T4. Abnormal anatomic changes that affect CSF can impact the level of blockade. Conditions such as severe kyphosis or kyphoscoliosis can result in decreased CSF volume and higher than expected blockade.



- **Patient position-** patient position during blockade is one of the most important factors along with local anesthetic dose and baracity that can affect the spread of local anesthetic and subsequent block height. This is a function of baricity and position of the patient. For example, a hyperbaric solution administered in the sitting position will result in a higher concentration of local anesthetic in the lower lumbar and sacral areas. A hyperbaric solution in the lateral position will result in a greater concentration of local anesthetic in the dependent portion of the patient. A hypobaric solution administered in the prone/jack knife position will result in blockade of the lower lumbar and sacral areas. Patient position is especially helpful after administering a hyperbaric solution. If the patient is left sitting up, the sacral and lower lumbar distribution will have a dense block. If the patient is supine, in a Trendelenburg position, hyperbaric solution will spread further reaching thoracic dermatomes.

Technique of Injection

Factors that influence the technique of injection include the site and direction of injection.

- **Site of injection**- the level of injection will influence spread. For example, a greater spread of local anesthetic will occur if injected at L2-L3 or above, as opposed to L4-L5.
- **Direction of injection**- if the local anesthetic is injected in a caudad direction, the spread of local anesthetic will be limited compared to injection in a cephalad direction.
- It does not appear that rate of injection, barbatoge, coughing, or straining affects the height of block. The exception is the use of isobaric solutions. Barbotage of isobaric solutions may achieve block height quicker than the usual injection.

Characteristics of Spinal Fluid

The volume and density of CSF influences subarachnoid block height.

- **CSF volume**- is inversely related to block height. This is the most significant physiologic factor. Obese patients have a smaller volume of CSF when compared to the non-obese patient. Decreased volumes of CSF result in a higher block, whereas increased volumes of CSF decrease the level of blockade. CSF volume is influenced by patient characteristics (i.e. abnormal spinal anatomy).
- **CSF density**- has an impact on the spread of the local anesthetic. For example, if CSF is concentrated with a higher specific gravity, the local anesthetic may not spread as far as it normally would. Alternatively, dilute CSF, with a lower specific gravity, will result in a greater spread of the local anesthetic solution.

Factors that do not affect block height

- Vasoconstrictor use
- Coughing, staining, baring down, and barbotage
- Rate of injection (with the exception of isobaric)
- Gender
- Weight

Factors that affect block height but are out of the anesthesia provider's control

- Volume of CSF
- Density of CSF

Factors under the anesthesia provider's control

- Dose (volume/concentration)
- Site of injection
- Baricity of local anesthetics
- Position of the patient

Most important factors that determine block height

- Baricity of local anesthetic solution
- Position of patient during/immediately after injection
- Dose
- Site of injection

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