



Spinal anesthesia: a review of theoretical aspects and description of the procedure

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ABSTRACT

INTRODUCTION: Spinal anesthesia is a common procedure in the arsenal of any anesthesiologist; therefore, it is of fundamental importance that the professional who performs the blockade has knowledge about aspects related to the different mechanisms of application, as well as the clinical responses to the different levels of blockade. Therefore, the objective of this study is to improve the understanding of the procedure, approaching important aspects with the purpose of generating more information for the professional, thus reducing failure rates and negative outcomes..

METHODOLOGY: To construct this study, literature was consulted and selected using the National Library of Medicine (Pubmed/Medline), Sociedade Brasileira de Anestesiologia (SBA) and Scientific Electronic Library Online (SciELO) databases. The search terms were: spinal anesthesia; spinal blocks; neuro-axial blocks; complications; management; epidemiology; treatment; prevention. Searches were filtered by publication date as of January 2007, human studies, and availability in Portuguese and English; review articles, protocols, guidelines, and manuals were included. In addition, the following textbooks were used: "Anesthesiology - 4th edition", "Manual of clinical anesthesiology - 7th edition", "Functional neuroanatomy - 3rd edition", "Spinal anesthesia treatise", and "Routines in anesthesiology and perioperative medicine".

CONCLUSION: Representing one of the fundamental resources of an anesthesiologist, spinal anesthesia is a broad and almost inexhaustible topic. Moreover, new works are published periodically, ensuring that professionals continue to refine their knowledge constantly. This work is an example of this and urges the reader to seek further sources.

Keywords: Spinal anesthesia, Neuroaxis block, Lumbar puncture, Anesthesiology.

1 INTRODUCTION

The discovery, so to speak, of subarachnoid anesthesia was the consequence of scientific advances contemporaneous with each other. In 1885, the American neurologist James Corning registered the effects of the application of cocaine on a dog's spine and "discovered" subarachnoid anesthesia. Four years later, in 1889, João Carlos Paes Lemes performed the first spinal anesthesia in Latin America, at Santa Casa de Misericórdia do Rio de Janeiro, but still with little acceptance. In 1898, Karl Bier registered three anesthetic procedures using cocaine in the subarachnoid space: (1) a 34 year old patient in the Royal Surgical Clinic of Kiel (Germany) had satisfactory analgesia for 45 minutes during the extirpation of a knee tumor; (2) a few days later, Bier with the help of his assistant Hildebrandt successfully repeated the procedure on himself and (3) after the success of the second anesthetic, Hildebrandt offered himself for a new attempt in which they also succeeded. Both Bier and his assistant suffered a terrible headache after the procedure, and the first record of post-rachianesthesia headache was then made. However, only at the end of the XIX century the technique was more accepted, when the French physician Tuffier methodized subarachnoid anesthesia and published a work with 63 cases of surgical procedures under his method in the V European Congress



of Surgery. After that, several studies have been published in order to make spinal anesthesia safer and more efficient (VALE, 1998) (MANICA, 2018).

After more than a century of improvements, subarachnoid blockade is a safer and more effective procedure than it once was. Currently, it is known that several factors exert influence on the aspects of the action of the local anesthetic (LA) and this has been widely explored by anesthesiologists, since from changes in these factors it is possible to adapt the block to the needs of each patient (MANICA, 2018).

Subarachnoid anesthesia is widely used in infraumbilical surgeries and has special importance among some groups such as pregnant women and the elderly, since it ensures clinical stability and has a satisfactory postoperative analgesic effect (OLIVEIRA et al, 2015).

2 ANATOMY

Hoppe and Popham (2007, p. 2) postulated that:

The success of spinal anesthesia requires the deposition of the correct dose of the appropriate drug in CSF adjacent to the medullary cone and cauda equina, without physical, physiological or biochemical barriers that prevent the known action of the drug on the nerve structures contained there, or in other words, the right agent, in the right dose, in the right place.

Considering the excerpt, knowing the anatomy of the lumbar region is fundamental, since it guides the performance of the block (PRAXEDES, 2010).

The spine consists of 33 vertebrae (7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal) articulated by ligaments, extending from the skull to the pelvis. In lateral view, the spine has physiological curvatures, while in posterior view there should be no curvatures. With the exception of the first cervical vertebra (which has neither body nor spinous process), the other vertebrae consist of a body in the anterior part, two pedicles that project posteriorly, and two laminae that join the pedicles and give rise to the transverse and spinous processes (BARASH, 2014) (MANICA, 2018).

According to Manica, the cervical vertebrae have a reduced body with a horizontal and bifurcated spinous process, while in the thoracic vertebrae the spinous process is descending and pointed (no longer bifurcated). The lumbar vertebrae, in turn, are larger, have a horizontal and non-bifurcated spinous process, a well-developed transverse process, and a triangular-shaped vertebral foramen.

The sacral vertebrae are fused, with the fifth fused only posteriorly, where the sacral hiatus is formed (structure that delimits the caudal termination of the epidural space). The final four vertebrae are also fused and form the coccyx (GAMERMANN, 2017).

Five ligaments are responsible for stabilizing the vertebral bodies, these being the (1) supraspinatus, (2) interspinatus, (3) yellow, and (4) anterior and (5) posterior longitudinal. The supraspinatus extends from C7 to the sacrum and has a fibrous constitution. The interspinous joins the spinous apophyses and fuses posteriorly to the supraspinous ligament and anteriorly to the ligamentum flavum. The latter receives this name due to its constitution of elastic fibers that guarantee the yellowish color to the structure, being the

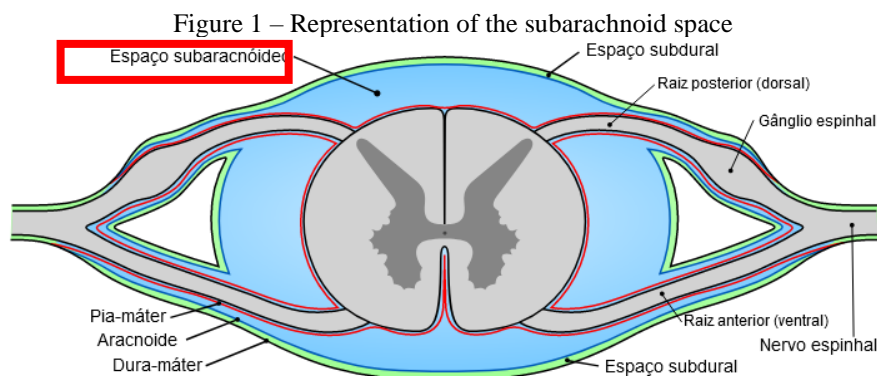
area of greatest resistance during the procedure; this ligament limits the epidural space posteriorly. Furthermore, the longitudinal ligaments join the vertebral bodies on their anterior and posterior sides (BARASH, 2014) (MANICA, 2018).

Spinal meninges refer to the three protective membranes of the spinal cord, being the dura mater, arachnoid and pia mater. The first is the outermost and densest, and is composed of collagen and elastin fibers. The inner edge of the dura is highly vascularized, making it an important route for elimination of drugs present in the cerebrospinal fluid (CSF) (BARASH, 2014) (GAMERMANN, 2017).

The arachnoid, in turn, is a serous and avascular membrane that acts as the main physiological barrier for drugs between the epidural and subarachnoid space. This meninge comes into contact with the dura by pressure from the CSF and joins the pia mater (GAMERMANN, 2017) (MANICA, 2018).

The pia mater is the innermost of the meninges. Carrying a vascular network, it is adhered to the surface of the spinal cord and penetrates its anterior median fissure. After the termination of the spinal cord in the conus medullaris this meninges extends caudally to form the terminal filament, which pierces the dural sacral fundus and extends to the sacral hiatus. Laterally, the pia mater presents triangular processes that insert firmly into the other two meninges in an alternating manner with the emergence of the spinal nerves (MACHADO, 2014).

The three meninges form three spaces between them, these being the (1) epidural, (2) subdural, and (3) subarachnoid. The first contains adipose tissue and part of the internal vertebral venous plexus, and is located between the dura mater and the periosteum of the spinal canal. Between the dura and the arachnoid there is the subdural space, being filled with a small amount of fluid, this region is usually virtual and avoids adhesion between the meningeal walls. The subarachnoid space is occupied by CSF and is located between the arachnoid and the pia mater (Figure 1). With special clinical importance, through the subarachnoid space it is possible to perform lumbar punctures for therapeutic or diagnostic purposes (MACHADO, 2014) (MANICA, 2018).



Source: Extracted from DRAKE, 2020.

Translation:

Espaço subaracnóideo: subarachnoid space

Espaço subdural: subdural space

Raiz posterior (dorsal): posterior (dorsal) root

Pia-máter: pia mater

Aracnoide: arachnoid

Dura-máter: dura mater

Gânglio espinhal: spinal ganglion

Raiz anterior (ventral): anterior (ventral) root

Nervo espinhal: spinal nerve

Espaço subdural: subdural space



The spinal cord is located internally to the spinal canal, which in adulthood extends from the bulb to the L1, where the conus medullaris is located. The marrow is cylindrical in shape, but slightly flattened in the anteroposterior direction and has two dilations, the cervical and lumbar intumescences. The spinal cord is formed by 31 pairs of spinal nerves, each of which is composed of a motor and a sensitive root. The region innervated by a spinal nerve and its corresponding segmental cord is what is known as a dermatome. After the medullary cone, the nerve roots become more oblique, extending through the subarachnoid space, forming the cauda equina (BARASH, 2014) (GAMERMANN, 2017) (MANICA, 2018).

3 PHYSIOLOGICAL REPERCUSSIONS

The blockade of efferent fibers of the sympathetic nervous system is responsible for the effects of spinal anesthesia. Among them, from the cardiovascular point of view, a decrease in peripheral vascular resistance due to generalized vasodilation is highlighted, as well as a reduction in preload due to a drop in circulating volemia. A drop in blood pressure (BP) is also expected, as well as a drop in central venous pressure and venous return, which may result in a decrease in cardiac output (CO) (IMBELLONI, 2001) (BARASH, 2014). When there is a blockade above T12, the blood volume directed to the lower limbs (LLLL) increases around 77%; until it reaches T10 it is not able to considerably change the CO distribution; when the blockade reaches T4 the CO can drop up to 40%, and finally, when it reaches T2 the blood supply to the kidneys and liver becomes highly impaired (IMBELLONI, 2001). With the installation of the blockade, there is a redistribution of plasma volume to the splanchnic bed and to the region below the blockade, thus providing a condition of marked heat loss, which can result in hypothermia and, consequently, increased oxygen consumption by the cardiac tissue (OLIVEIRA et al, 2015). Also according to Barash and Imbelloni, up to 15% of patients may have significant bradycardia - especially in blockades that reach T4 - due to the blockade of cardioaccelerator sympathetic fibers and reduced stretch of intracardiac receptors, and may require interventional management. However, any other arrhythmia that occurs under spinal anesthesia is not a consequence of the blockade, and further investigation is needed..

After the application of LA in the subarachnoid space, it will disperse into the CSF and come into direct contact with the spinal cord and spinal nerve roots, producing different degrees of sympathetic blockade, resulting in decreased sympathetic tone and/or increased parasympathetic tone. However, the exact site of action of anesthesia is still not certain, and it can happen at any or all points along the neural pathways (GAMERMANN, 2017) (BARASH, 2014). It is also known that diameter is not the only factor involved in the blocking sequence of autonomic fibers, in fact, the specific sensitivity of each type of fiber exerts more influence than the diameter itself. The anesthesia tends to follow the sequence: unmyelinated C-type fibers, fine myelinated B-type fibers, preganglionic autonomic fibers, and finally A-type fibers; while the regression of anesthesia takes place in the opposite direction to that described. This guarantees



the blockade in order of fibers responsible for pain, then for touch, and lastly for motor function (MANICA, 2018).

This condition in association with other factors (different concentrations of anesthetic in the CSF, baricity of the drug used, position of the patient during and immediately after the procedure) generates a clinical situation known as differential neural blockade in which the sympathetic pathway is blocked 2 to 6 dermatomes above the sensory blockade, while the latter extends 2 to 3 dermatomes above the motor blockade (BARASH, 2014).

Furthermore, spinal anesthesia does not interfere with brain tissue nutrition, since it is determined by two factors: mean arterial pressure (MAP) and intrinsic cerebrovascular resistance, which keeps blood flow constant even with variations in MAP (as long as parameters such as pCO₂ and blood pH are unchanged). Research in simians showed that spinal anesthesia up to T1 did not modify cerebral blood flow, nor the percentage of CO that nourishes the brain (IMBELLONI, 2001).

The respiratory repercussions of spinal anesthesia do not usually have great relevance, except in patients with pneumopathies, especially with obstructive lung disease that requires the use of accessory muscles for adequate ventilation (group that should be strictly monitored when under spinal anesthesia) (IMBELLONI, 2001).

After the installation of the spinal blockade, with parasympathetic predominance, there is an increase in visceral blood perfusion, peristalsis, and the production of secretions, besides accelerating gastric emptying and promoting sphincter relaxation. Many patients complain of nausea and the presence of hypotension associated with opioid use is the main cause of this adverse effect, although it can also occur in the absence of the cited conditions (MANICA, 2018) (BARASH, 2014).

In addition, hepatic blood flow drops accompanying the reduction in MAP. As a consequence, there is hypoperfusion of the liver. However, it is minimal and compensated by the increased oxygen extraction from the liver tissues. Liver dysfunction after subarachnoid block is transient (IMBELLONI, 2001).

Blockades that reach T12 cause sympathetic denervation of the kidneys, with vasodilation, but renal perfusion tends to be preserved. This is a result of autoregulation of the renal vascular network that maintains irrigation of the organ until the limit of 15mmHg of MAP, when renal perfusion ceases completely (IMBELLONI, 2001) (MANICA, 2018). The effect of the blockade on the pelvis increases bladder sphincter tone and causes bladder atony, which can cause urinary retention. Early ambulation has been shown to be efficient in reducing its incidence (GAMERMANN, 2017).

Among the reasons that make the anesthesiologist choose the subarachnoid block, the low metabolic stress in response to surgery is of special importance. Thus, reduced levels of catecholamines, cortisol, insulin, and thyroid hormones are expected. This is possibly due to blockade of the afferent sensory branches during spinal anesthesia (BARASH, 2014) (GAMERMANN, 2017).



4 INDICATIONS AND CONTRAINDICATIONS

There are no absolute indications for spinal block anesthesia, and it is potentially indicated in any procedure with an operative site within the area covered by the block, without causing increased morbidity and mortality (OLIVEIRA et al, 2015). There are even situations in which the opposite occurs, in which the blockade improves the clinical course and reduces adverse outcomes (GAMERMANN, 2017), due to the reduced metabolic stress under the effect of spinal anesthesia. It also reduces blood loss during the procedure, decreases the incidence of postoperative thromboembolic events, and provides better postoperative analgesia than those obtained with opioids (BARASH, 2014).

Therefore, the indications for spinal anesthesia are associated with the advantages attributed to its use, being indicated both for diagnostic procedures and in surgeries in the lower abdomen. As an extra advantage, it can be used in any age group (MANICA, 2018).

Regarding contraindications to spinal anesthesia, they are divided into absolute and relative. In the first group, the patient's refusal stands out (GAMERMANN, 2017), but other conditions also contraindicate the procedure, such as infection at the puncture site, coagulopathies, intracranial hypertension, as well as severe hypovolemia and sepsis (OLIVEIRA *et al*, 2015) (KOKKI, 2012) (MANICA, 2018).

In relation to relative contraindications, we highlight those that increase the risk of complications (hypovolemia, thrombocytopenia, brain herniation, anatomical deformities). Anyway, with the constant changes and updates in medicine, the relative contraindications have become more and more manageable. (OLIVEIRA et al, 2015)

5 THE PROCEDURE

5.1 PREPARATION

When regional anesthesia is not properly performed, it can be responsible for infectious complications, prolonging hospital stay, increasing costs and morbidity and mortality, and worsening pain. This in itself is a reason to reserve some care to make the procedure aseptic. The main measure is hand washing according to the ANVISA manual associated with the application of alcohol or alcoholic solutions and the use of sterile gloves, as well as the removal of watches, jewelry, and rings. The professional who performs the blockade should also wear a surgical mask and apply degerming agent on the skin in back and forth movements, waiting for the product to dry completely (AZI, 2020) (ANVISA, 2018).

5.2 TECHNIQUE

The performance of spinal anesthesia, as well as the achievement of the necessary result for the proposed surgical procedure, is closely related to the anatomical aspects of the spine and nervous system therein (AZI et al, 2020). Aspects such as the positioning of the patient during the blockade as well as in the first minutes after the administration of the agent, the puncture site, characteristics of the drug used, as



well as the dose administered and the use of adjuvant drugs to the LA are determining factors for the success of the lumbar puncture (MANICA, 2018).

5.3 PUNCTURE SITE

The spinal cord (cone cord) in the adult extends to the level of L1 and L2. Since the tip of the anesthetic needle is in close proximity to the neural structures, the puncture should be performed at a level below the end of the spinal cone in order to avoid traumatic lesions of the spinal cord. Thus, it is recommended to perform the puncture in the L2-L3 to L5-S1 interspaces (more common in paramedian approaches). The neural structure present in the mentioned region is the cauda equina, which in case it is injured does not produce definitive symptoms (BARASH, 2014) (GAMERMANN, 2017).

5.4 THE PUNCTURE

The patient can be positioned in lateral decubitus or sitting position. In lateral decubitus, the spine and lower limbs (LLLL) of the patient are flexed in order to widen the spaces between the vertebrae in its posterior region, facilitating the introduction of the needle. If the patient is in the sitting position, the spine is kept upright and flexed, undoing the lumbar lordosis, facilitating the puncture (GAMERMANN, 2017).

Usually, the puncture begins in the midline, passing through the skin, subcutaneous tissue, supraspinatus ligament, interspinous ligament, ligamentum flavum, epidural space, dura mater, and arachnoid membrane. The confirmation of the correct location in the subarachnoid space is given by the sensation of "click" after passing through the arachnoid and by the reflux of cerebrospinal fluid after the removal of the needle mandrel, usually occurring 4 or 5 cm from the skin (GAMERMANN, 2017) (MANICA, 2018).

5.5 MATERIAL

All the material used for the block should be sterile. It is common to use a tray, two syringes, vat and gases with antiseptic solution, lidocaine 1% (for local anesthesia), compresses, LA chosen for the blockade, as well as the appropriate needle (MANICA, 2018).

5.6 CHOICE OF THE ANESTHETIC

For the choice of the LA, one should take into consideration aspects such as the duration of anesthesia and the extent of metamers desired for blocking the surgery in question. Surgery in the abdominal cavity requires anesthesia of all sacral, lumbar, and thoracic spinal nerves up to the level of T4. To disperse the LA throughout this region, glucose is added to the LA to change its final density (hyperbaric) (MANICA, 2018).

After the increase in its density, the dispersion of the LA in the subarachnoid space will suffer interference from the position of the patient, both during the blockade and in the following minutes. The



more inclined the patient is, the greater the dispersion of the anesthetic in the liquoric space will be. The latency time for the effect of LA in spinal anesthesia is approximately 1 minute, therefore, it is possible to follow the dispersion of LA to the desired metamere for the surgery in question through clinical examination. The nerve fibers that conduct the painful stimulus have a sensitivity to LA similar to that of the fibers responsible for thermal sensation. Thus, loss of thermal sensitivity (confirmed by using a cotton pad soaked in alcohol on the patient's skin) indicates the extent of anesthesia (GAMERMANN, 2017) (MANICA, 2018).

Pure LA has a density similar to CSF, thus the anesthetic tends to stay in the vicinity of the region where it was applied, not being useful in surgeries that require extensive blockades. However, lower limb surgeries benefit from LA which diffuse less, achieving good results at the surgical site and little/no effect on thoracic chains (GAMERMANN, 2017).



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