Review Article

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The state of the art of thoracic spinal anesthesia. From Jonnesco in the early 20th century to the present day

Abstract

Over time, the indications for large-scale spinal anesthesia have fluctuated between cycles of popularity and periods of ostracism. Continuous technological advances in the manufacture of needles and catheters, in the synthesis of safer anesthetics, in the knowledge of nociceptive mechanisms, in the introduction of pharmacological adjuvants and in better control over the physiological changes resulting from the technique, have allowed this secular method, characterized by its simplicity, efficiency and safety, to continue to be useful and current in the anesthesiologic arsenal. Most anesthesiologists worldwide use thoracic epidural anesthesia, which has been shown in four studies with 6,609 patients to have an incidence of accidental perforation in 50 patients of (0.75%). However, they are reluctant to consider higher levels for spinal anesthesia because of the possibility of direct spinal cord injury. This article shows that thoracic spinal anesthesia began in the 20th century and has gained numerous followers worldwide in the 21st century, with effectiveness and safety, with no reports of neurological injury. TSA began with CSE for laparoscopic cholecystectomy and was used in several other procedures worldwide. Finally, its safety led several researchers to enthusiastically pursue the technique allowed the study of continuous thoracic spinal anesthesia and other indications such as breast surgery and spinal fractures.

More importantly, although the incidence of paresthesia is like lumbar puncture, which was transient and lasted a maximum of three days, the incidence of cardiocirculatory complications is lower than that of lumbar spinal anesthesia and, to date, there have been no reports of serious and permanent neurological complications, even with the catheter within the subarachnoid space. After numerous published studies and all referenced in this Narrative Review, we can conclude that TSA is safe and without complications and that possibly the anatomy of the subarachnoid space that places the spinal cord more anteriorly prevents its injury.

Keywords: Regional Anesthesia, Thoracic Spinal Anesthesia, Single Shot Spinal Anesthesia, Thoracic Spinal Approach, Continuous Spinal Anesthesia, Magnetic Resonance Imaging, Laparoscopic Cholecystectomy, Complications, Local Anesthetic, Adjuvants

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Key points

Question

Why do most anesthetists not use Thoracic Spinal Anesthesia?

- Anesthesiologist prefer epidural anesthesia with high doses of local anesthetics.
- Accidental puncture of epidural anesthesia in most cases does not cause spinal cord injury.
- Jonnesco in 1909 already described three points to perform TSA.
- Lack of knowledge of modern anatomy in living beings through MRI.
- Lack of knowledge of the distances between the dura mater and the spinal cord.
- Lack of knowledge anterior and posterior roots, to use hyperbaric, isobaric and hypobaric solutions.
- The mean dura mater to spinal cord distance at T2, T5, T10 is greater than the opening of the spinal anesthesia and epidural anesthesia needles, both in adults and children aged 0 to 13 years.
- The low incidence of cardiac and respiratory changes in TSA.
- In the literature, there is no spinal cord injury during TSA.
- Continuous TSA with catheter in the subarachnoid space is being used without neurological injury.

Meaning

- The use of single shot TSA with hyperbaric, isobaric, hypobaric solutions, CSE with thoracic puncture, and continuous TSA can provide segmental spinal anesthesia with low doses of local anesthetics and adjuvants and can be considered as a lack of knowledge of the benefits of these techniques for different types of patients and surgeries by most anesthesiologists.

Introduction

Thoracic spinal anesthesia in the 20th century

I would like to begin by saying that many people imagine that something is new, just because they don't know that it has already been done. For a long time, we were taught that only with epidural anesthesia could segmental anesthesia be performed in the neuroaxis. Total ignorance of history. In February 2025, it will be 117 years since Thomas Jonnesco published his article entitled "General Spinal Analgesia" through an approach of the three subarachnoid spaces at a thoracic region, providing condition for surgery on the skull, head, neck and thorax.[1] The technique described by Jonnesco was immediately challenged in 1910, when at the end of his article he wrote "spinal anesthesia is not yet recognized as a field of anesthesia".[2] And a year later, in an Editorial in which the complications of local anesthesia are discussed instead of the anesthetic technique proposed by Jonnesco.[3]

At that time, knowledge of anatomy was only available on cadavers, mainly from the studies of Leonardo da Vinci, who was considered the discoverer of Human and animal Anatomy and dissected over 20 cadavers in the School of Medicine, describing the vertebral column anatomical concepts when systematic dissections of human cadavers began.[4] In 1316, University of Bologna physician Mondino de Liuzzi performed the first public dissections of human cadavers and published the first modern anatomical text, Anathomia Corporis Humani, which he was the first to methodically pair with the study of classical texts.[5]

A few years later, the technique for segmental spinal anesthesia was described, approaching the lumbar subarachnoid space with the patient in a lateral position and with the head up position, aspirating the cerebrospinal fluid (CSF) and injecting air, and he used a hypobaric solution of nupercaine.[6] In 1933 were published proposing explanations for intrathecal spinal root blockade, showing the various possibilities for spinal anesthesia through a glass spinal canal.[7] Two years later, using the method in this study, the authors studied 200 patients and showed that analgesia extended to the highest segments of the thorax, and thus proposed segmental spinal anesthesia.[8,9] In 1954, segmental spinal anesthesia of the lower thoracic and upper lumbar dermatomes was produced in ten adult human subjects by intrathecal deposition of 0.5 ml of 5% procaine at the level of the 12th thoracic vertebra.[10] The pattern of segmental sensory block and the concentrations of procaine in the spinal fluid both at the point of deposition and at more caudal levels support the concept that the dorsal root ganglion is more sensitive to the local anesthetic agent than the cord or dorsal roots when a minimum threshold block is produced.

In the 1930s and 1950s, there was an expansion in the use of epidurals through lumbar and thoracic puncture, with the description of segmental epidurals, and the use of the epidural catheter for continuous epidural anesthesia for surgery and obstetrics respectively.[11,12] This changed the interest in spinal anesthesia and a greater study of epidural anesthesia.

Thoracic spinal anesthesia in the 21st century

The history of the development of spinal needles has stimulated the return of the technique worldwide. There is considerable evidence that the gauge and design of the needle tip are responsible for complications such as post-puncture headache.13 In 2007, a Belgian group studied 30 patients undergoing elective laparoscopic cholecystectomy with thoracic puncture at T10 and injection of bupivacaine and sufentanil.14 This study showed that segmental spinal anesthesia can be used successfully and effectively for laparoscopic surgery in healthy patients, without neurological complications.

In 2010, studying a prospective single-blind study for thoracic puncture between T10-T11 in 300 patients showed that 6.6% of paresthesia occurred without late neurological complications.[15] In a study comparing laparoscopic cholecystectomy with lumbar puncture and full dose with half dose of hyperbaric bupivacaine and thoracic puncture, it was shown that 7.5 mg plus 20 ug of fentanyl may have an advantage in ambulatory patients because of the earlier recovery of motor and sensory function and earlier discharge.[16] Studying 636 patients undergoing thoracic spinal anesthesia (TSA) with low doses of local anesthetic for various types of surgery, it was shown that it reduces latency, the incidence of motor blockade of the lower limbs, and cardiovascular stability.[17] A total of 200 orthopedic patients operated under TSA, using the hyperbaric solution and sitting puncture compared with the isobaric solution in left lateral decubitus, demonstrated that the onset is fast, reduces cardiovascular effects, and that the hyperbaric bupivacaine solution provides a longer sensitive block as compared to the isobaric solution.[18] Recently, the group from Italy started using continuous thoracic spinal anesthesia for surgeries in elderly urology and abdominal surgery patients with excellent results.[19-20] In a recent narrative review defining the role of TSA in the 21st century, it provides information on the evidence that justifies its use in modern anaesthesia.[21]

Anatomy for TSA

A. Cadaver anatomy

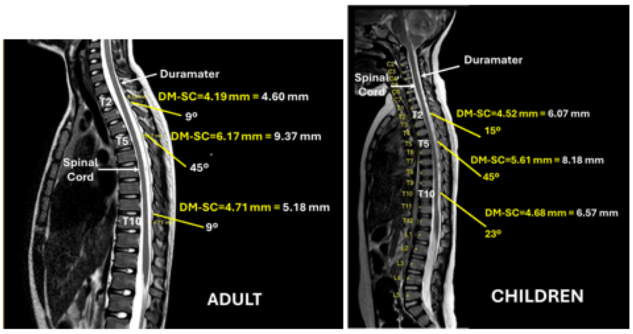
Anatomy has its first reports since the beginning of civilization, from the moment when man began to observe in other men and other animals, the various regions of the body of which they were composed. Anatomy using cadavers allowed the knowledge of the spinal column, the spinal cord and the dermatological metameres of the emerging nerves, allowing an adequate execution of techniques in the neuraxis. From simple observation, the practice of dissection evolved, which led to anatomy becoming established as a fundamental principle of practice in the health area, being considered a basic science. The vertebral column consists of 33 vertebrae, 7 cervical, 12 thoracic, 5 lumbar, 5 sacral and 4 coccygeal, providing a bony framework where the spinal cord is located, and it contains three curves, two of which are convex anteriorly cervical and lumbar, and the thoracic curve is convex posteriorly. The various precursors of TSA mentioned above probably found in cadavers that there was a space between the dura mater and the spinal cord, a space that would allow a needle to enter without touching and damaging the spinal cord.

B. Imagens anatomy

The possibility of studying anatomy even in living people, through imaging techniques such as radiography, endoscopy, angiography, computerized axial tomography, positron emission tomography, nuclear magnetic resonance imaging, ultrasound and thermography, has provided an understanding of the thoracolumbar spine.[22]

Various imaging tests such as radiography (X-rays), computed tomography (CT), magnetic resonance imaging (MRI), ultrasound (US) and fluoroscopy, each test has its own application and efficiency. MRI is considered the reference test for many spinal conditions and was chosen for the study of the various parts that include skin to the anterior bony structure, in adults and children.[23-26] Most MRI studies to assess distances from the skin to the posterior spinal cord are performed in the supine position. We also believe, when we give lateral or sitting position for subarachnoid block, cord will move more anterior due to the effect of gravity, leading to more space for drug installation and less chances of neurological injuries. In an MRI study performed in an adult Indian population, evaluating two thoracic segments (T5, T10) and one lumbar segment (L1), the same maximum space was found at the T5 level, followed by the T10 level.[26] The evaluation at the L1 level was justified because most anesthetists who use the seated puncture for subarachnoid access do so one or two spaces above L3.

MRI in adults and children aged 0 to 13 years showed the average measurements of the distance between the dura mater and the spinal cord, the entry angles between the skin and the spinal column, and the correction of the distance by the entry angle, showing that there is a smaller distance than the tip of any type of needle for spinal anesthesia (Figure 1). In Letter to the Editor was showed that cut-point needles would be safer for thoracic puncture.[27] Pencil-point needles have a lateral orifice that starts at 0.8 mm and ends at only 1.7 mm, so there is a need to penetrate the subarachnoid space 2 mm for CSF to appear, showing that this distance is always smaller than the distance between the dura mater and the spinal cord (Figure 2). A retrospective study with TSA in 1,406 patients showed safety and effectiveness without any neurological sequelae.[28]



Figures 1 Dura mater spinal cord distance by MRI in adult and child (0-13 years).

Table 1 Incidence of bradycardia and hypotension after single shot TSA

Ref	Author	Patients	Bradycardia	Hypotension
16	Imbelloni	70	2 (2.8%)	10 (14.2%)
17	Imbelloni	636	18 (2.8%)	97 (15.2%)
18	Imbelloni	200	9 (9%)	25 (12.5%)
27	Imbelloni	1406	44 (3.1%)	186 (13.2%)
40	Chandra	2074	273 (13.1%)	378 (18.2%)
42	Chandra	39	2 (5.1%)	5 (12.8%)
Total		**4425**	**348 (7.8%)**	**701 (15.4%)**

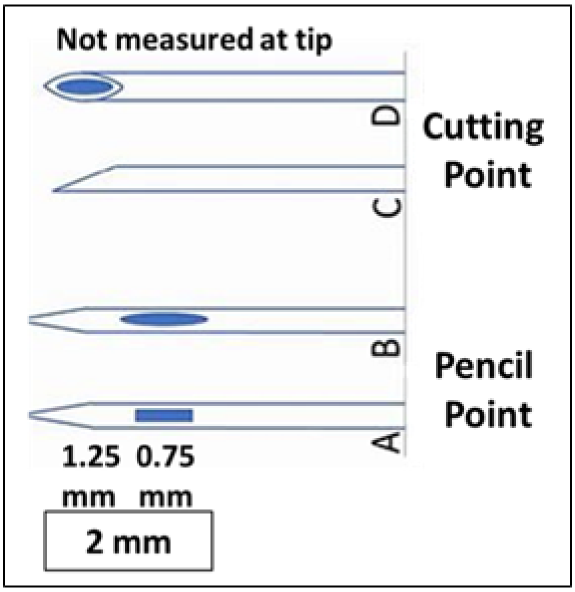


Figure 2 Needle design and hole spacing.

Innervation for TSA

The thoracic cage is supplied by twelve pairs of thoracic spinal nerves. The anterior rami of T1-T11 will form the intercostal nerves and the anterior rami of T12 will form the subcostal nerve. Thoracic spinal nerves innervate the muscles, joints, skin, and pleuroperitoneal lining of the thoracic and abdominal walls. They travel within the intercostal spaces and are called intercostal nerves.[29] Spinal nerves have both sensory and motor components. The sensory fibers arise from neurons in the dorsal root ganglia, enter the dorsolateral aspect of the spinal cord to form the dorsal root. The motor fibers arise from neurons in the ventral horn of the spinal cord, pass through the ventrolateral aspect of the spinal cord and form the ventral root. The dorsal and ventral roots converge in the intervertebral foramen to form a spinal nerve. After passing through the intervertebral foramen, the spinal nerve divides into dorsal and ventral rami. The dorsal ramus innervates muscle, bones, joints, and the skin of the back. The ventral ramus innervates muscle, bones, joints, and the skin of the anterior neck, thorax, abdomen, pelvis, and extremities.[29] TSA selectively targets the thoracic spinal segments responsible for thoracic and abdominal innervation, providing precise anesthesia and pain management while minimizing systemic side effects.

Local anesthetics

Mean density of CSF is 1.0003gm/L, range is between 1.0000 to 1.0006.[30,31] To understand the behavior of different local anesthetic solutions, it is essential to compare the densities of local anesthetics (LA) and the density of CSF. All LA, the most used adjuvants and their addition to local anesthetics were evaluated in the laboratory using the DMA 4500 desimeter at temperatures of 20°C, 25°C and 37°C.[32] LA solutions are hyperbaric if their density exceeds 1.00099, hypobaric when the density is below 1.00019 and isobaric when the density is greater than 1.00019 and less than 1.00099, and the densities of both local anesthetics and adjuvants decrease with the increase in temperature.[32] At 37°C, adjuvants such as morphine, fentanyl, sufentanil and clonidine are all hypobaric, and their addition to isobaric and hypobaric local anesthetics makes them more hypobaric and to hyperbaric anesthetics they only decrease their baricity, but they will always be hyperbaric.

Segmental spinal anesthesia demands a thorough knowledge of local anesthetics and adjuvants before conducting cases as here drug use is low because it must act on a specific target. If we use or select a wrong dose, the whole purpose of this technique will be abolished. It is always necessary to introduce local anesthetics at the target site to avoid diluting in CSF concept is based upon the baricity, concentration, dose, and volume of the drug. Right drug, carefully selected baricity in right volume and with right concentration is the key. Baricity is a ratio of the density of a substance compared to the density of human CSF. It determines the way a particular drug will spread in the intrathecal space. Baricity is analogous to specific gravity, but the ratio is the densities of LA and CSF, both at 37°C.

It is seen with the CSF of fresh cadavers that hyperbaric drugs tend to move towards gravity, isobaric drugs remain at the site, where they are injected, and hypobaric drugs always move away from gravity. So, baricity of a drug decides the spread of the drug in the subarachnoid space and height of the block. It also affects which position we are performing the subarachnoid block. Like in a lateral position thoracic spinal anesthesia drug requirement will be less in comparison to sitting position. Isobaric drugs are not affected by the position of the patient. Available drugs are isobaric bupivacaine, levobupivacaine, ropivacaine and hyperbaric bupivacaine, levobupivacaine and ropivacaine. Every drug has unique onset time, like isobaric levobupivacaine alone takes a long onset time than other isobaric drugs.[33] Drugs have different sensory and motor effect, like bupivacaine is having maximum muscle relaxation property followed by levobupivacaine, ropivacaine has the least muscle relaxation effect.[34,35] Levobupivacaine (isomer of bupivacaine) and ropivacaine are developed to abolish cardiotoxic property of bupivacaine.[36,37]

Baricity more than 1.0010 makes a drug hyperbaric, which is available commercially. A drug is made hyperbaric by adding dextrose. Changing to hyperbaric makes a drug more miscible to CSF leading to denser block. Hyperbaric drugs give more muscle relaxation than isobaric drugs. Isobaric drugs has a density between 0.9990 to 1.0006. They behave as hypobaric when they are warmed or dilute the isobaric solution with distilled water. Temperature of the drug inversely proportion to baricity. Warmed to 37° density 0.9984 becomes hypobaric cooled to 24° density 1.0032 becomes slightly hyperbaric.[30,32] Bupivacaine is having a density of 0.9990, it is always just on the edge of becoming hypobaric CSF density is lower in females than men, lower in pregnant than nonpregnant and premenopausal than menopausal that means solution in men behaves as isobaric will behave hyperbaric in them.

Hypobaric drugs are not available commercially, but they showed a promising role in posterior spinal hemianesthesia. Hypobaric solutions can be made from isobaric solutions of 2%, lidocaine, 0.5% bupivacaine, 0.5% ropivacaine and 0.5% levobupivacaine (S75:R25) by adding distilled water, thereby providing 0.6% hypobaric lidocaine, 0.15% and 0.1% hypobaric bupivacaine and levobupivacaine. A laboratory study showed that 0.1% hypobaric bupivacaine solution is significantly more hypobaric than 0.15% bupivacaine solution.[38] This 0.1% hypobaric bupivacaine solution allows achievement of analgesia without any degree of motor blockade.[38]

Adjuvants for TSA

They are added to enhance the onset and intensify the block. Available drugs are always preservative free either opioids or non-opioids. Opioids available are mainly morphine, fentanyl, sufentanil. Intrathecal morphine is under trial in thoracic spinal anesthesia, as it may cause respiratory depression, being hydrophilic again makes it spread more cranially and in TSA we already blocking intercostal muscles of respiration, so it is not advisable yet. Fentanyl is better suited for thoracic spinal anesthesia as it is devoid of side effects like urinary retention or respiratory depression.[16] Intrathecal fentanyl is used in the range of 25-50 µg, it is used to add volume to the drug and considered to be cardio stable. Adding fentanyl as adjuvant also make an isobaric drug to hypobaric, especially in sitting position.

Besides this buprenorphine (75-150 µg), tramadol (10-50 mg) are under trial for TSA.[39] Non opioid adjuvants include dexmedetomidine, clonidine, butorphanol, ketamine, midazolam, and dexamethasone. Intrathecal ketamine in the dose of 25-50 mg gives a very cardio stable hemodynamics, but it does not prolong the duration of the block Dexmedetomidine an alpha 2 blocker is remarkably effective. It can be used in a dose of 2.5, 5, 7.5 and 10 µg. It gives block duration according to the dose 5 µg is effective for 2 to 3 hours and 10 µg works for 6 to 8 hours. Although higher doses produce hemodynamic fluctuations, they are correctable easily and temporary. These side effects are less when it is combined with cardio stable levobupivacaine. Many advocate clonidine as an effective adjuvant, but it gives more hemodynamic fluctuations than dexmedetomidine, although belong to same alpha blocker group, but 7 times less site specific than dexmedetomidine.[40]

Sedation for TSA

Use of sedative agents is slightly tricky, when we have given TSA. There are certain different strategies when we are conducting surgeries under TSA. It is seen by various providers that TSA is more definitive than conventional lumbar spinal anesthesia, as it needs fewer local anesthetics. Sedation is mainly given to allay anxiety, after the achievement of definitive blocks. Agents are mostly used either intravenously or intrathecally. Available drugs, which can be used though both routes are preservative free ketamine, midazolam, fentanyl dexmedetomidine, morphine, butorphanol and clonidine. Few drugs in small doses can be used only intravenously are propofol, midazolam, fentanyl, dexmedetomidine, remifentanil, sufentanil and nalbuphine according to the availability of drug to that country. In laparoscopic surgeries, where now combinations of hypobaric and isobaric drugs are being used to overcome shoulder pain, very less sedative agents are needed. These patients only need anxiolysis with titrated dose of either of the drug or their combinations according to the requirements of the patient like fentanyl 1-2 µg/kg of ketamine 0.5-1 mg/kg dexmedetomidine 0.5 µg/kg, midazolam 1-2 mg or butorphanol 1-2 mg. Deep sedation here is avoided because it causes paradoxical breathing or deep jerky breathing, which becomes exaggerated with creation of pneumoperitoneum.[41]

Other surgeries which has a psychological impact like breast surgeries again needs this type of sedation, as here intercostal muscles are already blocked, so again deep sedation will lead may give loss of respiratory drive [**42**].

Few have started giving TSA, for thoracic vertebrae fractures, although studies are very less. But according to them, very minimal sedation is needed here. Unlike other fractures, patients with spine fractures do not receive any splint or cast to immobilize before surgery. And they used to face excruciating pain every second and used to face sleepless nights before surgery. Once they get block, majority of them used to sleep by themselves due to pain relief. Here authors who are conducting spine surgeries use very minimal sedation like midazolam 1 or 2 mg.[43] The crux of using sedation in TSA is avoidance of deep sedation, preservation of respiratory drive, once adequate block is achieved.

Thoracic approach

The use of imaging tests in living beings has shown new knowledge of anatomy, which was previously not possible in cadaver examinations.[44] The MRI evaluation of the subarachnoid space with the patient in the supine position demonstrated that the distance between the dura mater and the spinal cord in the thoracic segment of T5 is greater than in the cephalic segment of T2 or in the caudal segment of T10.[24] In any of these three segments the distance is greater than the orifice of the pencil point needle, which corresponds to 2 mm.[27] There are two schools of teaching in neuraxial anesthesia worldwide: the majority prefer the sitting position, and the minority prefer the lateral decubitus position. Likewise, many anesthesiologists worldwide routinely use hyperbaric bupivacaine solution for almost all types of surgery, mainly performed in the sitting position. Pencil point or cutting needles are normally used to perform thoracic puncture. However, as it is possible to perform hemi spinal anesthesia (unilateral and posterior) and completely sensory spinal anesthesia without any degree of motor blockade, it will only be possible using the puncture in lateral or ventral decubitus.

I. Single thoracic spinal anesthesia

Since the first spinal anesthesia performed by Bier, it has been commonly used in various surgical procedures.[45] Spinal anesthesia has the advantages of being a very safe and simple method, and with a low dose of local anesthetic it produces a profound sensory and motor effect, especially through lumbar puncture. However, anesthesiologists are reluctant to consider thoracic levels for performing subarachnoid puncture, largely due to direct threats to the spinal cord and a complete lack of knowledge of modern anatomy. In its inception in 1909, thoracic puncture for spinal anesthesia was used for operations on the skull, throat, and chest.[1] Most neurological complications related to spinal anesthesia are associated with paresthesia resulting from direct nerve trauma by the needle or pain during injection of the local anesthetic via intraneural location.[46] It is important to emphasize that this study was a survey sent to 4,927 French anesthetists with a response from only 736, which corresponds to 15% of the anesthetists consulted.

In the first single-puncture study with 300 patients for different types of surgery, comparing pencil point and cut point needles, in the sitting and lateral decubitus positions between T10-T11, it was shown that paresthesias occurred in 20/300 (6.6%) of patients, and all are transient.[15] From January 2007 to June 2011, with 636 patients and single thorax puncture between T9-T10 with pencil and cut point needles, for several procedures with low doses of anesthetics 0.5% hyperbaric and isobaric bupivacaine, in the sitting and lateral decubitus positions, showed that TSA decreases the latency time, degrees of motor block, cardiovascular changes, and without neurological complications.[17] In a recent study comparing thoracic paravertebral block and segmental TSA in breast cancer surgery, it was shown that thoracic puncture between T5-T6 with a 25 cut point needle and injection of 7.5 mg 0.5% isobaric bupivacaine plus 5 μg dexmethedomidine and immediately placed in lateral decubitus and 15 minutes in supine position for surgery.[47] The result showed that segmental TSA was faster, wider, and longer, with lower fentanyl requirements and it was associated with more hypotension, but with a higher degree of satisfaction.

II. Combined Spinal-Epidural Anesthesia

The combined spinal-epidural (CSE) technique offers advantages over the epidural or single injection spinal anesthesia alone. This technique is widely used in orthopedic, urologic, gynecologic surgery, and obstetric. It was used for laparoscopic cholecystectomy under segmental thoracic spinal anesthesia in 20 patients with a low dose of 0.5% hyperbaric bupivacaine (5 mg) and sufentanil (2.5 μg), without none requiring conversion to general anesthesia.[14] Segmental TSA is being used in several types of surgery. A woman aged 73 years was scheduled for resection of a tumor in the right colon, through CSE block with puncture between T9-T10 with a needle-in-a-needle set (Espocan®) and injection of 10 mg of 0.5% hyperbaric bupivacaine and catheter.[48] After 10 minutes of installation of the block, segmental thoracic anesthesia extending between the 3rd thoracic and 1st lumbar dermatomes, and the motor block of legs was grade one. Postoperative analgesia was obtained with infusion of 0.1% bupivacaine with an elastomeric pump for 40 hours. The CSE block offers flexibility because the duration of anesthesia can be extended with the help of the epidural catheter.

III. Continuous thoracic spinal anesthesia

Studying the formation of the spinal cord, it was noticed that it contains two anterior roots and two posterior roots, showing that the anterior horn is of a sensory nature and the posterior horn is of a motor nature. Thus, the three local anesthetic solutions (hyperbaric, isobaric, hypobaric) when injected into the subarachnoid space, both lumbar and thoracic, showed that each of them has its own onset time, propagation, quality of sensory blockade and duration of motor blockade. Hyperbaric local anesthetics, when injected into the sitting or lateral decubitus position and immediately placed in the supine position, will favor their dispersion to the posterior roots, providing a sensory block that lasts longer than the motor block. Isobaric (slightly hypobaric) and hypobaric solutions, when injected in the same manner as previously explained, will favor the anterior roots, with a motor block that lasts longer than the sensory block.[49] Recently, the Italian group introduced continuous TSA without complications with the catheter and spinal cord.[19,20] A new set consisting of a 21G spinal needle with a Tuohy tip that would perform the subarachnoid puncture and after the appearance of CSF, a 3-4 cm 24G catheter was inserted, and 2.5 mg hyperbaric bupivacaine plus 25 μg fentanyl was injected, and 3 minutes later another 2.5 mg hyperbaric bupivacaine.[19]

Neurologic complications

Four studies on accidental dural perforation during epidural anesthesia in adult patients showed that in 1,071 patients, 4,185 patients, 1,240 patients and 113 patients, there were 50 (0.75%) accidental spinal dural perforations without any neurological sequelae.[50-53] There is probably an anatomical explanation for the absence of any neurological damage.[23,24] TSA is technique little used by anesthesiologists because they believe that it causes fear of spinal cord injury, cephalad spread of the blockade and hemodynamic instability. In a study where a retrospective audit was carried out, between January 2007 and December 2019, the incidence of paresthesia and neurological complications due to TSA was evaluated as two types of needles of the same gauge, with 0.5% isobaric and hyperbaric bupivacaine, with puncture in the sitting or left lateral position, and median and paramedian insertion.[54] The incidence of paresthesias was 5.9% of patients, with 41 patients having needlestick injuries and 43 patients having pencil point injuries, with no statistical difference. All paresthesias were transient and lasted a maximum of three days. No neurological sequelae were observed in any of the patients during this period.

In a study of cadaveric dura mater, it was observed that the dura mater was regularly pushed or tent up to 1 cm or more in front of the needle before CSF could be seen at the needle hook, indicating that a dural puncture had occurred.[55] Despite advances in spinal imaging, lateral puncture between C1-C2 for cervical myelography continues to be used in several institutions and is considered standard of care by most neuroradiology programs in several countries, with no reported spinal cord injury [**56**]. In studies with CTSA by the Italian group, there is no report of injury to any nerve with the presence of the catheter in the subarachnoid space.[19,20,57]

Alterations cardiocirculatory

The cardiocirculatory effects of spinal anesthesia are due to thoracolumbar sympathetic blockade. This blockade is a consequence of the action of the local anesthetic on the preganglionic fibers or white rami, which start from the sympathetic neurons located in the mediolateral horn of the spinal cord between T1 and L2, towards the paravertebral and paraaortic sympathetic ganglia. In a study examining the tolerance of spinal anesthesia in infants, researchers found that short-term heart rate variability (HRV) decreased with spinal anesthesia, but the balance between left and right HRV remained stable.[58] The study suggests that spinal anesthesia may reduce parasympathetic modulation of cardiac function in infants. In adults' hypotension and bradycardia are both well-recognized side effects of spinal anesthesia, although their clinical presentations are usually mild and respond rapidly to treatment.

In 1,330 procedures with lumbar puncture with a sensory level reaching C3 or C4 with the mixture of bupivacaine, clonidine and sufentanil, it was shown to be an effective option for surgeries on somatic structures distal to the metamer of the third cervical spinal nerve lasting no longer than 4 or 5 hours.[59] However, 100% of patients had to correct hypotension with vasopressors and 52% of bradycardia with atropine. Regarding the incidence of bradycardia and hypotension during CSE performed on 20 patients, only 2 (10%) patients presented hypotension and no bradycardia.[14] And during continuous TSA in three articles studies by the same group with a total of 193 patients, arterial hypotension occurred in 125 (65%) with need for continuous administration of vasopressor, and bradycardia was reported in 16 patients (17.7%).[19,20,57]

New indications

1. Breast cancer surgery

Surgery on mid thorax needs midthoracic intrathecal puncture at T5-T6 or T6-7. In a study with 40 patients scheduled for unilateral mastectomy with axillary dissection, 20 patients received segmental TSA in the T5-T6 interspace, in lateral decubitus or sitting position, with 5 mg 0.5% isobaric bupivacaine plus 20 µg of fentanyl, compared with the same number receiving general anesthesia, it was demonstrated that segmental TSA has some advantages and can be considered as a sole anesthetic in breast cancer surgery with axillary lymph node clearance.[60] To perform a single case of modified radical mastectomy (MRM) in a bronchiectasis patient, the patient was placed in a sitting position between T5-T6 and injected with 5 mg of 0.5% hyperbaric bupivacaine plus 20 µg of fentanyl, achieving sensory from T1-T7, associated with axillary block, concluding that TSA can be a safer alternative to general anesthesia (GA) in patients undergoing MRM and other localized breast surgeries.[61] In this case, the hyperbaric solution would be more interesting, mainly to raise the level and allow axillary resection.

Studying 78 patients undergoing segmental TSA with 1.5 ml of isobaric levobupivacaine with 5 ug of dexmedetomidine was administered immediately placed in a supine position, for patients operated on modified radical mastectomies.[42] The results showed adequate sensory and motor blockade, less PONV than GA, with hemodynamic fluctuations like hypotension and bradycardia being there, but it was easily correctable with standard drugs. For mid thoracic punctures an angle for needle insertion was proposed for better instillation of drugs.[62] In 72 female patients, undergoing unilateral modified radical mastectomy with axillary dissection, were separated to receive thoracic paravertebral block and segmental TSA, both were effective and safe as sole techniques, with low complications.[47] The segmental TSA was faster, wider, and longer, with lower fentanyl requirements and patient satisfaction. However, it was associated with more hypotension.

Excising a large fibroadenoma with characteristics suggestive of a phyllodes tumor, a procedure traditionally conducted under general anesthesia. TSA was indicated for resection a large fibroadenoma with administration of 1.5 ml of 0.5% isobaric levobupivacaine and 5 µg dexmedetomidine, complemented by an ultrasound-guided erector spinae plane block for postoperative analgesia, and the technique showed minimal hemodynamic fluctuations and achieved immediate postoperative mobilization.[63] In a randomized study, 30 patients scheduled for elective breast surgeries for a duration of less than 90 min were divided into two groups under general anesthesia and TSA.[64] TSA presented better results than general anesthesia in terms of analgesic efficacy, patient satisfaction, recovery and cost-effectiveness for short-duration breast surgeries. In a recent meta-analysis with 4,060 articles, six studies were included for qualitative assessment, with four further analyzed quantitatively, and showed that segmental TSA is a safe and effective alternative to general anesthesia for breast cancer surgery, offering superior postoperative pain control, enhanced patient and surgeon satisfaction, and a reduced incidence of postoperative vomiting.[65]

2. Endoscopic discectomy

The concept of minimally invasive spine and the increasing patients' demand for rapid recovery, minimally invasive techniques have gained increasing attention in spinal treatment due to their minimal invasiveness and accelerated recovery. Endoscopic spine surgery is considered least invasive. Various anesthetic techniques have been used for endoscopic discectomy (ED) such as local and sedation, general anesthesia, epidural anesthesia and spinal anesthesia. But none of the method fulfilled the criteria of a pain free patient following command of intraoperative leg movements. GA needs neurological monitoring throughout the surgery,which is not available everywhere and it has its own demerits. Conventional lumbar spinal anesthesia does not provide leg movements. Epidural anesthesia provide patchy effects, whereas local anesthesia with sedation sometimes become difficult for the patient to tolerate leading to incomplete disc removal. A new method by TSA using titrated dose at lower thoracic level leads to solve all the issues. It has given good analgesia with preserved leg movements throughout the procedure. The TSA at lower thoracic level with very small dose of local anesthetic with adjuvant fentanyl, which preserved the leg movements and patient tolerated the surgery very well, because received good analgesia.[66]

3. Thoracolumbar spine fractures

Thoracolumbar junction is a common site for fractures due to mobile lumbar spine and fixed thoracic cavity. These types of fractures are common due to fall from height or road traffic accidents. Many times, they are associated with rib fractures, hemothorax etc. Conducting these cases under GA is a difficult task for the anesthesiologists. So, during Covid era, double needle technique was devised for thoracolumbar spine fractures, with two subarachnoid blocks punctured simultaneously at T5 and another at lower lumbar or conventional site.[43] At both sides isobaric drugs with adjuvants were given, as these drugs do not affect by positioning. Here position for the block was given in lateral position by the curling of the spine. In these cases, no or minimal sedation is used as patient was already facing so much pain throughout. Unlike other fractures of limbs, we do not give any splint or cast to spine fractures, so they face excruciating pain always before fixation. Here when patients receive subarachnoid block, after 10 minutes they fell asleep as pain has gone. Patients used to remain hemodynamically stable with very little blood loss, as spontaneous respiration led to less engorgement of epidural veins leading to less blood loss. It also saved surgical time because of the need for cautery, finally lead to more satisfied surgeons and patients.

4. Robotic surgeries

This is the future of TSA. Minimally invasive liver resection has become a standard of care for liver tumors. In a case report of awake robotic liver surgery, a CSE anesthesia with conscious sedation to avoid general anesthesia was performed in a 77-year-old man, with hemodynamic stability and minimal bleeding, and an uneventful postoperative period.[67] Before this one case of robotic prostatectomy was using a combination of US-guided cervical plexus block and TSA, associated with sacral erector spinae plane block at the end of the procedure for postoperative pain control.[68] Prospects will include robotic surgeries, video assisted thoracoscopy and cervical and upper thoracic spine surgeries using TSA, because we believe that there is lot to explore in the field of neuraxial anesthesia.

5. Safety profile now changed

Use of US for the measurement of safe distance between posterior dura and cord has made the life of anesthesiologists very easy. We can do subarachnoid block either US assisted, or US guided. Now TSA is being used safely in very sick patients with respiratory diseases undergoing upper abdominal and thoracic surgeries. High frequency nasal canula or high frequency nasal canula can be used as a supportive one for these patients, in terms of improving oxygenation, reducing dead space ventilation. Its use in TSA will open another dimension.[69]

Conclusion

Understanding the anatomy of the spinal canal is essential for the correct introduction of medications and spinal catheters. Any reader unfamiliar with the practical side of spinal anesthesia reading this article may excusably make the inference that the question of spinal anesthesia for any operation in surgery has been so perfectly settled that it would hardly be worthwhile to make further enquiries into the subject. This article showed otherwise. From which the authors are enthusiasts of the technique. The authors sought to convince us that, by adopting TSA, it is controllable. It is essential to understand that sensory without motor blockade can be obtained in several ways, such as reducing the dose, using isobaric, hypobaric and hyperbaric anesthetics, puncture position, table position after subarachnoid puncture and finally using the continuous thoracic spinal anesthesia technique. Probably Jonnesco in 1909, only with studies on cadavers, had the vision that only a century later with the help of new imaging methods, allowed the return of thoracic spinal anesthesia for numerous procedures previously performed only with general anesthesia.

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