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Safety in Spinal Anesthesia from Asepsis and Antisepsis to Total Recovery from Block

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ABSTRACT

In the early 20th century, glucose was added to local anesthetics, making it the preferred choice of anesthesiologists worldwide. Before offering a patient spinal anesthesia, an anesthesiologist not only must be aware of the indications and contraindications of spinal anesthesia but also must be able to weigh the risks and benefits of performing the procedure. Asepsis and antisepsis of the back should be carried out with alcoholic chlorhexidine or 70% alcohol, allowing it to dry spontaneously. The MRI confirmed Jonnesco's teachings on the safety of thoracic spinal anesthesia using puncture above T11. Likewise, when a lumbar puncture is performed, it should be performed below L3, preferably as low as possible. Subarachnoid puncture should be performed with a needle of the smallest gauge and tip preferred by the anesthesiologist. If using an introducer, make a puncture in the skin to avoid introducing skin tissue. For safety, use isobaric, hyperbaric and hypobaric solutions. Adjuvants should be injected into separate syringes, as they alter the baricity of local anesthetics. Always remember that the spinal cord was placed inside a bony tube to avoid the injection of any drugs. This educational article shows some ways to perform single shot spinal anesthesia safely for patients.

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Key Points

Question

What are the main safety guidelines for single shot spinal anesthesia?

- Selection of patient, asepsis and antisepsis, puncture position (sitting, lateral decubitus, posterior), choice of needle (cutting tip or pencil tip), needle gauge (22G to 29G), use of hypobaric, isobaric, hyperbaric anesthetics, factory-sterilized products, assessment of anesthetic dispersion.

What does the educational article propose?

- Wash your hands before entering the operating room.
- Asepsis and antisepsis on the back with alcoholic chlorhexidine or 70% alcohol.
- Choose the needle with the tip preferred by the anesthetist and always the smallest gauge.
- If using an introducer, make an incision in the skin to avoid introducing cellular tissue into CSF.
- Use Local Anesthetics (LA) and adjuvants in a sterile pack.
- If using adjuvant, use a separate syringe from the LA and insulin.
- Do not perform spinal anesthesia on a febrile patient or one with an infection.
- Study modern anatomy with MRI, especially in the thoracic region.
- If you perform a lumbar puncture, do so below L3.
- If paresthesia occurs, withdraw the needle.
- If pain occurs during injection, remove the needle and stop the injection.
- If US disposer evaluate the conus medullaris terminus.

Meaning

- If the spinal cord is protected by a bony structure from the brain to the coccyx, doctors should be more careful with the products deposited there. This space is not a dumping ground for injecting any drug.

Introduction

Whether the emergence of human beings was the result of evolution or God's creation, both protected the brain and spinal cord within a rigid tube of bone so that penetration into this space would not become a wasteland. Thus, the injection of any substance into the subarachnoid space should be strictly controlled to avoid complications. Due to this excellent protection created by the evolution of man or even during creation by God, we must remember that this space should not be used by products that are not yet authorized. The subarachnoid space is not a trash can.

Alleviating human suffering has always been a reason for questions and constant research throughout history, whether through philosophy, theology, medicine or related sciences. It would not be surprising if the chronology of local anesthetics and adjuvants dates to ancient civilizations in the search for individual hedonism: the definitive or partial relief of everyday pain to ensure harmony in community life, and spinal anesthesia has provided constant evolution since its first use.

Spinal anesthesia is widely practiced technique for its safety margin [1]. However, it can be associated with complications such as cardiovascular collapse, meningitis, paralysis, and death [2]. Thoracic spinal anesthesia (TSA) is considered safe and without neurological sequelae in a study with 1,406 patients [3].

I finished my one-year residency in 1975, having completed 50 years of dedication to medicine and anesthesiology at the end of December 2024. When I started my career as anesthesiologist, the needles for spinal puncture were made of metal and were reprocessed countless times. Likewise, local anesthetics were produced by laboratories with little scientific rigor and were sterilized in germicides.

When using disposable material of a quality that allows for the performance of excellent spinal anesthesia, other risks imposed by this technique must be considered. This is the possibility of mixing up vials, leading to extremely serious complications for patients who would otherwise undergo an extremely simple technique [4]. It is not worth knowing all these materials without adequate knowledge of the safety and hygiene principles for using drugs in the subarachnoid space. Likewise, a common practice throughout the world is to mix all adjuvants with local anesthetics, which significantly alters the baricity of these mixtures [5]. And the baricity of the mixture being injected is not known.

In an excellent Editorial published in 1994, requesting the Brazilian pharmaceutical company to produce 0.5% bupivacaine for spinal anesthesia, which happened immediately [6]. With the production of bupivacaine by a laboratory with greater scientific rigor, studies began with all presentations of this local anesthetic.

This article will address the safety of the technique from the moment the patient enters the Operating Room (OR) until full recovery from anesthesia. The pre-anesthetic visit will not be addressed, since it is essential to explain the entire procedure, which is routinely performed in Brazil and India. Because spinal anesthesia is the most widely used technique in several countries, and continuous spinal anesthesia and combined epidural-spinal anesthesia are different techniques from single-shot, the article will only address the safety conduct carried out during 50 years of practice for spinal anesthesia.

Articles for medical use are divided into critical, those that penetrate through the skin or mucous membranes, reaching subepithelial tissues; semi-critical, which encounter non-intact skin or intact mucous membranes; and non-critical, which come into contact only with the patient's intact skin). Therefore, the needles used in neuraxial and locoregional blocks are considered critical, and must always be sterilized single-use and disposable, preferably by the manufacturers.

Recently, 14 subsequent steps for performing a subarachnoid puncture were described, from entry into the surgical center (SC) to the complete injection of the local anesthetic and placement in position on the surgical table (Table 1) [7].

Table 1: Conduct technique for Spinal Puncture [8]

N	Conduct to be Followed for Safety
1	Entrance to the surgical center washing hands with soap
2	With the patient in the antisepsis puncture position with 70% alcohol or alcoholic chlorhexidine
3	After antisepsis with a single layer, opening the tray for blocking
4	Never dry the antiseptic with gauze and allow it to dry spontaneously.
5	After opening the tray, place the needle and sterilized local anesthetics
6	Verification of the batch, date of manufacture and expiration date of anesthetics
7	Aspiration of liquid from the ampoule
8	Choosing the space to be punctured
9	Infiltration with local anesthetic with syringe and insulin needle
10	Wait for it to take effect
11	Subarachnoid puncture with the chosen needle
12	If Whitacre uses a 20G introducer
13	If it is Quincke, do not use an introducer
14	Subarachnoid injection with chosen dose and local anesthetic

With the advent of Ultrasound (US), spinal anesthesia is now less scary in terms of neurological injury. A pre procedural scan leads to guidance towards successful and safe subarachnoid block. Subarachnoid blocks can be US assisted, or US guided depending upon the anesthesiologists skill. This technique is not routine in most hospitals in Brazil.

Asepsis and Antisepsis

Asepsis of professionals' hands and patients' backs is the set of methods and processes for cleaning a given environment, to avoid its contamination by infectious and pathological agents, while antisepsis is the set of measures used to inhibit the growth of microorganisms or remove them from a given environment, if they can be destroyed [8]. Only in the event of visible dirt at the site of the future puncture, remove it with soap and water before applying the antiseptic [8]. In view of this Agência Nacional de Vigilância Sanitária (ANVISA) standard in Brazil, we suggest that doctors, nurses and all OR employees wash their hands with soap and water, without brushing them.

The use of iodinated alcohol in hospitals was banned because of its adverse effects, such as hypersensitivity, intoxication, and interference with some laboratory tests, however, there is no justification approved by ANVISA [8]. Antiseptics most used today for skin antisepsis are alcohols (ethanol, isopropanol and n-propanol), chlorhexidine, commonly available as Chlorhexidine

Gluconate (CHG) and associated with alcohol.

Rub the skin with an alcohol-based solution: 0.5% chlorhexidine gluconate or 70% alcohol [8]. The application of chlorhexidine or alcohol is for 30 seconds. It is essential to wait for the antiseptic to dry spontaneously before proceeding with the puncture, and a sterile cap and mask are mandatory to wear.

Anesthesiologist is frequently faced with situations where there is a potential risk of cross-cutting infection, and it is important to recognize and minimize this risk. In two articles from the beginning of this century, both authors may suggest that anesthesiologists have difficulty assimilating and adopting antisepsis practices [9,10]. Hand hygiene is a cornerstone preventing transmission from health care personnel to patients via contaminated hands and from contaminated environmental surfaces and medical devices via health care personnel hands to patients [11]. The association between improved hand hygiene compliance from low to higher rates and reductions in health care associated infection rates has been well described [11].

With the aim of studying how many applications of chlorhexidine/ethanol should be used for skin disinfection before neuraxial procedures, it showed that single application of chlorhexidine/ethanol solution is sufficient to disinfect the skin before regional anaesthesia, particularly in the emergency when waiting for a second application to dry may add needless delay and risk translocation of excess chlorhexidine into the subarachnoid space [12].

In a systematic review and meta-analysis comparing the action of Povidone Iodine (PI) with Chlorhexidine Alcohol (CHA) is the antiseptic agent of choice to prevent Surgical Site Infection (SSI) showed that skin preparation with CHA is more effective than PI in preventing SSI across clean and clean-contaminated surgery [13]. This study demonstrated that the same should be applied for access to the neuraxis during spinal anesthesia. In our opinion, without evaluating the level of evidence in the available evidence, 0.5% chlorhexidine in 70% alcohol is the ideal skin preparation for neuraxial procedures, and certainly a meticulous application technique must always be more important for patient safety than the concentration of the solution.

Spinal Needles

In the first spinal anesthesia performed by Bier, a reusable metal cutting needle type was used [14]. It was not until 1926 that Greene introduced a needle with a rounded tip and a terminal orifice [15]. The early development of spinal needles paralleled the early development of spinal anesthesia. The ideal spinal anesthesia needle should facilitate identification of the subarachnoid space and injection of the local anesthetic, not deform and not cause headaches. The two main types of needles frequently used are: cutting needles (Quincke-Babcock and Pitkin) and needles with non-cutting tips, rounded tips (Greene) and pencil tips (Whitacre and Sprotte). Needles from different manufacturers, even with the same gauge, may have different sizes in their production.

The use of disposable needles for spinal anesthesia begam in the 1960s [16]. The needles were introduced to simplify their use and minimize complications, as finer needles were easily damaged and difficult to sterilize and sharpen [16]. In 1980 and 1981 I defended my thesis on epidural morphine at the Department of Anesthesia at the Faculté Louis Pasteur in Strasbourg, France. In 1990 I returned to the Hautepierre Hospital, Strasbourg, France, for a 1-month refresher course, and returned with all disposable spinal needles, from April 1991 we started using 25G and 27G needles, and only at the end of 1993 the 29G needle [17]. In contact with the manager of B. Braun's regional anesthesia products in Brazil, they began importing spinal anesthesia needles and other products in 1993 and began sales in 1995. In 2001 my group published 5050 spinal anesthesia with the three types of disposable needles such as Quincke (25G, 26G, 27G, 29G), Whitacre (27G) and Atraucan (26G), with the lowest incidence (0.3%) of headache with the 29G Quincke needle (Table 2) [18].

Table 2: Headache Incidence According to Needle Type and Gauge in 5050 Patients [15]

	25G Q	26G Q	27G Q	29G Q	26G A	27G W	TOTAL
Patients	324	138	3234	924	220	210	5050
Headache	10 (3%)	2 (1.4%)	23 (0.7%)	3 (0.3%)	1 (0.4%)	1 (0.4%)	40 (0.8%)

Q=Quincke, A=Atraucan, W=Whitacre

The standard needle for spinal anesthesia is the Quincke-Babcock type and is used for comparison with the others in terms of construction, advantages, disadvantages, complications and incidence of headache. It has a cutting tip, a mandrel that fits perfectly on the tip and a medium-sized and angled end, being the only needle with a 29G gauge. After entering the subarachnoid space, cerebrospinal fluid (CSF) appears immediately (Figure 1).

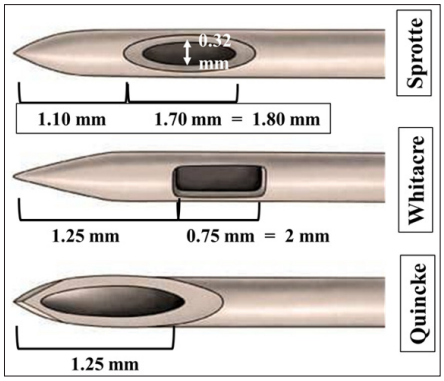

Figure 1: Three drawings of the needle tips and the measurements of their openings

The Whitacre needle is preferred worldwide, especially in obstetrics, and in most procedures, it is used with an introducer. The Whitacre needle has a tip like a pencil tip, rounded, firm and non-cutting. On the side, 1.25 mm from the tip, there is a 0.75 mm hole through which the CSF and local anesthetic will flow. It has a mandrel that fits perfectly with the needle, preventing the CSF from appearing before it is withdrawn. The pencil-shaped tip separates the fibers of the dura mater, leaving a small hole that quickly closes. Due to the small lateral orifice, the CSF is difficult to extract, and it is necessary to aspirate the CSF with a 2 ml syringe. The sharp tip is easily damaged, making its introduction difficult, and for this reason, some authors recommend the use of an introducer. The exit orifice is small, resulting in resistance when injecting the local anesthetic, creating a flow directed towards the side where the orifice is facing (Figure 1).

The Sprotte needle is like the Whitacre pencil needle, with a larger orifice further from its tip, allowing for rapid appearance of CSF and facilitating injection of local anesthetic. This larger orifice may cause loss of anesthetic to other spaces during injection, with a higher incidence of failure (Figure 1).

Puncture with a 29G needle causes less injuries and minimal functional changes of the spinal cord, which can serve as a new means for studying spinal neurotoxicity of local anesthetics [19].

Use of The Introducer for Spinal Needles

The introducer was designed with a metal needle reprocessed in 1990, having a cannulated needle shaft of 5 cm with a cutting tip [20]. The introducers can be of different sizes (18G, 20G and 22G) and their length depends on the manufacturer, and in different manufacturers it measures 5.5 cm (Figure 2).

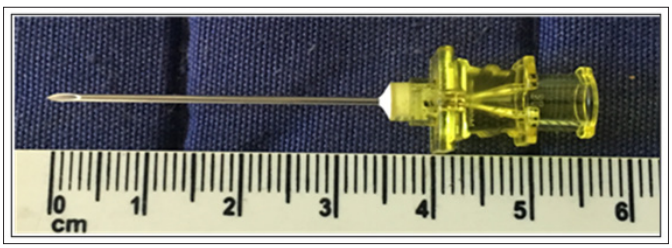

Figure 2: Introducer Measurement 20G

There are two ways to access the subarachnoid space. The first involves passing a small-gauge spinal needle through the skin and ligaments, which can cause a less traumatic puncture, but can result in bending and misdirection of the fine-gauge needle [19]. The second approach uses a larger-gauge introducer needle (usually 20G) to penetrate the skin and fibrous layers, and the fine-gauge spinal needle can then pass through the introducer needle with less resistance, guided by the stiffer shaft of the needle, toward the diameter [21]. The use of a large-gauge introducer needle can cause tissue trauma, inflammation, and late epidermoid tumors [22]. Lumbar puncture is a common, iatrogenic cause of epidermoid formation, but can theoretically be prevented with the use of stylette needles. In a recent literature review a total of 65 cases (including the current case) of epidermoid tumor showed that thirty cases were acquired from either lumbar puncture or prior surgery [22]. In thin patients using the 20G introducer of 35 mm in length resulting in severe headache and lasting for three days [23].

Subarachnoid puncture with different types and calibers of spinal needles may lead to skin fragments during lumbar punctures may develop intraspinal epidermoid tumors [22]. To determine the incidence of epithelial cells that reflow along with the first and third drops of CSF in 39 patients undergoing spinal anesthesia with a 25G Quincke needle, a high percentage of epithelial cells was found in the first (89.7%) and third (87.2%) drops of CSF reflow and in used needles (61.5%) [24]. If epithelial cells were found in the puncture with a 25G Quincke needle up to the 3rd drop of CSF, no study of the cells was found with the introducer, which will certainly perform a skin biopsy upon entry into the skin.

For greater safety during subarachnoid puncture, the most used introducer (20G) should be used, and an incision should be made in the skin before its introduction to avoid performing a biopsy of the cellular tissue that will remain in the introducer barrel.

Local Anesthetics

Local anesthetics (LA) used before 1950 were cocaine, procaine, tetracaine and lidocaine, and after this date 2-chloroprocaine, mepivacaine, prilocaine, bupivacaine and ropivacaine were introduced. Levobupivacaine, the pure S-enantiomer of bupivacaine, was developed in 2000 as an alternative to bupivacaine with similar pharmacokinetics but a safer side effect profile [25]. In Brazil, an enantiomeric excess of bupivacaine containing 75% of the S-enantiomeric and 25% of R-enantiomeric was investigated (S75:R25) and later approved for use in regional anesthesia [26]. In several articles published in Brazil with the enantiomeric mixture of bupivacaine (S75:R25) whether in epidural, brachial or lumbar plexus block, postoperative analgesia by bilateral pudendal nerve block, there is no report of toxicity with cardiac arrest [27].

The main objective of this article is to address the safety of access to the subarachnoid space for the single shot technique of spinal anesthesia. The various LA used in spinal anesthesia can be hyperbaric (with added glucose), isobaric (plain or pure) and hypobaric (with added distilled water).

Therefore, regardless of the country, LA should always be sterilized by the manufacturers, using hydrogen peroxide and packaged in sterile pack sets, described below. Thus, all anesthetics produced for spinal anesthesia should be supplied in sterile packaging. Likewise, all adjuvants used in spinal anesthesia should also be offered to anesthetists for application to patients, which would increase safety during the procedure. And it should be mandatory to write down (or discard) the packaging where the batch and expiration date appear and include it in the anesthesia record.

Local Anesthetic Mixtures in Spinal Anesthesia

Although many anesthesiologists mix LA, there is still no rationale on pharmacokinetic principles for mixing short- and long-acting local anesthetics to hasten onset and extend duration. When two LA are combined, the concentration of each is correspondingly decreased. If we mixed, 1 ml of lidocaine 2% with 1 ml of bupivacaine 0.5% becomes lidocaine 1% and bupivacaine 0.25%, respectively. This lower concentration means less of each drug penetrates the nerve to bind to the sodium channels. Only LA in its unionized form can transverse the lipid layer of the nerve and this is determined by the pKa of the drug and pH of the solution. Therefore, combining lidocaine (fast onset) with other agents such as bupivacaine, levobupivacaine, S75:R25 and ropivacaine (slower onset) decreases the pH, resulting in a lower proportion of unionized lidocaine.

The rationale, therefore, for mixing LA to hasten onset is flawed and not supported by pharmacological principles or clinical research [28]. LA mixtures are used in peripheral nerve blocks to improve onset, though study results remain conflicting. In a recent systematic review and meta-analysis comparing the efficacy

of long-acting LA with their combination with short-acting LA in ultrasound-guided peripheral nerve blocks, with the primary outcome being the onset of sensory block [29]. The result showed that LA mixtures did not affect the onset of sensory and motor blockade in peripheral nerve block but could shorten the duration of sensory blockade.

In a search on several websites, no article was found with the mixture of LA for single shot spinal anesthesia. Unlike the addition of adjuvants, with numerous articles.

Spinal Anesthesia Products in Sterile Pack in Brazil

The history of packaging in Brazil has evolved from the simple barrel of food in the 19th century to state-of-the-art equipment and substrates resulting from research and development. The treatment method to deactivate viable microorganisms from objects or products is termed sterilization, having numerous forms of sterilization, each intended to be applied for a specific target, which depends on - but not limited to - the thermal, physical, and chemical stability of that target [30].

Sterile pack is the name given to the packaging of anesthetics and adjuvants that undergo a sterilization process before being used in clinical practice, consisting of a chemical sterilization process at low temperature, in which hydrogen peroxide is used. Hydrogen peroxide (H_2O_2) is known for its strong and fast acting microbicidal properties [31]. Gaseous mixtures with varying concentrations of H_2O_2 are widely applied for sterilization of surfaces in the pharmaceutical, food, and beverage sectors.

In a study aimed at comparing the sterility and microbial load (bacteria and fungi) on the outside of the vials of hyperbaric bupivacaine (Neocaína®) in ampoules and bupivacaine in vials of conventional and sterile presentations (sterile-pack), it was concluded that the use of sterile packaging (sterile-pack) reduces the microbial load of the bottling vials, which would reduce the chance of exposure to potential contamination of the anesthetic solution [32].

Therefore, regardless of the country, LA should always be sterilized by the manufacturers, using hydrogen peroxide and packaged in sterile pack sets. Thus, all anesthetics produced for spinal anesthesia should be supplied in sterile packaging. The Brazilian Society of Anesthesiology (SBA) recommends the following recommendations on safety in regional anesthesia [33]:

- That cleaning the neck of the glass ampoule with alcohol before opening it be part of the anesthesiologist's routine, or that aspiration be performed with needles with an antibacterial filter.
- That sterile packaging be used to increase safety and reduce bacterial contamination of the solutions used in anesthesia.

During my 50 years of practice having visited and taught in 23 of the 26 states, and practically all Latin American countries. I have never been given a bacterial filter to aspire to the contents of the ampoules. However, in a survey carried out with numerous anesthesiology societies, few uses local anesthetics and adjuvants sterilized in sterile packs to avoid infections.

In Brazil, for single-shot spinal anesthesia, we have local anesthetics and adjuvants in sterile packaging (Table 3). The Sterile-pack kit ensures that all primary packaging of the medication is sterile, free from any contamination, preventing post-spinal puncture infections. Safety for the doctor and the patient.

Table 3: Local Anesthetic and Adjuvants in Sterile-Pack

Local Anesthetic	Bupivacaine isobaric 0.5% = 4 ml Bupivacaine hyperbaric 0.5% = 4 ml Levobupivacaine (S75:R25) isobaric 0.5% = 4 ml Lidocaine isobaric 2% = 5 ml Lidocaine hyperbaric 5% = 2 ml
Adjuvants	Morphine 0.1 mg/ml = 1 ml Morphine 0.2 mg/ml = 1 ml Fentanyl 0.05 mg/ml = 2 ml Sufentanil 5 µg/ml = 2 ml Clonidine 150 µg/ml = 1 ml

Adjuvants For Spinal Anesthesia

Local anesthetics have potential to be used in a wide variety of situations for spinal anesthesia. Their use can be limited by their duration of action and the dose-dependent adverse effects on the cardiac and central nervous system. Adjuvants are drugs which, when coadministered along with local anesthetic agents, improve the latency of onset and duration of analgesia and counteract disadvantageous effects of local anesthetics.

In 2009, studying the baricity of various LA and numerous adjuvants used in spinal anesthesia using a DMA 4500 densimeter, it was shown that both LA and adjuvants exhibit a decrease in density when the temperature increases [5]. At 37°C, all adjuvants studied are hypobaric [5]. Thus, the addition of any adjuvant to hyperbaric, isobaric and hypobaric anesthetics alters the baricity of the mixture to be injected.

There is a wide armamentarium of adjuvant drugs to choose to be added in spinal anesthesia. They can be broadly divided into non-opioids and opioids (Table 4). The addition of any adjuvant in the same syringe to the hyperbaric solution will make the LA less hyperbaric, the isobaric solution will make the LA hypobaric, and the hypobaric solution will make the LA less hypobaric. Thus, since the beginning of the association of adjuvants to LA, I have always used any adjuvant in an insulin syringe injected before LA in single shot spinal anesthesia.

Table 4: Classification of Adjuvant Drugs

Opioids	• Morphine • Pethidine • Fentanyl • Sufentanil • Hydromorphone • Buprenorphine • Diamorphine • Tramadol
Vasoactive agents	• Epinephrine • Phenylephrine
Alpha-2 adrenergic agonists	• Clonidine • Dexmedetomidine
Steroids	• Dexamethasone
Nonsteroidal anti-inflammatory drugs	• Parecoxib • Lornoxicam
Other agents	• Ketamine • Midazolam • Neostigmine • Droperidol • Magnesium sulfate • Sodium bicarbonate • Potassium chloride • Adenosine • Dextran • Calcium channel blockers

Since this article is addressing safety in spinal anesthesia, we suggest that each product to be injected into the subarachnoid space be administered in separate syringes. This way, we will not be changing the baricity of any of them. A variety of adjuvants to LA are available now, yet the data about most of there remains inconclusive. And a range of adjuvants are still used without authorization (off-label). So, more studies are required to find out the best adjuvants with the most desirable profile and the least adverse effects.

Precise documentation of studies of adverse effects or systemic effects is required for each adjuvant and is fundamental for its use. Since the combination of adjuvants with LA is always not positive.

Due to the positive effects shown by drugs from non-opioid adjuvants group , indications for their administration broadened [34]. However, there are still some restraints in clinical practice because neurotoxicity and demonstration of neurological complications in regional anesthesia haven't been properly researched yet [34]. The study aimed not to give an advantage to one drug over another, but rather to encourage the rational application of adjuvants in regional anesthesia, either as a monoadjuvant or as a combination of adjuvants, with the aim of further optimizing regional anesthesia and the application of LA [34]. For patient safety and maintaining the baricity of each substance, it is essential that all drugs used in spinal anesthesia are injected in separate syringes.

Spinal Anesthesia Kits

Commercially available kits typically include: Chlorhexidine with alcohol, Sterile drape, Local infiltrating anesthetic (usually 1% lidocaine), Spinal needle (Quincke, Whitacre, Sprotte, or Greene), 3 mL and 5 mL syringes, Preservative-free spinal anesthetic solutions (lidocaine, ropivacaine, bupivacaine, levobupivacaine, procaine, or tetracaine). The components of a spinal kit should contain everything necessary for achieving the optimal outcome, ensuring patient safety, and minimizing complications. No spinal anesthesia kit contains a bacterial filter component to aspirate non-sterile ampoules.

Throughout my spinal anesthesia practice, I have practiced and taught the placement of batches and expiration dates of all ampoules used in the anesthesia records. In the same way, it is essential for better control of the technique to evaluate, at least 15 minutes after injection, the sensory level and motor block obtained with the technique. And during subsequent spinal anesthesia, it is essential to evaluate proprioception, since some techniques allow the patient to walk [35].

Practically everything that enters the surgical center to be used on the patient must be sterile, and this is because the drugs used in the neuraxis are not always packaged in sterile cases. In 2003, Brazil began implementing the sterile-pack hydrogen peroxide sterilization process for substances administered in the neuraxis. This greatly increases safety, especially in injections, by avoiding product mix-ups.

Infection During Spinal Anesthesia

Local infection at the injection site or systemic infections can increase the risk of complications, which develop abscesses that can lead to localized swelling, pain, and inflammation following the procedure to spinal anesthesia. The infectious source may be endogenous (a bacterial origin in the patient seeding to the needle or catheter site) or exogenous (contaminated equipment, drugs, etc.). Microorganisms can also be transmitted via a break-in aseptic technique. Indwelling catheters may be sites of colonization (skin) and subsequently serve as a wick for spreading infection from the skin to the intrathecal space [36]. Despite the apparent low risk of central nervous system infection after regional anesthesia, anesthesiologists have long considered sepsis to be a relative contraindication to the administration of spinal or epidural anesthesia [36]. Seven recommendations are suggested for performing regional anesthesia in the febrile or infected patient [37]. In an Editorial written in 1992, it is suggested that performing a neuroaxis puncture in patients with fever is contraindicated [38]. This conduct has remained in place throughout my 50 years of practice, during which I have not had any neurological complications after spinal anesthesia, nor have I filed any lawsuits against my patients. Infectious complications related to regional anesthesia are rare.

Modern Anatomy for Spinal Anesthesia

In a recently published educational article, the anatomy studied in cadavers from the 16th century by Leonardo da Vinci to the 20th century by Jonnesco and the most recent studies of imaging technology for spinal anesthesia [39]. The use of modern radiological imaging technology as computed Tomography (CT), magnetic resonance imaging (MRI), Ultrasound Imaging (US), and fluoroscopic imaging (FI) has provided important insights into understanding anatomical and pathophysiological aspects implicated in spinal anesthesia. The vertebral level at which the spinal cord finishes varies widely from T12 to the L3-L4 intervertebral disc, and the spinal cord extends to the L1-L2 and the L2-L3 [39].

In studies of the spinal column including all its components, cerebrospinal fluid (CSF) and fat act as natural contrast agents in spinal MRI. The spinal cord is difficult to evaluate on CT, given the inherent contrast limitations. To adequately study the size and morphology of the spinal cord, the addition of intrathecal contrast during myelography has proven to be a very important technique [40].

The use of MRI in adults and children showed a large space between the dura mater and the spinal cord in the thoracic region [41,42]. These studies with MRI in the thoracic region showed that there is substantially more space in the dorsal subarachnoid space at the thoracic level, which might lead to potential applications in regional anesthesia. The measurement of the spaces between the dura mater and the spinal cord in adults was T2 = 4.19 mm, T5 = 6.17 mm, T10 = 4.71 mm, and corrected for the angle of entry into the skin there is an increase in all distances to T2 = 4.60 mm, T5 = 9.37 mm, T10 = 5.18 mm [43]. The same study in children aged 0 to 13 years showed that there is the same space being at T2 = 4.52 mm, T5 = 5.61 mm, T10 = 4.68 mm, and corrected for the angle of entry into the skin there is an increase in all distances to T2 = 6.07 mm, T5 = 8.18 mm, T10 = 6.57 mm [43].

Studying the Indian adult population with MRI, evaluating the thoracic segments of T5 and T10 and the lumbar segment of L1, the greatest distance was found in T5 followed by T10, and the study of the lumbar space was justified because most of the anesthetists who use sitting puncture for spinal access do so one or two spaces above L3 [44].

In front of these spaces the segmental thoracic spinal anesthesia is a feasible, safe and economical anesthesia technique for various abdominal and thoracic surgeries. It is also associated with less postoperative complications and patient satisfaction.

Conus Medullaris Terminus

An important issue for the safety of spinal anesthesia when puncturing the lumbar region is the true anatomical location of the caudal taper of the spinal cord, the Conus Medullaris Terminus (CMT). The classic teaching for performing spinal anesthesia considered safe is that subarachnoid puncture should be performed in the L2–L3 intervertebral space or below it. In the previous topic it was shown that thoracic puncture is safe in view of the spaces between the dura mater and the spinal cord.

The position of the CMT has been studied in 1935 with 240 cadavers, having found that 55% percent of the spinal cords terminated below the middle of the intervertebral disc between the first and second lumbar; 45% percent of the spinal cords ended above this level [45]. The highest level of termination was the middle third of the 12 thoracic vertebra, and the lowest level of termination was the lower third of the third lumbar vertebra.

In a retrospective study using MRI, to determine CMT in 944 adult patients, the relationship between age, sex, height, BMI, spinal pathology and CMT level was explored by logistic regression [46]. The study used Tuffier's line (TL) as the L4–L5 intervertebral space as an anatomical landmark, through the study of 720 lumbar radiographs from the same cohort of patients. This study confirms that spinal anesthesia at the L2–L3 interspace or below can be considered safe, and the findings indicate that Tuffier's line can be used as a reliable anatomical landmark. Upright weight-bearing MRI may be an interesting technique to assess anatomic changes in supine and upright position [47].

To evaluate the variation of the CMT position in 105 healthy neonates born over an 18-day period, they underwent US examinations of the lower spine to relate the conus medullaris to the intervertebral disc or to the nearest mid-vertebral level [48]. The mean position of the conus medullaris was midway between the L1-L2 disc and the midbody-L2, ranging from T12/L1 to L3, with the modal position being L1-L2 (47.6%). Assessments of conus medullaris termination in adult patients at L1 and children at L2 studied with MRI in our publications (Figure 3).

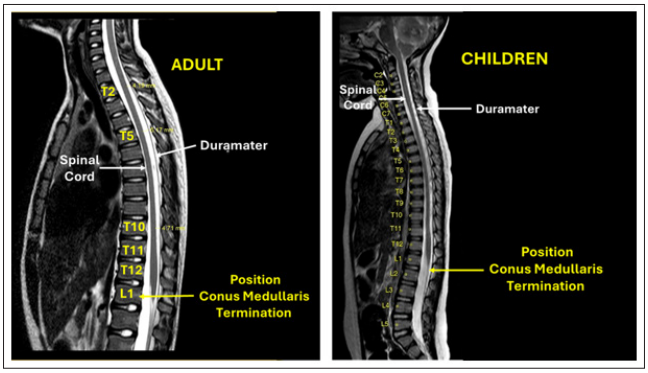

Figure 3: Conus Medullaris Termination in Adult and Children

Spinal Cord Injury after Spinal Needle Puncture

Spinal cord injury after spinal needle puncture can have serious complications. Careful patient management and close monitoring during spinal anesthesia are essential to minimize the risk. The patient's ideal position is the lateral recumbent position with the knees and the neck flexed, or the seated position with the neck flexed. The lateral recumbent position is preferred to the sitting position [49].

Spinal cord injury after spinal needle puncture is a rare but serious complications. It can occur if the needle I accidentally inserted into the cord during the procedure. Immediate withdrawal of the needle and appropriate management are essential to prevent permanent damage. In a systematic review of spinal cord injuries due to anesthetic practice, the results suggest that the main risk factors reported were extremes of age, obesity, and diabetes, as consequences of hematoma, trauma, abscess, ischemia, infarction, resulting in motor deficits, sensory loss, and pain [50].

Presentation of 14 patients who suffered CMT damage during spinal anesthesia [51-54] (Table 5). The presentation of all cases shows that there are several problems in their description, and the causes may be numerous. However, a lumbar puncture below L4 does not report the injury.

Table 5: Anesthetic Details of 14 Patients who Suffered Damage CMT [51-54]

AUTHOR	AG	SX	SURGERY	NEED	POS	INS	NI	P/P	CSF	NEW PUNCTURE
Ahmad	26	F	Cesarean	22 Q	LD	M	L3-L4	No	Yes	No
Netravathi	21	F	Cesarean	25 Q	LD	NR	L1-L2	No	No	T12-L1 – 25 Q - CSF
Hamandi	39	F	Cesarean	24 W	NR	NR	L2-L3	Pain	No	L3-L4 - 24 W - CSF
	81	M	Knee+GA	26 Q	NR	NR	L3-L4	No	NR	No
	69	F	Knee+CSE	25 W	NR	NR	L3-L4	Pain	No	Pain during injection
	41	F	Cesarean	25 W	SIT	NR	L3-L4	No	Yes	No
	57	F	Hip	26 Q	NR	NR	L2-L3	No	Yes	Difficult injection
Reynolds	NR	F	Cesarean	27 W	LD	NR	L2-L3	No	Yes	
	NR	F	Cesarean	25 W	SIT	NR	L2-L3	No	Yes	
	NR	F	Cesa+CSE	25 W	LD	NR	L2-L3	Pain	Yes	
	NR	F	Vaginal Deli	25 W	NR	NR	L2-L3	No	Yes	
	NR	F	Cesarean	26 W	SIT	NR	L2-L3	No	Yes	
	NR	F	Cesarean	25 W	SIT	NR	L2-L3	No	NR	
	NR	NR	Hernia+CSE	27 W	SIT	NR	L1-L2	Pare	NR	

AG=Age; SX=Sex; GA=General Anesthesia; CSE=Combined spinal anesthesia; Q=Quincke; W=Whitacre; LD=Lateral decubitus; SIT=Sitting; M=Median; NR= Not reported; P/P=Pain/Paresthesia; Pare=Paresthesia

Subarachnoid Space

The subarachnoid space is the interval between the arachnoid mater and pia mater with the meninges that surround the brain and spinal cord. It is filled with CSF and contains branches of the arteries and veins of the brain, delicate connective tissue trabeculae, and intercommunication, and serves as a protective cushion for the central nervous system. The subarachnoid space continues down the spinal cord. The vertebral column, known more familiarly as the backbone or spine, is a series of bones through which the spinal cord passes as it descends the back. Drug in CSF goes directly to the spinal cord through diffusion and rest drug goes to Virchow Robin s space for action on spinal nerves.

Off-label Drugs in Spinal Anesthesia

Each medicine registered in Brazil requires prior approval from the National Health Surveillance Agency (ANVISA), being authorized for one or more therapeutic indications [55]. The use of off-label medications has become a recurring theme in the health sector, mainly due to its relevance in the treatment of diseases that do not have officially approved effective therapies [55]. The term "off-label" use refers to use of a drug that is not included in the package insert (approved labeling) for that drug, the term "off-label" does not imply an improper, illegal, contraindicated, or investigational use. For placing on the market, drugs used in medicine must include all clinical indications for which adequate data are available to establish the safety and efficacy of the product. Among generic medications, labeled indications often do not reflect the full range of indications for which there is compelling evidence of safety and effectiveness. Using the phrase "off-label drugs should not be used in the spinal anesthesia" was searched on four scientific article search sites with the following result: PubMed with 4,454 results, Science with 58 results, Medline with 13 results and Google Academic with 2,710 results, totaling 7,235 articles. Many articles in this medical research addressed the topics of oncology, pediatrics, infertility, Crohn's disease or ulcerative colitis, chronic pain, spinal anesthesia and several Editorials discussing its use.

Unlike pediatric articles and especially editorials, no articles were found discussing the off-label use of drugs in the subarachnoid space. The recommendation when using off-label drugs in spinal anesthesia would be to create a collaboration between doctors, medical societies, manufacturers, pharmacies and ANVISA to reach a conclusion on the safety of this practice.

Conclusion

Most professionals in the department of anesthesia, school of medicine, Debre Tabor University, Ethiopia, have a good preparation of all necessary anesthesia equipment and resuscitation drugs, while the assessment of the patient's emotional reaction and pain during injection, the preparation of the skin so that it is dry, and the assessment of the degree of sensory and motor blockade of the patient were insufficient, for spinal anesthesia [56].

During my 50 years of anesthesia practice, in addition to this conclusion, I consider it important for patient safety to record the batches and expiration dates of all substances injected into the subarachnoid space, and I have exhaustively taught this conduct in daily clinical practice and during the performance of 117 events called Spinal Anesthesia Saturdays, starting in 1988. According to the size, scale, and type of point, sharp or pencil point, several varieties of spinal needles have been characterized based on their length child, adult, obese, and the presence or absence of a particular style.

Otherwise, I have never used a product designed for a kit for epidural continuous anesthesia technique (such as a catheter) to perform continuous spinal anesthesia. I have only used the Spinocath® after its production for continuous spinal anesthesia with extensive experience [57]. And I am sparing with the use of adjuvants in spinal anesthesia, using only the permitted by Anvisa and FDA.

In modern anesthesia, serious problems are uncommon. Risk cannot be removed completely, but modern drugs, equipment and training have made anesthesia a much safer procedure in recent years. In Brazil, ampoules for use in spinal anesthesia are produced and packaged in Sterili pack cases with a traceability bar code, making it a product that is excellent for use and offers safety to patients.

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