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Role of Ultrasound-Guided Spinal Anesthesia for Elder Patients Going Through Surgeries of Lower Limb: Review Article

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ABSTRACT

Background: Patients above the age of 65 have an increased risk of adverse effects from anesthesia up to death. For elderly people with a variety of medical conditions, spinal anesthesia is the preferable method of anesthesia. After surgery, spinal anesthesia provides excellent postoperative pain control and reduces the perioperative opioid use, which minimizes opioid adverse effects. Spinal anesthetic is traditionally administered with the use of palpation of specific anatomical landmarks. Ultrasonography (US) has brought a revolutionary improvement in anesthesiology. Using ultrasound prior to neuraxial blocks can increase the success rate on the first attempt, minimize the number of attempts, and enhance both clinical as well as technical consequences. Subarachnoid space depth measurement can be performed using ultrasound to locate the spine's midline and intervertebral level as well as guides the correct needle insertion location and needle insertion angle. **Objective:** This study aimed to determine the role of ultrasound-guided spinal anesthesia in geriatric persons receiving lower limb surgery.

Methods: PubMed, Google scholar and Science direct were searched using the following keywords: Spinal anesthesia, ultrasound guided and elderly. The authors also screened references from the relevant literature, including all the identified studies and reviews, only the most recent or complete study was included. Documents in a language apart from English have been excluded as sources for interpretation. Papers apart from main scientific studies had been excluded (documents unavailable as total written text, conversation, conference abstract papers and dissertations).

Conclusion: There are numerous researches and evidence-based guidelines supporting the use of US neuraxial blocks that are safer and more convenient especially in elderly patient with age-related spinal changes.

Keywords: Spinal anesthesia, Ultrasound guided, Elderly.

INTRODUCTION

For lower-limb procedures, spinal anesthesia provides dense motor and sensory block, postoperative analgesia and eliminates risk of general anesthesia e.g. minimizes postoperative nausea and vomiting, lowers the chance of developing a chest infection, lessens the effects of general anesthesia on hangovers, and lessens the chance of cognitive impairment in elderly patients following surgery [(1)]. However spinal anesthesia in elderly may be associated with technical difficulties due to age-related changes in spinal anatomy such as spinal arthrosis that causes narrowing of interspinous and interlaminar spaces, ossification of ligaments, and hypertrophy of facet joints represent a major changes that create abnormalities in their anatomies [(1)]**.** It's four times more common for the elderly to need surgery compared to the general population. Patients above the age of 65 have an increased risk of adverse effects from anesthesia up to death. For elderly people with a variety of medical conditions, spinal anesthesia is the preferable method of anesthesia [(2)]**.**

Ultrasonography (US) has brought a revolutionary improvement in anesthesiology. Neuraxial US was first described in by **Cork *et al.*** [(3)] where they used ultrasound prior to neuraxial blocks and concluded that the success rate can be improved, the number of attempts can be reduced, and the clinical and technical outcomes can be improved [(4)]**.**

Epidural space depth and optimum needle insertion point can all be determined by US [(5)]. Reduced procedure-related complications and enhanced patient satisfaction with the use of ultrasound analgesia were proved by **Perlase *et al.*** [(6)]**.**

This review aimed to identify the advantage of ultrasound-guided spinal anesthesia in elderly patients during lower limb surgeries.

Ultrasound and Spinal Anesthesia

The fundamentals of ultrasonography are summarized as follows:

When an ultrasound transducer transmits and receives sound waves at frequencies ranging from 2–15 MHz (human hearing functions at 1–20 kHz), images can be captured. Nowadays, the majority of transducers employ artificial polycrystalline ferroelectric ceramics such as PZT, which are made from lead zirconate titanate (PZT), where piezoelectric characteristics can be found. The crystal contracts as well as expands depending on the voltage polarity. It causes a sequence of pressure sound waves to occur. At the time of return of sound waves, it squeezes and strains the crystal, causing shift of voltage over the surface of the object that provides, the detecting signal is intensified [(7)]**.**

When it comes to sound propagation in tissue, the densities and compressibility influence its speed. In order for a US beam to be reflected at the interface between two different structures, it must have the right angle and the right acoustic impedance.

Grey US image is made up of a matrix of picture elements or pixels that reflect off of these interface reflections. There will be more of the US beam transferred to deeper structures when there are slight changes in acoustic impedance. There is greater reflection when the acoustic impedance of different tissues differs significantly, making the deeper-seated tissues harder to

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see. The highest reflectivity is achieved when the object under observation is perpendicular to the US beam's angle [8]. A picture is not formed if the angle of incidence is less than 90 degrees, because the transducer is shielded from the US beam. In some cases, sound is absorbed as heat; in other cases, it is reflected as helpful echoes; and in yet other cases, it penetrates through tissues. In order to create an image, only reflected sound waves are involved. The frequency of the US beam has a direct effect on sound absorption. Low-frequency waves are more effective at penetrating tissues because they are less attenuated than high-frequency waves. To get adequate spatial resolution, a high-frequency linear array probe (5–10 MHz) that lacks the ability to penetrate the nerves and plexuses (1–5 cm deep) is ideal. Low-frequency probes, on the other hand, can penetrate deeper but have a lower resolution than high-frequency ones [9].

Advantages of ultrasound in neuraxial anesthesia [10]:

1. To be able to see and identify the target nerves, as well as their relation to the surrounding structures (e.g., other nerves, lungs, veins, arteries).
2. Decide how far, in what direction and at what angle a needle should go to reach a nerve.
3. Local anesthesia is visualized (encircling nerve) and a catheter can be inserted.
4. Safety and portability (no ionizing radiation).
5. Adapt to the varying needs of each individual patient (e.g., shape or anatomical variations).
6. Instantaneous steering of needle to target via real-time visualization of technique.
7. Safely perform the procedure on anaesthetized patients (for example, children).

Structures seen by ultrasound for neuraxial procedure [11]:

Patients with anatomical anomalies that cannot be detected by surface landmarks benefit greatly from ultrasound imaging to better understand their underlying anatomy. When using ultrasonography, it is possible to identify the following significant structures:

1. **Bone:** structures appear as bright white hyperechoic 'drop-outs' because to the lack of penetration of ultrasound through this material.
2. **Ligaments:** However, the drop-out will not be completely complete, because their acoustic impedance is lower than that of the bone, they will be visible in the gloom.
3. **Dura:** Some patients' dura may create a signal, however this is not always the case. Because ultrasound does not reflect well in the spinal cord and CSF, its absence will be apparent in the image.
4. **Soft tissue and muscle:** Dorsally, these structures can be seen as well.
5. **Fluids and fats:** Hypoechoic and have low acoustic impedance.

Ultrasonographic views for neuraxial block:

Understanding spinal sonoanatomy requires pattern recognition, as depth and limited acoustic windows frequently make it impossible to see the key anatomic components clearly. A thorough approach to scanning helps the overall performance of ultrasound-guided neuraxial blockade [12].

The spine can be seen with ultrasonography in five different ways:

Parasagittal articular process view, parasagittal transverse process view, transverse spinous process view and parasagittal oblique (interlaminar) view, as well as transverse interlaminar (interspinous) view.

1) **Parasagittal transverse process view:** Using a parasagittal position, the ultrasound probe is placed on the lower lumbar spine, few centimeters to the side of the center line. The striated psoas major muscle, which sits deep to the transverse processes, creates finger-like acoustic shadows. Anterior to the transverse processes (posteriorly) is erector spinae muscle [11] (Figure 1).

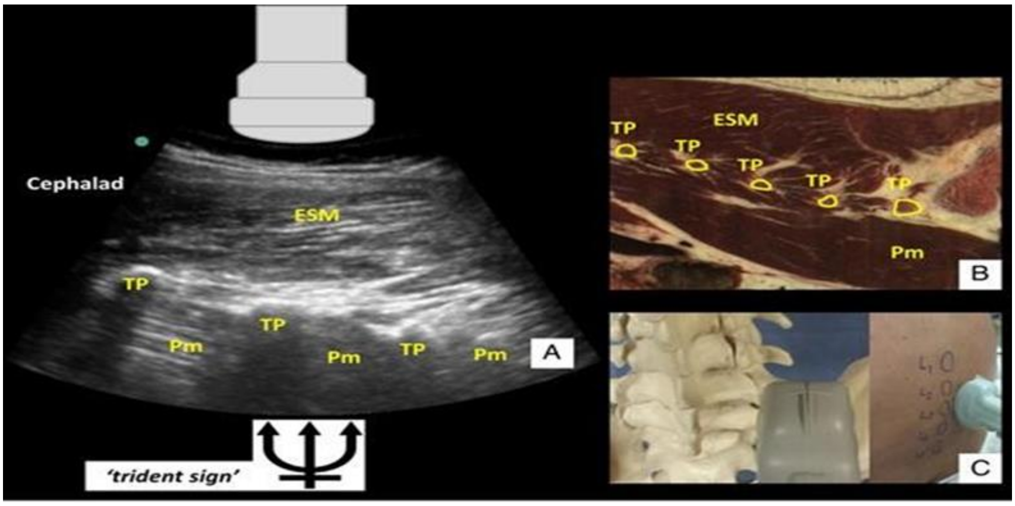

Figure (1): The lumbar spine is seen from the parasagittal transverse process (A) in conjunction with the relevant anatomy (B), and the positioning of an ultrasound probe (C). Transverse process (TP); Psoas muscle (PM); Erector spinae muscle (ESM. The 'trident sign' refers to causes transverse processes to produce finger-like acoustic shadows[13].

2) **Parasagittal articular process view:** When the transverse processes are no longer discernible, the ultrasonic probe is moved medially until a pattern of continuous hump-like shadows appears, superior and inferior processes overlap to generate. Another distinguishing feature of the articular process image is the shallower acoustic shadows [14] (Figure 2)**.**

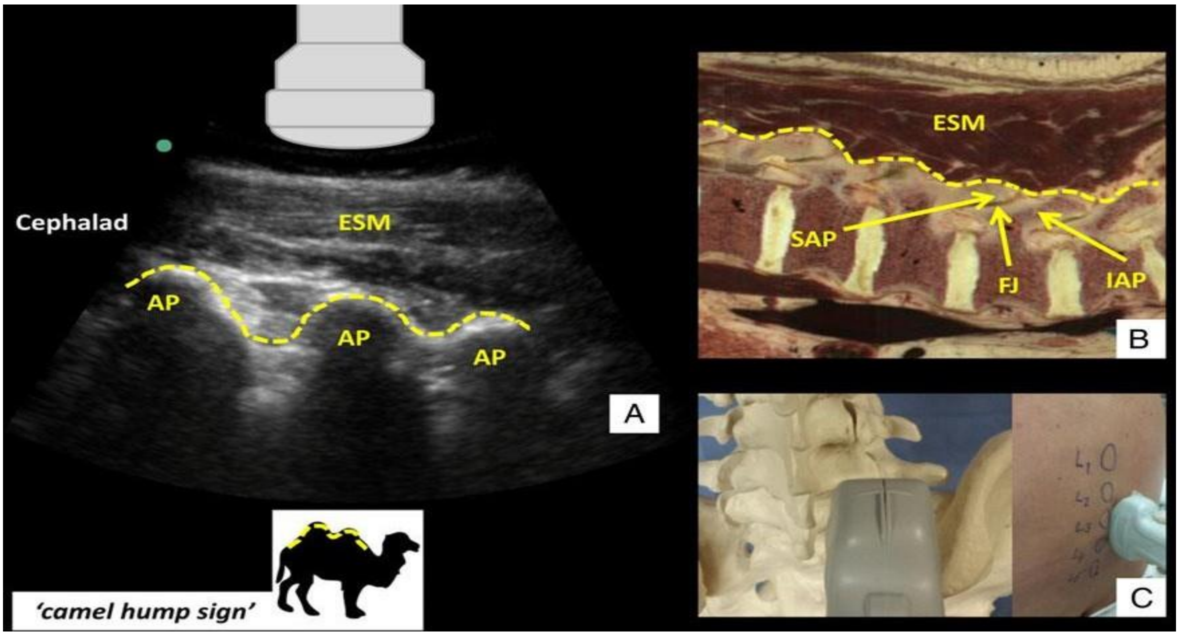

Figure (2): Lumbar spine view from the parasagittal angle (A) in conjunction with the relevant anatomy (B) and the positioning of the ultrasound probe (C). A facet joint is referred to as a "facet joint" when referring to the erector spinae muscle (ESM). "Camel hump sign": the articular processes are highlighted in (A) and (B) by a series of dotted lines [13].

3) **Parasagittal oblique (interlaminar) view (PSO view):**

From this parasagittal view, the ultrasonic probe is gently tilted to aim the beam in a lateral-to-medial orientation such that the humped pattern of these processes changes into a "sawtooth" pattern. Interlaminar spaces are represented as 'teeth'. We are able to see into the spinal canal with the PSO view because of this acoustic window it provides [15]**.**

The ultrasonic beam can penetrate structures (starting posteriorly to anterior portion): firstly; ligamentum flavum, then the epidural space, followed by dura posteriorly, then passes to intrathecal space, then anteriorly to dura, as well as posterior longitudinal ligament. Hyperechoic lines appeared from the following structures: posterior dura, ligamentum flavum as well as epidural space. Anterior complex appears as deeper hyperechoic structures: posterior border formed of the vertebral body and discs, as well as anterior dura, posterior longitudinal ligament. In the real world, it's difficult to tell apart the constituent parts of these complexes [15] (Figure 3).

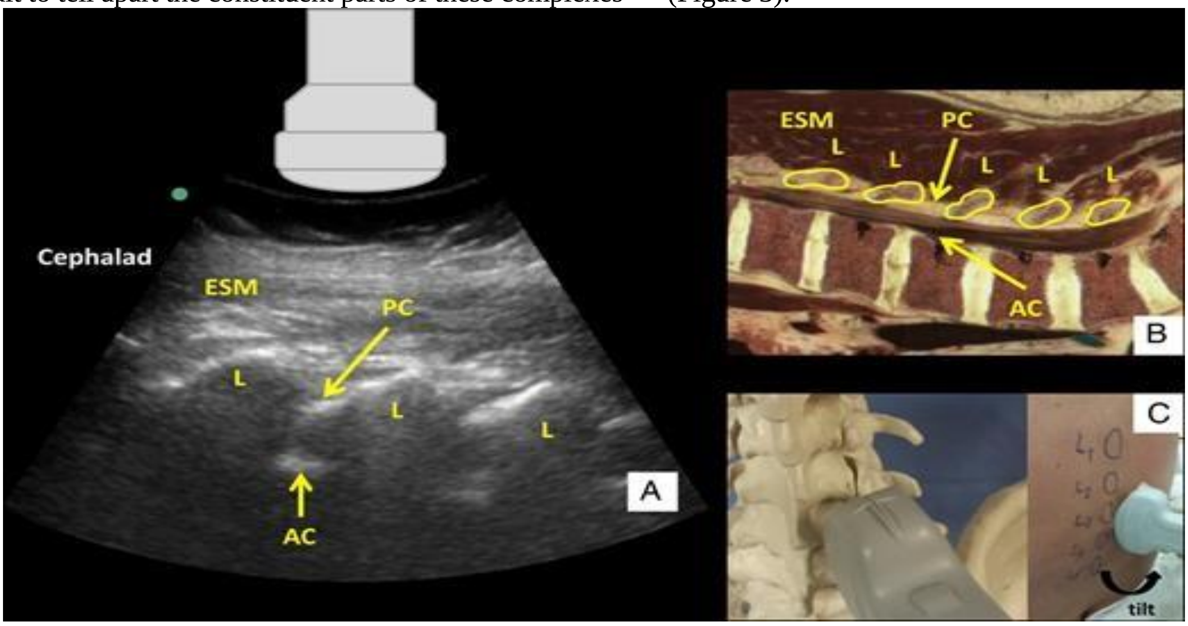

Figure (3): The lumbar spine from a parasagittal oblique angle. (A) in conjunction with the relevant anatomy (B) and the positioning of the ultrasound probe (C) AC, anterior complex L, lamina; PC, posterior complex, ESM, erector spinae muscle [13].

4) **Transverse spinous process view:** The ultrasonic probe is inserted horizontally with the center of the probe placed above the midline in order to achieve a transverse spinous process image. Spinous processes are visible as a hyperechoic "cap" at the tip of an ultrasonic "shadow" when the ultrasound beam is passed over them. As the spinous process is seen, the anterior border of the erector spinae muscle can be seen to be cast by the lamina of the vertebral body, which produces a dense acoustic shadow [16] (Figure 4).

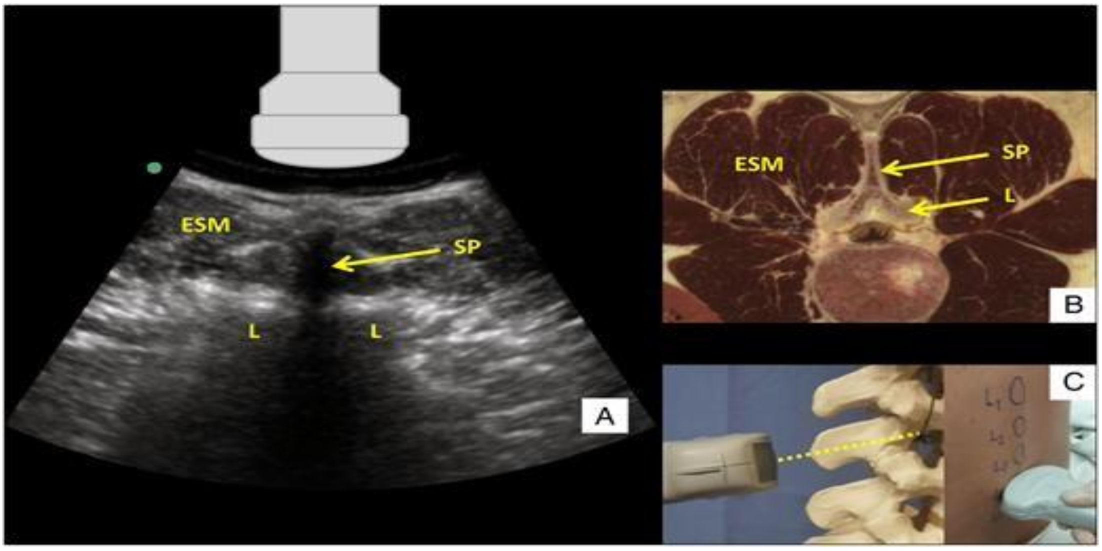

Figure (4): The lumbar spine's transverse spinous processes can be seen here (A) in conjunction with the relevant anatomy (B) and the positioning of the ultrasound probe (C). L, lamina; ESM, erector spinae muscle; SP, spinous process. (C) Meaning which way an ultrasonic beam is moving [5].

5) **Transverse interlaminar/interspinous view (TI view):**
The TI view is achieved by sliding the probe in either a cephalad or a caudad direction until the beam penetrates the acoustic window between the spinous processes, starting with the transverse spinous process view. The angle of the spinous processes may necessitate a small tilt in the horizontal plane to compensate. Interspinous ligament appears as a midline stripe of hypoechoic color. The anterior and posterior complexes' parallel hyperechoic lines encircle the hypoechoic intrathecal region on each side [17] (Figure 5).

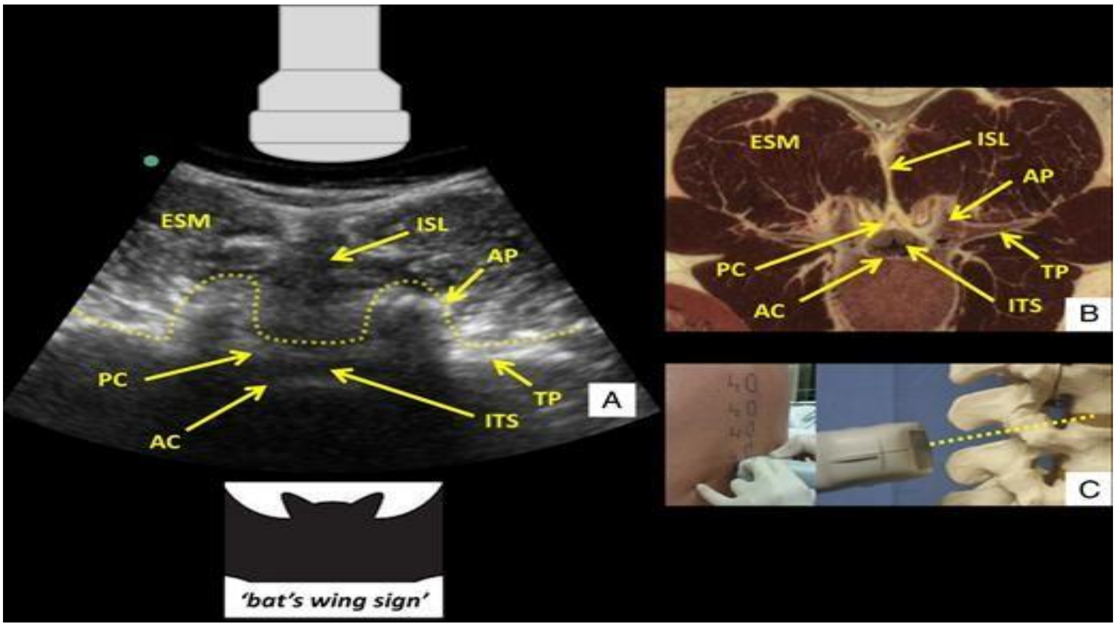

Figure (5): Interlaminar image of the lumbar spine in transverse position (A) in conjunction with the relevant anatomy (B) and the positioning of the ultrasound probe (C). PC, posterior complex; ESM, erector spinae muscle; ITS, intrathecal space; AC, anterior complex; AP, articular process; ISL, interspinous ligament, TP, transverse process (A) delineates the shape of the ultrasonographic structures that give birth to the "bat's wing sign." sign (C) Meaning which way an ultrasonic beam is moving [17].

CONCLUSION

There are numerous researches and evidence-based guidelines supporting the use of US neuraxial blocks that are safer and more convenient than the anatomic land mark, which may be difficult especially in elderly patient with age-related spinal changes.

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