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Original Research Article

Pre-procedural ultrasound scanning for subarachnoid block versus landmark guided subarachnoid block in obese patients: A prospective randomized controlled study

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Abstract

Background and Aim of the Study: Obese patients present unique challenges for subarachnoid block due to difficulty in identifying surface landmarks, which increases the risk of multiple attempts and complications. Pre-procedural ultrasound (US) guidance can enhance precision in identifying intervertebral spaces. This study aimed to compare the efficacy of ultrasound-guided versus landmark-guided techniques for spinal anaesthesia in obese patients. The primary objective was to compare the number of attempts required for successful subarachnoid block, while secondary objectives included comparisons of needle passes, time to identify intervertebral space, time for successful lumbar puncture, and time to achieve successful subarachnoid block.

Materials and Methods: A prospective randomized controlled study was conducted on 90 obese patients (BMI 30–40 kg/m²) scheduled for surgery under spinal anaesthesia. Patients were randomly allocated to either Group-L (landmark-guided, n=45) or Group-P (US-guided, n=45). Data collected included the number of attempts, needle passes, time to identify intervertebral space, time for scanning, time for lumbar puncture, and time to achieve successful subarachnoid block.

Result: The mean number of attempts for Group P (1.42 ± 0.62) was significantly lower than Group L (1.91 ± 0.73, $p < 0.01$). The mean number of needle passes was also significantly reduced in Group P (2.6 ± 1.81) compared to Group L (4.96 ± 2.27, $p < 0.01$). The first-attempt success rate in Group P (64.4%) was more than double that of Group L (26.6%). Additionally, the mean time to achieve a successful block was shorter in Group P (164 ± 61 seconds) compared to Group L (177 ± 44.2 seconds, $p < 0.01$).

Conclusion: Pre-procedural ultrasound scanning significantly improves the success rate of subarachnoid block in obese patients by reducing the number of attempts, needle passes, and procedural time compared to the traditional landmark-guided technique.

Keywords: Subarachnoid block, Ultrasound guidance, Obese patients.

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1. Introduction

Spinal anaesthesia is the most commonly used central neuraxial block in surgical settings. Since its first description in humans by Bier in 1898, the identification of the subarachnoid space has traditionally relied on an anatomical landmark-guided technique.[1,2] Regional anaesthesia has come to occupy an important part in clinical anaesthesiology, it has gone under major developments both in techniques and drug availability. Surface anatomical landmarks are useful, they serve as surrogate markers and can be challenging to rely on in patients with atypical anatomy, previous spinal surgery, oedema and in obese patients because of truncal deposition of adipose tissue and this leads to miss identification of level of intervertebral space.[2]

The incidence of post-spinal headache, paraesthesia, and spinal hematoma is directly associated with multiple attempts during the administration of spinal anesthesia.[2]

During preprocedural ultrasound scan one can accurately locate the midline as well as correct interspace and also assess the depth to subarachnoid space and thus identify patients in whom a spinal anaesthesia may be challenging, thereby it

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improves the overall success rate of the procedures, their safety and speed.[3,4]

The Tuffier's line, an imaginary line connecting the anterior superior iliac spines, is traditionally used as a landmark to estimate the L4-L5 interspace. However, the correlation between this landmark and the actual interspace is inconsistent. The landmark-guided approach fails to account for anatomical variations or abnormalities, often leading to the incorrect identification of the intended lumbar interspace.[2]

Studies by Chin KJ et al. and Conroy et al. have demonstrated that ultrasound guidance significantly reduces the technical difficulty of central neuraxial block, especially in obese patients.[4,5] The paramedian approach, offers distinct advantages over the median approach, including easier access to the interlaminar space and the ability to bypass the supraspinous and interspinous ligaments. This minimizes complications such as trauma, dural puncture, paresthesia, and bloody taps.[6]

The aim of this study was to evaluate the efficacy of preprocedural ultrasound scanning in obese patients undergoing spinal anaesthesia. The primary objective was to compare the number of attempts required for successful subarachnoid block between ultrasound-guided and landmark-guided techniques. Secondary objectives included comparing the number of needle passes, time taken to identify the interspace, overall procedure time, and success rate, as well as monitoring hemodynamic changes and complications such as nausea, vomiting, hypotension, bradycardia, and neurological sequelae.

2. Materials and Methods

This study was conducted at a tertiary care hospital between October 2023 and May 2024 as a prospective randomized controlled trial, including a total of 90 patients. Ethical approval was obtained from the Institutional Ethical Committee (IECHR and registered with CTRI, India (CTRI/2023/10/058970).

Patients aged 18–70 years, of either gender, with a BMI of 30–40 kg/m², and classified as ASA II or III were included. Exclusion criteria included local site infections, pregnancy, coagulopathy, elevated intracranial pressure, and contraindications to central neuraxial block.

Patients were randomized into two groups, Group P (Pre-scan group) and Group L (Landmark group), in a 1:1 ratio using a computer-generated randomization method via the randomizer.org website. Group P included patients who underwent ultrasound-guided pre-procedural scanning for spinal anaesthesia, while Group L consisted of patients who underwent the traditional landmark-based approach for spinal anaesthesia.

A pilot study involving 20 patients (10 in each group) was conducted to calculate the sample size. The mean number of attempts in Group P (pre-scan using ultrasound group) was 1.6 ± 0.69, and in Group L (landmark-based technique group), it was 2.1 ± 0.73. Based on a mean difference of 0.5, with a 95% confidence interval, alpha error of 0.05, and a power of 80%, the calculated sample size was 42 patients per group.

Upon arrival in the operating room, venous access was secured for all patients, and they were preloaded with Ringer's lactate solution at a dose of 10 ml/kg 30 minutes prior to induction. Premedication included intravenous ondansetron (4 mg) and glycopyrrolate (0.2 mg), administered five minutes before the induction of anaesthesia. Baseline parameters were recorded, and patients were positioned in a sitting posture on a level table for the procedure.

In the landmark-guided technique (Group L), the intervertebral space was identified using Tuffier's line, an imaginary line connecting the highest points of the iliac crests, which corresponds to the L4-L5 level. Once identified, the area was cleaned, draped, and infiltrated with 2% lignocaine. A subarachnoid block was administered using a 23 G Quincke spinal needle, and preservative-free heavy bupivacaine (0.3–0.5 mg/kg) was injected after confirming the free flow of cerebrospinal fluid (CSF).

For the ultrasound-guided technique (Group P), Using ultrasound guidance, a low-frequency curvilinear probe was utilized to identify the interlaminar space accurately. The ultrasound probe was initially placed vertically in the paramedian plane (**Figure 1**), where the sacrum was visualized as a flat, hyperechoic structure (**Figure 2**). The probe was then gradually slid cranially (**Figure 3**) to visualize the L5-S1, L4-L5, and L3-L4 interlaminar spaces. Once the L3-L4 interlaminar space was identified, it was marked at the midpoint of the probe using a surgical skin marking pen (**Figure 4**).

To enhance precision, the probe was rotated 90 degrees and placed transversely (**Figure 5**) in the midline, allowing visualization of the marked interlaminar space. This provided an optimal view of the spinous process, which appeared as a linear hypoechoic acoustic shadow. The central point along the long axis of the probe was marked, and a vertical line was extended from this point using a surgical skin marking pen to correspond to the central neuraxial midline (**Figure 6**). The intersection of the two lines was determined to be the point of spinal needle insertion.[7-9]

The ultrasound image was then frozen, and the distance from the skin to the subarachnoid space was measured. This distance was later compared with the actual needle depth required to achieve the subarachnoid space during the procedure. After marking, the skin was cleaned sequentially with 5% betadine and surgical spirit, followed by sterile

draping. Under strict aseptic conditions, the marked intervertebral space was infiltrated with 2% lignocaine. A 23 G Quincke spinal needle was then inserted into the identified intervertebral space, and a subarachnoid block was administered using preservative-free heavy bupivacaine (0.3–0.5 mg/kg) after confirming the free flow of cerebrospinal fluid (CSF).

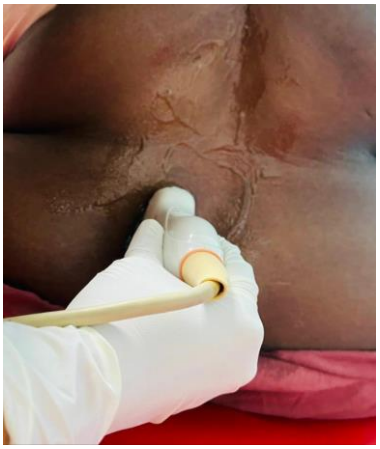

Figure 1: Paramedian scan probe position

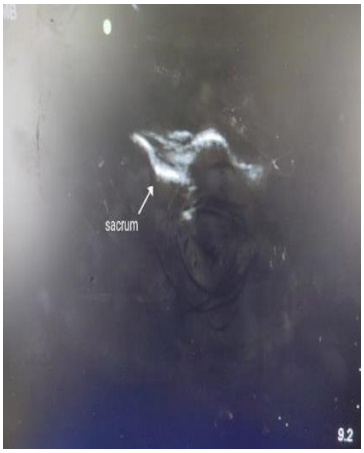

Figure 2: Paramedian USG view at sacrum

Figure 3: Paramedian probe position at L3-L4

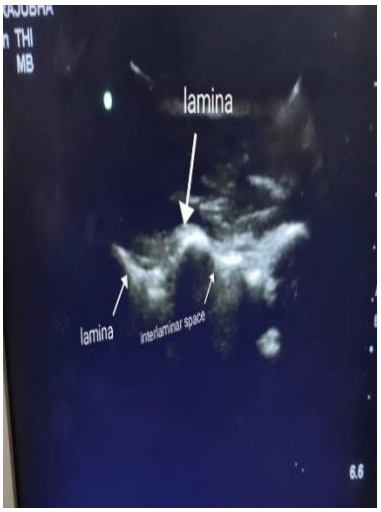

Figure 4: Paramedian ultrasound view at L3-L4

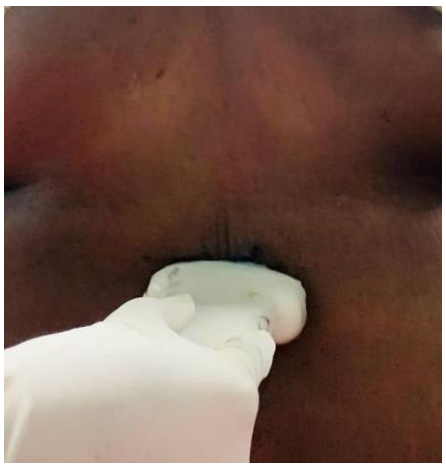

Figure 5: Transverses view probe position at L3-L4

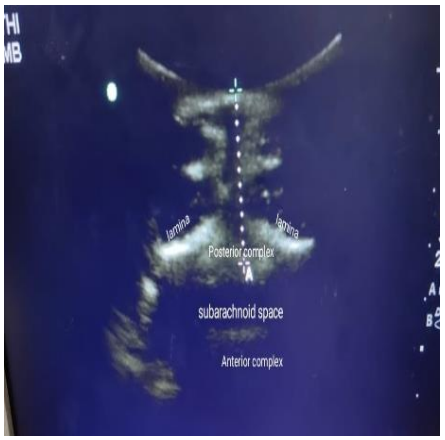

Figure 6: Transverses ultrasound view at L3-L4

The primary outcomes included the number of attempts, defined as the number of times the spinal needle was withdrawn and reinserted through the skin, and the time for intervertebral space identification, measured from palpation (Group L) or ultrasound probe placement (Group P) until the space was identified.

Secondary outcomes included the number of needle passes (forward movements of the needle without withdrawal from the skin), the time required for the subarachnoid block (from patient positioning to visualization of CSF in the needle hub), and the time to achieve a successful block (from positioning until sensory and motor blockade was achieved with a Bromage score of 3).

Hemodynamic parameters, including pulse rate, blood pressure, and SpO2, were recorded at baseline, 1 minute, 5 minutes, 10 minutes, 30 minutes, and then half-hourly until the end of surgery. Complications were also monitored, including early complications such as bradycardia, hypotension, nausea, vomiting, and respiratory depression, as well as late complications such as post-dural puncture headache and neurological sequelae.

Data were analysed using Jamovi statistical software version 2.3.28. Results were presented as mean ± standard deviation (SD) or median with interquartile range (IQR). Parametric data were analysed using the student's t-test, while non-parametric data were evaluated using the Chi-square test. Statistical significance was defined as follows: $p > 0.05$ was considered not significant, $p < 0.05$ was significant, and $p < 0.001$ was highly significant.

3. Results

The demographic data of the patients in both groups were comparable, with no statistically significant differences, as shown in **Table 1**. The mean age in Group P was 47.1 ± 11.5 years, while in Group L, it was 44 ± 11.5 years ($p > 0.05$). The male-to-female ratio was 29:16 in Group P and 25:20 in Group L. The ASA grading distribution (II:III) was also similar between the groups, with 23:22 in Group P and 24:21 in Group L. The BMI of the patients was comparable, with a mean of 33.2 ± 2.17 kg/m² in Group P and 33.1 ± 2.27 kg/m² in Group L ($p > 0.05$). Both groups primarily included patients undergoing lower limb orthopaedic surgeries.

The procedural outcomes demonstrated significant advantages in the ultrasound-guided group (Group P) compared to the landmark-guided group (Group L), as summarized in **Table 2** and **Figure 7**. The number of attempts required for successful spinal anaesthesia was significantly lower in Group P, with a mean of 1.42 ± 0.62 attempts compared to 1.91 ± 0.73 in Group L ($p < 0.001$). The median number of attempts in Group P was 1 (IQR 1–2), whereas it was 2 (IQR 1–2) in Group L. Notably, the first-attempt success rate in Group P was 64.4%, more than double that of Group L, which had a success rate of only 26.6%.

The mean number of needle passes was also significantly reduced in Group P, with a mean of 2.6 ± 1.81 passes compared to 4.96 ± 2.27 in Group L ($p < 0.001$). The median number of needle passes in Group P was 2 (IQR 1–4), while in Group L, it was 5 (IQR 4–6). This indicates a substantial improvement in procedural efficiency with ultrasound guidance.

The time taken to identify the intervertebral space was significantly longer in Group P, with a mean of 81.7 ± 12.1 seconds compared to 8.78 ± 2.18 seconds in Group L ($p < 0.001$). The median time in Group P was 79 seconds (IQR 73–89), whereas in Group L, it was 8 seconds (IQR 7–10). Similarly, the time required for successful lumbar puncture was significantly lower in Group P, with a mean of 83.8 ± 42.5 seconds compared to 137 ± 56.3 seconds in Group L ($p < 0.001$). The median time for Group P was 64 seconds (IQR 56–98), whereas for Group L, it was 136 seconds (IQR 76–185).

However, there was no statistically significant difference in the time taken to achieve a successful block between the two groups. The mean time in Group P was 177 ± 44.2 seconds compared to 164 ± 61 seconds in Group L ($p > 0.05$), with median times of 157 seconds (IQR 149–188) and 160 seconds (IQR 104–217), respectively.

Perioperative hemodynamics, including heart rate, blood pressure, and oxygen saturation, were comparable between Group P and Group L, with no statistically significant differences observed ($p > 0.05$).

Table 1: Demographic data

Group	Group-P (MEAN±SD)	Group-L (MEAN±SD)	p value
Age in years (mean ± SD)	47.1±11.5	44±11.5	>0.05
Sex (M:F)	29:16	25:20	
ASA grading (II :III)	23:22	24:21	
BMI (Mean±SD)	33.2±2.17	33.1±2.27	>0.05

Table 2: Procedural parameters observed

Parameters	Group -P	Group-L	p value	Group - P (Median, IQR)	Group - L (Median, IQR)
No of Attempts (MEAN±SD)	1.42±0.621	1.91±0.733	<0.001	1 (1-2)	2 (1-2)
1ST Attempt success rate	64.4%	26.6%	<0.001	-	-
2nd Attempt success rate	28.8%	60%	-	-	-
No of needle passes (MEAN±SD)	2.6±1.81	4.96±2.27	<0.001	2 (1-4)	5 (4-6)
Time for identifying intervertebral space (MEAN±SD)	81.7±12.1	8.78±2.18	<0.001	79 (73-89)	8 (7-10)
Time taken for successful lumbar puncture (MEAN±SD)	83.8±42.5	137±56.3	<0.001	64 (56-98)	136 (76-185)
Time taken to achieve successful block (MEAN±SD)	177±44.2	164±61	0.281(>0.05)	157 (149-188)	160 (104-217)

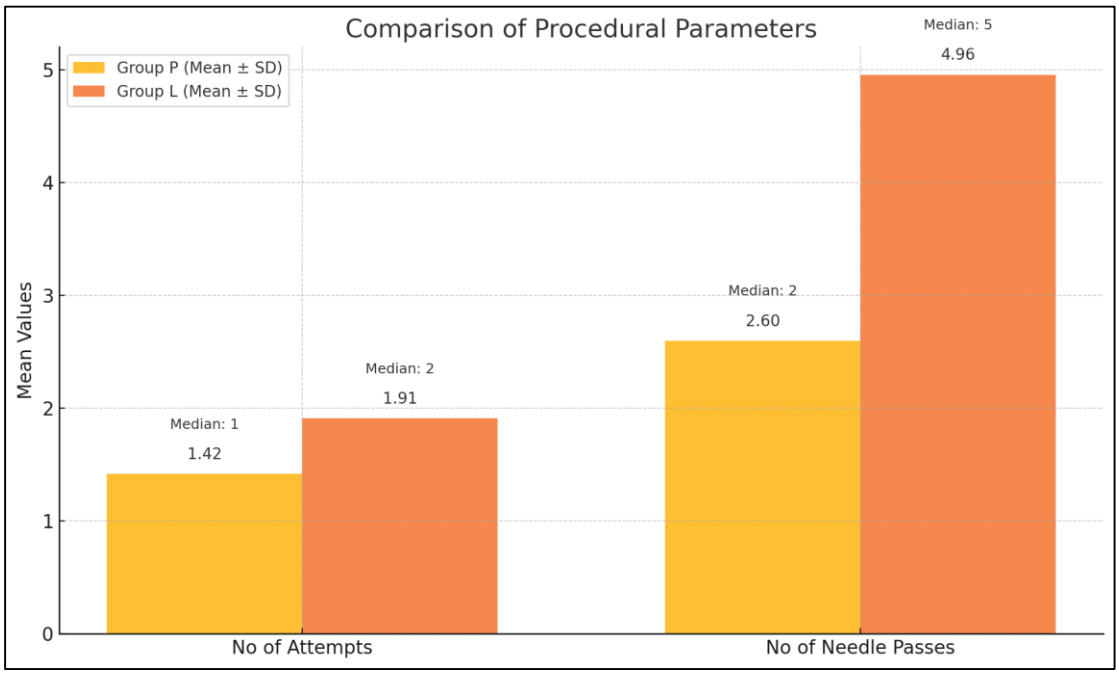

Figure 7: Comparison of procedural parameters

4. Discussion

Spinal anaesthesia is widely regarded as one of the most effective anaesthetic techniques due to its simplicity, rapid onset, and the ability to preserve patient consciousness during surgery. It offers excellent sensory and motor block, complete muscle relaxation, and effective analgesia. Traditionally, spinal anaesthesia is administered using the landmark-guided technique, relying on Tuffier's line, which connects the highest point of the iliac crest and typically corresponds to the L4-L5 interspace.[2] However, technical challenges often arise in patients with obesity, pregnancy, spinal deformities (e.g., scoliosis, kyphosis), fused spines in older age, or a history of spinal surgery.[4] Ultrasound has proven to be a valuable tool for neuraxial procedures, especially in patients with challenging anatomy. It facilitates the identification of the optimal interspace and its orientation, significantly improving accuracy and safety.[10] Chin et al. demonstrated that ultrasound guidance can minimize technical difficulties associated with central neuraxial blocks, particularly in obese patients.[4] In such cases, ultrasound allows for clear visualization of structures in the paramedian oblique view and transverse interspinous view during spine assessment. Additionally, preprocedural ultrasound can estimate the needle insertion depth, aiding procedural precision.

Our study confirmed that the number of attempts and needle passes (defined as forward movements of the needle without withdrawal from the skin) were significantly reduced in the ultrasound-guided group (Group P) compared to the landmark-guided group (Group L). Among these, the number of needle punctures is particularly critical, as it directly correlates with complications such as patient discomfort, multiple dural punctures, vascular punctures, hematoma, paresthesia, neurological deficits, and post-dural puncture headaches.[3] Similar findings regarding reduced attempts and needle passes have been reported by Chin et al., Khan et al., and Dhanger S et al.[1,4,11]

In our study, the first-attempt success rate in Group P was 64.4%, which was double that of Group L at 26.6%. Comparable results were observed in studies by Qu and Chen et al., who reported similar first-attempt success rates, although their study focused on older patients and the paramedian approach for spinal anesthesia.[4,12] Additionally, Chin et al. and Khan et al. documented similar findings regarding the first-attempt success rate, with rates in the ultrasound-guided group being twice as high as in the landmark-guided group.[1,4]

Ultrasound-guided scanning of the spine, however, requires expertise and is time-consuming, particularly in cases where the spine is deeply located or obscured by obesity. Consequently, the time to identify the intervertebral space was higher in the ultrasound-guided group compared to the landmark-guided group, a finding consistent with the study by Karthikeyan Kallidaikurichi Srinivasan et al.[13] On the other hand, the time required to perform a lumbar puncture was significantly shorter in the ultrasound-guided group due to the reduced number of attempts and needle passes. Ultrasound guidance aids in directing the needle, thereby minimizing the number of needle punctures and improving procedural efficiency. Overall, ultrasound enhances success rates, reduces needle insertion attempts, minimizes procedure-associated pain, and improves patient satisfaction, as corroborated by previous studies.[14,15]

In terms of hemodynamic parameters, there was no statistically significant difference between the two groups concerning pulse rate, systolic and diastolic blood pressure, or oxygen saturation at any point during the study ($p > 0.05$). Intraoperatively, only one patient in Group L developed hypotension, which was effectively managed with intravenous injection of ephedrine (0.2–0.5 mg/kg).

Postoperatively, three patients in Group L reported headaches, which were successfully managed with paracetamol 500 mg. This highlights that while ultrasound guidance improves technical aspects of the procedure, the overall safety and hemodynamic stability remain comparable across both groups.

Our study also had few limitations. We did not include the use of a real-time ultrasound-guided approach for spinal anaesthesia due to challenges in maintaining sterile precautions during the procedure. Additionally, the study was limited to obese patients, excluding other categories of patients with difficult surface landmarks, such as pregnant women, elderly individuals with fused spines, or patients with scoliosis or kyphosis. As a result, the findings of this study may not be directly applicable to these patient populations.

5. Conclusion

Preprocedural ultrasound scanning for subarachnoid block is a valuable tool that should be considered for all obese patients when available. It significantly reduces the number of attempts required and minimizes associated complications, enhancing both procedural efficiency and patient safety.

6. Source of Funding

None.

7. Conflict of Interest

None.

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