e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(3); 131-137

Original Research Article

Comparison of Ease of Access of Spinal Anaesthesia by Ultrasound-Assisted Versus Landmark Guided Technique among Anaesthesia Residents

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Received: 01-12-2025 / Revised: 15-01-2026 / Accepted: 21-02-2026

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Conflict of interest: Nil

Abstract

Background: Spinal anaesthesia is one of the most commonly used regional anaesthetic techniques for lower abdominal, pelvic, and lower limb surgeries. Traditionally, the subarachnoid space is accessed using surface anatomical landmarks. However, this landmark-guided technique may be challenging in certain patients due to anatomical variations, obesity, or poorly palpable landmarks. Ultrasound imaging has recently been introduced as an adjunct to improve the identification of spinal anatomy and facilitate accurate needle placement. Ultrasound-assisted spinal anaesthesia may improve the ease of access to the subarachnoid space, particularly for anaesthesia residents who are still developing procedural skills.

Aim: To compare the ease of access of the subarachnoid space using the ultrasound-assisted technique versus the landmark-guided technique among anaesthesia residents.

Materials and Methods: This prospective randomized comparative study was carried out in the Department of Anaesthesiology and Critical Care at Sri Siddhartha Medical College and Hospital, Tumkur, Karnataka, India, over a period of 24 months. A total of 70 patients scheduled for surgeries requiring spinal anaesthesia were included in the study and randomly allocated using computer-generated randomization into two equal groups of 35 patients each.

Group A (USG Group) consisted of 35 patients in whom spinal anaesthesia was administered using the ultrasound-assisted technique. Group B (LG Group) consisted of 35 patients in whom spinal anaesthesia was administered using the conventional landmark-guided technique.

The procedures were performed by anaesthesia residents under supervision. Parameters assessed included number of attempts required to achieve successful dural puncture, time taken to access the subarachnoid space, first-attempt success rate, need for needle redirection, and overall ease of access as assessed by the performing resident. Data were analyzed using appropriate statistical tests, and a p-value of <0.05 was considered statistically significant.

Results: The first-pass success rate was significantly higher in the ultrasound group compared with the landmark group (77.1% vs 37.1%, $p < 0.001$). The mean number of attempts and needle redirections required to achieve successful dural puncture were lower in the ultrasound group. Additionally, the time required to identify the intervertebral space and access the subarachnoid space was reduced with ultrasound assistance. Residents reported better ease of access and procedural confidence when using ultrasound guidance compared to the conventional landmark technique.

Conclusion: Ultrasound-assisted spinal anaesthesia significantly improves the ease of access to the subarachnoid space compared with the landmark-guided technique when performed by anaesthesia residents. The use of ultrasound helps in better identification of spinal anatomy, increases first-pass success rate, and reduces the number of attempts required. Incorporating ultrasound guidance in training programs may enhance procedural success and improve patient safety in spinal anaesthesia.

Keywords: Spinal anaesthesia; Ultrasound guidance; Landmark technique; Neuraxial block; Anaesthesia residents.

DOI: 10.25258/ijcpr.18.3.21

Introduction

Spinal anaesthesia is one of the most widely practiced regional anaesthetic techniques for lower abdominal, pelvic, perineal, and lower limb surgeries. It involves the injection of local anaesthetic agents into the subarachnoid space to produce reversible sensory and motor blockade. Due to its rapid onset, reliable block characteristics, minimal systemic drug exposure, and reduced postoperative complications compared with general anaesthesia, spinal anaesthesia has become a preferred technique in many surgical procedures. It is also associated with advantages such as reduced blood loss, decreased risk of thromboembolism, and improved postoperative analgesia. However, the success of spinal anaesthesia largely depends on accurate identification of the intervertebral space and proper needle placement into the subarachnoid space. [1,2]

Traditionally, spinal anaesthesia is performed using the landmark-guided technique, which relies on palpation of surface anatomical landmarks such as the iliac crests, spinous processes, and interspinous spaces. The intercristal line (Tuffier's line), drawn between the highest points of the iliac crests, is commonly used as a reference point to identify the L3–L4 or L4–L5 intervertebral space for needle insertion.3 While this technique is widely practiced and cost-effective, it has several limitations. Identification of anatomical landmarks may be difficult in patients with obesity, spinal deformities, degenerative spinal changes, or poorly palpable landmarks. [4] In such situations, the success rate of spinal puncture may decrease, and multiple attempts may be required, increasing patient discomfort and the risk of complications such as post-dural puncture headache, traumatic puncture, nerve injury, and infection. [5,6]

The landmark technique also presents challenges for anaesthesia residents and trainees who are still developing procedural skills. Achieving successful subarachnoid access may require multiple attempts and needle redirections, particularly during the early phase of training. Studies have shown that the success rate of spinal anaesthesia performed by inexperienced operators is significantly lower compared with experienced anaesthesiologists. Therefore, techniques that can improve accuracy and facilitate easier identification of the puncture site are valuable in improving both training outcomes and patient safety. [7,8] In recent years, ultrasonography has emerged as a useful adjunct in regional anaesthesia and pain management. Ultrasound imaging provides real-time visualization of anatomical structures and helps in identifying important landmarks such as the spinous processes, laminae, ligamentum flavum, and the posterior complex of the spinal canal. Preprocedural ultrasound scanning allows anaesthesiologists to determine the optimal puncture site, needle insertion angle, and depth to the subarachnoid space, thereby improving the accuracy of needle placement. [9] Ultrasound-assisted techniques have been increasingly used in neuraxial blocks to enhance procedural success, particularly in patients with difficult spinal anatomy. [10,11]

Ultrasound-assisted spinal anaesthesia generally involves performing a preprocedural scan of the lumbar spine to identify the midline and appropriate intervertebral space before needle insertion. The scanning can be performed using either a transverse or paramedian sagittal approach. Once the optimal space is identified, the skin is marked, and spinal puncture is performed at the marked point using conventional sterile technique. This approach does not necessarily require real-time needle visualization but provides valuable anatomical guidance that improves procedural success. [12,13]

Several studies have demonstrated that ultrasound guidance improves the first-attempt success rate of neuraxial blocks and reduces the number of needle insertions and redirections. It has also been shown to reduce procedural time and increase operator confidence, particularly among trainees. [14] Ultrasound-assisted techniques may therefore be particularly beneficial in teaching hospitals where residents frequently perform spinal anaesthesia under supervision. The use of ultrasound may facilitate learning by providing a better understanding of spinal anatomy and improving procedural accuracy. [15]

Another important advantage of ultrasound imaging is its ability to estimate the depth of the epidural and intrathecal spaces before needle insertion. This information helps in selecting the appropriate needle length and reduces the likelihood of repeated attempts due to incorrect needle depth estimation. Additionally, ultrasound can help identify anatomical variations and spinal abnormalities that may not be detectable through palpation alone. Such benefits are particularly useful in patients with obesity or abnormal spinal curvature. [16]

Despite these advantages, the use of ultrasound for neuraxial anaesthesia is not yet universally adopted in routine clinical practice. Factors such as the need for specialized equipment, additional training, and perceived increase in procedural time have limited its widespread implementation. However, with increasing availability of portable ultrasound machines and growing evidence supporting its benefits, ultrasound-assisted neuraxial techniques

are gradually becoming an integral part of modern anaesthesia practice. [8] In the context of anaesthesia training, the integration of ultrasound guidance may significantly improve the learning curve for residents performing spinal anaesthesia. By enhancing anatomical visualization and reducing technical difficulty, ultrasound may increase the success rate of spinal puncture and reduce complications associated with multiple attempts. Therefore, comparing ultrasound-assisted and landmark-guided techniques is important to determine their relative effectiveness in facilitating easier access to the subarachnoid space among anaesthesia residents. [9] Hence, the present study was undertaken in the Department of Anaesthesiology and Critical Care at Sri Siddhartha Medical College and Hospital, Tumkur, Karnataka, to compare the ease of access of the subarachnoid space using ultrasound-assisted technique versus the conventional landmark-guided technique among anaesthesia residents.

Material and Methodology

Study Design: This study was conducted as a prospective randomized comparative study.

Study Setting: The study was carried out in the Department of Anaesthesiology and Critical Care, at Sri Siddhartha Medical College and Hospital, Tumkur, Karnataka, India, over a period of 24 months. The study was approved by the Institutional Ethics Committee of Sri Siddhartha Medical College (IEC approval number: SSMC/MED/IEC-035/FEB-2024, Dated: 09/02/2024). Written informed consent was obtained from all participants.

Source of Data: The study population comprised patients posted for elective lower abdominal and lower limb surgeries under spinal anaesthesia at Sri Siddhartha Medical College and Hospital, Tumkur, Karnataka, India. The procedures were performed by postgraduate residents from the Department of Anaesthesiology and Critical Care.

Sample Size

A total of 70 patients were included in the study.

- **Group A (USG Group):** 35 patients in whom spinal anaesthesia was administered using the ultrasound-assisted technique.
- **Group B (LG Group):** 35 patients in whom spinal anaesthesia was administered using the landmark-guided technique.

Inclusion Criteria

- Patients aged between 18 and 60 years
- ASA physical status I, II, and III
- Patients posted for elective lower abdominal and lower limb surgeries
- Surgeries requiring subarachnoid block (spinal anaesthesia)
- Anaesthesia postgraduate residents willing to participate in the study

Exclusion criteria

- Anaesthesia postgraduate residents inexperienced in using ultrasound
- Resident refusal to participate in the study
- Patient refusal to give informed consent
- Patients undergoing emergency surgeries
- Patients with localized skin infection at the injection site
- Patients with a history of drug allergy
- Patients with haemorrhagic diathesis

Methodology

After obtaining approval from the Institutional Ethics Committee and written informed consent from the patients, eligible patients were enrolled in the study. All patients were advised overnight fasting: 6 hours for solids, 4 hours for semi-solids, and 2 hours for clear liquids. Patients received routine preoperative medication as per institutional protocol. On arrival in the operating room, an intravenous line was secured under aseptic precautions, and Ringer lactate was infused at 4–6 ml/kg/hour. Standard multi parameter monitoring including non-invasive blood pressure, electrocardiogram, and pulse oximetry was instituted. Patients were positioned in the sitting position, and the back was painted and draped under strict aseptic precautions.

Group A – Ultrasound-Assisted Technique: Using a sterile ultrasound curvilinear probe, parasagittal scanning is performed along a vertical axis, while transverse scanning is performed horizontally. The intersection point of these two ultrasound planes corresponds to the optimal midline needle insertion site for accessing the targeted intervertebral disc space (L3–L4 intervertebral space). Using a sterile marker, parasagittal scanning is performed along a vertical axis, while transverse scanning is performed horizontally. The intersection point of these two ultrasound planes corresponds to the optimal midline needle insertion site.

A 25G Quincke spinal needle was inserted at the identified mid-point, and successful dural puncture was confirmed by free flow of cerebrospinal fluid. Total procedural time under USG guidance = Time taken to identify L3-L4 intervertebral space under USG guidance + Time taken to reach the subarachnoid space after skin prick.

Group B – Landmark-Guided Technique: Using surface anatomical landmarks, Tuffier's line and spinous processes were palpated to identify the L3–L4 intervertebral space. A 25G Quincke spinal

needle was inserted using midline approach, and successful dural puncture was confirmed by free flow of cerebrospinal fluid. Total time taken to reach subarachnoid space in landmark group = Time taken to identify L3-L4 intervertebral space by palpation method + Time taken to reach the subarachnoid space after skin prick. In both groups, upon obtaining free flow of cerebrospinal fluid, it was considered as successfully reaching the subarachnoid space.

Parameters Assessed

- First-pass needle success rate.
- Number of needle attempts.
- Total time taken to reach subarachnoid space.
- Ease of access to reach subarachnoid space.

Resident Assessment: After completion of spinal anaesthesia, anaesthesia postgraduate residents were asked to complete a structured questionnaire assessing the ease of access and difficulty level of the technique used to reach the subarachnoid space.

Statistical Analysis: Data were entered into Microsoft Excel and subsequently analysed using the Statistical Package for the Social Sciences (SPSS) software, version 26.0. Descriptive statistics were applied to summarise demographic and clinical variables. Continuous data were expressed as mean ± standard deviation (SD) for normally distributed variables and as median with interquartile range for non-normally distributed variables. Categorical variables were presented as frequencies and percentages. The normality of continuous data was assessed using the Shapiro–Wilk test. Comparisons between the two groups for normally distributed continuous variables were performed using the independent samples t-test, whereas the Mann–Whitney U test was employed for data that did not follow a normal distribution.

Categorical variables were analysed using the Chi-square test or Fisher's exact test, as appropriate. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 70 patients undergoing spinal anaesthesia were included in the study and were randomly allocated into two groups of 35 patients each.

- **Group A (USG Group):** Ultrasound-assisted spinal anaesthesia
- **Group B (LG Group):** Landmark-guided spinal anaesthesia

The procedures were performed by anaesthesia residents under supervision. Various parameters including demographic characteristics, number of attempts, time required to access the subarachnoid space, and success rate were compared between the two groups.

Table 1: Demographic Characteristics of Study Participants

Parameter	Group A (USG) (n=35)	Group B (LG) (n=35)	p-value
Age (years) Mean ± SD	45.89 ± 11.38	45.69 ± 11.42	0.942
Gender (Male)	21	19	0.629
Gender (Female)	14	16	
ASA I	11	16	0.399
ASA II	20	17	
ASA III	4	2	

The demographic and clinical characteristics of patients in both groups were comparable. The mean age of patients in Group A (USG) was 45.89 ± 11.38 years, while in Group B (LG) it was 45.69 ± 11.42 years, showing no statistically significant difference (p = 0.942). Regarding gender distribution, 21 males and 14 females were included in Group A, while 19 males and 16 females were included in Group B. The difference in gender distribution between the groups was not statistically significant (p = 0.629). In terms of ASA physical status, 11 patients were ASA I, 20 ASA II, and 4 ASA III in Group A, whereas 16 were ASA I, 17 ASA II, and 2 ASA III in Group B. The distribution of ASA grades between the groups was statistically comparable (p = 0.399).

Table 2: Comparison of First-Pass Needle Success Rate between Groups

First-Pass Needle Success	Group A (USG) n=35	Group B (LG) n=35	χ^2 value	p-value
Success	27 (77.1%)	13 (37.1%)	11.43	<0.001
Failure	8 (22.9%)	22 (62.9%)		

First-pass needle success was achieved in 27 patients (77.1%) in the ultrasound-guided group compared to 13 patients (37.1%) in the landmark-guided group. First-pass failure occurred in 22.9% of patients in the ultrasound group and 62.9% in the landmark group. The difference between the two groups was statistically highly significant (χ^2 = 11.43, p < 0.001), indicating that ultrasound assistance significantly improves first-pass success during spinal anaesthesia.

Table 3: Comparison of Procedural Characteristics between Ultrasound-Guided and Landmark-Guided Groups

Parameter		Group A (USG) (n=35)	Group B (LG) (n=35)	Test Value	p-value
Number of needle attempts	First attempt	27 (77.1%)	13 (37.1%)	Mann–Whitney U = 885.5	<0.001
	Second attempt	8 (22.9%)	15 (42.9%)		
	≥3 attempts	0 (0%)	7 (20.0%)		
Total Time to Reach Subarachnoid Space (minutes)		82.23±13.36	103±23.43	t = 4.638	<0.001
Resident Ease-of-Access Assessment	Easy	21 (60.0%)	9 (25.7%)	$\chi^2 = 8.427$	0.015
	Moderate difficulty	9 (25.7%)	16 (45.7%)		
	Difficult	5 (14.3%)	10 (28.6%)		

The number of needle attempts required to achieve successful spinal anaesthesia was significantly lower in the ultrasound-guided group, where 77.1% of patients achieved success on the first attempt, compared to 37.1% in the landmark-guided group ($p < 0.001$). No patient in the ultrasound group required more than two attempts, whereas 20.0% of patients in the landmark group required three or more attempts.

The total time taken to reach the subarachnoid space was also significantly lower in the ultrasound-guided group ($t = 4.638$, $p < 0.001$), indicating improved procedural efficiency.

Regarding the resident ease-of-access assessment, 60.0% of procedures were rated easy in the ultrasound group, compared to 25.7% in the landmark group, while difficult access was more common in the landmark group (28.6% vs 14.3%). The difference between the groups was statistically significant ($p = 0.015$), suggesting that ultrasound guidance improves ease of access to the subarachnoid space for anaesthesia residents.

Discussion

Spinal anaesthesia remains one of the most widely used regional anaesthesia techniques for lower abdominal, pelvic, and lower limb surgeries. Successful spinal anaesthesia depends on accurate identification of the intervertebral space and correct needle placement in the subarachnoid space. Traditionally, the landmark-guided technique has been used for this purpose; however, difficulty in identifying anatomical landmarks may result in multiple needle attempts, prolonged procedure time, and increased patient discomfort. In recent years, ultrasound has been introduced as a useful adjunct for neuraxial procedures, allowing better visualization of spinal anatomy and facilitating easier needle placement. [1]

The present study compared the ease of access of the subarachnoid space using ultrasound-assisted versus landmark-guided techniques among anaesthesia residents. The results demonstrated that ultrasound assistance significantly improved procedural success, reduced the number of attempts, decreased the time required to reach the subarachnoid space, and enhanced operator ease during spinal anaesthesia.

In the present study, the first-pass needle success rate was significantly higher in the ultrasound-guided group (77.1%) compared to the landmark-guided group (37.1%) ($p < 0.001$). These findings suggest that ultrasound assistance provides better identification of the optimal puncture site and needle trajectory, thereby increasing the likelihood of successful dural puncture on the first attempt. Similar findings were reported by Shaikh et al., who conducted a systematic review and meta-analysis and reported that ultrasound guidance significantly improves the first-pass success rate of neuraxial procedures compared with conventional landmark techniques. [2] Likewise, Perlas et al. observed that ultrasound imaging improves identification of the intervertebral space and increases the success rate of spinal anaesthesia, particularly in patients with difficult anatomical landmarks. [3]

The number of needle attempts required to achieve successful spinal anaesthesia was also significantly lower in the ultrasound group. In the current study, 77.1% of patients in the ultrasound group required only one attempt, whereas only 37.1% of patients in the landmark group achieved success on the first attempt. Additionally, 20.0% of patients in the landmark group required three or more attempts, while none of the patients in the ultrasound group required more than two attempts ($p < 0.001$). Multiple needle attempts increase the risk of complications such as post-dural puncture headache, traumatic puncture, and nerve injury. Therefore, reducing the number of attempts not only improves procedural efficiency but also enhances patient safety. These findings are consistent with the results of Arzola et al., who reported that ultrasound-assisted neuraxial techniques significantly reduce the number of needle insertions and needle redirections compared with landmark-based methods. [4]

Another important finding in the present study was the significant reduction in the total time required to reach the subarachnoid space in the ultrasound-guided group ($p < 0.001$). Although ultrasound

scanning requires an additional step before needle insertion, the improved visualization of anatomical structures helps in accurately identifying the intervertebral space and determining the appropriate needle insertion point. This reduces repeated attempts and ultimately decreases the overall procedural time. Similar results were reported by Chin and Chan, who demonstrated that preprocedural ultrasound scanning significantly reduces the time required to perform neuraxial blocks by facilitating accurate identification of spinal anatomy. [5]

The ease-of-access assessment by anaesthesia residents also showed a significant difference between the two groups. In the present study, 60.0% of procedures in the ultrasound group were rated as easy, compared with only 25.7% in the landmark group, while difficult access was reported in 28.6% of cases in the landmark group and 14.3% in the ultrasound group ($p = 0.015$).

These findings suggest that ultrasound assistance improves the technical ease of spinal anaesthesia, particularly for less experienced operators such as residents. Ultrasound imaging allows visualization of important structures such as the spinous processes, laminae, and posterior complex of the spinal canal, enabling residents to better understand spinal anatomy and perform the procedure with greater confidence. Similar observations were reported by Karmakar et al., who demonstrated that ultrasound imaging provides valuable anatomical guidance and improves procedural confidence during neuraxial blocks. [6]

The use of ultrasound in neuraxial anaesthesia has been particularly beneficial in patients with difficult anatomy, such as those with obesity, scoliosis, or poorly palpable landmarks. Balki et al. showed that ultrasound can accurately estimate the depth to the epidural and intrathecal spaces, which helps in selecting the appropriate needle length and reduces failed attempts.[7] Similarly, Grau et al. reported that ultrasound imaging improves the success rate of neuraxial blocks and decreases the incidence of multiple punctures, especially among trainees. [8]

In teaching hospitals where residents frequently perform spinal anaesthesia, ultrasound guidance can play an important role in improving training outcomes. By providing a clear visualization of spinal anatomy, ultrasound helps residents understand the relationship between surface landmarks and underlying structures. This not only increases the success rate of the procedure but also reduces the learning curve associated with neuraxial techniques. Perlas et al. emphasized that ultrasound guidance is particularly useful for teaching neuraxial procedures and improving the technical skills of trainees. [9] Overall, the findings of the present study are consistent with previous literature demonstrating the benefits of ultrasound-assisted neuraxial techniques. The significant improvement in first-pass success rate, reduction in needle attempts, decreased procedural time, and improved ease of access observed in the ultrasound group highlight the value of ultrasound as a supportive tool in spinal anaesthesia. Incorporating ultrasound guidance into routine anaesthesia practice and resident training programs may therefore improve patient safety and procedural success.

Limitation of study: This study had certain limitations. The sample size was relatively small and the study was conducted in a single centre, which may limit the generalizability of the findings. Additionally, the procedures were performed by residents with varying levels of experience, which may have influenced procedural outcomes.

Conclusion

The present study demonstrated that ultrasound-assisted spinal anaesthesia significantly improves the ease of access to the subarachnoid space compared with the conventional landmark-guided technique when performed by anaesthesia residents. Ultrasound guidance was associated with a higher first-pass success rate (77.1% vs 37.1%), fewer needle attempts, and significantly reduced procedural time ($p < 0.001$).

Additionally, residents reported greater ease of access and procedural confidence when using ultrasound assistance. Therefore, the incorporation of ultrasound guidance in neuraxial anaesthesia training and clinical practice may enhance procedural success, reduce complications associated with multiple needle attempts, and improve overall patient safety.

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