

A Prospective Study Comparing Landmark Technique Versus Preprocedure Ultrasound-Guided Paramedian Spinal Anaesthesia in the Elderly

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Background: Spinal anaesthesia is commonly used for infra-umbilical surgeries in elderly patients due to its favourable safety profile. Age-related spinal changes can make landmark-based paramedian approaches challenging, increasing the risk of multiple needle passes and procedural complications. Pre-procedural ultrasound guidance may improve success rates and reduce complications.

Objective: To compare the efficacy and safety of pre-procedural ultrasound-guided versus conventional landmark-guided paramedian spinal anaesthesia in elderly patients.

Methods: This prospective, randomised study included 70 patients aged >60 years scheduled for infra-umbilical surgery under spinal anaesthesia. Patients were randomised into two groups: Landmark (n=35) and Ultrasound-guided (n=35). The primary outcome was the number of needle passes. Secondary outcomes included the number of insertion attempts, time to identify landmarks, total procedural time, periprocedural pain, first-pass success, and complications.

Results: The median number of needle passes was significantly lower in the ultrasound group (1 [IQR 1–2]) compared to the landmark group (4 [IQR 2–7]; $p < 0.001$). Ultrasound guidance also significantly reduced needle insertion attempts (1 [1–2] vs. 3 [2–4]; $p < 0.001$), total procedural time (31.5 ± 8.9 s vs. 71.3 ± 12.6 s; $p < 0.001$), and periprocedural pain scores (2 [1–3] vs. 4 [3–6]; $p < 0.001$). First-pass success was higher in the ultrasound group (65.7% vs. 17.1%; $p < 0.001$). Minor complications such as radicular pain and bloody tap were observed only in the landmark group.

Conclusion: Pre-procedural ultrasound-guided paramedian spinal anaesthesia is superior to the conventional landmark-based technique in elderly patients. It improves first-pass success, reduces needle passes, procedural time, and minor complications, and enhances patient comfort. Routine use of ultrasound guidance is recommended for geriatric patients, particularly those with difficult spinal anatomy.

Keywords: Spinal anaesthesia, ultrasound guidance, paramedian approach, elderly, first-pass success, procedural complications.

INTRODUCTION

Spinal anaesthesia is a widely employed technique for infra-umbilical surgeries, particularly in elderly patients, due to its favourable safety profile and reduction in perioperative complications compared to general anaesthesia (1). In the geriatric population, spinal anaesthesia is associated with decreased risk of deep vein thrombosis, postoperative hypoxia, myocardial infarction, and pulmonary complications like pneumonia (1).

Conventionally, spinal anaesthesia is performed using surface anatomical landmarks to identify the appropriate intervertebral space. Common approaches include midline, paramedian, and lumbosacral techniques, with the midline

approach being the most widely used. However, age-related degenerative changes in the spine, such as ligament calcification and decreased intervertebral space, often make the midline approach challenging in elderly patients (2,3). The paramedian approach, which bypasses the supraspinous and interspinous ligaments and directly penetrates the ligamentum flavum, has been shown to have a higher success rate in geriatric patients (3,4).

The ideal spinal anaesthesia technique achieves successful dural puncture with a single needle pass. Multiple needle passes increase the risk of patient discomfort, post-dural puncture headache, paresthesia, and tissue trauma (4). Pre-procedural ultrasonography of the neuraxial axis has emerged as a valuable adjunct to improve accuracy, particularly in the paramedian approach. Both transverse midline (TM) and parasagittal oblique (PSO) ultrasound views can be used to optimise needle insertion, with PSO providing a more comprehensive visualisation of the neuroaxis (4,5).

Previous studies have demonstrated the efficacy of ultrasound guidance in reducing needle passes and increasing first-attempt success rates. Park et al. (5) reported significantly fewer needle passes (median 1 vs. 4.5) and higher first-attempt success (65% vs. 17.5%) in the ultrasound-guided paramedian group compared to landmark guidance. Similarly, Kampitak et al. (6) observed reduced needle redirections, insertion attempts, and complications such as radicular pain and bloody tap in elderly patients undergoing total knee or hip arthroplasty. Conversely, Rizk et al. (7) found that for novice operators, pre-procedural ultrasound did not significantly improve ease of spinal anaesthesia compared to conventional landmark guidance, although procedural time was reduced.

Given these findings, there is a need to further evaluate the effectiveness of ultrasound-assisted paramedian spinal anaesthesia in elderly patients, particularly in terms of needle passes, insertion attempts, procedural time, and complications. Therefore, the present study was designed to compare pre-procedural ultrasound-guided versus conventional landmark-guided paramedian spinal anaesthesia in elderly patients undergoing infra-umbilical surgery (8–12).

MATERIALS AND METHODS

Study Design

This was a prospective, randomised comparative study conducted at **Navodaya Medical College and Hospital** over a period of 16 months (February 2024 – June 2025). The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants.

Study Population

A total of **70 patients aged above 60 years** scheduled for infra-umbilical surgeries under spinal anaesthesia were enrolled. Patients were randomly allocated using a computer-generated table into two groups of 35 each:

- **Group L (Landmark Group):** Conventional surface landmark guided paramedian spinal anaesthesia
- **Group U (Ultrasound Group):** Pre-procedural ultrasound-guided paramedian spinal anaesthesia

Inclusion Criteria:

- Age > 60 years
- ASA physical status I–III

Exclusion Criteria:

- Contraindications to spinal anaesthesia (allergy, bleeding disorders)
- Spinal deformities or prior spine surgery
- Infection at the puncture site

Procedure

Preoperative Preparation

Standard monitoring (NIBP, pulse oximetry, ECG) was established. No sedatives were administered before the procedure. IV access was secured, and patients were placed in a sitting position with an arched back.

Ultrasound-Guided Technique (Group U)

- A curvilinear low-frequency (2–5 MHz) probe was used.
- **Transverse midline (TM) view:** Midline marked to guide medial angulation of needle.
- **Para-sagittal oblique (PSO) view:** Probe placed 1–2 cm lateral to midline to visualise interlaminar space.
- Optimal interspace was selected where ligamentum flavum, posterior dura, epidural space, and vertebral body were clearly visible.
- Skin markings were made at the midpoints of the long and short probe borders. Needle insertion was at the intersection point, with the medial angle of the probe as the insertion angle.
- The needle was inserted under strict aseptic conditions without palpating anatomical landmarks.

Landmark-Guided Technique (Group L)

- Preferred interspace between L2–L5 was identified by palpation.
- Ease of palpation graded on a 4-point scale (easy, moderate, difficult, impossible).
- Needle inserted 1 cm lateral and 1 cm caudal to the superior spinous process at 10–15° cephalomedial angle.

Spinal Block

- In both groups, a 25G Quincke needle was used after local infiltration with 2 ml of 2% lignocaine.
- Correct placement confirmed by free flow of CSF.
- Type and dose of intrathecal drug at anesthesiologist discretion.
- Hemodynamic parameters monitored for 20 minutes post-block.
- After 4 failed attempts, an alternative interspace or technique was used.

Outcome Measures

Primary Outcome: Number of needle passes required for successful spinal anaesthesia.

Secondary Outcomes:

- Number of needle insertion attempts
- Time taken to identify landmarks
- Time to accomplish spinal anaesthesia
- Periprocedural pain score (0–10)
- Complications: radicular pain, paresthesia, bloody tap
- First-pass success rate

Statistical Analysis

Continuous data were expressed as mean $\pm$ SD or median (IQR). An independent t-test or Mann-Whitney U test was used for comparisons. Categorical variables were analysed using the Chi-square test. p -value < 0.05 was considered statistically significant.

RESULTS AND OBSERVATIONS

Table 1: Demographic and Baseline Characteristics

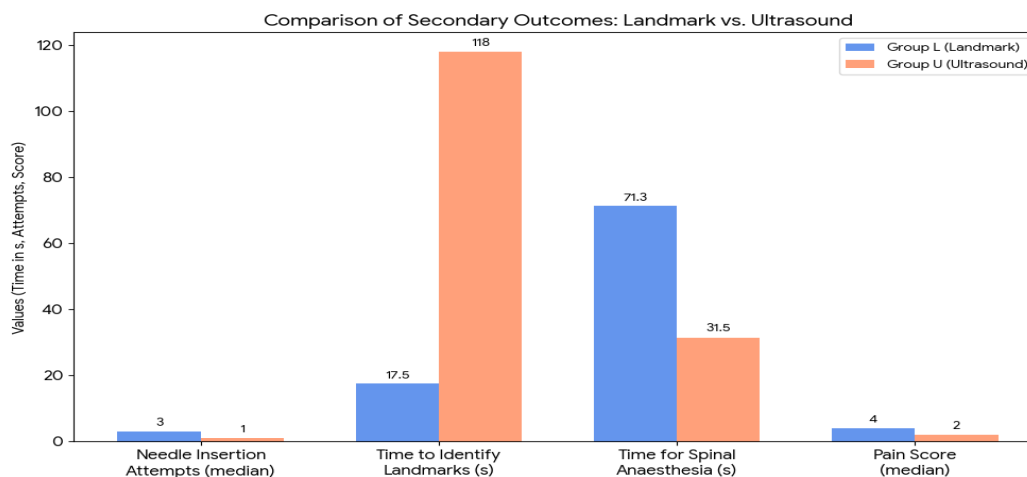
Parameter	Group L (Landmark) (n=35)	Group U (Ultrasound) (n=35)	p-value
Age (years)	68.4 $\pm$ 5.6	69.2 $\pm$ 6.1	0.54
Gender (M/F)	20/15	21/14	0.80
BMI (kg/m ²)	24.5 $\pm$ 2.8	24.1 $\pm$ 3.1	0.52
ASA Physical Status I/II/III	8/20/7	9/19/7	0.94

Table 2: Needle Passes for Successful Spinal Anaesthesia (Primary Outcome)

Parameter	Group L (Landmark)	Group U (Ultrasound)	p-value
Median number of needle passes (IQR)	4 (2–7)	1 (1–2)	<0.001*

Table 3: Secondary Outcomes: Needle Insertion Attempts and Times

Parameter	Group L (Landmark)	Group U (Ultrasound)	p-value
Needle insertion attempts (median, IQR)	3 (2–4)	1 (1–2)	<0.001*
Time to identify landmarks (s)	17.5 $\pm$ 4.3	118 $\pm$ 15.2	<0.001*
Time to accomplish spinal anaesthesia (s)	71.3 $\pm$ 12.6	31.5 $\pm$ 8.9	<0.001*
Periprocedural pain score (0–10 scale, median IQR)	4 (3–6)	2 (1–3)	<0.001*



Figure; 1 Secondary Outcomes: Needle Insertion Attempts and Times

Table 4: Complications

Complication	Group L (Landmark) n (%)	Group U (Ultrasound) n (%)	p-value
Radicular pain	5 (14.3)	0 (0)	0.02*
Paresthesia	2 (5.7)	0 (0)	0.15
Blood in needle hub	6 (17.1)	0 (0)	0.01*

Table 5: First-Pass Success Rate

Parameter	Group L (Landmark) n (%)	Group U (Ultrasound) n (%)	p-value
First-pass success	6 (17.1)	23 (65.7)	<0.001*

DISCUSSION

The present study demonstrates that pre-procedural ultrasound-guided paramedian spinal anaesthesia significantly reduces the number of needle passes, insertion attempts, and procedural time compared to the conventional landmark-guided technique in elderly patients. Additionally, ultrasound guidance improved patient comfort and reduced minor complications such as radicular pain and bloody tap.

Primary Outcome

In our study, the median number of needle passes was significantly lower in the ultrasound group (1 [IQR 1–2]) compared to the landmark group (4 [IQR 2–7]), consistent with the findings of Park et al. (5), who reported a median of 1–2 needle passes in the ultrasound-assisted group versus 2–7 in the landmark group. This confirms that ultrasound guidance enhances precision and increases first-pass success rates by allowing accurate identification of interlaminar spaces, particularly in elderly patients with degenerative spinal changes (2–5).

Secondary Outcomes

The number of needle insertion attempts and time to accomplish spinal anaesthesia were also significantly reduced in the ultrasound group. Although time to mark landmarks was longer due to pre-procedural scanning (118 ± 15.2 s vs. 17.5 ± 4.3 s), the total procedural time was markedly shorter (31.5 ± 8.9 s vs. 71.3 ± 12.6 s). These findings align with Park et al. (5) and Kampitak et al. (6), demonstrating that the initial investment in ultrasound scanning is offset by greater procedural efficiency and reduced patient discomfort.

The periprocedural pain score was significantly lower in the ultrasound group, likely due to fewer needle redirections and improved first-pass success. Similar trends were reported by Kampitak et al. (6) and Bayoumi et al. (8), highlighting ultrasound guidance as a tool to improve patient tolerance, particularly in the geriatric population.

Complications

Minor complications such as radicular pain, paresthesia, and blood in the needle hub were significantly higher in the landmark group. Ultrasound guidance allowed visualization of the ligamentum flavum, epidural space, and posterior dura, minimizing inadvertent trauma. These findings corroborate the results of Bayoumi et al. (8), Chong et al. (9), and Chen et al. (10), supporting the role of ultrasound in reducing procedural complications in elderly patients.

Comparison with Previous Studies

Our results are in agreement with previous randomised trials (5–10), which showed that ultrasound guidance improves the technical success of paramedian spinal anaesthesia. However, the study by Rizk et al. (7) noted limited benefits for novice operators, suggesting that operator experience influences the effectiveness of ultrasound guidance. In our study,

all procedures were performed by anesthesiologists experienced in ultrasound-assisted neuraxial blocks, which may account for the improved outcomes.

Clinical Implications

Ultrasound-assisted paramedian spinal anaesthesia provides several advantages in elderly patients:

- Reduced needle passes and insertion attempts
- Increased first-pass success
- Shorter procedural time and reduced patient discomfort
- Lower incidence of minor complications

These findings support incorporating ultrasound guidance as a standard approach for geriatric spinal anaesthesia, especially in patients with difficult spinal anatomy (1,4,8–12).

Limitations

- Single-centre study with relatively small sample size (n=70)
- Operators were experienced, which may limit generalizability to novice practitioners
- Study focused only on elective infra-umbilical surgeries; results may differ in emergency settings or other types of surgeries

CONCLUSION

This prospective study demonstrates that pre-procedural ultrasound-guided paramedian spinal anaesthesia provides significant advantages over the conventional landmark-guided technique in elderly patients undergoing infra-umbilical surgeries. Ultrasound guidance significantly reduces the number of needle passes and insertion attempts, shortens the total procedural time, increases first-pass success rates, and decreases minor complications such as radicular pain, paresthesia, and bloody tap. Additionally, it improves patient comfort and procedural efficiency.

These findings support the routine incorporation of pre-procedural ultrasound guidance for paramedian spinal anaesthesia in geriatric patients, especially those with difficult spinal anatomy, to enhance procedural success, safety, and patient satisfaction.

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