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Ultrasound Assisted versus Landmark Guided Spinal Anesthesia in Patients with Abnormal Spinal Anatomy

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ABSTRACT

Objective: To compare the efficacy of ultrasound assisted versus landmark guided spinal anesthesia in patients with difficult anatomy.
Study Design: Quasi-experimental study.
Place and Duration of Study: Department of Anesthesiology, Pak-Emirates Military Hospital, Rawalpindi Pakistan, from Nov 2021 to Mar 2022.
Methodology: We enrolled a total of 70 patients, scheduled for elective lower extremity surgery, under spinal anesthesia for this study. Patients were randomly divided into two groups with the help of random numbers generated using MS Excel. Patients in Group-A, underwent spinal anesthesia using the surface landmark–guided approach (Landmark Group) and in Group-B, patients underwent pre-procedural ultrasound–assisted (Ultrasound Group) technique.
Results: Single puncture and single re-direction rate was found to be significantly higher for patients in Group-B and rate of single attempt (1 attempt: Group-A: 13(37.1%) vs. Group-B: 24(68.6%), *p*-value=0.031) along with number of needle redirections (1-2 attempt: Group-A: 9(25.7%) vs. Group-B: 23(65.7%), *p*-value=0.009) was also significantly higher for patients in Group-B. No significant difference in complications was seen between groups. However, Group-A encountered higher frequency of complications as compared to Group-B.
Conclusion: Pre-procedural ultrasound assisted technique is more effective for successful access to subarachnoid space at the first attempt and reduces the number of needle redirections as compared to landmark-guided technique.

Keywords: Abnormal Spinal Anatomy, Landmark Spinal Anesthesia, Ultrasound.

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INTRODUCTION

Spinal anesthesia may be challenging in patients with difficult surface markers or abnormal spinal anatomy and pre-procedural lumbar spine ultrasound imaging may help determine the best needle insertion location, as the procedure is still done blindly, even while using ultrasound guidance, due to which multiple attempts are associated with more complications.[1] In spinal degeneration, supraspinous and interspinous ligament calcification, narrowing of the intervertebral space, scoliosis, or abnormalities may develop, and the identification of intervertebral levels may be incorrect, presenting problems in needle insertion.[2,3] In obese, elderly or obstetric patients, the ultrasound-assisted combined spinal-epidural (CSE) anesthetic approach improves accuracy and effectiveness by overcoming the technical limitations of executing the procedure in these populations,[4-6] thus, patients with difficult-to-find and aberrant anatomical surface landmarks also benefit from this approach.[7,8] The landmark-guided approach can be more time-consuming in patients with aberrant spinal architecture, but the first attempt success rate is higher with lower pain levels.[9,10] As no local study is available on the comparison of both techniques, we designed this study to generate local evidence of efficacy of both techniques for spinal anesthesia in patients with difficult anatomy.

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METHODOLOGY

This was a Quasi experimental study conducted at Department of Anesthesiology, Pak-Emirates Military Hospital (PEMH), Rawalpindi Pakistan, from November 2021 to March 2022, after obtaining ethical approval from the Institutional Ethical Review Board committee (IERB Letter no: A/28/168) with written, informed consent taken from all participating patients. Sample size of 70 patients, with 35 patients in each group, was calculated using hypothesis tests for two populations proportion with WHO sample size calculator, keeping level of significance as 2.3%, power of the test as 95% and expected percentage for

successful dural puncture at the first pass with landmark technique and with ultrasound as 9.1% and 50% respectively.[7] Nonprobability convenience sampling was used to enroll the required sample. Before the procedure, the history and previous radiological examination findings of all patients were evaluated. With patients in sitting position, their vertebral column was physically examined, and palpation difficulty was scored from 0-3, from easy to difficult using classification criteria of Ekinci *et al*.[11]

Inclusion Criteria: Patients aged between 60-80 years, from either gender, categorized as American Society of Anesthesiologists' (ASA) Class-I to III, with Palpation Difficulty Score of 2 or 3, those with anatomical abnormalities, such as scoliosis, and a history of surgery in the lumbar spine and scheduled for elective lower extremity orthopedic surgery under spinal anesthesia were included in the study.

Exclusion Criteria: Patients with contraindications to spinal anesthesia, coagulopathy, allergy to local anesthetic, infection in the intervention area, severe stenotic heart disease, high intracranial pressure and those refusing to participate in the study were excluded.

Patients were divided into two groups, where Group-A underwent spinal anesthesia using the surface landmark–guided technique (Landmark Group) and Group-B underwent pre-procedural ultrasound–assisted (Ultrasound Group) technique. The procedures were performed by two anesthetists experienced in neuraxial ultrasonography. No sedation was performed before or during the procedure. When administering spinal anesthetic in the Landmark Group, the anesthesiologist used either a midline or paramedian technique, depending on the patient's anatomy.[12] The anesthesiologist rated the ease of palpation on a four-point scale after the procedure.[13] In the Ultrasound Group, a USG device and a 3-5 MHz convex transducer were used for systematic screening of the spine with the probe placed on the sacrum then shifted toward the cranium to count the intervals of the intervertebral disks until L4-L5 and L3-L4 interspinous spaces. Slowly sliding the probe in either a cranial or caudal direction identified interspinous processes in the midline between L4-L5 and L2-L3, as well as bilaterally situated horizontal laminae, to capture pictures of the ligamentum flavum, dorsal dura complex, vertebral body, and articular processes. On both sides, photos of the laminae were taken, and the midway of the probe was clearly highlighted. The midline of the needle insertion position was determined by the junction of the longitudinal and transverse markings in USG scanning. An electronic protractor was used to measure the tilt of the transducer in relation to the transverse plane in order to get the best possible picture of the intrathecal space with the needle pass and orientation then oriented at this angle.

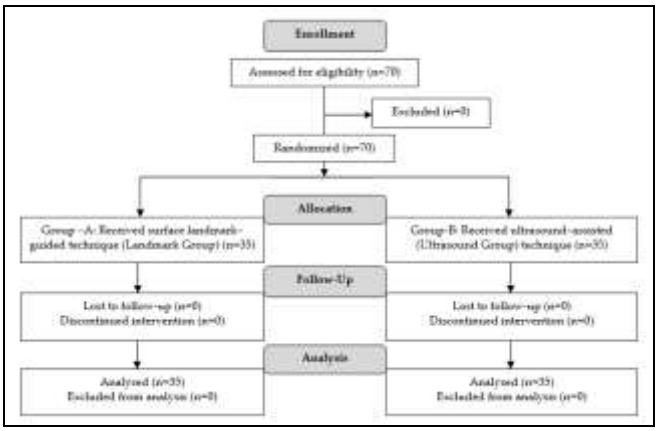

Figure: Patient Flow Diagram (n=70)

Aseptic protocols were strictly followed in both groups. Alternate methods (for Ultrasound Group: midline approach/landmark palpation; and for Landmark Group: ultrasound-assisted technique) were available if dural puncture could not be completed after five tries with separate needle insertion. Number of tries and needle redirections, time spent establishing landmarks, and the overall operation duration were all included as outcome variables. Additionally, spinal anesthesia-related complications and rates of successful access to subarachnoid space were also considered. Statistical Package for the Social Sciences (SPSS) version 23.0 was used for data entry and analysis. Independent sample t-test was used to compare quantitative variables between groups and chi-square test was used to compare qualitative variables between groups where p-value <0.05 was considered statistically significant.

RESULTS

In Group-A, 26(74.3%) patients were male and 9(25.7%) were female while in Group-B, 17(48.6%) patients were male and 18(51.4%) were female. As shown in Table-I, Group-A had 14(40%) patients who underwent THR, 13(34.3%) who underwent TKR and 9(25.7%) underwent other surgical procedures while in Group-B, 13(37.1%) underwent THR, 13(37.1%) underwent TKR and 9(25.7%) underwent other

surgical procedures. Single puncture and single re-direction rate was significantly higher for Group-B patients as shown in Table-II, with rate of single attempt (1 attempt: Group-A: 13(37.1%) vs. Group-B: 24(68.6%), *p*-value=0.031) and number of needle redirections (1-2 attempt: Group-A: 9(25.7%) vs. Group-B: 23(65.7%), *p*-value=0.009) being significantly higher for Group-B patients.

Table-I: Patients Characteristics in Study Groups (n=70)

	Group-A (n=35)	Group-B (n=35)
Age (years)	65.77±2.94	65.71±3.25
Gender		
Male	26(74.3%)	17(48.6%)
Female	9(25.7%)	18(51.4%)
Height (cm)	157.22±4.31	157.42±5.25
Weight (kg)	61.68±4.30	62.68±4.36
Scoliosis	7(20%)	5(14%)
Type of Surgery		
THR	14(40%)	13(37.1%)
TKR	12(34.3%)	13(37.1%)
Other	9(25.7%)	9(25.7%)

Table-II: Comparison Between Groups of Outcome Variables (n=70)

	Group-A (n=35)	Group-B (n=35)	*p*-value (≤0.05)
Single Puncture	21(60%)	31(88.6%)	0.006
Single Redirection	9(25.7%)	17(48.6%)	0.048
Number of Attempts			
1	13(37.1%)	24(68.6%)	0.031
2	12(34.3%)	6(17.1%)	
3	10(28.6%)	5(14.3%)	
Number of Needle Redirections			
1-2	9(25.7%)	23(65.7%)	0.009
3-4	18(51.4%)	11(31.4%)	
>4	8(22.9%)	1(2.9%)	
Procedure Time	134.05±11.48	130.57±5.9	0.116
Complications			
Radicular Pain	4(11.43%)	2(5.71%)	0.393
Bloody Tap	4(11.43%)	1(2.86%)	0.164
Backache	0(0%)	0(0%)	-
Post-dural Puncture Headache	0(0%)	0(0%)	-
Nausea	4(11.43%)	2(5.71%)	0.393
Vomiting	2(5.71%)	1(2.86%)	0.555
Vasovagal attack	5(14.29%)	1(2.86%)	0.087

DISCUSSION

Ultrasound guided spinal anesthesia technique was found to be more effective in terms of successful number of needle passes required, increased single attempts and number of needle redirections without significant difference in procedure duration. No significant difference was seen in complications between both techniques. Conversely, frequency of radicular pain, bloody tap, nausea, vomiting and vasovagal attack was higher among patients who underwent landmark guided spinal anesthesia. Ultrasound guided spinal anesthesia has been used in many studies in individuals with complex anatomy, but little work has been done on this group in terms of how easy it is to utilize ultrasonography for spinal anesthesia.[12,13] Thus, spinal anesthesia may be performed more easily using pre-procedural US in patients who are predicted to present technical issues[8] and is not without significant benefit over the traditional landmark technique.[14,15] Our results are consistent with the findings of another author who reported high success rate for successful dural puncture at the first pass, number of attempts, performance time and peri-procedural pain score[7] with similar findings reported in another study showing that the rate of successful access to the subarachnoid space at the first needle insertion attempt was significantly higher for ultrasound group, however, no statistically significant difference was found between the groups regarding total procedure time, pain scores, patient satisfaction scores, and spinal anesthesia-induced complications.[9] Spinal anesthetic problems, such as back discomfort, patient discontent, post-dural puncture headache, paresthesia, hematoma, and chronic neurologic impairment, may be predicted by several needle passes and manipulations[16] as reported by another study, in which the use of USG increased first-pass success rates, but there was no indication of a decrease in the number of unsuccessful punctures.[17] However, another research found that unskilled practitioners may make effective USG efforts in a short period of time after getting proper training[18] but no improvement in the ease of midline and paramedian spinal anesthesia was found by another study conducted on junior residents in the senior population.[19] It is reasonable to infer that ultrasound guided spinal anesthesia is superior to the landmark approach in many respects, particularly in patients with challenging anatomy.

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LIMITATION OF STUDY

This study had several notable limitations. The relatively small sample size and single-center design may limit the generalizability of findings to broader populations. The quasi-experimental design, rather than a randomized controlled trial, could introduce selection bias. The brief study duration of five months may not account for changes

in operator proficiency. Furthermore, the study focused primarily on immediate procedural outcomes without addressing long-term follow-up or patient satisfaction measures.

CONCLUSION

Results of this study demonstrate that pre-procedural ultrasound assisted technique is more effective in terms of successful access to subarachnoid space at the first attempt and reduces the number of needle redirections as compared to e landmark-guided technique.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

QAB & WT: Data acquisition, data analysis, critical review, approval of the final version to be published.

MAR & AH: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

MMR & MHB: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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