Original Article

A comparative study of ultrasound assisted versus landmark technique for combined spinal-epidural anaesthesia in patients undergoing lower limb orthopaedic surgery

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ABSTRACT

Background and Aims: Spinal anatomy is better visualised in the para sagittal oblique view with the aid of ultrasonography. The present study was undertaken to investigate whether preprocedural ultrasonography can facilitate the ease of establishing combined spinal epidural (CSE) via paramedian approach versus landmark approach in patients undergoing lower limb orthopaedic surgery. **Methods**: This prospective randomised study was conducted in 100 American Society of Anesthesiologists (ASA) grade I-II patients, aged 18-60 years requiring CSE and randomly divided into two groups: Ultrasound-assisted (USG) group (n = 50) and Surface landmark (SLG) group (n = 50). The primary outcome was to compare the first pass needle success rate to establish CSE and the secondary outcomes were to compare the number of needle puncture attempts, time to establish landmarks (t1), time to accomplish CSE (t2) and complications. **Results:** First pass needle success rate in USG group was 43 (86.0%) versus 36 (60.0%) in SLG group ($P = 0.001$). Number of attempts taken to establish CSE was lower in USG group as compared to SLG group ($P = 0.023$). t1 was greater in USG group (1.45 ± 0.47) minutes as compared to (0.79 ± 0.34) minutes in SLG group ($P = 0.003$). t2 was reduced in USG group (1.47 ± 0.55) minutes versus (2.73 ± 1.36) minutes in SLG group ($P = 0.005$). **Conclusion:** Preprocedural USG for CSE via paramedian approach increases first pass needle success rate and reduces needle puncture attempts in patients undergoing lower limb orthopaedic surgery.

Key words: Epidural, orthopaedic, spinal, ultrasonography

INTRODUCTION

Central neuraxial block (CNB) refers to the placement of local anaesthetic in the subarachnoid space or epidural space (ES) thereby achieving blockade of sympatho-somatic outflow from the spinal cord. CNB can be given by various routes like median, paramedian, Taylor's approach. Paramedian approach has many advantages over the median approach as it provides a larger area to negotiate through interlaminar space, avoidance of supraspinous and interspinous ligaments, thus reducing complications like trauma, dural puncture, paraesthesia and bloody tap.[1] It has a better success rate with fewer complications especially in the elderly and patients with difficult positioning during anaesthesia.[2] There could be multiple punctures/redirections of the needle while performing CNB by blind surface landmark technique. Multiple CNB attempts increase morbidities such as trauma, pain, the incidence of postdural puncture headache, paraesthesia, spinal haematoma, and failure.

Ultrasonography (USG) is non-invasive, safe, simple to use, provides real time images, devoid of any radiation

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hazards and is beneficial in abnormal variants of spinal anatomy.[3] Real time USG and preprocedural ultrasound scanning before CNB has resulted in an improved first pass success rate and also reduced the number of attempts and redirection for performing spinal and epidural anaesthesia.[4,5] Combined spinal-epidural (CSE) block can be achieved rapidly using spinal components while the epidural catheter is used to prolong, modify the block and provide postoperative analgesia. When adopting a needle through needle approach, a spinal needle with acceptable cerebrospinal fluid (CSF) return indicates correct Tuohy needle placement in the epidural area.[6]

Age-related degenerative changes of the spine and difficulty in positioning due to associated osteoarthritis and fracture-related pain favour paramedian approach for CNB.[7,8] Very few studies have been done on USG assisted CSE (needle-through-needle technique) via paramedian approach and thus the present study was undertaken to evaluate if preprocedural USG assisted marking of the puncture point will improve the success rate of CNB. The primary objective of the study was to determine the first pass needle success rate while the secondary objectives were to compare the number of needle puncture attempts to establish successful CSE, time taken to establish landmarks, time taken to accomplish CSE and complications. We hypothesised that the use of a preprocedural ultrasound scan would result in a greater first pass needle success rate and decrease the number of attempts as compared to landmark guided CSE.

METHODS

This study was conducted in the Department of Anaesthesiology of a tertiary care hospital from August 2020 to June 2021 after approval of the Institutional Ethics Committee and Clinical Trials Registry of India (CTRI) registration (CTRI/2020/08/026959). The study followed all the principles of the Declaration of Helsinki. After getting written and informed consent, 100 patients of the American Society of Anesthesiologists (ASA) class I and II posted for elective lower limb orthopaedic surgery requiring CSE were recruited. The patients who refused to give consent, those with bleeding diathesis and having contraindication for CSE were excluded from the study. A computer-generated randomised number table was used for randomisation of patients into two groups of 50 each.

Ultrasound-assisted group (USG) (n=50): pre procedural ultrasound scan was used to identify the needle insertion point via the paramedian route.

Surface landmark (SLG) group (n = 50): land mark technique was used to identify needle insertion point and CSE (needle through needle technique) via paramedian route.

Screening, randomisation, concealment and patient allocation were performed by a fellow anaesthesiologist unaware of the study using sequentially numbered sealed opaque slips.

Detailed history taking, general physical and systemic examination were performed by an anaesthesiologist (different from the one who did screening) and the anaesthetic procedure was explained a day prior to surgery to patients in both groups. Patients were kept fasting for 6 hours for solid/semisolid food prior to surgery. Tablet alprazolam (0.25 mg) and tablet ranitidine (150 mg) per oral were given as premedication, on the night before the surgery with sips of water.

In the USG group, ultrasound scanning in sitting position was done in the preoperative room by an anaesthesiologist, having experience of more than 50 preprocedural ultrasound-guided paramedian CSE, with M-Turbo®R System Sono™ MB technology Fujifilm SonoSite portable ultrasound using a convex probe (2-5 Hz). An ultrasound probe was placed transversely in the midline in the lumbar region to visualise the best view of the spinous process which appeared as a linear hypoechoic acoustic shadow. Using the M mode of USG, the central point at the long border of the probe was marked, which was extended as a vertical line using a surgical skin marking pen corresponding to the central neuraxis midline (A). The probe was then rotated at 90° and moved 1-2 cm in the paramedian plane with oblique angulation towards the midline. The probe was moved caudally to visualise the sacrum which appeared as a flat hyperechoic structure with a large acoustic shadow anteriorly. After the sacrum was identified, the probe was gradually slid cranially to visualise the L5 vertebra lamina, then L4-L5 and L3-L4 interlaminar space were marked at the midpoint of the probe and medial angulation was noted with a 180° protractor which was used as the angle for needle advancement. Intervertebral anatomy at both the marked spaces were seen as ligamentum flavum, epidural space and posterior dura posteriorly,

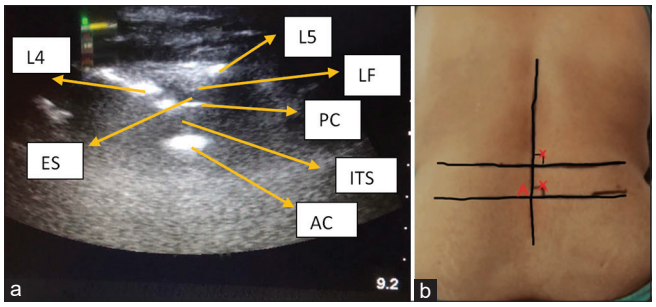

Figure 1: (a) Sonoanatomy of the spine in para sagittal oblique view showing: L5: Lamina of L5; LF: Ligamentum Flavum; PC: Posterior Dural Complex; ITS: Intrathecal Space; AC: Anterior Dural Complex; L4: Lamina of L4; ES: Epidural Space (b) Showing marked point X; the site of needle puncture point. A: neuraxial midline

vertebral body and anterior dura anteriorly [Figure 1a]. This point was marked as "X" which was used for introducing the Tuohy needle [Figure 1b]. CSE was performed at L4-L5 interlaminar space and L3-L4 space was used as rescue interspace if CSE could not be accomplished in three attempts.

Both the groups of patients were taken to the operation room (OR) and non-invasive blood pressure (NIBP), electrocardiogram (ECG) and oxygen saturation (SpO_2) monitors were attached. The intravenous line was secured with an appropriate size cannula and crystalloid infusion started at the rate of 15-20 ml/kg. The patient was kept in sitting position and the patient's back was prepared under aseptic precautions preserving the skin markings. The skin and deeper tissues were infiltrated with 2 ml of 2% lignocaine at the puncture site. Combined spinal/epidural Minipack with Lock pencil point spinal needle 27G/18G, Portex® Smith, UK was used for CSE.

In the USG group, 18G Tuohy needle was introduced by an anaesthesiologist, having experience of performing more than 50 preprocedural ultrasound-guided paramedian CSE, at the preprocedural ultrasound-assisted marked point "X" maintaining the same angle in which the ultrasound probe was kept. The epidural space was confirmed by the loss of resistance to air. Keeping the Tuohy needle in place, Whitacre spinal needle was introduced by needle-through-needle technique and subarachnoid space location was confirmed by free backflow of clear CSF. 2 ml of 0.5% hyperbaric bupivacaine was given and the epidural catheter was advanced up to 4 cm in the epidural space.

In the SLG group, the spine was palpated in the midline and two intervertebral spaces L4-L5 and L3-L4 were marked 1.5 cm lateral to the midline and an 18G Tuohy needle was introduced by an anaesthesiologist, having previous experience of performing more than 50 paramedian CSE blocks by conventional palpatory surface landmark technique, and epidural space was confirmed by loss of resistance to air. Keeping the Tuohy needle in place, a 27 G Whitacre spinal needle was introduced using the needle-through-needle technique and subarachnoid space location was confirmed by free backflow of clear CSF. 2 ml of 0.5% hyperbaric bupivacaine was given and the epidural catheter was advanced up to 4 cm in the epidural space.

The first pass needle insertion success and number of needle puncture attempts taken to reach the ES were recorded. t1 was time taken from the first skin contact of the patient to the time the investigator had marked the puncture point with a preprocedural scan in the USG group and located the surface landmarks for needle puncture in the SLG group. t2 was time taken from the local infiltration of the skin to epidural catheter placement at the desired length in both groups. Successful CSE was assessed by sensory and motor block. The sensory block level was assessed with the loss of pin-prick sensation and motor block level with the modified Bromage scale. Pain while performing CSE was recorded on the visual analogue scale (VAS). Patients in both groups were observed for procedure related complications for 24 hours. We planned that if CSE could not be accomplished in three attempts, an alternative technique would be used.

The sample size was determined based on the ability to perform successful paramedian CSE in the first attempt. Based on a previous study in which 70 elderly patients were randomly assigned to receive either the conventional surface-landmark guided paramedian (n=35) or pre-procedural ultrasound-guided paramedian (n=35) spinal anaesthesia for total knee or hip arthroplasty,[9] it was calculated that 45 patients in each group would provide 80% power to the study with an alpha error of 0.05. We assumed that a 20% baseline ratio of first pass needle success rate for CSE between the two groups would provide a clinically meaningful effect. Considering a dropout rate of approximately 5%, 50 patients in each group were enroled.

Statistical analysis was performed using International Business Machines Statistical Package for the Social Sciences (IBM SPSS) version 21. Continuous variables were presented as mean ± standard

deviation (SD). Categorical variables were expressed as frequencies and percentages. Normally distributed continuous variables were compared using Student's t test. Nominal categorical data were compared using Fisher's exact test. Non-nominal distribution continuous variables were compared using Mann Whitney U test. $P < 0.05$ was considered statistically significant.

RESULTS

Subsequent to screening, 100 patients who qualified the inclusion criteria, were enroled and randomised into two groups (n=50). Patient allocation is depicted in the Consolidated Standards of Reporting Trials (CONSORT) flow diagram [Figure 2]. The distribution of demographic data like age, gender, body weight, height, body mass index (BMI) was similar between the two groups [Table 1]. The first pass needle success to establish CSE was found to be greater in the USG group as compared to the SLG group. Out of 50 patients in the USG group, 43 patients (86%) had successful CSE in single needle puncture in comparison to 30 patients (60%) in the SLG group, the difference was statistically significant ($P = 0.001$). Number of attempts taken to establish successful CSE was lower in the USG group as compared to the SLG group with $P = 0.023$. t1 was more in the USG group with a mean and SD of (1.45 ± 0.47) minutes, while in the SLG group it was (0.79 ± 0.34) minutes with P value = 0.003. In USG group, t2 was lower (1.47 ± 0.55 minutes) than in SLG group (2.73 ± 1.36 minutes) with P value = 0.005. Total time (t1 + t2) taken for CSE was lower in USG group (2.90 ± 0.83) minutes as compared to SLG group (3.52 ± 1.35) minutes with $P = 0.007$ [Table 2]. There was no occurrence of bloody tap, radicular pain and dural puncture in both the groups. Procedure-related pain and discomfort associated with an increased number of attempts and needle redirections as rated by patients on the VAS scale (range 0-10) was more in the SLG group as compared to the USG group.

Table 1: Comparison of demographic profile data

Parameters	USG Group Mean±SD++	SLG Group Mean±SD	*P*
Body Weight (kg)	73.56±12.63	71.90±9.64	0.462
Height (cm)	158.06±9.20	155.16±6.86	0.078
*BMI (kg/m^2)	29.34±4.63	27.74±3.82	0.061
Age (Years)	54.45±12.75	57.72±13.16	0.023
+ASA (I/II) *n* (%)	40/10 (%)	38/12 (%)	0.120

Data are presented as mean±SD, or n (%). *BMI: Body Mass Index, +ASA: American Society of Anesthesiologists, ++SD: Standard Deviation

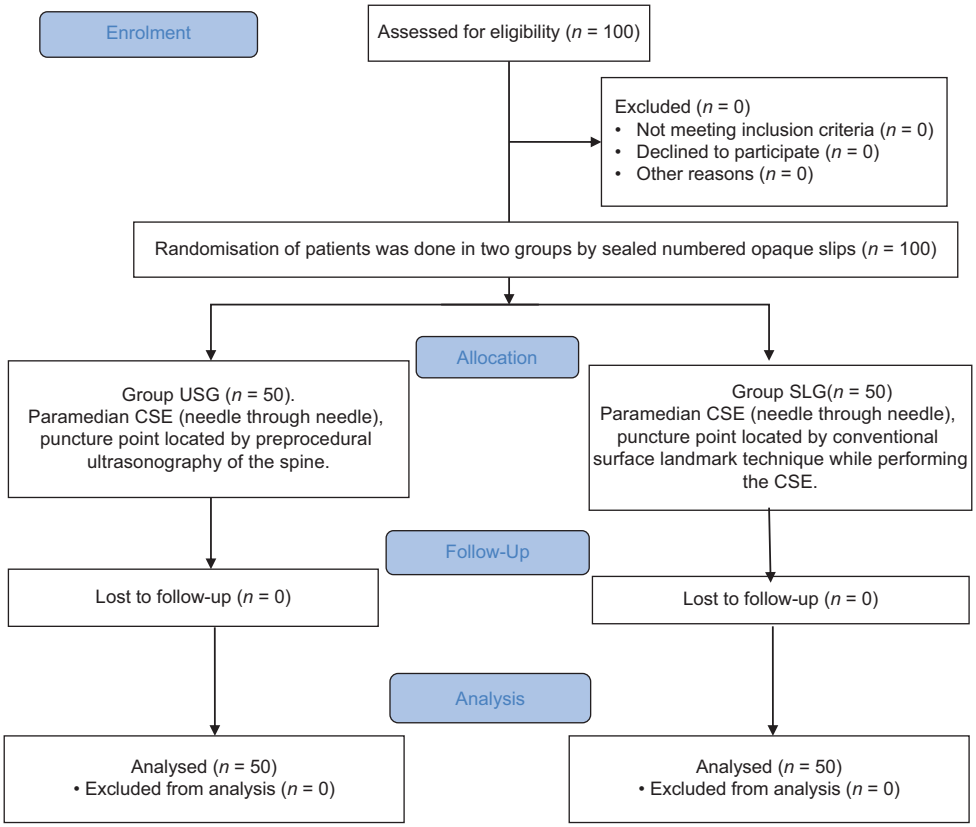

Figure 2: Consolidated standards of reporting trials (CONSORT) flow chart. USG:Ultrasonography; CSE:Combined spinal-epidural

Table 2: Comparison of number of attempts and time taken to establish CSE expressed in frequency (%)

Parameters	*USG GROUP Frequency *n* (%)	+SLG GROUP Frequency *n* (%)	*P*
1st	43 (86.0%)	30 (60.0%)	0.001
2nd	7 (14.0%)	12 (24.0%)	0.023
3rd	0 (0.0%)	8 (16.0%)	0.012
†t1 (minutes)	1.45±0.47	0.79±0.34	0.003
¥t2 (minutes)	1.47±0.55	2.73±1.36	0.005
**T (t1+t2) (minutes)	2.90±0.83	3.52±1.35	0.007

Data presented as mean±SD, *n* (%). *USG: Ultrasound Group, +SLG: Surface Landmark Group, †t1 (minutes):time taken to establish the landmark for needle puncture, ¥t2: Time taken to accomplish CSE, from local skin filtration to epidural catheter placement, **T: Total time for performing CSE, SD: Standard deviation, CSE:Combined spinal-epidural

DISCUSSION

In patients undergoing lower limb orthopaedic surgeries, a preprocedural ultrasound scan to determine the needle puncture point increased the first pass success rate and decreased the number of attempts and needle redirections to establish the CSE by paramedian approach.

USG has become the modality of choice because it precisely identifies the spinal canal anatomy and predicts the difficulty associated with the CNB.[10] Some authors have reported a higher first pass success rate in the USG group (65%) compared to the SLG group (17.5%) for patients undergoing orthopaedic surgery requiring spinal anaesthesia via the paramedian approach.[11] Grau *et al*.[3,12] reported an increased first pass success rate while performing epidural anaesthesia in difficult surface anatomy in two separate studies, including one with real time USG. In a case report of osteogenesis imperfecta for fracture femur, it was found that USG increased the success of subarachnoid block and significantly decreased the number of attempts and needle redirections when compared to the surface landmark group. Our findings are similar to those of other authors; however, their studies were conducted for spinal blocks using a midline approach and either real-time or preprocedural scanning.[13-17]

In a study of 80 elderly orthopaedic patients with hip fractures requiring paramedian CSE, the authors observed that the first pass success rate in the USG group was 70%, compared to 86% in our study. The most likely reason is that they enroled patients of higher mean age group (82.86 ± 8.8 years) compared to lower mean age group (54.45 ± 12.75 years) in the present study, which may have resulted in age-related degenerative changes and calcification of ligaments, making needle advancement more difficult. The authors also included scoliosis patients whose spine anatomy was affected. The time it took to determine the needle puncture point, the medial angle measurement, the total procedure time, and complications were all comparable to our study.[8] No patient in either group required a different anaesthesia technique.

A study found that when compared to conventional landmark midline technique performed by junior residents, preprocedural ultrasound did not improve the ease of spinal anaesthesia by midline or paramedian approach in the elderly.[18] This is most likely because the procedure was performed by new trainees who may not be well versed in the use of ultrasound and may require more experience when using ultrasound for the neuraxial block. CSE through the paramedian route in the USG and SLG groups was performed in our study by an experienced anaesthesiologist who was well versed and experienced with ultrasound in neuraxial block.

USG of the spine has a steep learning curve and necessitates a sound understanding of anatomy and how different parts of the vertebrae produce acoustic shadows.[19] A spinal ultrasound is particularly difficult because the neuraxial structures are not only deep but also protected by bones and because of its high acoustic impedance, bone obstructs the passage of ultrasound waves making identification of epidural/spinal space difficult.[20] Changes in patient position between preprocedural image acquisition and procedure can impact the accuracy of the neuraxial block.[21]

Time taken (t) from marking the puncture point to the completion of CSE was longer in the USG group, but the time taken (t2) to complete CSE was shorter in the USG group in current study. The time required for preprocedural scanning was longer in the USG group, but as it was done outside the OR, the effective OR time for performing CSE was shorter. Other authors found that the time required to establish the landmark for needle puncture was longer in the ultrasound group, but the time required for spinal anaesthesia was shorter in the ultrasound group when compared to the surface landmark group, however they did not comment on the total time taken for the procedure.[10,22]

Our study had some limitations in that we did not include obese patients, pregnant women, or geriatric patients, thus making it difficult to comment on the

first pass success rate of needle insertion in these group of patients. Also, in our study, blinding was not possible.

CONCLUSION

In conclusion, using a preprocedural ultrasound scan as a guide for needle trajectory while performing CSE via paramedian approach increases the first pass success rate and decreases the number of multiple needle puncture attempts when compared to the surface landmark technique in patients undergoing lower limb orthopaedic surgeries.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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