

Comparative evaluation of three techniques for paramedian subarachnoid block: Point-of-care preprocedural ultrasound assisted, real-time ultrasound guided and landmark based

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ABSTRACT

Background and Aims: Preprocedural ultrasound (US) assisted and real-time US-guided subarachnoid block (SAB) are useful adjuncts for successful SAB. This study compared the feasibility and efficacy of real-time US-guided SAB with preprocedural US-assisted and landmark-based SAB using paramedian approach. **Methods:** The study enrolled 150 American Society of Anesthesiologists I and II patients, aged 20–65 years, scheduled for lower limb orthopaedic surgery under SAB. In group L (n = 50), the patients underwent landmark-guided SAB utilising paramedian approach. In group P (n = 50), preprocedural US-assisted SAB was instituted and in group M (n = 50) real-time US-guided SAB was administered. The number of needle attempts for a successful SAB was the primary outcome. The secondary outcomes included successful SAB in first attempt, time taken to perform SAB and patients' satisfaction. **Results:** The number of attempts for SAB were (mean ± standard deviation = 1.05 ± 0.35, 1.00 ± 0.28, 1.03 ± 0.26) in groups L, P and M, respectively (P = 0.436). The SAB was successful in the first attempt in 82%, 82% and 80% in groups L, P and M, respectively (P = 0.207). The time taken for the successful SAB was more in group M as compared to groups L and P (groups L and M, P = 0.045 and groups P and M, P = 0.004). The patients' satisfaction score was comparable. **Conclusion:** Real-time US guidance for spinal anaesthesia resulted in needle attempts comparable to landmark and preprocedural US-assisted SAB in patients with a normal spine. The time required for the completion of the block was more in real-time US-guided SAB.

Key words: Anaesthesia, analgesia, point-of-care, spinal, ultrasonography

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INTRODUCTION

The current literature encourages the use of point-of-care ultrasound (US) as adjunct to subarachnoid block (SAB) as it facilitates accurate needle placement, thereby reducing the number of needle redirections. Studies have shown that preprocedural US-assisted neuraxial blocks reduces the number of attempts required for successful block.^[1,2] Recently, real-time US-guided SAB has been used with encouraging results by virtue of its improving on the limitations of the preprocedural ultrasonography (USG).^[3] Furthermore, studies have shown that the real-time

US-guided technique reduces the chances of error during angulation of the spinal needle as compared to preprocedural US-assisted SAB.^[4,5] Real-time

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US guidance provides the advantage of taking into account the probable positional changes of the patients, while instituting the SAB. However, studies comparing real-time USG and preprocedural-assisted SAB are limited. Therefore, this prospective study was undertaken to observe the feasibility and efficacy of real-time US-guided SAB through paramedian approach and compare it with landmark based and preprocedural US-assisted SAB.

METHODS

After approval by the Institutional Ethics Committee [Reg No ECR/866/2019] and written informed consent, a prospective randomised study was carried out in 150 patients aged 20–65 years, American Society of Anesthesiologists (ASA) physical status I/II having body mass index (BMI) of 18.5–29.9 kgm⁻² and scheduled for orthopaedic surgeries under SAB from the period of January 2020 to January 2021 in a tertiary healthcare institute [Figure 1]. The study was done in accordance with the principles of the Declaration of Helsinki. The trial was registered with the Clinical Trials Registry-India (CTRI 2020/01/022924). Exclusion criteria were patient refusal for spinal anaesthesia, previous spinal surgery, infection at the puncture site and coagulopathies. Parturients and patients with BMI greater than 30 kgm⁻² were also excluded from the study. All patients were kept nil per oral for 6 h for solid foods and 2 h for clear liquids. The patients were explained the procedure in detail during the preoperative visit, one day prior to the surgery. A computer generated block randomisation schedule was used to allocate patients in a 1:1:1 ratio in three groups comprising landmark-based spinal anaesthesia (Group L), preprocedural US-assisted paramedian SAB (Group P) and real-time US-guided paramedian SAB (Group M). Group allocation and concealment was done by a closed envelope technique. The envelope was opened by the attending anaesthesiologist immediately before performing the procedure.

After shifting the patient to the operating theatre, intravenous access was initiated with an 18 gauge cannula and normal saline (0.9%) was started. After application of standard monitoring (non-invasive blood pressure, pulse oximetry and five-lead electrocardiogram), the patients were positioned sitting on the operating table. The patients were administered intravenous (IV) fentanyl 25–50 µg before the positioning, if required. 2% lidocaine (2–5 mL) was used for skin infiltration at the intended site of

needle puncture. Under all aseptic conditions, a 26 gauge Quincke spinal needle was used for instituting SAB and after ensuring free flow of cerebrospinal fluid, 15 mg of 0.5% hyperbaric bupivacaine was administered to all the patients. After completion of the spinal anaesthetic injection, the patients were placed in supine position.

In group L, the L3–L4 or L4–L5 interspace was identified by traditional landmark technique using paramedian approach and time taken for the identification of the interspace (time from starting of palpation to identify the landmark to completion of palpation) was noted by the assistant. SAB was performed by an anaesthesiologist having more than five years of experience.

In group P, the desired inter-vertebral level (L3-4 or L4-5) was first identified by manual palpation of surface landmarks, similar to the control group. A 2–5 MHz curvilinear probe was utilised for initial pre-procedural marking, covered with a sterile sleeve, and normal saline was used as at the skin interface. The paramedian sagittal oblique (PSO) view was used to identify specific lumbar interspaces, starting at the sacrum and moving cephalad to identify the successive laminae (L5, L4, L3). The L3-4 or L4-5 intervertebral levels were identified in this plane and marked on the skin. This mark was compared with the level identified by palpable anatomical surface landmarks. The sloping hyper-echoic laminae of the lumbar vertebrae forming saw tooth pattern were observed. In the interlaminar spaces, the posterior complex (PC) and anterior complex (AC) were visible as two hyperechoic lines separated by uniform hypoechoic subarachnoid space [Figure 2]. The distance from skin to PC, AC was measured and recorded. At this interspace, and with the probe positioned to obtain the clearest US image with the interspace in the middle of the screen, the midpoint of the long and short borders of the probe was marked. At the same horizontal level as the midpoint of the long border of the probe, the midpoint of the line drawn between the two short borders was used as a paramedian insertion point for the spinal needle. A transverse median view at the same level was also obtained and the midline was marked. This marking was used to aid the medial angulation of the spinal needle. Following skin marking, under all aseptic conditions, the SAB was performed with the assistance of preprocedural US-guided markings by an anaesthesiologist having experience of US assisted SAB in more than 50 patients.

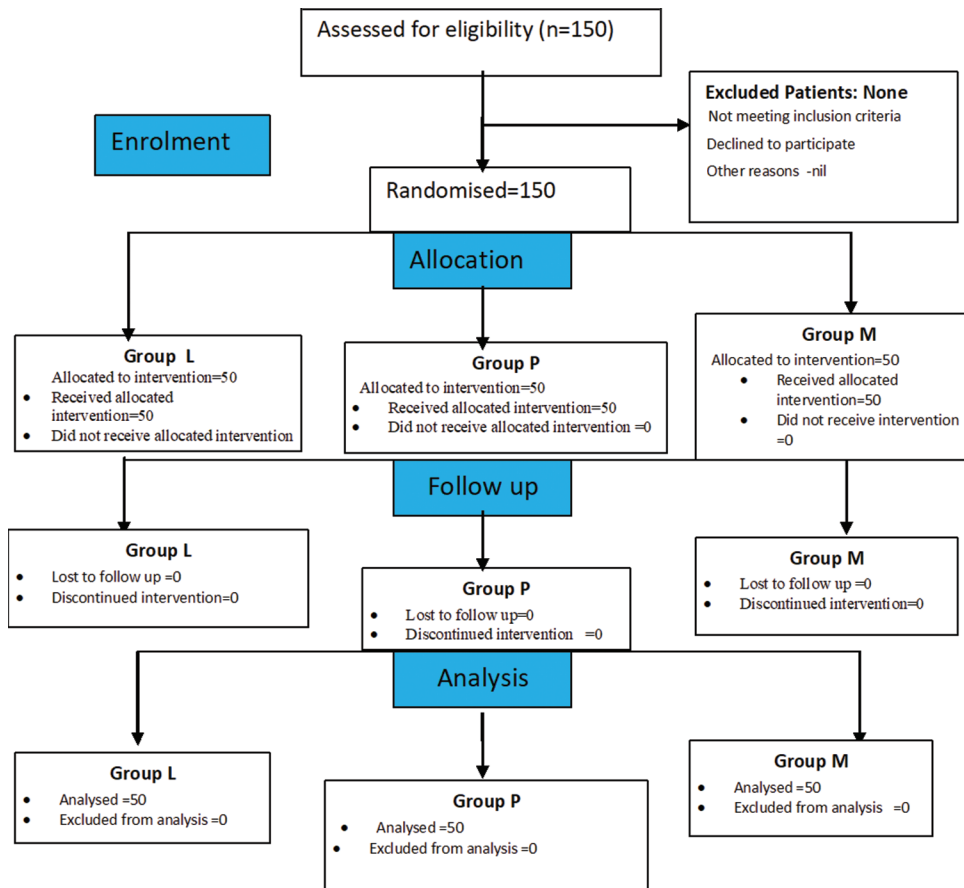


Figure 1: Consolidated standards of reporting trials (CONSORT) flow chart

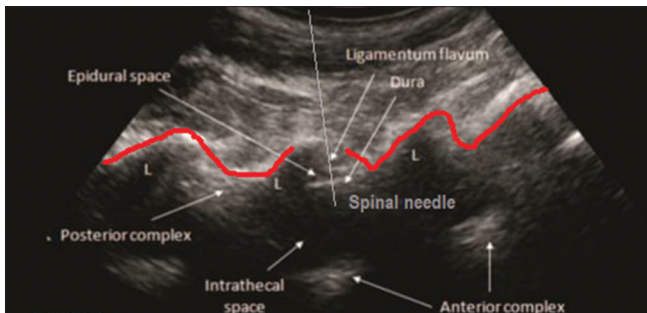


Figure 2: Paramedian sagittal oblique view of lumbar spine depicting saw tooth appearance, anterior complex, posterior complex and intrathecal space

In group M, the desired inter-vertebral level (L3-4 or L4-5) was first identified by manual palpation of surface landmarks, similar to the control group, and marked on the skin. The PSO view was used to identify specific lumbar interspaces starting at the sacrum and moving cephalad to identify the successive laminae (L5, L4, L3). The L3-4 or L4-5 intervertebral level was identified in this plane and marked on the skin. The desired interspinous space was approached through PSO. The skin to intrathecal distance was measured after a clear view of AC and PC. Spinal

needle was inserted utilising an in-plane technique. The needle tip was advanced under real-time US guidance until the intrathecal space was entered. The blocks were performed by an anaesthesiologist having experience with real-time US-guided SAB in more than 50 patients.

A subsequent needle attempt was defined as needle insertion proceeded by complete withdrawal of the spinal needle from the patient’s skin including change of spinous interspace. A needle redirection was defined as any change in needle insertion trajectory not involving complete withdrawal of the needle from the patient’s skin. The total number of insertion attempts and needle redirections were considered as needle passes.

In group L, the time taken to establish the landmark was defined as time required for the anaesthesiologist to palpate and mark the appropriate spinal interspace. In groups P and M, this was defined as the period beginning when the probe was first placed on the patient’s back till the time the landmarks were marked. The time taken to perform the SAB was defined as the

period between the first insertion of the spinal needle and withdrawal of the spinal needle after injection of the anaesthetic solution into the intrathecal space. The patients were asked to rate their satisfaction with the procedure immediately after completion of successful block and positioning. The score was assessed on 5-point scale (5 - very good, 4 - good, 3 - satisfactory, 2 - unpleasant and 1 - very unpleasant).

The number of needle attempts for a successful SAB was the primary outcome. The secondary outcomes included successful puncture in first attempt, time taken to perform spinal anaesthesia and patient's satisfaction.

The data was entered into Microsoft Excel and the statistical analysis was performed by statistical software Epi-Info version 7.1. The quantitative variables were expressed as mean \pm standard deviation (SD) and the qualitative (categorical variables) as frequency and percentage. One-way analysis of variance test was used for comparing the mean values (continuous data) between the three groups, whereas Chi-square test was applied for comparing the categorical data (frequency). The *P* value was considered to be significant when less than 0.05.

The sample size was calculated using OpenEpi, version 3. We hypothesised that the real-time US-guided SAB would result in 20% lesser number of attempts for successful SAB as compared to landmark-based SAB.^[4] At 0.05 significance and 80% power, the required sample size was 49 per group. Thereby, we recruited 50 patients per group.

RESULTS

The 150 patients in the three groups were comparable with regard to age, gender, BMI and ASA physical status [Table 1]. The number of needle attempts for the successful SAB were (mean \pm SD = 1.05 \pm 0.35, 1.00 \pm 0.28 and 1.03 \pm 0.26) in groups L, P and M respectively (*P* value = 0.436) [Figure 3]. In group L, the success rate of puncture in the first attempt was 41 (82%), while in groups P and M, the rate was 41 (82%) and 40 (80%) respectively (*P* value = 0.207). With regards to the needle redirections, nine patients required single needle redirection in group L, seven patients in group P and two patients required redirections twice in group P. In group M, single needle redirection was needed in eight patients, whereas two patients required needle redirections twice (*P* value = 0.531) [Figure 4].

Table 1: Demographic profile of the patients in the three groups

Parameters	Group L (n=50)	Group P (n=50)	Group M (n=50)
Age(years)* (mean \pm SD)	39.66 \pm 13.27	42.88 \pm 12.72	43.6 \pm 15.24
BMI (kg/m ²)* (mean \pm SD)	22.77 \pm 2.78	22.42 \pm 3.43	23.85 \pm 3.03
(Male/female) [†] (n)	38/12	35/15	36/14
ASA Status I/II [†] (n)	28/22	29/21	27/23

Data expressed as *mean \pm Standard deviation and [†]number as appropriate. BMI: Body Mass Index, ASA: American Society of Anesthesiologists

The time taken for landmark identification in group L, P and M was 33.1 \pm 8.44, 35.68 \pm 7.42 and 36.14 \pm 3.02 seconds, respectively (*P* value = 0.467), whereas time taken for spinal injection was 56.68 \pm 9.16, 53.16 \pm 5.73 and 70.34 \pm 2.61 seconds, respectively (*P* value = 0.001). On post-hoc analysis, the time taken till the spinal injection was significantly more in group M as compared to groups L and P (*P* value: groups L & M = 0.045 and groups P and M = 0.004), respectively [Figure 5].

With regards to patient satisfaction, in group L, 44 patients had satisfaction score of 5, while in groups P and M a satisfaction score of 5 was observed in 47 and 43 patients, respectively (*P* value = 0.062). Apart from two patients in group L and one patient each in group P and M having paraesthesia (*P* = 0.532), no other adverse effect was observed.

DISCUSSION

This study enrolled patients with a normal spine, in contrast to other studies having patients with abnormal spines, BMI >30 kg.m⁻² or parturients. The results of the study showed a non-significant trend towards lesser number of needle attempts in the preprocedural US-assisted group compared to the landmark group and real-time USG group. However, the time taken for the completion of the successful SAB was significantly more in the real-time US-guided group as compared to the preprocedural and landmark groups.

In our study, the mean number of needle attempts in the landmark and preprocedural US-assisted groups were (1.05 \pm 0.35 and 1.00 \pm 0.28), respectively, and 1.03 \pm 0.26 in real-time US-guided group. The successful first attempts were comparable: in landmark group 82%, preprocedural US-assisted group 82% and real-time US-guided group 80%.

In another study, it was observed that the number of attempts were more in landmark group (1.90 \pm 0.02)

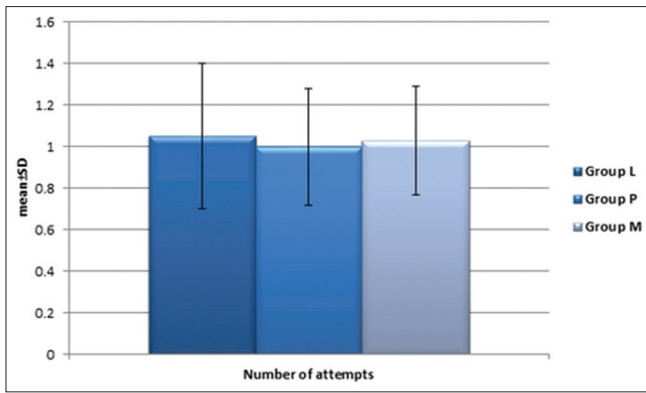


Figure 3: The comparative evaluation of number of needle attempts for successful subarachnoid block in the three groups. SD = Standard deviation

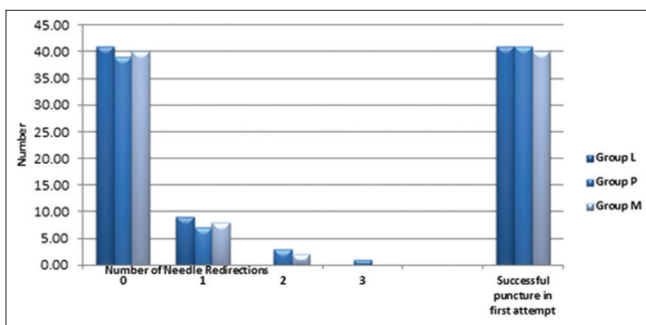


Figure 4: The number of needle redirections and first attempt success rate for subarachnoid block in the three groups

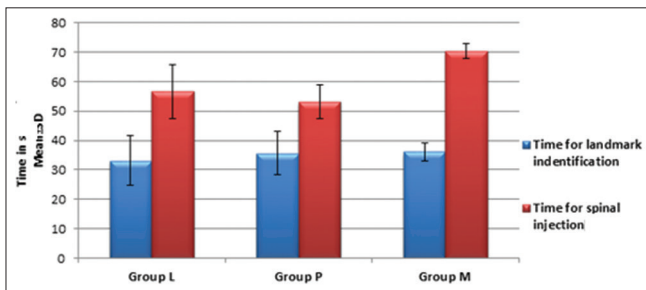


Figure 5: Time taken for landmark identification and for successful subarachnoid block in the three groups. SD = Standard deviation

as compared to preprocedural US group (1.07 ± 0.03 , $P = 0.035$) in patients belonging to geriatric age-group.^[6] However, more attempts were required for successful SAB in both groups as compared to our study, maybe because the study included patients with a difficult anatomy of the spine. Similarly, in a study on patients with an anticipated difficult spine, the number of attempts for successful SAB were more in the landmark group median (IQR) 6 (2–9.3) as compared to the preprocedural USG group 1.5 (1–3).^[7] The first successful attempt was 50% patients in USG group as compared to 9.1% in landmark group (P value = 0.001). The less success in

the first pass was again attributed to the anticipated difficult spine.^[7]

In a recent study, the first attempt success rate was 42.5% and 85% in landmark and US-guided preprocedural groups, respectively.^[8] Nevertheless, in both the above-mentioned studies, patients with a difficult spinal anatomy were enrolled, thereby the preprocedural US-assisted SAB resulted in better first attempt success rate as compared to our study.^[7,8]

With regards to real-time US-guided SAB, the median number of attempts were (IQR) 1 (IQR 1-2) in the study done by Conroy *et al.*,^[9] whereas Elsharkawy *et al.*^[5] observed that the mean number of attempts were 1.4 ± 0.6 in the real-time US-guided SAB group as compared to 1.6 ± 1.1 attempts in landmark group. Although the results of both studies correlate well, the attempt rate was more in the study by Elsharkawy *et al.*, the reason probably being that the patients with anticipated difficult spinal anatomy were included in this study. However, in another study comparing real-time US-guided SAB (group RUS) versus preprocedural US-guided SAB (group PUS) in obese patients, the authors observed that the median number of attempts were 4 (IQR 2-4) and 2 (IQR 1-2), respectively, in the PUS and RUS groups (P -value = 0.001). As the obese patients having BMI more than 30 kgm^{-2} were included in the study, the real-time US guided SAB resulted in lesser attempts as compared to preprocedural US-guided SAB.^[3]

In the present study, the time for spinal injection was more in real-time US-guided group as compared to the preprocedural and landmark groups. In a study conducted in parturients scheduled for caesarean section, the authors observed that the time taken for successful SAB was more in landmark group (51.80 ± 12.28 seconds) versus preprocedural US-assisted group (31.90 ± 6.30 seconds).^[10]

However, in the study by Srinivasan KK, *et al.*^[11] the time taken was less in landmark group (127.4 seconds) as compared to preprocedural US group (137.2 seconds). The authors used midline approach for the landmark technique and paramedian for the US assisted SAB at the level of L5-S1. This might have contributed to the contradictory results in this study as compared to other studies. In the study by Ravi *et al.*,^[3] the time taken for successful SAB with preprocedural US-guided spinal block was more 288.31 (IQR 251.74-320.19 seconds)

as compared to real-time US-guided 264.32 (IQR 251.46-348.31 seconds) in obese patients.

The patient satisfaction scores in the three groups were comparable in our study. However, in a study comparing landmark versus US-assisted paramedian techniques in combined spinal-epidural anaesthesia in elderly patients with hip fractures, it was observed that 90% of the patients in the US group had satisfaction scores of 4 to 5 as compared to 65% in the landmark group.^[8] The patients in the study belonged to elderly age groups, contributing to the higher patient satisfaction rate with US-assisted SAB when compared to landmark-based technique as SAB has been shown to be more difficult in elderly patients.

The limitations of our study are the exclusion of patients with anticipated difficult spinal, parturients, geriatric patients and patients having a BMI of more than 30 kg.m⁻². Further, randomised controlled studies are required to observe the efficacy of real-time US-guided SAB in terms of experience of the operator and number of attempts, time required for the block as compared to landmark based and preprocedural US-assisted SAB in patients with normal spine anatomy.

CONCLUSION

To conclude, real-time US-guided SAB provides visualisation of the needle trajectory in real time; however, the advantages in terms of needle attempts for successful SAB and time for the performance of the block are comparable to the preprocedural US-assisted SAB in patients with a normal spine.

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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