INTRODUCTION

Spinal anaesthesia is widely performed using a surface landmark-based “blind” technique. The incidences of post-dural puncture headache, paresthesia, and spinal haematoma are directly associated with multiple passes and attempts while administering spinal anaesthesia.[1]

A pre-procedural neuraxial ultrasound technique has been used successfully to perform spinal anaesthesia. Information on the use of real-time ultrasound (RUS) guided spinal anaesthesia has, to date, been limited to case series and case reports and few prospective observational studies.[2,3] The RUS permits more accurate estimation of the appropriate needle insertion site and trajectory. There has been no study done to compare the efficacy of RUS-guided spinal anaesthesia, and pre-procedural ultrasound (PUS) guided spinal anaesthesia. Hence, this study was aimed at evaluating the efficacy of these two modalities of spinal anaesthesia, i.e., PUS and RUS approach, in an obese patient undergoing lower abdominal, perineal and lower limb surgeries by comparing the number of attempts, number of passes, and time taken for successful lumbar puncture. The secondary variables
were median time for identifying space, median time to achieve successful analgesia, and time taken for a successful lumbar puncture.

**METHODS**

Following the Institutional Ethical Committee’s approval, informed written consent was obtained from the participating patients. As with other uses of ultrasound, specific training is required to correctly identify the landmarks and interspaces necessary for neuraxial blockade. Therefore, 25 scout scans were performed on healthy individuals before performing scans on the patients in the study group. All the procedures were done by anaesthesiologists with adequate training in ultrasound. Eighty patients aged between 20 and 85 years, American Society of Anesthesiologists (ASA) grade II or III obese with body mass index (BMI) >30 kg/m² scheduled for the elective lower abdominal, perineal and lower limb surgeries under spinal anaesthesia, were included in the study. The exclusion criteria included contraindications to neuraxial blocks, pregnant patients and the patient refusal for spinal anaesthesia. Patients were monitored with oxygen saturation, blood pressure (systolic, diastolic, mean arterial pressure) and electrocardiogram. Basal values were recorded. Intravenous line was secured. The patient was positioned sitting on a level table with feet resting on a footrest with an assistant holding the patient to aid positioning. The skin was cleaned with betadine 5% with prior enquiries about allergic history.

Under strict asepsis, local infiltration of 2% lignocaine was done. The dural puncture was carried out at L3-L4/L4-L5 level. About 2.5-3.5 mL of hyperbaric bupivacaine 0.5% was injected intrathecally using 25G Quincke’s needle in both the groups.

The study was a randomised single-blinded controlled study. Group 1 (RUS group) participants received real-time USG guided paramedian spinal anaesthesia and Group 2 (PUS group) received pre-procedural paramedian spinal anaesthesia. The data collection for the study was done during the period from September 2018 to October 2019.

A Mindray USG machine (Model-UMT 150) of Shenzhen Mindray Bio-medical Electronics Co. of China was used with the 2.5 MHz curvilinear probe and sterility maintained with the application of a transparent sheet. In the PUS group, ultrasound (US) was used to identify the L3-L4, L4-L5 interspinous space with the best image of the anterior complex (ligamentum flavum dura complex- LFD) and the posterior complex (posterior longitudinal ligament- PLL) being in the parasagittal oblique (PSO) view. At these selected interspaces, the probe was positioned to obtain a clear ultrasound image, after which, a skin marker was used to mark the mid-point along the long border of the probe, and the mid-points along the short borders of the probe [Figure 1]. At the same horizontal level as the mid-point of the long border of the probe, the mid-point of the line drawn between the two short border mid-points of the probe was used as a paramedian insertion point for the insertion of the spinal needle. Spinal anaesthesia was then administered based on these landmarks [Figure 1a and b].

In the RUS group, the L3- L4, L4-L5 interspinous space was identified by using the real time images in PSO view, and the needle was visualised breaching into the spinal space [Figure 2]. The sacrum was the first structure to be identified, after which the probe was advanced cephalad with an angle of 20° tilted towards the midline. Then, the lumbar lamina was identified along with a target space between L3-L4 and L5-S1. The probe was then further rotated 25° towards the midline to achieve a classical oblique parasagittal approach. The biggest advantage of this view is that not only is one able to visualise the lamina, inter-vertebral space and the posterior longitudinal ligament complex, but the ergonomic advantage of handling the needle and the probe together is also provided. The needle was gradually advanced into the interlaminar space, until the tip breached the ligamentum flavum/dura complex. Frequently at this point, the classical giveaway feeling was also observed [Figure 1 and 1a].

The patient’s vital parameters were monitored throughout the procedure. Patients were assessed for the feeling of nausea, dizziness, and pruritus and observed for vomiting. Hypotension and bradycardia were treated as per institutional protocol.

The primary variables which were compared between the two groups included the number of attempts (defined as the number of times the spinal needle was withdrawn from the skin and reinserted), number of passes (defined as the number of forwarding advancements of the spinal needle...
in a given interspinous space), and the time taken for successful lumbar puncture. The secondary variables were median time for identifying space, median time to achieve successful analgesia and time taken for a successful lumbar puncture. In the RUS group, it was defined as the time from which the ultrasound probe was placed on the skin until the anaesthesiologist declared that the dura had been breached with the evidence of spinal fluid at the hub of the spinal needle. In the PUS group, it was defined as the time from which the ultrasound probe was placed on the skin to the anaesthesiologist declaring that the dura had been breached with evidence of spinal fluid in the hub of the needle. The time taken for performing successful spinal anaesthesia was defined as the time from which the probe was placed on the skin until a loss of sensation and motor blockade was achieved with a Bromage score of 3. A failure to do lumbar puncture was considered when no fluid was noted or the needle was not visualised through US.

This study evaluated the variables, and/or their mean of values, and determined whether they are statistically significant in order to “predict” the efficacy of two modalities of spinal anaesthesia in obese patients. A null hypothesis of no change in both the modalities of spinal anaesthesia was assumed. Based on the pilot study, a difference of 20% in the primary outcome of the two groups was hypothesised. Using this, a power calculation was done which showed a sample size of 40 in each group with an alpha of 0.05, beta of 0.3, a power of 0.8 and a confidence level of 95% giving a study population of 100. Randomisation was done using computer-generated random number sequence. The study participants were blinded. The number of attempts, number of passes, time taken for identifying landmark(s), and time taken for a successful lumbar puncture (sec) were considered as the outcome variable. The Mann Whitney U test and the Chi-square test were used to evaluate statistical significance. \( P \) value < 0.05 was considered statistically significant. International Business Machine Statistical Package for the Social Sciences (IBM SPSS version 22 [Chicago IL, USA]) was used for statistical analysis.

**RESULTS**

A total of 80 subjects were included in the final analysis [Figure 3]. Both the groups were comparable for gender, age, and BMI [Table 1]. Among the patients in the PUS group, the median number of attempts was 4 (IQR 2-5), and it was 2 (IQR 1-2) in the RUS group, this was statistically significant (\( P \)-value <0.001). The median number of passes in the PUS group was 8.50 (IQR 4-10), and it was 4 (IQR 3-4) in patients with RUS spinal anaesthesia, which was statistically
significant (P-value < 0.001). The median time for identifying space, the median time to achieve successful analgesia and the time taken for a successful lumbar puncture(s), was statistically significantly less in the RUS group in comparison to the PUS group. A successful needle puncture was achieved during the first needle insertion in twice the number of patients in RUS group (60%), in comparison to the PUS group (27.5%).

**DISCUSSION**

The identification of the subarachnoid space has traditionally been achieved by an anatomical landmark-guided approach. Surface anatomical landmarks are useful, however, they may be difficult to palpate in obese patients, as well as those with oedema. They also do not take into account all the anatomical variations or abnormalities, and frequently lead to incorrect identification of a given lumbar interspace.\(^5\) Multiple attempts at needle placement may cause patient discomfort/anxiety, higher incidence of spinal haematoma, post-dural puncture headache, and trauma to neural structures.\(^5\) Neuraxial ultrasound is a relatively recent development in the field of regional anaesthesia. A “pre-procedural” ultrasound examination of the spine accurately delineates the underlying relevant anatomy, thus, aiding in successful insertion of a spinal needle. Real-time US image accusation of the spinal needle appears to be a better alternative as it excludes all the blind spots which occur during the needle insertion in “pre-procedural US-assisted blocks”.

Our study demonstrated that the time taken to identify the spinal space was significantly lesser in the RUS (38.19 s) group, in comparison to the pre-procedural group (78.35 s). Chong et al.\(^3\) and Conroy and colleagues\(^2\) reported that the time taken for a successful identification of spinal space was 69 and 90 s, respectively, with real-time US-guided procedure. This difference in time may be due to the fact that the procedure in our study was performed only by consultants, who were specifically trained in the US of spinal spaces. The level of training in the other studies was not mentioned. However, these two studies compared the RUS technique with the

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**Table 1: Comparison of various parameters in PUS and RUS group**

| Parameter | PUS group | RUS group |
|-----------|-----------|-----------|
| Age (years) Median (IQR) | 9.50 (52.25,65.75) | 58.50 (50.25,65.75) |
| Male | 15 (37.5%) | 12 (30%) |
| Female | 25 (62.5%) | 28 (70%) |
| BMI | 34.9 (33.1, 36.40) | 34.9 (33.1,36.35) |
| Number of attempts | 4 (2.5) | 2 (1.2) |
| Number of passes | 8.50 (4.10) | 4 (3.4) |
| Time taken to identify space (s) | 78.35 (60.20,90.67) | 38.19 (25.05, 57.95) |
| Time taken for successful lumbar puncture (s) | 288.31 (251.74,320.19) | 264.32 (251.46,348.31) |
| Success rate | 35 (98%) | 37 (92.5%) |
| Converted to GA | 2 (5%) | 3 (7.5%) |

PUS: Pre-procedural ultrasound-guided spinal; RUS: Real-time ultrasound-guided spinal; SD: Standard deviation; IQR: Inter-quartile range; BMI: Body mass index; GA: general anaesthesia

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**Figure 3:** Box plots of comparison of median value in age between study group (N = 80). PUS: Pre-Procedural Ultrasound-Guided Spinal; RUS: Real-Time Ultrasound-Guided Spinal
traditional landmark technique. This time it did not include the “scouting time”, which was approximately 120-240 s in these studies, which is similar to our studies. The decreased time in the RUS group may be due to the fact that the scanning and spinal needle insertion was done simultaneously, while it was done at two different times in the PUS group.

The number of successful dural punctures during the first needle insertion was almost double (60%) in the RUS group in comparison to the PUS group (27.5%). This was also statistically significant. In the real-time group, the success rate was similar to that of other studies on real-time imaging.[3,6] However, no study has compared the RUS with the PUS. Chong et al.[3] reported the first successful attempts at a rate of almost 87% higher than our study. Conray et al.[3] have reported it at 47%. This was comparable with the studies of Brinkmann and colleagues[6] at 39%. The significant difference between our study and other studies was that all the other studies were done on patients with varying weight, whereas our study only included patients who had BMI above 30. The rate of successful dural puncture during the first needle insertion among the pre-procedural group was similar as in other studies.[7-9] This is an important finding since multiple attempts at needle placement are directly related to incidences of spinal haematoma, post-dural puncture headaches, and trauma to neural structures. Further, the number of needle passes required were also statistically less in the RUS group in comparison to the PUS group. Multiple attempts would have significantly contributed to patient discomfort and the time taken to identify the dural space. The number of passes mentioned in the other studies varies due to many reasons. First, the patient population was different. Mean age and BMI in our study was 59 years and 34.9 kg/m², respectively, versus 63-68 years and 28.5-30.5 kg/m² in the referenced studies (Chin et al., Srinivasan et al., and Abdelhamid et al.) Second, in the study by Chong et al.,[3] the number of passes were self-reported, whereas in our study, it was recorded by an independent observer. This is important because it has been shown that the number of self-reported passes is always lower than the actual number of passes.[7] Third, the age of our population group was, on average, 59 years and spinal anaesthesia has been shown to be more difficult in older populations compared to the general adult population.[8] Fourth, we used a paramedian approach to the neuraxis. In the presence of interspinous ligament calcification, and an inability to achieve adequate flexion (both of which are common in the elderly), this paramedian approach might be valuable.[9] It has also been shown that both the length and width of the lumbar spinous process increases significantly with ageing, which further narrows the interspinous space available for a midline approach.[9,10] The interlaminar space is least affected by the changes attributable to ageing, and offers a potential window for spinal anaesthesia.[11]

The technical difficulty of the neuraxial blockade is measured using two main parameters: the number of needle manipulations required for success, and the time taken to perform the block. Of the two, the first is more important because multiple needle insertions are an independent predictor of complications, such as inadvertent dural puncture, vascular puncture and paraesthesia.[1] Elicitation of paraesthesia is a significant risk factor for persistent neurological deficit after spinal anaesthesia.[9]

The success rates for achieving spinal anaesthesia in both groups were similar (RUS 98%, PUS 92.5%). However, in 95% of the patients in the RUS group, successful dural puncture was achieved within seven needle passes, while this was achieved in only 60% of the patients in the PUS group. The success rates in the PUS group in our study are comparable to other studies.[4,6,9,12] Regarding the time taken for successful lumbar puncture between the groups, the real-time US-guided method took significantly (P-value = 0.048) less time (264.32 s), compared to the pre-procedural US method (288.31 s). We did not find any study comparing or mentioning this. The statistical difference may be due to the early injection of the drug in the RUS group, since the dural breach was achieved earlier in that group.

In the learning curve study that used CT scan as a reference standard; Rakhi Khemka et al.[10] and Halpern et al.[13] reported an overall identification accuracy rate for an ultrasound of about 68%. However, analysis of the learning curve showed that the two anaesthesiologists in the study with no previous experience with neuraxial US scanning, achieved accuracy rates of 90% or greater after 22 and 36 procedures, respectively. In conclusion, it is not technically difficult to learn to identify spinal spaces with real-time ultrasonography.

Our study had some limitations. Elderly patients have anatomical changes in the spine like facet hypertrophy and ligament calcification because of which obtaining
ultrasound views becomes difficult. Our study population did include some elderly patients. Also, if multiple anaesthesiologists are involved in the procedures, their individual preference and style of practice, the time and number of attempts taken before the use of alternative methods can bring heterogeneity to the procedure. This has also been observed in the studies by Kallidaikurichi Srinivasan K et al. and Creaney et al.\cite{14,12}

CONCLUSIONS

Real-time ultrasonography can be a useful adjunct to safe spinal anaesthesia. It facilitates the performance of spinal anaesthesia in the non-obstetric patient population with difficult anatomic landmarks, like obese patients. The RUS method of needle insertion needed a significantly lesser number of attempts, a lesser number of passes, less time taken for identifying the space and less time taken for successful lumbar puncture as compared to the PUS method for successful spinal anaesthesia.

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Conflicts of interest

There are no conflicts of interest.

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