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A Comparative Study between Landmark Based and Real Time Ultrasound Guided Sub Arachnoid Block

Kunal Tewari[1], Om Bahadur Thapa[2], Deepak Mishra[1], Manjot Multani[2], Jyotsna Sharma[2], Akash Ray Mohapatra[2], Sandhya Khwaunju[1]

[1]Department of Anesthesiology and Critical Care, Armed Forces Medical College, Pune, India
[2]Department of Anesthesiology and Critical Care, AFMC, Pune, India
Email: doctorkunaltewari@gmail.com, obt181@hotmail.com, deepak4789mishra@gmail.com, drmanjotmultani1211@gmail.com, jyotsnasharma286@gmail.com, dr.akash8anaes@gmail.com, sndyakhwaunju03@gmail.com

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Abstract

Background: Sub arachnoid block (SAB) performed by traditional landmark palpation technique can be inaccurate. This problem is exacerbated by altered patient anatomy due to obesity and age-related changes. A pre-procedural ultrasound scan of the lumbar spine has been shown to be of benefit in guiding lumbar epidural insertion in obstetric patients. Information on the use of real-time ultrasound (RUS) guided SAB, to date, been limited. This study compared RUS guided SAB to traditional landmark guided technique in patients undergoing spinal anesthesia for different surgical procedures. **Methods**: This was a prospective, single center, comparative observational study conducted in the department of anesthesiology at our center. 560 patients who underwent spinal anesthesia either by landmark based technique or real-time ultrasound-guided methods. The primary outcome was the first attempt success rate of dural puncture when employing the two methods. **Results**: Baseline characteristics were similar in the two study groups. The first attempt success rate of dural puncture in landmark guided group was 64.3% compared to 72.6% in the ultrasound guided group. This difference was not statistically significant. The procedure performance time was significantly shorter with landmark palpation compared to use of real-time ultrasound guided method. **Conclusion**: Use of RUS-guided technique does not significantly improve the first attempt success rate of SAB dural puncture during spinal anesthesia compared to the traditional landmark-guided technique.

Keywords

Sub Arachnoid Block (SAB), Real Time Ultrasound (RUS)

1. Introduction

The practice of subarachnoid block (SAB) has traditionally relied on the palpation of bony anatomical landmarks; namely the iliac crests and spinous processes, together with tactile feedback during needle insertion. However, these landmarks may be difficult to identify accurately—a problem exacerbated by altered patient anatomy, including obesity, age-related changes, and previous spinal surgery. The inaccuracy of using Tuffier's line between the iliac crests to identify a safe lumbar interspace have been well documented [1] [2]. Reducing the technical difficulty of neuraxial blockade is desirable as multiple needle insertion attempts may increase the risk of complications such as post-dural puncture headache, paraesthesia, and epidural hematoma [3].

Medical ultrasound is based on the use of high-frequency sound to aid in the diagnosis and treatment of patients [4]. The ultrasound beam originates from mechanical oscillations of numerous crystals in a transducer, which is excited by electrical pulses (piezoelectric effect). The ultrasound waves (pulses of sound) are sent from the transducer, propagate through different tissues, and then return to the transducer as reflected echoes. The returned echoes are converted back into electrical impulses by the transducer crystals and are further processed to form the ultrasound image presented on the screen. Ultrasound waves are reflected at the surfaces between the tissues of different density, the reflection being proportional to the difference in impedance. Bone is not penetrated by ultrasound and casts a dense acoustic shadow. The contours of the posterior bony surfaces of the lumbar vertebra thus have characteristic patterns of acoustic shadowing that are key to interpretation of the sonoanatomy of the lumbar spine. Visualization of the vertebral canal is only possible through the soft-tissue acoustic windows of the interlaminar and interspinous spaces. The interlaminar parasagittal oblique (PSO) view is one of the most important views in clinical practice, since they provide a view of the neuraxial structures through acoustic windows.

A pre-procedural ultrasound scan of the lumbar spine has been shown to be of benefit in guiding lumbar epidural insertion in obstetric patients [5]. A study in patients with difficult surface anatomical landmarks showed that the success of spinal anaesthesia upon first attempt was twice as high after a pre-procedural ultrasound scan compared to manual palpation [6]. Information on the use of real-time ultrasound (RUS) guided spinal anaesthesia has been limited [7].

The aim of this study was to observe if the use of a real-time ultrasound (RUS) scan during SAB helped achieve a better first attempt success rate than traditional landmark technique and compare the two techniques in terms of the number of needle redirections, procedure performance times, success rates and incidence of complications. The primary outcome was the percentage of successful dural puncture with the first attempt. Secondary outcomes were the time taken to perform SAB, the number of redirections and immediate complications (bloody tap, paraesthesia) and success rate of SAB.

2. Methods

This was a prospective, single centre, comparative observational study conducted in the department of anaesthesiology at our centre; a tertiary care, referral and teaching hospital.

Study population included American Society of Anaesthesiologists (ASA) Physical Status Classification I and II adult patients (aged 18 to 60 years) who underwent surgeries under SAB. Patients unwilling to participate in study, with any contraindication to SAB (including allergy to local anaesthetic or a bleeding diathesis); were excluded from study.

The study was commenced after Institutional Ethical Committee Approval. Written Informed Consent was taken from all patients. Assuming the alpha error at 5% and the power of study at 80%, based on previous studies comparing the success rates of the two methods determined a minimum sample of 230 patients in each group [8] [9]. Patients who received SAB with the traditional landmark-based technique were labelled as group A; and those who underwent SAB guided by RUS, as group B. Baseline characteristics of the patients such as age, gender, body mass index (BMI), presence of spinal abnormalities (including scoliosis and previous spine operations with instrumentation), ease of palpation of anatomical landmarks were recorded. Standard monitoring and fluid management was done in both groups.

SAB was performed in sitting position. In Group A patients; after cleaning and draping the back, the landmark for lumbar puncture was determined using the line joining the superior aspect of the iliac crests posteriorly which corresponds to the L_4 vertebral body (Tuffier's line). The midline was established by palpation of the tips of the spinous processes. The spinal anaesthesia was performed with a 25-gauge, Quincke needle. Once dural puncture was achieved and confirmed by backflow of cerebrospinal fluid from the needle hub, a predetermined dose of 0.5% bupivacaine (heavy) with or without additives was administered. In group B patients; GE Vivid T8 machine and 5 - 9 MHz, curvilinear probe was used for RUS scan. Subsequent to cleaning and draping the back the probe, was covered by a sterile probe cover; and scan was performed by an anaesthesiologist trained in ultrasound guided procedures for more than 2 years. Using ultrasound scan, the L_3-L_4 and L_4-L_5 interspinous spaces were identified in PSO view, a 25 gauge Quincke needle was used for the lumbar puncture, and the needle was visualised in RUS scan. The needle was gradually advanced into the interlaminar space; until the tip breached the ligamentum flavum, and subsequently dura complex. After dural puncture was achieved and confirmed by backflow of cerebrospinal fluid from the needle hub, a predetermined dose of 0.5% bupivacaine (heavy) with or without additive was injected. The number of attempts required (each skin puncture considered a separate attempt), number of needle redirections (where needle is redirected without complete withdrawal from skin) and time taken to perform the dural puncture (time of needle insertion to obtaining cerebrospinal fluid) were recorded along with complications; if

any. Successful spinal anaesthesia was defined as sensory block level of above T_{10} within 30 minutes of administration of local anaesthetic.

The data was noted down in a pre-designed study proforma, collated in an excel data sheet and analysed using SPSS Ver. 26.0. Qualitative data was represented in the form of frequency and percentage. Association between qualitative variables was assessed by Chi-Square test and Fisher's exact test. Quantitative data was represented using mean ± SD and median with interquartile range (IQR). Analysis of quantitative data between the two groups was done using unpaired t-test for normally distributed data and by Mann-Whitney test if data failed "normality test". A p-value < 0.05 was taken as level of statistical significance.

3. Results

A total of 460 patients were analysed during the study; 230 in each group. There were 283 males (group A-132/group B-151) and 177 females (group A-98/group B-79). Mean age of the study population was 53.35 years (group A) and 52.15 years (group B). There was no statistically significant difference in age and gender amongst the two groups (p value: 0.069 and 0.186 respectively). Other characteristics of the study population were as shown in Table 1. There was no significant difference between the two groups for the first attempt success rate of dural puncture (p value: 0.057), needle redirections (p value: 0.544), and successful SAB (p value: 0.399). The time to dural puncture was less when using landmark technique compared to RUS guided technique and this difference was statistically different (p value: 0.001). No complications like paraesthesia, bloody tap was noted (Table 2). Number of patients in whom successful SAB was administered in first, second and third attempts are analysed in Figure 1.

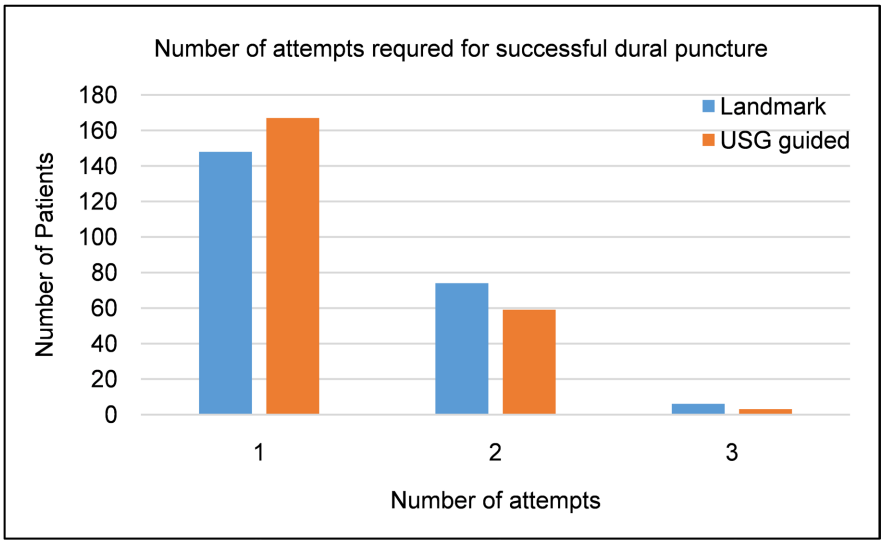

Figure 1. Number of patients in whom successful spinal anaesthesia was performed in first, second and third attempt.

Table 1. Patient demographics for the landmark group and USG guided group.

	Group A (landmark based)	Group B (USG guided)	P value
Age (years)	53.35 (10.43)	52.15 (11.15)	0.186
Gender			
• Male	132 (57.4)	151 (65.7)	0.069
• Female	98 (42.6)	79 (34.4)	
BMI (kg/m^2)	25.78 (4.61)	26.69 (4.67)	0.229
Surgical discipline			
• General Surgery	124 (53.9)	104 (45.2)	
• Obstetrics and Gynaecology	3 (1.3)	6 (2.6)	
• Surgical oncology	1 (0.4)	2 (0.9)	0.056
• Orthopaedics	79 (34.3)	101 (43.9)	
• Urological surgery	5 (2.2)	9 (3.9)	
• Vascular surgery	18 (7.8)	8 (3.5)	
ASA grade			
• 1	128 (55.7)	115 (50)	0.427
• 2	101 (43.9)	113 (49.1)	
• 3	1 (0.4)	2 (0.9)	
Ease of palpation of spine			
• Easy	103 (44.8)	95 (41.3)	0.5
• Moderate	117 (50.9)	120 (52.2)	
• Difficult	10 (4.3)	15 (6.5)	

Values are mean (standard deviation) in age, gender, and BMI and number (%) in the ASA grade and ease of palpation of spine. BMI = Body Mass Index, ASA = American Society of Anaesthesiologists physical status.

Table 2. Primary and secondary outcomes in landmark and USG guided groups.

Outcome	Group A (landmark based)	Group B (USG guided)	P value
First attempt success	148 (64.3)	167 (72.6)	0.057
Needle redirections	1 (0 - 2)	1 (0 - 2)	0.544
Time to dural puncture	25 (17 - 37)	32 (24.7 - 38.25)	0.001
Successful spinal anaesthesia	225 (97.8)	222 (96.5)	0.399

4. Discussion

In our study, the first attempt success rate of dural puncture in the patients undergoing SAB guided by RUS was found not to be significantly different than those undergoing the procedure by manual palpation of landmarks. However, the time to dural puncture after introduction of spinal needle was significantly longer in the RUS group compared to the landmark palpation group. This could be attributed to the ultrasound guided method not being a routinely followed practise for spinal anaesthesia and the skill level of the operator. The first attempt success rate of dural puncture in our study was 64.3% in the landmark guided group and 72.6% in the ultrasound guided group, lower than that achieved by Chin *et al.* [10]. The success rate of ultrasound-guided spinal anaesthesia was found to be 84% in a prospective, descriptive study conducted in patients undergoing elective joint arthroplasty. In contrast to our study, all procedures were performed by a single, experienced operator. The nature of surgeries that the patients were undergoing may also have contributed to the difference in the success rates. Our study included patients undergoing all types of surgeries amenable to spinal anaesthesia while the above mentioned studies included only patients undergoing elective joint arthroplasty or orthopaedic lower limb surgeries. Some investigators have reported that independent predictors of first-attempt success rate include adequacy of patient positioning, the quality of anatomical landmarks and the provider's level of experience. A prospective randomised study by Bhardwaj *et al.* also reported a higher first attempt success rates for spinal anaesthesia, 82% and 80% respectively for landmark based and RUS guided techniques with no significant difference between the two [11]. In contrast to our study, the age group of patients in this study was lesser compared to our study (mean age in years being 39.66 and 43.6 in landmark based and RUS groups respectively versus 53.3 and 52.15). Also the procedure was performed by a senior attending anaesthesiologist.

Further, in our study, there was no significant difference in the number of needle repositions between the two groups, the median number of repositions being 1 in both the groups. No needle repositioning was needed in around 40 percent of the cases in both the groups. This finding contrasted the findings of study by Chin et al, in which median number of needle repositioning were 6 and 13 in ultrasound guided and landmark based groups respectively [12]. However, it has to be noted that the study only included patients with anticipated difficult spine (BMI > 35 kg/m^2, poorly palpable interspinous spaces, clinically apparent scoliosis etc.). Our findings were similar to those reported by Bhardwaj *et al.* which also enrolled general population and only those with anticipated difficult spine [11].

The time taken for dural puncture was found to be more when using RUS guidance compared to landmark-based method (25 versus 32 seconds); and this difference was statistically significant. The findings were similar to those reported in their studies by Chin *et al.* and Elsharkawy *et al.* where the procedure

time was also longer in ultrasound group than landmark based group [10] [12]. The longer time required for performance of spinal anaesthesia using real time ultrasound guidance may be attributed to difficulty holding the ultrasound probe in position with one hand to achieve the precise acoustic window while advancing the spinal with the other hand.

There are some limitations to our study. Due to the design of the study, the patients to undergo procedure by landmark and ultrasound guided spinal anaesthesia were not randomised. Subgroup analysis was not performed according to BMI, difficulty of palpation of landmarks and other variables. The overall time taken to perform the procedure, which included significant preparation time in ultrasound guided procedure was not recorded. The procedure was performed by more than one operator with different level of experience and skill.

5. Conclusion

Our study did not show a statistically significant higher first attempt success rate of dural puncture by the use of a RUS guidance during SAB. The time taken to administer spinal anaesthesia was longer when ultrasound was used. Thus, real time ultrasound guided spinal anesthesia is not a substitute to the traditional landmark technique. Although, there is some data to justify pre-procedural scan of patient's spine before performing SAB, current evidence to support routine use of RUS guided SAB in general population is inadequate.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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