Role of pre-procedural ultrasound imaging of lumbar spine in predicting the ease of performance of spinal anaesthesia

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Abstract

Introduction: Spinal anaesthesia is the most commonly performed technique among the anaesthetic procedures and the role of pre-procedural ultrasound (USG) in predicting the ease or difficulty in performing a lumbar puncture (LP) is uncertain. This study tests the hypothesis, that a good USG image of the intervertebral space is associated with an easy path for the passage of the spinal needle.

Methods: Seventy patients, belonging to ASA I-III, scheduled to undergo elective surgeries under spinal anaesthetic technique at our institution were subjected to USG imaging of their lumbar spine L2-L5, before the procedure and the Transverse Midline(TM) views of the intervertebral spaces (IVS) were obtained. The visualised images were graded as BEST, GOOD and POOR according to the visibility of both the anterior and posterior complex, either of the two or none of them, respectively. A blinded anaesthetist was allowed to perform the lumbar puncture and the number of attempts in terms of skin puncture & needle passes were noted and DIFFICULTY was defined as more than 2 skin punctures and more than 5 needle passes. Statistical analysis was done using SPSS Version 20.

Results: Most of the operators (81.43%) chose L3-L4 level as suitable intervertebral space and only 11.43% chose L2-L3 level and 7.14% chose L4-L5 by palpation. As a whole, spinal technique was easy in 81.43% and difficult in 18.57%. The blinded operators had chosen IVS with best views in 34.30%, with good views in 51.40% and with poor views in 14.30%. When the operator had chosen an IVS with best/good USG TM view, the spinal was performed with ease in 91.7% of the cases and proved difficult only in 8.3%. In cases where IVS with poor USG TM views had been chosen, spinal technique was easy only in 20% and difficulty was encountered in remaining 80% of the cases. USG TM view of IVS as a screening tool in predicting the ease of performance of spinal anaesthesia has a sensitivity of 96.49%, specificity of 76.92% positive predictive value of 94.83% and negative predictive value of 83.88%.

Conclusion: Pre-procedural ultrasound imaging of lumbar spine can serve as a good screening tool for predicting the ease of performance of spinal anaesthesia. A good ultrasound view of the intervertebral space predicts an easy spinal technique.

Keywords: Pre-procedural ultrasound imaging of lumbar spine, ultrasound transverse midline view, performance of spinal anaesthesia.

Introduction

Spinal anaesthesia is the most commonly performed technique in anaesthesia practice. Uncertainty in administering a spinal technique is always present. As it is a blind procedure, the path of the spinal needle cannot be visualised. Appearance of CSF is the only confirmation of the presence of spinal needle in sub arachnoid space.

Ultrasound (USG) has revolutionised the regional anaesthetic techniques, in terms of safety and efficacy. Despite its extensive use for peripheral nerve blocks, its use in spinal anaesthesia is not popular. Problems with sterility and needle visualisation are present in administering a spinal anaesthesia with real time

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ultrasound whereas pre-procedural USG eliminates such issues[1].

Pre-procedural USG of the lumbar spine can be used to visualise the interlaminar structures, through which the spinal needle has to pass through to reach the subarachnoid space[2]. The structures that can be visualised through the interlaminar window are the lamina, ligamentum flavum, posterior longitudinal ligament and posterior surface of the vertebral body.

The association of a clear visualisation of the interlaminar structures with an easy passage of spinal needle is unclear[3]. This study aims in identifying the role of ultrasound as a screening tool in predicting the ease of performance of spinal anaesthesia.

Material and Methods

After obtaining the approval of the institutional ethical committee, ninety adult patients were included in this study. Written informed consents were obtained from all the participants. The study was conducted in a tertiary care centre during the period between January 2015 and June 2015. Patients who belonged to ASA I-III, scheduled to undergo various elective orthopaedic and general surgeries under spinal anaesthesia were included in the study. Patient of age less than 18 years, BMI > 35kg/m^2 and those with absolute or relative contraindications to spinal anaesthesia, such as patient refusal, presence of local site infection, and presence of coagulopathy were excluded from the study.

All patients were subjected to USG imaging of Lumbar spine, in a pre-procedural room. A Sonoray Digital Ultrasonic Diagnostic Imaging system, DS-30 plus (LCD B/W Machine)was used, which has a 12.1" TFT-LCD Monitor and standard two probe connector, manufactured by Shanghai International Holding Corp, Germany. A 2-5MHz low frequency curvilinear probe was used to image the spine with image depth adjusted at 7 to 10cm.

USG imaging of spine of all the cases was done by the first author, who has 2 years of experience in Ultrasound.
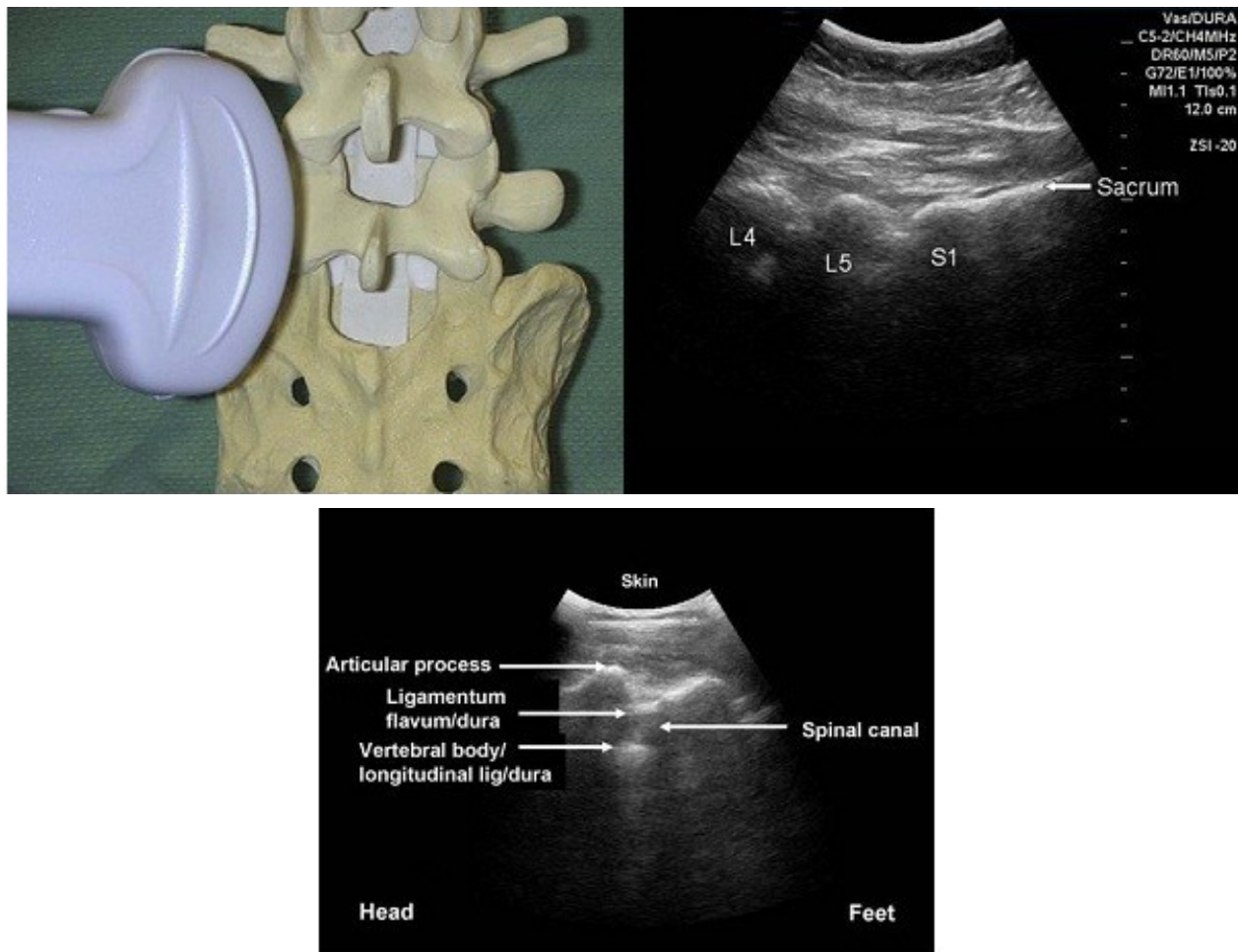

Figure 1. Parasagittal oblique (PSO) view of lumbo-sacral spine

In order to identify the lower lumbar spines, a parasagittal oblique (PSO) view of the lumbosacral spine was first obtained by placing the probe longitudinally 2 cm from the midline tilted and aimed towards the midline. In PSO view (Figure1), the L5-S1 IVS was first identified as the gap between the saw tooth appearance of the L5 lamina and the line of sacrum. Probe was then traced upwards to identify the L2-L5 laminae, in parasagittal view (Figure 2).


Figure 2. Probe position and Parasagittal oblique (PSO) view of lower lumbar spines

After identification of the L2-L5 intervertebral spaces, a Transverse Midline (TM) view of each of these intervertebral spaces were obtained. For a TM view (Figure 3), the probe was placed transversely in midline, over the identified L4-L5, L3-L4, and L2-L3 intervertebral spaces and the interlaminar structures were scanned[4]. (Figure 4).

Figure 3. Probe position in transverse midline view and USG image of L3-L4 intervertebral space.
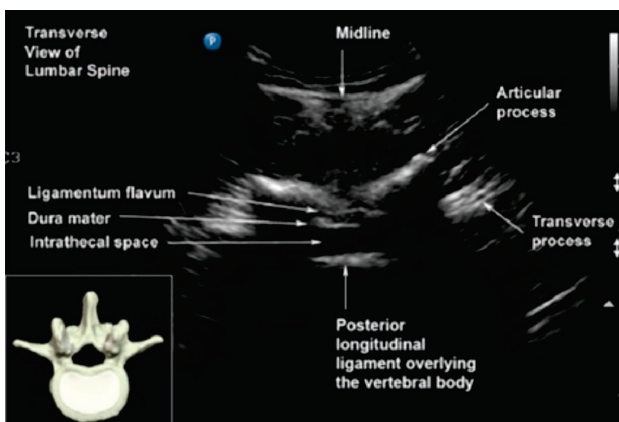
Figure 4. Transverse midline view of L3-L4 intervertebral space showing the anterior and posterior complex

The TM USG views of each intervertebral space from L2-L5 were documented in terms of the visibility of the interlaminar structures. The ligamentum flavum-dura mater complex called the posterior complex and the posterior longitudinal ligament and the posterior surface of the vertebral body, called the anterior complex are seen as two hyperechoic bright lines. The intrathecal space appears as a hypoechoic dark shadow between the two complexes.

When both the complexes could be visualised, the view was graded as "Best", and the view was said to be "Good" when at least one complex was seen. It was called a "Poor" view, when none of the complexes could be visualised.

After completion of the scan, the patient was shifted to the operating room and the basic monitors were connected and the patient was positioned for a spinal anaesthesia. The spinal anaesthetic technique was performed under strict aseptic precautions using midline approach, by a blinded anaesthetist with a minimum 2 years of experience in spinal technique. The operator was allowed to choose any suitable intervertebral space between L2 to L5 of his choice by palpating the anatomical landmarks. A standard 25G Quincke's spinal needle was used.

The ease of performance of dural puncture at the selected intervertebral space was assessed in terms of number of skin punctures and needle passes. Appearance of CSF was considered as a successful dural puncture.

Needle pass was defined as the intermittent or continuous passage of the spinal needle without removing completely from the skin, which includes redirections. A dural puncture was considered difficult if it required more than 2 skin punctures, or more than 5 needle passes and if any change in spinal needle was requested[5].

Statistical analysis: A pilot study was conducted in the study centre. Based on the results of the pilot study, a sample size of ninety patients was required, to achieve the level of significance. Statistical analysis was performed using SPPS Version 20. Demographic data was analysed using mean and standard deviation. Sensitivity, specificity of USG as a screening tool was analysed using contingency table and the association between the USG views of the selected intervertebral space and the difficulty score in performance of spinal anaesthesia was analysed using fisher exact test.

Results

Ninety patients were enrolled in the study between January 2015 and July 2015. The study could be completed only in seventy patients due to various reasons such as lack of time (n=12), change in the technique of anaesthesia (n=6) and cancellation of the surgical procedure (n=4). Dural puncture was successful in all the seventy patients who were included in the study.

Of the Seventy patients who participated in the study, 67.14% were males and 32.86% were females. Patient demographic characteristics summarised in Table 1.

In 81.43% of the cases, L3-L4 level was chosen as the suitable intervertebral space by palpation of anatomical landmarks. L2-L3 and L4-L5 intervertebral space was chosen only in 11.43% and 7.14% of the cases respectively.

The blinded operators had chosen intervertebral spaces with "best views" in 34. 30% (24 patients), with "good views" in 51.40% (36 patients) and with "poor views" in 14.30% (10 patients).

Table 1: Demographic Data

Patient Characteristics	Mean +SD n=70
Age (yrs)	44.828 +13.48
Wt (kg)	66.64 + 10.11
Ht (m)	1.627 + 0.06
BMI (kg/m2)	22.09 + 3.56
Female:Male	1:1.92

USG as a Screening Tool in Predicting an Easy Spinal Technique, has a Sensitivity of 96.49%, Specificity of 76.92%, Positive Predictive Value (PPV) of 94.83% and Negative Predictive Value (NPV) of 83.33%

Discussion

Spinal anaesthesia requires insertion of a needle through the lower lumbar intervertebral spaces to reach the subarachnoid space. The insertion of the needle cannot be visualised. Many times, spinal is not successful in the first attempt. This is because individual anatomy is unique. Some cases require several needle redirections, some have calcified ligaments which do not allow easy passage, and in

Table 2: Association of USG Imaging of selected Intervertebral Space and the performance of Spinal anaesthesia technique

EASY		PERFORMANCE OF SPINAL ANAESTHESIA TECHNIQUE		TOTAL	P Value*
		DIFFICULT			
Ultrasound view of the selected intervertebral space	GOOD & BEST	55 (91.7%)	5 (8.3%)	60 (100%)	
	POOR	2 (20%)	8 (80%)	10 (100%)	<0.05
TOTAL		57 (81.4%)	13 (18.6%)	70 (100%)	

As a whole, Spinal technique was easy in 81.43% and difficult in 18.57% of the cases.

When the operator had chosen an IVS with best/good USG TM view, the spinal was performed with ease in 91.7% of the cases and proved difficult only in 8.3%. In cases where IVS with poor USG TM views had been chosen, spinal technique was easy only in 20% of the cases. Difficulty was encountered in remaining 80% of the cases (Table 2).

Among the 24 cases who had Best USG views, 23 of them required only one skin puncture for a successful dural puncture whereas 32 of the 36 cases who had good USG views required 1-2 skin punctures. Out of the 10 cases who had poor views on ultrasound, 8 cases required more than 5 needle passes. Spinal technique was easy with only two of the ten cases with poor USG views

other cases, a suitable intervertebral space may not be always chosen by palpation[6].

Sometimes, spinal technique may be even abandoned due to technical difficulty in obese and elderly patients[7]. In such cases, an alternative procedure, mostly general anaesthesia may be resorted to, which could have been avoided, if the difficulty was anticipated[8]. There arises the need for screening the spinal anatomy in advance. This would help in identifying any abnormal anatomy and choose an appropriate intervertebral space, as well. Ultrasound has emerged as an indispensable guiding tool for administering various peripheral nerve blocks. Studies on use of Ultrasound in neuraxial blockade has been found to be promising in delineating abnormal anatomy, estimating the depth of ligamentum flavum for epidural needle insertion and catheter placement[9].

But there was not much information on how well

ultrasound can help in anticipating the performance of spinal technique.

Imaging (TM views) of the inter-spinous spaces between the lower lumbar spines, helps in identifying the hyperechoic structures such as the lamina, articular process, transverse process and in midline, structures such as ligamentum flavum, dura complex, posterior longitudinal ligament and the hypoechoic dark intrathecal space between the two.

Though there were many cases where L2-L3, L4-L5 had best views on ultrasound compared to L3-L4, 81.43% had chosen L3-L4 as the best suitable intervertebral space for spinal by palpation. Thus ultrasound definitely can help in choosing the best intervertebral space which can be missed by palpation[10].

The ability to see the anterior and posterior complex suggests an open acoustic window, signifying that, a spinal needle inserted will have an easy path to reach the dura. Among the sixty cases, who had good-best ultrasound images of the chosen IVS, 91.7% had an easy spinal technique. Thus a good-best USG image can anticipate absence of difficulty in administering a spinal anaesthesia.

In 8.3% of the cases spinal was difficult in spite of a good USG view, probably due to other factors such as experience of the anaesthetist. The number of redirections might be lesser in hands of more experienced anaesthetists.

The inability to identify the anterior/posterior complexes suggests the presence of any bony structures, calcifications, or a narrowing between the lamina, which may cause technical difficulty in lumbar puncture. When a poor USG view was obtained, in 80% of the cases, the technique was also difficult requiring more number of skin punctures and redirections.

The spinal was Easy in 2 cases out of the ten cases with Poor USG view. This may be due to poor skin-probe contact and the potential for misinterpretation of the images by the examiner. The experience of the anaesthetist in spinal ultrasound also plays a role, in determining the grade of the ultrasound view of the spine.

In a similar study by KJ Chin et al[2], the utility of ultrasound in predicting the absence of technical difficulty in performing the spinal technique was assessed in 100 orthopaedic patients, who underwent USG examination of L1-S1 spines before spinal anaesthesia. The study had also compared the diagnostic ability of Transverse median (TM) and Parasagital Oblique views (PSO) and results showed

that TM has a better diagnosing accuracy in predicting the feasibility of dural puncture via midline approach.

When a good-best TM view could be obtained, the probability of easy dural puncture at that level was 94.83% (positive predictive value). This is slightly higher than the PPV of 85% obtained in the KJ Chin et al[2] study. This was because both novices and experts were allowed to perform the spinal technique in their study whereas in our study only anaesthetists with minimum 2 years of experience were allowed to perform the technique. In their study, the positive predictive value was slightly higher for experts compared with novices (90% vs 80%).

This study shows that USG has a good NPV of 83.33% whereas in the study by KJ Chin et al[2], the NPV was only 30%. This was probably because our study group included patients of all age groups, whereas they had evaluated only patients undergoing orthopaedic procedures who were mostly elderly, contributing to the increased poor views in USG.

Simple routine use of spinal ultrasound for deciding the best intervertebral space can help in minimising the number of needle passes which cause unnecessary trauma and complications.

The accuracy in interpretation of the ultrasound images, depends upon the competency of the investigator with spinal ultrasound and the model of the ultrasound machine itself, which is a limitation of this study. Ultrasound images were difficult to obtain in patients with contracted interspinous spaces and in those with prominent spinous processes which hinder adequate skin-probe contact. In such cases, an USG probe with smaller footprint would be required.

Conclusion

Pre-procedural ultrasound imaging of lumbar spine can serve as a good screening tool for predicting the ease of performance of spinal anaesthesia. A good ultrasound view of the intervertebral space predicts an easy spinal technique

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