Evaluation of Ultrasonography as a Clinical Tool for Localisation of Epidural Space Compared to External Landmark Technique

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ABSTRACT

Introduction: Ultrasonography (USG) can be used to identify epidural space and also aid in decreasing attempts and complications. This study aims to evaluate the use of USG as a clinical tool for localisation of epidural space compared to landmark technique.

Material and methods:
60 adult patients scheduled to receive epidural were randomly allocated into two groups of 30 patients each. Group C: In the control group, palpation of the spinous processes and intervertebral space was done to localise the puncture point. Group U: In the USG group, paramedian sagittal oblique (PSO) and transverse approach were used for imaging the spine. In the PSO view, ligamentum flavum was considered to be the most hyperechogenic structure to be seen posteriorly. The distance from skin to this point was considered as the "predicted depth" of epidural space. In the transverse view once a clear image was obtained, two marks were drawn on the skin, one coinciding with the midpoint of the upper horizontal surface of the probe and other coinciding with the midpoint of the lateral surface of the probe. The optimal point for insertion of the needle is determined by the intersection of the extensions of these two marks.

Results: Statistical analysis was performed using SPSS 12 for windows. We observed a good correlation between the predicted depth (41.3 ±6.10 mm) and actual obtained depth (41.40 ±6.30 mm) in the USG group (correlation coefficient=0.96). However, the difference in the number of attempts (p=0.408) and immediate complications in Group U and Group C were statistically not significant.

Conclusion: The usefulness of ultrasound as a clinical tool for localisation of epidural space compared to external landmark technique is limited. USG can be used to accurately predict the depth but there is no benefit with respect to the number of attempts or decrease in incidence of dural puncture.

Keywords: Ultrasound, Epidural, Depth of Epidural Space.

INTRODUCTION

Epidural anaesthesia is considered beneficial as it results in attenuation of stress response, improved pulmonary functions, decreased risk of thrombo-embolic phenomenon, early ambulation and improved gastrointestinal function.

Epidural needle placement has traditionally relied upontwo aspects. First, palpation of the iliac crest and spinous processes to predict the intervertebral space i.e, landmark technique and second, tactile feedback received during needle insertion which both in turn rely on the skills of the operator. However, palpation can be difficult in conditions like obesity, subcutaneous oedema and deformities of the spine leading to repeated attempts.Repeated attempts can make the patient apprehensive and increase the chances of complications such asdural puncture, nerve damage, infection and ineffective/failed epidural.This led to different technologies like USG and fluoroscopy being considered to improve the predictability.

The efficacy of USG has only improved over a period of time due to greater exposure and better understanding. USG has an advantage as it is portable and has no ionising radiations. It helps in identifying the epidural space and also aids in confirming the exact placement of the epidural catheter if used in real time. Meta-analysis suggest that use of ultrasonography (USG) improves the precision and efficacy of neuraxial anaesthetic techniques.[1,2] Therefore, the need of this study was to find whether the USG-guided technique is superior than landmark-guided technique for epidural space localization.

MATERIAL AND METHODS

After scientific and ethics committee approval, an open prospective randomized controlled study was conducted. 60 adult patients scheduled to receive epidural anaesthesiawere randomly allocated (computer generated) into two groups of 30 patients each.Inclusion criteria were age of 18–65 years either sex, BMI (18–30), ASA physical status I–III. Exclusion criteria were infection at the site of infection, patient refusal, significant coagulopathies, history of allergy to local anaesthetic agents and previous spine surgery or spine deformity.

The investigator was trained by performing 10 ultrasound guided examination of the spine by a senior radiologist before beginning the study. The same investigator took all the readings.

In both the groups, the patients were in sitting position,

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supported with pillows andwith their back curved towards the operator.

In the control group (Group C), palpation of the spinous processes and intervertebral space was done to localise the puncture point for introduction of epidural needle.The L4 vertebra was identified using Tuffier's line (line joining the highest points of the iliac crests) and the lower tip of the scapula was considered as T7.

In the ultrasonography group (Group U), ultrasound guided examination of the spine was done using a portable ultrasound machine (Sonosite MicromaxxR) with a 5MHz low frequency curvilinear ultrasound probe. Two approaches, paramedian sagittal oblique (PSO) approach and transverse approach were used for imaging the spine.

For the PSO view (Fig 1), the probe was placed vertically parallel to the long axis of the spine. Initially, it was placed over the sacral region about 1-2 cm lateral to the midline and slightly angled to target the midline of the spine to visualise a continuous hyperechoic (bright) line representing the sacrum.

After identification of the sacrum, the probe was gradually moved in the cephalad direction to identify a "sawtooth-like" hyperechoic image. This represents the articular processes and interspace between the lumbar vertebra. Keeping the image in view, the ultrasound probe was moved further cephalad till the desired interspace was reached. The exact level of the interspace was marked with a skin marker pen for future reference. Ligamentum flavum was considered to be the most hyperechogenic i.e. bright structure to be seen posteriorly. The distance (in millimetre) from skin to this point was measured using in built callipers. This distance was considered as the "predicted depth" of epidural space by ultrasonography.

For the transverse approach, the probe is placed perpendicular to the spine and midline of the spine corresponding to the spinous process is identified. Within the interspace, ligamentum flavum and the posterior dura can be seen as a hyperechoic image. The classical image to be obtained is a "bat-wing" appearance. (fig.2) Once a clear image was obtained, the probe was kept steady andtwo marks are drawn on the skin, one coinciding with the midpoint of the upper horizontal surface of the probe and other coinciding with the midpoint of the lateral surface of the probe. The point of insertion is determined by the intersection of the extensions of these two marks. This point was marked with a marker for future reference.

In both groups, the back was cleaned taking universal precaution. 2 ml of 2% lignocaine was infiltrated in the desired interspace. A 16 gauge "PORTEX SYSTEMR 3" epidural set was used for epidural anaesthesia. In the control group, the epidural needle was inserted through midline approach and epidural space was located using the loss of resistance technique. In the USG group, the aforementioned marked point was used for needle insertion. A mark was made on the needle with the help of a sterile marker at the level of the skin surface after locating the epidural space. The distance from the tip of the needle to this marked point which represents the "actual depth" from skin to ligamentum flavum was noted. The "number of attempts" was also noted. This was defined as the one involving a new skin puncture and did not include change in the needle trajectory without complete withdrawal from the skin.

Once the space was obtained, epidural catheter was fixed and patient was then administered anaesthesia depending upon the modality planned i.e. either spinal and epidural or general anaesthesia with epidural.

Outcome measures:

The primary outcome was to compare the number of attempts andimmediate complication (dural puncture). The secondary outcome was to compare the depth from skin at which epidural space was obtained in millimetre (mm) to that predicted in the ultrasound group.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS 12 for windows. The comparison of data between groups was determined by using Chi-square test, Unpaired t test, Mann-Whitney test. Fisher exact test, Wilcoxon Signed Rank Test where appropriate were used to identify differences between the two groups. Correlations between continuous variables were assessed using the Pearson correlation coefficient. The results were expressed as mean ± standard deviation. A probability value of <0.05 was considered statistically significant.

RESULTS

The demographic data (age, sex, and weight) was comparable between the two groups. The mean weight in Group U was 66.17± 9.41 kgs while in Group C it was 65.8 ± 7.54 kgs (p=0.868). The mean age in Group U was 52.87 ± 15.12 yrs (range 22 to 77 years. In Group C, the mean age was 54.87± 10.41 (range 34 to 78 years).

The comparison of total number of attempts in Group U and Group C revealed that in group U, the number of attempts were 1.10±0.31 whereas in Group C it was 1.23±0.57. This data was statistically not significant (p=0.408). 3 patients in Group U required 2 attempts whereas in Group C, 5 patients required 2 or more attempts. (Table 1)

Variables	Groups					Unpaired	t-test
		Mean	SD	Median	IQR	t-value	p-value
Number of attempts^	U	1.10	0.31	1.00	0.00	-0.827	0.408
	C	1.23	0.57	1.00	0.00	Difference is not significant	
^ata failed 'Normality' test. Hence Mann-Whitney test applied. T-value replaced by Z-value. IQR= Interquartile Range (i.e. 75th Percentile-25th Percentile)							

Table-1: Comparison of number of attempts between Group U and Group C

Variables ^	No.	Group U				Wilcoxon Signed Rank Test	
		Mean	SD	Median	IQR	Z-value	p-value
Depth Predicted (mm)	30	41.30	6.10	41.50	5.50	-0.468	0.640
Actual depth obtained (mm)	30	41.40	6.41	40.00	3.50	Difference is not significant	

	No.	Correlation	p-value
Depth Predicted (mm) & Actual obtained (mm)	30	0.968	2.12E-18

Table-2: Comparison of predicted and actual depth obtained in Group U

Complications		Group		Total
		U	C	
Yes	No.	0	1	1
	%	0.0%	3.3%	1.7%
No	No.	30	29	59
	%	100%	96.7%	98.3%
Total	No.	30	30	60
	%	100%	100%	100%

Table-3: Comparison of complications in Group U and Group C

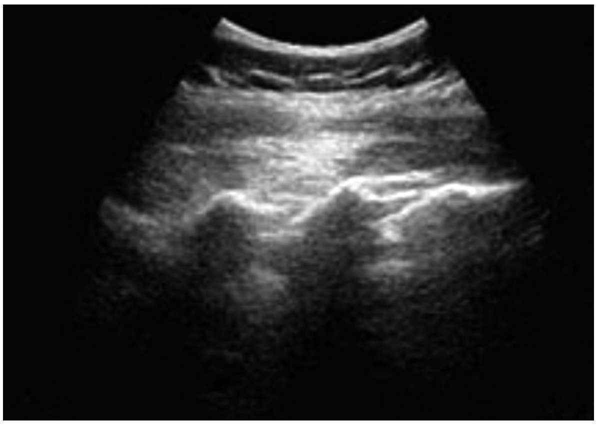

Figure-1: PSO view of the lumbar epidural space

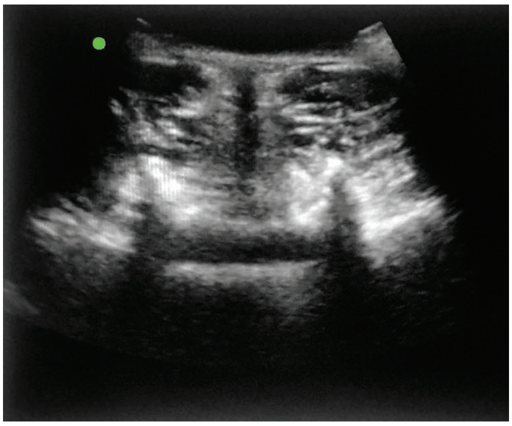

Figure-2: Transverse view of the Lumbar Spine showing the Bat wing appearance

The depth predicted by ultrasonography was 41.30 ±6.10 mm (millimetre) and actual obtained was 41.40± 6.41 mm, which showed no significant difference (p=0.640).
Also, there was a good correlation between the depth predicted and the depth obtained.(Table2)
The control group had 1 case with complication i.e. dural puncture (confirmed by aspiration of cerebrospinal fluid) whereas the ultrasound group had none. A statistical difference was not found (p=1.000).(Table 3)

DISCUSSION

The first report of ultrasound guided lumbar puncture appeared in the Russian literature in 1971.[3] In 1980, Cork et al described the use of ultrasound to delineate neuraxial anatomy.[4] They were able to identify the lamina, ligamentum flavum, spinal canal and vertebral body despite images being of poor quality. Thereafter, USG was used mostly to preview the spinal anatomy and measure the distances to the lamina and epidural space.[5,6] Between 2001 and 2004, Grau and colleagues conducted a series of studies that demonstrated the utility of USG in epidural analgesia and were pivotal in improving our understanding of spinal sonography.[7-17] Since then, there have been an increasing number of anaesthesia related publications including a set of National Institute for Health and Clinical Excellence (NICE) guidelines on ultrasound guided epidural and spinal anaesthesia.[18] There have been numerous reports published on use of USG in paediatric patients for neuraxial anaesthesia.[19-25] There has also been interest in the use of this technique by emergency physicians to guide lumbar puncture.[26-31] However, the use of USG for epidural is still far from satisfactory, partly due to unfamiliarity with the technique or learning curve associated with it. USG though a promising modality, presents with a certain degree of difficulty when it comes to the spine. Anatomically, the spinal cord/epidural space is enclosed in a very complex, articulated encasement of bones, ligaments, and adjacent muscles that have homogeneous density. This not only makes the US of spine challenging but also demands a certain degree of technical skill and proficiency.Hence, we decided to conduct an open prospective randomized controlled study to evaluate the utility of USG in localisation of the epidural space.

Number of attempts: A decrease in the number of attempts helps in improving patient compliance and decreasing the rate of complications. In our study, the comparison of total number of attempts in Group U and Group C revealed that the number of attempts in group U (1.10±0.31) and Group C (1.23±0.57) were statistically not significant (p=0.408)

(Table no 1). 3 patients in Group U required 2 attempts whereas in Group C, 5 patients required 2 or more attempts. Our study has similar results to a study conducted by Issam Khayata,Gustavo Angaramoet alwhichenrolled 29 patients scheduled to receive epidural anaesthesia. The mean number of attempts was 2 ± 1 and the authors claimed the results were inconclusive.[32]

Contrary to our study, a systematic review and meta-analysis done by Shaikh *et al*. showed US imaging as a useful adjunct which can reduce multiple attempts, risk of failed or traumatic lumbar punctures, and epidural catheterizations.[33]

Some investigators analysed needle passes instead of needle insertion. A needle pass was defined as any forward advancement of the needle.Vallejo MCet al conducted a study in 370 parturients receiving labour epiduralswere randomized in USG guided group and control group. USG examination of the spine was done by a single experienced investigator and the procedure was done by 15 first year residents supervised by a blinded anaesthesiologist. The investigators showed that the total number of needle passes were significantly lower in the USG group than in control group ($p<0.01$).[34] A study by Grau T, Conradi Ret al had significantly lower number ofneedlepasses in the USG guided group as compared to control group (10).

Arzola C, Davies S, et al found that the success rate on first needle insertion using USG was 91.8% i.e. 52 out of 61 parturients which was comparable to our study (90%). However, the mean number of attempts were not recorded.[35]

Grau T, Leipold RW et al also noted that the success rate on the first needle pass was 75% in the ultrasound guided group as compared to 20% in the control group which was statistically significant ($p<0.001$).[14]

Accurate prediction of depth could decrease the incidence of failed epidurals and dural punctures. There was a high degree of correlation (correlation coefficient=0.96) between depth predicted by ultrasound (41.3± 6.10 mm) and actual depth (41.40± 6.30 mm) in our study (Table no 2). We had findingssimilar to several studies conducted earlier.Bonnazi M et al concluded that ultrasound scanning of the lumbar spine provides an accurate measurement of the depth of the epidural space (correlation coefficient=0.99), which can facilitate the performance of the epidural anaesthesia.[2] A study by Grau T, Leipold RW et al revealed that there was a good correlation between ultrasound predicted depth and needle depth ($r=0.92$).[14] A trial by Arzola C, Davies S et alinvolving 61 parturient showed that USG can accurately predict the epidural depth and that needle depth and ultrasound measured depth had a good correlation ($r=0.89$).[35]

Complications: The only complication observed was an accidental dural puncture in one patient in the control group (Table no 3). However, this was not found to be statistically significant ($p=1.00$). Our study has similar results to few studies conducted previously.Out of 150 patients,Grau T, Leipold RW and colleagues reported 1 case of accidental perforations of the dura in the Ultrasound group and 2 cases in the Control group which was statistically not significant.[10] Another study by Grau T, Leipold RW, Motsch J and colleagues also showed that pre procedural ultrasonography did not demonstrate significant effect on incidence of accidental dural punctures.[13] Vallejo MC, Phelps AL et alalso found no difference in the incidences of accidental dural punctures between patients of ultrasound or palpation group.[34]

Limitation

The success of US-guided epidural access depends on the quality of US images which we did not document. Also, patient groups with potentially difficult epidural placement for e.g. obesity, previous spinal surgery in whom USG maybe beneficial were not included in the study. Additional time required to perform the USG examination was also not documented. There is a learning curve associated with it as is the case with any new technique but as experience increases, the time taken for examination should reduce.

CONCLUSION

The current evidence supports the use of neuraxial ultrasound as a useful adjunct to conventional CNB techniques: it can be used to accurately identify lumbar intervertebral levels and allows precise measurement of depth to the epidural space. Neuraxial ultrasound may also improve the efficacy and safety of CNB by facilitating more accurate needle placement and decreasing the number of needle redirections and skin punctures.

Ultrasound-assisted CNB is not designed to replace the conventional surface landmark-guided technique, which is simple and effective in the majority of patients. Rather, it is an advanced tool to be used when technical difficulty is anticipated or when increased precision is desired. We therefore recommend thatanaesthesiologist should incorporate neuraxial ultrasound into their clinical practice whenever possible until they attain the desired level of comfort with the ultrasound-assisted approach to CNB.

From our study we conclude that USG may not be superior to manual palpation in localising the epidural space. It does allow precise measurement of depth to the epidural space.Having said that, the acquisition and maintenance of competency in neuraxial ultrasound requires practice.To assess the real benefits of USG, we suggest further studies with the use of USG in real time as well as in presumed cases of difficult epidural insertion.

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