

Ease of lumbar epidural catheter insertion with prepuncture ultrasound as guidance compared with conventional palpatory technique when performed by anesthesiology residents: A randomized controlled trial

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Abstract

Background and Aims: Lumbar epidural catheter insertion is conventionally performed by anesthesia residents by palpation of anatomical landmarks with relatively blind localization of epidural space which may lead to an increase in failure rate. We aim to compare the ease of lumbar epidural catheterization using prepuncture ultrasound as guidance with that of conventional palpatory technique. Comparisons were made with reference to number of insertion attempts, total time taken for the procedure, frequency of dural puncture, and overall satisfaction score as assessed by Likert's scale.

Material and Methods: Eighty, ASA 1-3, patients undergoing elective surgeries requiring lumbar epidural catheterization were recruited for the study. Study participants were randomized into two groups. In group P, epidural catheterization was performed using the conventional palpatory method and in group U, it was performed with the help of ultrasound determined parameters. Number of insertion attempts, total time taken for successful insertion of epidural catheter, frequency of dural puncture, and overall satisfaction of ease of insertion as determined by Likert's scale were compared between both the groups. Data were analyzed using SPSS statistical software version 17 and P value <0.05 was considered statistically significant.

Results: The number of insertion attempts was significantly lesser in Group U ($P = 0.019$). The total procedure time was significantly higher in group U ($P < .001$). There was no significant difference in ease of insertion score, as measured by Likert's scale between both the groups ($P = 0.45$).

Conclusion: Prepuncture ultrasound guidance improves the first attempt success rate of lumbar epidural catheterization with reduced incidence of dural puncture with similar overall satisfaction score but increases the total time taken for the procedure when compared to conventional palpatory technique.

Keywords: Anesthesiology residents, lumbar epidural, prepuncture ultrasound

Introduction

Lumbar epidural catheterization is commonly performed for intraoperative anesthesia and postoperative analgesia

for abdominal and lower limb surgeries. Conventionally, lumbar epidural catheter insertion is done using palpation of anatomical landmarks.

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Using the conventional technique, it may be difficult to palpate the interspinous space in obese patients and in patients with anatomical variations leading to difficulty in localizing the epidural space. The success rate also depends upon the experience of anesthesiologists and these difficulties will be experienced more frequently during the training period. Hence, when such procedures are performed by anesthesia residents, it may lead to multiple needle punctures, varying degree of patient discomfort, and failure of the procedure.^[1]

In modern anesthesia, ultrasound has emerged as a valuable tool in the performance of regional anesthesia. Ultrasound examination of the lumbar spine prior to epidural catheter insertion provides important information regarding the optimal site of skin puncture, identification of correct interspace, and estimation of the angle of insertion.^[2-4] Ultrasound examination also helps in the measurement of the approximate depth of epidural space from the skin surface.^[5-7] With these vital information, the success rate of epidural catheterization can be improved significantly when performed by trainees and may prevent complications associated with the procedure including accidental dural puncture.^[8]

Very few studies are available comparing the effectiveness of conventional palpatory technique with prepuncture ultrasound-guided epidural catheter insertion when performed by anesthesiology trainees. Hence, the present study was designed to compare both the techniques in terms of the number of insertion attempts, time taken for successful catheterization, and overall assessment of ease of insertion as observed by trainees while performing these two techniques.

Materials and Methods

After approval from the institute ethics committee (JIP/IEC/2016/1148), the trial was registered under clinical trial registry (CTRI/2018/03/012690).

After obtaining written informed consent, 80 patients undergoing elective surgeries requiring lumbar epidural catheterization were enrolled for the study. Patients belonging to ASA class 1-3, aged between 18 and 70 years were included in the study. Patients with prior lumbar surgery, coagulation abnormality, local site infection, and severe hepatic and renal impairment were excluded from the study. Study participants were randomized into two groups, based on computer-generated randomization table. In patients with group P, epidural catheterization was performed by a conventional palpatory method and in group U, the catheterization was performed with the help of ultrasound determined parameters.

A 20g IV cannula was inserted in all the patients and standard monitors including ECG NIBP and pulse oximetry were attached. The procedure was performed in either lateral or sitting position based on patient comfort. Strict asepsis was followed in all patients.

All the procedures were performed by anesthesiology residents with 1 year of experience in epidural anesthesia and with knowledge of ultrasound for lumbar neuraxial procedures. In the conventional group, lumbar epidural catheter insertion was done conventionally with palpation of anatomical landmarks. The point of needle insertion and needle angulation was left to the discretion of the resident performing the procedure.

In the ultrasound group, ultrasound examination of the lumbosacral spine was performed by identification of sacral spinous process and then the probe was moved in cephalad direction for identification of suitable level. The upper and lower spinous process were marked and a line was drawn joining the two points. Then, a transverse scan was performed to locate the intervertebral space. The midpoint of both the lateral ends of the probe was marked and a line was drawn to join these points. The point of intersection of these two lines was taken as the entry point. In addition, the depth of dura from the skin site is measured using ultrasonography and noted. The optimal angle of the probe at which dura is clearly visible is also noted using the goniometer.

The data collected were the number of insertion attempts taken for epidural catheter insertion, total time taken for the procedure which was the time from the end of draping to insertion of epidural catheter, and frequency of dural puncture in both the groups. Also, we noted the time taken for insertion of epidural catheter after localizing the site of needle insertion. The ease of insertion using either of the technique was noted on the five-point Likert's scale: 1. very difficult, 2. difficult, 3. neutral, 4. easy, and 5. very easy.

The sample size was calculated based upon our primary outcome on number of insertion attempts. With expected mean and standard deviation based upon the number of insertion attempt in intervention group and control group to be 1.3 ± 0.6 and 2.2 ± 1.1 , respectively, with 95% confidence interval and 90% power accounting to 20% attrition and 10% nonresponse rate, the calculated sample size was 32 in each group. In our study, we recruited 40 patients in each group.

Results

A total of 80 patients were included in this prospective randomized controlled trial [Figure 1]. In group P ($n = 40$), epidural catheterization was achieved by conventional

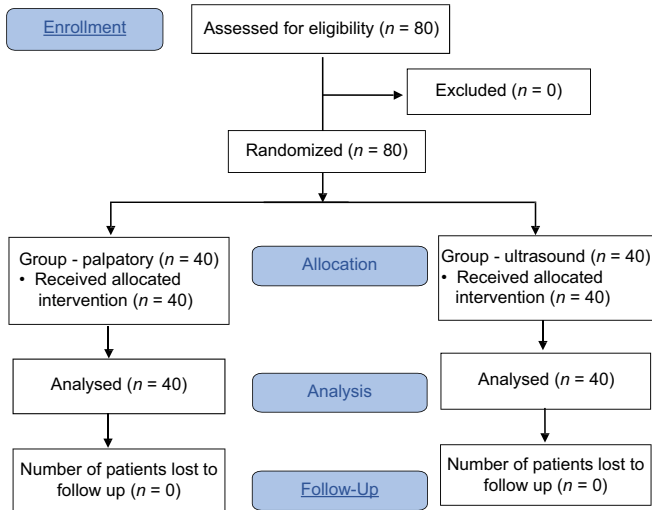


Figure 1: Consolidated standards of reporting trials (CONSORT) flow diagram showing patient progress through the study phases

technique after palpation of anatomical landmarks. In group U, the procedure was performed with prepuncture ultrasound as guidance. There was no significant difference in the demographic profile of both the patient population [Table 1].

The first attempt success rate was significantly higher in the ultrasound-guided group. First attempt success was achieved in 75% of patients in ultrasound group as compared to only 52.5% patients in the conventional group [Table 2].

The total procedure time which included the time taken for ultrasound scanning or manual palpation to identify the landmarks was significantly longer in patients in whom ultrasound was used as guidance before puncture. The mean time in group U was 19.48 ± 2.14 min as compared to 10.60 ± 4.63 min in group P [Table 3].

The total duration of time taken from epidural needle insertion to catheterization was measured; the time taken in Group P was 3.081 ± 0.01 min and in Group U was 2.58 ± 0.62 . The mean time was lesser in ultrasound group when compared to palpatory group, which is statistically significant with a *P* value of 0.010 [Table 4].

There was no significant difference in ease of insertion score, as measured by Likert’s scale between both the groups (*P* = 0.45) [Table 5]. One case of dural puncture was reported in the palpatory group. There was no incidence of dural puncture in the ultrasound group.

Discussion

There are several studies available in the literature which has demonstrated the utility of preprocedure ultrasound

Table 1: Patient demographic details

	Group P (n=40)	Group U (n=40)	<i>P</i>
Age (years)	43.55±15.90	43.60±15.63	0.989
Height (cm)	164.88±3.58	164.43±4.59	0.626
Weight (kg)	63.80±5.02	64.20±5.80	0.742
Body mass index (kg/m ²)	23.48±1.80	23.79±2.45	0.513
Gender (M/F)	27/13	24/16	0.485

Table 2: Number of insertion attempts in the two groups

Number of Insertion Attempts	Group P	Group U	<i>P</i>
1	21 (52.5%)	30 (75%)	0.019
2	14 (35%)	10 (25%)	
3	5 (12.5%)	0 (0%)	

Table 3: Comparison of total time taken for the procedure in the two groups

Time Taken (min)	Group P	Group U	<i>P</i>
<10 min	20 (50%)	0 (0%)	<0.001
10-20 min	19 (47.5%)	26 (65%)	
>20 min	1 (2.5%)	14 (35%)	
Mean time taken (Mean±S.D)	10.60±4.63	19.48±2.14	

Table 4: Time taken from needle insertion to catheterization in two groups

Time taken catheterization	Group P	Group U	<i>P</i>
<2.5 min	12 (30%)	19 (47.5%)	0.010
2.5-4.5 min	26 (65%)	21 (52.5%)	
>4.5 min	2 (5%)	0 (0%)	
Mean time taken (Mean±SD)	3.08±1.01	2.58±0.62	

Table 5: Ease of insertion as assessed by Likert’s scale in two groups

Likert’s Scale	Group P	Group U	Total	<i>P</i>
1	4 (10%)	6 (15%)	10 (12.5%)	0.445
2	12 (30%)	18 (45%)	30 (37.5%)	
3	11 (27.5%)	8 (20%)	19 (23.8%)	
4	10 (25%)	5 (12.5%)	15 (18.8%)	
5	3 (7.5%)	3 (7.5%)	6 (7.5%)	

examination before epidural catheterization. They have shown to be beneficial in several aspects including localizing the correct interspace,^[9-12] reducing the risk of traumatic puncture, and^[8] reducing the number of needle insertion and total duration of the procedure.^[13,14] They have also been found to improve the success rate of the procedure^[15] with better patient comfort. Very few studies had been done to demonstrate the efficacy of lumbar neuraxial ultrasound when performed by anesthesiology residents during their training period.

The results of our study indicate that prepuncture ultrasound assessment prior to lumbar epidural placement by the anesthesia trainees decreases the number of insertion attempts and frequency of dural puncture as compared to the conventional palpatory method. Ultrasound examination of the spine prior to puncture provides some important information including localizing the needle puncture site, depth of epidural space, and angle needed for needle insertion.

In our study, the success rate of epidural catheter insertion was significantly more in ultrasound group when compared to that of palpatory group ($P = 0.036$). While epidural catheter insertion was done within two attempts in all the patients allocated to the ultrasound group, in five patients in the palpatory group, it required three attempts for successful catheter insertion.

Grau^[4] and colleagues in a prospective, randomized study for assessing the efficacy of ultrasound imaging in obstetric epidural anesthesia found that the use of ultrasound for structure detection reduced the rate of puncture attempts significantly from 2.18 ± 1.07 to 1.35 ± 0.61 . The mean rate of necessary puncture level was 1.30 ± 0.55 and with ultrasound detection 1.136 ± 0.36 with $P < 0.029$.

Tawfik *et al.*^[16] compared the efficacy of ultrasound in obstetric population in terms of rate of successful epidural catheterization in first needle pass and found that first attempt success rate was 60% and 58.5% in palpatory group and in ultrasound group, respectively, with no significant difference between the groups. Results of this study were contradictory to our results and this may be due to the fact that in their study all the procedures were performed by experienced anesthesiologist, while in our trial, procedures were done by novice learners. This suggests that the use of ultrasound improves the first attempt success rate among anesthesia resident trainees.

Vallejo *et al.*^[17] in a prospective randomized nonblinded study randomized 370 parturient requesting labor epidural analgesia to receive their epidural by first-year anesthesia residents with or without prior ultrasound determination of epidural space depth. They found that the incidence of epidural catheter replacement for failed analgesia was fewer in the ultrasound group and the number of attempts and accidental dural punctures were also lesser in ultrasound group when compared to palpatory group. In their study, depth of epidural space was the only parameter that was assessed during ultrasound examination, whereas in our study, we also utilized ultrasound examination to determine needle puncture site and also angle of insertion. In their study, ultrasound scanning time was $60 \text{ s} \pm 15 \text{ s}$.

In our study, total time taken for the procedure from the preparation to epidural catheterization was significantly increased in the ultrasound group compared to the palpatory group. This could be attributed to the multiple parameters that were assessed during the ultrasound examination and also due to the fact that it was performed by the residents with limited experience in the use of ultrasound.

The mean time taken from epidural needle insertion to catheterization was significantly lesser in ultrasound group as compared to palpatory group (2.58 ± 0.62 and 3.08 ± 1.01 min, respectively). This could be attributed to the decreased number of insertion attempts in the ultrasound group as compared to palpatory group.

In a meta-analysis performed by Choi *et al.*,^[18] they studied frequency, onset, and duration of post dural puncture headache (PDPH) and found that the frequency of dural puncture in parturients is approximately 1 in 67 during needle insertion. In the same study, the incidence of accidental dural puncture among 2400 patients is reported in 36 patients with PDPH rate of 18 patients. In our study, we had one incidence of dural puncture in palpatory group with no dural puncture noted in the ultrasound group. Usage of ultrasound helps in measuring the approximate depth of dura which helps the residents in avoiding the dural puncture during the procedure.

When we compared the trainee's assessment of ease of procedure by Likert's scale, there was no significant difference in ease of insertion score between both the groups. Although the residents were trained in neuraxial ultrasound, their limited experience has resulted in an overall increase in time taken for the ultrasound examination and then subsequent epidural insertion. The ease of procedure may get improved with an increase in the usage of ultrasound.

Our study has its own limitations. We did not restrict our study to one particular surgical population and analyzed only the needle insertion attempts and not the number of needle redirections. The study was done only in lumbar epidural catheter insertion which was technically easier even with conventional palpatory technique and not in the thoracic epidural.

Conclusion

Prepuncture ultrasound guidance when utilized by the anesthesia residents improves the first attempt success rate of lumbar epidural catheterization with reduced incidence of dural puncture with similar overall satisfaction score but increases the total time taken for the procedure when compared to conventional palpatory technique.

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Conflicts of interest

There are no conflicts of interest.

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