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The Use of Ultrasound to Measure the Depth of Thoracic Epidural Space

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Abstract

The use of ultrasound to aid in regional blocks has increased in recent years as a result of improvement in ultrasound technology. Ultrasonography can be used to measure the depth of thoracic epidural spacewith a good correlation with the actual depth as detected by the loss of resistance technique.

Background

The use of ultrasound to aid in regional blocks has increased in recent years as a result of improvement in ultrasound technology. There have been many studies conducted to evaluate the use of ultrasound to measure the depth of epidural space in the lumbar region [1-12]. From a clinical standpoint, the depth of the epidural space depends on the trajectory of the needle. Several attempts to relate this depth with patient-related parameters, such asweight and height, have proven to be ineffective for clinical use [13-15]. Since the 1980s studies have shown a strong correlation between the depth of the lumbar epidural space as measured by ultrasound and the distance of the needle from the skin to the epidural space as observed by the loss of resistance techniquethus, ultrasound has been considered a useful tool to identify the depth of the epidural space and its anatomical structures in the lumbar region [2,3,6,7,9].

Less information is available regarding the utility of ultrasonography in determining the depth of the thoracic epidural space. Consequently, we performed a study to visualize thoracic spine anatomy, to evaluate the accuracy of ultrasonography in measuring the depth of the epidural space in the thoracic region compared to a gold standard (loss of resistance technique) and to determine the best needle insertion point to limit the number of puncture attempts.

Methods

The primary outcome was the feasibility and accuracy of ultrasonography to measure the depth of the epidural space and the correlation with the actual depth recorded at the time of loss of resistance. The secondary outcome was the accuracy of the ultrasonography in defining the best needle insertion point based on the frequency of the needle redirection, or the use of different insertion points other than the one defined by ultrasound scan.

After approval of the IRB at the University of Massachusetts Medical School, the study was conducted at UMass Memorial Medical Center between May 2010 and March 2011. Inclusion criteria included patients with an age greater than 18 years who were scheduled for an elective surgical procedure under general anesthesia and who were to undergo thoracic epidural catheter placement for post-operative pain control. Exclusion criteria included pregnancy, patients with an absolute contraindication to thoracic epidural placement (e.g.severe scoliosis or deformity, previous spine surgery in the thoracic region with or without hardware placement or anticipated postoperative mechanical ventilation for a period more that 24 hrs). All patients gave a written consent to be enrolled in the study and for epidural catheter placement.

The study was conducted in the Surgical Admission Care Unit (SACU). An intravenous catheter was inserted and routine ASA monitors and maximum barrier precautions were used during epidural catheter placement.

Ultrasound scan technique

All ultrasound scanning was performed using a GE logic E portable machine.

Using a curvilinear probe (2-5 MHz) both longitudinal paramedian and transverse scans were done before the placement of the epidural catheter. The scanning was performed in the sitting position with the back in a curved position. Measurements were taken on the still image after freezing the scan (Figure 1). Once the best image of the interspace structures was captured and with the transducer stabilized, the skin was marked at the midpoints of the cephalad and caudad aspects and at the midpoints of the right and left aspects of the transducer. The transducer was removed, and lines were drawn to connect these marks. The puncture site was determined by the intersection of these 2 lines. The US Depth (UD), that is, the depth to the epidural space or the distance from skin to Ligamentum Flavum (LF), was measured using built-in calipers on the US machine (Figure 2). The UD was also

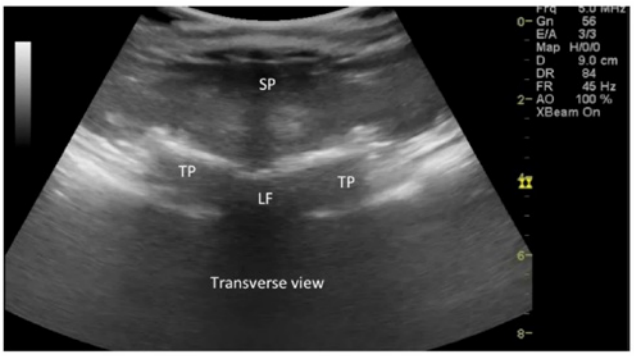

Figure 1:

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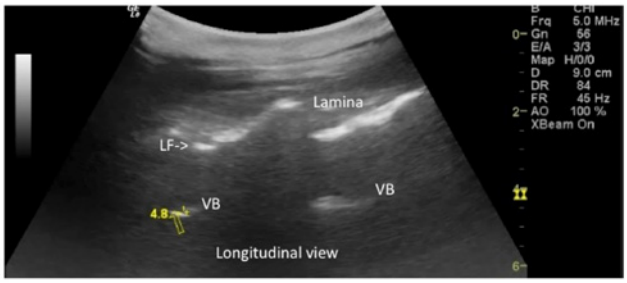

Figure 2:

performed on the transverse view to improve the power and accuracy of the measurements.

The primary investigator reviewed all Ultrasound scans and measurements.

Epidural Catheter placement

The epidural catheter was placed using the standard technique. Patients received IV sedation prior to the epidural placement with midazolam 2 mg IV ± Fentanyl 100 mcg IV if needed.

Under sterile conditions, the defined insertion point was infiltrated with lidocaine 1%. A 17 gauge 10 cm epidural needle (B. Braun, Bethlehem, PA) was utilized for locating the epidural space by the loss of resistance to air or saline technique. Once the loss of resistance was established, the depth of the needle was marked and recorded using the markings on the needle. A 19-gauge wire enforced epidural catheter (B. Braun) was inserted 5 cm passed the loss of resistance depth. After securing the catheter in place and establishing negative aspiration, a test dose was given which included a 3 ml of Lidocaine 1.5% mixed with epinephrine 1:200,000. A base line blood pressure was recorded at this point and compared with another blood pressure measured 10 minutes from the first recording. Data that were collected included whether not the catheter was placed with a needle hold, the occurrence of a sympathectomy 15 minutes after the test dose, sensory level in the PACU after dosing the catheter, and the pain level and score on post-operative day number one (numeric pain score).

The number of attempts was defined as the number of skin puncture points by a single provider or the number of providers attempting catheter insertion at the same insertion point. Due to inconsistency in the literature about the significance of the angle of insertion, the lack of a reliable angle determination method and the variable angle used by anesthesiologists ranging from 90-120 degrees, the insertion angle was not defined.

Assessing the Function of the epidural catheter

The success of epidural catheter placement was based on a combination of several criteria: 1) The ease of catheter threading into the space with or without needle hold; 2) presence of a sympathectomy within 15-20 minutes of dosing with 5 ml of bupivacaine 0.25%; 3) The establishment of a sensory level in the Post anesthesia Care Unit (PACU); and 4) The use of IV rescues opioid pain medications in the PACU and on post-operative day one.

Patients were divided into three groups according to the function of the catheter:

Functioning epidural: no supplementation with iv/po opioids to treat pain that would be expected to be covered by the epidural and the epidural was used as the primary pain control modality.

Non-functioning epidural: multiple attempts to achieve pain control with the catheter failed and an alternative pain modality was chosen (e.g. PCA, iv/po opioids) and the epidural catheter was removed.

Partially functioning epidural: the epidural catheter was partially controlling the pain and at least one side of the sensory level or bilateral partial dermatome sensory block was able to be established. The catheter was kept in place with the addition of PCA supplementation after epidural splitting (epidural local anesthetic only with iv pain medication supplementation).

Statistical analysis

The distributional characteristics of the measures were evaluated using the Kolmogorov Smirnov Goodness of Fit Test for Normality. We used the Pearson Correlation analysis to evaluate between the Ultrasound measured Depth (UD) and the Actual Depth (AD) detected by loss of resistance technique. Loss of Resistance (LOR) was modeled using a general linear model (linear regression with a categorical term for gender). Differences by gender groups were evaluated using Student's t-tests.

Results

Twenty-nine patients participated in the study. The mean age was 55 ± 18 years and, 17 (58.6%) were males. The mean height of 165.64 cm ± 11 cm and weight was 78.9 ± 21.0 kg. Mean BMI 27.7 ± 6.1 kg/M^2. Patients underwent vascular surgery (5[17%]) urological surgery (5[17%]), general surgery (14[48%]) and thoracic surgery (4([14%]) [1].

Mean UD was 4.22 ± 0.82 cm and the mean AD was 5.59 ± 1.29 cm. The Pearson correlation coefficient between AD and Ultrasound Longitudinal USL, Ultrasound Short axis USS were 0.637 and 0.566, {respectively} [2].

The mean number of attempts was 1.96 ± 1 [3].

The use of the ultrasound was able to identify the depth of the thoracic epidural space in 24/29 of the cases[4].

The catheter was considered at least partially functioning in 26/29 patients (20 functioning, 6 partially functioning [89.65%]). One patient could not be initiated and assessed as the patient remained incubated after surgery and the catheter was removed before function could be established. Data for One patient was not available, one catheter was considered to be non-functioning.

Statistical results

UD Long, UD short and LOR were all found not to significantly deviate from the normal distribution [5].

There was a significant difference between genders on LOR but not UD short or UD Long (p=0.028)LOR was significantly associated with UD short and UD long (r=0.637 and 0.566 respectively). When LOR was modeled as a function of gender and UD short or UD Long gender remained significant though interaction was found, hence gender has a independent contribution to predicting LOR.

UD Long with gender accounted for a larger proportion of the variability in LOR than did UD short and gender i.e. r^2=0.495 vs. 0.453 respectively, (or 49.5% of the variation vs. 45.3% of the variation in LOR).

In reference to complications of epidural catheter placement, there was one case of wet tap, one case of hypotension required removal of the catheter on post-operative day one and one catheter was removed and replaced in the ICU. There were no cases of paresthesia or other major neurological complications.

Discussion

This study showed a good correlation [6] between the actual depth of the epidural space as detected by the loss of resistance and epidural depth measured by ultrasound technique in the thoracic region. Since the 1980's, a number of studies have been published on the use of Ultrasonography to measure the depth of the epidural space, many of which were performed in the lumbar region [1-9]. This study (like the lumbar investigations) revealed that the ultrasound is capable of obtaining a fair quality of ultrasound in a high percentage of patients (83%) of a different body habitus.

Unlike other studies which advocated only the transverse approach [3,7] or the paramedian approach [1,2] we used both approaches [7,12].

It was not clear from this study whether or not the use of ultrasound to define the insertion point helped in reducing the number of attempts to place the epidural catheter. Our mean number of attempts was 2 ± 1 whereas Grau reported a mean of 1.3 ± 0.5 [12].

One limitation of this study was that the angle of insertion was neither determined nor measured. The anesthesiologist who inserted the epidural catheter was given instructions to start at 90 degrees to the skin and has the liberty to angle the needle in a cephalad direction in small increments until the intralaminal space has been found. The inability to accurately measure the angle of insertion has been reported in Balki's study [3]. The variable angle of insertion used in this study could contribute to the difference between UD and AD.

Conclusion

Ultrasonography can be used to measure the depth of thoracic epidural spacewith a good correlation with the actual depth as detected by the loss of resistance technique. More studies need to be performed in the thoracic region in order to determine whether the use of ultrasound can improve the success of epidural catheter placement.

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