Sonographic Estimation of Needle Depth for Cervical Epidural Blocks

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BACKGROUND: Cervical epidural steroid injections are often used to treat acute and chronic pain syndromes involving the face, neck, and upper extremities. Ultrasound has evolved as a valuable tool for performing neuraxial blocks, providing useful prepuncture information on the structure. Our goal was to evaluate the accuracy and precision of ultrasound by comparing skin to dura distance from ultrasound with the actual skin to epidural depth.

METHODS: We enrolled 50 patients undergoing cervical epidural blocks at the pain clinic. Ultrasound images with transverse and longitudinal median views of the C6/7 area were taken. The epidural needle was inserted, reproducing the direction of the ultrasound beam on the longitudinal median view. Measured distances from skin to dura on each ultrasound view were compared with the actual needle depth. Additionally, we examined ultrasound visibility, the number of puncture attempts, and any complications related to the procedure.

RESULTS: Concordance correlation coefficients between the measured distances on ultrasound and actual needle depth were 0.9272 and 0.9268 on transverse and longitudinal median view, respectively. The cervical epidural block was successfully performed on 48 patients (96%). There were two incidents (4%) of dural puncture. No bloody taps, postprocedure complications, or hemodynamic instability related to cervical epidural blocks occurred.

CONCLUSIONS: Ultrasound provides very accurate information on the skin to dura distance for epidural blocks in the cervical spine. Knowledge of skin to dura distance and a preview of spinal anatomy before puncture can more safely identify the epidural space.

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Cervical epidural steroid injections are often used to treat acute and chronic pain syndromes involving the face, neck, and upper extremities. Between 64% and 76% of patients receiving these injections report subjective improvement in pain management. The risks associated with performing cervical epidural blocks (CEBs) are higher than those of lumbar epidural blocks.

In an anatomical study of the cervical spine, the proximity of the spinal cord to the cervical epidural space is much smaller when compared with lumbar levels. Reportedly, there is also a higher incidence of discontinuity in the ligamentum flavum. Both of these factors can result in an increased failure rate when performing CEBs. Inadvertent dural puncture may lead to postdural puncture headaches and even arachnoiditis if steroids are administered intrathecally. The risk of spinal cord injury is probably the most serious complication that may occur when performing CEBs. Only highly experienced physicians should perform these procedures.

According to prior imaging studies on the epidural structures, knowledge of the location of the epidural space aids in the success of epidural blocks. It is also safe to assume that knowledge of the epidural space depth for CEBs will be facilitated by taking prepuncture measurements.

Ultrasound has evolved as a valuable tool for performing neuraxial blocks, providing useful prepuncture information on neuraxial structures. The skin to epidural space distance (needle depth, ND) measured by ultrasound confirms needle depth specifications and helps the lumbar epidural blocks. Our goal was to determine whether ultrasound could provide accurate information by comparing the skin to dura distance obtained from an ultrasound scan (ultrasound depth, UD) to the distance measured by the actual epidural needle depth in the cervical region.

METHODS

After approval by the Local Ethics Committee (Severance Hospital IRB), written informed consent was obtained from all 50 patients undergoing CEBs at the
pain clinic. Demographic data (sex, age, height, and weight) were obtained. Patients with spinal anomalies, infectious diseases, drug allergies, and coagulopathies were excluded from the study.

All patients were monitored using electrocardiographs, noninvasive arterial blood pressure monitors, and pulse oximetry in the treatment room at the pain clinic. CEBs were performed on patients in a sitting position bending forward and holding a pillow, so that the cervical spine was parallel to the floor. After palpat- ing spinous processes of the cervical spine, we marked a needle insertion point at the midpoint of the C6/7 interspace, noting that C7 was the most prominent spinous process. Before the epidural block, ultrasound examination was performed at the marked point using a 5–7 MHz linear probe (SONOACE-8800™, Medison CO Ltd., Seoul, Korea). On “frozen images” of transverse and longitudinal median views, UD was measured in 0.1-mm intervals using the built-in caliper on the ultrasound machine (Fig. 1). The optimal puncture angle was also measured between the expected trajectory of the needle and the line perpendicular to the skin from the marked insertion point on longitudinal median view using the built-in protractor. Visibility using the ultrasound was identified as “invisible (cannot define),” “hardly detectable (can define with manipulation of probe),” “detectable (can define without manipulation of probe),” or “very well defined (can define the corpus of the vertebra).” All ultrasound examinations were performed by one pain physician (D.M. Yoon).

Figure 1. Ultrasound imaging of cervical vertebra 6–7. A, Transverse view shows the vertebral body, ligamentum flavum, and dura mater. B, Longitudinal median view shows the spinous process, ligamentum flavum, and dura mater.
After bactericidal preparation, epidural needle insertion was performed following a midline approach using a 22-gauge × 70.0-mm epidural needle (Muraco Medical Co., Tokyo, Japan) with a rubber stopper. The needle was introduced at the optimal puncture angle on the marked insertion point using a goniometer, reproducing the direction of the ultrasound beam from the longitudinal median view. When necessary, the needle was reintroduced at a steeper angle and advanced millimeter by millimeter. The epidural space was identified by observing the spontaneous inflow of a drop of saline placed in the needle hub (an alternative to the hanging-drop method). The epidural space was reconfirmed through the loss-of-resistance technique using normal saline.14 Once the epidural space was identified, the depth of the needle in the skin was marked with a rubber stopper. The actual ND was measured by 0.05-mm intervals using a Vernier Caliper (Mitutoyo Co., Kawasaki, Japan). All epidural block procedures were performed by one fellowship trainee (S.H. Kim).

Descriptive statistics were calculated using means and standard deviations for continuous data and percentages for discrete variables. We used concordance correlation coefficient (CCC) to evaluate agreement between UD and ND.12,15 CCC provides sound intuitive interpretations because they include components of both precision (degree of variation) and accuracy (degree of location or scale shift). Bland–Altman analysis was performed to determine the magnitude of the difference between the two measurements.16,17

The sample size required 43 patients to determine the probability of detecting a significant concordance between UD and ND setting the baseline CCC as 0.7, assuming 90% power and an α-error of 5%, based on the correlation coefficient (0.881) of the previous study.12 We chose to evaluate 50 patients to compensate for possible protocol violations during the study period. According to the CCC between UD on longitudinal view and ND (Table 1), the sample size of 50 achieved 99.9% power to detect a difference of −0.9258 using a one-sided hypothesis test with a significance level of 0.01. All statistical calculations were performed using MedCalc software 9.3.6.0 (MedCalc Inc., Mariakerke, Belgium). We also evaluated the number of needle puncture attempts to identify the epidural space as well as any complications that occurred.

RESULTS

We collected data on 50 patients between May and August 2007. Patients ranged in age from 21 to 81 years, and body mass index ranged from 14.30 to 29.36 (mean, 21.94 ± 4.79) (Table 1). ND was 45.73 ± 6.84 mm (range, 31.55–60.45) while UD was 45.56 ± 6.64 mm (range, 32.70–62.30) in the transverse view, and 45.67 ± 6.53 mm (range, 33.60–60.90) in the longitudinal median view (Table 1).

UD in the transverse view showed slightly higher CCC with ND (CCC = 0.9272, 95% CI: 0.8755–0.9579, accuracy 0.9992) when compared with longitudinal median view (CCC = 0.9258, 95% CI: 0.8735–0.9570, accuracy 0.9989) (Table 2, Fig. 2). Bland–Altman analysis between UD and ND indicated a mean difference of ±1.96 so with +0.2 ± 5.0 mm in the transverse view and +0.1 ± 5.0 mm in longitudinal median view (Fig. 3). Visibility of anatomical structures on the ultrasound was defined as “hardly detectable” in five patients, “detectable” in 27 patients, and “very well defined” in 18 patients (Table 3.) CEBs were successfully performed in 48 patients (96%). There were two incidents (4%) of dural puncture. No bloody taps, postprocedure complications, or hemodynamic instability related to CEBs occurred.

Table 1. Demographic Data

| Gender (male/ female) | 19/31 | N/A |
| Age (yr) | 52.04 ± 14.29 | (21–81) |
| Height (cm) | 161.85 ± 7.18 | (150.0–178.0) |
| Weight (kg) | 60.86 ± 10.72 | (42.0–86.0) |
| Body mass index (kg/m²) | 23.16 ± 3.18 | (14.30–29.36) |
| Ultrasound depth a (mm) | | |
| Transverse view | 45.56 ± 6.64 | (32.70–62.30) |
| Longitudinal view | 45.67 ± 6.53 | (33.60–60.90) |
| Needle depth b (mm) | 45.73 ± 6.84 | (31.55–60.45) |

a Ultrasound depth, measured distance from skin to dura using ultrasound in each view.
b Needle depth, actual epidural needle depth from skin to epidural space.

Table 2. Agreement Between Ultrasound Depth and Needle Depth

| Concordance correlation coefficient | 95% Confidence interval | Precision (Pearson’s r) | Accuracy (Bias correction factor) | P |
| UD a vs ND b (transverse) | 0.9272 | 0.8755–0.9579 | 0.9279 | 0.9992 | <0.001 |
| UD vs ND (longitudinal) | 0.9258 | 0.8735–0.9570 | 0.9268 | 0.9989 | <0.001 |

a UD, measured distance from skin to dura using ultrasound in each view.
b ND, actual epidural needle depth from skin to epidural space.
DISCUSSION

At the pain clinic, cervical epidural steroid injections are widely used for the management of a variety of acute, chronic, and cancer-related pain syndromes involving the face, head, and upper extremities. Because of concerns of potentially serious complications and difficulty in identifying the epidural space because of anatomic variations, accurate CEBs are not always feasible. Information on the optimal puncture angle and point of the needle (expected angle and depth) could increase success in cervical epidural puncture processes. Some researchers have tried to provide clinically useful information for CEB procedures but, with the exception of information about measured distances using magnetic resonance imaging (MRI), findings from these studies have not be validated for use in clinical practice.\textsuperscript{10,18}

In our study, the needle was introduced at the optimal puncture angle on the marked insertion point, reproducing the direction of the ultrasound beam in the longitudinal median view. The CCC for epidural needle depth and measured distance from the transverse and longitudinal median views were 0.9272 and 0.9258, respectively. Based on our results, the expected depth can be predicted from the ultrasound views.
within a range of ±5.0 mm. This implies that ultrasound provides very accurate measurements of ND in cervical spine regions.

When using ultrasound to measure ND, measuring the distance from the skin to the inner surface of the ligamentum flavum is the most accurate method. According to Lirk et al., however, the cervical ligamentum flavum may be discontinuous from the midline in 58%-74% of patients, making it difficult to identify the ligamentum flavum with ultrasound, thus leading to inaccurate measurements of epidural depth. Therefore, we used the UD as the epidural depth in this study. The actual needle depth was longer than the measured distance determined by ultrasound (Table 1). Because the UD measured by ultrasound is the shortest possible distance of the epidural needle, even the slightest deviation in the needle insertion angle from the midline will result in longer needle lengths compared with the measured distance.

Ultrasound has the potential to become a valuable tool in determining the correct placement of neuraxial blocks. For epidural blocks, pre puncture measurements using ultrasound facilitate lumbar epidural catheterization. When conducting ultrasound for neuraxial blocks, it is possible to obtain pre puncture measurements in the neck-flexed sitting position, which is the position used for CEBs. Because MRI or computed tomography imaging is only possible in a special setting, ultrasound has the merit of providing relatively accurate information that can be directly applied in practice. The use of ultrasound imaging for teaching epidural anesthesia in obstetrics also demonstrated a higher rate of success compared with conventional techniques. There are some limitations when measuring the UD or ligamentum flavum with ultrasound. The ultrasound approach to the epidural space is complicated by vertebral bones surrounding the spinal and epidural space, particularly in the thoracic levels. In CEB cases, the ultrasound approach to the cervical epidural space is not as complicated as in thoracic epidural spaces. The angle between the spinous processes in the 6th and 7th cervical spine is less acute than that in the thoracic spine in the neck-flexed position. The dura mater, the inner surface of the ligamentum flavum, can be visualized in the cervical and lumbar spine using ultrasound.

Aldrete et al. reported that epidural spaces above C6 are difficult to identify in axial and sagittal MRI views and that distances from the ligamentum flavum to the dural sac, representing the depth of the epidural space, averaged 0.3 cm (C6/7) and 0.4 cm (C7–T1). Han et al. reported that the greatest depth from the skin to the epidural space is at the C6/7 and C7–T1 levels, and that decreases in depth occur with the presence of fatty tissue along the lower cervical and upper thoracic areas. In lumbar epidural blocks, it has been determined that the shallower the depth from the skin to the epidural space, the greater the risk of dural puncture. The incidence of dural puncture is three times higher in patients with 2–4 cm of lumbar epidural space depth than in patients with 4–6 cm of epidural depth. For these reasons, we decided to perform the ultrasound examination and puncture only at the C6/7 level on all patients, allowing us to reduce the risk of dural puncture and more easily identify the dura mater.

Because the cervical ligamentum flavum may be discontinuous in the midline, the loss-of-resistance method may be problematic when used as the sole confirmation method in CEBs. To prevent the false loss-of-resistance, we confirmed the spontaneous inflow of a drop of saline into the epidural space (hanging-drop method). Additionally, we checked the epidural space using the loss-of-resistance method with a syringe filled with normal saline.

There are some limitations in the present study. First, we did not use real-time ultrasound imaging technique for the CEBs. A real-time ultrasound technique provides an accurate reading of the location of the needle tip and is helpful in procedures. The paramedian approach could be applicable during real-time monitoring, whereas the midline approach was used for CEB in our study. During the midline approach for the CEB, the operator’s hands can interfere with the probe on the paramedian longitudinal plane. Second, visualization of the distribution of epidural medication can be limited by ultrasound, whereas the fluoroscopy and epidurography can show the spread of contrast to the area of pathology. Third, the incidence of inadvertent dura puncture was not significantly reduced in our study. A real-time ultrasound imaging technique can reduce complication rates during the procedure.

According to previous studies, knowledge of the location of the epidural space improves the success of lumbar epidural puncture. Ultrasound imaging for CEBs is a new technique that improves the quality of puncture diagnostics for neuraxial analgesia and may also reduce the possibility of complications. Ultrasoundography, which is less invasive, faster, more mobile, and easier to handle than other imaging techniques, is a useful tool for properly identifying the epidural space.

REFERENCES