Posterior epidural space depth: safety of the loss of resistance and hanging drop techniques

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We have compared skin to epidural space distance (SED) and tip to tip distance (TTD), a measure of posterior epidural space depth (PESD), in 40 patients with a 27-gauge Whitacre needle after identification of the epidural space using the hanging drop (HD) or loss of resistance (LOR) to air technique. After the LOR technique, TTD was found to be 2 mm greater than that after the HD technique, whereas SED was the same. We conclude that identification of the epidural space can be performed successfully with both techniques, but with a diminished risk of dural damage after LOR compared with the HD technique.

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The anatomy of the posterior epidural space is variable. At the intervertebral level, a real space exists containing fat and connective tissue, but it only exists potentially at the vertebral level. Post-dural puncture headache (PDPH), caused by inadvertent perforation of the dura, is one of the most frequent complications of epidural anaesthesia. For this reason, several techniques have been advocated for epidural anaesthesia. The two most commonly used are the loss of resistance (LOR) and hanging drop (HD) techniques. During the LOR technique, the injectate pushes the dura mater forward and compresses the dural sack. This was confirmed by magnetic resonance imaging after epidural blood patch. Recently, several authors have showed interest in measuring the skin to epidural space distance (SED) and the posterior epidural space distance (PESD). Both factors may be important in the success rate and complication rate of epidural anaesthesia.

In this study, we have investigated the hypothesis that both efficacy and complication rate are better with the LOR technique compared with the HD technique. Also, we quantified the influence of injecting small volumes of air on PESD during LOR.

Methods and results

After obtaining approval from the Hospital Ethics Committee and informed consent, we studied 40 patients undergoing neurosurgical procedures for which an indwelling lumbar intrathecal catheter was required. Via this catheter, cerebrospinal fluid (CSF) 30–40 ml was withdrawn to lower intracranial pressure during the intraoperative period. All procedures were performed by the attending anaesthetist with the patient fully awake and co-operative. After placement of venous and arterial catheters, patients were placed in the lateral position. In all patients, a combined spinal–epidural tray with a lockable spinal needle (Durasafe-Adjustable, Becton-Dickinson, Franklin Lakes, NJ, USA) was used. After sterilization and local anaesthesia of the skin, a 17-gauge Tuohy needle was placed in the vertebral interspace L2–3 or L3–4. The epidural space was identified randomly using either the HD or the LOR to air technique. With the HD technique, the needle was filled with saline and advanced until a clear inward movement of saline, as a sign of reaching the epidural space, was observed. With the LOR technique, a syringe filled with air 4 ml was placed on the Tuohy needle. While slowly advancing the needle, resistance to injection of air was examined constantly until clear loss of resistance identified the epidural space. All 4 ml of air were injected. The distance from the skin to the epidural space (SED) was read from the Tuohy needle and rounded to the nearest 0.25 cm.

Subsequently, in both groups, a 27-gauge lockable Whitacre spinal needle was introduced and advanced slowly. As soon as the dural click was felt, the needle was locked and the stylet removed to look for backflow of CSF to confirm subarachnoid placement, followed by removal of the spinal needle in its locked position. With the stylet inserted, the Tuohy needle was advanced slowly until a dural click was felt. Again, subarachnoid placement was confirmed by backflow of CSF. Finally, a 19-gauge spinal catheter was introduced after which general anaesthesia was induced.

After the procedure, the locked Whitacre needle was
Table 1 Patient data, SED and TTD (mean (SD) [range]) using the loss of resistance (LOR) and hanging drop (HD) techniques. **P<0.01

<table>
<thead>
<tr>
<th></th>
<th>LOR</th>
<th>HD</th>
<th>P</th>
<th>Mean diff. (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>54.8</td>
<td>59.1</td>
<td>0.34</td>
<td>—</td>
</tr>
<tr>
<td>BMI (kg m⁻²)</td>
<td>26.34 (4.02)</td>
<td>26.38 (4.43)</td>
<td>0.98</td>
<td>—</td>
</tr>
<tr>
<td>SED (cm)</td>
<td>5.4 (0.6)</td>
<td>5.4 (0.8)</td>
<td>0.91</td>
<td>0.05</td>
</tr>
<tr>
<td>[4.0–6.3]</td>
<td>[4.0–7.0]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTD (mm)</td>
<td>7.1 (2.4)</td>
<td>4.7 (2.5)**</td>
<td>0.004</td>
<td>2.8</td>
</tr>
<tr>
<td>[2.2–13.3]</td>
<td>[1.9–9.8]</td>
<td></td>
<td></td>
<td>(1.2–4.5)</td>
</tr>
</tbody>
</table>

again introduced into the Tuohy needle and its extension beyond the tip of the Tuohy needle was measured with calliper compasses (accuracy 0.05 mm) and noted as the tip to tip distance (TTD), a measure of SED. Taking into account design and size of both needles, TTD can be assumed to slightly underestimate SED.

The spinal catheter was withdrawn directly after operation. All patients were awake and their tracheas extubated before transfer to the intensive care unit. All patients were transferred to the ward the next day where further follow-up was performed by the neurosurgeons familiar with PDPH. Excessive headache, dependent on the posture of the patient and lasting for more than 3 days, was treated with an epidural blood patch performed by an anaesthetist.

A two-tailed Student’s t test, paired or unpaired when appropriate, was used for statistical analysis (StatView 4.0 on a Macintosh 6320 computer). P<0.05 was considered statistically significant.

Patient data in the two groups were comparable (Table 1). The epidural space was identified easily in all 40 patients. No accidental dural taps occurred with either technique. In every patient, a distinctive click with both needles preceded backflow of CSF fluid. An epidural blood patch was necessary in 10% of patients (two in each group).

Mean SED was 5.4 cm in both groups (ns) (Table 1). Mean TTD was 7.1 mm in the LOR group and 4.7 mm in the HD group (Table 1). This difference was statistically significant (P=0.004). The mean of the difference was 2.8 mm (95% confidence interval 1.2–4.5).

Discussion

The epidural space is a potential space in the areas where bone or ligaments contact the dura. However, it does have contents in other areas. This compartmentalization of the epidural space was demonstrated in anatomical and radiological studies. As the ligamentum flavum has a somewhat oblique course (more dorsal at the cranial than at the caudal attachment), PESD varies at each intervertebral level (mean 4–7 mm), depending on whether a cranial or a caudal approach is used. Several methods have been developed to identify the epidural space. Of these, the LOR technique is favoured, whereas the HD technique may be of value in placing thoracic epidurals because of the intrinsic negative pressure within the thoracic epidural space. Several authors demonstrated the absence of a true negative pressure in the lumbar epidural space, whereas a generated negative pressure was detected caused by the sudden recoil of the ligamentum flavum at the moment of perforation.

Accidental dural puncture followed by PDPH is one of the most frequent complications of epidural anaesthesia. Although without serious consequences, PDPH can be very debilitating. Some studies estimated that an SED of less than 4 cm was associated with up to a three-fold greater risk of accidental dural puncture. For this reason, the distance from the skin to the epidural space has been the subject of several studies. However, it seems logical that other variables are also likely to determine the occurrence of dural perforation.

In our study, SED was comparable with both techniques. This indicates that the HD technique may be equally effective in identifying the lumbar epidural space. In contrast, one can assume that with the LOR technique, the pressure difference between the period of passage through the ligamentum flavum and the moment of perforation is accentuated compared with the HD technique because of the pressure exerted on the plunger of the LOR syringe. In more difficult cases, this could be an advantage.

Epidural anaesthesia or analgesia is often used in obstetric practice. Because of the numerous changes that take place during pregnancy, including changes in the epidural space, it is uncertain if the HD technique is suitable for routine obstetric practice.

The HD technique may be regarded as an illogical choice to identify the lumbar epidural space because of the absence of a true negative pressure in this region. Although the number of patients in our study was limited, a clear inward movement of the hanging drop was noted in every case. This may indicate that the generated negative pressure during the HD technique is more important than absolute pressure within the epidural space.

Measurement of PESD has been subject of other studies. Invasive measurements are likely to be influenced by factors such as resistance of the dura to needle penetration, age, the chosen interspace, needle design, the applied locoregional and the angle of the Tuohy needle. Furthermore, in this discussion, we have to take into account that a Whitacre needle has a side hole and that measurement of the distance by which the tip of the Tuohy needle has entered the epidural space is impossible. However, even when taking these limitations into consideration, our data are comparable with those of non-invasive studies using magnetic resonance imaging (mean PESD 6 mm, range 4–9 mm), particularly after the HD technique.

Our results showed that TTD was greater after the LOR technique compared with the HD technique. The most plausible hypothesis for this observation is widening of the epidural space by the injectate, although only small volumes of air were injected. This is in accordance with compression of the dural sack, as observed in MRI studies after injection of autologous blood. This implies that at the lumbar level,
the LOR technique diminishes the risk of damaging the dura mater compared with the HD technique.

In summary, we found no differences between the LOR and HD techniques in accuracy and safety for identifying the lumbar epidural space. However, as a safety margin is created by the injection technique, this may be preferred at the lumbar level.

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