Ultrasonographic control of the puncture level for lumbar neuraxial block in obstetric anaesthesia

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Background. Errors in the judgement of puncture level during neuraxial anaesthesia can lead to significant complications. The aim of this study was to assess, in obstetric anaesthesia, the accuracy of clinical determination of the lumbar spinal interspace level, using surface ultrasound imaging as control.

Methods. At the anaesthesia follow-up visit, women who had received lumbar neuraxial anaesthesia during labour were prospectively included. The intervertebral level of needle insertion, located by the needle scar position, was identified by ultrasonography and compared with the clinical level reported on the chart by the anaesthetist who performed the block.

Results. Ninety-nine women were studied. The clinical puncture level was accurate in 36.4% of patients. Ultrasound examination showed the puncture level to be more cephalad than the level noted in the anaesthetic record in almost 50% of patients. In 15% of patients, the puncture level was more caudad than the anaesthetist had assessed. Factors including type of anaesthesia, indication, time period, level of anaesthetic experience, BMI, and spinal pathology did not seem to influence the frequency of errors.

Conclusions. The observed differences between clinical and ultrasonic identification of spinal puncture level highlight the potential for serious complications associated with the performance of neuraxial blocks above the spinous process of L3 in the parturient. With the increase in popularity of techniques involving puncture of the dura mater for labour anaesthesia, we feel that awareness of this risk is important.

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Iatrogenic neurological deficits after neuraxial block are rare.1 However, recently, there has been an increase in incidence of severe neurological trauma after spinal anaesthesia, particularly at the level of the conus medullaris. These incidents occurred most often in the obstetric population and direct puncture of the spinal cord by the needle has been suggested as the mechanism.2–4

One of the reasons cited for the cause of these complications is the misjudgement of the intervertebral space by the anaesthetist; this has previously been reported in radiological5 and surgical6 (hip surgery) studies. These studies have shown that the error is usually made in a cephalad direction (i.e. the true puncture level was higher than the predicted). None of these studies have been carried out in the obstetric setting. Furthermore, it has been shown that palpating Tuffier’s line to ascertain the intervertebral level can lead to errors in a cephalad direction, particularly in obese patients.5 The same may apply to the pregnant women.

Another factor that must be considered is the variability in the level of the end of the conus medullaris. This has been shown to reach the upper part of the body of L2 in 43% of women and 27% of men.7 8 Finally, the need to angle the needle in a cranial direction and the increasing use of combined spinal-epidural techniques may present additional risk factors for
iatrogenic injury by direct contact of the needle with the spinal cord.

The aim of this prospective study was to assess the reliability of the usual anatomical landmarks in identifying the intervertebral puncture level for neuraxial anaesthesia in the clinical setting of the obstetric patient in labour.

Methods

Local Ethics Committee approval was obtained, and all patients and anaesthetists gave their informed consent to be involved in this non-interventional study. Inclusion criteria were pregnant women having undergone a neuraxial block for labour, the ability to adopt the required position for ultrasonography, and the ability to understand and communicate.

Between 24 and 72 h after delivery, patients were reviewed on the ward by a single independent investigator, unaware of what had been recorded on the chart by the anaesthetist who performed the block. The investigator collected the patient details including age, height, BMI at the time of delivery, and history of any spinal pathology such as lumbar back pain, arthritis, sciatica, scoliosis, and previous lumbar spine surgery.

The patient was examined both clinically and with ultrasound in the same position in which the block had been performed. In cases of multiple punctures and inability to identify the puncture scar, patients were excluded.

A portable ultrasound machine (Tosbee™, Toshiba, Tokyo, Japan) fitted with a soft tissue probe (3.7 MHz) was used to identify the sacrum. The image of the sacrum appeared as a continuous hyperechogenic band. The probe was then moved in a cranial direction to identify the lumbar spinal processes, recognized as hyperechogenic signals with a posterior shadow cone. The intervertebral spaces were seen as areas of hypechochogenicity surrounding zones of hyperechogenicity. If the imaging quality was poor, making identification of the intervertebral spaces uncertain, the patients were excluded from the study.

The intervertebral level of the puncture scar on the skin was established using ultrasound and recorded as the echoraphic level (EL). The following information was then retrieved from the anaesthetic record: type of anaesthesia (spinal, epidural, or CSE), the indication (analgesia for epidural, or CSE), the indication (analgesia for block for labour, the ability to adopt the required position (4D Inc. San Jose, USA) to allow crossed analysis of the different variables. The calculations were performed by solving Fleiss equations9,10 on an excel spreadsheet (Excel™, Microsoft, Seattle, USA) and by using statistical software (SPSS 10.0™ for Windows, SPSS Inc. Chicago, USA; MH program, Version 1.2; Cohen’s unweighted Kappa, VassarStats). P<0.05 was considered significant.

Results

Twenty anaesthetists treated 128 patients; of whom 29 were excluded because of the following reasons: multiple puncture sites at different intervertebral levels (16 patients), inability to identify the puncture point scar (7 patients), poor echogenicity (2 patients), and inadequate completion of anaesthetic record (4 patients). The final study population consisted of 99 subjects.

The mean (SD) age of the studied population was 28 (4.2) yr and the BMI was 28 (4.0) kg/m². No clinically significant spinal pathology was recorded or observed in this series despite reports of mild backaches and observation of minor scoliosis in 27 patients (Table 1). The spinal interspace levels determined on clinical examination by the anaesthesit and the interspace scar levels identified by ultrasonography are shown in Table 2. Statistical analysis by Kappa test showed the absence of agreement between the clinical and the ultrasound evaluations of the puncture levels (K=−0.027). The Stuart–Maxwell χ² test of marginal homogeneity showed the existence of a systematic error in clinical determination of the punctured level (P=0.0001).
Analysis of confounding factors did not reveal any contribution by these factors (Table 1).

The frequency of choice of intervertebral levels used for performing neuraxial block, the error and the direction of this error is shown in Table 3. There were no serious complications or neurological sequelae in this series.

**Discussion**

To our knowledge, this is the first clinical study carried out in the obstetric population which assesses, with ultrasound imaging, the actual intervertebral level punctured during neuraxial block. We found that the intervertebral level assessed clinically corresponded to the actual level imaged by ultrasound in only 36.4% of patients. This result is consistent with previous smaller studies, all carried out in non-obstetric populations, which showed error rates of 59–71%. A concerning result is that in these 99 patients, 6 punctures were actually carried out at the L1/L2 intervertebral space. At this level, there is considerable risk for neurological damage as the conus terminus may reach the body of L2 in 43% of women.

Errors in the caudad direction (neuraxial block sited lower than the anaesthetist thought) were more frequent.
Ultrasound in obstetric regional anaesthesia

Table 1 Potential confounding factors: none of these factors influenced the accuracy of the clinical estimation of the intervertebral space

<table>
<thead>
<tr>
<th>Potential confounding factors</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of block</td>
<td></td>
</tr>
<tr>
<td>Epidural anaesthesia</td>
<td>93 (93.9)</td>
</tr>
<tr>
<td>Spinal anaesthesia</td>
<td>6 (6.1)</td>
</tr>
<tr>
<td>Time of insertion</td>
<td></td>
</tr>
<tr>
<td>Day</td>
<td>54 (54.5)</td>
</tr>
<tr>
<td>Night</td>
<td>45 (45.5)</td>
</tr>
<tr>
<td>Indication of block</td>
<td></td>
</tr>
<tr>
<td>Labour analgesia</td>
<td>92 (92.9)</td>
</tr>
<tr>
<td>Caesarean section</td>
<td>7 (7.1)</td>
</tr>
<tr>
<td>Minor spinal pathology</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>27 (27.3)</td>
</tr>
<tr>
<td>No</td>
<td>72 (72.7)</td>
</tr>
<tr>
<td>Anaesthetist seniority</td>
<td></td>
</tr>
<tr>
<td>Junior</td>
<td>29 (29.3)</td>
</tr>
<tr>
<td>Senior</td>
<td>70 (70.7)</td>
</tr>
<tr>
<td>BMI (kg m(^{-2}))</td>
<td></td>
</tr>
<tr>
<td>&lt;30</td>
<td>72 (72.7)</td>
</tr>
<tr>
<td>&gt;30</td>
<td>27 (27.3)</td>
</tr>
</tbody>
</table>

Table 2 Contingency table crossing the clinically evaluated lumbar interspace level with the echographically evaluated level

<table>
<thead>
<tr>
<th>Clinical evaluation</th>
<th>Echographic evaluation</th>
<th>L1L2</th>
<th>L2L3</th>
<th>L3L4</th>
<th>L4L5</th>
<th>L5S1</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1L2</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>L2L3</td>
<td></td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>L3L4</td>
<td></td>
<td>4</td>
<td>28</td>
<td>29</td>
<td>7</td>
<td>1</td>
<td>69</td>
</tr>
<tr>
<td>L4L5</td>
<td></td>
<td>1</td>
<td>4</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>L5S1</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>6</td>
<td>38</td>
<td>44</td>
<td>10</td>
<td>1</td>
<td>99</td>
</tr>
</tbody>
</table>

(15.1%, up to two intervertebral spaces) than reported in previous studies (3–4% with a maximum of one intervertebral space).\(^5\)\(^6\) Another point noted in our study is that the more cephalad the intervertebral space chosen, the greater the error rate in the caudal direction (Table 3). We found a statistically significant difference between the clinical and ultrasound estimation of the intervertebral level. Possible causes for this include inaccurate landmark palpation, in particular the palpation of the iliac crests, and puncture point level lower than the anaesthetist’s horizontal eye plane leading to tangential vision of the surface landmarks. When aimed at the L4–L5 space, we found that the errors were usually in a cranial direction, which could support this theory. Conversely, if the iliac crest is palpated in front or behind its peak, this may lead to errors in identification of the spinal process of L4 by mistaking it for L5. This will promote puncture errors in a caudal direction.

The anatomical landmark of Tuffier’s line can be more difficult to palpate in pregnant women because of pregnancy-related changes in soft tissues and increase in BMI. Pregnant women have also a more pronounced lumbar lordosis. These elements, added to specific obstetric difficulties (neuraxial blockade is often carried out as an urgent procedure and during the night time), could explain why our results are slightly different from clinical studies performed in non-obstetric anaesthesia populations (errors: 64% in our study vs 59% in orthopaedic hip surgery).\(^5\)\(^6\) The fact that the errors we found in our series were more frequently observed in a caudal direction than published in previous studies may be attributed, at least in part, to learn from previous publications showing a tendency to overestimate the actual punctured level.\(^5\)\(^6\)

We have studied the puncture level using ultrasound imaging; a reliable, easy to learn, safe, and acceptable technique, starting with the identification of the sacrum and counting upwards. Other identification methods have been described, counting down the spinous processes from T12 using the 12th rib line as anatomical landmark, or from C7, directly identified as the vertebral prominens.\(^12\) Although these methods are applicable, they may be subject to a greater degree of uncertainty because errors could occur in counting a greater number of spinous processes and in the clinical identification of the spinal process of reference (T12 or C7). These methods rely on manual palpation of the spine and have not been shown to be as accurate as ultrasound imaging.

Using the same ultrasound probe (3.7 MHz), using a mixed patient population and with investigators new to ultrasonography briefed for only 5 min, Watson and colleagues\(^13\) reported a 76% agreement between ultrasound and MRI identification of the L3/L4 intervertebral space. This shows that ultrasound is an acceptable tool for the identification of spinal levels. Although ultrasonography allows accurate identification of the vertebral level, this technique unfortunately cannot identify the level at which the conus medullaris ends. Hence, because of the variable position of conus medullaris (Table 4),\(^7\) ultrasonography is unlikely to exclude completely the risk of its damage.

None of the potential confounding factors (type of anaesthesia, indication, time period, experience of
anaesthetist, spinal pathology, and BMI) were shown to significantly influence our accuracy in clinical identification of the vertebral interspace.

Epidurals performed at night have been shown to have an increased incidence of inadvertent dural puncture independent of the level of experience of the anaesthetist. Timing of the procedure did not influence the error rate in our series. Unlike studies looking at other practical procedures (orotracheal intubation or arterial cannulation), we found no difference associated with the level of experience of the anaesthetist. This highlights the usefulness of ultrasound imaging for all grades of anaesthetists as an aid to identify difficult intervertebral space.

In our study, we did not find increased BMI to be a significant confounding factor; however, these patients can present a particular challenge and we feel that the use of ultrasound can be very helpful in this situation by showing both the depth of the epidural space and the inclination of the interspace. Reports have already been published describing the role of ultrasound in obese parturients and in facilitating or rescuing difficult epidural needle insertion.

Patients who had multiple needle puncture points were excluded from the study (12.5% of patients recruited). This could represent a bias in our study results because more difficult cases have been excluded. However, showing a high rate of error, even in uncomplicated patients, can only serve to reinforce our study result.

In our study, the same investigator performed all of the ultrasound examinations thereby preventing operator variability. The patients were placed in the same position as they were in at the time of the block, aiming at placing the puncture scar in the same position in relation to deeper structures. Nevertheless, early postpartum changes in cutaneous tissues may have introduced a bias. However, these changes are more noticeable in the anterior abdominal wall than in the lumbar region.

The use of sacrum as a reference point can prove difficult as a result of anatomical variation at the lumbosacral junction. In ~6% of the population, there is either sacralization of the lumbar vertebra or lumbarization of the sacrum. The exact influence of this anatomical variability on our results is unknown, but is unlikely to be major. This anatomical variability and its possible influence on the echographic assessment was not taken into account in the study by Watson and colleagues. Nevertheless, the echographic assessment was validated by MRI control in this series with an agreement of 76% between both methods.

In conclusion, using ultrasound imaging, a safe, validated, non-invasive, radiation-free, easy-to-learn technique, we have shown that in obstetric patients the traditional methods of assessing the intervertebral level by palpation of Tuffier’s line is not a reliable technique, with an error rate of >60%. The evidence of puncture points up to three intervertebral levels higher than the expected highlights the potential risk, which is increased with higher target levels, and particularly if the target level chosen is above L3.

Anaesthetists must be aware of this risk, particularly when performing spinal or combined spinal–epidural anaesthesia in obstetric patients.

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