Evaluation of S1 motor block to determine a safe, reliable test dose for epidural analgesia

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Background. Accidental intrathecal injection of bupivacaine during epidural analgesia in labour remains a hazard, with the potential to cause total spinal anaesthesia and maternal collapse. Sacral block appears early after intrathecal injections compared with epidural ones, and we therefore used S1 motor block to determine a safe and reliable test dose for epidural catheter misplacement.

Methods. Mothers booked for elective Caesarean section were given various intrathecal doses of bupivacaine with fentanyl during routine combined spinal-epidural anaesthesia.

Results. Using sequential allocation we found that the ED50 for S1 motor block 10 min after intrathecal injection was bupivacaine 7 mg with fentanyl 14 μg (95% CI, 6.2–7.8 mg). We then used intrathecal bupivacaine 13 mg to look for the ED95. We found the calculated ED97.5 to be bupivacaine 9.7 mg with fentanyl 19.4 μg (95% CI, 8.7–11.4).

Conclusion. We conclude that testing for S1 motor block 10 min after epidural injection of bupivacaine 10 mg is a reliable test to detect accidental intrathecal injection in the obstetric population.

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The accidental intrathecal injection of bupivacaine during epidural analgesia in labour remains a hazard, with the potential to cause total spinal anaesthesia and maternal collapse. The main features, which are said to distinguish between epidural and intrathecal injection, are rapid analgesia, excessive sensory block, early sacral block, intense motor block and hypotension in the latter. There have been no specific tests that have been shown to reliably differentiate between the two sites of administration.

This study was designed to evaluate the use of S1 motor block as a reliable and easily reproducible clinical sign that will differentiate between an epidural injection and an accidental subarachnoid injection for labour analgesia.

We used S1 motor block as our clinical test because during epidural anaesthesia there is a sequence of motor blockade, starting with an early lumbar motor block involving hip flexion, and then extending to a sacral motor block involving the plantar flexion of the foot. In spinal anaesthesia, early sacral anaesthesia is characteristic. In other words, S1 blockade appears early after an intrathecal injection and is the last dermatome to be affected after an epidural injection. Yarnell and colleagues¹ showed that after 10 ml of 0.25% bupivacaine, only 3% of mothers had S1 motor block.

Methods

With full local research ethics committee approval and patient written informed consent, we recruited mothers who were booked for elective Caesarean section at term with a singleton foetus. The anaesthetic technique was a combined spinal epidural (CSE). Exclusion criteria included maternal refusal, contraindications to regional technique, multiple pregnancy and complicated medical history including pregnancy-induced hypertension.

I.v. access and routine monitoring were established in the anaesthetic room. The non-invasive arterial pressure cuff was set for a 2-min recording cycle. I.v. fluids were infused before and during the anaesthetic (Hartmann’s solution 500–1000 ml).

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S1 motor block as a safe, reliable test dose

Table 1 Assessment of motor block. A study responder was motor block of the ankle grade 2 or 3 (significant weakness of ankle plantar flexion) at 10 min.

<table>
<thead>
<tr>
<th>Grade of motor block</th>
<th>Hip movement</th>
<th>Ankle movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>1</td>
<td>Can SLR against a small downward pressure</td>
<td>Can plantar flex foot against some resistance</td>
</tr>
<tr>
<td>2</td>
<td>Cannot SLR against any downward pressure</td>
<td>Cannot plantar flex foot against resistance</td>
</tr>
<tr>
<td>3</td>
<td>No ability to SLR</td>
<td>No plantar flexion</td>
</tr>
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</table>

The CSE technique was performed in the sitting position at the L3-4 interspace, a standard 16 gauge Tuohy needle was inserted into the epidural space using loss of resistance to air and a 119 mm 27 gauge Becton-Dickinson pencil-point spinal needle was inserted through the epidural needle once the epidural space was located. After injection of the study mixture, the spinal needle was withdrawn and the epidural catheter was inserted. The Tuohy needle was then removed and the mother placed in the full right lateral position. After 5 min, the block was assessed and the mother turned supine with a 15° left lateral tilt. At 10 min, the block was tested again.

The loss of resistance to air was used to increase the reliability of detecting that the intrathecal dose was injected into the subarachnoid space, rather than being misplaced in the epidural space. The CSE technique had to be technically perfect with free flow of cerebrospinal fluid seen at the first pass of the spinal needle and no spillage of the spinal anaesthetic on injection, for the patient to remain in the study.

Arterial pressure was monitored non-invasively on a 2-min cycle and ephedrine was used in 6-mg i.v. boluses if the mother felt light-headed or nauseous or if her arterial pressure fell by 20% from her pre-block base line.

The study was divided into two parts. The first part was to determine the ED50 of S1 motor block, 10 min after spinal injection. The drugs used were 0.25% bupivacaine with fentanyl in a fixed ratio of bupivacaine 1 mg to fentanyl 2 μg. We chose this drug combination to mimic the bupivacaine–fentanyl mixture that is in common use as an epidural solution for labour analgesia. The first patient in the study was given intrathecal bupivacaine 3 mg with fentanyl 6 μg. At 10 min there was no S1 motor block (non-responder), and the next patient in the study received 4 mg and so on until the next patient did have S1 motor block (responder) (Table 1). The next patient after a responder received bupivacaine 1 mg and fentanyl 2 μg less, while the next patient after a non-responder received bupivacaine 1 mg and fentanyl 2 μg more. From this up–down sequential allocation, the ED50 for S1 motor block at 10 min was calculated after 20 patients.

After the 10-min initial study period, the assessor decided if the block was adequate for Caesarean section. An adequate block was considered to be a T4-S1 temperature block and a T6-S1 light touch block, together with a dense motor lumbar–sacral block. If the block was inadequate, increments of 0.5% bupivacaine 5 ml were injected into the epidural space at 5-min intervals until a satisfactory block was obtained, and epidural morphine 4 mg given for postoperative analgesia.

The plan for the second part of the study was to use a fixed dose equal to roughly twice the ED50, derived from part one of the study, in 60 patients. The choice of twice the ED50 was based on the rule-of-thumb that sensitivity to injected drugs amongst the population ranges from half the ED50 to twice the ED50. The number 60 was chosen on the grounds that if r patients did not respond, where r was zero or very small, the upper 95% confidence limit of non-responders2 would be between approximately r+3 and r+6 out of 60, i.e. an uncertainty of 5–10%. In fact, 62 mothers were given bupivacaine 13 mg (plain 0.5% bupivacaine with 26 μg of fentanyl) using the CSE technique. We chose 13 mg rather than 14 mg because we did not want to deviate too far from our routine practice of bupivacaine 12.5 mg and fentanyl 25 μg for elective Caesarean section. S1 motor block was assessed at 10 min, as before. Epidural morphine was given for postoperative analgesia.

Results
Applying the formula of Dixon and Massey3 to the 20 patients in the first part of the study showed that the ED50 for S1 motor block at 10 min was bupivacaine 7.0 mg with fentanyl (95% CI, 6.2–7.8) (Fig. 1).

In the second part of the study all the 62 patients given bupivacaine 13 mg with fentanyl had S1 motor block 10 min...
after intrathecal injection. Therefore, on the basis of those patients alone, the estimated incidence of non-responders to a dose of 13 mg is 0 with an upper 95% confidence limit of 3.6 in 62 patients i.e. a 2.5% risk that 6% of patients will not respond to 13 mg.

Logistic regression analysis of the results for all 82 patients made use of all the data. This confirmed the Dixon Massey result, ED50 being 7.0 mg (95% CI, 6.2–7.8) with an estimated ED50 of 9.1 mg (95% CI, 8.2–10.6) and ED97.5 of 9.7 mg (95% CI, 8.7–11.4) (Fig. 2).

Differences between the characteristics of the blocks and haemodynamic stability were seen after the two parts of the study. Statistical analysis was not performed because the groups were not randomized and are of unequal size. The data from patient number one has also been excluded from this part of the analysis, as she required ephedrine 39 mg following the smallest intrathecal dose of bupivacaine 3 mg, by far the largest dose of ephedrine of any patient in any part of the study.

Fifty per cent of mothers in the first part required ephedrine with an average dose of 13.6 mg, whilst 75% of mothers in the second part of the study required an average of 17.3 mg. Nine of 10 mothers who developed hypotension in part one of the study, did so after the spinal injection and then tended to need more ephedrine during the epidural top-ups to maintain arterial pressure. Only one mother needed a small 6-mg dose of ephedrine after her epidural top-up; she did not require ephedrine after her intrathecal injection. A wide dose range of epidural 0.5% bupivacaine was given to supplement the intrathecal injection (0–25 ml (0–125 mg)), and the mean time to establish the final block height was 25 min (range 15–50 min).

There were no excessive sensory blocks at final block assessment just before surgery commenced in the first part of the study, where a maximum intrathecal dose of bupivacaine 9 mg was used, followed by incremental epidural top-ups. There was, however, an 8% incidence of a sensory block to ice at C6 or above, and a 14% incidence of block to light touch at T2 and above, in part two of the study where only the higher dose intrathecal injection was given (Table 2).

### Discussion

This study has determined a safe test-dose that can be used in the obstetric population to reliably detect, after 10 min, a top-up that was intended for the epidural space but has been given intrathecally. A combination of rapid sensory block, motor block, hypotension and analgesia has previously been assessed. This study has looked at only one element i.e. S1 motor blockade, to allow reliable early detection. We found that there is a very steep dose response curve for S1 motor block and that bupivacaine 13 mg was in excess of the ED97.5. There was also a significant incidence of high sensory blockade and hypotension using bupivacaine 13 mg, which could pose a problem if it occurred in a delivery room rather than theatre.

Historically, the test dose contained a mixture of low volume high dose local anaesthetic and a vasoconstrictor. The vasoconstrictor was used as an indicator of an accidental intravascular injection. A vasoconstrictor has never been shown to be very predictive of an intravascular injection and careful aspiration of the epidural catheter has now taken its place. The high concentration, low volume local anaesthetic that has traditionally been used, aimed to identify an accidental subarachnoid block before a high volume, high concentration local anaesthetic was given into the epidural space.

It was suggested that an epidural test dose should be mandatory and Kumar and colleagues recommended the use of 1.5 ml of 0.5% bupivacaine (7.5 mg). Prince and colleagues suggested 1.6 ml of 0.5% bupivacaine (8 mg) plus 10 min waiting time in order to avoid false negative tests. Others recommended more than 10 yr ago that 10 ml of 0.125% bupivacaine (12.5 mg) is a safe and effective test dose. A review of the literature shows that obstetric

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**Table 2: Haemodynamic results and block characteristics of the first and second parts of the study**

<table>
<thead>
<tr>
<th></th>
<th>Part 1</th>
<th>Part 2</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>(n=20)</td>
<td>(n=62)</td>
</tr>
<tr>
<td>Mothers requiring ephedrine (n (%))</td>
<td>10 (50)</td>
<td>46 (75)</td>
</tr>
<tr>
<td>Mean ephedrine use of those requiring ephedrine (mg)</td>
<td>13.6</td>
<td>17.3</td>
</tr>
<tr>
<td>Final block to ice: C6 or above (n (%))</td>
<td>0 (0)</td>
<td>5 (8)</td>
</tr>
<tr>
<td>Final block to light touch: T2 or above (n (%))</td>
<td>0 (0)</td>
<td>9 (14.5)</td>
</tr>
</tbody>
</table>

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**Fig 2: Probability of response (S1 motor block at 10 min after bupivacaine with fentanyl) against dose on a logarithmic scale. Circles represent individual patients, with the circles at probability 0 being 'no response' and those at 1 being 'response'. The largest circle represents the 62 patients receiving a 13-mg dose. The curve is the fitted logistic regression. Error bars are the 95% confidence limits of the ED50, ED95 and ED97.5.**

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444
anaesthetists use a wide range of test doses on initial epidural placement and previous research has suggested a number of regimen ranging from 1.5% lidocaine 3 ml (45 mg) to 0.5% bupivacaine 3 ml (15 mg). No research has been able to demonstrate the safety and reliability profile of any of these regimen, or the exact test that should be performed.

It is now accepted that the main determinant of a so-called test dose is the actual dose of local anaesthetic injected in the epidural space. In other words, it has been shown that when injected intrathecally, 0.1% bupivacaine 10 ml (10 mg) results in the same spread and intensity as 2 ml of 0.5% bupivacaine (10 mg). Therefore, the use of low volume, high concentration test doses are not necessary.

Another potential danger of epidural analgesia in labour is that accidental intrathecal injection has been reported many hours after an apparently uneventful epidural block. Obstetric anaesthetists use epidural boluses of 5–50 mg of bupivacaine for labour pain.

This wide range of doses would produce widely differing clinical pictures if the catheter migrated into the subarachnoid space. The use of 10-mg top-ups can therefore be recommended for use throughout labour as they give reliable analgesia with a margin of safety. Routine assessment of the mother’s ankle plantar flexion can be taught to anyone giving the top-ups, allowing early detection of catheter migration. We feel that it would remain a valuable test even if there were some hip flexion weakness.

A spin off from our study design was a comparison between low dose spinal anaesthetics followed by epidural top-ups and high dose spinal anaesthesia for Caesarean section. There was improved haemodynamic stability in the low dose group and fewer high blocks. The spinal blocks were easily supplemented by 0.5% epidural bupivacaine in the epidural space and in most cases there was only a few minutes increase in preparation time. We now use the low dose spinal anaesthetic technique with epidural top-ups, if the test dose is negative, the same dose can be used to establish and then maintain full analgesia in labour as required.

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