INFLUENCE OF OBESITY ON THE SPREAD OF SPINAL ANALGESIA AFTER INJECTION OF PLAIN 0.5% BUPIVACAINE AT THE L3–4 OR L4–5 INTERSPACE

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SUMMARY

Spinal anaesthesia was compared in 40 obese patients (increased body mass index (BMI)) and 40 patients with normal BMI when 3 ml of plain 0.5% bupivacaine was injected at either the L3–4 or L4–5 interspace. More extensive cephalad spread of sensory block was achieved in patients with increased BMI compared with patients with normal BMI after injection at both L3–4 and L4–5 (P < 0.05). The use of the L3–4 interspace instead of L4–5 resulted in a higher mean spread of block in patients with both increased (T4 vs T8) or normal (T9 vs T11) BMI (P < 0.05). The interindividual variability of the blocks was relatively small in patients with normal BMI injected at L4–5, compared with the three other groups (normal BMI injected at L3–4, increased BMI injected at L3–4 and L4–5). Good anaesthesia was produced in all patients for orthopaedic surgery of the lower extremity. In an obese patient it is recommended that plain bupivacaine be administered at L4–5 instead of L3–4 when extensive spread of the block is to be avoided.

KEY WORDS

Obesity (increased body mass index (BMI)) is associated with extensive cephalad spread of spinal analgesia when plain 0.5% bupivacaine is used as an anaesthetic and the vertebral interspace used for the injection is L3–4 [1, 2]. However, because of large interindividual variability in spread of the block, it has not been possible to use this phenomenon to any clinical advantage.

In patients with normal BMI the spread of spinal block with plain 0.5% bupivacaine is more predictable—that is, there is less variation when the site of injection is L4–5 rather than L2–3 [3] or L3–4 [4, 5].

We therefore investigated the degree of spread of spinal block in obese patients (increased BMI) when plain bupivacaine was injected at the L4–5 interspace instead of L3–4.

PATIENTS AND METHODS

We studied 80 patients (ASA I and II), aged 20–60 yr, undergoing orthopaedic surgery of the lower extremity under spinal anaesthesia. The study was approved by the Institutional Ethics Committee and informed consent was obtained. The study was open, and 40 patients (table I) with a body mass index (BMI = weight/(height)^2: kg m^-2) value exceeding 15 % of the normal upper range of BMI for Finnish adults [6] were allocated randomly to receive spinal anaesthesia via the L3–4 (group A) or L4–5 (group C) spinal interspace. BMI, a measure of relative weight, is thought to be one of the most accurate indices for assessing the proportion of fat tissue in the body [7]. To exclude the muscular patient who has increased BMI without being obese, we considered a patient to be fat if the BMI exceeded 15 % of the normal value, and we did not accept athletes. Another 40 patients (table I) with normal BMI were allocated randomly to receive spinal anaesthesia via the L3–4 (group A) or L4–5 (group C) spinal interspace. BMI, a measure of relative weight, is thought to be one of the most accurate indices for assessing the proportion of fat tissue in the body [7]. To exclude the muscular patient who has increased BMI without being obese, we considered a patient to be fat if the BMI exceeded 15 % of the normal value, and we did not accept athletes. Another 40 patients (table I) with normal BMI were allocated randomly to receive spinal anaesthesia at the L3–4 (group B) or L4–5 (group D) interspace.

The chosen spinal interspace was always identi-
OBESITY AND BUPIVACAINE SPINAL ANALGESIA

TABLE I. Patient data. Number of patients and mean values (sd)

<table>
<thead>
<tr>
<th>Site of injection: BMI (kg m⁻²):</th>
<th>Group A L3-4</th>
<th>Group B L3-4</th>
<th>Group C L4-5</th>
<th>Group D L4-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (M/F)</td>
<td>11/9</td>
<td>15/5</td>
<td>9/11</td>
<td>15/5</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>43.0(7.5)</td>
<td>33.3(8.8)</td>
<td>44.8(11.9)</td>
<td>35.9(11.0)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>99.5(11.4)</td>
<td>69.5(9.1)</td>
<td>101.3(13.4)</td>
<td>73.8(11.0)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>171.4(7.4)</td>
<td>173.8(7.3)</td>
<td>170.9(9.6)</td>
<td>176.4(12.5)</td>
</tr>
<tr>
<td>Type of surgery (n)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thigh</td>
<td>1</td>
<td>2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Knee</td>
<td>16</td>
<td>14</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>Ankle or foot</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Tibial region</td>
<td>—</td>
<td>2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Use of tourniquet (n)</td>
<td>19</td>
<td>16</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Tourniquet time (min)</td>
<td>69.4(24.4)</td>
<td>77.0(25.4)</td>
<td>65.5(33.3)</td>
<td>69.6(17.1)</td>
</tr>
<tr>
<td>Time from injection to end of operation (min)</td>
<td>89.0(36.9)</td>
<td>99.7(28.5)</td>
<td>80.3(34.1)</td>
<td>94.5(27.0)</td>
</tr>
</tbody>
</table>

fied and agreed upon by two anaesthetists. Premedication comprised diazepam 0.15 mg kg⁻¹ orally. In the operating theatre, an infusion of lactated Ringer's solution was started and a volume of 1.5 ml kg⁻¹ was administered before injection and 6 ml kg⁻¹ during the 30 min following injection of the anaesthetic. Thereafter, the infusion rate was approximately 50 ml h⁻¹ throughout anaesthesia.

Spinal anaesthesia was performed using a 25-gauge spinal needle with the patient in the lateral decubitus position. In one patient (BMI 42.5 kg m⁻²) the spinal block was performed using a long 22-gauge needle. Before injection of the anaesthetic, CSF pressure was measured manometrically. Thereafter, 3 ml of plain 0.5% bupivacaine (Marcain, Astra, Sweden) at room temperature (density 1.004 g ml⁻¹) was injected in 15 s, and the patients were turned immediately to the supine position.

Segmental spread of analgesia was studied by pinprick (27-gauge needle). Analgesia was defined as inability to detect a sharp pinprick. Motor nerve block was assessed using a modified Bromage scale (0-3) [8]. Assessments were made 5, 15, 30, 45 and 60 min after injection of the anaesthetic by one of the authors. Thereafter, assessments were made at 15-30 min intervals until recovery of normal sensation at the L1 spinal segment and the motor block. The moment when the patient was able to produce a visible contraction in the rectus femoris muscle was taken as the time for recovery from motor block.

ECG was monitored continuously. Arterial pressure and heart rate were measured at 5-min intervals in the operating theatre and at 10-min intervals in the recovery room. Decreases in systolic arterial pressure of more than 30% of the control value were treated with ephedrine 5 mg i.v. Bradycardia (heart rate < 45 beat min⁻¹) was treated with atropine 0.01 mg kg⁻¹ i.v.

Statistical analysis of the data used regression analysis and analysis of variance (ANOVA). If statistical differences between the groups were found, Scheffe’s F test was used. For comparison of standard deviations, Bartlett’s χ² test was used.

RESULTS

There were no significant differences between groups A and C, or between B and D, with regard to age, sex, type of surgery, BMI values, tourniquet times and time from injection to end of operation (table I).

Sensory block

The onset time of cephalad spread of pinprick analgesia is presented in figure 1. Administration of plain 0.5% bupivacaine in groups A (increased BMI, L3-4), B (normal BMI, L3-4), C (increased BMI, L4-5), and D (normal BMI, L4-5) produced a mean (std) cephalad spread of analgesia 60 min after injection to T4 (2.4), T9 (2.5), T8 (3.2) and T11 (1.9), respectively. In obese patients the mean cephalad spread of the block was significantly higher than that of patients with normal BMI at both levels of injection (P < 0.05). Injection at L3-4 produced a significantly higher level of mean cephalad spread of analgesia than injection at L4-5 in normal and in obese patients.
The change in spread of analgesia from 5 to 15, from 15 to 30, and from 30 to 60 min was significant \((P < 0.05)\).

BMI correlated \((P < 0.001)\) with maximal level of analgesia both at the L3–4 interspace (groups A and B) \((r = 0.71)\) and the L4–5 interspace (groups C and D) \((r = 0.6)\).

The interindividual variation (figs 1, 2) of cephalad spread of pinprick analgesia was greater on average in groups A, B and C compared with group D (L4–5, normal BMI), but the difference was statistically significant only at 30 min after the injection \((P < 0.05)\). All the blocks were symmetrical: the difference in the spread of pinprick analgesia between the two sides of the body was never more than two segments.

In all groups, the block was adequate for surgery of the lower extremity. There were no statistically significant differences in the need for intraoperative sedatives or analgesics between the groups. Diazepam 2.5–10 mg was administered for sedation to two patients in groups A and B, one in group C and three in group D. Tourniquet-induced discomfort was treated with fentanyl 0.05–0.25 mg in no patients in group A, three in group B (maximal sensory blocks to T4, T7 and T11), two in group C (T5, T11) and four in group D (L1, L1, L1 and L2). Pain in the area of surgery was treated with fentanyl 0.05–0.1 mg in one patient in group A (T2), one in group B (T7), two in group C (L1, L2), and one in group D (L1).

**Motor block**

Motor block was complete (score 3 on the Bromage scale) in 20 patients in group A, 18 in B, 20 in group C and 17 patients in group D. After 30 min there were no significant differences in the motor block between the four groups. The first sign of motor block was inability to flex the ankle in one patient in group B and seven patients in group D. One patient in group B and three patients in group D were not able to flex the ankle,
but could raise the leg and flex the knee throughout the period of block.

Recovery

The differences between the groups in the mean (SD) times from injection of bupivacaine to recovery of normal sensation of the L1 segment (A = 176 (38) min, B = 164 (58) min, C = 167 (33) min, D = 153 (49) min) and to start of motor recovery (A = 177 (43) min, B = 165 (52) min, C = 162 (41) min, D = 161 (38) min) were not significantly different.

CSF pressure

The mean (SD) CSF pressures were 17.5 (6.3) cm H₂O, 15.4 (5.1) cm H₂O, 19.0 (5.8) cm H₂O and 14.5 (4.5) cm H₂O in groups A, B, C and D, respectively. There was a tendency to greater CSF pressure in patients with increased BMI compared with patients with normal BMI (P = 0.05). There was no correlation between CSF pressure and height of the block.

Other effects

Ephedrine was administered for hypotension in one patient (three doses) (maximum sensory block T4) in group A, one patient in group B (maximum sensory block T11) and one patient in group C (maximum sensory block T7).

One patient (male, 28 yr) in group C developed postdural puncture headache, which was treated successfully with an extradural blood patch on the 5th day after operation.

DISCUSSION

In the present study a more extensive spread of block was achieved in patients with increased BMI compared with patients with normal BMI after injection both at L3-4 and at L4-5 interspaces. The use of the L3-4 interspace instead of L4-5 resulted in a higher spread of the block in patients with increased or normal BMI. The correlation found between BMI and cephalad spread of analgesia has been demonstrated previously [1, 2].

The relatively small variation in cephalad spread of spinal analgesia found in group D (normal BMI, L4-5) was demonstrated also in our previous study, where spinal anaesthesia was performed at L4-5 or L2-3 in patients with normal BMI [3]. The observation that the mean maximal spread of analgesia in the obese patients was lower when the injection was made at L4-5 (T8 vs T4) may not be clinically important, because the individual variability remained quite large (L2-T4). Thus obesity may or may not enhance the distribution of the injected local anaesthetic in a cephalad direction. The position of the needle tip in relation to the lordotic curve may vary from patient to patient. This cannot be standardized and therefore, when the patient is lying in the horizontal position, a small volume of the slightly hypobaric bupivacaine solution (baricity 0.9990 at 37 °C) in some instances may remain in the lower part of the dural sac long enough to block only the lower lumbar and sacral nerve roots. Ten patients (seven in group C, three in group D) had maximal cephalad sensory block to only L1 or L2. Most of these patients complained of tourniquet discomfort, which was treated with small doses of fentanyl.

In four patients, the only sign of motor block was inability to flex the ankle (innervation L4-L5), which paradoxically would indicate a score of 0 on Bromage's scale. Flexion of the hip (innervation L1-L3) and extension of the knee (innervation L3-L4) were intact in these patients. When a lower lumbar interspace, for example L4-L5, is used for injection of plain bupivacaine (slightly hypobaric solution at 37 °C) and the patient is kept supine, the greatest local anaesthetic concentration is found initially below the injected level. This may explain why motor block of the ankle occurred earlier in some patients, and was more intense than motor block of the thigh, for example.

A high thoracic sensory block has been associated usually with more or less total block of the sympathetic nervous system [9]. However, none of the patients developed bradycardia and only three patients needed a vasopressor for hypotension. This is in accordance with other studies [4, 10] in which decreases in arterial pressure have been moderate. It is possible that, with bupivacaine spinal anaesthesia, cephalad spread of sympathetic block may not always exceed that of sensory block [11].

The mechanism for the higher spread of analgesia in obese patients may be compression of the inferior vena cava caused by the weight of the abdominal mass, which results in congestion of the extradural veins [12]. Thus the volume of the spinal canal is reduced, augmenting the initial distribution of the anaesthetic in CSF [1, 13]. The external compression may explain why the CSF...
pressure was generally somewhat greater in the obese patients than in the control patients. The amount of extradural fat surrounding and possibly compressing the dural sac is also an unpredictable factor as regards spread of local anaesthetics in the CSF. Recent endoscopic observations suggest that there is no apparent relationship between the amounts of extradural and subcutaneous fat [14].

In conclusion, the injection of plain 0.5\% bupivacaine 3 ml at the L3—4 or L4—5 interspace produced good anaesthesia for orthopaedic surgery of the lower extremity. In obese patients, administration of plain bupivacaine at L4—5 instead of L3—4 would decrease the likelihood of extensive spread.

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REFERENCES