Spinal anaesthesia for Caesarean section with bupivacaine 5 mg ml\(^{-1}\) in glucose 8 or 80 mg ml\(^{-1}\)

C. Connolly, G. A. McLeod and J. A. W. Wildsmith*

University Department of Anaesthesia, Ninewells Hospital and Medical School, Dundee DD1 9SY, UK

*Corresponding author

The standard spinal preparation of bupivacaine contains a high concentration of glucose (80 mg ml\(^{-1}\)). However, the addition of only a small amount of glucose (8 mg ml\(^{-1}\)) to plain solutions of bupivacaine results in a solution which, although no more than marginally hyperbaric, produces a more predictable block when used for spinal anaesthesia in non-pregnant patients. However, bupivacaine 5 mg ml\(^{-1}\) in glucose 8 mg ml\(^{-1}\) has a density [1.00164 (SD 0.00008) at 37°C] which is relatively greater than that of the cerebrospinal fluid (CSF) of the pregnant patient at term (1.0003 at 37°C) because CSF density decreases during pregnancy. Therefore, a double-blind, randomized, controlled study was carried out to compare intrathecal bupivacaine (glucose 8 mg ml\(^{-1}\)) with bupivacaine (glucose 80 mg ml\(^{-1}\)) in 40 pregnant patients at term. Although there was no difference between groups in onset of sensory block, dose of ephedrine or patient satisfaction, patients receiving bupivacaine (5 mg ml\(^{-1}\)) with glucose (8 mg ml\(^{-1}\)) had persistently higher sensory blocks between 60 and 120 min after intrathecal injection, suggesting that the spread of spinal solutions in the pregnant patient at term is not dependent on density.

Br J Anaesth 2001; 86: 805–7

Keywords: anaesthetics local, bupivacaine; anaesthetic techniques, regional, intrathecal; pregnancy

Accepted for publication: November 20, 2000

Studies in non-pregnant subjects have shown that intrathecal bupivacaine 5 mg ml\(^{-1}\) in glucose 8 mg ml\(^{-1}\) produces blocks with a range (T10–T6) particularly suitable for most of the surgery for which spinal anaesthesia is appropriate.\(^1\)\(^2\) Block of the lower limbs and lower abdomen is guaranteed, but spread to the level of the cardio-accelerator nerves is unlikely. In contrast, the standard preparation of bupivacaine contains glucose 80 mg ml\(^{-1}\) and produces unnecessarily extensive spread (T6–T2) for most operations.\(^3\) However, this is the range of block generally considered necessary for Caesarean section. Therefore, a study was performed to compare these two solutions in pregnant patients at term.

Methods

Forty women (aged 18–40 yr) undergoing elective Caesarean section gave informed consent for this study, which was approved by the local research ethics committee (Tayside Committee on Medical Research Ethics). Patients at >37 weeks of gestation, >150 cm height and <110 kg weight (at time of delivery) were recruited; patients with pre-eclampsia, multiple pregnancies or placenta praevia were excluded from the study. After premedication with ranitidine 150 mg and 0.3 M sodium citrate 30 ml, and a preload of 500 ml crystalloid solution, patients were placed in the right lateral position with a pillow under the dependent shoulder. Under aseptic conditions, a 25 swg spinal Whitacre needle was introduced at the third lumbar interspace level with the needle port facing cephalad. The study solution (2.5 ml) was injected over 12.5 s and the end of injection was defined as time zero. Patients in group A received bupivacaine 5 mg ml\(^{-1}\) with glucose 8 mg ml\(^{-1}\) (prepared by mixing plain and hyperbaric solutions in the proportion of 9:1) and group B received bupivacaine 5 mg ml\(^{-1}\) with glucose 80 mg ml\(^{-1}\) (AstraZeneca, Kings Langley, UK). Allocation to groups was randomized using sealed envelopes, and the one investigator who assessed all the blocks did not know which solution had been used.

Immediately after lumbar puncture, patients were placed in the left, wedged position. Sensory block was determined using the blunt end of a 27 g dental needle at 2, 5, 10, 15, 20, 25 and 30 min, and every 15 min for 2 h thereafter. The extent of block was measured on both sides and an average
taken if there was a difference. Blood pressure was measured pre-operatively, every 2 min for 10 min and then every 5 min for 2 h after lumbar puncture. Hypotension (defined as a systolic blood pressure more than 30% below the pre-operative figure or symptoms related to poor perfusion, such as nausea or dizziness) was treated with ephedrine 6 mg i.v. The spinal anaesthetic was supplemented with i.v. increments of either alfentanil or morphine as required.

Post-operatively, all patients received diclofenac 100 mg per rectum. The time to first morphine requirement was noted and the first dose was given i.v. by an investigator. The spinal anaesthetic was supplemented with i.v. increments of either alfentanil or morphine as required.

Statistical analysis of results was performed with Statview (Palo Alto, CA, USA). Patient characteristics, sensory block times and blood pressures were compared using the $t$-test with Bonferroni correction as appropriate. Sensory block height was compared using the Mann–Whitney $U$-test.

### Results

There were no differences between the groups with respect to patient characteristics (Table 1). Speed of onset of sensory block, time to maximum sensory block (Table 2) and median maximum block height (Fig. 1) were the same in both groups. In five patients in group A and two in group B, the block extended to the cervical dermatomes. Intra-operative opioid supplementation was required by six patients in group A and eight in group B. Patient satisfaction scores were equivalent: 16 patients in each group regarded their anaesthesia as ‘excellent’. Although there was no statistically significant difference in two-segment regression, regression to T10 or time to first request for morphine, median block was higher at 60, 90, 105 and 120 min (Fig. 1) in the group which received glucose 8 mg ml$^{-1}$. No statistically significant difference existed between the groups with regard to cardiovascular changes or ephedrine requirement, although there was a tendency towards a lower systolic blood pressure after delivery in those receiving glucose 8 mg ml$^{-1}$ (Fig. 2). The density of bupivacaine 5 mg ml$^{-1}$ in glucose 8 mg ml$^{-1}$ (group A) was 1.00164 (SD 0.00008) and bupivacaine 5 mg ml$^{-1}$ in glucose 80 mg ml$^{-1}$ (group B) 1.02081 (0.00017).

### Discussion

This study has shown that a tenfold difference in glucose concentration has little effect on the spread of bupivacaine

---

**Table 1** Patient characteristics, ephedrine requirements (mean and standard deviation) and numbers experiencing hypotension or requiring opioids in two groups of patients receiving spinal anaesthesia with bupivacaine 5 mg ml$^{-1}$. Group A received glucose 8 mg ml$^{-1}$; group B received glucose 80 mg ml$^{-1}$

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>29.8 (22–39)</td>
<td>32.0 (23–38)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>160.0 (6.6)</td>
<td>163.4 (7.0)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>71.3 (9.5)</td>
<td>76.0 (11.3)</td>
</tr>
<tr>
<td>Ephedrine dose (mg)</td>
<td>23.7 (17.4)</td>
<td>15.9 (14.9)</td>
</tr>
<tr>
<td>Opioids given (n)</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Hypotension (n)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Patient satisfaction</td>
<td>16/3</td>
<td>16/3</td>
</tr>
</tbody>
</table>

**Table 2** Sensory block characteristics (mean and standard deviation) in two groups of patients receiving spinal anaesthesia with bupivacaine 5 mg ml$^{-1}$. Group A received glucose 8 mg ml$^{-1}$; group B received glucose 80 mg ml$^{-1}$

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset time at T4 (min)</td>
<td>13.3 (9.8)</td>
<td>14.7 (6.5)</td>
</tr>
<tr>
<td>Time to maximum block (min)</td>
<td>20.0 (8.4)</td>
<td>20.0 (6.9)</td>
</tr>
<tr>
<td>Two-segment regression (min)</td>
<td>69.2 (31.3)</td>
<td>69.0 (20.3)</td>
</tr>
<tr>
<td>Regression to T10 (mg)</td>
<td>127.1 (20.8)</td>
<td>105.0 (25.3)</td>
</tr>
<tr>
<td>Time to first post-operative request for morphine (min)</td>
<td>101.5 (35.1)</td>
<td>87.8 (31.0)</td>
</tr>
</tbody>
</table>

---

Figure 1: Changes in median (with interquartile range) maximum block height over time in two groups of patients receiving spinal anaesthesia with bupivacaine 5 mg ml$^{-1}$. *$P<0.05$.

Figure 2: Changes in mean (with standard deviation) systolic blood pressure over time in two groups of patients receiving spinal anaesthesia with bupivacaine 5 mg ml$^{-1}$. W, ward; PS, pre-spinal.
after intrathecal injection in pregnant patients at term. There were virtually no differences between the two groups in the profile of the blocks produced or in the quality of surgical anaesthesia. This is in marked contrast to the situation in the non-pregnant subject, where a high concentration of glucose is needed to ensure spread to the upper thoracic segments in supine horizontal subjects. In fact, even plain solutions of bupivacaine will produce spread to that level when used for Caesarean section. It is generally recognized that baricity is the most important factor determining the spread of local anaesthetic in the non-pregnant patient, but this is clearly not the case in the pregnant patient at term. It is interesting to consider why this might be so.

Baricity is the ratio of the density of a local anaesthetic solution compared with that of cerebrospinal fluid (CSF). If the patient is turned supine after injection in the lumbar region, a hyperbaric solution will spread under the influence of gravity down the slopes created by the lumbar spinal curvature. Bupivacaine 5 mg ml\(^{-1}\) in glucose 8 mg ml\(^{-1}\) has a density (1.00164 at 37°C) that is only marginally greater than that of normal adult CSF [1.0007 (SD 0.0003) at 37°C], so that it will spread more slowly than the standard preparation with glucose 80 mg ml\(^{-1}\) (density 1.02081 at 37°C). The actual concentration of the dilute preparation is crucial: an increase to only 10 mg ml\(^{-1}\) produces blocks that are almost indistinguishable from those produced by much higher concentrations. However, CSF density decreases with CSF protein concentration during pregnancy, reaching a minimum [1.0003 (0.0004) at 37°C] at term. Thus, the difference in density between CSF and the solution containing glucose 8 mg ml\(^{-1}\) will be greater than in the non-pregnant patient and thus result in more extensive spread.

This analysis would account for the lack of difference between the two groups reported here, but not for the extensive spread of plain bupivacaine (0.9993 at 37°C) in pregnant patients. This solution is hypobaric relative to CSF even at term. The generally accepted reason is that the exaggerated spread is a consequence of occlusion of the inferior vena cava being only partially relieved in the left, wedged supine position. Distention of the veins of the vertebral plexus causes compression of the dura, reduces CSF volume and encourages greater bulk spread of the injected solution. This is clearly the major factor at the end of pregnancy. However, it is interesting to note that this study produced some evidence that physical characteristics of the local anaesthetic solutions were having some influence, most notably that a prolonged offset of block occurred in those receiving the less dense solution (Fig. 1).

A less viscous solution would flow more easily through a compressed subarachnoid space, allowing a greater proportion of the injected dose to reach the thoracic nerves and cause a longer duration of action.

In conclusion, this study has shown that density has little effect on the intrathecal spread of local anaesthetics at the end of pregnancy, and therefore that the glucose concentration of a spinal anaesthetic solution is of little consequence in this group of patients. The major reason for this is probably a secondary effect of partial inferior vena cava obstruction, although the viscosity of the injectate may have some influence. One fortunate consequence of this independence of intrathecal drug spread from density is that a change, as may be produced by mixing the local anaesthetic with an opioid solution, would not have the same possible consequences as in the non-pregnant population.

Acknowledgements

We wish to thank Dr Jonathan Whiteside for measuring the densities of the spinal solutions used and AstraZeneca for financial support.

References

11. Richardson MG, Wissler RN. Densities of dextrose-free intrathecal local anesthetics, opioids, and combinations measured at 37°C. Anesth Analg 1997; 84: 95–9