Effect of crystalloid and colloid preloading on uteroplacental and maternal haemodynamic state during spinal anaesthesia for Caesarean section

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Summary

We have studied the effects of crystalloid 1 litre (lactated Ringer’s) or colloid 0.5 litre (hydroxyethyl starch) preloading in 26 healthy parturients undergoing elective Caesarean section under spinal anaesthesia. Maternal placental uterine artery circulation was measured using a pulsed colour Doppler technique with simultaneous measurement of maternal haemodynamics. A high incidence of maternal hypotension was observed during spinal anaesthesia in the crystalloid group (62 %) but the incidence was lower in the colloid group (38 %). Central venous pressure was increased significantly in both groups after preload but decreased shortly after induction of spinal anaesthesia to baseline values. The mean pulsatility index (PI) in the uterine arteries did not change during preload or spinal block. A surprising finding was the widespread variation and some high values for the uterine artery PI after spinal anaesthesia. These individual increases in PI were transient and always returned to baseline values within 2 min. These results suggest that preloading with either solution is ineffective in preventing maternal hypotension and that changes in maternal heart rate, systolic arterial pressure and central venous pressure during spinal anaesthesia were not associated with rapid individual increases in uteroplacental vascular resistance. These changes seemed not to have any major effect, however, on the clinical condition of the newborn, as assessed by Appgar scores and umbilical artery pH values. (Br. J. Anaesth. 1995; 75: 531–535)

Key words


Spinal anaesthesia is used widely for elective and emergency Caesarean section. Its advantages include more rapid onset of action, better quality of sensory and motor block and ease of use compared with extradural anaesthesia. Its disadvantages are shorter duration of block and lack of a top-up facility unless using a catheter. Maternal hypotension, however, frequently follows onset of spinal anaesthesia. The measures usually used to reduce maternal hypotension during spinal anaesthesia are volume pre-loading with an i.v. crystalloid solution, prophylactic use of a vasopressor infusion and left uterine displacement. The use of mechanical or pneumatic compression of the lower limbs with preloading has also been shown to decrease the incidence of hypotension [1, 2].

The commonly used prophylactic administration of crystalloid preload [3] or reduced crystalloid preload with ephedrine infusion [4] did not decrease the incidence of hypotension during anaesthesia, but may have prevented the most severe forms of hypotension. Thus recent studies have questioned the role of preloading in the prevention of hypotension [5, 6]. However, few studies have examined utero- and fetoplacental circulation immediately after induction of spinal anaesthesia with intrathecal bupivacaine [7–9].

The aim of this study was to compare the effects of crystalloid and colloid preloading on uteroplacental haemodynamic state using the pulsed colour Doppler technique during the first 20 min of spinal anaesthesia for Caesarean section.

Patients and methods

We studied 26 parturients at term (gestation 38–41 weeks) undergoing elective Caesarean section. The study was approved by the Oulu University Ethics Committee and written informed consent was obtained from each patient. All parturients were healthy, with an uncomplicated singleton pregnancy, and were scheduled to undergo Caesarean section because of fetopelvic disproportion, breech presentation or repeat Caesarean section. None of the patients was in labour.

Patients were given 30 ml of sodium citrate 0.3 mol litre⁻¹ orally 30–60 min before entering the operating theatre, where they were placed in the supine position with a left lateral tilt. Monitoring was with a three-lead ECG, pulse oximetry and automated non-invasive arterial pressure (Cardiocap, Datex,
Instrumentarium Group, Finland). Oxygen 3 litre min⁻¹ was administered by nasal cannula. A peripheral vein was cannulated for administration of i.v. fluid, and a vein in the right antecubital fossa was cannulated under local anaesthesia with a 16-gauge central venous catheter for continuous monitoring of central venous pressure (CVP) [10]. The correct location of the tip of the CVP catheter was confirmed by recording the CVP waveform. Baseline maternal heart rate (HR), non-invasive systolic arterial pressure (SAP) and CVP were recorded, and the first Doppler ultrasound examination was performed before preloading.

The maternal uterine artery (main branch on the placental side of the uterus) was identified and the blood velocity waveform recorded with the pulsed Doppler method (with a 3.75-MHz sector probe, 120 Hz high-pass filter). The pulsatility index (PI) was assessed by calculation of Pearson’s correlation coefficient. Differences were considered statistically significant if \( P < 0.05 \). All statistical tests were performed on a standard PC using the program SPSS for Windows release 6.0 (SPSS Inc., USA).

### Results

There were no differences in data between the two groups (table 1). The mean volume of crystalloid infused after induction of spinal anaesthesia until delivery was 1162 (SD 196) ml in the crystalloid group and 1023 (164) ml in the colloid group. This difference was not significant \((P = 0.15)\). There were no signs of maternal overhydration, although some patients were given up to 3 litre of crystalloid infusion during the surgical procedure. Maternal arterial oxygen saturation was 97 % or more in all cases and there were no problems with excessive blood loss during the procedure. Because of the design of the study, eight patients were given alfentanil 0.5 mg i.v. at the end of the surgical procedure because the spinal block was wearing off.

Mean maternal HR tended to decrease during spinal anaesthesia but this was not statistically

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Maternal and newborn characteristics (mean (SD) or range) or number). Systolic arterial pressure (SAP) and heart rate (HR) are before preload. I-D time = induction of anaesthesia to delivery time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal</td>
<td>Crystalloid group ((n = 13))</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>32.0 (23–41)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>68.8 (8.0)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>157.8 (5.5)</td>
</tr>
<tr>
<td>SAP (mm Hg)</td>
<td>127.2 (10.8)</td>
</tr>
<tr>
<td>HR (beat min⁻¹)</td>
<td>81.1 (11.9)</td>
</tr>
<tr>
<td>Parity (n)</td>
<td>3</td>
</tr>
<tr>
<td>Primiparae</td>
<td>3</td>
</tr>
<tr>
<td>Multiparae</td>
<td>10</td>
</tr>
<tr>
<td>Newborn weight (g)</td>
<td>3440 (265)</td>
</tr>
<tr>
<td>Umbilical artery pH</td>
<td>7.28 (7.10–7.35)</td>
</tr>
<tr>
<td>I-D time (min)</td>
<td>49.9 (40–64)</td>
</tr>
</tbody>
</table>
significant and the tendency was similar in both groups (fig. 1). One patient in the colloid group required one 0.5-mg dose of atropine for transient bradycardia (HR = 45 beat min⁻¹) 8 min after induction of spinal anaesthesia.

Mean maternal SAP decreased during spinal anaesthesia in both groups and the incidence of hypotension was 62 % (8/13) in the crystalloid group and 38 % (5/13) in the colloid group (ns). The mean maximal percentage decrease in SAP was 27.6 (95 % CI 20.5 — 34.7)% in the crystalloid group and 21.3 (16.0 — 26.6)% in the colloid group. This difference was not statistically significant (P = 0.15). Mean SAP was significantly lower in both groups from 2 to 20 min after induction of spinal anaesthesia compared with baseline values (P = 0.001). The difference in SAP between the groups was only statistically significant 4 min (P = 0.037) and 14 min (P = 0.030) after induction of spinal anaesthesia (fig. 2). One patient in the crystalloid group required ephedrine 5 mg after all ultrasound measurements were completed.

Mean CVP increased significantly in both groups after preloading (P = 0.0001) and returned towards baseline values shortly after injection of intrathecal bupivacaine (P = 0.004). There was no significant difference between the crystalloid (●) and colloid (□) groups. B = Before preload, A = after preload, S = spinal anaesthesia.

PI of the uterine artery tended to increase in both groups after induction of spinal anaesthesia but this was not statistically significant between or within groups (table 2). Surprisingly, marked individual increases in PI with a reverse diastolic flow (i.e. a sign of very high vascular resistance) were even seen in subjects with near normal maternal HR, SAP and
CVP (fig. 4). Most of these increases appeared from 4 to 10 min after induction of spinal block and all disappeared within 2 min. PI also showed marked individual variation in both groups during spinal anaesthesia. There was no correlation between uterine artery PI, maternal HR, SAP and CVP.

Neonatal outcome was similar and uneventful in both groups, apart from one newborn with a cleft palate with an Apgar score of 6 at 1 min. The pH value of the umbilical artery was greater than 7.15, except for one patient in the crystalloid group with a pH of 7.10. In this patient there were no signs of bradycardia or hypotension requiring medication during spinal anaesthesia.

**Discussion**

We found a high incidence of maternal hypotension in both crystalloid (62%) and colloid (38%) groups, similar to that reported in earlier studies [4, 5, 7]. The reason for the decrease in SAP during central neural block is peripheral vasodilatation. The policy of preloading before spinal anaesthesia has recently been re-evaluated and the primary role of vaso-pressors, rather than preload, has been emphasized in the prevention and treatment of maternal hypotension [5, 11]. Transient maternal hypotension does not seem to harm the fetus or newborn if corrected promptly [12]. In our study all normal infants had Apgar scores of 8 or more and the pH values of the umbilical artery were normal.

We were surprised to find widespread variation and occasionally very high individual values for the uterine artery PI values during spinal anaesthesia. The explanation for this is obscure. Spinal block causes peripheral vasodilatation and venous pooling. This may subsequently lead to alterations in maternal haemodynamic state similar to hypotension and a decrease in CVP. Maternal SAP decreased in both of our groups 4 min after induction of spinal anaesthesia but HR did not change significantly. The possible effect of cardiac sympathetic block may be of minor importance as a cause of changes in uterine artery PI values because maternal bradycardia occurred in only one patient. In our study, CVP decreased from the increased values caused by preload to near baseline values in both groups immediately after induction of spinal anaesthesia; this is similar to the results of Rout and colleagues [3]. It is possible that this change was caused by a decrease in venous return to the heart. Robson and colleagues [9] showed that cardiac output decreased in 12 of 16 patients during spinal anaesthesia in spite of the left semi-lateral (45°) position used to prevent aortocaval compression and a volume preload with 1 litre of crystalloid solution given to expand maternal circulation. They also found a significant negative correlation with stroke volume, cardiac output and umbilical artery PI but no significant changes in peripheral resistance of the maternal circulation after spinal anaesthesia. In their study, the increase in umbilical artery PI did not correlate with changes in maternal arterial pressure or HR. In some studies umbilical artery PI was either unchanged [7] or decreased [8] during spinal anaesthesia reflecting no harmful effect on the fetal circulation.

Wright and colleagues [13] demonstrated that acute hypotension during extradural anaesthesia was also associated with increases in uteroplacental Doppler indices but there were no changes in umbilical arteries. They also found that ephedrine had no influence on uterine or umbilical artery PI. Therefore, the reduction in cardiac output in obstetric regional anaesthesia may be an explanation for the individual changes in PI values and for the occasional pathological blood flow waveforms reflecting increased vascular resistance in the uterine arteries.

Marked peripheral vasodilatation as a result of central neural block may also cause the so-called “steal syndrome” that directs blood flow away from the uteroplacental circulation to the lower limbs as occurs with extradural anaesthesia [14]. The increases in uterine artery PI in our study were transient and returned to baseline values within 2 min in all patients. These transient changes in PI

![Figure 4](image-url)  
Figure 4 Maternal heart rate (HR beat min⁻¹) systolic arterial pressure (SAP mm Hg) and central venous pressure (CVP mm Hg) at the time of the most extreme changes in pulsatility index (PI) of the uterine arteries in four individual patients in the crystalloid (●) and the colloid (■) groups (two patients from each group). B = Before preload, A = after preload.
may reflect the sensitive and rapid haemodynamic regulation of the uteroplacental circulation and responses to external factors. Changes in mean maternal HR and SAP were similar in both groups and there was no correlation between these variables and PI values in uterine arteries during the study. Similarly, individual high PI values did not correlate with simultaneous maternal HR, SAP or CVP.

We have shown that volume preloading with either crystalloid or colloid solution did not prevent maternal hypotension during spinal anaesthesia for Caesarean section and therefore the effectiveness of preventive measures for minimizing hypotension should be re-evaluated.

References