RAPID ADMINISTRATION OF CRYSTALLOID PRELOAD DOES NOT DECREASE THE INCIDENCE OF HYPOTENSION AFTER SPINAL ANAESTHESIA FOR ELECTIVE CAESAREAN SECTION

C. C. ROUT, S. S. AKOOJEE, D. A. ROCKE AND E. GOUWS

SUMMARY

Twenty parturients undergoing elective Caesarean section were allocated randomly to receive crystalloid preload 20 ml kg⁻¹ over either 20 min or 10 min before spinal anaesthesia. Significant hypotension (systolic arterial pressure < 100 mm Hg and < 80% of baseline value) occurred in six of the 10 patients in the 20-min preload group and seven of 10 patients in the 10-min preload group (ns). Both groups had a significant (P < 0.05) increase in central venous pressure during the preload period. The mean central venous pressure in the 10-min group was 11.9 mm Hg (range 6-19 mm Hg), which was significantly greater (P < 0.05) than that in the 20-min group (mean 7.3 mm Hg, range 2-13 mm Hg). Three patients in the 10-min group had clinically unacceptable increases in central venous pressure. This study has demonstrated that rapid administration of crystalloid preload before spinal anaesthesia did not decrease the incidence or severity of hypotension, and questions the role of crystalloid preload.

KEY WORDS

Hypotension associated with spinal anaesthesia for Caesarean section remains a serious and common complication, despite several measures used to reduce both incidence and severity. The cornerstones of prevention are the use of a left lateral tilt and volume preloading. In our institution, preloading is undertaken with crystalloid solution 20 ml kg⁻¹ administered over 20 min before subarachnoid injection. This regimen may still fail to prevent hypotension, possibly because of redistribution of crystalloid from the intravascular compartment. This study has investigated if a shorter period of preloading would reduce the incidence and severity of hypotension without adverse maternal and neonatal effects.

PATIENTS AND METHODS

The study was approved by the Professional and Ethical Standards Committee of the Faculty of Medicine, University of Natal. Informed consent was obtained from 20 healthy parturients undergoing elective Caesarean section. Patients with medical or obstetric complications or evidence of impaired placental function were excluded. All patients were at term (38-41 weeks gestation), had singleton pregnancies with cephalic presentations and did not weigh more than 90 kg. Patients were transported to the theatre in the full lateral position and received 30 ml of sodium citrate 0.3 mol litre⁻¹ after entry to the theatre.

A 14-gauge peripheral i.v. cannula and a 16-gauge central venous pressure (CVP) catheter were inserted under local anaesthesia in the left forearm and antecubital fossa, respectively. The location of the tip of the CVP line was confirmed by transduced waveform. The cuff of an automated non-invasive arterial pressure monitor (Critikon Dinamap) was applied to the patient’s right arm. With the patient comfortably at rest in the left supine wedged position, baseline arterial pressure, heart rate and CVP were obtained. Baseline heart rate and arterial pressure were taken as the mean of three consecutive readings at 3-min intervals during which the systolic pressure did not vary by more than 10% from its average value. The zero point for the CVP was taken as the fourth intercostal space in the anterior axillary line.

After baseline recordings the patient was positioned on the operating table. To allow spinal injection at the exact conclusion of the preload period, the patient was placed in the full left lateral position with the legs flexed. Another set of baseline values were obtained in this position before the fluid preload was started. Patients were then allocated randomly to receive crystalloid preload 20 ml kg⁻¹ (Plasmalyte-L) over either 20 min (group 1) or 10 min (group 2) immediately before spinal anaesthesia. To ensure consistency between patients during the preloading period, the zero point for the CVP was taken as the midline at the level of the sixth thoracic vertebra. After these further readings, preloading was commenced and timed with a stopwatch. In group 2, a high flow i.v. administration set was required in order to administer the 20 ml kg⁻¹ over 10 min. Haemodynamic variables were recorded at 5-min intervals during the preloading period. At the conclusion of the preloading
FLUID PRELOAD AND SPINAL ANAESTHESIA

TABLE I. Group data (mean (range or SD)). *Parity not known for one patient in group 2. ID = Subarachnoid injection—delivery interval; UD = uterine incision—delivery interval.

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (20-min preload)</th>
<th>Group 2 (10-min preload)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>25.4 (21-29)</td>
<td>28.6 (23-37)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>68.8 (8.28)</td>
<td>68.4 (8.03)</td>
</tr>
<tr>
<td>Parity*</td>
<td>2.2 (1.03)</td>
<td>2.4 (1.94)</td>
</tr>
<tr>
<td>Thoracic sensory level at 5 min</td>
<td>3.7 (1.06)</td>
<td>3.6 (0.70)</td>
</tr>
<tr>
<td>ID time (min)</td>
<td>20.3 (11.48)</td>
<td>18.5 (3.78)</td>
</tr>
<tr>
<td>UD time (s)</td>
<td>53.9 (25.74)</td>
<td>70 (48.63)</td>
</tr>
<tr>
<td>Preload (ml)</td>
<td>1390 (180.74)</td>
<td>1390 (171.92)</td>
</tr>
<tr>
<td>Total volume (ml)</td>
<td>1720 (278.09)</td>
<td>1795 (296.69)</td>
</tr>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic pressure (mm Hg)</td>
<td>121.9 (7.58)</td>
<td>117.9 (11.05)</td>
</tr>
<tr>
<td>Diastolic pressure (mm Hg)</td>
<td>66.9 (7.41)</td>
<td>66.8 (11.59)</td>
</tr>
<tr>
<td>Heart rate (beat min⁻¹)</td>
<td>84.2 (14.12)</td>
<td>89.3 (14.58)</td>
</tr>
<tr>
<td>CVP (mm Hg)</td>
<td>0.7 (1.49)</td>
<td>-0.1 (2.85)</td>
</tr>
</tbody>
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period, 0.5% plain bupivacaine 1.5 ml was injected via a 25-gauge spinal needle at the L4-5 interspace. The patient was returned promptly to the left supine wedged position and arterial pressure and heart rate recorded at 1-min intervals for 10 min and at 5-min intervals thereafter.

Hypotension was defined as a decrease in systolic pressure to both less than 100 mm Hg and 80% of baseline value. Hypotension was treated by increased rate of fluid infusion and incremental i.v. bolus doses of ephedrine 5 mg at 1-min intervals until the pressure had returned to within 20% of baseline value or greater than 100 mm Hg. All patients received 40% oxygen by mask after the spinal injection and an oxytocin infusion after delivery.

Neonatal condition was assessed by modified Apgar score (Apgar minus colour) at 2 and 5 min after delivery and by umbilical venous and arterial blood-gas and acid–base analysis of samples obtained from an isolated, double-clamped segment of umbilical cord. A sample of maternal radial arterial blood was obtained between uterine incision and delivery. The times of spinal injection, uterine incision and delivery (first clamping of cord) were recorded.

The haemodynamic data, collected in a repeated measures experimental design, were analysed statistically with the appropriate analysis of variance testing for differences between groups and for changes within groups. The groups were compared with respect to patient data and blood-gas variables using Student’s unpaired t-test; the Mann–Whitney U test was used where appropriate for non-parametric data.

RESULTS

There were 10 patients in each group (table I). There were no significant differences between the two groups.

There was no significant change in the mean baseline CVP values when the patient was moved from the left supine wedged position to the full lateral position (0.7 (SD 1.49) mm Hg to 1.1 (2.47) mm Hg in the 20-min group and −0.1 (2.85) mm Hg to 0.3 (2.21) mm Hg in the 10-min group). Both groups showed a significant (P < 0.05) increase in CVP during the preload period (fig. 1). The mean CVP after fluid administration in those patients receiving the fluid over 10 min was 11.9 mm Hg (range 6–19 mm Hg), which was significantly greater (P < 0.05) than in those patients receiving the same volume over 20 min (mean 7.3 mm Hg, range 2–13 mm Hg). Heart rate increased from a mean of 84.8
UMBILICAL ARTERIAL BLOOD TO SAMPLE. There were no significant differences between the groups.

In one in the 20-min group there was insufficient cord clamps were removed on the operating table in both groups. There was no significant difference between groups or between subjects in the behaviour of CVP with time, but there was a highly significant (P = 0.0002) within-subject effect. CVP values were significantly less (P < 0.01) than the value after preload at all times from 1 to 10 min after spinal injection. There was no significant difference between the groups at any time.

Seven patients in the 10-min group developed hypotension severe enough to require ephedrine, compared with six patients in the control group. The duration of hypotension, and thus dose requirement of ephedrine, was less in the 10-min group than in the 20-min group, but this was not statistically significant. Mean ephedrine requirement was 9.3 (5.34) mg in the 10-min group and 15.8 (10.68) mg in the 20-min group (P = 0.18).

There were no significant differences in systolic pressure after spinal injection between the groups (fig. 1). There was a significant (P = 0.002) change in group average systolic pressures with time in both groups, with a significant (P = 0.0001) increase at 1 min and significant decreases at 4 min (P = 0.01), 5 min (P = 0.004) and 6 min (P = 0.05). Group average systolic pressure decreased to a minimum of 108 (19.9) mm Hg at 4 min and 103 (23.6) mm Hg at 5 min in the 20-min and 10-min groups, respectively.

Each group showed a significant increase in heart rate compared with baseline values after spinal injection (fig. 1). However, heart rate returned to baseline values much more rapidly in patients who had received their preload over 10 min. This group had significant increases in heart rate from 1 to 4 min, whereas the group of patients receiving their preload over 20 min had significantly increased mean heart rates from 1 to 10 min. Percentage change in mean heart rates in the two groups were significantly (P < 0.05) different at 5–9 min after spinal injection.

All the neonates were in good condition at delivery of CVP with time, but there was a highly significant (P = 0.0002) within-subject effect. CVP values were significantly less (P < 0.01) than the value after preload at all times from 1 to 10 min after spinal injection. There was no significant difference between the groups at any time.

It was not possible to obtain accurate CVP values from all subjects at all times following spinal injection, because of patient movement and surgical interference. However, sufficient data sets were available to permit a repeated measures analysis of the first 10 min. Mean CVP decreased rapidly in both groups. There was no significant difference between groups or between subjects in the behaviour of CVP with time, but there was a highly significant (P = 0.0002) within-subject effect. CVP values were significantly less (P < 0.01) than the value after preload at all times from 1 to 10 min after spinal injection. There was no significant difference between the groups at any time.

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All the neonates were in good condition at delivery with maximum Apgar (A–C) scores at 2 and 5 min, with the exception of one neonate in the 10-min preload group who scored 7 at 2 min. Delivery of this infant was delayed because of surgical difficulties (U–D time 195 s).

There were no significant differences in maternal arterial blood-gas and acid–base state between the two groups. Umbilical venous and arterial samples were obtained in all but two subjects, one in each group. In one, in the 10-min group, the umbilical cord clamps were removed on the operating table and in one in the 20-min group there was insufficient umbilical arterial blood to sample. There were no significant differences between the groups.

DISCUSSION

This study has demonstrated that rapid infusion of crystalloid preload 20 ml kg⁻¹ over 10 min did not reduce the incidence of hypotension after spinal anaesthesia for Caesarean section, compared with the same volume infused over 20 min, despite the significantly greater central venous pressures demonstrated immediately before spinal injection. Whilst the severity of hypotension was similar in both groups, the duration of hypotension and ephedrine dose requirement were greater in the 20-min group. Although this difference did not achieve statistical significance, the number of patients studied was small, and a true difference cannot be excluded.

The increase in CVP achieved after infusion over 20 min in our study is comparable to that produced by Wollman and Marx, who infused 1000 ml over 14–20 min [1]. They concluded that rapid infusion of crystalloid solutions was safe in parturients with no cardiovascular compromise. Whilst the mean CVP achieved after preload in the 10-min group was within clinically acceptable ranges, three patients had values which caused concern (16, 19 and 19 mm Hg). In 1966, Askrog was unable to demonstrate any untoward effects of infusing 1000 ml over 4 min and only a transient increase in pulmonary artery pressure, although his subjects were receiving halothane anaesthesia and were not pregnant [2]. There is evidence to suggest that parturients might be more susceptible to pulmonary oedema after rapid administration of crystalloid solutions, possibly because of an increase in lung water during pregnancy with a reduced pulmonary interstitial safety margin [3]. In addition, Wennberg and colleagues compared crystalloid administration with colloid during the onset of extradural anaesthesia and demonstrated more pronounced increase in thoracic fluid index, indicative of thoracic fluid accumulation, after crystalloid than after colloid administration [4]. They also demonstrated a significant difference in colloid osmotic pressure between the two groups.

One reason why rapid crystalloid preloading did not significantly reduce the incidence of post-spinal hypotension, despite the high CVP values observed, might be the rapid loss of fluid into the lungs. If this were the case, it is possible that colloidal solution might be more effective. Matharu and co-workers [5] compared 15 ml kg⁻¹ of colloid-containing solution with the same volume of crystalloid solution administered over 15–20 min before spinal anaesthesia for elective Caesarean section. They reported a zero incidence of hypotension following spinal anaesthesia in patients receiving albumin, compared with a 33% incidence in patients receiving crystalloid. However, this has not been supported by comparisons of colloid with crystalloid preload before extradural anaesthesia [6, 7]. Also, if fluid transfer to the lungs was significant in our study, this was not reflected by a difference in maternal arterial oxygen tensions (23.5 (2.70) kPa and 21.2 (4.60) kPa in the 20-min and 10-min groups, respectively).

An alternative explanation of our results is that volume preloading has only a limited role in the prevention of post-spinal hypotension. The early
evidence for the use of volume preloading before spinal anaesthesia for Caesarean section comes from studies performed before lateral uterine displacement was routine practice or where the initial diagnosis of hypotension was made before uterine displacement. In a study examining the effects of volume preloading and uterine displacement Clarke, Thompson and Thompson [8] demonstrated a significant reduction in the incidence of post-spinal hypotension after volume preloading (from 92% to 57%) in patients not in labour. However, the incidences of hypotension requiring ephedrine following left lateral tilt were 48% (no preload) and 42% (preload) (ns).

The rapid decrease in mean CVP values in both groups after spinal anaesthesia confirms that a decrease in venous return is relevant to the aetiology of post-spinal hypotension. However, the rapidity of onset of hypotension and the severity of the decrease in CVP (despite preloading) suggest that fluid therapy during the onset of sympathetic block is not a practical method of preventing hypotension, as sufficient volume cannot be administered in the time available. Alternative methods of increasing venous return, such as leg elevation and leg wrapping after spinal injection may be more successful [9].

In 1989 Murray, Morgan and Whitwam summarized the literature which showed that, with few exceptions, preloading did not eliminate hypotension, which remained as much as 52.8% in one paper [6]. Our study supports this and, in addition, demonstrates that rapid administration of preload did not reduce the incidence of hypotension, leading us to question the value of crystalloid preload in the prevention of hypotension.

REFERENCES