"*I would have everie man what he knows and no more.*"—MONTAIGNE

# *BRITISH JOURNAL OF ANAESTHESIA*

VOLUME 75, No. 3 SEPTEMBER 1995

EDITORIAL I

## Volume preloading, spinal hypotension and Caesarean section

Hypotension is the commonest serious problem following spinal anaesthesia for Caesarean section, with an incidence reported in the literature of up to 83 % [1]. For the past 25 yr, left uterine displacement and volume loading before subarachnoid block have been the cornerstones of prevention of hypotension. In this issue of the journal is the first randomized, double-blind study evaluating lateral displacement without significant volume loading, and the authors concluded that preloading was ineffective and they have now "abandoned the routine of formal preloading in women undergoing Caesarean section under regional anaesthesia" [2]. Is such a statement justified?

Rapid administration of crystalloid solutions to correct established hypotension was first advocated by Greiss and Crandell in 1965; they showed that 500 ml of i.v. fluid partly restored uterine blood flow in gravid ewes rendered hypotensive by spinal anaesthesia [3]. Two subsequent clinical studies from Marx and co-workers demonstrated that hypotension could be eliminated by the use of 1 litre of 5 % glucose in lactated Ringer's solution (D5RL) before spinal anaesthesia [4, 5]. However, the first of these studies was undertaken with a small number of patients, some of whom were in labour, a group now known to have a lower incidence of hypotension, and some of whom received spinal anaesthesia for vaginal delivery. Also, lateral tilt was not used in this study. In the second larger study, a rolled up blanket was used under the right buttock; it included only Caesarean section patients who were allocated to small subgroups [5]. Again, hypotension was eliminated by preloading and where hypotension occurred in the non-hydrated group it was corrected rapidly by fluid therapy. The authors concluded that the key to prevention of spinal hypotension was the use of prophylactic fluid preload. Regarding neonatal outcome, the study tells us more about the effects of hypotension than fluid loading, in that neonates of mothers who became hypotensive showed significantly higher base deficits.

The remarkable success of crystalloid preload in these two studies has not been subsequently reproduced. The first study to challenge the value of preload was that of Clark, Thompson and Thompson who perceived spinal hypotension as a persistent problem and studied the use of fluid loading, both with and without uterine displacement, compared with controls with neither prophylactic method [6]. Both elective and emergency sections were included but the study was sufficiently large (247 patients) to allow meaningful analysis of the results. The uterus was displaced by a mechanical device (a sustained left uterine displacer or "sluder"). When hypotension occurred in patients in whom the sluder was not used, the table was tilted to the left and only if this was unsuccessful in correcting hypotension was ephedrine administered. In elective (non-labouring) patients the initial incidences of hypotension were 92 % in patients receiving neither preload nor the "sluder", 57 % in patients receiving fluid preload only and 53 % in those receiving both preload and the sluder (table 1). Disappointed with the poor performance of the sluder, Clark, Thompson and Thompson concluded that fluid preload was the most important prophylactic measure. However, their results should be viewed in relation to their methodology. If their use of ephedrine is taken as a definition of significant hypotension (i.e. when aortocaval compression had been eliminated) instead of the initial diagnosis of hypotension in the supine position, the case for fluid preloading is not as strong, as the use of ephedrine in each of the three groups differed little (table 1). Viewed in this light, the sluder was as effective as lateral table tilt and the reduced incidence of hypotension produced by fluid preload was unimpressive and not statistically significant. An additional group of patients receiving uterine displacement alone with no preload would have added useful information to the study. However, the importance of the study of Clark, Thompson and Thompson was that it documented the lower incidence of hypotension in labouring patients and also that the combination of lateral tilt with fluid preloading was still associated with a significant incidence of spinal hypotension.

One reason why crystalloid preload may not successfully prevent hypotension is the short intravascular half-life of crystalloid solutions. Other than increasing the volume of preload there are two ways

*Table 1* Number (%) of hypotensive patients and those requiring ephedrine in three subgroups who received no therapy, fluid preload only and both preload and the "sluder" (modified from [6])

| | No therapy | Fluids | Fluids+sluder |
|---|---|---|---|
| Not in labour | | | |
| *n* | 27 | 76 | 53 |
| Hypotension | 25 (92) | 43 (57) | 28 (53) |
| Ephedrine | 13 (48) | 32 (42) | 23 (43) |
| In labour | | | |
| *n* | 18 | 39 | 34 |
| Hypotension | 9 (50) | 18 (46) | 5 (15) |
| Ephedrine | 4 (22) | 13 (33) | 5 (15) |

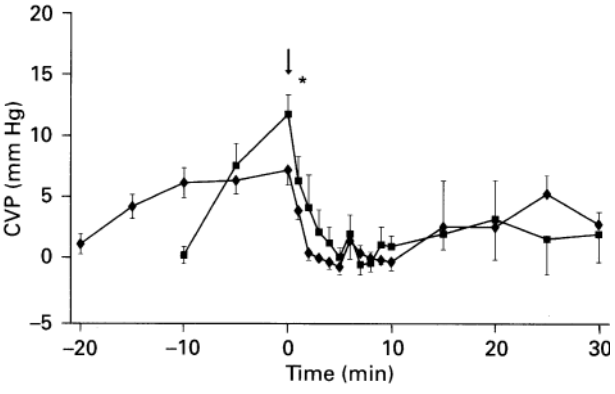


*Figure 1* Changes in central venous pressure (CVP) (mean, SEM) during crystalloid preload administered over 10 (■) or 20 (◆) min before spinal anaesthesia. Arrow indicates time of spinal injection of bupivacaine. $*P < 0.05$ between groups. (Reproduced from [9].)

of approaching this problem: first by preloading with a colloid solution with a longer intravascular half-life, or second by administering the crystalloid solution over a shorter period than the recommended 20 min. Mathru and colleagues used 5 % albumin in D5RL 15 ml kg$^{-1}$ administered over 15–20 min before spinal anaesthesia and compared the effects with those in patients receiving the same volume of D5RL without albumin [7]. Hypotension was eliminated in albumin-treated patients compared with a 30 % incidence in crystalloid controls, and the clinical and biochemical status of the neonates improved. Other investigators, albeit studying extradural anaesthesia, have not shown any advantage of colloid [8].

The effect of rapid administration of crystalloid 20 ml kg$^{-1}$ over 10 min compared with 20 min has been evaluated [9]. Rapid administration of preload failed to reduce the incidence of spinal hypotension and was accompanied by a significant increase in central venous pressure (CVP), up to 19 mm Hg in two subjects. An important additional finding of this study was the rapidity with which CVP decreased at the onset of spinal anaesthesia, despite preload (fig. 1). It is thus difficult to see how CVP could be maintained during this period by i.v. fluids, either colloid or crystalloid, as there are limits to the speed of administration.

The persistent failure of crystalloid preload led Rout and colleagues to question the value of such preload. However, widespread acceptance of large volumes of fluid before spinal anaesthesia as essential, created difficulties in performing a controlled study which included a group receiving no preload. In an attempt to overcome this problem a sequential analysis design was used whereby the number of patients receiving potentially "inferior" treatment (i.e. no preload) was restricted and the study could be terminated as soon as a significant difference was seen [10]. Although a statistically significant reduction in the incidence of hypotension from 71 % in unpreloaded patients to 55 % in preloaded patients occurred, this was considerably less than that anticipated from previous studies and challenged the perceived value of crystalloid preload. In addition, there was no difference in the clinical or biochemical status of neonates. Indeed, apart from a slightly higher neonatal base deficit, hypotension did not appear to affect neonatal outcome, suggesting that early detection and prompt treatment can counteract much of the effect of hypotension on uteroplacental flow. These results facilitated progression to randomized, comparative studies.

Following this study, Birnback and Datta suggested that increasing the amount of volume loading could have resulted in a decreased incidence of hypotension [11]. However, there is no evidence to support such a suggestion. By continuing rapid administration of fluids during the onset of block, Norris achieved an average fluid administration of $3.3 \pm 0.1$ litre (40–50 ml kg$^{-1}$) by the time maternal arterial pressure was stabilized before delivery [12]. Despite such large volumes, the incidence of mild to moderate hypotension was 74 % and the neonatal status of hypotensive mothers in this retrospective study did not differ from that of non-hypotensive mothers. While this was ascribed to the use of the large volume of fluid, repeated doses of ephedrine were used to correct hypotension when it occurred, and again, good neonatal conditions may have resulted from early detection and prompt treatment.

Large volumes of fluid may also be counterproductive. Kempen studied the influence of Ringer's lactate 1.5–2 litre infused before regional anaesthesia for Caesarean section and noted that 30 % of parturients were markedly anaemic (packed cell volume (PCV) 28–29 %) [13]. Hypotension occurred in 35 % of patients but was absent in those in whom PCV decreased by less than 6 %. Carvalho and colleagues subsequently compared maternal and fetal effects of infusion of Ringer's lactate 10 and 20 ml kg$^{-1}$ and showed that in the group receiving 20 ml kg$^{-1}$, haemoglobin concentration declined from a mean value of 11.4 to 9.9 g dl$^{-1}$ [14]. No patient in the 10-ml kg$^{-1}$ group developed hypotension, whereas 30 % of the patients who received 20 ml kg$^{-1}$ developed hypotension and required ephedrine. While these results remain unexplained, there has been some interesting work demonstrating a correlation between volume expansion and plasma concentrations of atrial natriuretic peptide, the effects of which include a direct relaxant effect on the vascular musculature [15].

Large volumes of crystalloid fluid could also decrease oxygen carrying capacity or increase the risk of pulmonary oedema in susceptible patients. It has been suggested that term parturients might be at greater risk of pulmonary oedema, with a reduced pulmonary interstitial safety margin because of a decrease in oncotic pressure and increase in plasma volume [16]. While pulmonary oedema precipitated by fluid loading in parturients before spinal anaesthesia has not been described, we documented unacceptably high CVP values after rapid fluid administration [9].

Why have some workers found preload to be effective? Marx and co-workers recently suggested that hypoglycaemia may be a factor involved in the genesis of hypotension during regional anaesthesia [17, 18]. Marx, Domurat and Costin reported three parturients who developed severe hypotension after

extradural anaesthesia for Caesarean section which was difficult to reverse until low blood glucose concentrations were normalized [17]. Hypoglycaemia is common in obstetric practice, especially when the fasting period is prolonged beyond 11 h [19]. Although the role of the glycaemic state of the patient remains unclear at present, the use of glucose-containing solutions by some researchers and not by others may partly explain differences in outcome.

Jackson, Reid and Thorburn have now shown that there was no advantage in giving 1 litre of crystalloid preload compared with 200 ml, to reduce the incidence or severity of hypotension after spinal anaesthesia for elective Caesarean section [2]. Neonatal outcome, as assessed by Apgar scores and cord blood–gas and acid–base status, was similar between the groups, and of a quality to be expected from well managed spinal anaesthesia. It might be argued that the use of prophylactic i.v. ephedrine in this study masked any effect of preloading, but the use of similar doses of ephedrine in each group suggests that this was not the case. Indeed, the use of prophylactic ephedrine failed to reproduce the degree of success achieved by Kang, Abouleish and Caritis [20] despite larger doses of ephedrine and a more stringent definition of hypotension by Jackson, Reid and Thorburn.

What recommendations can be made? The most significant preventative measure is lateral displacement of the uterus, a manoeuvre that was introduced after recognition of aortocaval compression as a potent cause of reduced venous return. Recent invasive studies have confirmed the decrease in cardiac output associated with the supine position and hence the mandatory use of lateral tilt [21]. As regards preload, we now have two studies which question its value [2, 10]. We still believe that in regard to elective cases where time is available, a modest amount of preload of up to 10 ml $kg^{-1}$ would seem not to be harmful and may confer some benefit on the fetus [22]. However, an obsession with administration of a fixed volume of preload before subarachnoid block in emergency cases is clearly unwarranted. Choosing general anaesthesia as an alternative in these circumstances would be inappropriate as the risk associated with spinal hypotension in unpreloaded subjects is not as great as the risk associated with general anaesthesia. Should we abandon fluid administration? On the available evidence we think not, and we would wish to see more data from other centres to corroborate the findings of Jackson, Reid and Thompson. Our current practice therefore in both elective and emergency cases is to commence preloading by rapid administration, to proceed with spinal anaesthesia without delay and to monitor and manage timeously any decreases in maternal arterial pressure.

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