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Research Article

Comparison of crystalloid and colloid preload on maternal hemodynamics in elective caesarean section under spinal anaesthesia

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ABSTRACT

Background: Hypotension after spinal anaesthesia for caesarean section remains a common and potentially serious complication. Crystalloids are commonly used to counteract this adverse effect. Colloid solutions, such as albumin, hydroxylethyl starch (HES) and gelatin is effective alternatives. The main objective was to study to compare the effect of crystalloid and colloid preloading in elective caesarean section.
Methods: It was a randomized controlled study conducted at North Bengal Medical College under Department of Anesthesiology in collaboration with Department of Gynaecology and Obstetrics from July 2011 to June 2012. Eighty patients were randomly allocated to two equal groups of 40 each in group 1 (Patients with Ringer's lactate) and group 2 (Patients with hydroxylethyl starch) before performing spinal anaesthesia.
Results: In the present study, the incidence of hypotension was more in Ringer's lactate group than hydroxylethyl starch group. The fall of systolic blood pressure, mean blood pressure were higher in Ringer's lactate group (group 1) than 6% hydroxylethyl starch group (group 2). The changes in heart rate, SpO2 and respiratory rate were clinically insignificant in both groups. Also, the time intervals from induction to reach block height upto T5, incision-delivery were similar for group 1 and group 2. Also, there was no clinical difference in neonatal outcome as measured by Apgar scores at 1 minute and 5 minutes between group 1 and group 2.
Conclusions: The preloading with 6% hydroxyethyl starch in elective caesarean section was able to prevent the maternal hypotension better than preloading with Ringer's lactate solution without any significant neonatal adverse effect.

Keywords: Hypotension, Ringer's lactate, Hydroxyethyl, Heart rate, SpO_2, Respiratory rate

INTRODUCTION

Spinal anaesthesia for caesarean section is the preferred option when balancing the risks and the benefits to the mother and foetus. With regional anaesthesia, the mother is able to share in the experience of the delivery, which may enhance mother-baby bonding. Hypotension after spinal anaesthesia for caesarean section remains a common and potentially serious complication.[1] Sympathetic block due to spinal anaesthesia along with aortocaval compression causes venous pooling leads to relative hypotension. This jeopardizes haemodynamic stability of mother and hampers blood flow to the placenta which may have detrimental effect on foetus.

Techniques currently in use for preventing hypotension in elective caesarean section under spinal block include intravenous fluid pre-hydration, sympathomimetic drugs,

and left uterine displacement.[2,3] Wollman and Marx in 1968 proposed the importance of fluid infusion to counteract the relative hypovolemia induced by vasodilatation during spinal anaesthesia.[2]

Various fluids, including crystalloids and colloids, have been used for preloading. There are many studies regarding their effects on the incidence and severity of hypotension, induced by spinal anaesthesia, but none of them proved to be ideal.[4-6] Among the crystalloids, Ringer's lactate is commonly used because its osmolarity nearer to plasma and adequate volume can be given rapidly. But it is a poor plasma volume expander because it has a short intravascular half-life due to its rapid migration into the interstitial space. This may explain why hypotension associated with spinal anaesthesia cannot be completely eliminated by crystalloid preloading. Large volumes of crystalloid fluid can also decrease oxygen-carrying capacity, and may increase the risk of pulmonary and peripheral edema during the puerperium.[7] Still rapid administration of crystalloid solution to parturients undergoing spinal anaesthesia for caesarean section has been recommended to reduce the incidence and severity of hypotension before the induction of spinal anaesthesia.[2,8,9]

Colloid solutions, such as albumin, hydroxylethyl starch (HES) and gelatins are effective alternatives. The advantages of colloids preload are that they leak into the interstitial space lesser than crystalloids and thus lesser volume is required for adequate volume expansion. But they have some adverse effect like vomiting, mild fever, itching, flu like symptoms, chills, coagulopathy, renal complications and rarely anaphylactoid reactions like urticaria, periorbital oedema, and bronchospasm. Nowadays, HES 130/0.4, a novel 3rd generation hydroxyethyl starch with a relatively low incidence of side effects, an average molecular weight of 130,000 Dalton has been popular to use as colloid. Its molecular weight distribution is the narrowest among all available HES types and it has a volume effect of approximately 100% and for 4 to 6 h duration. Still use of colloids, aimed at the volume expansion to counteract the vasodilation induced hypotension by spinal anaesthesia, does not eliminates the requirement of vasopressor drugs, but reduces the total dose in most of the cases.[10] Sharma et al observed that the incidence of hypotension was 52% in the Ringer's lactate solution group and 16% in the HES group.[11]

So there is a controversy about the use of crystalloid or colloid preload to maintain the haemodynamic stability in mother going for elective caesarean section under spinal anaesthesia.

On this background, the current study is planned to explore the effect of crystalloids or colloids preload on haemodynamic stability in mother undergoing spinal anaesthesia for elective caesarean section.

The aim of the study was to compare the effect of crystalloid and colloid preloading in elective caesarean section in respect to

- Reducing the incidence of maternal hypotension (primary outcome).
- Reducing other haemodynamic changes.
- Minimizing requirement of vasopressor.
- Decreasing neonatal adverse outcome.
- Decreasing incidence of any other adverse effects.

METHODS

It was randomized controlled study conducted at North Bengal Medical College under Department of Anaesthesiology in collaboration with Department of Gynaecology and Obstetrics from July 2011 to June 2012. Study population includes women aged 20 to 35 years, ASA grade I and II, with singleton term pregnancy scheduled for elective caesarean delivery under spinal anaesthesia. Eighty patients were randomly allocated to two equal groups of 40 each (group 1 and group 2) by computer generated randomization. In group 1, patients received preload of Ringer's lactate and in group 2 patients received hydroxyethyl starch before performing spinal anaesthesia.

The study was conducted after getting permission from institutional ethics committee. Reference population was selected from the patients undergoing elective caesarean section living in the catchment area of North Bengal Medical College. At antenatal clinic, the routine pre-anaesthetic checks up were done to select the patients for this study following the inclusion and exclusion criteria. Informed consent and performa sheet was taken from patients.

Inclusion criteria

- Women aged 20 to 35 years
- ASA grade I and II, with singleton term pregnancy

Exclusion criteria

- Unwilling patient.
- Chronic or pregnancy-induced hypertension.
- Cardiac, cerebrovascular and pulmonary disease.
- Diabetes mellitus.
- Extremes of weight (<40 or >100 kg).
- Extremes height (<140 cm or >165 cm)
- Anaemia (Hb <10.0 g/dl),
- Any contraindications to neuraxial anaesthesia.
- History of allergy to any drug used for the procedure.
- A known foetal abnormality.

Demographic parameters like height, weight, BMI, gestational age, parity, gravida, duration from induction of spinal anaesthesia to delivery, parameters to measure the haemodynamic stability of mother. Systolic blood

pressure, mean arterial blood pressure, heart rate, electrocardiography, SpO_2, respiratory rate, total requirement of vasopressor during operation, neonatal outcome – Apgar score at 1 and 5 minutes and Incidence of nausea, vomiting and other side effects were studied.

There was pre-anaesthetic visit for every patient on the day before operation to allay anxiety. Randomly allotted group were given premedication with tab. alprazolam and tab. ranitidine (300mg) night before the operation.

On the day of surgery the patient ECG, heart rate, NIBP, SpO_2, respiratory rate was monitored. Group1 or group 2 was determined by coin toss technique. The pregnant mother is prone to develop 'supine hypotension syndrome. To prevent this, every patient was transferred to the operation theatre in left lateral position. Mean heart rate (HR), blood pressure (SBP, MAP), SpO_2, respiratory rate was calculated after three successive measurements taken 1–2 min apart. A 16-gauge IV cannula was inserted in the anterior aspect of forearm of the non-dominant hand. The patients received either 1000 ml of Ringers' lactate solution or 500ml of 6% Hydroxyethyl starch according to their group allocation.

Statistical analysis

Data were tested by Independent-samples t test (continuous data) or by Pearson Chi-square test and Fisher's exact test as appropriate (categorical data). For descriptive purposes, p value <0.05 was considered statistically significant. All analysis was conducted using Epi-Info and SPSS for Windows (version 12).

RESULTS

Initially, 88 patients undergoing elective caesarean under spinal anaesthesia were included in the study, but 8 patients among them refused to give consent. So, the remaining 80 patients were randomly allocated into two equal groups (group 1 and group 2) by computer generated block randomization. Patients of group 1 received 1 lit of Ringers lactate solution. Group 2 received 500 ml of 6% HES solution.

Demographic characteristics are shown in Table 1. All the values were statistically insignificant (p>0.05) between groups. Mean age of patients in group 1 was 26.35±4.61 years (p=0.960) compared with mean age of patients in group 2 (26.40±4.26). Average weight of patients in groups were 50.98±3.96 kg and 51.95±5.42 kg in group 1 and 2, respectively (p=0.361). Patients had average height of 145.08±5.15 cm in group 1 and 145.88±7.76 cm in group 2 which was also statistically insignificant (p=0.589). BMI of the groups were also comparable (p=0.620). Statistical analysis by Pearson-Chi square test revealed no significant difference in ASA status (I/II) for each group (p=1.000). Average gestational age in groups were 38.44±0.89 weeks and 38.45±0.89 weeks in group 1 and group 2 respectively which were statistically insignificant (p=0.98). So patients in both groups were comparable regarding demographic characteristics.

Table 1: Demographic parameters.

Parameters	Group 1 (n=40)	Group 2 (n=40)	*P* value
Age (year)	26.40±4.53	26.45±417	0.959(NS)
Weight (kg)	50.98±3.96	51.95±5.42	0.361(NS)
Height (cm)	145.08±5.15	145.88 ±7.76	0.589(NS)
BMI (kg/m^2)	24.23±1.75	24.48±2.64	0.620(NS)
ASA status (I/II)$^{\$}$	23/17	24/16	1.000(NS)
Gestational age (weeks)	38.44±0.89	38.45±0.89	0.98(NS)

NS-non significant

Table 2 shows the mean and standard deviation of baseline systolic blood pressure and the variations of systolic blood pressure after induction of spinal anaesthesia in two groups. In group 1, systolic blood pressure was low at 6 min (102.45±4.94) after spinal induction and in group 2 systolic blood pressures was low at 12 min (100.60±6.83) after spinal induction. Statistically significant difference between two groups was noted at 2, 4, 6, 8, 12, 16 and 18 mins (p=0.000).

Table 3 shows the mean and standard deviation of baseline mean arterial blood pressure and the variations of mean arterial blood pressure after induction of spinal anaesthesia in two groups. In group 1, arterial blood pressure was low at 6 min (76.76±4.38) after spinal induction and in group 2 arterial blood pressures was low at 16 min (76.17±4.67) after spinal induction. Statistically significant difference between two groups was noted at 2 min (p=0.004) whereas at 4, 6, 12, 14, 16, 18 and 20 min (p=0.000), and at 8 min (p=0.003) after induction of spinal anaesthesia.

In group 1, heart rate was high at 6 min (89.23±8.15) after induction of spinal anaesthesia whereas in group 2 HR was high at 12 and 18 min (93.08±4.97) after spinal induction. Statistically significant difference between two groups noted only at 12 min (p=0.032) and 14 min (p=0.000), 16 min (p=0.032), 18min (p=0.000) and 20 min (p=0.040) after induction of spinal anaesthesia as shown in Table 4.

In Table 5 mean and standard deviation of SpO_2 was low at 12, 16 and 20 min (98.33±0.85)in group 1 and in group 2 it was low at 16 and 20 min (98.08±1.09). Statistically significant difference between two groups was at 10 min (p=0.010) after induction of spinal anaesthesia.

Table 2: Baseline and variations in systolic blood pressure (SBP) after induction of spinal anaesthesia

Parameter	Group 1	Group 2	p-value
SBP	**(Mean±SD)**	**(Mean±SD)**	
Baseline SBP	121.28±4.05	120.78±5.95	0.662 (NS)
2 min after spinal induction	111.68±5.09	117.28±6.29	0.000 (S)
4 min after spinal induction	105.45±5.10	112.98±5.95	0.000 (S)
6 min after spinal induction	102.45±4.94	111.50±4.56	0.000 (S)
8 min after spinal induction	103.83±6.83	106.83±6.23	0.044(S)
10 min after spinal induction	104.15±7.98	103.05±5.47	0.475(NS)
12 min after spinal induction	106.38±7.26	100.60±6.83	0.000(S)
14 min after spinal induction	108.40±6.46	102.70±7.30	0.000(S)
16min after spinal induction	106.85±7.43	100.85±6.59	0.000(S)
18 min after spinal induction	108.40±6.46	102.70±7.30	0.000(S)
20 min after spinal induction	106.73±7.43	103.40±7.75	0.054(NS)

NS-non significant; S- significant

Table 3: Baseline and variations in mean arterial blood pressure (MAP) after induction of spinal anaesthesia.

Parameter	Group 1	Group 2	p-value
MAP	**(Mean±SD)**	**(Mean±SD)**	
Baseline MAP	92.64±3.68	91.83±3.07	0.288 (NS)
2 min after spinal induction	84.70±3.73	87.44±4.39	0.004 (S)
4 min after spinal induction	79.93±4.13	84.67±4.04	0.000 (S)
6 min after spinal induction	76.76±4.38	83.89±3.36	0.000 (S)
8 min after spinal induction	77.74±5.43	80.95±3.86	0.003(S)
10 min after spinal induction	77.38±5.38	78.15±4.34	0.481(NS)
12 min after spinal induction	81.22±6.59	76.32±4.39	0.000(S)
14 min after spinal induction	82.65±5.60	77.75±6.30	0.000(S)
16 min after spinal induction	81.33±6.66	76.17±4.67	0.000(S)
18 min after spinal induction	82.65±5.60	77.75±6.30	0.000(S)
20 min after spinal induction	81.35±6.66	76.40±5.19	0.000(S)

NS-non significant; S- significant.

Table 4: Baseline and variations in heart rate (HR) after spinal induction.

Parameter	Group 1	Group 2	p-value
Heart rate(BPM)	**(Mean±SD)**	**(Mean±SD)**	
Baseline heart rate	82.28±5.55	85.18±9.63	0.103 (NS)
2 min after spinal induction	84.08±14.79	87.53±11.17	0.243 (NS)
4 min after spinal induction	88.58±10.18	88.38±11.50	0.935 (NS)
6 min after spinal induction	89.23±8.15	87.35±8.30	0.311 (NS)
8 min after spinal induction	88.00±17.17	88.35±6.84	0.905(NS)
10 min after spinal induction	89.20±7.99	91.35±7.97	0.232(NS)
12 min after spinal induction	88.15±7.76	91.83±7.31	0.032(S)
14 min after spinal induction	86.10±7.28	93.08±4.97	0.000(S)
16 min after spinal induction	88.15±7.76	91.83±7.31	0.032(S)
18 min after spinal induction	86.10±7.28	93.08±4.97	0.000(S)
20 min after spinal induction	88.40±7.34	91.83±7.31	0.040(S)

NS-non significant; S- significant.

Table 6 shows the mean and standard deviation respiratory rate was high at 6 min (15.48±1.28) in group 1 and in group 2 it was high at 14 and 18 min (17.02±1.38). Statistically significant difference between two groups noted at 12 min (p=0.011), at 14 min (p=0.000), at 16 min (p=0.011), at 18 min (p=0.000) after induction of spinal anaesthesia.

Table 7 shows mean and standard deviations of time to reach block height at T5 in group 1 were 9.05±1.75 and in group 2 was 8.22±1.78. Results of independent Student's t test suggested that both groups had no statistically significant difference (p=0.5).

Table 8 shows the time interval from induction to delivery (minute) in group 1 and group 2. It was 18.57±1.27 minutes in group 1 and 18.47±1.21 minutes in group 2. There was no statistically significant difference in time interval from induction to delivery (minute) between the two groups (p=0.721).

Table 5: Baseline and variations in SpO_2 after induction of spinal induction.

Parameter	Group 1	Group 2	p-value
SpO_2 (%)	**(Mean±SD)**	**(Mean±SD)**	
Baseline SpO_2	97.98±1.29	98.18±1.05	0.451 (NS)
2 min after spinal induction	98.43±1.05	98.63±1.00	0.389 (NS)
4 min after spinal induction	98.55±0.74	98.58±1.03	0.902 (NS)
6 min after spinal induction	98.45±0.87	98.50±0.87	0.799 (NS)
8 min after spinal induction	98.50±0.81	98.28±0.93	0.255 (NS)
10 min after spinal induction	98.60±0.95	98.03±1.00	0.010 (S)
12 min after spinal induction	98.33±0.85	98.08±1.09	0.259 (NS)
14 min after spinal induction	98.55±0.71	98.50±0.96	0.792 (NS)
16 min after spinal induction	98.33±0.85	98.08±1.09	0.259 (NS)
18 min after spinal induction	98.55±0.71	98.50±0.96	0.792 (NS)
20 min after spinal induction	98.33±0.85	98.08±1.09	0.259 (NS)

NS-non significant; S- significant.

Table 6: Baseline and variations in respiratory rate after induction of spinal induction.

Parameter	Group 1	Group 2	p-value
Respiratory rate (rr/min)	**(Mean±SD)**	**(Mean±SD)**	
Baseline respiratory rate	14.78±1.27	14.95±1.60	0.590 (NS)
2 min after spinal induction	15.13±1.39	15.45±1.33	0.292 (NS)
4 min after spinal induction	15.30±1.38	15.30±1.38	1.000 (NS)
6 min after spinal induction	15.48±1.28	15.23±1.33	0.394 (NS)
8 min after spinal induction	15.00±1.28	15.23±1.07	0.397 (NS)
10 min after spinal induction	15.35±1.54	15.45±1.33	0.758 (NS)
12 min after spinal induction	15.35±1.27	16.02±1.05	0.011(S)
14 min after spinal induction	15.45±1.19	17.02±1.38	0.000 (S)
16 min after spinal induction	15.35±1.27	16.02±1.05	0.011(S)
18 min after spinal induction	15.45±1.19	17.02±1.38	0.000 (S)
20 min after spinal induction	15.35±1.27	16.02±1.05	0.259 (NS)

NS-non significant; S- significant.

Table 7: Time to reach block height at T5 for group 1 and group 2 and their statistical analysis.

Parameters		Group 1 (n = 40)	Group 2 (n = 40)	p value
Time to reach block height at T5	Mean±SD	9.05±1.75	8.22±1.78	0.571 (NS)

NS-non significant.

Table 8: Time interval from induction- delivery (in minute) in group 1 and group 2 and their statistical analysis.

Parameters		Group 1 (n = 40)	Group 2 (n = 40)	p value
Induction- delivery (minute)	Mean±SD	18.57± 1.27	18.45± 1.21	0.721(NS)

NS-non significant.

Incidence of hypotension in group 1 was 60% and in group 2 was 30% as shown in Table 9. Both groups had statistically significant difference (p=0.011). In group 1 incidence of nausea/vomiting was 30% and in group 2, it was 17.5%. Value of Pearson-Chi square test indicated that there was no statistically significant difference (p=0.189) between two groups.

In group 1, Apgar score at 1 min was 6.47±0.84 and in group 2 it was 6.77±0.83 as shown in Table 10. Results of independent Student's t test suggested that both groups had no statistically significant difference (p=0.114).

Apgar score at 5 min in group 1 was 8.90±0.81 and in group 2 it was 8.95±0.74.

Table 9: Adverse events-incidence of hypotension and nausea/vomiting in two groups.

Parameters	Group-1 (n=40)	Group-2 (n=40)	p-value
Hypotension	24 (60%)	12 (30%)	*0.011
Nausea/vomiting	12 (30%)	7 (17.5%)	0.189 (NS)

NS-non significant.

Table 10: Apgar score at 1 minute and Apgar score at 5 minute for group 1 and group 2 and their statistical analysis.

Parameters		Group 1 (n = 40)	Group 2 (n = 40)	p value
Apgar score At 1 minute	Mean±SD	6.47±0.84	6.77±0.83	0.114 (NS)
Apgar score At 5 minute	Mean±SD	8.90± 0.81	8.95± 0.74	0.775 (NS)

NS-non significant.

Table 11 shows average dose of phenylephrine used in two groups. In group 1, it was 45.00±42.06 µg and in group 2 it was 18.75±31.39µg. Results of independent Student's t test suggested that both groups had statistically significant difference (p=0.002).

Table 11: Average dose of phenylephrine (µg) used for group 1 and group 2 and their statistical analysis.

	Group 1 (n=40)	Group 2 (n=40)	P value
Mean±SD	45.00± 42.06	18.75±31.39	0.002

DISCUSSION

Hypotension during spinal anaesthesia is a common problem. Hypotension during spinal anaesthesia is the result of sympathetic blockade leading to relative hypovolaemia and decreased venous return.

Susceptibility to hypotension varies among patients. Recent studies used multivariable analysis to identify the following factors that increase risk: age (≥35 years), obesity (BMI >29–35 kg/m^2) and higher block (>T4–T6).[12,13] Maayan-Metzger et al retrospectively reviewed 919 elective caesarean deliveries and found that nearly half had a decrease in mean arterial pressure by at least 30%. The risk factors for hypotension included preoperative hypertension, older age, type of spinal anaesthesia and higher infant birth-weight.[14]

Cesur et al described a novel technique of sequential injection of 5mg bupivacaine followed by 5mg hyperbaric bupivacaine, injected over 10s in the sitting position. Compared with 10mg hyperbaric bupivacaine, hypotension and related symptoms were less (13.9 versus 66.7%) despite similar maximum height of block.[15]

Excessive crystalloid administration may produce pulmonary and peripheral oedema and have little effect on plasma volume. There is evidence to suggest that postpartum patients might be more susceptible to pulmonary oedema after the rapid administration of crystalloid, possibly because of an increase in lung water during pregnancy.[7] The IV administration of colloid has been shown to be associated with less lung water compared with Ringer's lactate solution.[16]

There were no statistically significant difference considering the incidence of nausea and vomiting in both groups. This was also similar to the study conducted by Sharma et al where in group 1, 24 (60%) cases required vasopressor phenylephrine, (45.00±42.06 µg), where as in group 2, only 12 (30%) cases required phenylephrine to control hypotension (18.75±31.39µg).[11]

Smiley et al showed that infusions titrated in the range of 25–100mcg/min are highly effective for maintaining maternal BP, but Warwick et al showed that the administration by bolus is simple but the optimal dose is unknown.[17,18]

In the present study, both groups were compared considering the incidence of hypotension. It has been found that 24 out of 40 mother in group 1 developed hypotension (fall of MBP>20% from baseline) and 12 out of 40 mother developed hypotension. So the incidence of hypotension in group 1 was 60% and in group 2 was 30% which was statistically significant.

In a similar study by Riley et al, the incidence of hypotension during spinal anaesthesia for caesarean section was 45% in patients who received a combination of hetastarch 500 mL with Ringer's lactate solution 1000 ml.[19] On the other hand, the incidence of hypotension was 85% in those who received only Ringer's lactate solution 1000 ml. Karinen et al noted a low incidence of maternal hypotension with hetastarch 500 ml alone (38%) as compared with LR 1000 mL (62%) in patients undergoing caesarean section.[21]

In a similar study Madi-Jebara et al compared pre-hydration with 1 litre Ringers lactate solution versus 500 ml hydroxyethyl starch (HES) 130/0.4 solution and found that in the colloid group, the incidence of hypotension was smaller (63.9 versus 81.4%, P=0.033), the minimal recorded SBP was higher.[20]

After considering all the above factors, we found that the preloading of 6% HES is superior to Ringer's Lactate solution in elective caesarean section after sub arachnoid block in mother to prevent hypotension and to maintain a stable haemodynamic status.

CONCLUSION

The preloading with 6% hydroxyethyl starch in elective caesarean section was able to prevent the maternal hypotension better than preloading with Ringer's lactate solution without any significant neonatal adverse effect. Other hemodynamics changes are more or less similar in both groups. The vasopressor requirements were lesser in the mothers who were preloaded with 6% hydroxyethyl starch.

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