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Prospective Comparative Study of Crystalloid Coloading Versus Preloading for Prevention of Spinal Anaesthesia Induced Hypotension in Elective Caesarean Section

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Abstract
Cesarean section is preferably performed under spinal anesthesia owing to its quick onset, dense neural block, minimal fetal drug transfer and toxicity. However sympathetic inhibition causes hypotension, treated by intravenous fluid boluses. Brief duration of crystalloid infusion in the intra vascular compartment raises timing concerns regarding rapid fluid redistribution and excretion, reducing preload’s efficiency in preventing hypotension. Co-loading is favored as it increases the intra vascular volume during the vasodilatory phase of sympathetic inhibition. To compare the effectiveness of crystalloid preloading and co-loading against the incidence of hypotension after spinal anaesthesia in caesarean section. A prospective comparative study was conducted in 60 parturient. Patients were randomly assigned to either groups by consecutive sampling. Before spinal anesthesia, parturients in group P received a preload of 15 ml/kg ringer's lactate over 20mins. Parturient in group C received 15ml/kg ringer's lactate over 20mins, immediately following spinal anesthesia. Heart rate, systolic, diastolic blood pressure, mean arterial pressure, incidence of hypotension and ephedrine use were evaluated. Results were noted and analysed. Statistically significant difference was present in the incidence of spinal anesthesia induced hypotension between the preload and co-load group. The two groups differed with heart rate, blood pressure, mean arterial pressure, nausea and vomiting. The group P also required more ephedrine than group C. Co-loading crystalloid was more effective than preloading for preventing maternal hypotension following spinal anesthesia.

INTRODUCTION

Anesthesia during cesarean sections, whether elective or emergency, is a challenging endeavour[1]. Because of its quick onset, extensive neural block, low risk of anesthetic toxicity and minimal fetal drug transfer, spinal anesthesia is preferred for caesarean sections. Hypotension during spinal anesthesia for cesarean section carries the risk of harm to both mother and child[2].

The primary cause of post-spinal hypotension is sympathetic inhibition, resulting from venous pooling and peripheral vasodilation. There is decline in cardiac output and venous return. When hypotension occurs, the mother and fetus may suffer negative consequences. Symptoms affecting the mother includes syncope, aspiration, nausea, vomiting, dizziness and arrhythmias[3].

Both non-pharmacological and pharmaceutical techniques can reduce the incidence of hypotension caused by spinal anesthesia. Inflatable splints or boots, leg wrapping techniques, thromboembolic deterrent stockings are examples of non-pharmacological approaches yielding less satisfactory outcomes[4]. Pharmacological techniques include the intravenous fluid boluses, oxygen supplementation and intravenous vasopressors like ephedrine (5-15mg) or phenylephrine (25-50 mcg) boluses[5].

Preloading involves the use of various crystalloids, such as Ringer lactate (RL), normal saline and colloids, such as gelatin, dextran, hetastarch, pentastarch and tetrastarch to prevent hypotension. Colloids have a number of drawbacks, including price, allergic responses and effect on coagulation. So anesthesiologists continue to favour crystalloids[6,7].

The timing of the infusion is crucial in preventing hypotension since the volume-expansion of crystalloid administration peaks at that precise moment. Crystalloids do not stay in the intravascular compartment, but instead spread quickly into the extracellular fluid. Preloading is the delivery of fluid 10 to 20 minutes before spinal anesthesia in the preoperative room, whereas co-loading is the administration of fluid during spinal anesthesia in the operating room[8].

Preload has long been thought to be the best defense against spinal-induced hypotension. However, co-loading may be more physiologically suitable. This may restrict fluid redistribution and excretion and enhance intra vascular volume expansion during vasodilatation following sympathetic inhibition[9].

A number of studies have been conducted to assess the effectiveness of co-loading and preloading. Due to its short intra vascular half-life of 15-20 minutes, numerous authors have questioned the impact of preloading on the occurrence of hypotension in their research. Because co-loading increases intravascular volume at the moment of maximal vasodilatation, which is often within 15-20 minutes after intrathecal injection, authors have therefore recommended quick crystalloid administration at the time of spinal anesthesia.

The purpose of this study was to examine the effectiveness of volume co-loading and volume preloading with crystalloids in preventing spinal anesthesia-induced hypotension in patients undergoing elective caesarean section.

MATERIALS AND METHODS

This prospective comparative study was carried out on 60 parturients who were posted for elective caesarean section in Sree Mookambika Institute of Medical Sciences, Kulasekharam for a period of 4 months from November 2023 to February 2024. Participants in the study were adult gravida patients (18-40 years) with an American Society of Anesthesiologists physical status (ASA) 1 or 2 undergoing an elective caesarean section under spinal anesthesia without any contraindications. Exclusions from the study included individuals with ASA class III, IV and V, history of hypertension, allergies to local anesthetics, cardiac conditions, serious illnesses, coagulation disorders and patient refusal.

Informed and Written consent was taken from all the participants. Upon thorough pre-anesthesia evaluation and inquiry, research participants who satisfied the inclusion requirements were recruited. A computer-generated random number was used to divide the 60 patients into two groups of 30 patients each. Group P - The patient was preloaded with RL at a dose of 15ml/kg. Group C-patients who are receiving RL co-loading at a dose of 15mL/kg.

Prior to their scheduled surgery, patients were usually given 150 mg of Tab Ranitidine the previous night. Pre-operative baseline vitals were recorded as soon as the patient entered the operating room. These includes the oxygen saturation (SpO2), heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and electrocardiogram (ECG). Every patient received additional oxygen, 4 l/min through facemask.

Two peripheral intravenous catheters were secured, one for medication administration and the other for fluid administration. In Group P, 15 ml/kg of RL was administered over 20 minutes before to spinal anesthesia in the preoperative room (Preload) , while in Group C, 15 ml/kg of RL was administered over 20 minutes following the detection of clear CSF in the operative room (Co-load).

Both groups received spinal anesthesia using a 25-gauge Quincke Babcock spinal needle at the L2-L3 or L3-L4 level, with a total volume of 2ml of 0.5% heavy bupivacaine with 60µg Inj buprenorphine given under aseptic precautions. The parturient was immediately positioned in a supine position with a 15° left lateral tilt. During the intra operative phase, 8ml/kg/hr of maintenance fluid was infused. Pinpricks were used bilaterally and ascendingly to measure the degree of sensory blockage, beginning at the T12 dermatome. Surgery was then permitted to begin after the T6 dermatomal level was reached.

SBP measures were taken in both groups at 2 min intervals for the first 10mins of the regional block, then at 5min intervals for the next 30mins and then every 15mins until the end of the procedure. HR readings were also noted in a similar manner. SBP falling by greater than 20% of baseline, or less than 90 mmHg, was referred as hypotension. An intravenous dose of 6 mg of ephedrine was used to alleviate hypotension. Fall in heart rate below 60 beats per minute or more than 15% from baseline was considered bardycardia. Atropine injection was stored in preparation for treating bardycardia. The level of oxygen saturation was continuously observed. Respiratory rate less than 10 breaths/min was considered respiratory depression. The mother received 10 IU of Inj. oxytocin as an infusion in her intravenous fluid after the baby delivery. To evaluate the fetal outcome, APGAR scores were taken one minute and five minutes after delivery. Following the procedure, every patient was moved to a post-anesthesia recovery unit for close observation. The data was entered in MS Excel spreadsheet, and version 21.0 of the Statistical Package for Social Sciences (SPSS) was used for analysis. For quantitative data, the Student's t-test was employed., for qualitative data, the Chi-square was utilized. A p-value less than 0.05 were considered statistically significant.

RESULTS AND DISCUSSIONS

The demographic data was comparable in both the groups and the difference was not statistically significant. (Table 1).

The baseline HR and SBP were comparable in both the groups and the difference of these parameters in the two groups was not statistically significant. (Table 2).

The mean heart rate changes between the two groups were comparable, with the greatest variation recorded from the 3rd to 4th min after spinal block. The co-load group continued to have a significantly greater heart rate than the preload group after spinal anesthesia, despite the preload group having a significantly higher baseline heart rate. There was a decrease trend in heart rate near the end of surgery. Aortocaval decompression and anxiety release upon delivery could be the cause.

The lowest blood pressure readings were observed between the 3rd and 4th min after spinal block. The mean SBP changes between the two groups were of statistical significance ($p<0.05$). Following spinal anesthesia, there was a significant difference in the mean blood pressure variation between the two groups.

There was a statistically significant difference in the incidence of hypotension between Group P and Group C, with 53.33% and 23.33%, respectively. The incidence of nausea was not statistically significant however it was higher in Group P (26.67%) than in Group C (13.33%). Vomiting and bradycardia rates were high in P group. (Table 3).

The mean number of ephedrine doses needed to stabilize blood pressure was higher in group P than in group C and this difference was statistically significant. (Table 4) APGAR scores at 1 and 5 mins were comparable in both groups. (Table 5).

Even with the growing use of spinal anesthesia for Cesarean sections, anesthesiologists are still baffled by the cause of hypotension. Increased venous capacitance, decreased systemic vascular resistance and aortocaval compression were the causative variables. Because of the increased venous capacitance, varied quantities of crystalloid and colloid solutions were administered before spinal anesthesia to prevent hypotension subsequently[10].

Starling's law states that the hydraulic pressure of the interstitial and capillary fluids as well as the oncotic pressure controls the fluid exchange. During crystalloid infusion, the capillary hydraulic pressure gradually rises, which may cause an increase in the hydraulic pressure differential and fluid filtration from plasma into the interstitium. The distribution of crystalloids across extracellular into interstitial space, results in inefficient intravascular expansion, depending critically on the timing of the fluid infusion[11].

Ringer lactate is utilized as a preloading fluid because it is the most physiological fluid, with an osmolality comparable to plasma. The intravascular volume can be increased and water and electrolytes can be maintained with the use of crystalloids. Because interstitial space absorbs 75% of its volume, its effect on growing plasma volume is very temporary. On the other hand, co-loading provides additional intravascular space with fluid during the time after spinal anesthesia that is most likely to cause hemodynamic abnormalities[12]. Research comparing co-loading with preloading in the obstetric population has shown that the incidence of hypotension varies greatly.

The current study found that the Co-loading group had a considerably lower mean vasopressor demand and a lower incidence of hypotension. The total blocking of sympathetic nerves occurs approximately 10 minutes after the administration of heavy bupivacaine in the subarachnoid space. During this time, hypotension is most likely to occur. The avoidance of maternal hypotension was thus better

Table 1: Demographic and clinical Characteristics of Study Participants

Variable	P group(n = 30)	C group (n = 30)	p-value
Age (years)	24.54±2.05	25.1±1.71	0.201
Height (cm)	71.81±7.4	72.03±7.6	0.410
Weight (kg)	162.3±2.9	161.5±3.2	0.168
ASA score, I/II	25/5	27/3	0.297
Gestational age (weeks)	38.0±1.4	38.0±1.6	0.302
Surgical duration (min)	76.24±10.06	73.86±12.76	0.637

Table 2: Comparison of Hemodynamic parameters

Parameter	Group P	Group C	p-value
Heart rate(bpm)	88.1±7.5	84.4±8.2	0.512
Systolic BP	124.4±9.6	120.5±7.9	0.322
Diastolic BP	82.7±3.8	84.4±3.9	0.431
Mean BP	92.9±4.1	93.6±3.6	0.172

Table 3: Perioperative adverse events

Parameter	P group(n = 30)	C group (n = 30)	p-value
Hypotension	16 (53.33%)	7 (23.33%)	0.032
Nausea	8 (26.67%)	4 (13.33%)	0.425
Vomiting	2 (6.67%)	1 (3.33%)	0.084
Bradycardia	4 (13.33%)	2 (6.67%)	0.167

Table 4: Neonatal outcome compared using APGAR score.

Variable	Group P	Group C	p-value
Ephedrine requirement(mg)	6.51±3.74	3.44±3.17	< 0.001

Table 5: Parameters of Ephedrine requirements

	Preload	Co-load	p-value
Apgar score at 1 min	9(6-9)	9(6-9)	0.962
Apgar score at 5 min	10(9-10)	10(9-10)	0.836

achieved by co-loading, since it resulted in increased intravascular fluid volume, decreased fluid redistribution and decreased crystalloid excretion.

Singhal A[13] examined the pre- and co-loading effects of 15 ml/kg of Ringer Lactate solution in 25 patients per group. They came to the conclusion that the best way to avoid maternal hypotension is to quickly administer crystalloids following spinal anesthesia. These results support the current study.

Tiruneh A[14] in their study, there was a statistically significant difference in the incidence of spinal anesthesia-induced hypotension between the preload group (81.2%., 39/48) and the co-load group (17.4%, 17/48).

Findings in the current study correlated with Hunie M[15] which was a study using a prospective cohort design in which 96 parturient receiving spinal anesthesia for cesarean sections. In the preloading group, they observed a greater incidence of hypotension. Similar findings were also observed by Verma S[16], Devi A[17] and Quarshie A[18,19].

The study by Artawan IM[20] used the Bonferroni post hoc test to compare the declines in SBP, DBP, MAP and HR between the therapy groups. The findings demonstrated that the preloading group and the co-loading group had significantly different SBP, DBP and MAP reductions (P<0.001), as did the co-loading group and the control group (p<0.001).

When treating hypotension, the co-loading group used a statistically lower total number of doses and cumulative dose of ephedrine than the preloading group. This was comparable to the study conducted by Gajjar VA[21] According to the findings of Borse DY[22]. The required dosage of ephedrine for the preload and co-load of crystalloid was 4.6mg and 3.4mg, respectively. There was no statistically significant difference in the APGAR scores of the newborns in the two groups. Similar results were noted by Borse DY[22].

CONCLUSIONS

The present study found that co-loading with crystalloids was more successful than preloading technique for preventing spinal anesthesia induced hypotension. In emergency cesarean procedures, when speed is of the essence, this can save the precious time allotted for preloading. According to the ASA clinical practice guideline, "Spinal anesthesia should not be delayed to administer fixed volume of intravenous fluid, even though fluid preloading reduces the frequency of maternal hypotension." As a result, significant time should not be squandered preloading the parturient, as preloading was ineffective in preventing maternal hypotension following a caesarean operation under spinal anesthesia.

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