Original Research Article

A comparative study of colloid versus crystalloid as preloading infusion for prevention of hypotension in spinal anaesthesia

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Abstract

Background: Subarachnoid block is considered a safe regional anaesthesia technique. This technique is widely used for both elective as well as emergency surgical procedures. It is a good anaesthesia technique for surgeries like caesarean section, lower abdominal surgeries, lower limb orthopaedic surgeries and urological procedures. Though spinal anaesthesia has several advantages, it has few disadvantages as well like hypotension, post dural puncture headache, neurological damage etc. As far as hypotension is concerned, both crystalloids and colloids are used as preloading intravenous fluid before spinal anaesthesia. Different crystalloids commonly used in preloading are Ringer lactate, normal saline and colloids that are used in preloading are gelatin, dextran, hetastarch, pentastarch, tetrastarch. We have compared the efficacy of Crystalloid Vs Colloid as preloading infusion for prevention of hypotension in Spinal anaesthesia. **Methods**: A comparative prospective double blinded randomised study of volume preloading prior to subarachnoid block in lower abdominal surgery with Voluven® and Physiomax TM was undertaken at Meenakshi medical College and Research Institute, Kanchipuram, during April 2017 and August 2018, after institutional Human ethical committee approval and informed consent from the patients. The study population included 60 in-patients belonging to either sex of ASA physical status class I and II undergoing elective lower abdominal surgeries under spinal anaesthesia. The person who administered the fluids was not involved in any part of the study further. Afterwards spinal block was given and both intraoperative and post-operative observations and parameters in the study were noted. **Results:** Sixty patients in the age group of 18 to 70 years were randomly allocated into two groups. Group A consisted of 30 patients who received 10 ml/kg of colloid (Voluven®) as preloading fluid 20 minutes prior to spinal anaesthesia and Group B received 10 ml/kg of crystalloid (Physiomax™).The incidence of hypotension in Colloid group was 10% and in Crystalloid group 57%. The requirement of vasopressor Ephedrine to counter hypotension was significantly less in Colloid group when compared to Crystalloid group. **Conclusion:** It can be concluded from the present study that Colloids (Voluven®) offset hypotension and hypovolemia more effectively than Crystalloids (Physiomax™) in patients scheduled for elective lower abdominal surgery under spinal anesthesia.

Key Word: Hypotension, Crystalloid, Colloid, Systolic blood pressure, Diastolic blood pressure, Mean arterial pressure.

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INTRODUCTION

Subarachnoid block is considered a safe regional anaesthesia technique. This technique is widely used for both elective as well as emergency surgical procedures. It is a good anaesthesia technique for surgeries like caesarean section, lower abdominal surgeries, lower limb orthopaedic surgeries and urological procedures. Spinal anaesthesia has several advantages as compared to general anaesthesia; such as minimizing the risks of difficult intubation, decreasing the incidence of aspiration

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pneumonia, well postoperative pain relief. However spinal anaesthesia does have some drawbacks, especially of having high incidence of hypotension in upto 80 to 90 percentage of cases. Hypotension occurring during spinal anaesthesia is common and can cause significant morbidity and mortality. Prior to performing spinal anaesthesia crystalloid administration is recommended to reduce the incidence of hypotension and this is referred to as preloading, although it's value has been questioned. Crystalloid solutions have a short intravascular time and are poor plasma volume expanders, which 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[1], and may increase the risk of pulmonary and peripheral oedema. Colloids remain in the circulation for a longer period, seem to be an effective alternative. Hexastarch is a synthetic colloid with a mean molecular weight of 130,000 Daltons, which is widely used for volume expansion in-patients with trauma, shock or sepsis. Balanced crystalloid solutions with multiple different formulations available worldwide[2].balanced solution closely mimics human plasma in its content of electrolytes, osmolality, and P^H. They also have additional buffer capacity and contain anions such as acetate, gluconate, and even lactate that are converted to bicarbonate, CO2, and water. The advantages of balanced solution include volume and electrolyte deficit correction while addressing acidosis. This study was aimed to compare the efficacy of crystalloid (Physiomax™) to colloid (Voluven®) as preloading infusion in reducing the incidence and severity of spinal induced hypotension and requirement of vasopressors given during surgery to maintain stable hemodynamics.

METHODOLOGY

A comparative study of volume preloading prior to subarachnoid block in lower abdominal surgery with Voluven® and Physiomax™ was undertaken at Meenakshi medical College and Research Institute, Kanchipuram, during April 2017 and August 2018, after institutional Human ethical committee approval and informed consent from the patients. The study population included 60 in-patients belonging to either sex of ASA physical status class I and II undergoing elective lower abdominal surgeries under spinal anaesthesia. Study design was Prospective double-blinded randomised control study. Cases were randomized by lottery method .The person who administered the fluids was not involved in any part of the study further. Afterwards spinal block was given and both intraoperative and post-operative observations and parameters in the study were noted. Patients with ASA physical status class 1 and 2,Age between 18 and 70 years, Weight between 40 and 70 Kgs were included in the study and emergency surgeries, severe anaemia, coagulation abnormalities and bleeding disorders, patients with previous history of surgeries on the spine, patients with spinal deformities, patients with history of chronic backache, patients with active skin lesions over lumbosacral region, patients with obesity, chronic hypertension, diabetes, and heart disease were excluded from the study. A thorough pre-anaesthetic evaluation was done, general and systemic examination was carried out for baseline vital parameters, airway assessment, cardiorespiratory and CNS abnormalities. Height and weight were recorded. Written informed consents were taken and following investigations were done. Investigations included hemoglobin, bledding time, clotting time**,** random blood sugar**,** blood urea, serum creatinine**,** Urine Analysis for albumin, sugar and microscopy**,** electrocardiograph in 12 leads**,** Chest radiography, lignocaine test dose**.** Patients were advised to be nil per oral from 10 p.m. onwards and were pre-medicated with Tab. Alprazolam 0.5 mg and Tab. Pan 40mg on the previous day of surgery. Patients were randomized into 2 groups of 30 patients each, Group A Patients received preloading with 10ml/kg of Voluven®, Group B patients were preloaded with 10ml/kg of Physiomax™. Before shifting the patient to the operation table, anaesthesia machine was checked, emergency drugs and airway equipments were kept ready. Monitors were checked for their proper functioning. Patients were shifted to OT all standard monitors were connected 18 G IV cannula was inserted. Baseline pulse rate, systolic blood pressure and diastolic blood pressure were measured in supine position. The fluids were administered prior to spinal anaesthesia over 20 minutes. After intravascular administration, pulse rate and blood pressure were measured. With all aseptic precautions and patients in lateral position, spinal anaesthesia was performed at L3-L4 interspace with a 25 gauge Quinke's spinal needle with 3.5ml of 0.5% bupivacaine heavy .The patient was turned to supine position. Pulse rate, systolic and diastolic blood pressure was recorded at 1, 5, 10, 15, 30, 45, 60, 90 minutes and at 3 hours. Adequate level of anaesthesia was confirmed and surgery was started. Any incidence of hypotension was managed with increase in fluid infusion rate and administering 100% oxygen by mask. If hypotension still persists, despite the above measure, injection Ephedrine 6mg was administered intravenously and repeated until the blood pressure increased to acceptable levels. After preloading all patients were given Physiomax™ as maintenance fluid. The number of patients developing hypotension and the total dose of Ephedrine required for treatment was noted.

If the above measures fail in treating hypotension such patients were exempted from the study and was managed accordingly.

OBSERVATIONS AND RESULTS

A total of 60 patients satisfying the inclusion and exclusion criteria were included in the study. They were allotted randomly in both the fluid groups. Table 1 represents the age distribution of the patients. The average age of the patients was 45.7 (±11.5) years. Of the total 60 patients, majority (53.3%) were in the age group of 41-60 years followed by 38.3% in the 21-40 years age group.

Table 1: Age distribution of patients

Age group	Number	Percentage
18-20 years	1	1.7
21-40 years	23	38.3
41 -60 years	32	53.3
60-70 years	4	6.7
Total	60	100

Majority of the patients selected for the study were males (68.3%) while 31.7% were females. **(Table 1 a)**

Table 1 A: Gender distribution of patients

Gender group	Number	Percentage
Male	41	68.3
Female	19	31.7
Total	60	100

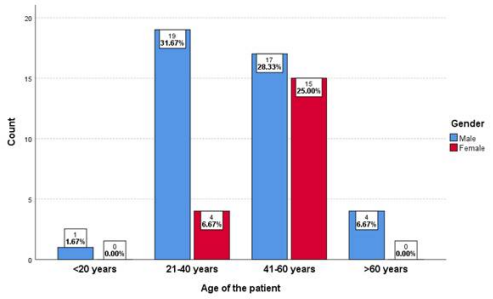

Figure 1: Distribution of age vs gender of the patients (N=60)

Table 2: Distribution and association of anthropometric and vital measurements at baseline in both fluid groups

Variables mean (±SD)	Group A (n=30)	Group B (n=30)	Total (N=60)	p value#
Weight	59.8 (±8.2)	59.5 (±8.7)	59.7 (±8.4)	0.867
Pulse rate	72.5 (±9.4)	73.9 (±10.6)	73.2 (±9.9)	0.599
Systolic Blood Pressure	125.1 (±10.7)	126.9 (±9.5)	126 (±10.1)	0.496
Diastolic Blood Pressure	78.4 (±5.9)	75.8 (±6.2)	77.1 (±6.1)	0.106
Mean Arterial Blood Pressure	93.8 (±6.5)	92.5 (±6.2)	93.2 (±6.3)	0.428

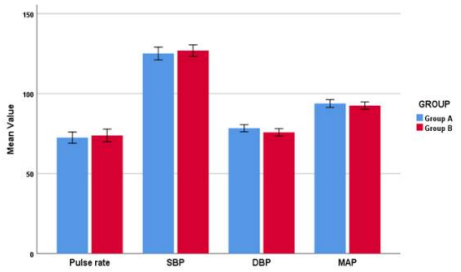

Figure 2: Distribution of vital measurements at baseline in both fluid groups.

Table 2 and Figure 2 shows the distribution of the independent variable- weight and outcome variables such as pulse rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure among the fluid groups (A and B). The association between weight, pulse rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure and the fluid groups was found to be insignificant (p>0.05). This implies that there was no significant difference in weight, pulse rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure in both the fluid categories i.e. equal values of the weight, pulse rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure were allotted to the fluid categories A and B (effect of randomization). The association was done using independent t test.

Table 3: Mean Systolic Blood Pressure at various time intervals and its association with the two fluid groups.

Timeline	Systolic Blood pressure (mm Hg), mean(±SD)		p value#
	Group A (n=30)	Group B (n=30)	
Baseline	125.1 (±10.8)	126.9 (±9.5)	0.496
1 min	123 (±8.9)	119.1 (±10.9)	0.136
5 min	116.3 (±10.1)	96.7 (±7.4)	<0.001#
10 min	115.9 (±9.3)	98.5 (±6.8)	<0.001#
15 min	117.7 (±4.3)	104.3 (±6.2)	<0.001#
30 min	118.9 (±3.8)	109.2 (±4)	<0.001
45 min	121.2 (±4.4)	110.2 (±3.9)	<0.001
60 min	120.8 (±6.3)	112.5 (±5.1)	<0.001
90 min	123.5 (±4.9)	115.7 (±4.9)	<0.001
3 hrs	122.7 (±6.2)	118.7 (±5)	<0.001

#- p value by independent t test

Table 3 and Figure 3 represents the distribution mean systolic blood pressure (SBP) at various time intervals and its association with the two fluid groups. The mean SBP (in mmHg) at 5min, 10 min,15 min, 30 min, 45 min, 60 min, 90 min and 3 hrs in group A are 116.3 (±10.1), 115.9 (±9.3), 117.7 (±4.3), 118.9 (±3.8), 121.2 (±4.4), 120.8 (±6.3), 123.5 (±4.9) and 122.7 (±6.2) respectively. The mean SBP (in mmHg) at 5min, 10 min,15 min, 30 min, 45 min, 60 min, 90 min and 3 hrs in group B are 196.7 (±7.4), 98.5 (±6.8), 104.3 (±6.2), 109.2 (±4), 110.2 (±3.9), 112.5 (±5.1), 115.7 (±4.9) and 118.7 (±5) respectively. There was statistically significant difference ($p<0.05$) in SBP among the two fluid groups (A and B) at all the measured timelines from 1 minute to 3 hours. The SBP in group A was significantly higher when compared to Group B. Independent samples t test was used to find the existence of significant differences in SBP between the two fluid groups.

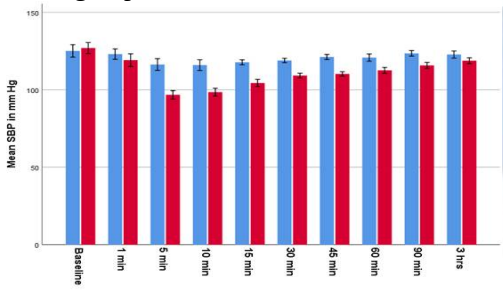

Figure 3: Distribution of mean Systolic Blood Pressure at various time intervals in the two fluid groups (bar Diagram)

Table 4: Mean Diastolic Blood Pressure at various time intervals and its association with the two fluid groups

Timeline	Diastolic Blood Pressure (mm Hg), mean(±SD)		p value#
	Group A (n=30)	Group B (n=30)	
Baseline	78.4 (±5.9)	75.8 (±6.2)	0.106
1 min	74.5 (±5.3)	71.9 (±5.7)	0.074
5 min	69.5 (±4.1)	64.2 (±5.2)	<0.001#
10 min	69.2 (±5.1)	65.6 (±4.2)	0.004
15 min	69.6 (±2.7)	67.3 (±3.4)	0.006
30 min	72.1 (±4.6)	68.2 (±2.9)	<0.001#
45 min	74.2 (±5.8)	70.9 (±3.7)	0.013
60 min	72.8 (±3.7)	69 (±3.2)	<0.001#
90 min	74.9 (±3.4)	70.9 (±3.7)	<0.001#
3 hrs	79.9 (±3.7)	77.6 (±3)	0.010

#- p value by independent t test

Table 4 and Figure 4 represents the distribution mean Diastolic Blood Pressure (DBP) at various time intervals and its association with the two fluid groups. The mean DBP (in mmHg) at 5min, 30 min, 45 min, 60 min and 90 min in group A are 69.5 (±4.1), 72.1 (±4.6), 72.8 (±3.7) and 74.9 (±3.4) respectively. The mean DBP (in mmHg) at 5min, 30 min, 45 min, 60 min and 90 min in group B are 64.2 (±5.2), 68.2 (±2.9), 69 (±3.2) and 70.9 (±3.7) respectively. There was statistically significant difference ($p<0.05$) in DBP among the two fluid groups (A and B) at all the measured timelines from 5 minutes to 3 hours. The DBP in group A was significantly higher when compared to Group B. Independent samples t test was used to find the existence of significant differences in DBP between the two fluid groups.

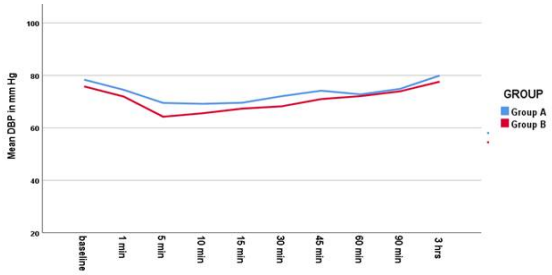

Figure 4: Distribution of mean Diastolic Blood Pressure at various time intervals in the two fluid groups (Line diagram of means)

Table 5: Mean MAP at various time intervals and its association with the two fluid groups

Timeline	Mean Arterial pressure (mm Hg), mean(±SD)		p value#
	Group A (n=30)	Group B (n=30)	
Baseline	93.8 (±6.5)	92.5 (±6.2)	0.428
1 min	90.6 (±5.4)	87.3 (±6.4)	0.036
5 min	84.9 (±5.1)	74.8 (±5.3)	<0.001#
10 min	84.4 (±5.8)	76.3 (±4.5)	<0.001#
15 min	85.2 (±2.6)	79.3 (±3.6)	<0.001#
30 min	87.3 (±3.8)	81.6 (±2.9)	<0.001#
45 min	89.5 (±4.9)	83.7 (±2.9)	<0.001#
60 min	88.4 (±3.9)	85.3 (±2.3)	<0.001#
90 min	90.8 (±3.4)	87.8 (±2.8)	<0.001#
3 hrs	93.8 (±3.6)	90.9 (±2.9)	<0.002

#- p value by independent t test

Table 5 and Figure 5represents the distribution of mean arterial Pressure (MAP) at various time intervals and its association with the two fluid groups. The mean MAP (in mmHg) at 5min, 10 min,15 min, 30 min, 45 min, 60 min and 90 min in group A 84.9 (±5.1), 84.4 (±5.8), 85.2 (±2.6), 87.3 (±3.8), 89.5 (±4.9), 88.4 (±3.9) and 90.8 (±3.4) respectively. The mean MAP (in mmHg) at 5min, 10 min,15 min, 30 min, 45 min, 60 min and 90 min in group B are 74.8 (±5.3), 76.3 (±4.5), 79.3 (±3.6), 81.6 (±2.9), 83.7 (±2.9), 85.3 (±2.3) and 87.8 (±2.8) respectively. There was statistically significant difference ($p<0.05$) in MAP among the two fluid groups (A and B) at all the measured timelines from 5 minutes to 3 hours. The MAP in group A was significantly higher when compared to Group B. Independent samples t test was used to find the existence of significant differences in MAP between the two fluid groups.

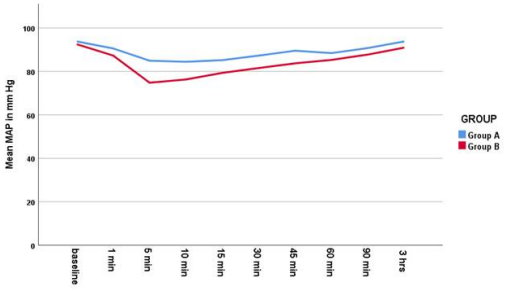

Figure 5: Distribution of mean MAP at various time intervals in the two fluid groups.

Table 6: Incidence of hypotension and its association with the two fluid groups

Incidence of Hypotension, n(%)	Group A (n=30)	Group B (n=30)	Total (N=60)	p value*
Hypotension	3 (10%)	17 (56.7%)	20 (33.3%)	**<0.001**
No Hypotension	27 (90%)	13 (43.3%)	40 (66.7%)	

*- p value by chi square test

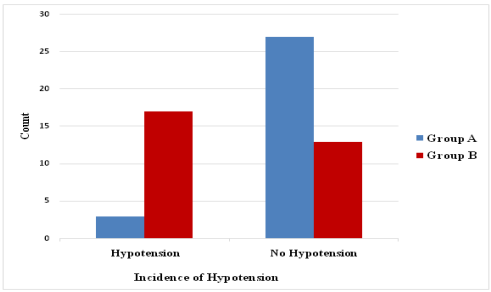

Figure 6: Distribution of patients with hypotension in both fluid groups

Table 6 and Figure 6shows the distribution of Incidence of hypotension and its association with the two fluid groups. Only 10 % in Group A developed hypotension while 56.7% developed hypotension in Group B. there was statistically significant difference in incidence of hypotension between the two fluid groups (A and B). The incidence of hypotension was significantly higher in group B when compared to Group A. The association was done using chi-square test.

DISCUSSION

Spinal anaesthesia is very commonly administered procedure for pelvic, lower abdominal and lower limb procedures. It is popular because of simplicity and reliability of the technique as well as the relative rapidity with which adequate anaesthesia can be established. In contrast to general anaesthesia, it avoids poly-pharmacy as well as situations of difficult intubation. This reduces considerably the morbidity and mortality. Satisfactory analgesia for abdominal surgeries under spinal block requires sensory block from T6 to S5. This level of high thoracic block induces widespread vasodilatation with resultant hypotension. A number of patients suffer from disturbing hypotension and relative hypovolemia during this procedure. Many authorities suggest that crystalloid preloading is not effective in reducing the incidence of hypotension after spinal anaesthesia [3]as 75% of the infused fluid diffuses into interstitial spaces, and it's efficacy in expanding plasma volume is only very transient. Elderly patients subjected to lower abdominal or lower limb surgery under spinal anaesthesia and preloading with crystalloid solutions did not experience any benefit as regards the incidence of hypotension. Attempts to correct the hypotension with crystalloid solutions may result in large volumes of infusion, which can be hazardous for the individual. Furthermore, it has been observed that the infusion of even a small amount of crystalloid such as one litre of normal saline increases the closing volume and decreases the dynamic compliance of the lungs[4,5]. A colloid solution is the more effective and logical choice in preventing hypotension since it remains in the circulation for a longer period because of its oncotic pressure. Hydroxyethyl starch being hyperoncotic, has the ability to withdraw fluid from interstitial into intravascular space[6-8]. Extent of volume expansion is 150%. Duration is 24 hours. In our study we randomized 60 patients into two groups with 30 patients each. Group A received 10ml/kg of Voluven,group B received 10 ml/kg of Physiomax. Patients receiving Voluven had a lower incidence of hypotension when compared to Physiomax. Group Apatients had a incidence of 10% of hypotension whereas group B had the maximum incidence of hypotension of 57%. Also the dose of Ephedrine required was less in the colloid groups compared to the Crystalloid group. Three patients required ephedrine in group A whereas in group B sixteen patients which was statistically significant. These findings are consistent with the findings of others who have compared colloid and crystalloid preloading prior to spinal anaesthesia. Karinen *et al*[9] study in 1995 aimed to compare the effect of Ringer`s lactate and Hydroxyethyl starch preloading on the hemodynamic state during spinal anaesthesia on patients undergoing caesarean section. The study showed high incidence of hypotension in the crystalloid (62%) group as compared to the colloid group (38%). In our study the incidence of hypotension in physiomax group was 57% and it was 10% in the Voluven group. Baraka *et al*[10] study in 1994 compared intravascular administration of polymerized gelatin and isotonic saline before spinal anaesthesia for prevention of spinal anaesthesia induced hypotension. They reported 11% incidence of hypotension after administration of 7 ml/kg of 3% gelatin compared with 52% after same

volume of crystalloid in males undergoing transurethral resection of prostate under spinal anaesthesia. In our study we measured the hemodynamic variables – pulse rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure. The baseline values were not significantly different in the two groups. There was an increase in the pulse rate immediately after preloading and upto 25-30 minutes after spinal anesthesia in both the groups, though statistically not significant. Only one patient in Group B has bradycardia during the study and was managed with atropine. The SBP increased to about three to five mm hg after preloading in both the groups with no statistical significance. The fall in SBP to less than 100 mm of Hg after spinal block was as early as 5 minutes in the group B whereas in group A the SBP was maintained to a significantly longer time. The same trend was observed when mean arterial pressure (MAP) was taken into consideration. Colloids are known to cause anaphylactoid reactions and hypotension is an important feature of this reaction along with rash and bronchospasm[11]. In our present study none of the patients developed any adverse effects. The increase in plasma oncotic pressure which produced by colloid helps draw fluid into the intravascular space and thereby expands the plasma volume and remains in the intravascular space for a long time[12]. This effect counteracts the hypovolemia caused by spinal anaesthesia. About 75 to 80% of any crystalloid solution given as preloading diffuses into the interstitial space within 15 to 20 minutes, while 75% of the colloid remains largely within the intravascular space for a longer period. From our present study it was confirmed that the colloids offset hypotension and hypovolemia more effectively than crystalloids in patients scheduled for elective surgery under spinal anesthesia.

CONCLUSION

It was concluded from the present study that Colloids (Voluven®) offset hypotension and hypovolemia more effectively than Crystalloids (Physiomax™) in patients scheduled for elective lower abdominal surgery under spinal anesthesia.

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