A Comparative Study of Crystalloid and Colloids as Preloading in Spinal Anaesthesia for Prevention of Hypotension.

Bharti Jalandhara*, J.C.Makwana**

Abstract

Objectives : To compare the efficacy of crystalloids and colloids as preloading infusion to prevent hypotension, requirement of vasopressors and requirement of total fluid given during surgery to maintain stable hemodynamic. **Methodology :** A total of 60 patients scheduled for elective lower abdominal, lower limb and gynaecological procedures were selected to participate in this prospective, randomized, double-blind study. Patients were randomly allocated into two groups for preloading. Group A received 15 ml/kg Ringer lactate for preloading and group B 5ml/kg gelatin for preloading. Vital parameters (PR, SBP, DBP, and MAP) were recorded. Incidence of hypotension in both groups was noted and requirement of mephentine to treat hypotension and total intravenous fluid required intraoperatively was also recorded. **Results :** After spinal anesthesia SBP in the crystalloid group decreases to minimum 101.77±14.18 after 15 minutes and rises again at the end of surgery. In colloid group systolic blood pressure decreases to minimum106.00±12.15 after 20 minutes and then increases at the end. P value 0.010, 0.015, 0.029, 0.046 during 8 20 min. suggest significant fall in SBP in crystalloid group. 40% pt. required mephentine to treat hypotension compared to 16.7% in colloid. Intraoperatively requirement of IV fluid in crystalloid group was 1662.33±179.30 and in colloid group was 1260.67±158.22. **Conclusion :** There was significant hypotension with crystalloid group intraoperatively in spite of preloading and also intraoperatively fluid requirement was high. The incidence of nausea, vomiting, rigors and postoperative hypotension was comparable in both groups.

Key Words : preloading, crystalloid, colloid, hypotension

Introduction :

Subarachnoid block is considered a safe regional anesthesia technique. This technique is widely used for both elective as well as emergency surgical procedures. It is a good anesthesia technique for surgeries like caesarean section, lower abdominal surgeries, lower limb orthopedic surgeries and urological procedures. Though spinal anesthesia has several advantages like excellent surgical analgesia, inhibits stress response, post operative analgesia, good skeletal muscle relaxation, airway instrumentation can be avoided, reduced chances of post operative deep vein thrombosis and pulmonary embolism. It has few disadvantages as well like, hypotension; post dural puncture headache, neurological damage etc. As far as hypotension is concerned, after the introduction of different vasopressors and intravenous fluids, spinal anesthesia has become relatively safe. Both crystalloids and colloids are used as preloading intravenous fluid before spinal anesthesia.

Different crystalloids commonly used in preloading are Ringer lactate, normal saline and colloids that are used in preloading are gelatin, dextran, hetastarch, pentastarch, tetrastarch. This study was aimed to compare the efficacy of both as preloading infusion to prevent hypotension, requirement of vasopressors and requirement of total fluid given during surgery to maintain stable hemodynamics.

* Senior Resident
** Associate Professor
Department of Anaesthesia, GMERS Medical College Sola, Ahmedabad, Gujarat
Correspondence : bjalandhara@gmail.com

Methodology

This was a prospective, randomized double blind, two groups parallel study conducted at tertiary care hospital, Ahmedabad after approval from local ethical committee. 60 patients between 25- 60 years of age, belonging to American society of anaesthesia grade I or II going for lower abdominal and lower limb orthopedic surgeries lasting for around 2 hours under spinal anesthesia were screened for the study eligibility criteria.

Patients were included in the study if they met the following criteria: 1) Age between 25-60 years, 2) base line systolic blood pressure 110-130 mm Hg. 3) Surgery going to be performed under spinal anesthesia. 4) Had no history of hypertension or any cardiovascular disorder 5) had no liver or renal dysfunction, 6) had no contraindication to spinal anesthesia, and agreed to sign a written informed consent.

Patients were consecutively assigned into either group A (n=30) or group B (n=30) depending upon the preloading fluid used. Both the investigators and the subjects were blinded to the randomization, using closed envelop technique. After complete preoperative evaluation and thorough physical examination and necessary preoperative investigation, informed and written consent of patient was taken and baseline hemodynamic parameters were recorded.

Patients in the group A received 15ml/kg. Crystalloid (Ringer lactate) solution and those in the group B received 5 ml/kg colloid (gelofusin) in preloading.

In preoperative room intra venous access was taken with 18 gauge canula, vital parameters like pulse rate, non invasive blood pressure (NIBP), SPO_2 were recorded and iv fluid according to the group to which patient belonged was started as preloading agent. Amount of the fluid was calculated according to the body weight (15 ml/kg Ringer lactate and 5 ml/kg gelofusin). For the sake of convenience in the measurement, its near multiple of 25 was taken as amount of the fluid to be given in preloading (e.g., 375 ml for 370 calculated values) and Preloading was done within 15-20 min. After preloading fluid was given, the same IV point used for preloading was removed before going to Operation theater for keeping the study blind.

In OR standard monitoring devices including electrocardiogram, pulse oximeter, and non invasive blood pressure (NIBP) were used to measure the hemodynamic variables.

Subarachnoid injection was performed, using 23-gague Quincke spinal disposable needle at the L3-4 or L4-5 intervertebral space. Inj. Bupivacaine 0.5%, 3.5 -4 ml was used to give spinal anesthesia and sensory level was achieved up to T6-T8 level. Intraoperatively HR, SBP, DBP, RR, SPO_2 were recorded every 2 to 3 minutes up to 15 min. and then after every 5 min. up to 30 min. After 30 min. vitals were recorded every 15 min. up to 120 min. total amount of IV fluid given intraoperatively was calculated at the end of surgery. Hypotension was considered when SBP<90 mm Hg. [1, 2]

Hypotension was treated with rapid IV fluid infusion and inj. Mephenteramine, 6 mg IV. Blood loss was replaced with crystalloids and blood transfusion as required. Patients were observed for nausea, vomiting, rigors, and allergic reaction. Urine output, total fluid requirement and blood loss were recorded at the end of surgery. And patients were observed for 1 hour in recovery room postoperatively and PR, NIBP, SPO2 were recorded.

Statistical analysis was performed using ANOVA, paired t test and chi square test.

Results:

There were no significant differences between the two groups prior to the surgery with regard to mean age, weight, gender and ASA grading.

Table 1: Comparison of preoperative vital parameters in both groups

Variable	Crystalloid group	Colloid group	P value
Pulse Rate/min.	84.17±5.11	84.73±4.03	0.635
Systolic Blood Pressure (mmHg)	123.80±5.90	122.13±7.35	0.337
Diastolic Blood Pressure (mmHg)	78.40±6.69	79.00±6.10	0.718
Mean Arterial Pressure (mmHg)	93.53±5.78	93.38±6.03	0.919

Preoperative vital parameters in both groups were not different from each other significantly as shown in table 1.

Mean volume of preloading fluid in crystalloid group was 869.17±125.38 ml and in colloid group was 313.33±39.79 ml whereas intraoperatively requirement of IV fluid in crystalloid group was 1662.33±179.30 and in colloid group was 1260.67±158.22.

Table 2: Comparison of vital parameters before and after preloading

Variable	CRYSTALLOID			COLLOID		
	Before	After	P value	Before	After	P value
Pulse Rate/min.	88.40±4.79	88.43± 5.1	0.99	88.03 ± 3.68	88.2±4.1	0.87
Systolic Blood Pressure (mmHg)	125.8±7.60	126.17±7.74	0.85	124.87 ±10.39	124.43±10.18	0.87
Diastolic Blood Pressure (mmHg)	78.87±7.50	78.7 ± 7.08	0.93	79.27 ± 5.81	79.73 ± 5.12	0.74
Mean Arterial Pressure (mmHg)	94.51±6.74	94.52 ± 6.54	0.99	94.47 ± 6.58	94.63 ± 6.12	0.92

Above table describes that difference in vital parameters before and after preloading in both crystalloid and colloid groups was not significant.

Mean dose of bupivacaine was 3.75±0.21 in crystalloid group and 3.77±0.22 in colloid group. The observed difference in both groups was not significant. (P=0.634)

Table 3: Comparison of Blood Pressure in both groups at different time interval intraoperatively

Time (min)	SBP (mean ± SD)			DBP (mean ± SD)		
	crystalloid	Colloid	P value	crystalloid	colloid	P value
1	124.43±6.79	123.37±9.42	0.617	76.57±6.96	78.30±5.37	0.285
3	120.30±30	121.40±8.63	0.624	75.13±7.33	77.27±6.02	0.223
5	114.37±10.04	117.60±10.37	0.225	72.83±8.05	75.70±6.44	0.133
8	107.9313.13	116.03±10.35	**0.010**	70.83±8.44	74.87±6.46	**0.042**
10	104.40±15.56	113.40±11.94	**0.015**	69.13±9.39	73.90±6.59	**0.027**
13	102.37±15.56	110.40±11.94	**0.029**	68.23±9.48	72.63±6.60	**0.041**
15	101.77±14.18	108.67±11.93	**0.049**	66.10±9.47	71.00±6.85	**0.025**
20	101.93±12.29	106.00±12.15	0.202	65.23±7.92	70.30±7.37	**0.013**
25	104.03±12.53	106.37±11.47	0.455	67.93±7.67	70.53±6.71	0.168
30	104.77±10.60	108.10±11.62	0.250	69.10±7.90	71.03±6.66	0.310
45	105.73±9.85	109.53±11.67	0.178	68.17±6.40	71.43±6.60	0.056
60	105.17±9.30	109.70±11.20	0.093	70.37±6.75	72.73±6.57	0.174
75	106.13±10.65	111.47±10.24	0.053	70.50±7.28	73.07±6.65	0.159
90	108.30±10.08	113.43±9.89	0.051	71.33±7.15	73.70±6.14	0.174
105	108.87±9.26	113.50±10.09	0.069	71.77±7.12	74.13±6.00	0.169
120	110.43±9.05	115.0±10.03	0.069	72.83±7.28	75.20±5.80	0.169
ANOVA	F = 9.779	F = 6.442		F =4.535	F = 4.075	
	P <0.001	P <0.001		P <0.001	P <0.001	

Above table describes that after spinal anesthesia systolic blood pressure in the crystalloid group decreases to minimum after 15 minutes and rises again at the end of surgery. In colloid group systolic blood pressure decreases to minimum after 20 minutes and then increases at the end.

Table suggests there is definite fall in the blood pressure in both groups. Calculating P value in different time intervals, it was seen that severity of fall in SBP was significantly more during 8-15 in crystalloid group.

Table 4: Fall in systolic blood pressure from the baseline

Range mmHg	Crystalloid Group		Colloid Group		Chi-square	P value
0 -20	10	33.33%	15	50.00%	1.832	0.059
21-30	7	23.33%	11	36.67%	1.200	0.093
>30	13	43.33%	4	13.33%	6.240	0.002

Table 4 suggests that there was no statistical significant difference between two groups in the range of 0 -20 mm Hg, 10 -20 mm Hg and 21- 30 mm Hg. But there is significant difference in the number of patients developing hypotension in range of > 30 mm Hg.

Table 5: Requirement of mephentermine to treat hypotension in both groups

Mephentine given	Crystalloid group		Colloid group	
	Frequency	Percentage	Frequency	percentage
Yes	12	40	5	16.7
No	18	60	25	83.3
Chi-square	**4.02**			
P value	**<0.001**			

40% patients in crystalloid group required mephentermine to treat hypotension while it was16.7% patients in colloid group. Observed difference was significant. This shows that preloading with colloids prevent hypotension more significantly in comparison with crystalloids. Therefore less no. of patients were required mephentine to treat hypotension in colloid group than crystalloid group.

Incidence of nausea/vomiting and rigor was comparable in both crystalloid and colloid groups. Post operatively 2 patients in crystalloid group while 1 in colloid group developed hypotension. Difference in both groups is not statistically significant.

Discussion

Various measures have been tried for prevention of hypotension induced by spinal anesthesia.

1) Volume preloading [3, 4]
2) Trendelenberg position[4]
3) Left lateral tilt in obstetric patient
4) Leg compression by inflatable splint[5]
5) Prophylactic use of vasopressors [6, 7, 8]

All measures have their own limitations. Volume preloading is an effective technique to prevent hypotension induced by spinal anesthesia. Different crystalloid and colloid have been used as preloading fluid for prevention of hypotension induced by spinal anesthesia. In this study this character has been studied by giving Ringer lactate and gelofusin as preloading fluid before giving spinal anesthesia.

We had selected Ringer lactate as preloading fluid because it is most physiological fluid, its osmolality is similar to plasma and most of the authors have selected it in their studies as preloading fluid [9, 10, 11, 12, 13, 14] Gelatin was used because its pH, osmolality are similar to plasma. Its plasma half life of about 4-6 hrs matches with half life of local anesthetic used. Volume of preload infusion was significantly higher in crystalloid group (869 ml) than colloid group (313 ml).

In spinal anesthesia, sympathetic denervation leads to vasodilatation and increases intravascular space leading to relative hypovolemia. Increase of intravascular volume can be done by IV fluid infusion. If Ringer lactate is used for preloading, large volume is required around 3 times more. It is due to its short half life ($t_{1/2}$ of 20 min. and it rapidly distributes in to interstitial space. [15]

With colloid solution less volume is required because of its longer $t_{1/2}$ of 4-6 hr. It also increases colloid oncotic pressure in intravascular space. [16, 17, 18] according to Wennberg EF et al 1990 [19] colloid solutions contain large molecules that do not immediately redistribute throughout the extra cellular fluid compartment. So they do not decrease plasma colloid oncotic pressure as much as crystalloid solution, and intravascular volume is better maintained.

0.5% bupivacaine was used for spinal anesthesia. The volume of the drug used in both the groups was comparable so it rules out the effect of local anesthetic drug on incidence of the hypotension. [20] Level of the anesthesia achieved in all cases was up to T6 T7. In our study we recorded vital parameters at every 2 -3 min. up to 1st 15 min., then at every 5 min. up to 30 min., because there are more chances of hypotension within this period. [21]

In spinal anesthesia fall in B.P. is due to sympathetic denervation leading to intravascular space expansion, resulting in relative hypovolemia. According to Lee JA, Atkinson RS and Watt JW, fall in SBP of 20 mm of Hg from baseline value is considered as physiological effect of spinal anesthesia. [22, 23] Fall in SBP between 20-30 mm of Hg from baseline considered as mild hypotension and fall in SBP >30 mm of Hg is considered as severe hypotension.

In our study there was fall in SBP in both groups. In group A, mean SBP decreased from 123.80 mm of Hg. To 101.77 mm of Hg. (15 min.) and then increased to 110.43 mm of Hg. (120 min.). There was significant fall in SBP. In group B, mean SBP became 122.13 mm of Hg. to 106.00 mm Hg. (20 min.) and then increased to 115.00 mm Hg. (120 min.). From ANOVA test the fall in SBP in both the groups was significant. After applying T test at different time intervals it was interpreted that values of SBP were significantly less in crystalloid group during 8 to 15 min. than colloid group. S.C. Shapira [14] LAH Critchley [7] Riley ET [24] and Shiv K. Sharma [25] also observed in their studies that fall in SBP was significantly more in crystalloid group than colloid group.

33% patients in group A and 50% patients in group B developed fall in SBP up to physiological limit of 20 mm Hg. 23.33% patients in group A and 36.67% in group B had fall in SBP between 20 30 mm Hg. and 43.33% patients of group A and 13.33% of group B showed fall in SBP>30 mm Hg. Data shows that fall in SBP >30 mm Hg. was observed in significantly high number of patients in crystalloid group than colloid group.

According to definition of hypotension in our study, SBP <90 mm Hg, incidence of hypotension was seen in 12 patients in crystalloid group, whereas in 5 patients in colloid group. The difference between 2 values is significant. These findings were comparable to the study of S.C.Shapira, Anchallee Satproedprai, N Surya Rao, Urmilla Sathe, Coe et al and Riley ET [14, 9, 12, 25, 24]

Requirement of Mephentine to treat hypotension was more in group A (40%) than in group B (16.7%).these findings were consistent with study of [9, 12, 24, 14, 26] There was also significant fall in DBP in crystalloid group compared to colloid group though both had fall in DBP. In spite of large amount of preloading, exaggeration of physiological effect of spinal anesthesia was more in case of crystalloid group because Ringer Lactate has short $t_{1/2}$ of 20 min. It is rapidly redistributed to 3rd space. [16, 17] This was observed as spinal anesthesia induced hypotension occurred most commonly within 1st 30 min. and effect of Ringer lactate preload infusion is not sustained up to this period. Therefore it doesn't help in prevention of hypotension intraoperatively. Also large volume of fluid promoted release of Atria natriuretic peptide factor

leading to vasodilatation and produce persistent hypotension. Modified gelatin has molecular wt. of 30,000 & due to its protein content it remains into intravascular space for long time about 4-6 hrs. [16, 17] less volume of gelatin is required for preload, so less release of atrial natriuretic peptide occurs and therefore less chances of hypotension is there. [18]

Intraoperative fluid requirement was high in crystalloid group compared to colloid group. (1662.33 ml vs 1260.67 ml). Similar was observed by Urmilla Sathe, Hallworth [21], Critchley [15], Riley ET. Intraoperative fluid was given to replace fluid deficit because of NPO status, 3rd space loss, and maintenance requirement and blood loss. Ringer lactate group required more fluid to counter the hypotension and replacement of blood loss because of its shorter $t_{1/2}$. This was not in case of gelatin. [17]

Allergic reaction was not observed in any case in colloid group.6 patient in group A and 4 patients in group B developed nausea, vomiting. Mostly it was associated with hypotension or because of uterine manipulation.

In conclusion there was significant hypotension with crystalloid group intraoperatively in spite of preloading and also intraoperative fluid requirement was high. The incidence of nausea, vomiting, rigors and postoperative hypotension was comparable in both groups.

References

1. Corke B. C. Datta S. et al: spinal anesthesia for caesarean section and effect of hypotension on neonatal outcome. Anesthesia: 1982: 37: 658 -662.
2. Hallworth. D. Jellicore JA, Wilkes RG: Hypotension during epidural anesthesia for caesarean sections, comparison of intravenous loading with crystalloid and colloid solution. Anesthesia: 1982: vol- 37: 53 56.
3. Pamela J. Morgan, Stephan H. Halpem, Jordan Tarshis: The effect of an increase of central blood volume before spinal anesthesia for caesarean delivery: A qualitative systematic review. Anaes. Anal. 2001.
4. Mc Crae AF, Wildsmith JAW: Prevention and treatment of hypotension during central neural blockade. BJA: 1993: 70: 672 680.
5. Bhagwanji. S. DA Rocke et al: prevention of hypotension following spinal anesthesia for elective caesarean section by wrapping of legs. BJA: 1990: 65: 819 822.
6. Clark RB, Thompson DS: Prevention of spinal hypotension associated with caesarean section. Anesthesiology: 1976: 45: 670 674.
7. Critchley LAH, Stuart JC, Short TG: Hemodynamic effects of subarachnoid block in elderly patients. BJA: 1994: vol: 73 Page 464 470.
8. K. D. Tripathi: Essentials of medical pharmacology. 5th Edition: 2003: page 103 118.
9. Anchalee Satproedprai: Effect of preload fluid for prevention of spinal anesthesia induced hypotension in cesarean section. Ind. Jr. of Int. medicine: 1995: vol: 5: page: 37-41.
10. Karineh J. Rasanen J et al: Effect of crystalloid and colloid preloading on uteroplacental and maternal hemodynamic status during spinal anesthesia for caesarean section. BJA: 1995: vol.75: no-5: page 531.
11. Murray AM, Morgan et al: Crystalloid vs. colloid for circulatory preload for epidural anesthesia for caesarean section. Anesthesia: 1989: vol: 44: page 463-466.
12. N Surya Rao, P. R. Vijayalaxmi: Crystalloid and colloid preload for prevention of hypotension in caesarean section under spinal anesthesia. IJA: 1996: Page: 19.
13. Rout CC, Rocke DA et al: A reevaluation of role of crystalloid preloading for prevention of hypotension associated with spinal anesthesia for cesarean section. Anaesthesiology: 1993: 79: 262-269.
14. S. C. Shapira, Y shri et al: comparison of intravenous loading for epidural anesthesia with ringer lactate and Haemacel. European j. of pain: 1991: vol 12: 100-103.
15. Sahar M. Siddik, Marie T. Aonad, Ghada E Kai Maria: HES is superior to ringer lactate for preloading before spinal anesthesia for caesarean section. Canadian Journal of Anesthesia: 2000: vol 47.
16. A Bhattacharya: Ideal plasma volume expander. Indian J. of clinical practice: 1996: may: 30 34.
17. Hillman KM: crystalloid or colloid fluid therapy. BJ of Hospital Medicine 1986: 35: 217
18. Lamke LO, Lijedahi SO: Plasma volume changes after infusion of various plasma expanders. Resuscitation L 1976: vol.5: 93 102
19. Wennberg E, Frid L et al: Comparison of Ringer lactate with 3%Dextran 70 for volume loading before anesthesia in caesarean section. BJA: 1990: 65: 654-656.
20. Cook PR, Malmqvist L, Bengstson M et al. Vagal and sympathetic activity during spinal anesthesia. Acta Anaesthesiol Scand 1990: 34: 271-275
21. Carpenter RL, Caplan RA, Brown DL: Incidences and risk factors for side effects of spinal anesthesia.
22. Greene NM: Physiology of spinal anesthesia .Reg. Anes. 1982: 7:55.
23. Lee JA, Atkinson RS, Watt JW: Lumber puncture and spinal anesthesia. 4th Edition: 1985: 106.
24. Riley ET, Cochen SE et al: Prevention of hypotension after spinal anesthesia for cesarean section with 6% Hetastarch vs. Ringer lactate. Anesthesia and Analgesia: 1995: 81: 838-842.
25. Shiv K. Sharma, Noor M. Gajraj, J. Elaine Diddarvi: Prevention of hypotension during spinal anesthesia: A comparison of intravascular administration of Hetastarch vs Ringer lactates. Anesthesia and Analgesia: 1997: 84: 111-114.
26. Urmilla Sathe, B.N.Shah et al: Spinal preloading: Crystalloid Vs Colloid. BJCC: vol.3: No:1 Feb:1996