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Comparative Study between Colloid versus Crystalloid Solutions during Spinal Anesthesia for Elective Cesarean Section

Faez Ahmed Mahdi [1], Hiwa Fateh Saber [2,*], Ziwar Nooruldeen Ahmed [3]

[1]*Anesthesia and Intensive Care, Alsadr Teaching Complex, Al Najaf, Iraq.*
[2]*Anesthesia and Intensive care, Hawler Teaching Hospital, Erbil, Iraq.*
[3]*Anesthesia, and intensive care, Soran Maternity Hospital, Erbil, Iraq.*

[*]*Corresponding author email: hiwasaber1976@gmail.com*

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ABSTRACT

Background: One of the most dangerous complications for mother and baby during cesarean section is hypotension due to spinal anesthesia. Several methods are used to prevent and treat hypotension, the safest of which is fluid replacement. This study aimed to compare the effectiveness of colloidal solutions and crystalloid solutions in preventing hypotension resulting from spinal anesthesia during elective cesarean sections, along with assessing the requirement for vasopressors to treat severe hypotension due to the spinal anesthesia.
Methods: This prospective comparative study was conducted in Erbil Maternity Teaching Hospital from May 2021 until October 2021. Two groups of 35 patients were prepared for elective cesarean section, crystalloid group received normal saline, while the colloid group received voluven infusion. Systolic blood pressure, diastolic blood pressure, and the need for vasopressors (a combination of ephedrine plus phenylephrine) were compared between the groups.
Results: There is no statistically significant difference in the prevalence of hypotension between the two groups (p-value>0.05), except at 5min, there was significant hypotension (p-value<0.0001 in the crystalloid group and p-value<0.003 in the colloid group). However, there is less need for vasopressor drugs to treat hypotension in the colloid group (p-value<0.001).
Conclusion: Both colloidal and crystalloid solutions have been effective in preventing hypotension due to spinal anesthesia in elective cesarean section. However, compared to the crystalloid group, in the colloidal infusion group, there is less need to use vasopressor drugs to treat hypotension.

Key words: Cesarean Section; Colloid Solution; Crystalloid Solution; Spinal Anesthesia; Voluven

INTRODUCTION

Although the cesarean section (C/S) carries the risk of immediate and long-term complications, for some women, cesarean delivery may be the safest or even the only way to have a healthy baby [1].

The choice of spinal anesthesia (SA) for C/S should be personalized, considering various factors such as anesthetic factors like SA is indicated in respiratory diseases while general anesthesia (GA) is preferred in heart diseases. Obstetric factors like elective C/S spinal anesthesia are preferred while GA is indicated in emergency C/S, severe placental abruption, severe hemorrhage, and ruptured uterus. Fetal factors e.g., profound fetal bradycardia in which GA is indicated [2].

The decision of the anesthesiologists and the preferences of the patient may be other factors to choose between SA or GA, e.g. most of our patients are afraid of SA and refuse it. Spinal anesthesia is recommended for women undergoing elective C/S because it is safer and has fewer maternal and neonatal complications than GA [3] .

The use of SA has beneficial effects, which include: better control of pain in response to intravenous opioids, less need for systemic opioids, faster improvement of intestinal function, and easier participation in the process of getting out of bed [4]. In addition to the benefits of SA, the side effects of this method of anesthesia are very rare, but it is worth knowing [5]. Among these complications, hypotension is a major problem with an incidence of 60 to 70% [6].

Risk factors for hypotension include a history of preoperative hypertension, age, type of anesthesia, rapid induction of anesthesia, the supine position of the pregnant woman, the heavy weight of the mother, and infant weight [7].

Sympathetic obstruction after spinal anesthesia leads to vasodilatation, which reduces venous return and thus cardiac output, leading to hypotension [8]. Prolonged hypotension leads to ischemia, loss of consciousness, uterine hypoperfusion, and cardiovascular arrest [9]. Hypotension causes morbidity in the mother and fetus such as reduced uterine blood flow and hypoxemia as well as acidosis in the fetus [7]. There is also evidence of a direct association between Apgar score and fetal acidosis (in the umbilical cord blood sample) and the severity of maternal hypotension [10, 11].

Various methods, including drug therapy with vasopressor drugs and fluid therapy, are used to prevent and treat hypotension caused by spinal anesthesia [8, 9, 12].

Colloids and crystalloids are types of fluids that are often used intravenously. In case of severe hypotension, it needs to give a large quantity of crystalloid solutions, which may lead to peripheral edema, increased CVP, and pulmonary edema in people with cardiovascular disease [13]. However, by giving the lesser quantity of colloid solutions the hypotension due to spinal anesthesia can be corrected [14]. In other words, colloids provide better stabilization of hemodynamic symptoms than crystalloids, therefore, using them as an alternative seems to be effective [15].

The other differences between crystalloid and colloid solutions explained in (Table 1).

Vasopressor drugs (sympathomimetic drugs) like ephedrine and/or phenylephrine intravenously can be used in addition to fluid therapy to treat and prevent sever hypotension [17]. Phenylephrine preferred in the absence of maternal bradycardia, because of improved fetal acid–base status in uncomplicated pregnancies [2] .

The objective of this study is to compare the effectiveness of colloidal solutions and crystalloid solutions in preventing hypotension resulting from spinal anesthesia during elective cesarean sections, along with assessing the requirement for vasopressors to treat sever hypotension due to the spinal anesthesia.

MATERIALS AND METHODS

This is a prospective comparative study, in which 70 pregnant women scheduled for elective cesarean section, patients were allocated by simple randomization into two groups (35 people in each group). Crystalloid group giving crystalloid solutions intravenously, and colloid group giving colloid solution intravenously.

Inclusion criteria: include the age between 18 and 45 years old, weight less than 100kg, height more than 150cm or BMI less than 40, American Society of Anesthesiologists (ASA) class II, and elective cesarean section candidate.

Exclusion criteria: include the age less than 18 years and more than 45 years old, weight more than 100kg, height less than 150cm or body mass index (BMI) more than 40, diabetes mellitus, preeclampsia, chronic hypertension, heart disease, twin or triple pregnancies, anemia or hemoglobin less than 10gr/dl, history of neurological or psychological diseases, and emergency cesarean section.

Informed consent was obtained from patients to participate in the study. Data collection started after receiving the approvals from the committee of the Iraqi Board for Medical Specializations. This study was performed at Erbil Maternity Teaching Hospital in Erbil/Iraq between the period of May 2021 till October 2021.

Table 1. Differences between crystalloid and colloid solutions.

	Crystalloid	Colloid
Size	Small molecule [16]	Large molecule [16]
Duration in bloodstream	Short half-life (stay for short period inside blood vessels)	Long half-life (stay for longer period inside blood vessels)
Cost	Less expensive	More expensive
Example	normal saline, ringer lactate, and ringer's solutions	Natural: albumin, fresh frozen plasma Synthetic: stretches, dextranes, gelatins, and voluven

All patients received 50mg of ranitidine before anesthesia. Four liters per minute of oxygen was administered through the nasal cannula for all patients. None of the patients had received a volume drift before anesthesia. Spinal anesthesia in a sitting position in L 2-L 3 or L 3-L 4 with 0.5% bupivacaine at a dose of 10mg without the addition of opioids was performed with a 25-gauge needle. The patient was immediately placed in the supine and left lateral positions. The level of anesthesia was assessed at 5, 10, and 15 minutes after the spinal anesthesia by the Pin Prick method, and at the level of T 6, surgery was allowed to begin. In the first 15 minutes after the start of spinal anesthesia, 1000ml of crystalloid solution (normal saline) was infused for the crystalloid group and 1000ml of colloidal solution (voluven) was infused for the colloid group. Then, to maintain the venous route, all patients received 500ml of crystalloid solution until the end of the operation. Changes in blood pressure and heart rate were measured during the surgery. Baseline blood pressure is the average systolic blood pressure that is measured three times five minutes before the patient is transferred to the operating room. Patients' blood pressure (systolic blood pressure, and diastolic blood pressure) was measured and recorded by an automatic sphygmomanometer every 5 minutes until 30 minutes, and vasopressor drugs needed for treating the hypotension were recorded. Hypotension refers to systolic blood pressure less than 80% of baseline blood pressure. If the patient's systolic blood pressure falls below 80% of baseline blood pressure, vasopressor is administered in a 10 ml syringe containing a combination of 5mg/ml ephedrine and 25 μg/ml phenylephrine according to the following instructions: if a patient's systolic blood pressure = 70 to 79% of basal systolic blood pressure 1cc of vasopressor was given intravenously (IV). If the patient systolic blood pressure = 60 to 69% of basal systolic blood pressure 2cc of vasopressor was administered IV. If the patient's systolic blood pressure = 50 to 59% of basal systolic blood pressure 3cc of vasopressor is administered IV. In each patient, the minimum systolic blood pressure was recorded before the fetus left. In critical conditions such as severe hypotension that did not respond to the vasopressor dose, with severe tachycardia (HR $\geq$ 140) or severe bradycardia (HR $\leq$ 40), the anesthesiologist prescribed additional doses of ephedrine or phenylephrine or even injected atropine, depending on the patient's needs. In addition to blood pressure and heart rate, the SpO2 of the patients was monitored and recorded by pulse oximeter. After the operation, all patients were transferred to the recovery room and after the sensory level of the patients reached T10 and stabilization of the vital signs, they were transferred to the ward.

Data were entered into SPSS software after collection. Chi-square test was used to evaluate the qualitative variables and compare them in the two groups. Normality tests (Shapiro-Wilk and Kolmogrov-Smirnov) was applied to confirm the distribution of data. Independent t-test and Mann-Whitney test were used to examine the independent variables in the two groups. A p-value of $\leq$ 0.05 was considered statistically significant.

RESULTS

Simple randomization was done before starting the study, dividing the patients into two group, each group 35 patients. To present the results of demographic variables, there is no difference between the two groups regarding maternal variables including the ages, BMI, parity, baseline systolic blood pressure (SBP), baseline diastolic blood pressure (DBP), baseline heart rate (HR), baseline peripheral hemoglobin-oxygen saturation (SpO2), and baseline temperature. However; the gravidity in the two examined groups showed significant differences, as shown in (Table 2).

Regarding the SBP and the DBP; there is no significant reduction between the crystalloid and colloid groups (p-value > 0.05), except at 5min there is a significant reduction in SBP and DBP in both crystalloid group (p-value < 0.0001) and colloid group (p-value < 0.003), as shown in (Figures 1,2).

Table 2. Evaluation of maternal variables in the two examined groups .

Maternal characteristics	Crystalloid group (±SD)	Colloid group (±SD)	P-value
Age	27.74 (±5.68)	27.14 (±6.35)	0.751*
BMI	31.23 (±3.45)	30.80 (±4.04)	0.634**
Gravidity	3.03 (±1.50)	2.54 (±1.40)	**0.01***
Parity	1.74 (±1.38)	1.38 (±1.32)	0.209*
Baseline SBP	119.40 (±4.67)	122.69 (±14.32)	0.293**
Baseline DBP	76.20 (±8.29)	79.03 (±12.25)	0.262**
Baseline temperature	37.01 (±0.32)	37.00 (±0.25)	0878*
Baseline HR	112.69 (±21.41)	112.26 (±20.79)	0.851*
Baseline SpO2	95.23 (±12.29)	95.17 (±12.32)	0.847*

* Mann-Whitney Test, ** T-Test, BMI=Body mass index, SBP=Systolic blood pressure, DBP=Diastolic blood pressure, HR=Heart rate, SpO2=Peripheral capillary oxygen saturation.

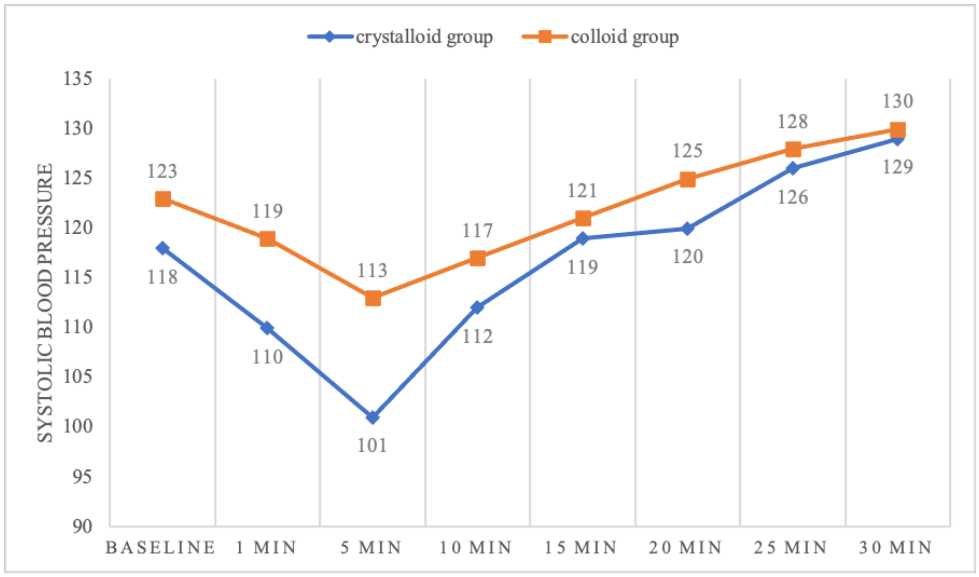

Figure 1. Systolic blood pressure during 30 minutes of the operation.

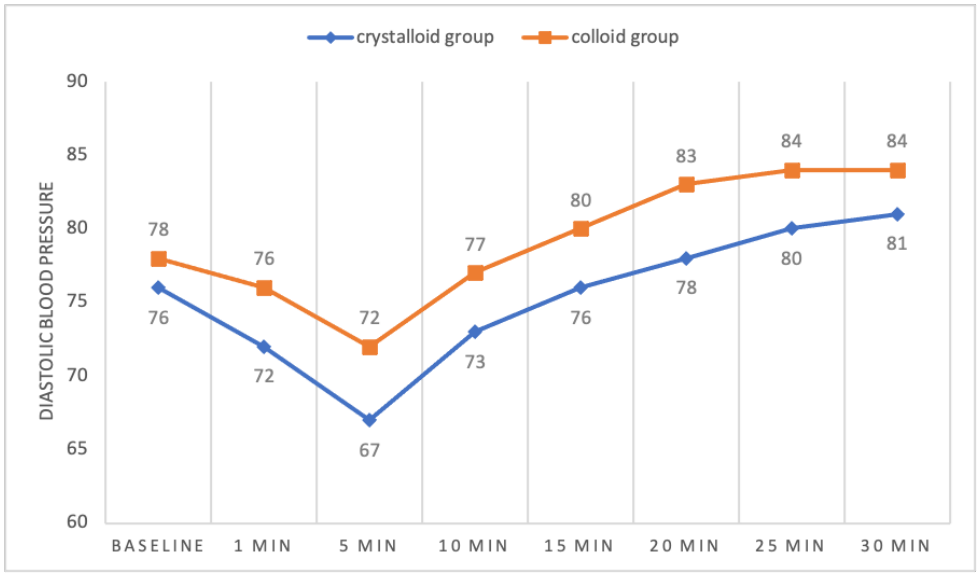

Figure 2. Diastolic blood pressure during 30 min of the operation.

Table 3. Difference between the baseline and the minimum value during the operation.

Time Differences	Crystalloid (Mean ± SD)	Colloid (Mean ± SD)	P-value
Baseline-minimum SBP	17.03 ± 4.232	11.40±7.754	**<0.0003**
Baseline-minimum DBP	9.029 ± 3.869	5.286±8.053	**<0.0157**

SBP=Systolic blood pressure, DBP=Diastolic blood pressure

Table 4. Factors and measures during the operation in crystalloid and colloid groups.

Other variables	Crystalloid (n=35)	Colloid (n=35)	P-value
need for vasopressors in mg	36.3 (33.5-39.1)	2.7 (1.6-4.9)	**0.001***
level of needle administration			0.962**
L2-L3	10	9	
L3-L4	19	20	
L4-L5	6	6	

* Mann-Whitney Test, ** X^2 Test

To evaluate the beneficial of colloid infusion over the crystalloid infusion in elective cesarean section done under spinal anesthesia, the difference between the baseline SBP and the minimum value of the SBP during the operation is calculated, the result shows significant difference between the two examined groups, the difference is more in crystalloid group than in colloid group, which means less reduction in SBP in colloid group. The same calculation is done for the DBP, with significantly more difference in crystalloid group than in the colloid group, (Table 3).

Other variables that seemed to affect the final outcome were also examined. The need of vasopressor drugs is more in crystalloid group than in colloid group with statistically significant difference. While there is no difference between the groups regarding the level of the needle injection in the lumber vertebrae, (Table 4).

DISCUSSION

Both crystalloid solutions and colloid solutions effectively reduced the incidence of hypotension due to the spinal anesthesia in elective C/S, except at 5min there was a significant reduction in blood pressure. However; colloid solutions had relatively more beneficial effects as there is less sever hypotension in colloid group which can be observed by the significantly less need for vasopressor drugs in colloid group, and the significant difference between the baseline blood pressure with the lowest value of blood pressure occurred during the operation time (less difference in colloid group means less sever hypotension).

In both crystalloid and colloid groups, there was no any reduction in the blood pressure, except at 5min there is a significant reduction in SBP, and DBP. In previous studies, these variables have a statistically significant difference between the crystalloid and colloid groups [18–22] . For example, the results showed that it is more than Kaufner study [20] but less than Tawfik study [21] .

The difference between this study with the other studies in SBP and DBP may be explained by the rapid infusion of fluid (1000ml of normal saline in crystalloid group and 1000ml of voluven in colloid group) within a short period (15min), which is successful in preventing hypotension. However; in this study there is a lesser reduction in SBP and DBP in colloid group comparing to the crystalloid group detected by the significant difference between the baseline value with the minimum value of the SBP and the DBP during the times of the operation, which indicates the beneficial of colloid infusion in prevention of hypotension due to the spinal anesthesia for elective cesarean section, (baseline blood pressure minus lowest blood pressure occur during the operation, as much as the difference was less means less reducing the blood pressure, and greater difference means more reducing the blood pressure).

There was a significant difference between the two groups in the study of the need for vasopressors. In colloid groups there was a significantly lesser need for vasopressor than in crystalloid group, which indicates the benefit of colloid infusion in prevention of hypotension due to the spinal anesthesia for elective cesarean section. The result is consistent with the study of Jabalameli [23] , in which there is also a less need for vasopressors in colloid group. The needle level variable study did not show any difference between the two groups and the results were not consistent with the Kaufner study [20] .

The importance of this study is that the use of colloidal solutions was preferable given that they remain in the bloodstream longer and require less vasopressor therapy to treat hypotension. Of course, the type, dose of anaesthetic, combination with other drugs used, and the skill of the anesthesiologist are very important in preventing complications

such as hypotension. Colloid solutions can be safely used instead of crystalloid solutions to prevent hypotension due to spinal anesthesia, however; colloid solutions contraindicated in cases with renal failure and when there is hypersensitivity to it or to any of its contents and used with caution and in smaller amount in patients with heart failure, and volume overload.

Limitations of this study includes small sample size, the restriction to cases presenting to the Erbil Maternity Teaching Hospital, and most of our patients afraid from spinal anesthesia and refuse it. Due to the limited number of participants, it is suggested that researchers in other studies select higher sample sizes, test different colloidal solutions, cross-research designs, and anesthetics and other vasopressors.

CONCLUSION

both colloidal and crystalloid solutions have been effective in preventing hypotension due to spinal anesthesia in elective cesarean section. However; the results of this study show relative benefit effect of colloid versus crystalloid in prevention of lowering blood pressure, and there is less need to use vasopressor drugs to treat hypotension in comparing to the crystalloid infusion group. So, to prevent hypotension due to spinal anesthesia in patients undergoing cesarean section, we recommend to replace crystalloid fluids with colloidal solutions, because, using colloids instead of crystalloids helps to maintain intravascular volume for longer period, and there is also less need to use vasopressor drugs.

ETHICAL DECLARATIONS

- **Acknowledgements**

  None.

- **Ethics Approval and Consent to Participate**

  This study was approved by the Local Scientific Council of the Iraqi Board of Medical Specialization, An informed consent was taken from each participant.

- **Consent for Publication**

  Non.

- **Availability of Data and Material**

  The datasets are available from the corresponding author upon reasonable request.

- **Competing Interests**

  The authors declare that there is no conflict of interest.

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- **Authors' Contributions**

  All stated authors contributed significantly, directly, and intellectually to the work and consented it to be published.

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