Original Article

Comparison of the effects of colloid preload, vasopressor administration and leg compression on hemodynamic changes during spinal anesthesia for lumbar disc surgery in knee–chest position

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Abstract

Background: Hypotension is a serious and the most common adverse effect of spinal anesthesia. Many studies have focused on prevention of hypotension due to spinal anesthesia. The aim of this study was to compare the efficacy of three different methods of using colloid, ephedrine and wrapping of extremities on the incidence of hypotension and bradycardia following spinal anesthesia in patients undergoing elective lumbar disc surgery in knee–chest position.

Materials and Methods: A total of 180, ASA (I–II), adult patients candidate of lumbar disc surgery in one or two levels who met the inclusion criteria were randomly allocated in one of three treatment groups of receiving Voluven (6% hydroxyethyl starch 130/0.4 in 0.9% sodium chloride injection), ephedrine and leg wrapping. After establishment of spinal anesthesia, patients were outsourced and knee–chest position was done. Heart rate and blood pressure of patients were recorded at different times till 60 min after spinal injection. Statistical analyses of data were performed with SPSS (version 20) and by considering groups, values of $P < 0.05$ were considered statistically significant.

Results: Mean systolic blood pressure (119.5 ± 7.4 mmHg) and mean heart rate (71.7 ± 6.7 b/min) were higher in a group receiving Voluven ($P < 0.05$). The Voluven group significantly experienced less nausea and vomiting in recovery room in comparing with other groups ($P = 0.027$). They also received significantly less ephedrine ($P = 0.012$) and ondansetron [12 (20%)] ($P = 0.02$). Furthermore, patients receiving elastic bandage had significantly more blood loss than the other groups ($P = 0.013$).

Conclusion: Colloid therapy was the most effective method in keeping hemodynamic stability, prevention of decrease in systolic blood pressure and incidence of side effects during spinal anesthesia for lumbar disc surgery in knee–chest position.

Key Words: Colloid, colloid preload, ephedrine, hemodynamic changes, knee-chest position, leg wrapping, lumbar disc surgery, spinal anesthesia

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INTRODUCTION

Hypotension is the most common and serious adverse effect of spinal anesthesia. Various studies

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have focused on prevention and treatment of this complication. Spinal anesthesia leads to preganglionic sympathetic block and hypotension develops as a result of decreased systemic vascular resistance, blood pooling in the peripheral veins and decreased cardiac output.[1]

Several studies have focused on prevention of hypotension due to spinal anesthesia and many

prophylactic methods including crystalloid and colloid preloading, ephedrine prophylaxis and wrapping of the lower extremities have been suggested to prevent or correct hypotension.[2-6]

Recently, in one study the role of volume preload in prevention of hypotension after spinal anesthesia has been investigated and it is reported that preload with crystalloid has certain preventive role in reduction of hypotension after spinal anesthesia that even has superiority by consideration of cost and likely effects.[7,8]

One study has shown the effectiveness of phenylephrine infusion as low as 100 μm per minute, in reducing the incidence and magnitude of hypotension during spinal anesthesia for cesarean delivery, with no adverse effect on neonatal outcome.[9] A similar study on ephedrine also showed that infusion and prophylactic intramuscular injection of 15-30 mg ephedrine reduces the severity of hypotension after spinal anesthesia. However, due to unpredictability of the absorption of intramuscular ephedrine (IME) in different people and the possibility of cancellation of surgery, it is better to use 5-mg intravenous bolus during spinal block implementation.[1]

Warwick and his colleagues emphasized on the effect of preload with colloid and the average effect of elastic bandage of feet to reduce hypotension after anesthesia.[10] Furthermore, Iwama and his coworkers showed that the use of extra strong stocks in feet of cesarean patients under spinal anesthesia reduces the consumption of vasopressors and is recommended as a non-invasive preventive method of hypotension after spinal anesthesia.[11] Pamela *et al*. evaluated the effect of central blood volume increase by mechanical methods and reported that feet bandage continuously and significantly decreases the incidence of hypotension after spinal anesthesia compared to the control group.

In lumbar disc surgery, performing spinal anesthesia is safe and effective to the same extent as general anesthesia. One of the certain benefits of spinal anesthesia is the reduction of analgesic and anti-nausea drugs consumption. More hemodynamic stability and the less probability of bleeding are the other advantage of this method.[12]

There are various positions for surgery of spine and backbones, some of them obviously reduce lumbar lordosis and provide ideal condition for surgery. The correction of the surgical position leads to reduction of abdominal pressure and provides ideal condition for mechanic of respiration during operation in anesthetized patients.

Of the most frequently used patient positions during spinal surgery, two are the prone position on the Relton-Hall frame and the knee–chest position on an Andrews-type table. However, neither has ever yielded better operative conditions. The choice of the position is usually a matter of surgeon's preference.[13]

Since spinal anesthesia is widely used in our center for lumbar disc surgery in knee–chest position and no study has compared the effect of these methods to prevent hemodynamic instability during spinal anesthesia in this surgical position. The objective of our study was performed to compare the efficacy of three different methods using colloid, ephedrine and wrapping of extremities on prevention of hypotension and bradycardia following spinal anesthesia in patients undergoing elective lumbar disc surgery in knee–chest position.

MATERIALS AND METHODS

This randomized, single-blind clinical trial was conducted in two university hospitals (Alzahra and Kashani, in Isfahan, Iran) from summer 2012 to spring 2014 Following approval by our local Ethics Committee, 180 patients undergoing lumbar disc surgery in one or two levels were randomized with the use of randomization tables.

The inclusion criteria consisted of an age between 18 and 64 years, ASA (I–II), ability to provide informed consent for, cooperative with the study and lack of contraindication for performing spinal anesthesia.

Considering a level of significance of 5%, power of 80%, and the primary objective of blood pressure control by the occurrence of nausea and vomiting, it was calculated a sample size of 55 patients per group. Sixty patients in each group were investigated, for higher reliability.

The sampling method was consecutive, and eligible patients who met the inclusion criteria were

randomly placed in one of these three treatment groups:
Group 1: Patients received infusion of 7 cc/kg colloid solution (Voluven) within 30 minutes prior to spinal anesthesia
Group 2: Immediately after spinal anesthesia, 10 mg ephedrine IV bolus was injected.
Group 3: Before spinal anesthesia, tight wrapping of the lower extremities (from the feet to the mid-thigh) with an elastic bandage.

Before administration of spinal anesthesia all patients received 500 cc Ringer's Lactate solutions. Then spinal anesthesia was performed in all cases in sitting position by one spinal anesthesia expert at the L2-L3, L3-L4 or L4-L5 interspaces. The anesthesia was done with 3 mL plain Marcaine solution using a 23-gauge spinal needle (pencil point, Pajunk, Germany).

Then, the patients were set to the supine position and applied 5 L/min O_2 through face mask. After establishment of T12 or higher block with a pin prick test and confirmation of anesthesia, patients were outsourced and knee–chest position was done. Patients and all staff involved in the study were blind to the protocol used.

All patients were monitored by non-invasive blood pressure monitoring, pulse oximetry, electrocardiography, and bleeding and urine volumes from entering into the operating room till discharging from recovery room. If hypotension occurred, as defined by systolic blood pressure (SBP) fell to below 90 mmHg or greater than 20% below baseline, rescue boluses of ephedrine (5 mg) were given by an anesthesiologist who was blinded to the study each 5 min until hypotension resolves.

The nausea and vomiting severity are investigated and recorded by technician. In case of vomiting or severe nausea atropine (0.5 mg, IV) during operation, and ondansetron (4 mg, IV) in recovery room were administered. SBP, diastolic blood pressure (DBP), and heart rate (HR) of patients were recorded at the admission to operating room (baseline), immediately before and after spinal anesthesia, and at 3, 5, 15, 20, 25, 30, 45, and 60 min after spinal injection, at the time of entrance to recovery and 15 and 30 minutes after entrance to recovery. Time interval between the spinal injection and the occurrence of hypotension, incidence of hypotension, and the amount of rescue ephedrine administered were recorded. On arrival in the post-anesthesia care unit the sensory level was assessed by pinprick; patients were released from recovery room at least after four segments regression of spinal block. All data were collected and recorded by an anesthetist who was not aware of method of intervention.

Statistical analysis of data was performed with SPSS (version 20) and T-student, λ^2 and variance analysis tests with repetition of observations.

By considering quantitative and qualitative variables among the groups and values of $P < 0.05$ were considered statistically significant.

RESULTS

One hundred and eighty candidates of lumbar disk surgery were randomly distributed in three groups receiving Voluven, ephedrine and elastic bandage.

The three groups were similar in age, weight, gender, ASA, HR, systolic and DBP prior to the intervention. Also, there was no significant difference in duration of operation, duration of anesthesia, operation level and sensory block between three groups [Table 1].

During the study mean HR was 71.7 ± 6.7, 67.6 and 68 ± 4.7 beats per minute, in Voluven, ephedrine and elastic band groups, respectively. According to one-way variance analysis, the difference between three groups was meaningful ($P < 0.001$). Moreover, according to Scheffe follow-up test, the mean HR in the Voluven group was significantly higher compared to other groups; however, no significant difference was seen between ephedrine and elastic band groups [Figure 1].

Table 1: The distribution of general and demographic variables of three groups

Groups	Voluven (*n*=60)	Ephedrine (*n*=60)	Elastic bandage (*n*=60)	*P* value
Age (years)	41.8±10.2	36.3±7.8	39±9.3	0.073
Sex (m/f)	38/22	40/20	32/28	0.55
Weight (kg)	73.2±11.9	75.4±9.1	73.5±9.9	0.163
ASA				
I	54 (90)	60 (100)	58 (96.7)	0.32
II	6 (10)	0 (0)	2 (3.3)	
Duration of anesthesia (min)	167.2±10.3	164.2±11.4	163.3±14.2	0.2
Duration of surgery (min)	67±11.6	65.6±10	66.5±10.9	0.86
Surgical level				
L5-S1	22 (36.7)	26 (43.3)	16 (26.7	0.31
L4-L5	22 (36.7)	24 (40)	36 (60)	
L4-S1	16 (26.7)	10 (16.7)	8 (13.3)	
Upper sensory level				
T6	11 (18.3)	6 (10)	4 (6.7)	0.26
T7	20 (33.3)	20 (33.3)	26 (43.3	
T8	29 (48.3)	34 (56.7)	30 (50)	

ASA: The American Society of Anesthesiologists (ASA) Physical Status classification system

Similarly, mean SBP in Voluven, ephedrine and elastic band groups were 119.5 ± 7.4, 115.2 ± 6 and 115.1 ± 7.6 mmHg, respectively. The difference between three groups was significant ($P = 0.001$). The mean SBP in the Voluven group was significantly higher compared to other groups ($P = 0.004$); however, again no significant difference was seen between ephedrine and elastic band groups ($P = 0.99$) [Figure 2].

There was no significant difference in mean DBP and mean arterial blood pressure between groups ($P = 0.93$ and $P = 0.14$, respectively) [Figures 3 and 4].

Table 2 represents the frequency distribution of supplementary drugs consumption and showed that atropin consumption was not significantly different between groups ($P = 0.33$).

Also, in Voluven, ephedrine and elastic band groups, 6 (10%), 16 (26.7%) and 19 (31.7%) individuals received ephedrine, respectively. According to the λ^2 test, the Voluven group received significantly less ephedrine ($P = 0.012$). Similarly, ondansetron consumption in the Voluven group [12 (20%)] was less than ephedrine [24 (40%)] and elastic band groups [25 (41.7%)] and according to the λ^2 test, the difference was significant ($P = 0.02$).

Table 3 shows that patients suffered from nausea and vomiting during operation and later in recovery room. Patients receiving Voluven significantly experienced less nausea and vomiting in comparing with other groups ($P = 0.027$).

Furthermore, the volumes of blood loss and fluid intake in each group were measured and patients receiving elastic bandage had significantly more blood loss than the other groups ($P = 0.013$) [Table 3].

Table 2: The frequency distribution of atropine, ephedrine and ondansetron consumption in three groups

Supplementary drug requirement (mg)	*n* (%)			*P* value
	Voluven	Ephedrine	Elastic bandage	
Atropine	11 (18.3)	18 (30)	15 (25)	0.33
Ephedrine	6 (10)	16 (26.7)	19 (31.7)	0.012
Ondansetron	12 (20)	24 (40)	25 (41.7)	0.02

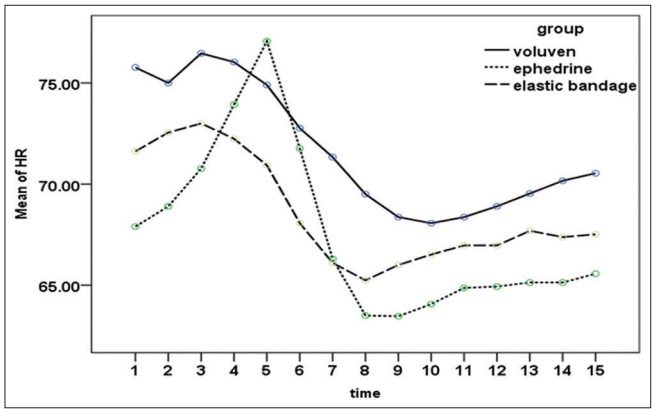

Figure 1: Heart rate changes from pre-operation till 30 minutes stay in recovery room in three groups (P=0.01)

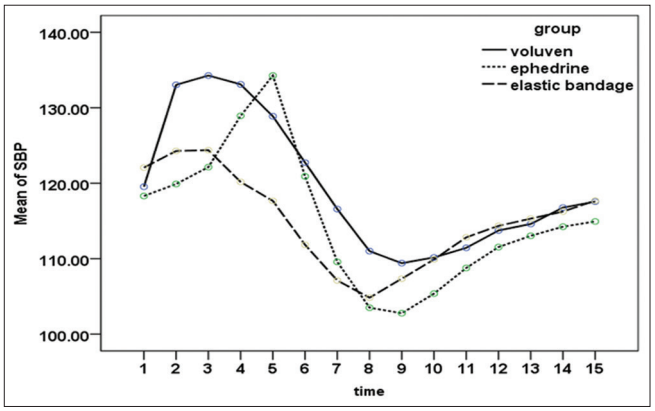

Figure 2: Systole blood pressure changes from pre-operation till 30 minutes stay in recovery room in three groups (P=0.026)

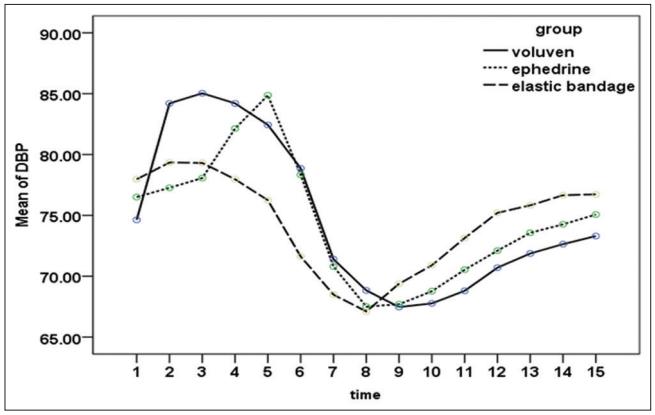

Figure 3: Diastole blood pressure changes from pre-operation till 30 minutes stay in recovery room in three groups (P=0.96)

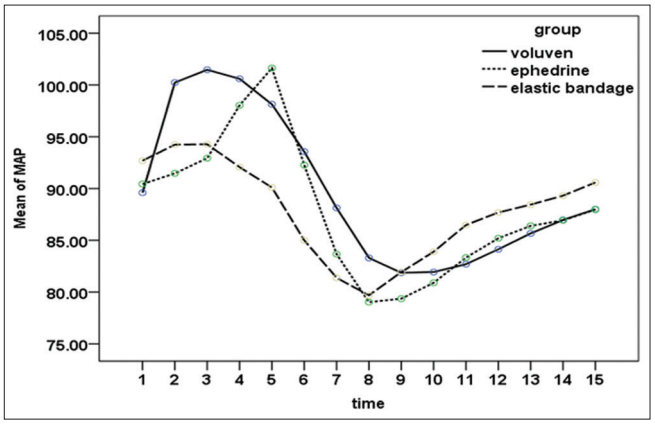

Figure 4: Mean blood pressure changes from pre-operation till 30 minutes stay in recovery room in three groups (P=0.38)

Table 3: The frequency distribution of post-operative side effects, bleeding volume and received liquids in three groups

Parameters	*n* (%)			*P* value
	Voluven	Ephedrine	Elastic bandage	
In operating room				
Vomiting	8 (13.3)	16 (26.7)	14 (23.3)	0.42
Headache	0 (0)	0 (0)	0 (0)	1
In recovery room				
Vomiting	12 (20)	24 (40)	24 (40)	0.027
Headache	4 (6.7)	4 (6.7)	4 (6.7)	1
Blood loss (mL)	261.8±40.5	271.3±49.5	299.6±55.1	0.013
Fluid intake (mL)	2789.7±156.1	2728.3±164.4	2682.1±171.7	0.051

The mean volume of fluid intake had no significant difference in three mentioned groups.

DISCUSSION

The aim of this study was to compare three methods of colloid preload, vasopressor and feet bandage on blood pressure and HR variation in patients undergoing lumbar disc operation under spinal anesthesia in knee- chest position. The investigation of general and demographic indices showed that three studied groups had no difference in terms of age and gender distribution, ASA, operation level, level of sensory block, duration of operation and anesthesia. Thus, the confounding effects of the above factors can be considered neutral in the study. Therefore, the obtained results concerning hemodynamic parameters, post-operative effects and drug consumption are likely related to the kind of method used for patients.

In our study we found that no single method completely prevents hypotension and none have been shown to eliminate the need to treat hypotension during spinal anesthesia. According to our results, colloid therapy is more effective in preventing the decrease in SBP and HR than prophylactic ephedrine and leg compression in patients undergoing lumbar disc operation under spinal anesthesia in knee-chest position. Our result was similar to that of other studies showing colloid administration reduced the incidence of low blood pressure after spinal anesthesia for cesarean delivery.[7,8]

In our study, since the interval between preloading with colloid and spinal anesthesia was 30 min, there was more time for the osmotic effect of colloid (with 30 min as preloading time) to increase total volume which have been responsible for better prevention of decrease in SBP in colloid group, when compared to other groups.[14]

Many studies have been done on prevention of hypotension after spinal anesthesia. Riley and his colleagues showed that preload of liquids, prescription of prophylactic vasopressors and feet bandage before spinal anesthesia reduce incidence and fall of blood pressure.[2] In a qualitative systematic review, Morgan and his colleges studied the efficacy of increasing central blood volume on the incidence of hypotension after spinal anesthesia for elective cesarean delivery. They concluded that although no technique totally eliminates the occurrence of hypotension, colloid administration (starch or gelatin containing fluids) and leg wrapping were the most effective.[7]

Weeks and his colleagues also investigated the role of preloading liquids on prevention of hypotension after spinal anesthesia, and they reported that colloid preload reduces the incidence of hypotension after spinal anesthesia for cesarean section and in spite of the fact that it is expensive and not without risk, most anesthesiologists will probably feel that the problem is not large enough to merit colloid use.[8]

The effect of ephedrine in prevention of hypotension due to spinal anesthesia has been shown in some studies. Ephedrine has effects on cardiac beta receptors indirectly, leads to sinus node stimulation and consequently preventing decrease in HR following spinal anesthesia. In some cases, this led to increase in HR. Prophylactic ephedrine has been shown to prevent bradycardia in previous studies.[15] Azzolina *et al*. showed that infusion and prophylactic injection of 15-30 grams ephedrine intramuscularly reduces the severity and of hypotension after spinal anesthesia.[1]

In another study, Warwick emphasized on the effect of preload with colloid and average effect of elastic bandage of feet.[10] Furthermore, Iwama and his collogues showed that the use of extra strong stocks reduces usage of vasopressor agents during spinal anesthesia for cesarean section.[11] Pamela *et al*. studied the effect of increase of central blood volume by mechanical methods and reported that continuous feet bandage decreases the incidence of hypotension after spinal anesthesia in lumbar disc surgery compared to the control group.

We showed that colloid therapy is more effective in preventing the decrease in SBP and HR, but the benefits are still limited, and infusion of large volumes of colloid may have other risks, including fluid overload, decreased oncotic pressure, and anaphylactoid reactions. Although the incidence of allergic reaction with artificial colloid is high, no adverse reaction anaphylactic or anaphylactoid reaction to Voluven occurred in our study.

In our study, the groups were significantly different in the relative frequency of nausea and vomiting in recovery room, and in the frequency of administration of ephedrine and ondansetron. Due to less incidence of hypotension in the Voluven group, the frequency of nausea and vomiting and need to ephedrine and ondansetron administration were significantly less than other groups [Table 2]. This was in agreement with the results of some previous studies.[14]

The volume of blood loss in the Voluven group was significantly less than other groups which is in correlation with less incidence of hypotension in this group.

Our study had several limitations. The lack of a control group precluded determination of an absolute reduction in the incidence of hypotension and for ethical reasons, we could not include a group without prehydration.

CONCLUSION

In conclusion, among the three studied methods, colloid therapy was the most effective one in keeping hemodynamic stability, prevention of decrease in systolic blood pressure and incidence of side effects during spinal anesthesia for lumbar disc surgery in knee–chest position.

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