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Original Article

Effect of lower leg compression during cesarean section on post-spinal hypotension and neonatal hemodynamic parameters: nonrandomized controlled clinical trial

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A B S T R A C T

Objectives: This study aimed to determine the effect of lower leg compression during cesarean section (CS) on post-spinal hypotension (PSH) and neonatal hemodynamic parameters.
Methods: This study is a nonrandomized controlled clinical trial conducted in the cesarean delivery unit of the National Medical institute, Damanhour, Egypt. The sample included 120 parturients (60 intervention and 60 control). The researchers developed three tools for data collection: sociodemographic data and reproductive history interview schedule, electronic monitoring of maternal hemodynamic parameters, and neonatal hemodynamic assessment sheet. All parturients received ordinary pre-operative care. For the intervention group, a long elastic stocking (ordinary pressure 20–30 mmHg, 1 mmHg = 0.133 kPa) was applied on both legs during cesarean section. The control group received the same care without the elastic stocking.
Results: Systolic blood pressure, diastolic blood pressure, and mean arterial blood pressure were significantly higher in the intervention group throughout the entire operation period except in the last 5–15 min. Heart rate was significantly lower in the intervention group. Only 13.3% of the intervention group took ephedrine compared with 45% of the control group. Apgar score was higher among neonates of intervention group compared with the control group at 1 min. Neonatal acidosis was significantly higher in the control group than in the contral group.
Conclusion: Lower leg compression technique can effectively reduce PSH and neonatal acidosis.

What is known?

- Post-spinal hypotension is the most common complication following spinal anesthesia.
- The effect of lower leg compression during cesarean section on post-spinal hypotension (PSH) and neonatal hemodynamic parameters in literature is not conclusive.

What is new?

- Lower leg compression is effective in reducing PSH and neonatal acidosis during cesarean section.
- Lower leg compression is effective in reducing the need for ephedrine.
- Apgar score at 1 min is significantly higher among neonates of parturients with compression stocking during cesarean section.

1. Introduction

The incidence of cesarean section (CS) is incredibly increasing worldwide in general and in Egypt in particular. According to a 2014 demographic and health survey in Egypt, cesarean section rate surged from 6.6% in 1995 to 51.8% in 2014 [1]. World Health Organization (WHO) stated that cesarean section has numerous serious complications which may result in lifelong disabilities or even death. Thus, cesarean section should be performed only when required, and its complications should be controlled. The accepted rate of cesarean section should range between 10%-15% [2].

Local anesthesia (including spinal and epidural) is preferred

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over general anesthesia in case of emergency cesarean section, fetal distress, some chronic maternal diseases, and difficult intubation. Post-spinal hypotension (PSH) is the most common complication following spinal anesthesia; its incidence ranges from 60% to 70% [3]. PSH has numerous definitions; the most valid one states that it reduces blood pressure by 20% from the baseline. It is typically accompanied by nausea and vomiting [4]. PSH is a serious problem and can lead to maternal complications such as loss of consciousness, aspiration, and death if not efficiently managed. Fetus complications range from low Apgar score in mild PSH to fetal hypoxia, distress, fetal acidosis, and brain damage due to severe hypoxia reflected on umbilical PH samples [5].

The mechanism of PSH is complex and multi-factorial. Two major factors are acknowledged. The first is systemic decrease in blood vessel vascular resistance after spinal block due to sympathetic inhibition. The second is compression of gravid uterus in the inferior vena cava against the vertebral bone, resulting in reduction of venous return to the heart. These two factors are usually compensated by increased heart rate (HR) and cardiac output. However, in a relatively high dose of spinal block, this compensatory action is blocked, secondary to inhibition of cardio accelerator fibers leading to systemic hypotension. The placenta blood supply is pressure dependent; consequently, in case of PSH, the uteroplacental blood supply is decreased by around 16%–20%, leading to serious fetal complications [5,6].

Many pharmacological interventions are suggested to manage PSH as crystalloid and/or colloid preloading and co-loading. This method may decrease the severity of PSH but will not eliminate it. Colloids are expensive and not well tolerated by the body. Vasopressors are the main medications used to manage PSH. Vasopressors include, but are not limited to, ephedrine, metaraminol, and other α-adreno-receptor agonists. Some cases may require a combination of two drugs. Using vasopressors to manage PSH results in vasoconstriction of uterine blood supply, which may lead to increased fetal distress and hypoxia [5].

A recent meta-analysis concluded that anesthesia is accountable for 2.8% of obstetric complications and 13.8% of post-cesarean deaths [7]. This result necessitates the rapid management of anesthesia complications including PSH. PSH is a prevalent complication with 60%–70% occurrence rate, and its pharmacological therapy has serious side effects. These serious and mostly rarely avoidable side effects of pharmacological interventions necessitate the search for other simple non-pharmacological nursing measures and cost-effective techniques to manage PSH or at least decrease its severity by decreasing the dose of medication required. Studies suggested some interventions such as leg elevation [8], leg wrapping [9], and application of leg compression through elastic stocking [6]. However, none of those strategies was proven totally effective. More research is required to fill the research gap. If one of these simple nursing interventions or a combination of them is proven effective, then the need for pharmacological intervention would be unwanted or decreased. The nursing body of knowledge will also be enriched with simple and effective intervention for PSH. Therefore, this study aims to evaluate the effect of lower leg compression during cesarean section on PSH and neonatal hemodynamic parameters.

2. Materials and method

2.1. Study design

This study is a nonrandomized controlled clinical trial where the effect of one independent variable (lower leg compression) on two dependent variables (PSH and neonatal hemodynamic parameters) during cesarean section is examined.

This study aims to determine the effect of lower leg compression during cesarean section on PSH and neonatal hemodynamic parameters.

Research hypotheses: (1) Parturient who received lower leg compression during cesarean section has lower incidence of PSH than the control group. (2) Parturient who received lower leg compression during cesarean section has privileged neonatal hemodynamic parameters compared with the control group.

Operational definition: hemodynamic parameters, Apgar score at 1–5 min, umbilical artery PH, base excess, bicarbonate, and PCO_2.

2.2. Participants and sample size

A convenience sample of 120 parturients was recruited. The inclusion criteria are as follows: normal pregnancy, full term (37–41 weeks of gestation), age of 19–40 years old, singleton pregnancy, parturient undergoing elective cesarean section with spinal anesthesia, willingness to participate in the study, freedom from any chronic disease, and body mass index (BMI) less than 30. Exclusion criteria include the following: history of leg injury, deep vein thrombosis. Subjects who fulfilled the inclusion criteria were assigned to one of two groups. Intervention group (G1) encompassed 60 parturients who were applied long elastic stocking (ordinary pressure 20–30 mmHg, 1 mmHg = 0.133 kPa) for both legs for the entire the duration of cesarean section. Control group (G2) comprised 60 parturients who were administered routine hospital care.

2.3. Study setting

This study was conducted in the operating room of Damanhour National Medical Institute, which is affiliated with the Ministry of Health in Elbehira governorate.

2.4. Instruments

Three instruments were developed by the researchers for data collection: Tool I: sociodemographic data and reproductive history interview schedule. It incorporates age, residence, education, occupation, weight, height, and BMI in addition to reproductive history as gravidity, parity, gestational age, previous cesarean section, and reason for current cesarean section. Tool II: Electronic monitoring of maternal hemodynamic parameters. It includes duration of cesarean section, maternal hemodynamic parameters, and follow-up assessment sheet. The sheet contains the assessment of maternal systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and HR at base line with repeated measures at 5 min intervals. Tool III: Neonatal hemodynamic assessment sheet. It contains neonatal Apgar scoring at 1 and 5 min, umbilical artery pH, base excess, bicarbonate, and PCO_2. The assessment of the same hematological parameters was done for the umbilical vein sample.

All tools were tested for content validity by a panel of five experts of obstetrics and gynecology nursing and one expert of statistics. The tool reliability was tested using Cranach alpha test. The reliability results were 0.807 and 0.730 for Tool II and III respectively. The pilot study was conducted on 10% of the study sample to ensure applicability of the tool.

2.5. Procedure of data collection

Data were collected over six months. Upon admission to the waiting room, oral consent was obtained from each parturient after explaining the study purpose. Rapid examination for the parturient file was done to ensure her eligibility for the study. Data of Tool I were collected from both groups through an interview schedule,

Table 1
Socio-demographic characteristics and reasons for cesarean section of parturients in two groups ($n = 120$).

Characteristics	Intervention group ($n = 60$)		Control group ($n = 60$)		Significant test	*P*
	n	%	*n*	%		
Age (year)						
≤20	8	13.3	10	16.7	2.041	0.416[a]
21–35	46	76.7	45	75.0		
≥36	6	10	5	8.3		
Working status						
Not working	57	95	50	83.3	–	0.602[b]
Working	3	5	10	16.7		
Education						
Illiterate	16	26.6	24	40.0	–	0.211[b]
Read and write	8	13.4	6	10.0		
Prim and prep	12	20	14	23.3		
Secondary/university	24	40	16	26.6		
Residence						
Rural	46	76.6	52	86.6	2.004	0.157[a]
Urban	14	23.4	8	13.4		
Reason for cesarean section						
Previous cesarean section	38	63.3	46	76.6	–	0.192[b]
Cephalo-pelvic disproportion	12	20	4	6.7		
Dystocia/failed induction	6	10	6	10.0		
Breach presentation	4	6.7	4	6.7		

Note: [a] Chi-square test;[b] Fisher Exact test.

which was conducted individually and in total privacy. Each study subject was interviewed for 10–15 min before cesarean section in the waiting area (half an hour before cesarean section). All parturients received ordinary pre-operative care which includes cannulates in the left antecubital vein with 16 G intravenous catheters (cannula) and 500 ml of lactated ringer solution as preloading fluid; indwelling catheters were inserted. All parturients received spinal anesthesia at levels between L3–L4 or L4–L5 interspaces while in the sitting position and given hyperbaric bupivacaine 0.5% 2.5 ml (12.5 mg) as routine. After receiving spinal anesthesia, the parturients were placed in supine position.

For intervention group, a long elastic stocking (ordinary pressure 20–30 mmHg) was applied on both legs for the entire duration of the cesarean section. Different elastic stocking sizes (L, XL, and XXL) were used in accordance with the suitable size of the parturient's leg. The control group received the same care without the application of the elastic stocking. For both groups, the parturient was attached with non-invasive electronic parturients received to track SBP, DBP, main arterial BP, and HR. The mother's base line hemodynamic parameters were registered immediately before skin incision and every 5 min until the end of the cesarean section. Other signs of hypotension such as nausea and vomiting were also registered. Hypotension was considered when the parturient's SBP, DBP, and MAP were reduced by 15%–20% from baseline. (Montoya BH, Ibrahim A Mohamed).

For the newborn: Immediately after delivery, the fetal Apgar score was registered at one and 5 min. Umbilical arterial and venous blood samples were drawn in heparinized tubes and taken immediately to the hospital laboratory.

Blinding: The pediatrician who completed the newborn care and the clinical staff of laboratory or who drown the blood sample were blind.

2.6. Statistical analysis

Data were fed to SPSS version 20 for investigation. Descriptive statistics was used to analyze data such as number, percentage, mean, and standard deviation. Chi-square, Fisher exact, Monte Carlo test, repeated ANOVA, and independent sample *t*-test were used to test differences between the two groups. Test results were considered significant at 0.05.

2.7. Ethical consideration

The researchers were committed to ethical guidelines in all stages of the study. First, the study was approved by Nursing College, Damanhour University. Second, an official letter was directed from Nursing College to Damanhour National Medical Institute to signify their agreement after the explanation of the study purpose and clarification of the needed procedures. Third, oral consent was taken from each woman in the operation room. Data of all women were managed confidentially and used only for research purpose.

3. Results

3.1. Description of study subjects

The general characteristics of all study subjects ($n = 120$) are elaborated in Table 1. No statistically significant difference is noted between the intervention group and the control group in relation to their sociodemographic characteristics. The largest proportion of intervention and control groups is aged 21–35 years, which is the safe reproduction period. The most common reason for performing the current cesarean section is having a history of previous one. Obstetric history elaborated in Table 2 confirms no statistically significant differences between the two groups in relation to their obstetric history ($P > 0.05$). Moreover, the mean of the intervention group BMI is 26.61 ± 2.59 compared with 27.37 ± 2.29 of the control group.

3.2. Maternal outcome

3.2.1. Maternal hemodynamic parameters

Maternal hemodynamic parameters in Table 3 show a statistically significant difference in the mean SBP between intervention and control group throughout the repeated measures except at 25,35 min and above, indicating higher SBP in intervention group. Moreover, a statistically significant difference is indicated through time group interaction ($P < 0.05$). A statistically significant difference is also observed in the mean DBP in the intervention group

Table 2
BMI and obstetric history of parturients in two groups (*Mean* ± *SD*).

Variables	Intervention group ($n = 60$)	Control group ($n = 60$)	t	P
BMI	26.61 ± 2.59	27.37 ± 2.29	1.696	0.230
Gravidity	2.47 ± 0.97	2.77 ± 1.13	1.568	0.120
Parity	1.47 ± 0.97	1.67 ± 1.15	1.035	0.303
Gestational age	39.07 ± 0.78	38.90 ± 0.88	1.035	0.273
Numbers of previous cesarean section	1.27 ± 0.97	1.33 ± 0.91	0.387	0.699
Total duration of cesarean section	47.17 ± 7.78	50.00 ± 8.03	1.964	0.098

and control group ($P < 0.05$) throughout the repeated measures except at 30, 40, 45 and 50 min. This indicates higher DBP in the intervention group. Likewise, a statistically significant difference within the intervention group itself is observed throughout the time measures ($P < 0.05$). A statistically significant difference in the mean MAP is observed between intervention group and control group ($P < 0.05$) throughout the repeated measures except at 40, 45, and 50 min, indicating higher MAP in intervention group. Furthermore, the table shows a statistically significant difference in the mean HR between intervention group and control group ($P < 0.05$) throughout the repeated measures except at 35, 45 and 50 min, indicating lower HR in intervention group.

3.2.2. *Signs of hypotension and ephedrine use*

Table 4 shows that nausea is more common in the control group, with statistically significant difference ($P < 0.05$). The occurrence of vomiting is generally low in the two groups, but it is higher in the control group, with statistically significant differences ($P < 0.05$). Only 13.3% of the intervention group took ephedrine compared with 45% of the control group. Consequently, the mean dose of ephedrine in the control group was twice that taken by the intervention group, with statistically significant differences.

3.3. *Neonatal outcome*

Table 5 shows that moderate asphyxia is more prevalent in the control group, with statistically significant difference ($P = 0.041$) at 1 min. At 5 min, Apgar score improved in the two groups, with no statistically significant difference ($P = 0.476$). Neonatal respiratory acidosis was present in the two groups but with higher incidence in the control group. The difference between the two groups in this respect is significant ($P < 0.05$). A very small proportion of the control group was admitted to the ICU compared with none of the intervention group. The differences between the two groups is not statistically significant ($P = 0.697$). Table 6 shows a statistically significant difference between the two groups regarding arterial pH, arterial PCO_2, arterial HCO_3, venous pH, venous PO_2, and venous HCO_3 ($P < 0.05$). By contrast, no statistically significant differences were found between the two groups in arterial PO_2 ($P = 0.226$) and venous PCO_2 ($P = 0.110$).

4. Discussion

Spinal anesthesia is the most common technique used for cesarean section. PSH combined with spinal anesthesia has serious side effect on the mother and fetus. Over the years, many interventions have been used to prevent hypotension, but no single technique was proven reliable and effective. This study was carried out to determine the effect of lower leg compression during cesarean section on PSH and neonatal hemodynamic parameters [10].

In the present study, leg compression has a significant effect on reducing spinal-induced hypotension during cesarean delivery. The findings show a statistically significant difference between the intervention group and the control group regarding SAP, DAP, and MAP. All values of SBP, DBP, and MAP are significantly higher in the intervention group (5–35 min).

The current study findings agree with at least seven other studies. *First,* Abdelati et al. in Port-Said, Egypt studied "prophylactic leg compression for reducing hypotension and fetal acidosis as subsequent for spinal anesthesia in cesarean delivery." They found a lower incidence of PSH in the leg-wrapped group, with statistically significant differences [11]. *Second,* Bagle et al. in USA studied "evaluation of leg wrapping for the prevention of PSH in cesarean section under spinal anesthesia." They reported that hypotension attacks occurred in 60% of the control group compared with only 10% of the leg compression group with steady higher MAP in the intervention group during the operation [12]. *Third,* Mohamed et al. in Benha, Egypt studied "utilization of lower leg compression technique for reducing spinal-induced hypotension and related risks for mothers and neonates during cesarean delivery" among Egyptian women. They concluded a highly statistically significant difference between the leg compression and control groups regarding MAP, SBP, and DBP. They added that the greater effect of lower leg compression was observed on MAP [6]. *Fourth*, Das and Swain in Odisha, India studied "effect of leg wrapping on hemodynamic and associated complications in cesarean section" among Indian women. They found a statistically significant difference in the degree of hypotension found between the two groups. The incidence of hypotension in leg-wrapped group was 13.33% compared with 63.33% in the control group [13]. *Fifth,* Singh et al. in New Delhi, India studied "hemodynamic changes after leg wrapping in elective cesarean section under spinal anesthesia" among American women. They elaborated that the frequency of hypotension was significantly lower in leg-wrapped group compared with the control group. A significant difference in MAP was observed between the two groups at 4, 6, and 8 min after anesthesia [14]. *Sixth*, Khedr in Egypt studied "preventive measures to reduce PSH for elective cesarean section." They noted a statistically significant difference between the leg-wrapped group and the control group with regard to MAP. They added that leg wrapping and elevation directly after anesthesia group resulted in higher MAP, lower percentage of hypotension, and lower percent of late hypotension compared with the control group [15].

Williamson et al. elaborated the positive correlation between the amount of pressure applied on the lower extremities and SBP, DBP, and MAP. They added that if the compression is applied on one leg, the elevation in blood pressure will be lower than that when compression is applied on two legs. A positive correlation is identified between the muscle mass volume compressed and the elevation in blood pressure. In-depth analysis of this result predicts that lower leg compression decreases blood pool to the lower extremities and compresses the dilated blood vessels, which is known as pressor response. The pressor response is mediated by muscle afferent nerves without effect on HR [16].

By contrast, Kuhn et al. in USA studied "hemodynamic of phenylephrine infusion versus lower extremity compression during spinal anesthesia for cesarean delivery." They reported lower SBP, DBP, and MAP among lower compression group compared

Table 3
SBP, DBP, MAP, and HR of parturients in two groups (*Mean* ± *SD*).

Group	Before intervention	At 5 min	At 10 min	At 15 min	At 20 min	At 25 min	At 30 min	At 35 min	At 40 min	At 45 min	At 50 min	*F* for time	*F* for group	*F for* time x group interaction
SBP(mmHg)														
Intervention ($n=60$)	131.10 ± 9.93	126.30 ± 13.13	115.57 ± 13.54	114.23 ± 12.98	116.63 ± 12.95	117.37 ± 11.19	115.03 ± 11.09	116.00 ± 11.32	112.17 ± 11.28	113.63 ± 7.42	115.88 ± 6.67	9.601	69.611	53.829
Control ($n=60$)	128.80 ± 9.72	102.23 ± 20.97	92.53 ± 18.72	97.77 ± 12.62	102.03 ± 12.53	101.20 ± 14.04	100.60 ± 10.04	100.70 ± 11.48	98.43 ± 16.01	105.27 ± 13.09	100.03 ± 13.49			
P	0.387	0.002	<0.001	<0.001	<0.001	0.052	0.042	0.314	0.250	0.625	0.424	<0.001	<0.001	<0.001
DBP(mmHg)														
Intervention ($n=60$)	81.60 ± 6.58	77.10 ± 8.06	69.23 ± 11.09	69.50 ± 12.36	71.13 ± 8.40	69.87 ± 7.12	68.70 ± 9.37	69.27 ± 9.70	69.87 ± 9.62	71.23 ± 8.16	70.60 ± 7.65	17.582	170.268	76.104
Control ($n=60$)	85.23 ± 8.31	58.90 ± 14.74	51.73 ± 12.37	53.10 ± 11.04	56.70 ± 10.80	55.23 ± 8.57	53.77 ± 7.22	51.60 ± 9.03	53.00 ± 9.23	60.72 ± 9.74	62.13 ± 10.04			
P	0.123	<0.001	<0.001	<0.001	<0.001	<0.001	0.097	0.034	0.751	0.884	0.425	0.001	<0.001	<0.001
MAP (mmHg)														
Intervention ($n=60$)	97.57 ± 7.95	92.50 ± 10.94	83.53 ± 10.17	83.07 ± 11.62	85.60 ± 10.37	84.77 ± 6.25	81.83 ± 8.74	83.87 ± 7.50	82.77 ± 9.11	83.25 ± 8.89	83.93 ± 8.08	14.77	116.4	76.360
Control ($n=60$)	99.53 ± 8.30	73.33 ± 18.24	64.67 ± 13.15	68.87 ± 12.30	71.20 ± 10.59	69.73 ± 9.79	69.50 ± 9.02	66.92 ± 9.36	68.87 ± 11.17	74.40 ± 10.82	75.95 ± 10.63			
P	0.886	<0.001	<0.001	<0.001	<0.001	0.017	0.015	0.030	0.638	0.897	0.570	<0.001	<0.001	0.030
HR														
Intervention ($n=60$)	102.63 ± 15.35	93.50 ± 18.70	88.10 ± 16.83	85.33 ± 16.02	85.53 ± 15.78	88.67 ± 13.21	88.33 ± 17.59	88.13 ± 11.92	84.12 ± 9.92	82.22 ± 9.24	79.20 ± 10.37	23.89	59.94	20.65
Control ($n=60$)	104.70 ± 13.60	108.30 ± 28.07	104.13 ± 28.29	101.10 ± 23.60	98.07 ± 21.34	99.27 ± 21.61	102.37 ± 18.78	95.95 ± 19.37	99.17 ± 20.23	94.07 ± 17.70	98.07 ± 13.52			
P	0.969	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.970	0.044	0.150	0.816	<0.001	<0.001	0.001

Note: SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; HR: heart rate.

with phenyelephrine group with statistically significant difference. The difference between the current study result and the later one may be attributed to the fact that lower leg compression is complementary simple nursing intervention and is difficult to be compared with medications, which have systemic rapid effect in elevating blood pressure [17].

Based on HR, the results of the current study showed a statistically significant difference between study group and control group. HR is higher in the control group compared with the lower leg compression group from 10 min to 45 min post-anesthesia. Heat rate increases in response to hypotension.

The results of the current study are consistent with at least two studies. Singh et al. reported a significant difference between the study group and control group in relation to HR at 6 and 8 min before fetus delivery, whereas no significant difference was observed after delivery [14]. Das and Swain indicated a significant HR change from 4 to 15 min with highly significant difference from 6 min to 10 min after spinal anesthesia in control group [13].

However, the current findings contradict two previously discussed studies. Bagle A et al. reported no significant changes between study and control groups in relation to HR. They elaborated some HR variation observed after taking vasopressors drugs [12]. Kuhn et al. reported that cardiac output and HR were significantly lower among phenylephrine group compared with leg wrapped group. The difference between the current study result and the latter one may be due to the pharmacologic effect of phenylephrine which creates systemic vasopressor effect and consequently decreases HR. Again, lower leg compression is complementary nursing intervention and is difficult to compared with medications, which have systemic effect [17].

An earlier study conducted by Adsumelli et al. in New York, USA to investigate the effect of “sequential compression device with thigh sleeves support mean arterial pressure during cesarean section under spinal anesthesia” concluded no significant difference in heart rate between the intervention group and the control group. The difference between the current study and this old one may be due to the difference in lower leg compression technique. The current study used different sizes of elastic stocking to generate lower leg compression, whereas Adsumelli et al. used a sequential compression device with thigh sleeves [18].

The present study revealed that incidence rate of nausea and vomiting was lower in the intervention than that in the control group.(Table 3). This finding may be due to the low incidence of hypotension in the intervention group. This finding agrees with two studies in 2016. Das and Swain revealed a significant difference in the incidence of nausea and vomiting in both groups. Incidence of nausea and vomiting among participants was 13.33% in leg compression group compared with 46.66% in the control group, with statistically significant difference[13]. Furtheremore, Mohamed et al. noted that leg compression group had less incidence of nausea and vomiting [6].

In the present study, women in the control group required ephedrine more than those in the intervention group, which is statistically significant. This finding is consistent with Bagle et al., Das and Swain, and Singh et al. The *first* indicated that vasopressor requirement was significantly lower in leg-wrapped group, which was highly significant [12]. The *second* found that 10% among his participants required rescue phenylephrine compared with 50% the control group, which is statistically significant [13]. The *third* reported that the control group required rescue dose with phenylephrine more than those in intervention group, which is statistically significant. This result seems to be logical because if lower leg compression increased SBP, DBP, and MAP, then less use of ephedrine will be required [14].

The results of the current study indicate that the neonates of the

Table 4
Occurrence of nausea, vomiting and use of ephedrine among parturients in two groups ($n = 120$).

Characteristic	Intervention group ($n = 60$)		Control group ($n = 60$)		Significant test	P
	n	%	n	%		
Nausea						
Yes	6	10.0	19	31.7	8.543	0.006[a]
No	54	90.0	41	68.3		
Vomiting						
Yes	5	8.3	14	23.3	5.065	0.043[a]
No	55	91.7	46	76.7		
Use of ephedrine						
Yes	8	13.3	27	45.0	23.155	<0.001[a]
No	52	86.7	33	55.0		
Dose of ephedrine, *Mean* ± *SD*	10.90 ± 8.32		25.35 ± 15.65		2.850	<0.001[b]

Note: [a]chi-square test;[b] independent sample *t*-test.

Table 5
Neonates' outcome in two groups.

Characteristic	Intervention group ($n = 60$)		Control group ($n = 60$)		Significant test	P
	n	%	n	%		
APGAR score at 1min						
Good (8–10)	55	91.7	47	78.3	4.183	0.041[a]
Moderate asphyxia (5–7)	5	8.3	13	21.7		
APGAR score at 5 min						
Good (8–10)	60	100	58	96.7	–	0.476[b]
Moderate asphyxia (5–7)	0	0	2	3.3		
Respiratory acidosis						
Yes	3	5.0	9	15.0	13.330	0.001[c]
No	57	95.0	51	85.0		
Admission to ICU						
Yes	0	0	3	5.0	5.350	0.697[c]
No	60	100	57	95.0		

Note: [a]chi-square test; [b]Fisher exact test; [c]Monte Carlo test.

Table 6
Blood gas parameters of parturients in two groups (*Mean* ± *SD*).

Characteristic	Intervention group ($n = 60$)	Control group ($n = 60$)	t	P
Arterial pH	7.39 ± 0.06	7.36 ± 0.06	2.808	0.006
Arterial PCO_2	43.04 ± 9.96	51.23 ± 12.35	−3.999	<0.001
Arterial PO_2	25.28 ± 4.66	24.27 ± 4.43	1.217	0.226
Arterial HCO_3	19.45 ± 2.60	21.64 ± 1.75	−5.419	<0.001
Venous pH	7.34 ± 0.07	7.31 ± 0.09	2.103	0.038
Venous PCO_2	47.40 ± 7.36	49.97 ± 9.93	−1.608	0.110
Venous PO_2	22.64 ± 8.33	16.93 ± 2.81	5.026	<0.001
Venous HCO_3	25.35 ± 2.39	23.51 ± 2.75	3.908	<0.001

intervention group had better outcome. The neonates of the intervention group had significantly better Apgar scores at 1 min only, and this difference disappeared at 5 min. Only 5% of the intervention group neonates had respiratory acidosis compared with 15% of the control group neonates, with statistically significant differences. Moreover, no significant difference was reported between the two groups in relation to neonatal ICU admission. The neonatal blood gases were significantly better in the intervention group.

The present finding is consistent with the studies of Abdelati et al. and Mohamed et al., who found a significant difference between intervention and control group neonates in relation to their Apgar score at 1 min and neonatal acidosis. They reported that the neonate of the intervention group had better Apgar score at 1 min and lower incidence of neonatal acidosis. These two studies have contradicting results with the current study in relation to Apgar score at 5 min and ICU admission. They found lower Apgar score at 5 min and higher ICU admission among control group neonates, with significant differences [6,11].

The results of the current study may be explained by the work of Ueyama et al. They studied "the effects of crystalloid and colloid preload on blood volume on the parturient undergoing spinal anesthesia for cesarean section." They observed that maternal hypotension has a strong correlation with neonatal academia [19]. Consequently, if SBP, DBP, and MAP are normal in the lower leg compression group in the current study, then the incidence of neonatal acidosis is expected to be less in the intervention group. Furthermore, the control group consumed more ephedrine than the intervention group. American guidelines from 2016 reported that ephedrine might lead to more fetal acidosis during cesarean section with spinal anesthesia [20]. Moreover, Reynolds and Seed in USA studied "anesthesia for cesarean section and neonatal acid-base status;" they reported a positive correlation between the use of ephedrine during spinal anesthesia for cesarean section and neonatal acid-base status [21].

5. Conclusion

The current study shows that Hypothesis 1 is accepted because SBP, DBP, and MAP are higher in the intervention group compared with the control group. Hypothesis 2 is also accepted because Apgar score at 1 min is higher among the neonates of lower leg compression group. A statistically significant difference is also observed between the two groups' neonates with regard to arterial pH, arterial PCO_2, arterial HCO_3, venous pH, venous PO_2, and venous HCO_3.

Recommendation: Lower leg compression should be included in spinal anesthesia care protocols during elective cesarean section. Further research includes replicating the current study on a larger population and different setting and evaluating the effect of other techniques of lower leg compression during cesarean section on maternal hemodynamic parameters and neonatal outcome should be conducted. Other neonatal hemodynamic parameters should be measured.

Conflicts of interest

The authors hereby declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2019.06.003.

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