

Original Article

Clinical study of air pressure uterus bracket in preventing supine hypotensive syndrome during C-section under combined spinal-epidural anesthesia

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Abstract: This study aimed to investigate the effects of air pressure uterus bracket (APUB) in preventing supine hypotensive syndrome (SHS) during C-section under combined spinal-epidural anesthesia (CSEA). A total of 90 pregnant women who underwent CSEA C-section were selected and randomly divided into the control group (group A) and the experiment group (group B), with 45 patients in each group. The patients in group A were quickly placed in the supine position after fixing the epidural catheter; the patients in group B were attached with APUB after fixing the epidural catheter, and the bracket airbag was pressurized. The incidences of SHS and intraoperative maternal comfort (IMC) between the two groups were then compared. The incidence of SHS between the two groups was significantly different (blood pressure decreased by 30 mmHg: 57.78% in group A and 24.44% in group B, $P < 0.05$); the IMC conditions between the two groups were also significantly different (comfort rate: 60.00% in group A and 91.11% in group B, $P < 0.05$). APUB can effectively prevent SHS during CSEA C-section.

Keywords: Air-pressure uterus bracket, combined spinal-epidural anesthesia, C-section, supine hypotensive syndrome

Introduction

Combined spinal-epidural anesthesia (CSEA) was first used in C-section [1], which has the advantages of both subarachnoid anesthesia (SA) and epidural anesthesia (EA); meanwhile, the surgical method is simple and smooth, and the effect is as efficient as those of SA and EA, with the muscles totally relaxed [2]. Mothers are sober during the parturition but with mild postoperative pain; since the pH value of the umbilical artery was normal, the infants were always born with normal neonatal Apgar scores [3]. With all these advantages, CSEA has been extensively applied in C-section [4]. However, hemodynamic disorders are common in CSEA with hypervagotonia caused by sympathetic block and supine hypotensive syndrome (SHS) [5]; its incidence was 80% in puerperae after CSEA, which was significantly higher than 45% after epidural anesthesia [6].

To reduce the occurrence of SHS, vasopressors [7-8] and fluid infusion [9-10] were always used; meanwhile, isobaric local anesthetics and dosage reduction [11-12] or postural intervention [13-14] were also used to maintain blood pressure (BP). However, all these methods have its own disadvantages, such as the side effects of drugs and excessive fluid infusion, inadequate anesthesia, or prolonged operation time.

To reduce the incidence of SHS during C-section without any of the abovementioned disadvantages, a homemade air pressure uterus bracket (APUB) (National Utility Model Patent of China; No: ZL 201320122209.6) in CSEA was used from July 2014 to December 2015 in our hospital. The tested APUB consisted of a metal skeleton and two pedia hemomanometer balloons stitched in cloth bags, which were connected with a handheld pressurized balloon and pressure gauge via hollow rubber tubes. We com-

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Table 1. General information

Groups	Age (year)	Height (cm)	Weight (kg)	Pregnancy (d)	Fundal Height (cm)	Abdominal Girth (cm)	Neonatal Weight (g)	Pre-anesthesia SHS	
								Yes	No
Group A (n=45)	32.71±3.60	159.31±6.31	76.00±7.44	267.69±9.53	34.36±3.66	95.13±12.89	3233.33±317.66	17 (37.78%)	28 (62.22%)
Group B (n=45)	31.73±3.40	159.89±4.84	78.58±8.91	265.26±8.19	35.20±3.64	97.53±5.97	3257.78±381.23	21 (46.67%)	24 (53.33%)
<i>t</i>	1.3239	0.4873	1.4892	1.2934	1.0978	1.1333	0.3305		
χ^2									0.7287
<i>P</i>	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05		0.393>0.05

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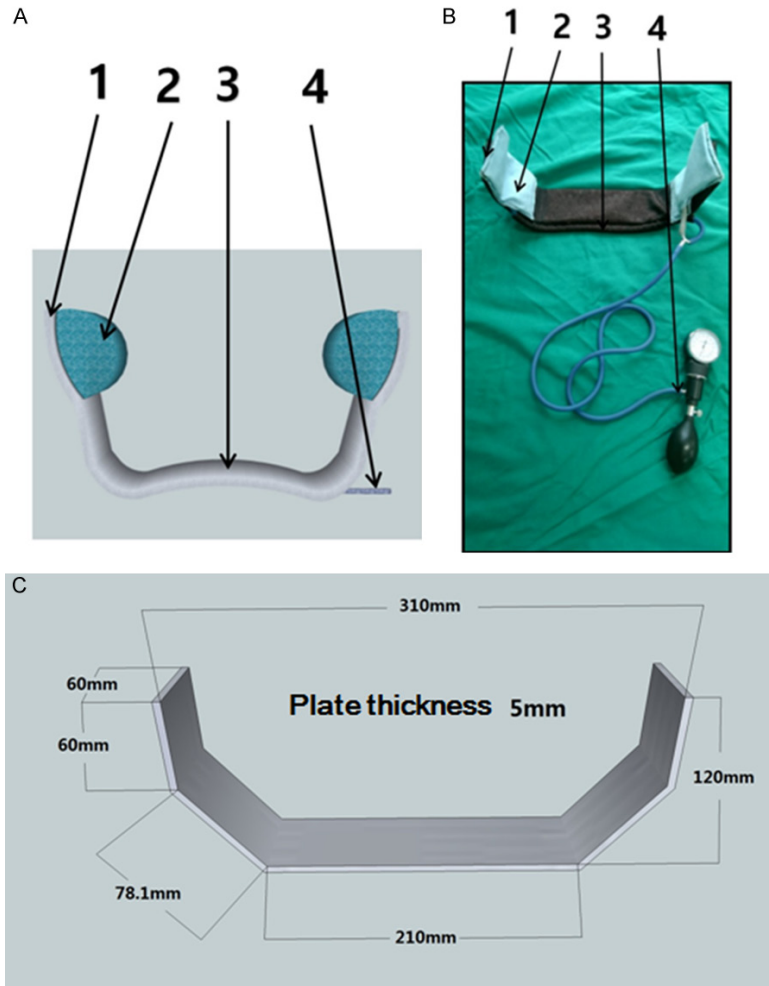


Figure 1. Instructure of APUB (A and B) and the detailed parameters of main steel plate (C). 1. Integrated medical-grade or Integrated metal curved plate; 2. Gasbag; 3. Hidden vent line; 4. Connect pressurized equipment. Note: The dimension data were designed based on patients in Chengdu, Sichuan, China, and the data might not be appropriate for Europe and America. Size of balloon on two sides was 60 mm × 110 mm. The working principle of air-pressure uterus bracket: pregnant woman was recumbent after installing APUB, inflated pneumatic balloon could lead to effect of uplift uterus through generating pressure after generated airflow by pressurized equipment entered into pneumatic balloon via weasand access.

pared the SHS incidence between the puerperae with and without APUB.

Materials and methods

Subjects

Ninety pregnant women who underwent CSEA C-section, aged 28 to 42 years, without gestational hypertension, and in grades 1-2 of the American Society of Anesthesiologists (ASA) were selected (July 2014-December 2015). This study was conducted in accordance with the declaration of Helsinki. This study was con-

ducted with approval from the Ethics Committee of Chengdu Medical College. Written informed consent was obtained from all participants.

Grouping

The patients were randomly divided into the control group (group A) and the experiment group (group B) using the random number table method, with 45 patients in each group. Basic information, including age, height, weight, pregnancy duration, uterine height, abdominal circumference, neonatal birth weight, and pre-anesthetic maternal SHS (pre-SHS) in the two groups is shown in **Table 1**. The APUB is shown in **Figure 1**.

Anesthetic methods

In the operating room, the BP (once every 3 min), heart rate (HR), oxygen saturation (SpO₂), electrocardiogram (ECG), and respiratory rate (RR) of each patient were routinely monitored; after establishing the intravenous access, 500-1000 mL of polygeline injection was rapidly infused within 15 min. Each patient was provided with an oxygen mask for 3 to 5 min before anesthesia induction and puncturing. All

the patients in the two groups were placed in the left lateral position; L2-3 epidural puncture using one 25 G lumbar puncture needle entering the subarachnoid space was then performed; 15 mg of ropivacaine hydrochloride (1.5 mL of 1% ropivacaine hydrochloride) in 3 mL of withdrawn cerebrospinal fluid was rapidly injected into the subarachnoid space (injection speed, 5 to 10 s); the epidural space was also catheterized for additional intraoperative local anesthesia and postoperative analgesia. The patients in group A were quickly placed in the supine position after fixing the epidural catheter.

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Figure 2. The installation position was at the rear waist (A) so that the bilateral air bags could be located at the soft spots between the left and right rib edges and the ilium (B) Each patient was then quickly placed in the supine position (C), and then the airbags were pressurized so as to raise the uterus for 3 to 5 cm (balloon pressure 280~300 mmHg).

Table 2. Anesthesia and operation time

Groups	Time from Subarachnoid Injection to Supine Position (T1, s)	Time from Supine Position to the End of the Operation (T2, m)
Group A	72.11±21.83	49.78±10.39
Group B	66.44±16.71	47.22±10.09
t	1.3827	1.1839
P	>0.05	>0.05

ter, while the patients in group B were attached with the APUB immediately after fixing the epidural catheter (the installation position was at the rear waist so that the bilateral air bags could be located at the soft spots between the left and right rib edges and the ilium; the installation method is shown in **Figure 2A**). The patients were then quickly placed in the supine position, and the airbags were pressurized to raise the uterus for 3 to 5 cm (balloon pressure, 280-300 mmHg) (**Figures 2B** and **2C**); when the lower uterine segment was incised, the airbags were quickly depressurized (pressurizing time, 3 to 7 min). Six milliliters of 0.75% ropivacaine hydrochloride were administered into the epidural space when the patients in the two groups were in the supine position, and the lateral lying time was controlled within 2 min. The data were then recorded.

Evaluation of anesthesia and surgical operations

The time interval from subarachnoid medical injection to the patient's lying in the supine position (T1) and that from lying in the supine position to the end of surgery (T2) were recorded.

Evaluation of anesthetic effects

Pain rating: the visual analog scale (VAS) was used to rate the pain with the following scores:

0 points: painless; 10 points: intense pain; 1-3 points: mild pain; 4-6 points: moderate pain; and 7-10 points: severe pain [15]. The rating was performed during the incision of the skin (M1), removal of the fetus (M2), and sewing of the skin (M3).

Muscle relaxation rating: the degree of abdominal muscle relaxation was evaluated by the surgeons after surgery with the following categories: very satisfied (without muscle tone which interfered with the surgery); satisfied (with muscle tone which interfered with the surgery; however, the degree was acceptable); and unsatisfied (with muscle tone which seriously affected the surgery) [16].

Main indices of SHS

Because SHS mainly occurs within 3-7 min [17] after anesthesia induction, namely the time interval between the anesthesia induction and lower uterine segment incision (A-I), we mainly observed the maternal condition during this period. During A-I, cases with an HR increased by >20 beats/min, systolic BP (SBP) decreased by 4 kPa (30 mmHg), SBP decreased to 10.6 kPa (80 mmHg), and severe SHS (HR >120 beats/min and SBP <70 mmHg), which must be promptly dealt with using rapid fluid infusion, 10 mg of ephedrine administration, etc. were recorded.

Evaluation of intraoperative maternal comfort (IMC)

IMC was evaluated by the mothers at the end of surgery with the following categories: very satisfied (no discomfort); satisfied (slight but tolerable discomfort); and unsatisfied (severe discomfort). The cases with dizziness, breathing difficulty, and nausea and vomiting were also recorded.

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Table 3. The effect of anesthesia

Groups	Pain score (VAS)			Evaluation of Abdominal Muscle Relaxation	
	Skin incision (M1)	Delivery of baby (M2)	Skin closure (M3)	Very Satisfied & Satisfied	Not Satisfied
Group A (n=45)	1.71±1.22	2.62±1.28	1.18±0.98	40 (88.89%)	5 (11.11%)
Group B (n=45)	1.58±1.14	2.80±1.31	1.16±1.02	37 (82.22%)	8 (17.78%)
t	0.5367	0.6507	0.1051		
X ²				0.8092	
P	>0.05	>0.05	>0.05	0.368	>0.05

Table 4. The situation of supine hypotensive syndrome

Groups	Time from anesthesia to uterus incision (m)	From anesthesia to uterus incision			
		Heart rate increased > 20 per minute	SBP declined 4 kPa (30 mmHg)	SBP declined to < 10.6 kPa (80 mmHg)	Rescue needed
Group A (n=45)	10.53±2.26	32 (71.11%)	26 (57.78%)	17 (37.78%)	14 (31.11%)
Group B (n=45)	10.27±2.14	18 (40.00%)	11 (24.44%)	6 (13.33%)	5 (11.11%)
t	0.5749				
X ²		8.82	10.3264	7.668	5.404
P	>0.05	0.003	0.001	0.008	0.020

Statistical analysis

Excel was used for the statistical analysis. The measurement data were expressed as means ± standard deviations ($\bar{x} \pm s$), and the t-test was performed; the count data were assessed using the chi-square test, with $P < 0.05$ considered as statistically significant.

Results

Comparison of basic information

Age, height, weight, pregnancy duration, uterine height, abdominal circumference, neonatal birth weight, and pre-SHS showed no significant difference ($P > 0.05$, **Table 1**).

APUB is a convenient device for anesthesia induction and surgery

The comparison of T1 and T2 between the two groups showed no significant difference ($P > 0.05$, **Table 2**). Therefore, APUB can be easily installed and will not adversely affect the decision of anesthesiologists and surgeons to use such.

APUB did not have an anesthetic effect

The comparison of the VAS scores at M1, M2, and M3 between the two groups showed no sig-

nificant difference ($P > 0.05$). Five (11.11%; 5/45) and eight cases (17.78%; 8/45) had poor outcomes of abdominal muscle relaxation evaluated by the surgeons in groups A and B respectively. The anesthetic effects between the two groups showed no significant difference ($P > 0.05$, **Table 3**).

APUB improved SHS

The incidence of SHS at M1 in the two groups is shown in **Table 4**, and the intergroup comparison showed no significant difference ($P > 0.05$). However, during A-I, 32 patients in group A had an HR increased by >20 beats/min, accounting for 71.11% (32/45); 26 patients had an SBP decreased by 4 kPa (30 mmHg), accounting for 57.78% (26/45); 17 patients had an SBP decreased to 10.6 kPa (80 mmHg), accounting for 37.78% (17/45); and 14 patients had severe SHS, which must be dealt with immediately, accounting for 31.11% (31.11/45) of the cases. The conditions in group B were significantly better than those in group A. In group B, 18 patients had an HR increased by >20 beats/min at M1, accounting for 40.00% (18/45); 11 patients had an SBP decreased by 4 kPa (30 mmHg), accounting for 24.44% (11/45); six patients had an SBP decreased to 10.6 kPa (80 mmHg), accounting for 13.33% (6/45); and 5 patients had severe SHS, which must be dealt

Table 5. The degree of satisfaction

Groups	Maternal evaluation			
	Dizziness	Nausea & Vomiting	Dyspnea	Very satisfied & satisfied
Group A (n=45)	17 (37.38%)	18 (40.00%)	19 (42.22%)	27 (60.00%)
Group B (n=45)	4 (8.89%)	5 (11.11%)	6 (13.33%)	41 (91.11%)
χ^2	10.4969	9.8702	9.36	11.7914
P	0.001	0.002	0.002	0.001

with immediately, accounting for 11.11% (5/45) of the cases. The chi-square test results on the incidence of SHS between groups A and B are shown in **Table 4**, indicating that the SHS conditions were significantly different ($P < 0.05$), and the incidence of SHS in group B was significantly lower than that in group A.

IMC was different between the groups

The number of cases with dizziness during the surgery in group A was 17, accounting for 37.38% (17/45), and that in group B was four, accounting for 8.89% (4/45) of the cases. The number of cases with nausea and vomiting during the surgery in group A was 18, accounting for 40.00% (18/45), and that in group B was five, accounting for 11.11% (5/45) of the cases. The number of cases with dyspnea during the surgery in group A was 19, accounting for 42.22 (19/45), and that in group B was six, accounting for 13.33% (6/45) of the cases. At the end of the surgery, 27 patients (60.00%; 27/45) in group A and 41 patients (91.11%; 41/45) in group B had “very satisfied” and “satisfied” comments. The differences in the BP reduction between the two groups were statistically significant ($P < 0.05$); that in the IMC between the two groups was also significant ($P < 0.05$, **Table 5**).

Discussion

SHS refers to a series of symptoms, such as dyspnea, reduced BP, tenuous pulse, dizziness, nausea, vomiting, or sweating occurring when pregnant women in late pregnancy are placed in the supine position but are alleviated when the lateral position is assumed [18]. More importantly, the placental circulation is a unique, capillary microcirculation-free, high-flow, and low-spiral arterial resistance system. Maternal hypotension can cause maternal fear and anxiety [19], thus leading to placental per-

fusion reduction, hazards to fetuses, fetal oxygenation reduction, acidosis, and even damages to the central nervous system. As a common obstetric syndrome, SHS is caused by a reduced returned blood volume, which is the result of the compression of the inferior vena cava owing to

the increased uterine cavity or insufficient pelvic collateral circulation [20]. Under CSEA conditions, the occurrence of hypotension in the puerperae with C-section is related to maternal age, fetal weight, SHS, or SBP; hypotension easily occurs during spinal anesthesia induction usually with an incidence of 30% to 40% [21] and even as high as 55% to 90% [22]. In this study, the incidence of severe SHS, which must be dealt with immediately, was 31.11% in group A; this finding is inconsistent with the incidence of hypotension described above and is mainly because the selected puerperae were between 28 and 42 years old, in which SHS has a high incidence, and because the measures, such as isobaric ropivacaine injection into the subarachnoid space [11] or rapid colloidal fluid infusion, can effectively prevent SHS. How to effectively prevent SHS under the premise of ensuring anesthetic effects remains to be a research topic frequently discussed in the field of obstetric anesthesia. The commonly used methods more or less have their limitations [23].

Position intervention

Clinically, the most common intervention is as follows: 1) tilting the operating table to the left side after spinal anesthesia induction to push the uterus to the left or 2) placing the wedge under the maternal lumbar vertebrae [13] to incline the uterus to the left, thereby avoiding uterine compressions by the inferior vena cava and abdominal aorta, increasing the venous return, and reducing the hypotension degree. However, these interventions impact the diffusion of the anesthetic plane and surgical procedures and increase maternal psychological fear. A previous study [14] pointed out that the complete left lateral position from the spinal anesthesia induction until the start of the surgery can not only provide anesthetic effects but also maintain a good maternal hemodynamic

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stability. However, there have been variety hospital-built uterus bracket but with practical difficulties, which seriously affect the sterilization and surgical procedures.

APUB is actually a special tool of position intervention, since it has the advantages of and can overcome the shortcomings of position intervention. The APUB used in this study can be proven to be a better tool than traditional methods in five aspects:

1. It has no impacts on anesthesia and surgical procedures; the comparison revealed that there was no significant difference in the anesthesia and operation time between the two groups; thus, this method can be accepted by most anesthesiologists and surgeons, and its installation is also easy. Some Chinese hospitals use self-made uterus-supporting brackets in their C-section surgeries; however, the installation is inconvenient, and it is difficult to be spread owing to the impacts on anesthesia and surgical procedures.

2. It has no impacts on anesthetic effects; Some research found that reducing the dose of fentanyl in subarachnoid anesthetics can effectively reduce the incidence of SHS [12], while which would also reduce the anesthesia time and effect. The use of opioids may have adverse effects on the neonatal Apgar score and umbilical arterial blood pH values [24-25]. The most important feature of APUB is that it will not sacrifice the anesthetic effects to prevent SHS and opioids was not needed.

3. Reduce the incidence of SHS effectively. It has been found that only prevention would not reduce SHS [11]. In this study, all patients in the 2 groups were taken medium density ropivacaine subarachnoid administration [11] and colloidal fluid rapid perfusion to prevent SHS, and the incidence in the patients who have used APUB decreased to 11.11%, even in high risk age (28~42), the incidence of SHS was much lower than 30%~40% [21] or 55%~90% [22] that has been reported.

4. APUB brought more comfort. Comfort during the cesarean is of most importance during the study, which decides not only the satisfaction but also the safety. There were 2 reasons for comfort improvement, first one was related with less SHS and less SHS symptoms includ-

ing dizziness, dyspnea, nausea and vomiting; second one was related with the airbag soft structure, which was comfortable.

5. Much more safe; recent studies suggest that intravenous vasopressor drugs pre anesthesia can reduce the incidence of SHS, such as ephedrine [7], norepinephrine [8]. However, in recent years many studies have confirmed that the application of ephedrine can reduce fetal umbilical artery blood pH and residual base [26], and with long acting time and rapid tolerance, tachycardia became common in maternal [27], which may related with direct excitatory effect of ephedrine on adrenergic receptors of the fetus. Riley et al. [28] has confirmed that ephedrine could enter the fetus through the placental barrier and increase the metabolic activity of the fetus, resulting in a decrease in the pH value of the umbilical arterial blood and a decrease in the residual base. In addition, high doses of ephedrine would cause hypertension, and should be used cautious for those with pregnancy-induced hypertension syndrome, hyperthyroidism, tachycardia or heart disease. Nowadays, ephedrine has been doubted for preventing and treating spinal hypotension in cesarean section, while phenylephrine is safer than ephedrine based on the neonatal safety, but it still would cause reflex bradycardia, accompanied by low cardiac output [29].

The change of position without medicine was the safest, APUB could be used in all puerpera which simulated the hands to rise the uterus, which can reduce the oppression of uterus to abdominal aorta and inferior vena cava effectively. It can prevent SHS caused by spinal anesthesia, avoid reducing the dosage of anesthetic and protect the mom and fetal. Further more, we'll find the change of umbilical vein arterial blood gas, APUB air bag pressure and the pressure time to find more comfortable APUB.

Conclusion

APUB can effectively prevent SHS during CSEA C-section, be conveniently installed without affecting the procedures of sterilization and decisions of anesthesiologists and surgeons, and improve IMC.

Disclosure of conflict of interest

None.

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