Effect of phenylephrine infusion on hypotension induced by the beach chair position
A prospective randomized trial

Myoung Jin Ko, MD[a], Hyojoong Kim, MD[a], Hyun-seong Lee, MD[a], Soo Jee Lee, MD[a], Yei Heum Park, MD[a], Jin-Young Bang, MD, PhD[b], Ki Hwa Lee, MD, PhD[a,*] iD

Abstract

Background: The beach chair position (BCP), used during shoulder surgery, is associated with hypotension, bradycardia, and risk of cerebral hypoperfusion. Phenylephrine is commonly used as a first treatment of choice of intraoperative hypotension during surgery. We evaluated the hemodynamic effects of 2 doses of intravenous phenylephrine infusion administered before being placed in BCP for arthroscopic shoulder surgery. The primary endpoint was the incidence of hypotension after positional change.

Methods: Sixty-six patients were randomized to receive either intravenous normal saline (group NS) or intravenous phenylephrine infusion (0.5 μg/kg/min, group LP or 1.0 μg/kg/min, group HP) for 5 minutes before being placed in the BCP. Mean arterial pressure (MAP), heart rate, stroke volume variation, and cardiac index were measured before and after positional change.

Results: The total incidence of hypotension after the BCP was 93.65%, but was not significantly different among the 3 groups. However, there was a significant difference in trends between the groups for MAP for 5 minutes after BCP ($P = .028$). Comparison of changes in MAP at 1 minute compared to post-induction MAP was significantly different between group HP and group NS ($P = .014$).

Conclusion: Infusion of 0.5 and 1.0 μg/kg/min of phenylephrine for 5 minutes before the BCP has no preventive effect for incidence of hypotension. However, this study showed that 1.0 μg/kg/min of phenylephrine infusion for 5 minutes can attenuate the severity of hypotension.

Abbreviations: ANOVA = analysis of variance, BCP = beach chair position, BIS = bispectral index, CI = cardiac index, HR = heart rate, IV = intravenous, MAP = mean arterial pressure, PIB = post-induction baseline, SVV = stroke volume variation, TSVRi = total systemic vascular resistance index.

Keywords: hypotension, phenylephrine, sitting position

1. Introduction

The beach chair position (BCP) is commonly used for arthroscopic shoulder surgery. It has several advantages compared with a lateral decubitus position, such as good visualization of the surgical field,

reduced traction neuropathy, and ease of conversion to an open surgery.[1] However, the BCP is frequently associated with increased hemodynamic instability, such as hypotension, bradycardia,[1] and cerebral hypoperfusion.[2]

There are many challenges in preventing intraoperative hypotension during the BCP. Application of compression stocking[3] and vasopressor infusion[4,5] can be helpful to prevent hypotension during the BCP. Arginine vasopressin, a strong vasoconstrictor, is effective in preventing hypotension during the BCP, but it causes a significant decrease of brain oxygenation.[4]

Phenylephrine, an α-adrenergic agonist, is widely used for treatment of hypotension during perioperative periods.[6] It is more commonly used as a first treatment of choice of intraoperative hypotension than vasopressin in our institution. Intravenous infusion of phenylephrine (1.5 μg/kg/min) before being placed in the BCP was effective in reducing the incidence of hypotension for shoulder surgery.[7] Cerebral oxygen saturation, however, decreased after phenylephrine infusion, possibly caused by cerebral vasoconstriction. To our knowledge, there is no previous research describing the hemodynamic effects of lower doses of intravenous phenylephrine infusion during the BCP.

In this study, we evaluated the hemodynamic effect of 2 doses of intravenous phenylephrine infusion (0.5 and 1.0 μg/kg/min) during the BCP for arthroscopic surgery. The primary outcome was incidence of hypotension after the BCP. The secondary outcome was the difference in hemodynamic effects among a control group and infusion groups.

2. Materials and methods

This study was approved by the Institutional Review Board of Inje University Haeundae Paik Hospital (IRB number: 129792-2015-096) and was registered as a clinical trial (clinical trial number: NCT02585570). Written informed consent was obtained from all patients. Sixty-six American Society of Anesthesiologists physical status 1 to 3 patients who were scheduled to undergo elective arthroscopic shoulder surgery in the BCP were enrolled. Patients were excluded if there was a history of significant cerebrovascular disease, cardiac disease (NYHA class ≥3), uncontrolled hypertension, and age <20 years.

Patients were premedicated with intravenous midazolam (1 mg) before being transported to the operating room. Patients underwent standard monitoring in the operating room in the supine position, including electrocardiogram, pulse oximetry, non-invasive blood pressure, capnography, and bispectral index (BIS). Hartmann's solution (6 mL/kg/h) was administered intravenously. The right or left radial artery was cannulated with a 20-guage angio-catheter to monitor invasive arterial blood pressure. The pressure transducer was placed at the level of external auditory meatus.[8] Mean arterial pressure (MAP), stroke volume variance (SVV), and cardiac index (CI) were measured using a Vigileo/Flotrac system (Edward Lifesciences, Irvine, CA). We calculated the total systemic vascular resistance index (TSVRi).[9,10]

Pre-induction hemodynamic parameters were measured, and then general anesthesia was induced with intravenous (IV) propofol 2 mg/kg, remifentanil 0.1 μg/kg/min, and sevoflurane 2 to 3 vol%. Rocuronium (0.6 mg/kg) was administered intravenously to facilitate endotracheal intubation. When vital signs were stabilized after endotracheal intubation, hemodynamic values were measured as a post-induction baseline (PIB). After endotracheal intubation, the patient's lungs were mechanically ventilated with an oxygen/air mixture (fraction of inspired oxygen of 50%) to maintain the end-tidal carbon dioxide between 35 and 40 mm Hg. Sevoflurane was adjusted to maintain a BIS between 40 and 60.

The patients were allocated into 3 groups (group NS, group LP, and group HP) using a single blinded randomization method. The blocked randomization was performed by using computer software generation. Group NS received normal saline IV infusion (0.3 ml/kg/hr), and Group LP and Group HP received phenylephrine IV infusion of 0.5 or 1.0 μg/kg/min, respectively, for 5 minutes before being placed in the BCP. Five minutes after the start of the IV phenylephrine infusion, patients were placed into the BCP. MAP, heart rate (HR), oxygen saturation, CI, SVV, and BIS were continuously monitored during intraoperative period, and all measurements were recorded every minute for first 15 minute after BCP under no surgical stimulation.

When hypotension (MAP <60 mm Hg) occurred, ephedrine (5 mg) was administered intravenously to the patients. When severe hypotension occurred with a decreased BIS value (<20) or increased SVV value (>30), the patient was removed from the study. When bradycardia (HR <50 bpm) occurred, atropine (0.5 mg) was administered intravenously.

2.1. Statistical analysis

The sample size was calculated using nQuery Advisor 7.0 program. When effect size was set at 0.3, and power was set at 0.95, the required number of patients for each group was 18. Assuming a drop-out rate of 20%, the final sample size was set at 22 patients per group.

Patients' baseline and clinical characteristics were summarized by subgroups using descriptive statistics. Chi-squared test or Fisher exact test was used to compare categorical variables between groups, while analysis of variance (ANOVA) or Kruskal–Wallis test was used to compare continuous variables between groups. Shapiro–Wilk test was employed for test of normality assumption. Repeated measurement analysis of variance was used to compare repeated measurements in groups and within each group, and the Bonferroni procedure was applied in post-hoc analyses. ANOVA with repeated measures with a Huynh-Feldt correction was used when sphericity was not

Table 1

Patient baseline demographic characteristics and hemodynamic parameters between groups.

Variable	Group HP (n = 22)	Group LP (n = 21)	Group NS (n = 20)	P value
ASA 1/2	6/16	5/16	4/16	.932[2]
Sex (M/F)	8/14	8/13	10/10	.627[1]
Age (yr)	59.27 ± 8.76	58.43 ± 8.91	56.75 ± 9.55	.661[3]
Height (cm)	163.00 ± 12.13	159.67 ± 9.43	165.45 ± 10.08	.225[3]
Weight (kg)	66.59 ± 12.45	67.33 ± 10.81	71.75 ± 13.58	.354[3]
DOS (min)	104.09 ± 26.44	110.24 ± 31.28	90.25 ± 25.47	.072[3]
DOA (min)	165.27 ± 27.29	170.48 ± 35.74	149.00 ± 25.27	.064[3]
DM (yes/no)	2/20	4/17	5/15	.382[2]
HTN (yes/no)	7/15	8/13	11/9	.293[1]
MAP (mm Hg)	94.86 ± 10.90	97.43 ± 10.79	94.5 ± 14.08	.691[3]
HR (bpm)	68.23 ± 12.14	71.24 ± 8.53	68.2 ± 8.19	.521[3]
CI (l/min/m^2)	2.914 ± 0.44	3.11 ± 0.811	3.310 ± 0.85	.212[3]
SVV (%)	10.18 ± 3.83	10.33 ± 5.00	11.10 ± 4.49	.779[3]
TSVRi	2664.08 ± 533.80	2694.28 ± 842.91	2470.16 ± 876.66	.597[3]
BIS	88.32 ± 10.04	88.95 ± 6.35	91.20 ± 4.99	.439[3]

[1] P values were derived using the Chi-squared test.
[2] P values were derived using the Fisher exact test.
[3] P values were derived by analysis of variance.
Shapiro–Wilk test was employed for test of normality assumption.
ASA = American Society of Anesthesiologists physical status, BIS = bispectral index, CI = cardiac index, DM = diabetes mellitus, DOA = duration of anesthesia, DOS = duration of surgery, HR = heart rate, HTN = hypertension, MAP = mean arterial pressure, SVV = stroke volume variation, TSVRi = total systemic vascular resistance index.

assumed. Mean ± the standard error of the mean plots were also graphically presented. All statistical analyses were carried out using SPSS version 25.0 statistical software (SPSS Inc, Chicago, IL) and Medcalc (Medcalc Software bvba, Ostend, Belgium). A P-value of <.05 was considered statistically significant.

3. Results

A total of 66 patients were enrolled in this study. A total of 3 patients, however, were excluded because of mechanical malfunction of the Vigileo/Flotrac system (n=1, group LP) and severe hypotension (n=2, group NS) after induction of general anesthesia (Fig. 1).

Patient baseline demographic characteristics and hemodynamic parameters before being placed into the BCP are described in Table 1. There were no significant differences in these parameters among the 3 groups.

The incidence of hypotension was not significantly different between groups (Table 2). The total incidence of hypotension after placement into the BCP was 93.65% in all patients. The incidence of bradycardia in group HP (66.7%) was relatively high compared with the other groups (10% in group NS and 4.8% in group LP) but was not statistically significant (P=.0869). The rescue dose of ephedrine (23.25±15.75, 27.5 ±13.25, and 23.33±13.90 mg) was not statistically different in group HP, group LP, and group NS, respectively (P=.541).
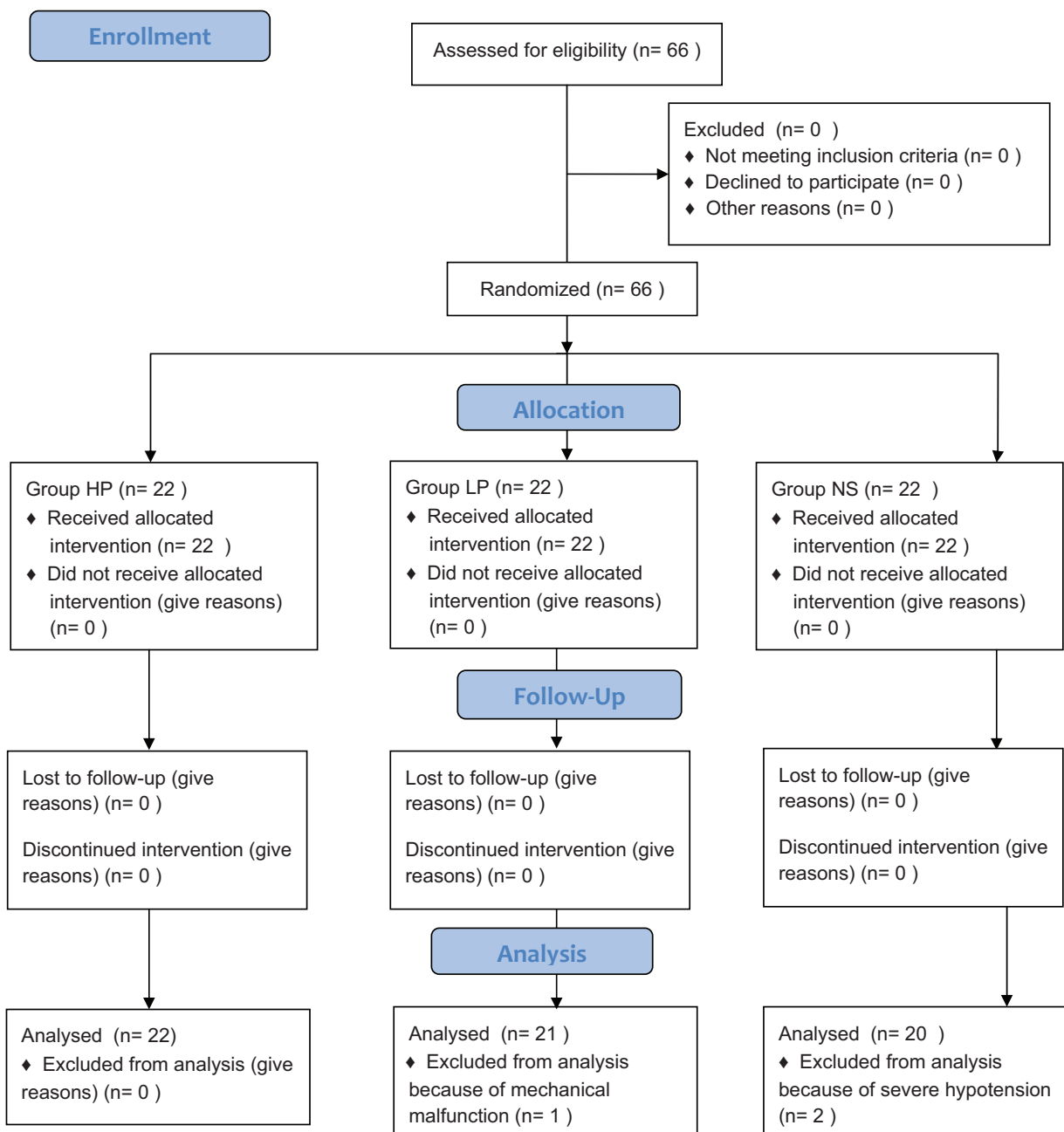

Figure 1. CONSORT flow chart.

Incidence of hypotension and bradycardia in patients after the beach chair position.

Variables	Group HP (n=22)	Group LP (n=21)	Group NS (n=20)	P value
Hypotension (yes/no)	22/0	20/1	17/3	.128[1]
Bradycardia (yes/no)	6/16	1/20	2/18	.086[1]

[1]P values were derived using the Fisher exact test.

Hypotension occurred in the majority of patients within 5 minutes after being placed in the BCP (84.7%, 50/59). The MAP of each group at 1-minute intervals within the first 5 minutes after being positioned in the BCP is described in Table 3. There was a significant difference in the trends between groups (P=.028). The changes between the MAP at 1 minute compared to at the PIB between groups was statistically different (P=.014), especially in Group HP (−20.09±21.79 mm Hg) and Group NS (−41.75± 18.24 mm Hg), which were different based on post-hoc Dunn test analysis.

The HR of each group at 1-minute intervals 5 minutes after the BCP are described in Table 4. There was significant difference in the HR between group HP and group NS 1 minute after BCP by post-hoc Dunn test (P=.031). The change of HR at 1 minute compared to PIB was statistically different (P=.047), especially in group HP (−14.59±10.05 bpm) and group NS (−9.35±17.08 bpm), which were different based on post-hoc analysis.

There were no statistically significant differences in CI, SVV, and TSVRi between groups (P>.05). However, when we

compared the TSVRi between group HP and group NS, there was a significant difference in the trend (time-group interaction P=.0496) (Table 5). This significance comes from difference in the TSVRi at 1 minute compared to PIB (P=.035). Group HP (− 681.5±712.8) and Group NS (−1188.9±794.7) were different by post-hoc analysis. The TSVRi at 1 minute after being placed into the BCP was significantly different between group HP and group NS (P=.012).

PIB MAP was significantly lower (P=.0259) in the hypotension group [n=59, 96 mm Hg (82.5–106.75)] than in the non-hypotension group [n=4, 122 mm Hg (110.5– 123.0)]. There were no postoperative neurological complications in the 3 groups.

4. Discussion

Low dose IV infusion of phenylephrine (0.5 or 1.0 μg/kg/h) did not decrease the incidence of hypotension after placement into the BCP. In this study, hypotension occurred in 93.65% of all patients within 1 minute after being placed in the BCP.

Hemodynamic instability associated with the BCP is mainly caused by a reduction in cardiac preload during general anesthesia.[11] Buhre et al[11] found that 14% of blood volume shifted from the intra- to the extra-thoracic space after raising patients to the sitting position. In the sitting position, venous pooling in the lower extremities decreases the central blood volume. The systemic vascular resistance index is increased after the BCP when the patients are awake, but the TSVRi and blood pressure are decreased after a position change when the patients

Mean arterial pressure at each time point by group.

Variable	Group			P value[3]	
	HP (n=22)	LP (n=21)	NS (n=20)	Time	Time × Group
MAP (mm Hg)					
PIB	92.32±17.46a[1]	98.95±15.44a	101.35±21.33a	<.001	.028
1 min	72.23±16.62b	66.43±17.24b	59.60±16.43b		
2 min	64.05±13.98c	64.14±14.62b	57.30±16.55b		
3 min	61.91±12.91bc	64.76±13.90b	60.60±11.32b		
4 min	59.77±12.15bc	63.43±13.22b	62.25±8.66b		
5 min	60.36±9.70bc	67.57±13.82b	60.70±11.00b		
P value[2]		0.451			

[1]Values are presented as mean ± SD, and Bonferroni post hoc test was used for multiple comparisons between each of the 6 time points. Means with different scripts are different from each other (P<.05).
[2]P values are derived from between-group effect.
[3]An analysis of variance with repeated measures with a Huynh–Feldt correction was used when sphericity was not assumed.
MAP=mean arterial pressure, PIB=postinduction blood pressure.

Heart rate comparison between groups in the 5-minute interval after the beach chair position.

Variable	Group HP (n=22)	Group LP (n=21)	Group NS (n=20)	P value	post hoc
HR (bpm)					
PIB	80.09±16.32	86.24±14.72	84.50±16.19	.424[1]	N/A
1 min	65.50±15.70	71.90±14.79	75.15±15.02	.031[2]	Group NS > Group HP
2 min	65.95±16.76	70.14±12.76	73.25±14.25	.107[2]	N/A
3 min	64.68±17.39	70.38±12.26	68.85±11.49	.195[2]	N/A
4 min	65.45±17.18	69.33±11.40	69.05±15.46	.422[2]	N/A
5 min	65.32±17.00	70.33±12.82	66.25±12.10	.319[2]	N/A

[1]P values were derived by analysis of variance.
[2]P values were derived using the Kruskal–Wallis test, and a post-hoc Dunn test was performed.
Shapiro–Wilk test was employed for test of normality assumption.
HR=heart rate, PIB=postinduction blood pressure.

Table 5

Total systemic vascular resistance index values between group HP and group NS.

Variable	Group		P value	
	Group HP (n=22)	Group NS (n=20)	Time	Time × Group
TSVRi				
PIB	2628.3±711.3a[1]	2630.1±985.5a	<.001	.0496
1 min	1946.8±733.0b	1441.3±483.8b		
2 min	1751.2±640.1b	1493.2±507.3b		
3 min	1703.6±671.3b	1617.3±480.4b		
4 min	1579.5±535.0b	1644.6±416.3b		
5 min	1642.7±454.9b	1661.8±433.1b		
P value[2]		.383		

[1]Values are presented as mean ± SD. Bonferroni post hoc test was used for multiple comparisons between each of the 6 time points. Means with different scripts are different from each other (P<.05).
[2]P values are derived from the between-group effect.
Repeated measures analysis of variance with a Huynh–Feldt correction was used when sphericity was not assumed.
PIB=postinduction blood pressure, TSVRi=total systemic vascular resistance index.

are under anesthesia. Thus, it is important to increase cardiac preload and the TSVRi. Application of a sequential compression device[12] or stocking[3] can reduce venous pooling in the lower extremities, and reduce hemodynamic derangements after a positional change.

Unlike in previous studies,[13,14] the incidence of hypotension was very high in this study. A reason for this may be that blood pressure was assessed at the external auditory meatus instead of the right atrium, and the incidence of hypotension would be lower if MAP was measured at the level of right atrium as the estimated height between the meatus and right atrium would be 20 cm, resulting in an increase of 14.5 mm Hg in MAP at the right atrium. The MAP, measured at the level of the external auditory meatus, not at the level of the heart, was significantly correlated with the left or right regional cerebral oxygen saturation (rSO2) measured by near-infrared spectroscopy in seated patients for shoulder surgery.[13] This study was performed in a clinical field, so we placed the transducer in the external auditory meatus to prevent cerebral ischemia because we could not measure rSO2. It is not clear that hypotension at the external meatus definitely reflects poor rSO2, however it gives a higher risk of low cerebral perfusion pressure and long-term hypoperfusion can lead to a decrease in rSO2 and subsequent complications. Therefore, the ABP transducer should be placed at the level of the external auditory meatus and not at the level of the heart upon insertion of an invasive percutaneous arterial catheter.[2,8] Further studies should be required for the clinical correlation between MAP at external meatus and rSO2. A second reason is that patients with hypertension or diabetes mellitus were included in this study. Preoperative use of antihypertensive medication was associated with an increased intraoperative hypotension episode.[15] Furthermore, hypotension after induction of general anesthesia is associated with the presence of diabetes mellitus.[16] Third, the dose of phenylephrine in this study is small. As the dose of phenylephrine increases, MAP increases.[17] Phenylephrine, an α1-adrenergic receptor agonist, causes a direct increase in systemic vascular resistances, arterial pressure, and left ventricular afterload.[17]

Hypotension occurred most frequently within 1 minute after placement into the BCP. In addition, the cardiac index 1 minute after BCP placement tended to increase compared with baseline CI. This is thought to be due to the increase in cardiac output and decrease in MAP associated with preload-dependency after the BCP.[17] Further evaluation of appropriate fluid loading is necessary.

Although phenylephrine infusion did not reduce the incidence of hypotension, group HP had a decrease in the severity of hypotension. The TSVRi was also higher in group HP compared to group NS 1 minute after placed in the BCP. It seems to effect of afterload due to the continuous infusion of 1 μg/kg/min of phenylephrine.

There was a difference in the post-induction MAP between the hemodynamic variables of the hypotensive group (59 patients) and the non-hypotensive group (4 patients). If the post-induction MAP is less than 96 mm Hg, severe hypotension may occur after postural conversion. In another study, pre-induction CI, SVI, and post-induction SVV before a positional change were potential important prediction factors for the development of hypotension after the BCP.[14] Further research is needed to determine whether post-induction MAP is an indicator of postural hypotension.

There are some limitations of this study. First, many studies have shown that during the BCP cerebral desaturation is mostly involved. Although cerebral oxygen saturation can provide a valuable endpoint when evaluating the effect of vasopressor therapy on cerebral perfusion,[7] we did not measure cerebral oxygen saturation. Cerebral oximetry monitoring of the BCP is difficult to use because it is not covered by insurance in South Korea, and we did not know if these doses (1.0 and 0.5 μg/kg/min) of phenylephrine would preserve cerebral oxygen saturation at an appropriate level during surgery. Second, we did not measure TSVRI using the Flotrac system in this study. To measure SVRI with the Flotrac system, central venous pressure should be measured. However, there was no indication for central venous pressure monitoring in the elective arthroscopic shoulder surgery in this study. Therefore, the TSVRi was calculated in this study.[10] Third, the remifentanil used for anesthesia may have had hemodynamic effects. BP were significantly decreased compared to baseline BP after induction of general anesthesia in normotensive and hypertensive patients.[18]

This study has shown that phenylephrine (1 μg/kg/min) can reduce the severity of hypotension but cannot prevent intraoperative hypotension after the BCP. Despite phenylephrine infusion, the incidence of hypotension after the BCP was very high. Careful observation and strict management of blood pressure are still needed in these patients.

Author contributions

Conceptualization: Ki Hwa Lee.
Data curation: Hyun-seong Lee, Jin-Young Bang.
Formal analysis: Myoung Jin Ko, Yei Heum Park.
Investigation: Hyun-seong Lee.
Methodology: Hyojoong Kim.
Project administration: Hyojoong Kim.
Supervision: Ki Hwa Lee.
Visualization: Hyun-seong Lee, Soo Jee Lee.
Writing – original draft: Myoung Jin Ko, Hyojoong Kim.
Writing – review & editing: Soo Jee Lee, Yei Heum Park, Ki Hwa Lee.

References

[1] Peruto CM, Ciccotti MG, Cohen SB. Shoulder arthroscopy positioning: lateral decubitus versus beach chair. Arthroscopy 2009;25:891–6.
[2] Pohl A, Cullen DJ. Cerebral ischemia during shoulder surgery in the upright position: a case series. J Clin Anesth 2005;17:463–9.
[3] Woo JH, Kim YJ, Jeong JS, et al. Compression stockings reduce the incidence of hypotension but not that of cerebral desaturation events in the beach-chair position: a randomized controlled trial. Korean J Anesthesiol 2018;71:127–34.
[4] Cho SY, Kim SJ, Jeong CW, et al. Under general anesthesia arginine vasopressin prevents hypotension but impairs cerebral oxygenation during arthroscopic shoulder surgery in the beach chair position. Anesth Analg 2013;117:1436–43.
[5] Cho SY, Kim J, Park SH, et al. Vasopressin ameliorates hypotension induced by beach chair positioning in a dose-dependent manner in patients undergoing arthroscopic shoulder surgery under general anesthesia. Korean J Anesthesiol 2015;68:232–40.
[6] Sookplung P, Siriussawakul A, Malakouti A, et al. Vasopressor use and effect on blood pressure after severe adult traumatic brain injury. Neurocrit Care 2011;15:46–54.
[7] Soeding PF, Hoy S, Hoy G, et al. Effect of phenylephrine on the haemodynamic state and cerebral oxygen saturation during anaesthesia in the upright position. Br J Anaesth 2013;111:229–34.
[8] Hayashi K, Tanabe K, Minami K, et al. Effect of blood pressure elevation on cerebral oxygen desaturation in the beach chair position. Asian J Anesthesiol 2017;55:13–6.
[9] Wang GY, Ma B, Tang HT, et al. Esophageal echo-Doppler monitoring in burn shock resuscitation: are hemodynamic variables the critical standard guiding fluid therapy? J Trauma 2008;65:1396–401.
[10] Atlas G, Berger J, Dhar S. Afterload assessment with or without central venous pressure: a preliminary clinical comparison. Cardiovasc Eng 2010;10:246–52.
[11] Buhre W, Weyland A, Buhre K, et al. Effects of the sitting position on the distribution of blood volume in patients undergoing neurosurgical procedures. Br J Anaesth 2000;84:354–7.
[12] Kwak HJ, Lee JS, Lee DC, et al. The effect of a sequential compression device on hemodynamics in arthroscopic shoulder surgery using beach-chair position. Arthroscopy 2010;26:729–33.
[13] Ko SH, Cho YW, Park SH, et al. Cerebral oxygenation monitoring of patients during arthroscopic shoulder surgery in the sitting position. Korean J Anesthesiol 2012;63:297–301.
[14] Jo YY, Jung WS, Kim HS, et al. Prediction of hypotension in the beach chair position during shoulder arthroscopy using pre-operative hemo-dynamic variables. J Clin Monit Comput 2014;28:173–8.
[15] Trentman TL, Fassett SL, Thomas JK, et al. More hypotension in patients taking antihypertensives preoperatively during shoulder surgery in the beach chair position. Can J Anaesth 2011;58:993–1000.
[16] Jor O, Maca J, Koutna J, et al. Hypotension after induction of general anesthesia: occurrence, risk factors, and therapy. A prospective multi-centre observational study. J Anesth 2018;32:673–80.
[17] Cannesson M, Jian Z, Chen G, et al. Effects of phenylephrine on cardiac output and venous return depend on the position of the heart on the Frank-Starling relationship. J Appl Physiol (1985) 2012;113:281–9.
[18] Maruta T, Kodama Y, Tanaka I, et al. Comparison of the effect of continuous intravenous infusion and two bolus injections of remifentanil on haemodynamic responses during anaesthesia induction: a prospective randomised single-centre study. BMC Anesthesiol 2016;16:110. doi: 10.1186/s12871-016-0275-1.