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Retrospective analysis of risk factors of hypotensive bradycardic events during shoulder arthroscopic surgery under interscalene blockade in the sitting position

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Background: Hypotensive bradycardic events (HBEs) are a frequent adverse event in patients who underwent shoulder arthroscopic surgery under interscalene block (ISB) in the sitting position. This retrospective study was conducted to investigate the independent risk factors of HBEs in shoulder arthroscopic surgery under ISB in the sitting position.

Methods: A total of 2,549 patients who underwent shoulder arthroscopic surgery under ISB and had complete clinical data were included in the study. The 357 patients who developed HBEs were included in the HBEs group, and the remaining 2,192 in the non-HBEs group. The potential risk factors for HBEs, such as age, sex, past medical history, anesthetic characteristics, and intraoperative medications were collected and compared between the groups. Statistically significant variables were included in a logistic regression model to further evaluate the independent risk factors for HBEs in shoulder arthroscopic surgery under ISB.

Results: The incidence of HBEs was 14.0% (357/2549). Logistic regression analysis revealed that the intraoperative use of hydralazine (odds ratio [OR] 4.2, 95% CI 2.9–6.3), propofol (OR 2.1, 95% CI 1.3–3.6), and dexmedetomidine (OR 3.9, 95% CI 1.9–7.8) before HBEs were independent risk factors for HBEs in patients who received shoulder arthroscopic surgery under ISB.

Conclusions: The intraoperative use of antihypertensives such as hydralazine and sedatives such as propofol or dexmedetomidine leads to increased risk of HBEs during shoulder arthroscopic surgery under ISB in the sitting position.

Keywords: Brachial plexus block; Bradycardia; Hypotension; Logistic models; Risk factors; Shoulder arthroscopy; Syncope.

Introduction

Hypotensive bradycardic events (HBEs) in patients who underwent shoulder arthroscopic surgery in the sitting position under interscalene block (ISB), while usually not serious, are very challenging complications for anesthesiologists [1,2]. The position of the patient in shoulder arthroscopy largely depends on the choice of the surgeon. The sitting position has benefits, such as easier airway access, easier conversion to open surgery, less bleeding, a familiar anatomical orientation, and low risk of brachial plexus injury. Despite these benefits, the sitting position can cause adverse cardiovascular events, such as HBEs and cerebrovascular desaturation events, as reported in many articles [2–7]. The incidence rate of HBEs in patients undergoing shoulder arthroscopic surgery ranges from 13% to 21% [1,3,4]. Severe asystolic cardiac arrests can be caused by HBEs, and can be life-threatening without immediate correct treatment [5]. Several previous studies have suggested that HBEs may be related to intravenous (IV) drugs administrated intraoperatively [3,6,7]. Although antihypertensives, sedatives, and analgesics such as propofol, dexmedetomidine, and fentanyl may be involved in the development of HBEs, it has not yet been investigated which of these drugs are independent risk factors. In addition to these drugs, HBEs may be associated with the underlying mechanisms responsible for neurally mediated syncope, carotid sinus hypersensitivity, orthostatic hypotension, and other types of syncope [1,8,9]. Thus, HBEs may be associated with the patient's age, sex, body mass index (BMI), past medical history, and the technical aspects of ISB, but the relationships between patient or anesthesia factors and HBEs in the clinical setting of shoulder arthroscopic surgery have not been studied. In this study, we retrospectively analyzed the records of 2,549 patients who underwent shoulder arthroscopic surgery in the sitting position to explore the independent risk factors of HBEs by logistic regression analysis.

Materials and Methods

Patients

The Institutional Review Board of Daegu Catholic University Medical Center approved this retrospective study (approval number, CR-16-005-L) and waived the requirement for written informed consent because of the retrospective study design. This study was registered at the Korea Clinical Research Information Service (registration number: KCT0004544). The data of 2,613 patients who underwent shoulder arthroscopic surgery in the sitting position under ISB from October 2002 to March 2018 were retrospectively analyzed. Among them, 64 patients were excluded by the following criteria: conversion from ISB to general anesthesia or intravenous general anesthesia; conversion from ISB to mask general anesthesia; and patients with additional brachial plexus block. Thus, this study analyzed the anesthetic records of 2,549 patients.

Definition of HBEs

HBEs were defined [3,6,7] as cases in which the minimum intraoperative systolic blood pressure (SBP) was under 90mmHg and ephedrine was administered to increase blood pressure, or in which the minimum intraoperative heart rate (HR) was under 50 beats/min and atropine was administered to increase HR.

Potential risk factors of HBEs

Demographic data, past medical history, preoperative medications, anesthetic characteristics of ISB, vital signs, and intraoperative use of vasoactive drugs and other medications were considered potential risk factors related to HBEs. The potential risk factors of HBEs were statistically analyzed using univariable analysis with the variables described in the following. Demographic data included: American Society of Anesthesiologists (ASA) physical status, operation type, age, sex (male versus female), height, weight, BMI, and preoperative diagnosis. Among the data related to past medical history or preoperative medication, the following were considered: hypertension, diabetes mellitus (DM), heart disease, pulmonary disease, liver disease, brain disease, antihypertensive medication, and diabetic medication. A previous study [4] has reported that the ISB site (right versus left) may be considered a risk factor of HBEs. Data related to ISB anesthesia included: guided device (ultrasound and/or nerve stimulator), ISB site (right or left), operation time, and total amount of local anesthetics (LA). Data about perioperative vital signs or intraoperative use of vasoactive drugs included: baseline SBP, baseline diastolic blood pressure (DBP), baseline HR, maximum and minimum SBP and DBP, maximum and minimum HR, use of ephedrine and atropine, and amount of IV fluid. Regarding intraoperative medications, the following were considered: hydralazine, diltiazem, nicardipine, fentanyl, propofol, midazolam, and dexmedetomidine.

Statistical analysis

For the univariate analysis, categorical data were analyzed using Chi-square tests, and continuous data were analyzed using an independent sample t-test.

For the multivariate analysis, the potential risk factors with $P < 0.05$ in univariate analysis were considered as independent variables in a binary logistic regression model to identify the independent risk factors, with HBEs as the dependent variable (Y: 1 = Yes, 0 = No). To solve the problem of multicollinearity, variable selection was performed with the forward conditional method. After variable selection, the analysis was performed adjusting for statistically significant covariates. P values < 0.05 were considered statistically significant. Odd ratios (ORs) and their 95% confidence intervals (CIs) were calculated. Data were analyzed using SPSS version 19.0 (SPSS Inc., USA).

Our standard ISB technique for shoulder arthroscopic surgery

The patient's neck was sterilized using iodine solution and sterile drapes were applied, then the patient's head was rotated contralaterally and the interscalene groove was identified. Local anesthesia infiltration was given with 1 ml lidocaine 2% in the needle insertion site. If using nerve stimulation, a 50-mm 22-gauge insulated needle (Stimuplex® insulated, B. Braun Medical, Germany) was introduced from lateral to medial parallel to the interscalene groove. A 2-Hz, 1-mA stimulus nerve stimulator (Stimuplex, HNS12, B. Braun Medical, Germany) was connected to the needle and the needle was inserted with 1 mA stimulus until muscle trigger was noted in the elbow and in the first and second fingers. The stimulus was then decreased to 0.3 mA, and while muscle trigger was still present 30–40 ml of a mixture of lidocaine 1% or mepivacaine 1% and ropivacaine 0.75%, or 25–30 ml of ropivacaine alone, were injected in divided doses with frequent aspiration. If using ultrasound, after disinfecting the skin and positioning the transducer (Alpha 7, Hitachi Aloka, Japan), a 50-mm 22-gauge insulated needle (Stimuplex® insulated, B. Braun Medical, Germany) was introduced from lateral to medial parallel to the interscalene groove in an in-plane technique, such that the entire needle was visualized. A total of 15–30 ml of the same type of LA was injected in divided doses with frequent aspiration and the LA spread was visualized with the ultrasound.

Intraoperative patient management

All shoulder arthroscopies were performed by the same surgeon, and three anesthesiologists were involved. The noninvasive blood pressure cuff was placed during surgery on the arm on the non-operative site. If needed, invasive arterial monitoring by catheter was performed on the radial artery of the non-operative site.

When sufficient ISB anesthesia was achieved, the surgeon started the operation. In case of pain when placing the port in the back of the shoulder, the surgeon performed local infiltration using 10 ml of 1% mepivacaine. In case of impaired visualization of the surgical field due to bleeding or if the patient's SBP increased above 170 mmHg during surgery, hydralazine (10 mg), nicardipine (0.25–5 mg) or diltiazem (5–10 mg) were administered intravenously, and induced hypotension was not used. Vasopressors, inotropes, or chronotropics (ephedrine, epinephrine, or atropine) were used at the discretion of the attending anesthesiologist in cases of HBEs. Routine sedation was not performed. In case of incomplete ISB blocks with the patient manifesting discomfort or strongly requesting sedation, a small dose of IV fentanyl (50 μg) or midazolam (1–3 mg) was administrated. Some patients received an IV bolus of propofol (20–30 mg) or propofol infusion (0.3–0.6 mg/kg/h) because of pain or discomfort not controlled by fentanyl and midazolam. Some patients received continuous IV infusion of dexmedetomidine (maintenance dose of 0.2–0.5 μg/kg/h) without loading infusion.

Results

The incidence of HBEs was 14.0% (357/2549). HBE incidence during shoulder arthroscopic surgery under ISB was examined using univariable analysis. The results revealed that demographic data, such as ASA physical status, age, sex, height, weight, and BMI were related to HBE incidence (P < 0.05, Table 1). However, preoperative diagnosis and the site of operation (right versus left) were not significantly correlated with the occurrence of HBEs (P > 0.05). The univariable analysis of the relationships between past medical history and preoperative medications and HBEs revealed that a history of hypertension and antihypertensive medication were risk factors for HBEs (P < 0.05, Table 2). However, history of DM, liver disease, heart disease, pulmonary disease, brain disease, and DM medication were not risk factors (P > 0.05). Regarding the anesthetic characteristics of ISB, univariable analysis revealed that a guided ISB device (sonography versus nerve stimulator), operation time, and total amount of LA (ropivacaine, mepivacaine, and lidocaine) were not related with HBEs (P > 0.05, Table 3). Table 4 shows the analysis of perioperative vital signs and intraoperative use of vasoactive drugs as risk factors for HBEs. Univariable analysis of the relationships between baseline vital signs and HBEs revealed that baseline SBP and DBP were significantly associated to HBEs (P < 0.05), while among intraoperative medications, the intraoperative use of IV hydralazine, propofol, midazolam and dexmedetomidine were significantly correlated with the occurrence of HBEs (P < 0.05, Table 5). However, the intraoperative use of nicardipine was not a risk factor for HBEs: Indeed the use of nicardipine in the HBEs group was significantly lower (P < 0.05, Table 5) than in the non-HBEs group. Furthermore, the intraoperative use of fentanyl was not significantly correlated with the occurrence of HBEs (P > 0.05).

The variables described above were examined through logistic regression analysis with the forward conditional method for variable selection, and the results indicated that the intraoperative use

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Table 1. Univariate Analysis of the Relationship between Demographic Data and HBEs

	HBEs			P value
	Yes (n = 357)	No (n = 2,192)	Total (n = 2,549)	
ASA physical status				0.011*
I	211 (59.1)	1459 (66.6)	1670 (65.5)	
II	144 (40.3)	729 (33.3)	873 (34.3)	
III	2 (0.6)	4 (0.2)	6 (0.2)	
Operation type				0.826
Elective	347 (97.2)	2135 (97.4)	2482 (97.4)	
Emergency	10 (2.8)	57 (2.6)	67 (2.6)	
Age	55.1 ± 15.1	52.9 ± 15.6	53.2 ± 15.6	0.012*
Sex				0.003*
M	186 (52.1)	1327 (60.5)	1513 (59.4)	
F	171 (47.9)	865 (39.5)	1036 (40.6)	
Height (cm)	163.4 ± 9.0	165.2 ± 8.5	165 ± 8.6	< 0.001*
Weight (kg)	62.2 ± 11.3	65.2 ± 11.9	64.7 ± 11.8	< 0.001*
BMI (kg/m^2)	23.2 ± 3.1	23.8 ± 3.2	23.7 ± 3.2	0.001*
Preoperative diagnosis				0.432
Rotator cuff tear	264 (74.4)	1573 (72.2)	1837 (72.4)	
Shoulder instability	36 (10.1)	292 (13.4)	328 (12.9)	
Calcified tendinitis	11 (3.1)	58 (2.7)	69 (2.7)	
Impingement syndrome	8 (2.3)	54 (2.5)	62 (2.4)	
SLAP or labral tear	10 (2.82)	76 (3.48)	86 (3.39)	
Frozen shoulder	0 (0)	6 (0.28)	6 (0.24)	
Pyogenic arthritis	26 (7.3)	122 (5.6)	148 (5.8)	
Site of operation				0.176
Right	257 (72.0)	1499 (68.4)	1756 (68.9)	
Left	100 (28.0)	692 (31.6)	792 (31.1)	

Values are presented as frequency (%) or mean ± SD. HBEs: hypotensive bradycardic events, ASA: American Society of Anesthesiologists, BMI: body mass index, SLAP: superior labrum anterior to posterior. *Statistically significant with P < 0.05.

Table 2. Univariate Analysis of the Relationship between Past Medical History or Preoperative Medications and HBEs

	HBEs			P value
	Yes (n = 357)	No (n = 2,192)	Total (n = 2,549)	
Hypertension	104 (29.1)	519 (23.7)	623 (24.4)	0.026*
DM	36 (10.1)	224 (10.2)	260 (10.2)	0.938
Liver disease	9 (2.5)	40 (1.8)	49 (1.9)	0.374
Heart disease	14 (3.9)	63 (2.9)	77 (3.0)	0.284
Pulmonary disease	6 (1.7)	20 (0.9)	26 (1.0)	0.180
Brain disease	8 (2.2)	50 (2.3)	58 (2.3)	0.961
Hypertension medications	94 (26.3)	468 (21.4)	562 (22.1)	0.035*
DM medications	34 (9.5)	201 (9.2)	235 (9.2)	0.830

Values are presented as frequency (%). HBEs: hypotensive bradycardic events, DM: diabetes mellitus. *Statistically significant with P < 0.05.

of IV hydralazine, propofol, and dexmedetomidine were independent risk factors for developing HBEs during shoulder arthroscopic surgery under ISB (P < 0.05, Table 6). The results of the logistic regression analysis adjusted by age, sex, BMI, preoperative medical history, perioperative medication, and vital signs are shown in Table 7. The intraoperative use of hydralazine (OR 4.2, 95% CI 2.9–6.3), propofol (OR 2.1, 95% CI 1.3–3.6), and dexmedetomidine (OR 3.9, 95% CI% 1.9–7.8) were identified as independent risk factors for the occurrence of HBEs during shoulder arthroscopic surgery (Table 7).

Table 3. Univariate Analysis of the Relationship between Anesthetic Characteristics of ISB and HBEs

	HBEs			P value
	Yes (n = 357)	No (n = 2,192)	Total (n = 2,549)	
Guided device				0.170
Sonography	239 (67.0)	1385 (63.2)	1624 (63.7)	
Nerve stimulator	118 (33.1)	807 (36.8)	925 (36.3)	
Operation time (min)	94.1 ± 35.9	92.3 ± 42.0	92.6 ± 41.2	0.457
Total amount of LA (ml)	30.9 ± 8.7	31.4 ± 8.4	31.4 ± 8.4	0.235
Ropivacaine (ml)	16.4 ± 4.8 (n = 357)	16.5 ± 4.5 (n = 2181)	16.5 ± 4.6 (n = 2538)	0.859
Mepivacaine (ml)	15.1 ± 5.1 (n = 311)	15.6 ± 4.9 (n = 1944)	15.6 ± 5.0 (n = 2255)	0.078
Lidocaine (ml)	7.8 ± 5.3 (n = 66)	7.2 ± 6.4 (n = 406)	7.3 ± 6.3 (n = 472)	0.469

Values are presented as frequency (%) or mean ± SD. ISB: interscalene block, HBEs: hypotensive bradycardic events, LA: local anesthetic.

Table 4. Perioperative Vital Sign and Intraoperative Use of Vasoactive Drugs

	HBEs			P value
	Yes (n = 357)	No (n = 2,192)	Total (n = 2,549)	
Baseline SBP (mmHg)	139.3 ± 23.1	142.7 ± 21.2	142.2 ± 21.5	0.006*
Baseline DBP (mmHg)	78.2 ± 12.3	80.7 ± 12	80.4 ± 12.1	< 0.001*
Baseline HR (mmHg)	72.7 ± 13.7	72.7 ± 13.5	72.7 ± 13.6	0.992
Maximum SBP (mmHg)	156.5 ± 24.1	160.4 ± 21.2	159.8 ± 21.7	0.002*
Minimum SBP (mmHg)	83.6 ± 11.2	125.2 ± 26.3	119.4 ± 28.7	< 0.001*
Maximum HR (mmHg)	86.5 ± 15.3	83.3 ± 16	83.8 ± 15.9	< 0.001*
Minimum HR (mmHg)	58.9 ± 12.6	68.5 ± 106.7	67.2 ± 99.1	0.091
Ephedrine	294 (82.4)	178 (8.1)	472 (18.5)	< 0.001*
Atropine	57 (16.0)	70 (3.2)	127 (5.0)	< 0.001*

Values are presented as mean ± SD or frequency (%). HBEs: hypotensive bradycardic events, SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate. *Statistically significant with $P < 0.05$.

Table 5. Univariate Analysis of the Relationship between Intraoperative Medications and HBEs

	HBEs			P value
	Yes (n = 357)	No (n = 2,192)	Total (n = 2,549)	
Hydralazine	49 (13.7)	91 (4.2)	140 (5.5)	< 0.001*
Diltiazem	5 (1.4)	34 (1.55)	39 (1.53)	0.830
Nicardipine	37 (10.4)	370 (16.9)	407 (16.0)	0.002*
Fentanyl	114 (31.9)	651 (29.7)	765 (30.0)	0.393
Propofol	20 (5.6)	68 (3.1)	88 (3.5)	0.016*
Midazolam	64 (17.9)	303 (13.8)	367 (14.4)	0.041*
Dexmedetomidine	14 (3.9)	23 (1.1)	37 (1.5)	< 0.001*

Values are presented as frequency (%). HBEs: hypotensive bradycardic events. *Statistically significant with $P < 0.05$.

Table 6. Binary Logistic Regression Analysis of HBEs during Shoulder Surgery with Forward Conditional Method as Variable Selection

Variable	OR	95% CI	P value
Hydralazine	3.9	2.7, 5.7	< 0.001*
Propofol	1.9	1.1, 3.2	0.018*
Dexmedetomidine	4.0	2.0, 7.8	< 0.001*

HBEs: hypotensive bradycardic events, OR: odds ratio. *Statistically significant with $P < 0.05$.

Discussion

Shoulder arthroscopic surgery is commonly performed in the sitting position under ISB, and the anesthesiologist should focus on monitoring the patient vital signs, so as to allow early detection and treatment of HBEs occurring during surgery. We retrospectively analyzed the data of 2,549 patients who underwent shoulder

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Table 7. Binary Logistic Regression Analysis of HBEs during Shoulder Surgery Adjusted by Age, Sex, BMI, Preoperative Medical History, Perioperative Medications, and Vital Signs

Variable	OR	95% CI	P value
Hydralazine	4.2	2.9, 6.3	< 0.001*
Propofol	2.1	1.3, 3.6	0.006*
Dexmedetomidine	3.9	1.9, 7.8	< 0.001*

HBEs: hypotensive bradycardic events, BMI: body mass index, OR: odds ratio. *Statistically significant with P < 0.05.

arthroscopic surgery under ISB, and found that the incidence rate of HBEs was 14.0%. In addition, our results indicated that the use of hydralazine, propofol, and dexmedetomidine before HBE occurrence were independent risk factors for developing HBEs.

The use of intraoperative antihypertensives during shoulder arthroscopic surgery can be increased by the operator's demand for blood pressure control, because high blood pressure can increase bleeding and blur the operation field. For the anesthesiologist, it is very challenging to use IV antihypertensive drugs in conscious sitting patients under ISB. Our results show that vasodilators such as hydralazine were strong risk factors for HBEs, but calcium channel blockers (CCBs) such as nicardipine and diltiazem were not. Especially the use of nicardipine in the HBEs group was significantly lower than in the non-HBEs group in our results. Therefore, the intraoperative use of nicardipine was not a risk factor for HBEs despite of statistical significance. In a previous study [6], another antihypertensive drug, namely urapidil, was identified as a risk factor for HBEs in shoulder arthroscopic surgery. Urapidil [10], which is currently not approved by the U.S. Food and Drug Administration, acts as an α1-adrenoreceptor antagonist and as a 5-HT1A receptor agonist. These findings suggest that the anesthesiologist should pay attention to the selection of antihypertensive agents during shoulder arthroscopic surgery under ISB.

Hydralazine is known to act directly on the vascular smooth muscle causing strong vasorelaxation and primary artery relaxation [11]. However, the action time of hydralazine is unpredictable, compared with other intravenous antihypertensives used for the treatment of malignant hypertension, and can be as long as 8 h in some cases [12]. The cause of such longer action time of hydrazine is not well known, but animal experiments confirmed that the active metabolite of hydralazine adheres to tissues in the vascular wall for a certain period of time, and that the hydralazine metabolites deposited on the vascular endothelial cells can continuously produce endothelial-dependent nitric oxide (NO) [12]. In contrast, CCBs block the L-type voltage-dependent calcium channels of the vascular smooth muscle, inhibiting calcium influx, thereby relaxing the vascular smooth muscle. The production of NO in vascular endothelial cells is usually caused by calcium-dependent nitric oxide synthase, and CCBs do not directly affect NO production [13]. Considering these aspects, when the need arises to use IV anti-hypertensive drugs during shoulder arthroscopy under ISB, it is safer to choose CCBs rather than hydralazine that alters NO production and has long-lasting effects.

A previous study [7] reported that a large single IV bolus dose of fentanyl (100 μg) was associated with the development of HBEs. However, the use of fentanyl in this study was not a risk factor for HBEs, possibly because we use fentanyl in a single bolus dose generally smaller than 50 μg. On the contrary, propofol was identified in this study as an independent risk factor for HBEs. However, Souron et al. [14] performed target-controlled propofol infusion (0.8–0.9 μg/ml) in 140 patients during shoulder arthroscopic surgery under ISB and found that the propofol infusion group had a low incidence of HBEs (5.7%). This discrepancy may be caused by the different purpose and protocol of propofol administration compared with this study. In our center, we do not routinely use patient sedation during shoulder arthroscopic surgery, and propofol is not used for patient sedation itself. In cases of insufficient block or strong patient's demand, if analgesics or sedatives such as fentanyl or midazolam are not effective, an IV bolus injection and/or IV infusion of propofol are used. Therefore, the effect of propofol in this study should be interpreted as a combination effect of propofol with fentanyl and midazolam. Although dexmedetomidine was used for sedation in a small number of patients, we found it to be an independent risk factor for HBEs. Since the stability of dexmedetomidine during shoulder surgery in the sitting position has not yet been established, the use of IV dexmedetomidine requires caution, and further studies are needed.

Various syncopal reactions, including HBEs, may be triggered by similar mechanisms and use the same efferent limb of the reflex [1,8]. HBEs often occur in response to an orthostatic stimulus (prolonged sitting position), other non-orthostatic stimuli (fear, emotional stress, pain), and a variety of activities (coughing, swallowing, and pressure on the carotid sinus) [15]. These stimuli cause a sudden transient failure of the autonomic nervous system, resulting in hypotension and bradycardia. This study revealed that lower baseline SBP and DBP (Table 4) were associated with the development of HBEs. We also found that older age, lower BMI, and the female sex were associated with the development of HBEs in univariable analysis. Sex differences in patients with HBEs in this study may be closely related with female predominance in neurally mediated syncope [9,16]. Women are more susceptible to orthostatic intolerance in warm environments. Recently, Meendering et al. [17] evaluated the influence of menstrual cycle and sex on the hemodynamic responses to combined orthostatic and heat stress, and found that men had greater orthostatic tolerance than women during combined upright tilting and passive heating. Neurally mediated syncope is more common in younger people [9], but in this study, HBEs tended to occur more frequently in older people. In addition, this study showed that higher ASA physical status (Table 1) and a history of hypertension (Table 2) were risk factors for HBEs. Although syncope in the elderly is usually multifactorial, and often associated with orthostatic hypotension and carotid hypersensitivity [18–20], further research is needed to clarify the association between HBEs and these factors.

Recent studies have reported the effects of ISB on sympathetic activity, possibly by the extension of ISB to the stellate ganglions [21,22], and some studies have reported the possibility of a difference between the left and right sides [4,21]. A previous retrospective study [4] has reported that the ISB site (right versus left) may be considered a risk factor of HBEs, but this result may be underpowered owing to the small sample size.

However, our results did not identify the ISB site as a risk factor of HBEs (Table 1), and we consider them to be more reliable, because our study had a much larger sample size than the previous one. Additionally, we also examined the association between the total amount of local anesthetics and HBEs, without finding a significant result. Our results may suggest that HBEs cannot be separated from various other types of syncopal reaction. However, preoperative ISB was reported as one of the risk factors associated with HBEs in a recent study of open shoulder surgery [23]. Further studies are thus needed before a definite conclusion can be drawn about the impact of the ISB on HBEs.

The definition of HBEs may differ somewhat from that of neurally mediated syncope that is defined using the tilting test [9,24]. The definition of HBEs used in this study was based on the general guidelines for the administration of ephedrine or atropine upon changes in patient blood pressure or heart rate during shoulder arthroplasty. This specific definition might explain the high prevalence of HBEs assessed in this study. In addition, as a retrospective analysis of data from a single research center, this study inevitably has some limitations. One of the potential limitations is the long study period, chosen so as to include all cases operated in our institution without selection; in particular, regarding nerve stimulator-guided ISB, the period included in the study was 16 years long. Owing to such a long period, there were some changes in anesthesia and surgical procedures that could affect the results of the study. However, as previously described, only one surgeon and three anesthesiologists were involved in the surgeries in this study, and we tried to standardize the anesthesia process, so that the changes occurred during the study period might not present a major concern. Unfortunately, a large part of the data was taken before our institution adopted an electronic medical record system; thus, a significant portion of data about the amount and type of perioperative drugs was missing. This made it difficult to analyze the role of the amount and type of perioperative drugs. However, all patients were analyzed simultaneously, without selectivity. Therefore, our results are more reliable than those of other retrospective studies, thanks also to the comparatively large sample size and the controlled ISB procedure.

In conclusion, our findings indicate that the use of hydralazine, propofol, and dexmedetomidine before HBEs increases the susceptibility to HBEs during shoulder arthroscopic surgery in the sitting position under ISB.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

Author Contributions

Taeha Ryu (Conceptualization; Data curation; Formal analysis; Methodology; Writing – original draft; Writing – review & editing)
Baek Jin Kim (Data curation; Formal analysis; Resources; Validation; Writing – original draft)
Seong Jun Woo (Data curation; Methodology; Resources; Visualization)
So Young Lee (Data curation; Resources; Software; Visualization; Writing – review & editing)
Jung A Lim (Resources; Software; Validation; Visualization; Writing – review & editing)
Sang Gyu Kwak (Data curation; Formal analysis; Methodology; Software; Validation; Visualization)
Woon Seok Roh (Conceptualization; Data curation; Formal analysis; Methodology; Project administration; Resources; Supervision; Writing – original draft; Writing – review & editing)

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