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The effect of block side on hemodynamic and respiratory parameters in patients who had interscalene block for upper limb surgery

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Abstract. – OBJECTIVE: The administration of interscalene block (ISB) may lead to several hemodynamic effects, likely due to the diffusion of local anesthetic to nearby structures such as carotid sinus baroreceptors. This study aimed to compare hemodynamic and respiratory changes resulting from right and left-sided ISB.

PATIENTS AND METHODS: A retrospective analysis was conducted on adults who had ultrasound-guided ISB for upper limb surgery between January 2020 and December 2021. All patients had ISB with bupivacaine 0.5% and lidocaine 2% mixture following premedication. Demographic data, arterial blood pressure, heart rate, and peripheral oxygen saturation (SpO_2) were measured before and after the block at regular intervals. Block characteristics, surgical and post-anesthesia care unit (PACU) durations, intraoperative analgesic requirements, and side effects were analyzed.

RESULTS: A total of 94 patients had ISB for upper limb surgery, 54 for the right and 40 for the left-sided surgeries. Patients' data were analyzed in two groups according to the block side. Increased arterial blood pressure was observed in both groups after the block compared to the control values. Systolic arterial pressure from 10 to 30 minutes, diastolic arterial pressure at the 25th minute, and mean arterial pressure at the 15th, 20th, and 25th minutes were significantly higher on the right-sided blocks. Heart rate, SpO_2, analgesic requirements, block characteristics, and PACU durations did not differ between the groups.

CONCLUSIONS: Ultrasound-guided ISB-applied patients demonstrated increased blood pressure compared to control values. This increase, without concurrent changes in heart rate, was more pronounced in right-sided ISB. These findings indicate that careful hemodynamic monitoring is necessary whenever hypertension should be avoided for the patients.

Key Words:
Hypertension, Interscalene block, Local anesthetic.

Introduction

Interscalene block (ISB) is defined[1] as the blocking of the brachial plexus between the anterior and median scalene muscles. The interscalene brachial plexus block method has been widely applied in shoulder joint and upper limb surgeries[2,3]. In addition to intraoperative anesthesia, ISB provides ongoing analgesia and lower pain scores in the postoperative period. It also has several advantages, such as fewer opioid requirements, fewer opioid-related side effects, a better postoperative joint range of motion, and higher patient satisfaction[4].

Interscalene brachial plexus block is a peripheral nerve block that blocks the brachial plexus in the most proximal region of the neck among brachial plexus blocking techniques and is close to the cervical nerve roots and important neighboring structures[4]. Due to this anatomical adjacency of the ISB injection site to the surrounding vital structures, ISB has several unique side effects and complications such as the high incidence of phrenic nerve block, blockade of the recurrent laryngeal nerve, Horner syndrome, bradycardia-hypotension episodes in the sitting position[5,6]. Bradycardia and hypotension in the sitting position are more pronounced when ISB is combined with general anesthesia, while hemodynamics are more stable in surgeries performed only with interscalene block[7,8]. Although common side effects and complications of ISB are well-known by anesthesiologists, hypertension after the block application is often overlooked. There are

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various case reports and limited studies[9-12] in which hypertension was detected after ISB. Although the mechanism cannot be fully clarified, it is explained as a blockage of the nerves innervating the carotid and aortic baroreceptors due to the spread of local anesthetics[10]. This situation can be a problem, especially in surgeries where hypotension is desirable. For example, surgeons need clear vision in shoulder arthroscopy cases, while increased micro bleeding due to high blood pressure interferes with their surgical vision[13,14].

In this study, we aimed to document whether or not the hypertension period after ISB application exists in our previous blocks. The primary outcome variable is the change in arterial blood pressure after the block, and the secondary outcome variables are the comparison of hemodynamic and respiratory effects in patients undergoing right and left-sided ISB.

Patients and Methods

After the Ethics Committee approval was obtained from the Izmir Katip Celebi University Atatürk Training and Research Hospital (26.01.2023-0008), patients over the age of 18 who underwent ISB due to shoulder and proximal humerus surgery between January 2020 and December 2021 were retrospectively reviewed. Patients were determined by searching for "age over 18", "interscalene block", and "shoulder and/or humerus surgery" in the patient database of our institution. The data of the patients were obtained by examining the electronic data processing system and anesthesia follow-up forms. In our hospital, the diagnosis and treatment of the patient, the method of anesthesia, used drugs and complications, as well as vital parameters measured every 5 minutes, are routinely recorded on the anesthesia follow-up forms. Patients under the age of 18 and patients with deficiencies in anesthesia follow-up forms were not included in the study. The patient's age, gender, body mass index (BMI), current systemic diseases, American Society of Anesthesiologists (ASA) scores, medications used, and the side of the block due to the surgery performed were recorded.

Anesthesia Management

At our institute, all patients were evaluated by anesthesiologists during the preoperative period, and blocks were performed by anesthesiologists who were experienced in peripheric blocks. All blocks were performed in the preoperative block application room.

All of the patients had intravenous (iv) access, and they were monitored with non-invasive arterial blood pressure, electrocardiography, and pulse oximetry. Arterial blood pressure, heart rate (HR), and peripheral oxygen saturation (SpO_2) were measured just before the block and every 5 minutes after the block. Premedication was achieved with 0.02 mg/kg iv midazolam in all patients. Using a sterile technique, ISB was performed under ultrasound guidance (SonoSite M-T; Fujifilm SonoSite Inc., Bothell, Washington, USA). ISB was carried out by identifying the C5-C6-C7 nerve roots of the brachial plexus with a 6-13 MHz linear ultrasound probe. Visualizing the spread of LA around the nerve roots, 10 mL of 0.5% bupivacaine (Marcaine®, AstraZeneca, Istanbul, Turkey) and 10 ml of 2% lidocaine (Lidon®, Onfarma, Samsun, Turkey) was injected. The block performance duration was defined as the time elapsed from the initial insertion of the needle to its removal upon completion of the block. After the ISB was completed, patients were evaluated to determine the loss of shoulder abduction and forearm flexion in the elbow and wrist. A modified Bromage scale was used to identify the motor block: 4= full muscle strength; 3= diminished muscle strength, but ability to lift the arm against resistance; 2= ability to move the relevant muscle group against gravity, but inability to lift the arm against resistance; 1= perceptible muscle contraction, but inability to lift the arm against gravity; 0= no movement in the corresponding muscle group[8]. Motor block onset time was defined as the time elapsed from ISB until the modified Bromage score was <2.

Simultaneously, the sensory block was evaluated by the cold or pinprick test applied to C4 to T1 dermatomes and scored as 1= complete sensation and 0= loss of sensation against the cold or pinprick test. Sensory block onset time was defined as the time elapsed from ISB until the loss of sensation to cold or pinprick test.

The complete block onset time was defined as the presence of complete motor block (modified Bromage score <2) and loss of sensation to cold or pinprick test.

In all patients, systolic, diastolic, and mean arterial blood pressure, HR, and SpO_2 were recorded just before the block and then every 5 minutes for the first 30 minutes after the block. In our institution, if there is no failure in the block, surgery is generally allowed 30 minutes after the block is performed, but depending on the

suitability of the operating room, this period can be extended. The number of patients who were administered 50-100 mcg iv fentanyl as rescue analgesia intraoperatively, according to the decision of the attending anesthesiologist, was recorded. The duration of surgery was defined as the total operative time from the incision of the skin to the closure of the skin. The data of the patients were analyzed in two groups according to the block side (right or left side). The demographic characteristics of the patients and the effects of the block on hemodynamic and respiratory parameters were statistically analyzed.

Statistical Analysis

Statistical analyses were performed using SPSS (version 28.0; IBM Corp., Armonk, NY, USA). Descriptive statistics, including mean, standard deviation, median, minimum, maximum, frequency, and percentage, were employed to summarize the data. The distribution of variables was assessed using the Kolmogorov-Smirnov test. For the comparison of quantitative data, the Independent Samples *t*-test and Mann-Whitney U test were utilized. Repeated measurement analysis was conducted using the Wilcoxon test and analysis of variance (ANOVA). The Chi-Square test was employed for the comparison of qualitative data. A *p*-value lower than 0.05 was considered statistically significant.

Results

It was found that ISB was applied to 94 patients who underwent shoulder and proximal humerus surgery between January 2020 and December 2021. It was determined that ISB was applied on the right side of the neck in 54 patients and on the left side of the neck in 40 patients before surgery. The patients were similar between the groups in terms of age, gender, BMI, and ASA scores. 35.2% of the patients in the right-side group and 42.5% in the left-side group were hypertensive. The distribution of hypertensive patients was similar between the groups. The groups were also comparable in terms of block performance durations and sensory, motor, and complete block onset times. The duration of surgery and post-anesthesia care unit (PACU) stay showed no significant differences between the groups (Table I).

None of the patients whose surgery was completed with ISB had a record of complications such as dyspnea due to phrenic nerve block. There was no record of Horner syndrome.

Systolic, diastolic, and mean arterial pressures of all patients in the first 30 minutes after ISB were evaluated. Systolic, diastolic, and mean arterial pressures were found to be significantly higher at the 5^{th}, 10^{th}, 15^{th}, 20^{th}, 25^{th}, and 30^{th} minutes than the control values measured before the ISB ($p<0.05$) (Figure 1).

Systolic arterial pressures were significantly higher on the right-side group of the patients at the 10^{th}, 15^{th}, 20^{th}, 25^{th}, and 30^{th} minutes compared to the left side group of patients ($p<0.05$). The systolic arterial pressure of the patients from the 5^{th} minute to the 30^{th} minute showed a significant increase ($p<0.05$) compared to the control values in both groups. The percentage of increase in systolic arterial pressure at the 10^{th}, 15^{th}, 20^{th}, and 25^{th} minutes on the right-sided blocks was significantly higher than the left-sided blocks ($p<0.05$) (Figure 2).

Diastolic arterial pressure was significantly higher on the right side at the 25^{th} minute than on the left side ($p<0.05$). Diastolic arterial pressure of the patients from the 5^{th} minute to the 30^{th} minute showed a significant increase compared to the control values in both groups ($p<0.05$). No significant difference was found between the right and left sides in terms of the percentage of the diastolic arterial pressure change at the measurement times (Figure 3).

Mean arterial pressure values were significantly higher on the right side at the 15^{th}, 20^{th}, and 25^{th} minutes compared to the left side ($p<0.05$). Mean arterial pressure values showed a significant increase from the 5^{th} minute to the 30^{th} minute compared to the initial values in both groups ($p<0.05$). The percentage of the increase of the mean arterial pressure in the 15^{th}, 20^{th}, and 25^{th} minutes on the right side was higher than on the left side ($p<0.05$) (Figure 4).

The SpO_2 values did not differ significantly ($p>0.05$) on the right and left sides at all measurement times. In the same way, there was no difference in heart rates between the two groups.

Discussion

The results of this study aimed to detect the hemodynamic responses following interscalene brachial plexus blockade and have demonstrated that an increase in blood pressure measurements occurs after the local anesthetic administration for ISB. In addition to the increase in arterial blood pressure after the block, it was also determined that the

Table I. Demographic data of patients, block characteristics, intraoperative analgesia, surgery and PACU durations.

		Right Side (n: 54)		Left Side (n: 40)		
		Mean ± sd, n (%)	Median	Mean ± sd, n (%)	Median	*p*
Age (year)		56.1 ± 18.8	60.0	62.1 ± 15.1	62.0	0.100*
Sex (F/M)		26 (48) / 28 (52)		24 (60) / 16 (40)		0.299***
Height (m)		1.73 ± 0.09	1.75	1.69 ± 0.08	1.70	0.024*
Weight (kg)		77.5 ± 14.6	77.5	72.7 ± 13.5	71.0	0.112*
BMI (kg/m^2)		25.9 ± 4.1	25.8	25.5 ± 4.5	24.8	0.702**
ASA Score	I	6 (11.1)		3 (7.5)		0.602***
	II	42 (77.8)		30 (75.0)		
	III	6 (11.1)		7 (17.5)		
Hypertension		19 (35.2)		17 (42.5)		0.471***
Block performance duration (min)		5.83 ± 2.18	5.00	5.63 ± 1.75	5.00	0.813**
Sensory block onset time (min)		12.1 ± 6.2	10.0	10.5 ± 6.4	10.0	0.113**
Motor block onset time (min)		14.4 ± 6.6	15.0	13.0 ± 6.0	10.0	0.314**
Complete block onset time (min)		15.4 ± 6.6	15.0	13.3 ± 6.9	10.0	0.117**
Rescue analgesia need n (%)		7 (13.0)		4 (10.0)		0.659***
Duration of surgery (min)		122.6 ± 48.2	120.0	131.0 ± 45.2	120.0	0.270**
PACU duration (min)		67.5 ± 18.8	60.0	73.5 ± 30.3	60.0	0.362**

*Independent Samples *t*-test ,** Mann-Whitney U test, *** Chi-Square test.

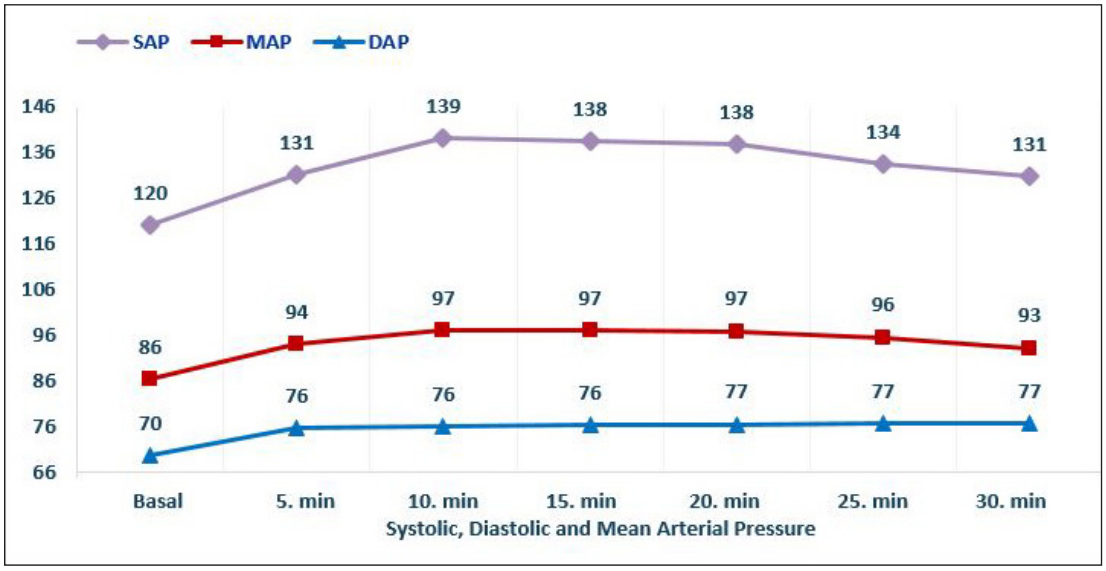

Figure 1. The change of systolic, diastolic, and mean arterial blood pressure by the measurement times.

increase in right-sided blocks was higher than the left-sided blocks. There were no differences in the mean heart rate or SpO_2 values.

Interscalene brachial plexus block was described almost a century before, and it is usually applied for surgeries in the shoulder or upper arm. It can be solely administered for anesthesia of the surgery, or frequently together with general anesthesia to supplement intraoperative or postoperative analgesia. In clinical practice, performing ISB under the guidance of ultrasound increases the block success rate by ensuring the observation of local anesthetic spread to C5 and C6 nerve roots[15].

The close proximity of the brachial plexus to important structures in the interscalene region causes many side effects associated with this approach[16,17]. These side effects include complications such as phrenic nerve paralysis, hoarseness, and Horner syndrome[18]. The reason for hoarseness and Horner's syndrome can be inadvertent recurrent laryngeal nerve block or stellate ganglion block by local anesthetic reaching these structures[19].

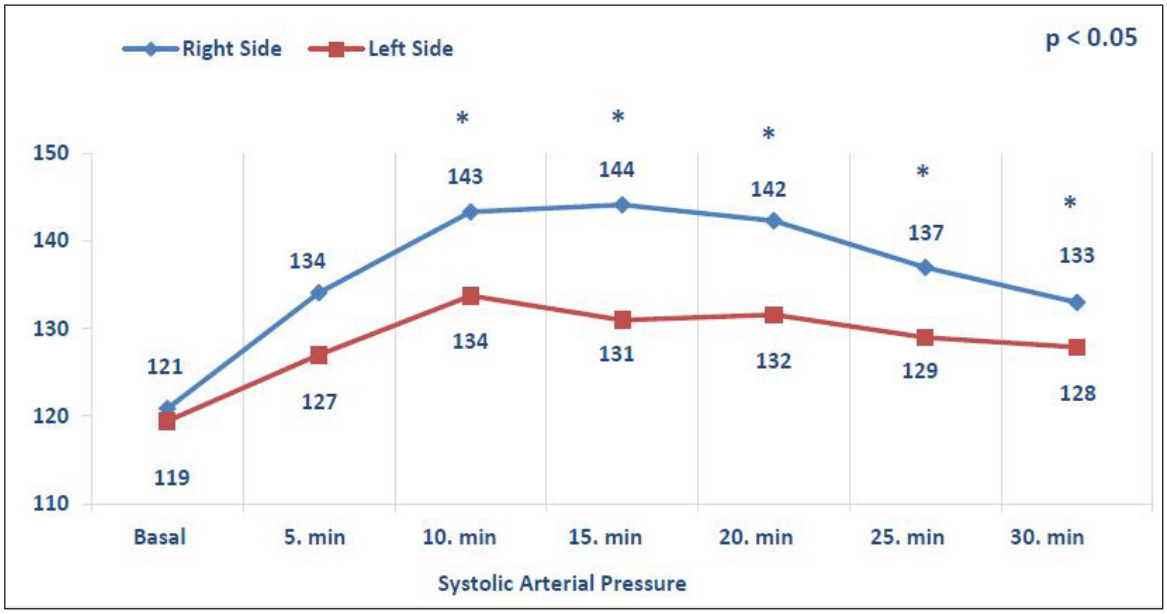

Figure 2. The change of systolic arterial blood pressure by the measurement times.

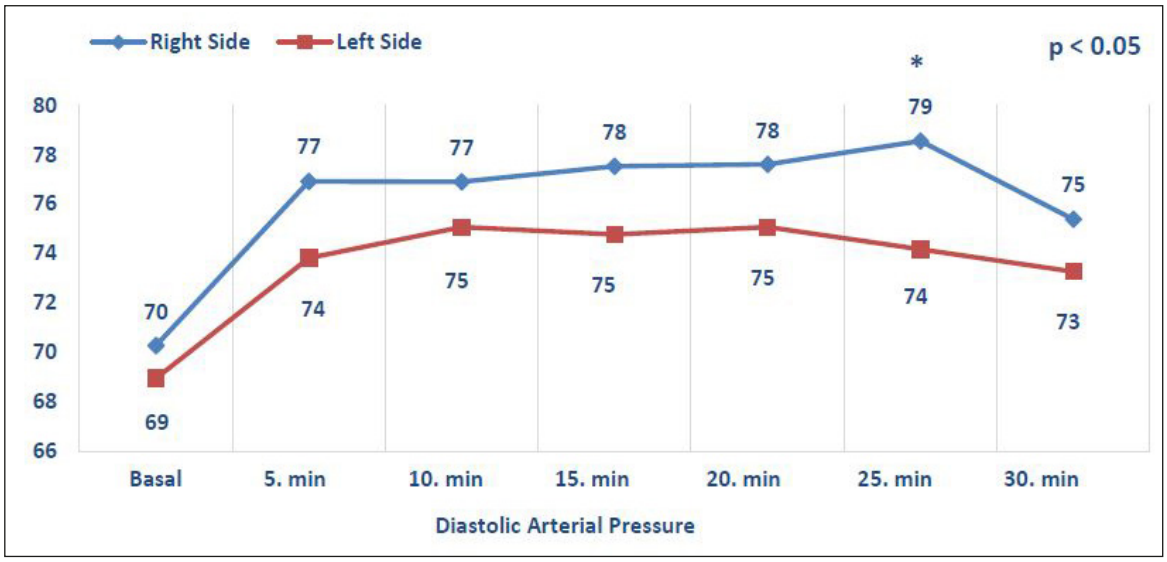

Figure 3. The change of diastolic arterial blood pressure by the measurement times.

The carotid sinus is a structure located at the base of the internal carotid artery, just at the bifurcation of internal and external carotid arteries, located at the level of the thyroid cartilage. The carotid sinus functions as a baroreceptor regulating blood pressure; its stimulation can decrease blood pressure by as much as 15%. In fact, there are evolving therapies to control blood pressure by stimulating the carotid sinus[20-22].

Therefore, inhibition of carotid sinus activity can be thought to lead to increases in blood pressure. The anatomical proximity of the carotid sinus to the local anesthetic injection site of the ISB may explain the clinical effects. We speculate that diffusion of even a small amount of local anesthetic for ISB to the carotid sinus may alter its function and eventually lead to temporary increases in blood pressure[23].

In the literature, although complications such as hypotension and bradycardia in a sitting position related to ISB are well emphasized, hypertension is not. The site of ISB application close to the carotid sinus baroreceptors can cause blockade of these receptors and can lead to neurogenic

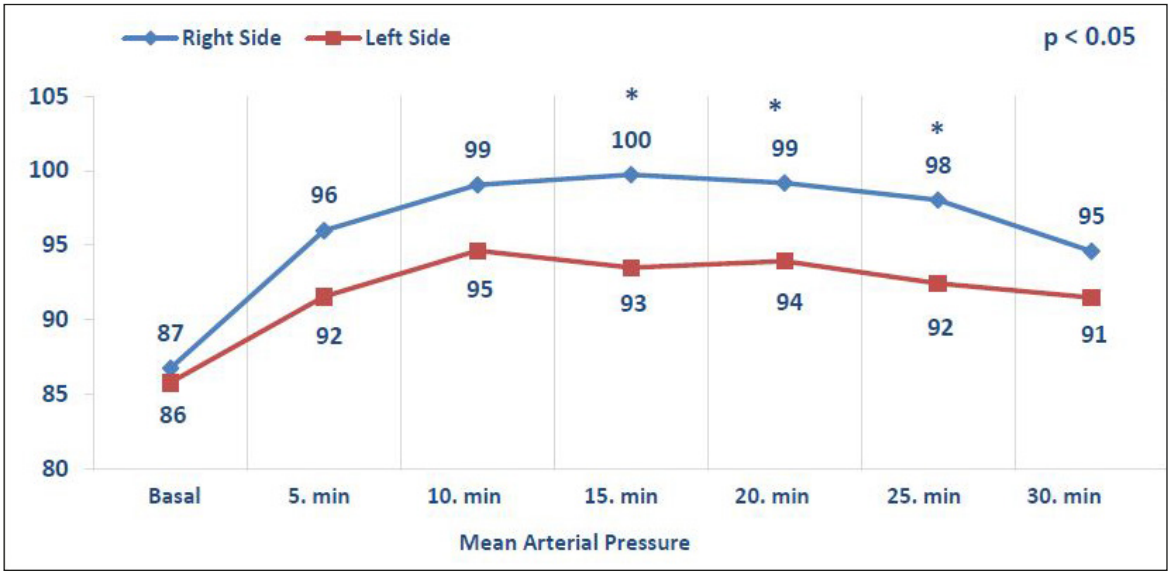

Figure 4. The change of mean arterial blood pressure by the measurement times.

hypertension. Carotid sinus baroreceptors are innervated by the Hering nerve, which is a branch of the glossopharyngeal nerve. There are a few reports on an accidental block of these nerves innervating the carotid and aortic baroreceptors and resulting hypertensive effects. In one of these reports, Kamel et al[4] shared their observation of hypertensive periods in two patients.

The first case was a 55-year-old male patient who had ISB for open reduction and internal fixation surgery of his left humerus shaft fracture. He had ISB with 15 ml lidocaine and 15 ml 0.5% bupivacaine mixture. Hypertension was observed from the 5th minute to the 25th minute. He had dysarthria and hoarseness together with hypertension; however, there were no respiratory problems or changes in the heart rate. The surgery was then performed under general anesthesia due to the hemodynamic instability.

The second patient was a 45-year-old male who had ISB with 1.5% lidocaine with epinephrine for repair of his olecranon fracture. He also had a hypertensive period starting from the 4th minute of the block and lasting until the 30th minute. He also did not have a change in heart rate. Authors[4] have postulated that a hypertensive period without tachycardia may have resulted from the blockade of carotid baroreceptors. They have concluded that hypertension without tachycardia after ISB should be accepted as an important complication.

In a different case report, an 80-year-old female patient at ASA 4 physical status had two times supraclavicular block with 40 ml of 0.25% bupivacaine and 10 ml 2% lidocaine + 10 ml 0.5% levobupivacaine mixture at two separate occasions[11]. Hypertensive episodes were observed after two blocks, and surgeries were canceled due to this hypertension. Authors have postulated that a one-sided carotid sinus block has initiated this hypertensive episode, and the contralateral baroreceptor reflex mechanism was unable to suppress the response.

Hernandez et al[12] applied ISB for shoulder surgery with 20-40 mL of 0.7% ropivacaine, 0.5% ropivacaine, or 1% mepivacaine + 0.25% bupivacaine before general anesthesia to 75 patients whose blood pressure and heart rate were normal during preoperative evaluation. They reported that 16% of these patients developed an increase in blood pressure without tachycardia 5-10 minutes after the procedure, and 50% of these patients needed hypertension treatment. The authors evaluated this situation as the carotid sinus baroreceptors may be blocked during ISB due to their proximity.

Gianesello et al[10] compared ultrasound and neurostimulation techniques to prevent hypertension after ISB in patients undergoing shoulder surgery. In this study, after the preoperative State-Trait Anxiety Inventory questionnaire was applied, 20 ml of 0.5% levobupivacaine-HCl (Group US) was administered to 15 patients under ultrasound guidance, and 40 ml of levobupivacaine-HCl 0.5% (Group NS) was administered to 15 patients with stimulator to perform ISB. Systolic blood pressure from the 15th minute to the 30th minute of block application, and diastolic blood pressure from the

10th minute to the 30th minute were significantly higher in the group using a stimulator than in the group using ultrasound. The authors[10] stated that the carotid sinus baroreceptor is innervated by a branch of the glossopharyngeal nerve, and that glossopharyngeal nerve damage is associated with transient hypertension in humans. In addition, they explained this situation as a high amount of LA spread, reducing the ability of baroreflex receptors to respond to blood pressure changes.

Previous findings[24] about the effects of ISB on heart rate and heart rate variability demonstrate that there are differences between the effects of right and left-sided blocks. They have concluded that ISB has a differential effect on the autonomic outflow to the heart, depending on the block side. Variation between the left and right sides was explained by the predominance of sympathetic autonomic cardiovascular outflow on the right, whereas parasympathetic dominance on the left. Thus, it is possible that a similar mechanism of action could be the reason for our findings demonstrating higher blood pressure values on the right-sided ISB. Local anesthetic reaching the right-sided carotid sinus may anesthetize the sinus and eventually inhibit its action of regulating increased blood pressure. Although a similar effect could be observed on the left side as well, it can be expected to be a smaller effect since sympathetic outflow predominance is right-sided.

Strengths and Limitations

The strengths of the current study are its well-defined patient population, the absence of epinephrine for the blocks, and its simple design, enabling researchers to reproduce the results easily. A limitation of the study could be that we did not know about the basal anxiety status of the patients before the study, which could have affected their sympathetic response to blocks. A second factor is the fact that we did not have information about the preoperative utilization of antihypertensive drugs on the operation day by hypertensive patients. So, if existed, the effects of these drugs could not be excluded.

Conclusions

In this study, patients who underwent ISB showed an increase in mean arterial pressure on both sides, with a more pronounced effect observed on the right side. No changes were observed in heart rate and respiratory parameters in these patients. These findings indicate that careful hemodynamic monitoring is necessary when hypertension should be avoided in the patients.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

No financial support was received from any institution or organization.

Ethics Approval

The study was approved by the Izmir Katip Celebi University Atatürk Training and Research Hospital Non-Interventional Ethics Committee (Protocol No.: 26.01.2023-0008).

Informed Consent

Informed consent was waived by the ethics committee in the study since the research is retrospective.

Data Availability

The data used and/or analyzed during the current study are available from the corresponding author.

Authors' Contributions

Conceptualization, DAY and AST; Data curation, MG, AST, and BEG; Formal analysis, DAY and MÇ; Investigation, DAY, AST, and MG; Methodology, DAY, MA, and MÇ; Resources, DAY and MG; Visualization, MG and BEG; Writing-original draft, DAY, MG, and AST; Writing-review & editing, DAY, AST, and MA. All authors have read and agreed to the published version of the manuscript.

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