

## Effects of controlled hypotension on regional cerebral oxygen saturation and cognitive function in hypertensive patients undergoing tympanoplasty

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### ABSTRACT

**Aims:** Controlled hypotension (CH) may impair tissue perfusion and inhibit autonomic regulation, potentially increasing the risk of cerebral ischemia in patients with hypertension due to altered autoregulation. This study aimed to compare the effects of CH on regional cerebral oxygen saturation (rSO<sub>2</sub>) and cognitive function in hypertensive and normotensive patients undergoing tympanoplasty.

**Methods:** Sixty patients (ASA physical status I-II, aged 18-63 years) scheduled for elective tympanoplasty between January 2018 and December 2018, after obtaining approval from the Clinical Research Ethics Committee were enrolled in this prospective study (Date: 09.01.2018, Decision No: 2017/0410). Patients were allocated into two groups: normotensive (Group N, n=30) and hypertensive (Group H, n=30). Demographic characteristics, hemoglobin and hematocrit levels, anesthesia and surgical durations, time to extubation, total remifentanyl consumption, additional analgesic requirements, and hemodynamic variables were recorded. Bilateral rSO<sub>2</sub> values (near-infrared spectroscopy), bispectral index (BIS), end-tidal carbon dioxide (EtCO<sub>2</sub>), body temperature, and inspired/expired sevoflurane concentrations were recorded at 5-minute intervals intraoperatively. Cognitive function was assessed using the Mini-Mental State Examination (MMSE) 24 hours preoperatively and at postoperative 6 and 24 hours.

**Results:** After achieving target blood pressure, mean arterial pressure (MAP) values were comparable between groups. Although hypertensive patients demonstrated greater reductions in blood pressure from baseline, rSO<sub>2</sub> values did not differ significantly between groups. No patient developed postoperative cognitive dysfunction (POCD) based on MMSE scores at 6 or 24 hours. The incidence of adverse events was similar between groups.

**Conclusion:** Within a defined MAP range, CH did not result in decreased rSO<sub>2</sub> or POCD in hypertensive patients. These findings suggest that CH may be safely applied in this patient population.

**Keywords:** Near-infrared spectroscopy, controlled hypotension, cognitive dysfunction

### INTRODUCTION

Hypotensive anesthesia involves the deliberate induction of controlled hypotension (CH) tailored to the patient's age, baseline blood pressure, and medical history. CH is defined as the intentional and reversible reduction of arterial blood pressure below baseline values while maintaining adequate cerebral, coronary, and renal perfusion.<sup>1</sup> It is commonly achieved by maintaining systolic blood pressure (SBP) at 80-90 mmHg and mean arterial pressure (MAP) at 50-65 mmHg.

Lowering arterial pressure reduces intraoperative bleeding and postoperative edema, improves surgical field visibility, and facilitates operative precision. Reduced bleeding also minimizes the need for traumatic hemostatic interventions and may limit tissue injury. CH is particularly advantageous in surgeries requiring a clear operative field, including middle ear surgery, endoscopic sinus surgery, plastic and reconstructive microsurgery, ophthalmic surgery, and neurosurgery. Tympanoplasty is one of the middle ear

procedures in which hypotensive anesthesia is frequently applied to reduce bleeding.

Despite its benefits, CH may compromise vital organ perfusion and contribute to tissue ischemia or autonomic dysfunction. In hypertensive patients, vascular structural changes and impaired autoregulation may increase susceptibility to cerebral hypoperfusion. In normotensive individuals, cerebral blood flow is generally preserved during moderate hypotension through autoregulatory mechanisms; however, this compensation may be impaired in patients with chronic hypertension, potentially increasing the risk of cerebral ischemia.<sup>2</sup> Therefore, careful intraoperative monitoring of end-organ perfusion is warranted.

Near-infrared spectroscopy (NIRS) is a noninvasive monitoring technique that provides continuous assessment of regional cerebral oxygen saturation (rSO<sub>2</sub>), representing the ratio of oxyhemoglobin to total hemoglobin, predominantly in the venous compartment. Although not routinely used in all procedures, NIRS has gained broader clinical application over the past two decades.<sup>3</sup> Its utility in detecting cerebral desaturation has been demonstrated in cardiac surgery, hypotensive anesthesia, and prolonged Trendelenburg positioning.<sup>4,5</sup>

Postoperative cognitive dysfunction (POCD) is defined as a decline in cognitive performance following surgery and anesthesia that may persist for weeks or months.<sup>6</sup> Clinical manifestations include memory impairment, psychomotor slowing, executive dysfunction, and mood disturbances. POCD is diagnosed using standardized neuropsychological testing and is considered a postoperative complication.<sup>7</sup> Prolonged or profound intraoperative hypotension is among the identified risk factors.

This study aimed to compare the effects of CH on rSO<sub>2</sub> and cognitive function in hypertensive and normotensive patients undergoing tympanoplasty, using continuous NIRS monitoring and perioperative Mini-Mental State Examination (MMSE) assessment. We hypothesized that CH would not result in a significant decrease in rSO<sub>2</sub> or deterioration in cognitive function in hypertensive patients compared with normotensive patients.

## METHODS

This prospective study was approved by the Clinical Researches Ethics Committee of İstanbul Medeniyet University Göztepe Training and Research Hospital (Date: 09.01.2018, Decision No: 2017/0410). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. The study was conducted between January 2018 and December 2018. Sixty patients aged 18-63 years with American Society of Anesthesiologists (ASA) physical status I-II scheduled for elective tympanoplasty were enrolled. Exclusion criteria included ASA physical status  $\geq$ III, age <18 or >65 years, known allergy to study medications, conditions affecting preoperative cognitive function, and a preoperative MMSE score  $\leq$ 23. All patients underwent preanesthetic evaluation and provided written informed consent. Patients were allocated into two groups

according to baseline blood pressure: normotensive (Group N) and controlled hypertensive (Group H). This was a non-randomized observational comparison, and group allocation was based on baseline blood pressure status. Standard monitoring included three-lead electrocardiography, heart rate, noninvasive systolic, diastolic, and MAP, peripheral oxygen saturation (SpO<sub>2</sub>), BIS). Bilateral NIRS sensors were applied to the frontal region to continuously measure rSO<sub>2</sub>. Intravenous access was established with a 20-gauge cannula, and isotonic crystalloid infusion was initiated. Premedication consisted of midazolam 1 mg intravenous (IV) and fentanyl 1  $\mu$ g/kg IV. After preoxygenation with 100% oxygen, anesthesia was induced with propofol 2 mg/kg IV and rocuronium 0.5 mg/kg IV. Following adequate neuromuscular blockade, endotracheal intubation was performed, and mechanical ventilation was initiated (tidal volume 7 mL/kg; respiratory rate 12 breaths/min). Anesthesia was maintained with 50% oxygen-air mixture and sevoflurane (target minimal alveolar concentration (MAC) 1-2), combined with remifentanyl infusion (0.05  $\mu$ g/kg/min in normotensive patients and 0.1  $\mu$ g/kg/min in hypertensive patients), titrated to achieve target MAP. If CH could not be achieved at remifentanyl doses up to 0.2  $\mu$ g/kg/min, esmolol infusion (50-300  $\mu$ g/kg/min) was planned as rescue therapy. Neuromuscular blockade was reversed at the end of surgery with neostigmine 0.03 mg/kg IV and atropine 0.015 mg/kg IV, and patients were extubated upon meeting standard criteria. Total remifentanyl consumption was recorded. Demographic data, ASA classification, body weight, hemoglobin and hematocrit levels, baseline vital signs, rSO<sub>2</sub>, and BIS values were documented. Hemodynamic parameters, rSO<sub>2</sub>, BIS, EtCO<sub>2</sub>, temperature, and inspired and expired sevoflurane fractions (FiSevo) were recorded after premedication, post-induction, post-intubation, and at 5-minute intervals intraoperatively. Anesthesia duration, surgical duration, time to discontinuation of anesthetic gases, time to extubation, total remifentanyl consumption, and additional analgesic requirements were recorded. Cognitive function was assessed using the MMSE at 24 hours preoperatively and at postoperative 6 and 24 hours. Intraoperatively, MAP was maintained between 65-70 mmHg using sevoflurane and remifentanyl infusion. If MAP decreased below 65 mmHg, hypotensive agents were reduced. Anesthesia depth was titrated to maintain BIS values between 40 and 60. Bradycardia was defined as heart rate <40 beats/min and treated with atropine 0.015 mg/kg IV if required. Ten minutes before the end of surgery, tramadol 1 mg/kg IV was administered for analgesia and metoclopramide 0.1 mg/kg IV for prophylaxis of nausea and vomiting. Patients with a visual analog scale (VAS) score >4 received paracetamol 10 mg/kg IV as rescue analgesia. Postoperative nausea and vomiting (PONV) were monitored; ondansetron 0.1 mg/kg IV was planned as rescue antiemetic therapy.

The primary outcome of the study was the comparison of intraoperative rSO<sub>2</sub> values between hypertensive and normotensive patients.

Secondary outcomes included postoperative cognitive function assessed by MMSE, intraoperative hemodynamic variables, anesthetic and analgesic requirements, and the incidence of perioperative adverse events.

Descriptive statistics were expressed as mean±standard deviation or median and interquartile range (IQR: Q1-Q3), as appropriate. Normality was assessed using histograms and the Kolmogorov-Smirnov test. Parametric variables were compared using the independent samples t-test, and nonparametric variables were analyzed using the Mann-Whitney U test. Categorical variables were compared using the chi-square test or Fisher's exact test. A p value <0.05 was considered statistically significant. All analyses were performed using IBM SPSS Statistics version 15.

## RESULTS

Between January 2018 and December 2018, a total of 60 patients completed the study, including 30 normotensive and 30 hypertensive patients. Comparison of demographic characteristics and laboratory parameters between groups demonstrated that patients in the hypertensive group were significantly older and had higher body weight compared with the normotensive group ( $p<0.05$ ). In addition, anesthesia duration, surgical duration, time to discontinuation of anesthetic gases, and total remifentanyl consumption were significantly greater in the hypertensive group ( $p<0.05$ ).

No significant differences were observed between groups with respect to other demographic or clinical variables ( $p>0.05$ ) (Table 1).

**Table 1.** Comparison of demographic characteristics and laboratory parameters between groups

	Groups			
		Group-N Mean±SD	Group-H Mean±SD	P
Age		31±9.4	40±13.8	0.006*
Weight		68±12.7	77±15.4	0.011*
ASA, n (%)	ASA 1	28 (93.3%)	23 (76.7%)	0.145
	ASA 2	2 (6.7%)	7 (23.3%)	
Hemoglobin		13.6±2.2	14.3±1.6	0.215
Hematocrit		40.6±5.5	43.0±4.5	0.067
Duration of anesthesia		102±31.1	126±29.9	0.004*
Duration of surgery		90±30.8	113±30.8	0.004*
Time to discontinuation of anesthetic gases		99±30.9	122±30.1	0.004*
Time to extubation		6±2.5	5±1.9	0.100
Total remifentanyl consumption		1002±579.3	151±838.9	0.008*
Additional analgesic requirement		80±16.5	86±16.3	0.151
Preoperative Mini-Mental Test score		28±1.6	28±1.4	0.746
Postoperative Mini-Mental Test score (6 <sup>th</sup> hour)		28±2.0	28±1.8	0.449
Postoperative Mini-Mental Test score (24 <sup>th</sup> hour)		28±1.7	28±1.8	0.413

SD: Standard deviation, ASA: American Society of Anesthesiologists

Comparison of SBP values between groups showed that median SBP at baseline (preinduction), after premedication, after induction, after intubation, after discontinuation of anesthesia, and after extubation was significantly higher in the hypertensive group than in the normotensive group ( $p<0.05$ ).

In addition, median SBP at postoperative 5 and 10 minutes remained significantly higher in hypertensive patients compared with normotensive patients ( $p<0.05$ ).

Heart rate (HR) values were compared between groups. Mean HR at baseline, after premedication, after induction, after intubation, after discontinuation of anesthesia, and after extubation was significantly higher in the hypertensive group compared with the normotensive group ( $p<0.05$ ).

Additionally, mean HR at 5, 10, 120, and 125 minutes after intubation was significantly higher in hypertensive patients ( $p<0.05$ ). No significant differences were observed between groups at other intraoperative time points ( $p>0.05$ ) (Tables 2 and 3).

Mean left rSO<sub>2</sub> values were compared between groups. In the hypertensive group, mean left rSO<sub>2</sub> at 50 minutes after intubation was significantly lower than in the normotensive group ( $p<0.05$ ).

No significant differences were observed between groups at other intraoperative time points ( $p>0.05$ ) (Table 3, Figure 1).

Mean right rSO<sub>2</sub> values did not differ significantly between the hypertensive and normotensive groups at any measured time point ( $p>0.05$ ) (Figure 1).

Median BIS values were also comparable between groups throughout the study period, with no statistically significant differences observed ( $p>0.05$ ) (Figures 1 and 2).

Mean MAC values were comparable between the hypertensive and normotensive groups, with no statistically significant differences observed ( $p>0.05$ ) (Figure 2).

Similarly, mean inspired FiSevo did not differ significantly between groups at any time point ( $p>0.05$ ).

Mean expired FeSevo was significantly higher in the hypertensive group at 125 minutes after intubation ( $p<0.05$ ). No other significant differences were observed between groups for FeSevo values ( $p>0.05$ ).

Median EtCO<sub>2</sub> values were comparable between groups, with no significant differences detected ( $p>0.05$ ). Mean body temperature values were also similar in both groups ( $p>0.05$ ).

Postoperative hemodynamic parameters were significantly higher in the hypertensive group. Mean systolic, diastolic, and MAP values at postoperative 5, 10, and 15 minutes were significantly greater in hypertensive patients compared with normotensive patients ( $p<0.05$ ).

Similarly, mean heart rate at postoperative 5, 10, and 15 minutes was significantly higher in the hypertensive group ( $p<0.05$ ).

A decrease of  $\geq 20\%$  from baseline in left rSO<sub>2</sub> was analyzed between groups, with no significant difference observed ( $p>0.05$ ) (Table 4).

**Table 2. Comparison of MAP values between groups**

	Groups		p
	Group-N	Group-H	
	Median (Q1-Q3)	Median (Q1-Q3)	
MAP baseline	92 (87-95)	108 (103-114)	<0.001*
Premedication	91 (85-95)	108 (103-110)	<0.001*
Induction	76 (71-84)	90 (77-97)	<0.001*
Intubation	103 (93-114)	115 (99-133)	0.017*
5 <sup>th</sup> min	84 (76-90)	96 (88-106)	<0.001*
10 <sup>th</sup> min	73 (68-79)	82 (73-91)	0.008*
15 <sup>th</sup> min	70 (65-77)	75 (68-82)	0.019*
20 <sup>th</sup> min	67 (65-76)	72 (68-79)	0.060
25 <sup>th</sup> min	70 (66-77)	71 (66-78)	0.641
30 <sup>th</sup> min	69 (66-73)	70 (68-75)	0.505
35 <sup>th</sup> min	69 (65-74)	70 (67-74)	0.381
40 <sup>th</sup> min	69 (65-73)	70 (66-75)	0.275
45 <sup>th</sup> min	67 (65-72)	67 (65-70)	0.899
50 <sup>th</sup> min	67 (65-70)	68 (65-71)	0.710
55 <sup>th</sup> min	66 (65-70)	69 (65-72)	0.135
60 <sup>th</sup> min	67 (65-70)	67 (65-69)	0.903
65 <sup>th</sup> min	66 (65-70)	67 (65-68)	0.861
70 <sup>th</sup> min	66 (64-69)	67 (65-70)	0.268
75 <sup>th</sup> min	67 (63-70)	69 (65-72)	0.488
80 <sup>th</sup> min	67 (64-73)	69 (65-73)	0.552
85 <sup>th</sup> min	67 (64-72)	68 (66-72)	0.816
90 <sup>th</sup> min	67 (65-69)	67 (65-71)	0.690
95 <sup>th</sup> min	67 (63-72)	67 (65-71)	0.852
100 <sup>th</sup> min	67 (64-71)	68 (65-73)	0.447
105 <sup>th</sup> min	68 (63-71)	71 (65-75)	0.150
110 <sup>th</sup> min	67 (60-75)	70 (66-75)	0.329
115 <sup>th</sup> min	68 (65-78)	67 (65-76)	0.966
120 <sup>th</sup> min	72 (68-75)	68 (66-73)	0.292
125 <sup>th</sup> min	70 (70-76)	69 (67-76)	0.605
130 <sup>th</sup> min	64 (53-74)	71 (65-77)	0.426
135 <sup>th</sup> min	65 (54-75)	70 (66-78)	0.521
140 <sup>th</sup> min	65 (54-76)	71 (67-82)	0.389
145 <sup>th</sup> min	66 (57-74)	71 (65-89)	0.359
150 <sup>th</sup> min	69 (58-79)	86 (68-97)	0.242
After discontinuation of anesthesia	82 (78-90)	94 (83-103)	0.010*
Extubation	95 (88-109)	105 (98-118)	0.008*

Mann-Whitney U test, \*p<0.05. MAP: Mean arterial pressure

Similarly, the incidence of a  $\geq 20\%$  reduction from baseline in right rSO<sub>2</sub> did not differ significantly between groups (p>0.05).

## DISCUSSION

In this study, we compared the effects of CH during elective tympanoplasty on intraoperative regional cerebral oxygenation and early and late postoperative cognitive function in hypertensive and normotensive patients. This topic is clinically important because hypertensive patients may have altered cerebral autoregulation, which could increase their vulnerability to cerebral hypoperfusion during

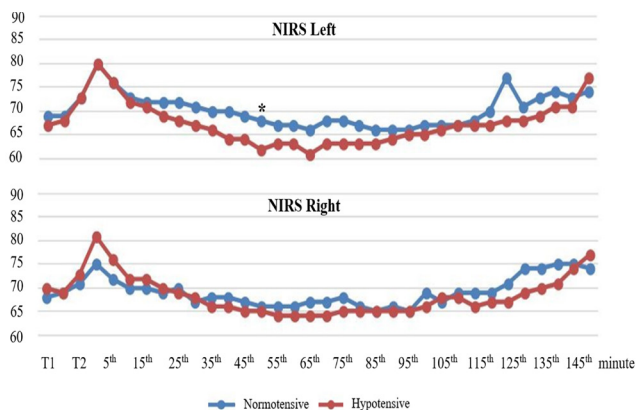
**Table 3. Comparison of heart rate values between groups**

	Groups		p
	Group-N	Group-H	
	Mean±SD	Mean±SD	
HR baseline	76±13	88±15	0.003*
Premedication	82±17	94±17	0.013*
Induction	78±13	87±14	0.009*
Intubation	89±13	100±17	0.009*
5 <sup>th</sup> min	83±12	91±14	0.014*
10 <sup>th</sup> min	78±11	85±15	0.046*
15 <sup>th</sup> min	75±11	80±16	0.166
20 <sup>th</sup> min	72±11	78±16	0.111
25 <sup>th</sup> min	68±10	73±15	0.125
30 <sup>th</sup> min	67±11	68±10	0.730
35 <sup>th</sup> min	65±10	66±10	0.651
40 <sup>th</sup> min	64±10	65±9	0.540
45 <sup>th</sup> min	63±9	64±9	0.659
50 <sup>th</sup> min	63±10	63±9	0.802
55 <sup>th</sup> min	62±10	62±7	0.949
60 <sup>th</sup> min	62±10	61±7	0.627
65 <sup>th</sup> min	62±9	60±7	0.370
70 <sup>th</sup> min	62±9	61±8	0.859
75 <sup>th</sup> min	62±10	61±8	0.811
80 <sup>th</sup> min	62±9	62±7	0.832
85 <sup>th</sup> min	60±7	62±7	0.305
90 <sup>th</sup> min	60±8	64±8	0.225
95 <sup>th</sup> min	60±7	63±6	0.249
100 <sup>th</sup> min	61±5	63±7	0.198
105 <sup>th</sup> min	60±5	64±7	0.068
110 <sup>th</sup> min	61±4	65±7	0.156
115 <sup>th</sup> min	61±6	65±7	0.127
120 <sup>th</sup> min	59±5	67±10	0.009*
125 <sup>th</sup> min	59±5	68±10	0.039*
130 <sup>th</sup> min	62±1	67±9	0.492
135 <sup>th</sup> min	63±1	64±9	0.779
140 <sup>th</sup> min	63±4	68±10	0.451
145 <sup>th</sup> min	62±4	71±12	0.385
150 <sup>th</sup> min	63±1	76±10	0.108
After discontinuation of anesthesia	76±20	89±24	0.027*
Extubation	90±13	102±18	0.005*

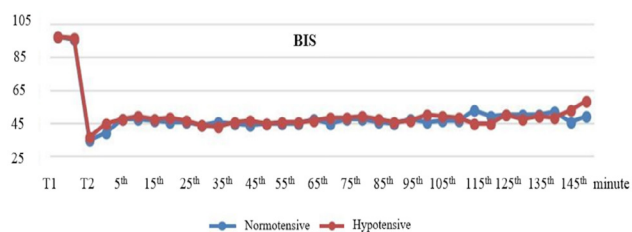
Independent samples t-test, p<0.05, SD: Standard deviation, HR: Heart rate

controlled hypotension. Although the reduction in blood pressure from baseline was greater in hypertensive patients, no significant differences were observed in NIRS-derived rSO<sub>2</sub> values between groups. Similarly, MMT scores were comparable, indicating no difference in early postoperative cognitive function.

Because a greater reduction in arterial pressure was required to reach target MAP in hypertensive patients, higher doses of remifentanyl were administered in this group. However, no additional hypotensive agent was required. Despite increased remifentanyl consumption, no clinically significant bradycardia requiring intervention or delay in extubation was observed.



**Figure 1.** Left and right Near-infrared spectroscopy regional cerebral oxygen saturation values according to study groups \*(p<0.05)



**Figure 2.** Bispectral index values according to study groups

**Table 4.** Comparison of postoperative blood pressure and heart rate values between groups

	Groups		P
	Group-N Mean±SD	Group-H Mean±SD	
MAP 5 <sup>th</sup> min	89±11.2	99±14.0	0.004*
10 <sup>th</sup> min	88±11.3	97±13.3	0.010*
15 <sup>th</sup> min	87±10.3	96±12.3	0.004*
5 <sup>th</sup> min <sup>a</sup>	99	99	0.115
10 <sup>th</sup> min <sup>a</sup>	99	99	0.078
15 <sup>th</sup> min <sup>a</sup>	99	99	0.055
HR 5 <sup>th</sup> min	80±12.0	88±16.6	0.022*
10 <sup>th</sup> min	78±11.5	88±16.2	0.008*
15 <sup>th</sup> min	75±10.7	88±15.3	0.001*

Independent samples t-test, Mann-Whitney U test p<0.05. SD: Standard deviation, MAP: Mean arterial pressure

CH is widely used in middle ear surgery to reduce intraoperative bleeding. Lower arterial pressure improves surgical field visibility, may shorten operative time, and may reduce procedure-related complications.<sup>8</sup> In procedures such as plastic, maxillofacial, and otorhinolaryngologic surgery, where rapid normalization of blood pressure may cause reactive bleeding, moderate hypotension with gradual onset and recovery is preferred.<sup>9</sup>

Nevertheless, concerns remain regarding the potential for vital organ hypoperfusion during deliberate hypotension.<sup>10-12</sup> This risk is particularly relevant in patients with chronic hypertension, in whom altered vascular structure and autoregulatory shifts may predispose to cerebral hypoperfusion.

Hypertensive patients represent a substantial proportion of the surgical population, and hypertension is a well-

established predictor of perioperative morbidity and mortality.<sup>13</sup> Even when blood pressure is medically controlled preoperatively, hypertensive patients are more prone to abrupt hemodynamic fluctuations during general anesthesia. Therefore, careful titration and hemodynamic stability are essential in this population. Ongoing investigations continue to evaluate whether maintaining MAP within a defined hypotensive range may predispose hypertensive patients to organ hypoperfusion.<sup>14</sup> Consequently, the application of CH in these patients raises concerns regarding potential adverse effects.

In normotensive individuals, cerebral blood flow is maintained independently of systemic pressure changes until MAP decreases to approximately 60 mmHg. In contrast, chronic hypertension leads to vascular remodeling, reduced arterial compliance, and a rightward shift of the cerebral autoregulatory curve, potentially impairing autoregulation.<sup>15</sup> Therefore, reducing MAP below a critical threshold in hypertensive patients may compromise cerebral perfusion.

CH is commonly defined as maintaining MAP between 50-65 mmHg. In a study by Erdem et al.,<sup>16</sup> MAP was maintained at 50-60 mmHg in 50 ASA I patients. Other studies have targeted MAP ranges of 60-70 mmHg during CH.<sup>17,18</sup> In a study by Nowak et al.,<sup>19</sup> 47 patients were stratified into mild (MAP >75 mmHg), moderate (65<MAP≤75 mmHg), and deep (MAP≤65 mmHg) hypotension groups.

In the present study, MAP was targeted at 65-70 mmHg. The desired MAP was achieved approximately 20 minutes after surgical incision. After reaching target levels, MAP values were comparable between groups. However, during the transition from baseline to steady-state hypotension, hypertensive patients exhibited significantly greater changes in MAP compared with normotensive patients.

Previous studies on controlled hypotensive anesthesia have primarily focused on intraoperative hemodynamic stability, postoperative recovery, and cognitive outcomes. Although several investigations have evaluated potential adverse effects of CH in hypertensive patients, we found no studies specifically assessing cerebral perfusion using NIRS in this population.

Kim et al.<sup>15</sup> investigated early hypertensive cerebrovascular changes in a rat model, examining cerebral morphological alterations and impaired vasodilation. Using magnetic resonance imaging techniques, they compared regional cerebrovascular characteristics between hypertensive and normotensive rats. Although global cerebral blood flow values were similar in both groups, hypertensive rats demonstrated lower regional cerebral arterial blood volume. In response to hypercapnia, hypertensive rats exhibited greater changes in cerebral blood flow, while arterial blood volume changes were comparable between groups.

In the present study, although greater reductions in blood pressure were required in hypertensive patients to achieve the same target MAP, no significant differences were observed in NIRS-derived rSO<sub>2</sub> values between groups. However, these findings should be interpreted with caution given the non-randomized design and potential confounding variables.

These findings suggest that within the MAP range maintained (65-70 mmHg), cerebral oxygenation was preserved despite larger hemodynamic fluctuations in hypertensive patients.

Potential impairment of organ perfusion-particularly cerebral perfusion-remains a major concern during controlled hypotension. Reduced rSO<sub>2</sub> reflects a mismatch between cerebral oxygen delivery and demand and may indicate compromised perfusion. NIRS is a noninvasive modality that provides continuous monitoring of regional cerebral tissue oxygenation and is considered a reliable surrogate of cerebral perfusion.

Rigamonti et al.<sup>20</sup> reported that decreases in rSO<sub>2</sub> correlated with electroencephalographic and clinical findings suggestive of cerebral ischemia, supporting NIRS as a simple and continuous noninvasive monitoring tool. Similarly, Kim et al.<sup>21</sup> demonstrated a correlation between rSO<sub>2</sub> and jugular venous oxygen saturation, a recognized reference method for assessing global cerebral oxygenation.

In a study by Erdem et al.,<sup>16</sup> CH in 50 ASA I normotensive patients resulted in reductions of more than 20% from baseline rSO<sub>2</sub> values; CH was discontinued when this threshold was reached. In contrast, Shear et al.<sup>22</sup> reported that maintaining MAP between 55-65 mmHg did not significantly affect NIRS values. Cox et al.,<sup>23</sup> evaluating patients undergoing shoulder arthroscopy in the beach-chair position, observed cerebral desaturation detected by NIRS and reported a correlation between intraoperative blood pressure and rSO<sub>2</sub> values.

In the present study, hypertensive patients required greater reductions in MAP from baseline to achieve the target range of 65-70 mmHg. This initially suggested a potential for greater impairment in cerebral perfusion and oxygenation compared with normotensive patients. However, despite larger blood pressure fluctuations, no significant differences in NIRS-derived rSO<sub>2</sub> values were observed between groups. These findings indicate that within the maintained MAP range, CH did not adversely affect regional cerebral oxygenation in hypertensive patients compared with normotensive individuals.

POCD is a potential concern associated with controlled hypotension. Murkin et al.<sup>24</sup> demonstrated that intraoperative cerebral desaturation was associated with postoperative cognitive decline, stroke, and prolonged hospital stay. Similarly, Li et al.<sup>25</sup> suggested that impaired rSO<sub>2</sub> may contribute to the development of POCD.

In a study by Nowak et al.,<sup>19</sup> cognitive function was assessed using the Stroop test, Trail Making Test, and verbal fluency test at baseline, postoperative 6 hours, and 30 hours. Although a decline in Stroop test performance was observed at 6 hours, this impairment resolved by 30 hours, and intraoperative hypotension did not appear to influence late psychometric outcomes. Choi et al.<sup>26</sup> evaluated cognitive function using the MMT preoperatively and at postoperative 1 week in 60 patients undergoing CH and found no evidence of postoperative cognitive decline.

Consistent with these findings, no cognitive impairment was detected in our study at postoperative 6 and 24 hours based on MMT scores. Moreover, no differences were observed between hypertensive and normotensive patients (postoperative 6 hours: 28±2.0 vs 28±1.8; postoperative 24 hours: 28±1.7 vs 28±1.8).

Various pharmacologic strategies may be used to achieve controlled hypotension. Choi et al.<sup>26</sup> compared nitroglycerin and nicardipine and reported no differences in cerebral oxygen saturation or postoperative cognitive outcomes between groups. Tirelli et al.<sup>18</sup> compared total intravenous anesthesia (TIVA) using propofol-remifentanyl with inhalational anesthesia using isoflurane-fentanyl and concluded that both techniques were safe for controlled hypotension; however, TIVA provided reduced bleeding and improved surgical field conditions, likely due to the selective arterial vasodilatory effects of propofol. Similarly, Eberhart et al.<sup>17</sup> compared propofol-remifentanyl with isoflurane-alfentanil and found no significant differences in blood pressure control; however, lower heart rates and improved surgical conditions were reported in the TIVA group.

In the present study, CH was achieved using sevoflurane combined with remifentanyl infusion. Hypertensive patients required significantly higher remifentanyl doses to reach target MAP (Group 1 vs Group 2: 1002±579.3 µg vs 1511±838.9 µg), yet no additional hypotensive agents were necessary.

Bradycardia is among the most common adverse effects associated with remifentanyl.<sup>27</sup> Despite higher remifentanyl consumption in hypertensive patients, no clinically significant bradycardia requiring intervention occurred.

Although increased opioid administration in hypertensive patients might theoretically delay emergence and extubation, no significant difference in extubation time was observed between groups (Group 1 vs Group 2: 6±2.5 min vs 5±1.9 min).

All patients received tramadol 1 mg/kg IV for postoperative analgesia. Additional analgesic requirements were comparable between groups (Group 1 vs Group 2: 80±16.5 mg vs 86±16.3 mg).

PONV is a common complication; however, no episodes were observed in our cohort. Prophylactic antiemetic therapy was administered to all patients due to tramadol use.

## Limitations

Several limitations should be acknowledged. First, this study was not randomized, and patient allocation was based on baseline blood pressure status, which may introduce selection bias and limit the internal validity of the findings.

Second, operative and anesthesia durations were longer in hypertensive patients (surgical duration: 90±30.8 min vs 113±30.8 min; anesthesia duration: 102±31.1 min vs

126±29.9 min). This may be attributable to the additional time required to achieve target blood pressure and potentially reduced surgical visibility during this period. Although the mean difference was approximately 20 minutes, we do not believe this interval was clinically sufficient to influence intraoperative rSO<sub>2</sub> or postoperative cognitive outcomes.

Third, cognitive function was assessed using the MMT alone. Although widely used, the MMT may not detect subtle cognitive changes. The lack of a comprehensive neuropsychological test battery may have limited the sensitivity for detecting mild postoperative cognitive dysfunction.

Additionally, potential confounding factors such as differences in intraoperative anesthetic requirements, hemodynamic variability, and duration of surgery between groups may have influenced the outcomes and should be considered when interpreting the results.

## CONCLUSION

In this study evaluating the effects of CH during tympanoplasty in hypertensive patients, no differences were observed compared with normotensive patients in terms of intraoperative rSO<sub>2</sub> or early and late postoperative cognitive function. Although hypertensive patients required greater reductions in blood pressure and higher remifentanyl doses to achieve target MAP, no increase in clinically significant bradycardia, delayed extubation, or PONV was observed. Within a MAP range of 65-70 mmHg, CH did not result in decreased rSO<sub>2</sub> or cognitive dysfunction in hypertensive patients. However, these findings should be interpreted cautiously due to the methodological limitations of the study, including the non-randomized design and limited cognitive assessment. Therefore, while CH appears to be feasible in this patient population under careful monitoring, further randomized controlled studies with more comprehensive cognitive evaluation are needed to confirm these findings.

## ETHICAL DECLARATIONS

### Ethics Committee Approval

This study was approved by the Clinical Researches Ethics Committee of İstanbul Medeniyet University Göztepe Training and Research Hospital (Date: 09.01.2018, Decision No: 2017/0410).

### Informed Consent

Written informed consent was obtained from all individual participants prior to their inclusion in the study. Participants were fully informed about the study's aims, procedures, potential risks and benefits, and their rights-including the right to withdraw at any time without consequence. All participants voluntarily signed a written informed consent form.

### Peer Review Process

This manuscript was subject to external peer review.

## Conflict of Interest

The authors declare no conflicts of interest related to this study.

## Financial Disclosure

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## Author Contributions

Concept and Study Design: CYA, SG; Data Collection: CYA; Manuscript Drafting: CYA, HAS; Critical Revision of the Manuscript: SG; Final Approval of the Manuscript: All Authors

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