Effects of Controlled Hypotension on Postoperative Cognitive Outcomes Following Nasal Surgery

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ABSTRACT

Objective: To assess the impact of varying levels of controlled hypotension on cerebral oxygenation and examine their association with postoperative delirium and cognitive dysfunction among individuals undergoing rhinoplasty or septoplasty.

Study Design: A randomised double-blind study.

Place and Duration of the Study: Department of Anaesthesiology and Reanimation, Faculty of Medicine, Hitit University, Corum, Turkiye, between May and August 2024.

Methodology: Seventy ASA (American Society of Anesthesiologists) I–II patients (aged 18-65 years) undergoing elective rhinoplasty or septoplasty were randomly assigned to two equal groups. Group A (n = 35) received anaesthesia with a target mean arterial pressure (MAP) of 50-57 mmHg, and Group B (n = 35) with 58-65 mmHg. Assessment of cognitive function and delirium was conducted using the Mini-Mental Test (MMT) and the Delirium Rating Scale-Revised-98 (DRS-R-98). Continuous variables were analysed using the independent samples t-test, Mann–Whitney U test, or Friedman test, depending on data distribution. Categorical variables were compared using the Chi-square test. A $p < 0.05$ was considered statistically significant.

Results: Delirium was significantly more frequent in Group A than in Group B within the recovery unit (31.4% *vs*. 5.7%, $p < 0.05$). DRS-R-98 scores were also notably higher in Group A than in Group B during both recovery and at the 24-hour mark ($p < 0.05$). There were no statistically significant differences identified between the groups in MMT scores at 24 hours ($p = 0.100$), 7 days ($p = 0.457$), or 3 months ($p = 0.114$). Prolonged operative duration emerged as an independent risk factor for delirium in the recovery phase ($p < 0.05$).

Conclusion: Controlled hypotension with MAP levels reduced to 50 mmHg appears to be safe with respect to medium- and long-term cognitive outcomes. However, the increased rate of early postoperative delirium in this group highlights the importance of close neurological monitoring during the immediate recovery period.

Key Words: *Controlled hypotension, Cerebral oxygenation, Delirium, Cognitive dysfunction, Rhinoplasty, Septoplasty*.

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INTRODUCTION

Nasal obstruction is one of the most common complaints in clinical rhinology practice, with nasal septum deviation being a primary aetiological factor.[1] Consequently, surgical interventions such as septoplasty or rhinoplasty are frequently performed to alleviate this condition. A primary challenge in these procedures is bleeding, which can obscure the surgical field, extend operative time, and increase the risk of complications.

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Controlled hypotension is a well-established anaesthetic strategy used to limit blood loss, improve visibility and reduce transfusion requirements.[2] The technique generally entails reducing systolic blood pressure to 80-90 mmHg and mean arterial pressure to 50-65 mmHg, or by 30-50% from baseline values.[3]

Controlled hypotension is routinely applied across various surgical fields. During its use, maintaining adequate perfusion to vital organs remains essential.[4]

Cognitive impairments, including syndromes such as delirium and dementia, are frequently assessed in the postoperative setting. Postoperative cognitive dysfunction (POCD) refers to a decline in memory, attention or concentration ability following the surgery, typically identified through neuropsychological testing.[5] This condition may persist from several days to even years after the operation, with increased prevalence observed among older adults.[6]

Delirium is an acute-onset cognitive disorder with fluctuating symptoms.[7] Frequently encountered in intensive care and postoperative settings, it is characterised by impaired attention and perception.[8] Effective prevention and management necessitate the recognition of underlying aetiologies and the timely implementation of appropriate interventions.[9] Prevention and management of delirium require identifying underlying causes and implementing appropriate interventions.[10]

This study aimed to evaluate the effects of controlled hypotension during rhinoplasty and septoplasty, with a particular focus on cerebral perfusion and postoperative cognitive outcomes. The primary aim was to assess whether cerebral oxygenation declines as mean arterial pressure (MAP) approaches 50 mmHg during controlled hypotension. The secondary objective was to examine whether reduced oxygenation correlates with increased rates of POCD and delirium. While cognitive dysfunction and delirium have been widely studied in elderly patients owing to their higher incidence, these complications have received limited attention in younger individuals. In clinical practice, younger patients are often considered to be at lower risk, and the potential impact of reduced blood pressure on their cerebral function is frequently overlooked. However, adequate cerebral perfusion remains essential across all age groups. This research was designed in response to the concern that insufficient attention to blood pressure targets in younger patients may contribute to adverse cognitive outcomes and aims to raise awareness of this possibility within anaesthetic practice.

METHODOLOGY

This randomised double-blinded study was conducted prospectively at the Department of Anaesthesiology and Reanimation, Faculty of Medicine, Hitit University, Corum, Turkiye, between May and August 2024. Ethical approval was granted by the Ethics Committee of Hitit University (Decision No. 2023-101; Dated: 13 September 2023), and the study was registered on ClinicalTrials.gov (Registration No. NCT0623 8973; Dated: 23 January 2024). Written informed consent was secured from all participants, with the study conducted in line with the Declaration of Helsinki.

Adults aged 18 to 65 years with ASA physical status I or II, scheduled for elective rhinoplasty or septoplasty under general anaesthesia, were enrolled in the study. Patients with a history of hypertension, diabetes, significant cardiac, pulmonary, renal, hepatic or cerebrovascular disease, hypovolemia, or conditions contraindicating controlled hypotension — such as coagulopathy, valvular heart disease, or emergency surgery — were excluded. Patients scoring ≤23 in the preoperative Mini-Mental State Examination (MMSE) were also excluded. Participants were consecutively enrolled and randomly allocated to one of two groups (n = 35 each) *via* an independent web-based randomisation tool. Group A was managed with a MAP target of 50-57 mmHg, while Group B with 58-65 mmHg. Blinding was maintained for both patients and perioperative evaluators.

Standard intraoperative monitoring included non-invasive blood pressure, electrocardiogram, SpO_2, and heart rate. Cerebral oxygenation was assessed with near-infrared spectroscopy (NIRS) *via* O_3 Sensor rSO_2 probes (Masimo Corp., Irvine, USA) placed bilaterally on the forehead. Baseline values were recorded during spontaneous breathing with 80% FiO_2 prior to induction. Anaesthetic depth was monitored using an entropy sensor (Entropy EasyFit Sensor, GE Healthcare, Finland) positioned on the non-dominant side. NIRS, entropy, MAP, SpO_2, heart rate, and urine output were documented at induction and every 30 minutes thereafter. Following a positive Allen's test, a radial artery catheter was inserted to monitor blood pressure and perform arterial blood gas analysis. Lactate was measured at baseline, 4 hours intraoperatively and at the end of the surgery.

Anaesthesia was induced with 0.5 mg/kg lidocaine (Lidon 100 mg/5 ml, Onfarma Ilac Sanayi Ltd. Sti., Samsun), 2 mg/kg propofol (1%, Fresenius Kabi, Hamburg, Germany), 0.6 mg/kg rocuronium (Esmeron 10 mg/ml, Merck Sharp & Dohme, Whitehouse Station, USA), and 1 µg/kg fentanyl (Fentanyl-PF 100 µg/2 ml, Polifarma Ilac San. ve Tic. A.S., Ergene/Tekirdag). Remifentanil (Ultiva 5 mg, GlaxoSmithKline, Finland) was infused continuously at 0.05-0.3 µg/kg/min. After confirmation of neuromuscular blockade, intubation was performed using a 7.0-7.5 mm ID tube in females and 8.0-8.5 mm in males.

Target MAP levels were maintained using sevoflurane at 0.5-1 MAC in a 40% oxygen/air mixture, alongside remifentanil infused at 0.05-0.3 µg/kg/min. Ventilation was delivered in pressure-controlled volume-guaranteed mode with tidal volume of 6-8 ml/kg, respiratory rate of 12-14/min, FiO_2 at 40%, an I:E ratio of 1:2, PEEP of 5-8 cmH_2O, and end-tidal CO_2 maintained between 35-40 mmHg. Esmolol was administered at 25-200 µg/kg/min when adequate blood pressure control was not achieved despite sufficient anaesthesia depth.

Postoperative analgesia and antiemesis included tramadol (1 mg/kg), paracetamol, and ondansetron (0.15 mg/kg). Following the discontinuation of inhalational anaesthesia, patients were ventilated with 80% oxygen at 4-6 L/min. Once spontaneous breathing resumed, sugammadex (2 mg/kg) was given to reverse neuromuscular blockade. Extubation was performed when patients regained sufficient muscle strength and could follow verbal commands.

Following the surgery, patients were transferred to the recovery unit for routine monitoring. When a modified Aldrete score greater than 9 was achieved, the Delirium Rating Scale-Revised-98 (DRS-R-98) test was administered, and patients were subsequently moved to the ward. At 24 hours postoperatively, cognitive function was evaluated using the MMT, and delirium was re-evaluated with the DRS-R-98. Patients diagnosed with delirium were referred to psychiatric services.

Follow-up assessments were conducted on postoperative day 7 and at 3 months. Patients attending these evaluations were re-assessed using the MMT, and the results were recorded to monitor long-term cognitive status.

Table I: Demographic and clinical characteristics.

Variables	Group A (n = 35)	Group B (n = 35)	p-values
Age (years)			
Median (IQR)	31 (21)	33 (23)	0.855*
Gender			
Male [n (%)]	11 (31.4)	13 (37.1)	0.615**
Female [n (%)]	24 (68.6)	22 (62.9)	
ASA score			
ASA I [n (%)]	10 (28.6)	6 (17.1)	0.393**
ASA II [n (%)]	25 (71.4)	29 (82.9)	
BMI (kg/m^2)			
Mean ± SD	27.34 ± 3.80	27.74 ± 4.20	0.678***
Operating time			
Mean ± SD	145.97 ± 52.44	122 ± 46.54	0.055***
Surgical Type			
Rhinoplasty [n (%)]	2 (5.7)	2 (5.7)	>0.99**
Septoplasty [n (%)]	33 (94.3)	33 (94.3)	
Preoperative systolic BP			
Median (IQR)	128 (14)	128 (15)	0.755*
Preoperative diastolic BP			
Mean ± SD	75.51 ± 4.85	73.49 ± 7.74	0.194***
Preoperative MAP			
Mean ± SD	94.89 ± 4.86	92.74 ± 7.13	0.146***
Preoperative heart rate			
Median (IQR)	81 (19)	78 (9)	0.147*

*BMI: Body mass index; BP: Blood pressure, *Mann-Whitney U test, **Chi-square test, ***Student t-test.*

Table II: Findings on delirium development between groups.

Variables	Patient group		p-values
	Group A n (%)*	Group B n (%)*	
Recovery delirium			
Absent	24 (68.6)	33 (94.3)	**0.014****
Present	11 (31.4)	2 (5.7)	
24^{th} hour delirium			
Absent	31 (88.6)	35 (100)	0.122**
Present	4 (11.4)	0 (0)	

**Column percentages. **p-value of the Chi-square test. p <0.05 was considered statistically significant.*

Table III: Findings on delirium assessment in the recovery unit.

Variables	Recovery delirium		p-values
	Absent	Present	
Operating time (minutes)			
Median (IQR)	130 (60)	170 (64)	**0.013***
Mean MAP			
Median (IQR)	59.67 (7.33)	56.20 (2.08)	0.230*
Serum lactate level (mmol/L)			
Median (IQR)	1.12 (0.65)	1.19 (0.58)	0.946*

**p-value of the Mann-Whitney U test; p <0.05 was considered statistically significant.*

Statistical analyses were conducted using IBM SPSS version 26. Categorical variables were summarised as frequencies and percentages, while continuous data were expressed as mean ± SD or median (IQR), depending on distribution. Normality was assessed using histograms, probability plots, the Kolmogorov–Smirnov test, and the Shapiro–Wilk test. Group comparisons employed the independent samples t-test or the Mann–Whitney U test, as appropriate. For repeated measures, the Friedman test was used based on data distribution. The Chi-square test was used for categorical comparisons. Statistical significance was set at p <0.05.

RESULTS

Eligibility was assessed in 103 patients. Thirty-three did not meet the inclusion criteria, 21 had hypertension, six had chronic obstructive pulmonary disease, and three were classified as ASA III. An additional three patients declined participation. The remaining 70 patients were randomised equally into two groups (n = 35 each). All allocated interventions were delivered as planned, and no participants were lost to follow-up or excluded. Demographic and clinical variables did not differ between the groups (Table I).

MMT scores demonstrated a significant decline at 24 hours postoperatively in both groups [Group A: 26 (IQR: 4); Group B: 28 (IQR: 3)], followed by improvement by the 7^{th} postoperative day [Group A: 28 (IQR: 3); Group B: 28 (IQR: 2)], and a near return to baseline values by day 90 [Group A: 29 (IQR: 2); Group B: 29 (IQR: 2)]. Intragroup comparisons conducted using the Friedman test confirmed statistically significant

changes over time ($p < 0.001$), particularly between the 24-hour and 7th-day measurements. Intergroup comparisons revealed no statistically significant differences at any of the measured time points ($p > 0.05$).

DRS-R-98 scores increased significantly in both groups during the immediate recovery phase [Group A: 14 (IQR: 11); Group B: 9 (IQR: 8)] compared to baseline values [Group A: 0 (IQR: 1); Group B: 0 (IQR: 1)], indicating the onset of postoperative delirium ($p < 0.001$ for both groups, Friedman test). Although a marked reduction was noted by the 24th postoperative hour [Group A: 6 (IQR: 4); Group B: 4 (IQR: 4)], scores remained elevated relative to preoperative levels. Between-group comparisons revealed significantly higher DRS-R-98 scores in Group A during both the recovery period ($p = 0.013$) and at 24 hours postoperatively ($p = 0.003$), suggesting greater severity or persistence of delirium symptoms in this group.

Table II compares delirium incidence between groups at recovery and 24 hours postoperatively. Delirium was significantly more frequent in Group A during recovery, while no difference was observed at 24 hours.

Lactate levels exhibited statistically significant intra-group changes over time in both Group A and Group B. In Group A, median lactate concentrations were 1.01 mmol/L (IQR: 0.50) at baseline, 1.05 mmol/L (IQR: 0.76) at the end of surgery, and 1.25 mmol/L (IQR: 0.48) at 24 hours postoperatively ($p < 0.001$). In Group B, the respective values were 0.96 mmol/L (IQR: 0.57), 1.18 mmol/L (IQR: 0.40), and 1.20 mmol/L (IQR: 0.64) ($p = 0.012$). Between-group comparisons revealed no statistically significant differences in lactate levels at any time point ($p > 0.05$ for all). The median serum lactate level in the recovery room was 1.12 mmol/L (IQR: 0.65) in patients without delirium and 1.19 mmol/L (IQR: 0.58) in those with delirium ($p = 0.946$).

Table III shows the relationship between recovery-phase delirium and perioperative variables. Delirium was significantly associated with longer operating time, while MAP showed no significant difference.

DISCUSSION

Controlled hypotension refers to the intentional reduction of arterial blood pressure, typically to a systolic pressure of 80–90 mmHg and a MAP of 50–65 mmHg, to reduce intraoperative bleeding and improve surgical field visibility.[11] First introduced by Harvey Cushing in 1917, it has since become a common technique in procedures prone to significant bleeding.[12]

Obata *et al.* demonstrated that prolonged intraoperative hypotension below MAP thresholds of 70-80 mmHg was independently associated with postoperative delirium in elderly patients undergoing major head and neck surgery.[13] Similarly, the present study observed higher incidence of early postoperative delirium in patients managed with deeper levels of hypotension, despite involving a younger cohort and less invasive procedures.

Wachtendorf *et al.* retrospectively analysed a cohort of over 300,000 patients who underwent noncardiac surgery and demonstrated that intraoperative hypotension, defined as a MAP below 55 mmHg, was associated with a duration-dependent increase in the risk of postoperative delirium.[14] Prolonged hypotensive episodes were found to be particularly significant in elevating this risk. In contrast to this large and heterogeneous population, the present study focused on a younger, low-risk cohort undergoing elective nasal surgery in the context of controlled hypotension. Despite the demographic and procedural differences, a comparable trend emerged. Patients managed with lower MAP targets of 50–57 mmHg exhibited significantly higher DRS-R-98 scores during the early postoperative period, indicating a transient increase in delirium risk.

Lizano-Díez *et al*. reviewed recent literature and identified consistent associations between perioperative hypotension and adverse outcomes, including mortality, acute kidney injury, and delirium.[15] Even brief deviations from the baseline values were also linked to increase the risk of adverse outcomes. These findings highlighted the importance of maintaining stable blood pressure, regardless of patient age or surgical risk. The current study supported this evidence, demonstrating that lower MAP targets were associated with higher early postoperative delirium scores, suggesting that hypotension may compromise cerebral perfusion even in low-risk populations.

Feng *et al*. conducted a meta-analysis of five randomised control trials (RCTs) and found no significant association between intraoperative hypotension and POCD, while a non-significant trend towards increased delirium was observed in low MAP groups.[16] In line with their findings, the present study did not identify POCD in either group. However, patients exposed to lower MAP targets demonstrated higher early postoperative DRS-R-98 scores, indicating a transient increase in delirium risk.

Lee *et al*. investigated the relationship between lactate levels and delirium in patients underwent trauma surgery by measuring both preoperative and postoperative (1-hour postoperative) lactate levels.[17] A linear association was identified, with significantly higher baseline and 1-hour postoperative lactate levels in patients who developed delirium compared to those who did not. In contrast, the present study found no significant differences in lactate levels between patients with and without delirium.

Nowak *et al*. examined cognitive outcomes following controlled hypotension in 47 patients undergoing sinus surgery, stratified by hypotension severity.[18] While all groups showed impaired Stroop A performance at 6 hours postopera-

tively, scores normalised by 30 hours, with no significant changes in Stroop B, TMT, or VFT. In the present study, MMT scores declined at 24 hours postoperatively in Group A but improved in both groups by day 7.

Ravi *et al*., in a large-scale study involving 68,131 patients undergoing hip fracture repair, demonstrated that prolonged operative time was linked to higher risk of postoperative delirium.[19] Specifically, each successive 30-minute extension of the procedure was linked to a 6% rise in delirium incidence. In the present study, the mean operative time among patients who developed delirium was 168 minutes, compared with 126 minutes in those who did not. The difference reached statistical significance ($p = 0.013$).

One of the limitations of this study was that rhinoplasty and septoplasty were primarily performed on younger patients; therefore, elderly patients were not included. Previous studies have shown that postoperative delirium and cognitive dysfunction are more prevalent in elderly populations.[20] However, the significant association between delirium diagnosis in the recovery unit and low blood pressure in this study suggests that factors other than age should not be overlooked in delirium development. As septoplasty and rhinoplasty are predominantly performed in younger to middle-aged populations, whereas cognitive complications such as delirium and postoperative dysfunction are more prevalent among older individuals, these findings highlight the need for future studies with larger, more age-diverse cohorts. Such research will be instrumental in defining the safe lower limits of MAP during controlled hypotension and elucidating its potential relationship with postoperative morbidity.

CONCLUSION

This study demonstrated that maintaining MAP as low as 50 mmHg did not result in significant differences in delirium or cognitive dysfunction over the medium to long term, suggesting that controlled hypotension at this level may not pose a cognitive risk. However, a higher incidence of delirium was noted in the 50-57 mmHg MAP group during the immediate postoperative recovery period; although, this difference was no longer evident at the 24-hour assessment, indicating that early postoperative delirium may not affect the duration of hospital stay.

ETHICAL APPROVAL:
The study was approved by the Ethics Committee of Hitit University, Corum, Turkiye (Approval No. 2023-101; Dated: 13 September 2023) prior to the initiation of the research. The study was registered on ClinicalTrials.gov (Registration No. NCT06238973, dated 23 January 2024). All procedures adhered to the ethical standards of the Declaration of Helsinki.

PATIENTS' CONSENT:
Written informed consent was obtained from all participants for the publication of their anonymised clinical data.

COMPETING INTEREST:
The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:
MK, SK, GD: Investigation, validation, formal analysis, data curation, writing, review, and editing.
MTK, MEB: Conceptualisation, supervision, project administration, methodology, writing of the original draft, validation, review, and editing.
OY: Investigation, methodology, writing of the original draft, review, and editing.
All authors approved the final version of the manuscript to be published.

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