Doi: 10.5152/TJAR.2018.36786

Original Article
General Anaesthesia

Turkish Journal of Anaesthesiology & Reanimation

# Comparison of the Effects of Minimal and High-Flow Anaesthesia on Cerebral Perfusion During Septorhinoplasty

Leyla Kazancıoğlu[1], Şule Batçık[1], Başar Erdivanlı[1], Ahmet Şen[1], Engin Dursun[2]
[1]Department of Anaesthesiology and Reanimation, Recep Tayyip Erdoğan University School of Medicine, Rize, Turkey
[2]Department of Otorhinolaryngology, Recep Tayyip Erdoğan University School of Medicine, Rize, Turkey

***ORCID IDs of the authors:*** L.K. 0000-0002-3833-0692; Ş.B. 0000-0003-1110-6786; B.E. 0000-0002-3955-8242; A.Ş. 0000-0001-8981-6871; E.D. 0000-0002-2070-8677

***Cite this article as:*** Kazancıoğlu L, Batçık Ş, Erdivanlı B, Şen A, Dursun E. Comparison of the Effects of Minimal and High-Flow Anaesthesia on Cerebral Perfusion During Septorhinoplasty. Turk J Anaesthesiol Reanim 2019; 47(1): 12-6.

## Abstract

**Objective:** The aim of this study was to analyse the effects of minimal-and high-flow anaesthesia on cerebral oxygenation during septorhinoplasty with controlled hypotension using near-infrared spectroscopy.

**Methods:** Eighty patients scheduled for septorhinoplasty under general anaesthesia with controlled hypotension were randomised into two groups: minimal-flow (MF) or high-flow (HF). Both groups received desflurane anaesthesia to maintain bispectral index values at 40%-50% and 0.25-0.5 μg $kg^{-1}$ $min^{-1}$ i.v. remifentanyl infusion to maintain mean arterial blood pressure between 55 and 65 mmHg. The MF group received 5 L $min^{-1}$ of fresh gas flow for the first 10 mins then the gas flow was reduced 0.4 L $min^{-1}$. The HF group received 2 L $min^{-1}$ of fresh gas flow throughout. Haemodynamic parameters and cerebral oxygen saturation were measured.

**Results:** There were no statistical differences in demographic variables, duration of anaesthesia and surgery, time to extubation and proceeding to an Aldrete score of 9. There were no statistical differences in haemodynamic parameters, end-tidal $CO_2$ and cerebral oxygen saturation. The amount of desflurane used in the MF group was significantly lower than that used in the HF group (30.5±9.8 mL vs. 48.5±12.1 mL; $p<0.05$).

**Conclusion:** MF and HF anaesthesia did not lead to any difference in cerebral oxygen saturation in patients undergoing septorhinoplasty with controlled hypotension. MF anaesthesia may thus be used as safely as HF anaesthesia is.

**Keywords:** Cerebral oxygen saturation, controlled hypotension, minimal-flow anaesthesia, near-infrared spectroscopy, septorhinoplasty

## Introduction

Low-flow anaesthesia is increasingly becoming more common. It is defined as minimal-flow anaesthesia, and has many advantages, such as limiting the fresh gas flow to 0.5 L $min^{-1}$, maintaining the heat and humidity of the inspired gases and the body temperature of the patient, reducing the cost of anaesthetic gases and the associated environmental pollution. However, hypoxaemia is the biggest concern for the use of low fresh gas flow. Although new equipment has been added to modern anaesthesia devices for providing adequate oxygen concentration (1, 2) and studies on the safety of minimal flow have been published (3-5), further studies are needed in this regard.

Near infrared spectroscopy (NIRS) is a technique that can continuously measure oxygen saturation in the frontal region of the brain in a non-invasive manner. However, it cannot measure the true value of haemoglobin concentration; therefore, it cannot provide the true value of cerebral oxygen saturation. Although, it can be used as a trend monitor because it can detect relative changes (6). It has been shown that cerebral oxygen saturation remains unaffected in surgical interventions (7), laparoscopic surgeries (8) and thyroid surgery (9) performed using NIRS in a sitting position in normotensive patients. In Turkish and English literature, no study has examined the effect of controlled hypotension on cerebral oxygenation in patients undergoing minimal-flow anaesthesia. In this study, we



Corresponding Author: Leyla Kazancıoğlu E-mail: leylahotaman@hotmail.com



Received: 15.12.2017 Accepted: 25.06.2018

aimed to compare minimal and high-flow applications with NIRS monitoring in patients undergoing septorhinoplasty under controlled hypotension.

## Methods

After receiving approval from the Clinical Research Ethical Committee in Recep Tayyip Erdoğan University (2016/54), 80 patients that were to undergo septorhinoplasty were included in the study.

The exclusion criteria were as follows: Age <18 years and >60 years, American Anesthesia Association (ASA) physical state classification >2, expected duration of surgery <1 hour, history of cerebrovascular disease, pathology in cerebrovascular vessels, morbid obesity, chronic obstructive pulmonary disease, peripheral artery disease, central nervous system disease, congestive heart failure, anaemia (haemoglobin <8 g $dL^{-1}$), liver disease, kidney disease, diabetes mellitus, alcohol or drug addiction and history of allergy to anaesthetic drugs. The patients, who accepted to participate in the study during preoperative anaesthesia evaluation and signed the informed consent form, were given closed envelopes including group names for providing randomisation. The study was conducted in accordance with the Declaration of Helsinki.

The patients, who were taken to the operating room without the application of premedication, were monitored using 3-derivation electrocardiogram, non-invasive blood pressure, peripheral oxygen saturation, regional cerebral oxygen saturation (rScO2) (INVOS 5100C oximeter, Somanetics, Covidien, Minneapolis, USA) and bispectral index (BIS) (DatexOhmeda, USA) and their baseline values were recorded.

Following the intravenous (IV) loading dose of 1 µg $kg^{-1}$ remifentanil in 30 s, pre-oxygenation with 100% oxygen at 5 L $min^{-1}$ was performed. Anaesthesia induction was provided using 2 µg $kg^{-1}$ IV fentanyl and 2 mg $kg^{-1}$ IV propofol, with muscle relaxation using 0.6 mg $kg^{-1}$ IV rocuronium. For all patients, the Dräger Primus (Dräger Medical, Lübeck, Germany) was used as the anaesthesia device and CLIC Absorber 800+ (Dräger Medical, Lübeck, Germany) was used as soda lime.

Controlled hypotension was provided using IV remifentanil infusion in a dose range of 0.25–0.5 µg $kg^{-1}$ $min^{-1}$ during the operation. The mean arterial pressure was planned to be maintained between 55 and 65 mmHg. Remifentanil infusion was planned to be discontinued if the mean arterial pressure dropped by more than 30% of the basal value; further, it was decided to administer 10 mg IV ephedrine in the absence of an increase in the blood pressure to stop remifentanil infusion when peak heart rate decreased below 45 beat $min^{-1}$, and to administer 1 mg IV atropine when the peak heart rate did not increase.

The heart rate, mean arterial pressure, peripheral oxygen saturation, left and right side cerebral regional oximetry values, BIS values and end-tidal carbon dioxide values measured during intubation were recorded at 5-minute intervals until patients were transferred to the recovery unit.

When the patients were brought to the operating room, the closed envelopes were opened and the group information was read. Following the intubation, the minimalflow (MF) group was given desflurane anaesthesia with 5 L $min^{-1}$ fresh gas flow (50% $FiO_2$) for 10 min by obtaining the BIS value in the range of 40%–50%. After the tenth minute, the $FiO_2$ was adjusted to ensure that the inspiratory oxygen fraction did not decrease below 50%, and the fresh gas flow was reduced to 0.4 L $min^{-1}$. In the highflow (HF) group, fresh gas flow of 2 L $min^{-1}$ (50% oxygen and 50% air) was applied following intubation.

In all patients, 6 mL $kg^{-1}$ tidal volume was applied, and the respiratory frequency was adjusted to ensure that the end-tidal carbon dioxide values were in the range of 35–40 mmHg. When the surgeon reported 10 min towards the end of surgery, fresh gas flow was increased to 5 L $min^{-1}$, desflurane was discontinued, and 100% oxygen support was provided. Remifentanil infusion rate decreased to 0.2 µg $kg^{-1}$. The patient was extubated after being observed to follow the commands and then taken to the recovery unit.

The Aldrete score was followed by an anaesthesia technician in the recovery unit. The time from the end of the surgery to the Aldrete score reaching up to 9 was recorded. In all patients, the time of recovery after cessation of desflurane and extubation, intraoperative and postoperative complications and desflurane consumption recorded by the anaesthesia device was noted.

**Statistical analysis**

In the power analysis, it was calculated that the sample size of 80 patients would be sufficient to detect a 5% difference in cerebral regional oximetry between the groups ($\alpha$=0.05, $\beta$=0.1). The SPSS software (version 12.0) was used for analyses. The conformity of the data to the normal distribution was examined using the Kolmogorov–Smirnov test. Parametric data were expressed as mean ± standard deviation and analysed using the t-test in the independent groups. Categorical data were expressed as percentages (%) and analysed using the Chi-square test. P-values less than 0.05 were considered statistically significant.

## Results

Data of 80 patients were analysed. Demographic data of the patients are given in Table 1. There was no significant difference between the two groups in terms of haemodynamic parameters, peripheral oxygen saturation, and end-tidal $CO_2$ values (Table 1).

The right and left hemisphere rScO2 values of the brain were similar between the groups (Table 2). The rScO2 values of both hemispheres were significantly higher in the HF group only at the end of the operation and after extubation (p=0.045–0.048). However, the difference was not clinically significant.

**Table 1. Demographic and operative data of the patients**

| | MF group (n=40) | HF group (n=40) | p |
|---|---|---|---|
| Age (year) | 36.5±14.3 | 36.4±12.5 | >0.05* |
| Female (n, %) | 23 (57.5) | 23 (57.5) | >0.05# |
| ASA I (n, %) | 28 (70) | 28 (70) | >0.05# |
| BMI (kg m$^{-2}$) | 25.6±5.1 | 26.9±4.3 | >0.05* |
| Duration of anaesthesia (min) | 89.5±5 | 83.4±3.9 | >0.05* |
| Duration of surgery (min) | 81.6±5 | 78.3±3.8 | >0.05* |

Values are presented as mean±standard deviation or n (%). MF: minimal flow; HF: high flow; BMI: body mass index; *Wilcoxon test; #Chi-square test

In the MF group, there was a decrease in the mean arterial pressure for more than 30% of the baseline value in 3 patients; therefore, the controlled hypotension was discontinued and 10 mg IV ephedrine was administered. The percentage of inspired oxygen increased from 90% to 100%. In the same period, it was observed that the rScO2 value decreased to 80% of the baseline value. Approximately after 30 s, a decrease in the peripheral oxygen saturation was also observed. After the application of ephedrine, the blood pressure increased to the normal values, and the value of rScO2 reached 10% of the baseline value in less than 2 min.

Although the durations of surgery and anaesthesia administration were similar in the groups, the amount of desflurane consumed was significantly lower in the MF group (p<0.001, Table 3). There was no significant difference between the two groups in terms of the duration of extubation and the duration of attaining an Aldrete score of 9 at the recovery unit (Table 3).

**Table 2. Mean cerebral oximetry values of the groups (%)**

| | Left cerebral hemisphere | | | Right cerebral hemisphere | | |
|---|---|---|---|---|---|---|
| **Time** | **MF (n=40)** | **HF (n=40)** | **p** | **MF (n=40)** | **HF (n=40)** | **p** |
| Pre-anaesthesia | 69.6±8.3 | 69.8±9.9 | 0.919 | 70.1±8 | 69.3±8.6 | 0.623 |
| Pre-oxygenation | 74.7±10.4 | 78.4±11.2 | 0.199 | 76.3±9.3 | 77.4±9.9 | 0.745 |
| During ETI | 73.5±9.9 | 76.3±10.7 | 0.3245 | 73.8±8.5 | 75.9±9.5 | 0.402 |
| After ETI | 72.2±9.8 | 73.9±10.4 | 0.493 | 71.8±8.9 | 73.9±9.1 | 0.325 |
| At the beginning of surgery | 69.5±11.1 | 72.9±10.8 | 0.176 | 69.2±9.6 | 72.6±8.8 | 0.085 |
| During surgery | 68.5±10.2 | 72.3±10.7 | 0.114 | 68.2±9.3 | 71.9±8.8 | 0.059 |
| At the end of surgery | 68.5±9.4 | 72.5±10.1 | 0.077 | 67.8±9.3 | 71.7±8.5 | 0.045* |
| After extubation | 68.4±9.6 | 72.9±10.3 | 0.048* | 68.2±9.3 | 71.5±8.7 | 0.087 |
| Before leaving the operation room | 67.9±9.1 | 70.6±9.9 | 0.504 | 67.1±8.1 | 70.8±9.4 | 0.266 |

Values are presented as mean ± standard deviation or n (%). MF: minimal flow; HF: high flow; ETI: endotracheal intubation; *statistically significant value

**Table 3. Duration of operation and the amount of consumed desflurane**

| | MF (n=40) | HF (n=40) | p |
|---|---|---|---|
| Duration of anaesthesia (min) | 89.5±32.3 | 83.4±27.9 | >0.05 |
| Duration of surgery (min) | 81.7±32.3 | 78.3±28.4 | >0.05 |
| Amount of consumed desflurane (mL) | 30.5±9.8 | 48.5±12.1 | <0.001, 95% CI: −22.8 ile −13.1 * |
| Duration of extubation after surgery (min) | 3±0.9 | 3±1 | >0.05 |
| Duration of reaching the Aldrete score of 9 after surgery (min) | 7±1.2 | 7±1.1 | >0.05 |

Values are presented as mean ± standard deviation or n (%). MF: minimal flow; HF: high flow; CI: confidence interval; *statistically significant value

## Discussion

Low-flow anaesthesia is applied in daily anaesthesia practice. Minimal-flow anaesthesia has many advantages, such as low cost and reduced environmental pollution (10-13). However, although inspired and expired oxygen and gas concentrations can be monitored using modern anaesthesia devices, there is still a need to monitor the oxygen value reaching the patient at the tissue level. Hence, a device monitoring the cerebral oxygenation through NIRS method was used to monitor patients. In a meta-analysis including 14 randomised controlled trials on the use of intraoperative cerebral oximetry (14), the use of cerebral oximetry was predicted to be associated with a decrease in the postoperative cognitive dysfunction considering the heterogeneity of the study groups. However, further studies are needed in this regard.

Kupisiak et al. (8) found that cerebral oxygen saturation values were similar in laparoscopic cholecystectomies in which low- and high-flow anaesthesia were administered. In our study, there was no significant difference between the groups in terms of cerebral oxygen saturation values.

Controlled hypotension is preferred to provide a bloodless surgical field in septum and sinus surgeries (15-17). Studies have also reported contradictory findings that neurological damage may occur due to insufficient cerebral perfusion or impaired cerebral autoregulation using this method in which the mean arterial pressure is maintained between 50 and 65 mmHg (18-21). Erdem et al. (22) concluded that cerebral oxygen saturation could be reduced by more than 20% even if peripheral oxygen saturation was normal in rhinoplasty patients undergoing controlled hypotension. Heller et al. (23) did not find a relationship between the mean arterial pressure and cerebral oxygen saturation in the Functional Endoscopic Sinus Surgery patients undergoing controlled hypotension. In this study, it was observed that 3 patients in the MF group developed cerebral desaturation following a decrease in the mean arterial pressure by more than 30%. Meanwhile, the application of 90% $FiO_2$ to patient and the rapid recovery of cerebral desaturation following the elevation of the blood pressure to the target values with ephedrine application suggest that this event was completely due to deterioration in perfusion and was not associated with minimal flow. The critical decrease in the mean arterial pressure to the rScO2 value before peripheral oxygen saturation indicated that NIRS was successful in demonstrating cerebral desaturation due to hypoperfusion, which was consistent with the study by Erdem et al. (22).

In our study, a 37% decrease in the amount of desflurane consumed in the MF group compared to the HF group was consistent with the results reported in similar studies in which MF was used (11, 24). In addition, the time of extubation, eye opening and orientation at the end of anaesthesia were similar in the MF and HF groups. There were no significant differences between the two anaesthesia methods in terms of duration of stay in the recovery unit after surgery and Aldrete scores.

In a study conducted by Elmacıoğlu et al. (25), authors stated that perioperative hemodynamic stability was provided in desflurane anaesthesia administrations at 0.5 L $min^{-1}$, 1 L $min^{-1}$ and 2 L $min^{-1}$ with fresh flow rates, and minimal-flow anaesthesia might be an alternative to highflow desflurane anaesthesia in patients with ASA score I–II because flow rates had no negative effect on recovery. In line with this result, we observed that minimal-flow anaesthesia did not have a negative effect on recovery.

In this study, the main limitation was that the mental state or cognitive functions before, after and 1-week after surgery were not evaluated. Perhaps, the relationship between these data and cerebral tissue oxygenation could be investigated in future. Minimal-flow anaesthesia, which is safely administered to patients applied for controlled hypotension, can also be safely administered to patients with various clinical conditions. We believe that our study method can help promote further studies.

## Conclusion

It was found that minimal and highflow anaesthesia did not cause any difference in cerebral oxygen saturation in patients undergoing septorhinoplasty under controlled hypotension. During minimal-flow anaesthesia, the NIRS method can be used as a trend monitor.

We concluded that minimal-flow anaesthesia can be used as safely as the high-flow applications, and it does not have a significant difference in cerebral oxygen saturation. However, further studies are required in special patient groups with pathologies, such as carotid artery stenosis or traumatic brain injury.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the ethics committee of Recep Tayyip Erdoğan University School of Medicine (07.10.2016-54).

**Informed Consent:** Written informed consent was obtained from patients who participated in this study.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Concept - L.K., Ş.B.; Design - L.K., Ş.B.; Supervision - B.E., A.Ş.; Resources - L.K., B.E.; Materials - L.K., E.D.; Data Collection and/or Processing - L.K., Ş.B.; Analysis and/or Interpretation - L.K., B.E.; Literature Search - L.K., Ş.B., A.Ş.; Writing Manuscript - L.K., Ş.B.; Critical Review - E.D.; Other - Ş.B., A.Ş., B.E.

**Conflict of Interest:** The authors have no conflicts of interest to declare.

**Financial Disclosure:** The authors declared that this study has received no financial support.

## References

1. Hargasser S, Mielke L, Entholzner E, Hipp R. Anesthesia with low fresh gas flow In clinical routine use. Anasthesiol Intensivmed Notfallmed Schmerzther 1995; 30: 268-75. **[CrossRef]**
2. Baum JA, Aitkenhead AR. Low-flow anaesthesia. Anaesthesia 1995; 50: 37-44. **[CrossRef]**
3. Lee JK, Um SY, Chung CJ, Chin YJ. Comparison of enflurane consumptions and costs in low-flow and high-flow anesthesia. Korean J Anesthesiol 1999; 37: 574-9. **[CrossRef]**
4. Chung CJ, Ko DK, Lee HJ, Lee SI. Clinical evaluation of low flow enflurane anesthesia in Infants. Korean J Anesthesiol 2000; 39: 523-7. **[CrossRef]**
5. Choi SR, Cho WJ, Chin YJ, Chung CJ. The effects of prolonged minimal-flow sevoflurane anesthesia on postoperative hepatic and renal function. Korean J Anesthesiol 2008; 54: 501-6. **[CrossRef]**
6. Ferradal SL, Yuki K, Vyas R, Ha CG, Yi F, Stopp C, et al. Non-invasive Assessment of Cerebral Blood Flow and Oxygen Metabolism in Neonates during Hypothermic Cardiopulmonary Bypass: Feasibility and Clinical Implications. Sci Rep 2017; 7: 44117. **[CrossRef]**
7. Yadeau JT, Liu SS, Bang H, Shaw PM, Wilfred SE, Shetty T. Cerebral oximetry desaturation during shoulder surgery performed in a sitting position under regional anaesthesia. Can J Anaesth 2011; 58: 986-92. **[CrossRef]**
8. Kupisiak J, Goch R, Polenceusz W, Szyca R, Leksowski K. Bispectral index and cerebral oximetry in low-flow and high-flow rate anaesthesia during laparoscopic cholecystectomy - a randomized controlled trial. Wideochir Inne Tech Maloinwazyjne 2011; 6: 226-30. **[CrossRef]**
9. Saracoglu A, Altun D, Yavru A, Aksakal N, Sormaz IC, Camcı E. Effects of Head Position on Cerebral Oxygenation and Blood Flow Velocity During Thyroidectomy. Turk J Anaesthesiol Reanim 2016; 44: 241-6. **[CrossRef]**
10. Weiskopf RB, Eger EI. Comparing the costs of Inhaled anesthetics. Anesthesiology 1993; 79: 1413-8. **[CrossRef]**
11. Ekbom K, Assareh H, Anderson RE, Jakobsson JG. The effects of fresh gas flow on the amount of sevoflurane vaporized during 1 minimum alveolar concentration anaesthesia for day surgery: a clinical study. Acta Anaesthesiol Scand 2007; 51: 290-3. **[CrossRef]**
12. Lindqvist M, Jakobsson J. Minimal flow anaesthesia for short elective day case surgery; high vaporiser settings are needed but still cost-effective. Ambul Surg 2011; 17: 27-9.
13. Ryan SM, Nielsen CJ. Global warming potential of inhaled anesthetics: application to clInical use. Anesth Analg 2010; 111: 92-8. **[CrossRef]**
14. Zorrilla-Vaca A, Healy R, Grant MC, Joshi B, Rivera-Lara L, Brown C, Mirski MA. Intraoperative cerebral oximetry-based management for optimizing perioperative outcomes: a meta-analysis of randomized controlled trials. Can J Anaesth 2018; 65: 529-42. **[CrossRef]**
15. Jacobi KE, Bohm BE, Rickauer AJ, Jacobi C, Hemmerling TM. Moderate controlled hypotension with sodium nitroprusside does not improve surgical conditions or decrease blood loss in endoscopic sinus surgery. J Clin Anesth 2000; 12: 202-7. **[CrossRef]**
16. Kosucu M, Omer S, Besir A, Uraloglu M, Topbas M, Livaoglu M. Effects of perioperative remifentanil with controlled hypotension on intraoperative bleeding and postoperative edema and ecchymosis. In open rhinoplasty. J Craniofac Surg 2014; 25: 471-5. **[CrossRef]**
17. Tuncel U, Turan A, Bayraktar MA, Erkorkmaz U, Kostakoglu N. Efficacy of dexamethasone with controlled hypotension on Intraoperative bleeding, postoperative oedema and ecchymosis in rhinoplasty. J Craniomaxillofac Surg 2013; 41: 124-8. **[CrossRef]**
18. Pohl A, Cullen DJ. Cerebral ischemia during shoulder surgery In the upright position: a case series. J ClIn Anesth 2005; 17: 463-9. **[CrossRef]**