Original Article

Evaluation of cerebral oxygen saturation during hypotensive anesthesia in functional endoscopic sinus surgery

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Abstract

Background and Aims: Controlled hypotensive anesthesia in endoscopic sinus surgery would provide a clean surgical field. Cerebral oxygen saturation (ScO_2) is important in endoscopic sinus surgery patients and it may be low during controlled hypotension.The aim of the present study was to assess ScO_2 in these patients.

Material and Methods: In this observational study, 41 patients who underwent endoscopic sinus surgery with hypotensive anesthesia were enrolled for the study and all of the patients received the same anesthetic medication, nitroglycerin for controlled hypotension. Variables were measured prior to surgery, after induction of anesthesia, 5 min, and every 30 min after controlled hypotension. Near-infrared spectroscopy was used for ScO_2 evaluation. Mean arterial blood pressure (MAP) was maintained at 55–60 mmHg in the surgical duration. We used *t*-test, Wilcoxon, and repeated measures analysis of variance (ANOVA). We examined the cross-correlation functions of the time series data between end-tidal carbon dioxide ($ETCO_2$)/MAP and ScO_2.

Results: The mean of intraoperative ScO_2 was not significantly different from the baseline evaluation ($P > 0.05$). $ETCO_2$ was cross correlated with current ScO_2 [r: 0.618, confidence interval (CI) 95%: 0.46–0.78]. We found moderate cross correlation between the MAP and current ScO_2 (r: 0.728, CI 95%: 0.56–0.88). About 92% of the patients recovered within 30 min. Recovery time was associated with intraoperative MAP (P: 0.004, r: 0.438), intraoperative $ETCO_2$ (P: 0.003, r: 0.450), and ScO_2 (P: 0.026, r: 0.348).

Conclusions: Based on our findings, the assessment of ScO_2 and maintained MAP >55 mmHg may provide safe conditions for endoscopic sinus surgery.

Keywords: Endoscopic sinus surgery, hypotensive anesthesia, near-infrared spectrometry

Introduction

Functional endoscopic sinus surgery (FESS) is a growing method, which is performed near important structures and even a small visible bleed into the surgical field may lead to increased complications and frustration of the surgeon.[1-3] Anesthesia with controlled hypotension is one of the suggested methods to reduce bleeding and improve surgical field visualization.[1,4] There are studies to emphasize the effectiveness of controlled hypotension in the reduction of bleeding in otorhinolaryngology, vascular, and orthopedic surgeries, but some authors have reported different complications and end organ damages due to inadequate perfusion.[5,6]

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In mentioned studies with this anesthetic technique, systolic blood pressure was kept between 80–90 mmHg or the mean arterial blood pressure (MAP) was kept between 50–60 mmHg to reduce surgical field bleeding and better visualization, but there is a concern about hypotension-induced cerebral damages.[7]

It is reasonable to monitor central nervous system, as a target of anesthetic medications, precisely to avoid adverse effects of the procedures.[8] Near infra-red spectrometry (NIRS) is a non-invasive method to assess cerebral oxygenation, and is frequently used for perioperative hemodynamic management aiming at sufficient cerebral perfusion and oxygenation.[9,10] This technique assists in timely diagnosis of insufficient oxygen saturation and the prevention of complications of hypoxemia and anesthesia.[8] The aim of the present study was the assessment of cerebral oxygen saturation (ScO_2) during hypotensive anesthesia and to answer the question: does hypotensive anesthesia cause reduction in cerebral saturation in FESS?

Material and Methods

Forty-one patients undergoing FESS in the Masih Daneshvari Hospital, Tehran, Iran were studied in a prospective, observational study to evaluate the effect of controlled hypotensive anesthesia on ScO_2. The inclusion criteria were as follows: aged between 18–65 years old, ability to complete an informed consent form, among the American Society of Anesthesiologists functional Class I and II, and who were candidates for FESS (chronic rhinosinusitis for >3 months despite maximal medical therapy). Patients with uncontrolled chronic diseases such as hypertension, diabetes mellitus, systemic vascular or cerebrovascular disease, current bleeding disorder or receipt of anticoagulant therapy within recent 10 days, patients with opium addiction, and allergic to anesthetic medications were excluded.

Ethical approval was obtained from the Ethic committee of the Shahid Beheshti University of Medical Sciences (IR.SBMU.RITLD.REC.1394.212).

Intra-arterial cannula was inserted in left brachial artery with local anesthesia before general anesthesia induction. All participants were intubated, mechanically ventilated, and received same anesthetic medications. All of them received clonidine (2 mg) 2 h prior to the surgery and fentanyl (1–2 μg/kg) plus midazolam (2 mg) intravenously in the operating room as premedication. General anesthesia was induced using propofol 1.5–2 mg/kg and atracurium 0.5 mg/kg and was maintained using propofol 100 μg/kg/min and remifentanil 0.1 μg/kg/min. Labetalol was used to reduce blood pressure (0.5 mg/kg stat and 2 mg/min infusion) and nitroglycerin (TNG) if needed in hypertensive situation. Body temperature was measured by the oropharyngeal thermometer and was maintained up to 36°C. MAP was maintained at 55–60 mmHg, end-tidal carbon dioxide ($ETCO_2$) was maintained at 30–40 mmHg, and the depth of anesthesia was maintained in 40–60 using the bispectral index (BIS, A-2000TM SP; Aspect Medical Systems, Norwood, MA, USA). Patients with severe hypotension (reduction >20% of baseline MAP) were treated by stopping antihypertensive and anesthetic medications, fluid therapy, and ephedrine administration (5–10 mg intravenously) if needed.

Calibrated NIRS (NIRS; INVOS™ Cerebral/Somatic Oximetry 5100 c) was used to evaluate ScO2. NIRS light penetrates the skull to assess real-time frontal cortical oxygenation. Invasive systolic blood pressure, diastolic blood pressure, MAP, pulse rate (PR), and respiratory rate (RR) were measured by the anesthetic monitors and manually recorded prior to the surgery, 5 min after induction, 5, 30, 60, 90, and 120 min after controlled hypotension, and at the time of epinephrine administration. Cerebral saturation was measured prior to administration of anesthesia and at the same interval as other variables. Baseline $ETCO_2$ concentration was measured after intubation and at intervals corresponding with other variables. The mean intraoperative values were compared with baseline evaluation.

For the assessment of bleeding, we recorded the volume of blood collected into suction bottle and the Gauze Visual Analogue guideline.[11] The same operator recorded the data. More than 20% changes of the baseline value in ScO_2 leads to medical intervention by correcting the MAP or CO_2 pressure.

All demographic, clinical, surgical, and post-surgical complication data were recorded. Recovery time was defined as post-anesthesia care unit (PACU) recovery time. Statistical analysis was performed using the SPSS software (version 12.0 for Windows; SPSS Inc, Chicago, IL, USA), paired t-test, Wilcoxon (if needed), and repeated measures analysis of variance (ANOVA). We examined the cross-correlation functions of the time series data between $ETCO_2$/MAP and ScO_2 using the Pearson's correlation coefficient test. Statistical significance was taken at $P < 0.05$.

Results

Twenty-six (63.4%) of the 41 studied patients were male. The mean age of the patients was 35.38 ± 14.22 years. The demographic characteristics and health status were summarized in Tables 1 and 2.

The mean of intraoperative MAP, HR, and $ETCO_2$ were significantly lower than the baseline values ($P < 0.0001$, Table 3). The mean of intraoperative ScO_2 was insignificantly lower than the baseline except 5 min after induction where it was more ($P = 0.019$). The comparison of the baseline and average of intraoperative studied parameters were summarized in Table 3.

Reduced cerebral oxygenation >20% of the baseline value was seen in two patients and >25% in one patient. We analyzed the cross correlation between $ETCO_2$/MAP and cerebral saturation. ScO_2 depends on arterial CO_2 concentration and cerebral perfusion pressure, so we considered $ETCO_2$ and MAP as independent variables; and ScO_2 as a dependent variable. $ETCO_2$ was cross correlated with current ScO_2 ($r = 0.618$, CI 95%: 0.46–0.78). We found moderate cross correlation between the MAP and current ScO_2 ($r = 0.728$, CI 95%: 0.56–0.88).

About 92% of patients recovered within 30 min. Recovery time was correlated with intraoperative MAP ($P = 0.004$, $r = 0.438$), intraoperative $ETCO_2$ ($P = 0.003$, $r = 0.450$), and ScO_2 ($P = 0.026$, $r = 0.348$).

Surgical and anesthesia complications were recorded as follows: agitation in four patients (9.8%), nausea in three patients (7.3%), and headache in one patient (2.4%).

Table 1: Patients characteristics and health status

Variables	Mean (SD)/ Median
Age (years)	35.38±14.22
Male/female, *n* (%)	26 (63.4)/15 (36.6)
Preoperative hypertension, *n* (%)	1 (2.4)
Preoperative hyperlipidemia, *n* (%)	1 (2.4)
Preoperative hyperthyroidism, *n* (%)	1 (2.4)
Preoperative diabetes	2 (4.9)
Preoperative asthma, *n* (%)	11 (26.8)
Preoperative allergy, *n* (%)	5 (12.19)
History of spina bifida, *n* (%)	1 (2.4)
Cystic fibrosis, *n* (%)	1 (2.4)

Discussion

In this observational study, ScO_2 of the patients who underwent FESS with controlled hypotension anesthesia was studied using the NIRS in both right and left hemispheres. The saturation of the occipital lobe of the brain was not studied, and was our study limitation. The mean cerebral saturation was insignificantly lower than the basic evaluation, except 5 min after induction. This could be due to mask oxygenation and the reduced metabolic rate of cerebral cells.

There are limited studies that assess cerebral saturation during FESS. Heller and his colleagues[11] studied 31 patients during FESS and showed the reduction of >10% from baseline in 62.5% of the patients and a fall in saturation <60% in 16.1% of the studied population respectively, and cross correlation between $ETCO_2$ and cerebral saturation. They did not find a cross correlation between MAP and cerebral saturation. We found cross correlation between $ETCO_2$ and MAP with current ScO_2. We recorded variables in different time, which may be the reason for having different results from Heller's study.

Dropped ScO_2 will be seen in MAP lower than auto-regulated brain flow pressure due to direct relationship between ScO_2 and MAP. Hypocapnia causes brain vasoconstriction and reduced ScO_2.

Ha and colleagues[12] evaluated the correlation between FESS with controlled hypotensive anesthesia, cerebral blood flow, and the surgical field. They showed direct correlation between MAP and the middle cerebral artery blood flow velocity ($r = 0.77$), and direct correlation between MAP and the bleeding assessment score ($r = 0.36$). They showed MAP levels >60 mmHg maintained at least 50% of baseline middle cerebral artery blood flow in almost 90% of the total time. They concluded that hypotensive anesthesia is an effective method in FESS, and MAP <60 mmHg may increase the risk of cerebral ischemia.[12] In the present study, the MAP was maintained at 55 mmHg.

Table 2: Baseline and intraoperative studied parameters

Time/variable	MAP (mmHg)	HR (beats/min)	$ETCO_2$	ScO_2 (%)
Prior to surgery	86.24±9.1	86.36±11.9	-	76.74±11.6
5 min after induction	78.95±14.4	80.76±13.1	30.21±3.6	80.01±11.3
5 min after controlled hypotension	66.22±4.1	75.09±9.8	30.19±3.8	76.02±11.5
30 min after controlled hypotension	65.41±4.6	76.07±10.0	30.61±5.0	76.95±8.1
After epinephrine administration	74.19±6.8	74.19±6.8	31.44±6.2	79.04±6.7
60 min after controlled hypotension	65.05±3.7	86.47±7.5	30.42±5.1	77.04±6.7
90 min after controlled hypotension	65.22±4.1	72.89±8.8	30.19±5.9	76.71±6.7
120 min after controlled hypotension	64.58±3.2	70.81±7.3	29.45±5.0	75.45±6.4

MAP=Mean arterial blood pressure; HR=Heart rate; $ETCO_2$=End-tidal carbon dioxide

Table 3: Baseline and Intraoperative data. Data expressed as mean (SD)

	Baseline	Intraoperative	*P*
Mean arterial blood pressure (mmHg)	86.24 (9.13)	69.05 (3.95)	<0.001*
Heart rate (beats/min)	86.36 (11.87)	77.18 (7.81)	<0.001*
$ETCO_2$	30.15 (3.05)	28.37 (2.76)	<0.001*
Cerebral saturation (%)	76.74 (11.60)	76.18 (8.04)	0.661
Length of anesthesia (min)	-	168.37 (42.66)	-
Length of controlled hypotension (min)	-	111.22 (32.29)	-
Length of surgery (min)	-	140.93 (43.58)	-
Volume of infused serum (ml)	-	2188 (951.01)	-
Volume of bleeding (ml)	-	232.927 (104.65)	-
Recovery time (min)	-	27.80 (9.68)	-

**Statistically significant; $ETCO_2$=End-tidal carbon dioxide*

The surgical complications of our study were anesthetic associated complications such as agitation, nausea, and headache. A review study of Suzuki *et al*.[13] on 50,734 patients undergoing FESS showed multiple sinus surgery was associated with higher rates of orbital injuries, but it did not significantly affect the overall complication rate. The surgeon's experience, extent and severity of sinonasal disease, history of previous sinus surgery, and intraoperative view of the surgical field are related factors in ocular injuries during the FESS.[12] Anesthesia with controlled hypotension may improve surgical view.

We did not evaluate postoperative cognitive function; our study had no control group and no power analysis, which are our study limitation.

Conclusion

Cerebral hypoperfusion is a potential adverse event in FESS using controlled hypotension technique, although most patients with a normal range of CO_2 did not reach the severe stage of cerebral hypotension (>20% of baseline); based on our findings MAP >55 mmHg and $ETCO_2$ within 30–40 mmHg are likely to prevent significant fall in cerebral oxygenation during endoscopic sinus surgery.

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Conflicts of interest
There are no conflicts of interest.

References

1. Degoute CS, Ray MJ, Manchon M, Dubreuil C, Banssillon V. Remifentanil and controlled hypotension; comparison with nitroprusside or esmolol during tympanoplasty. Can J Anaesth 2001;48:20-7.
2. Yoo HS, Han JH, Park SW, Kim KS. Comparison of surgical condition in endoscopic sinus surgery using remifentanil combined with propofol, sevoflurane, or desflurane. Korean J Anesthesiol 2010;59:377-82.
3. Tobias JD. Controlled hypotension in children: A critical review of available agents. Paediatr Drugs 2002;4:439-53.
4. Choi WS, Samman N. Risks and benefits of deliberate hypotension in anaesthesia: A systematic review. Int J Oromaxillofac Surg 2008;37:687-703.
5. Saricaoglu F, Celiker V, Basgul E, Yapakci O, Aypar U. The effect of hypotensive anaesthesia on cognitive functions and recovery at endoscopic sinus surgery. Eur J Anaesthesiol 2005;22:157-9.
6. Casati A, Fanelli G, Pietropaoli P, Proietti R, Tufano R, Montanini S, *et al*. Monitoring cerebral oxygen saturation in elderly patients undergoing general abdominal surgery: A prospective cohort study. Eur J Anaesthesiol 2007;24:59-65.
7. Fischer GW, Torrillo TM, Weiner MM, Rosenblatt MA. The use of cerebral oximetry as a monitor of the adequacy of cerebral perfusion in a patient undergoing shoulder surgery in the beach chair position. Pain Pract 2009;9:304-7.
8. McCormick PW, Stewart M, Goetting MG, Balakrishnan G. Regional cerebrovascular oxygen saturation measured by optical spectroscopy in humans. Stroke 1991;22:596-602.
9. Edmonds HL Jr. Multi-modality neurophysiologic monitoring for cardiac surgery. Heart Surg Forum 2002;5:225-8.
10. Ali Algadiem E, Aleisa AA, Alsubaie HI, Buhlaiqah NR, Algadeeb JB, Alsneini HA. Blood loss estimation using gauze visual analogue. Trauma Monthly 2016;21:e34131.
11. Heller JA, DeMaria S Jr, Govindaraj S, Lin HM, Fischer GW, Evans A, *et al*. Cerebral oximetry monitoring during sinus endoscopy. Laryngoscope 2015;125:E127-31.
12. Ha TN, van Renen RG, Ludbrook GL, Valentine R, Ou J, Wormald PJ. The relationship between hypotension, cerebral flow, and the surgical field during endoscopic sinus surgery. Laryngoscope 2014;124:2224-30.
13. Suzuki S, Yasunaga H, Matsui H, Fushimi K, Kondo K, Yamasoba T. Complication rates after functional endoscopic sinus surgery: Analysis of 50,734 Japanese patients. Laryngoscope 2015;125:1785-91.