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Comparison of the Effects of Desflurane and Sevoflurane on Cerebral Oxygen Saturation in Patients Undergoing Thyroidectomy: A Randomised Controlled Clinical Study

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Abstract

Objective: The commonly performed sitting position with head extended during thyroidectomy has been shown to cause adverse effects on cerebral regional oxygen saturation (CrSO2). Therefore, the present study aimed to investigate the effects of two well-known anaesthetic agents, desflurane and sevoflurane, on CrSO2 in patients undergoing thyroidectomy in the semi-sitting position by near-infra-red spectroscopy monitoring.

Methods: The study included 60 patients aged 18-65 years, with an American Society of Anesthesiologists (ASA) physical status classification score I-III, who underwent elective thyroidectomy in the semi-sitting position. The patients were randomly divided into two groups, depending on the anaesthetic agent administered: (1) sevoflurane group (Group S; n=30) and (2) desflurane group (Group D; n=30). After intubation, the patients were placed in a 45-degree semi-sitting position. Vital signs and the CrSO2 levels in both hemispheres were recorded both pre-induction and at the induction minute 1, post-intubation, post-positioning, every 5 minutes intraoperatively and in the case of sudden changes.

Results: No significant difference was found between the groups in terms of age, height, body weight, the ASA score, operative time and left- and right-hemisphere CrSO2 ($p>0.05$). Moreover, the two groups were statistically similar to each other with regard to peripheral capillary oxygen saturation, heart rate, systolic and diastolic blood pressure, mean artery pressure and end-tidal CO_2 ($ETCO_2$) levels.

Conclusion: Desflurane and sevoflurane had similar effects in the preservation of CrSO2 in patients undergoing thyroidectomy in the semi-sitting position.

Keywords: Cerebral oxygen saturation, desflurane, general anaesthesia, sevoflurane, thyroidectomy

Introduction

The effects of postural changes in awake healthy individuals can be compensated by the compliance mechanism, which can be impaired by a number of factors, including disease, injury, hunger, long-term physical inactivity and anaesthesia. It is commonly known that keeping the head at the level of the heart in the sitting position, along with the effects of gravity, leads to decreased arterial and venous pressure; therefore, a postural change from standing to sitting is likely to cause impaired cerebral perfusion in patients. On the other hand, although cerebral blood flow decreases in the sitting position cerebral oxygen consumption rate is unlikely to decrease. Therefore, the sitting position can be detrimental to patients with severe cerebrovascular disease (1).

Literature indicates that prior to thyroidectomy, the thyroid lobe is often pulled forward by extending the head backwards in the sitting position so as to achieve an optimal surgical field (2). This position may result in decreased cerebral blood flow and may also have adverse effects on the volume and rate of cerebral blood flow and on cerebral

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regional oxygen saturation (CrSO2). In addition, inhalation anaesthetics that are commonly used for administering general anaesthesia in patients undergoing thyroidectomy have been shown to have direct effects on the blood flow, cerebral oxygen consumption rate, cerebrovascular resistance and perfusion pressure (3).

Cerebral oxygen desaturation is an important risk factor for postoperative cognitive dysfunction (4). Near-infrared spectroscopy (NIRS) is a non-invasive technique based on pulse oximetry and is used for monitoring CrSO2. In NIRS measurements, the CrSO2 values below 40% and a 25% relative increase from the baseline values can be the predictors of neurological events, secondary to decreased cerebral oxygenation (5). A previous study showed that maintaining a CrSO2 value above the critical threshold (a 20% relative decrease from the baseline CrSO2 values) leads to lower postoperative complication rates and also decreases the length of postoperative hospital stay (6).

Literature reviews indicate that the effects of intravenous and volatile anaesthetic agents on cerebral oxygenation have been extensively studied; however, to the best of our knowledge, there has been no study comparing volatile anaesthetic agents with regard to their effects of on cerebral oxygenation (7, 8). In this study, we aimed to investigate the effects of desflurane and sevoflurane on CrSO2 in patients undergoing thyroidectomy in the semi-sitting position.

Methods

The study included 66 euthyroid patients aged 18-65 years, with an American Society of Anesthesiologists (ASA) physical status classification score I-III, who underwent elective thyroidectomy in the semi-sitting position at Yuzuncu Yil University, Dursun Odabas Medical School, Anaesthesiology and Reanimation Department between July and October, 2017. The study was designed as a single-centre, balanced-randomised (1:1), double-blind, Phase IV study based on parallel groups. Of the 66 patients, 6 patients were excluded from the study, including one patient who objected to participating in the study, one patient who had an endocrine disease other than thyroidism and three patients who had severe cardiac (n=1), renal (n=1), hepatic (n=1) and respiratory disease (n=1). The remaining 60 patients were randomly assigned into two intervention groups by an anaesthesiologist blinded to the study using Microsoft Excel 2013 (Excel, Microsoft, Remond, WA, ABD; Figure 1). The study

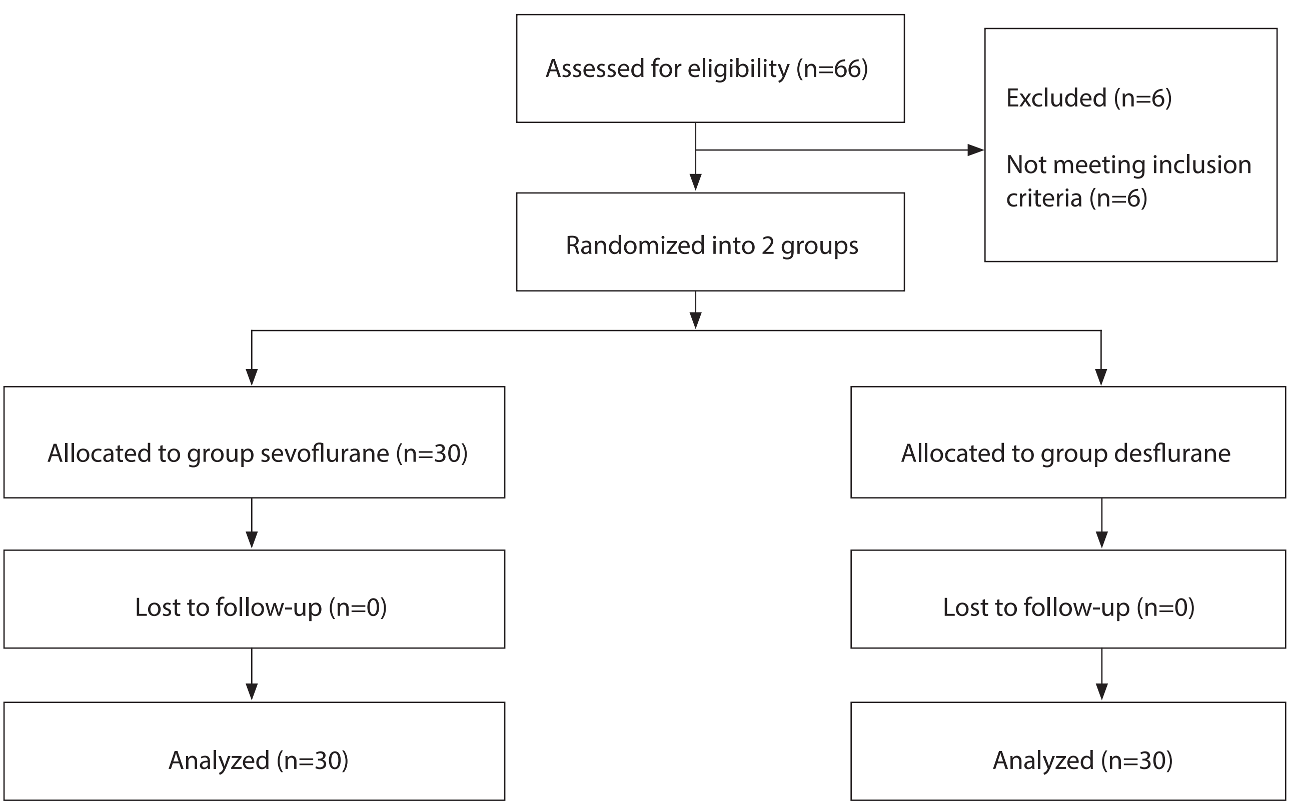

Figure 1. Flow-chart for sampling and grouping of the patients in the study

was approved by the Van Yuzuncu Yil University Clinical Investigation Ethic Committee (Aprowal date: 25.04.2017; Number: 07), and a written informed consent was obtained from each patient. Both the caregivers in the clinic and the anaesthesiologists who evaluated the results were blinded to the study protocol.

Each patient underwent preoperative examination at the Anaesthesiology and Reanimation Polyclinic at least 1 day prior to the surgery. On the operation day, each patient was premedicated with 1 mg intravenous midazolam (Demizolam, Dem, Turkey) prior to the surgery. Before anaesthetic induction, routine monitoring was performed including electrocardiography (ECG) and the measurement of haemodynamic parameters including peripheral capillary oxygen saturation (SpO_2), heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure (MAP). The post-intubation end-tidal carbon dioxide ($ETCO_2$) and end-tidal anaesthetic gas concentrations were measured. On the operating table, the forehead was wiped with alcohol cotton swab, and two sensors were placed over the right and left frontal-temporal regions of the forehead. The initial values measured for the right and left hemispheres separately were accepted as preoperative baseline values. A 20% relative decrease from the baseline CrSO2 values was defined as the critical threshold for intervention. In the case of a decrease below the critical threshold, the oxygen concentration was increased, normal haemodynamic parameters were restored, neck position was checked and adjusted and the surgeon was notified, as needed. An INVOS SOMANETICS Cerebral Oximeter was used for continuous monitoring of CrSO2 for both hemispheres separately throughout the surgical procedure. Haemodynamic parameters including SpO_2, HR, SBP, DBP and MAP and the CrSO2 for both hemispheres were measured pre-induction (baseline), at induction minute 1, post-intubation and every 5 minutes intraoperatively. $ETCO_2$ and end-tidal anaesthetic gas concentration were monitored and recorded after the intubation.

Anaesthesia was induced with propofol 2 mg kg^{-1}, fentanyl 2 µg kg^{-1} and rocuronium 0.5 mg kg^{-1}. Maintenance was accomplished with 40% O_2, 60% air and 1 MAC inhalation anaesthetics. Every 40 min, an additional 50 µg of fentanyl + 10 mg of rocuronium was administered. The patients were divided into two equal groups using the closed-envelope method depending on the volatile anaesthetic agent administered: sevoflurane group (Group S; n=30) and desflurane group (Group D; n=30). After the induction of anaesthesia and intubation, a soft cylinder cushion was placed under the shoulder to extend the head and neck backwards and the 45-degree semi-sitting position was achieved by supporting the head with a positioning pad and performing partial hip and knee flexion with the back of the table drawn up at a 45-degree angle. The right arm was abducted, and mechanical ventilation was performed to maintain the $ETCO_2$ level between 30 and 35 mmHg.

Care was taken to prevent hypoxaemia, hypercapnia, hypertension and hypotension throughout the anaesthesia. Hypertension was defined as a 20% relative increase from the baseline MAP per minute. In the case of hypertension, rudimentary signs of anaesthesia such as tearing and perspiration were evaluated, and an additional 1 µg kg^{-1} of intravenous fentanyl was administered. In the case of persistent hypertension, intravenous nitro-glycerine 0.3-10 µg kg^{-1} minute was administered. Hypotension was defined as a 20% relative decrease from the baseline MAP per minute. In the case of hypotension, the infusion rates of intravenous fluids were increased. However, in the case of persistent hypotension, ephedrine 5 mg was administered. Bradycardia was defined as a HR below 45 beats per minute and tachycardia as an HR over 100 beats per min. Atropine 0.5 mg was administered for bradycardia, and esmolol 5-10 mg was administered for tachycardia. The haemodynamic changes observed intraoperatively and during extubation were recorded. At the end of the surgery, extubation was performed after reversal with atropine and neostigmine administration.

Statistical analysis

The sample size calculated for the CrSO2 values was 71%±6. Therefore, we used an effect size (d) of 2.5 for a one-sided Type I error of 0.05 (Z=1.96) based on the equation [$n=z^2 s^2:d^2$], and we used a statistical power of 80%, which resulted in a sample size of 22 patients. We planned to recruit two groups with 30 patients each, considering that some patients could be excluded for protocol violation.

Data were analysed using the Statistical Package for the Social Sciences 13.0 for Windows (SPSS Inc.; Chicago, IL, USA). Continuous variables were expressed as the mean, standard deviation (SD) and minimum and maximum values. Categorical variables were expressed as frequencies and percentages. Continuous variables were compared according to the groups and the times of measurements by using repeated measures analysis of variance (ANOVA). Following the ANOVA, Duncan's multiple comparison test was used for measuring specific differences between pairs of means. A chi-squared test was performed to identify the relationship among the categorical variables. A p-value of <0.05 was considered statistically significant.

Results

The study included 60 eligible patients. Patient characteristics including age, height, body weight, the ASA score and mean operative time were similar in both groups (Table 1).

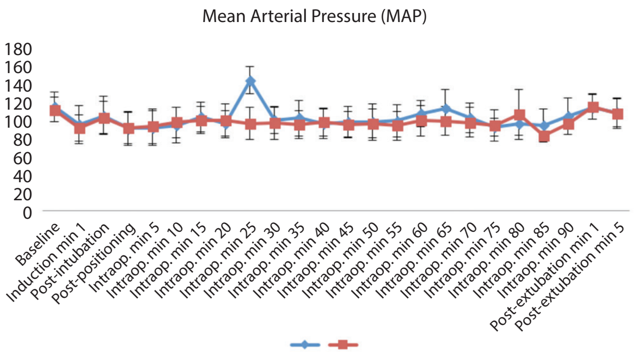

Figure 2. Comparison of MAP values between the two groups

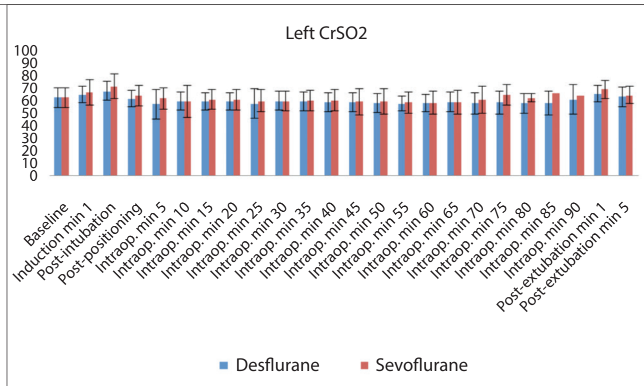

Figure 4. Comparison of left CrSO2 values between the two groups

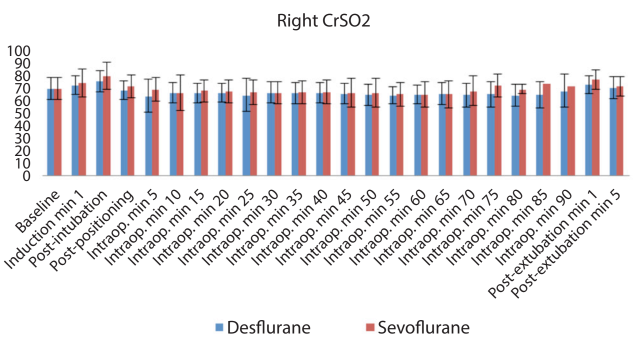

Figure 3. Comparison of right CrSO2 values between the two groups

Table 1. Patient characteristics in the groups

	Group D (n=30) (Mean±SD)	Group S (n=30) (Mean±SD)	p
Surgery time (min)	62.50±15.68	59.83±10.62	0.44
ASA	1.67±0.54	1.67±0.54	1.00
Height (cm)	163.53±6.04	165.13±6.62	0.33
Weight (kg)	71.50±11.23	71.60±10.09	0.97
Age (years)	43.43±12.66	43.27±14.66	0.96

ASA: American Society of Anesthesiologists; SD: standard deviation; Group D: desflurane group; Group S: sevoflurane group

The results indicated no significant difference between the SpO_2, HR, SBP, DBP and MAP values that were measured pre-induction (baseline), at intraoperative minutes 1 and 5, post-intubation and every 5 minutes intraoperatively and those measured at post-extubation minutes 1 and 5 ($p>0.05$) (Figure 2).

It was also revealed that no significant difference was established between the two groups with regard to the $ETCO_2$ values measured at intraoperative minutes 1 and 5 and every 5 minutes intraoperatively ($p>0.05$).

Right-hemisphere regional oxygen saturation (CrSO2R) was measured in both groups (Figure 3). The highest mean CrSO2R value was measured at post-intubation minutes 1 in both groups (Group S, 78.80±10.79; Group D, 74.76±8.34). On the other hand, the lowest mean CrSO2R value was measured at the intraoperative minute 5 in Group D (63.16±12.91) as opposed to intraoperative minute 60 in Group S (64.50±10.04). No significant difference was found between the groups in terms of CrSO2R values ($p>0.05$).

Left-hemisphere regional oxygen saturation (CrSO2L) was also measured in both groups (Figure 4). The highest mean CrSO2L value was measured at the post-intubation minute 1 in Group S (77.66±8.60) and at the post-positioning minute 1 in Group D (78.00±7.10). In addition, the lowest mean CrSO2L value was measured at the post-positioning minute 75 in Group S (61.66±12.89) and at the post-positioning minute 50 in Group D (63.36±9.06). No significant difference was established between the groups with regard to CrSO2L values ($p>0.05$).

Discussion

The present study investigated the effects of desflurane and sevoflurane on CrSO2 in patients undergoing thyroidectomy in the semi-sitting position and found no significant difference between the two anaesthetic gases with regard to the preservation of CrSO2.

There have been several studies in the literature evaluating the effects of various anaesthetic agents via NIRS monitoring. In these studies, sevoflurane was shown to preserve CrSO2 better than propofol. Therefore, we applied intravenous anaesthesia induction by using sevoflurane in one group and desflurane in the second group (9, 10).

Available evidence suggests that although CrSO2 values are not affected by anthropometric measurements (height, body weight, gender and head circumference) (11), they are affected by hypoxaemia, hypocapnia, hypercapnia and arterial hypotension (12). In our study, no significant difference was observed between the two groups in terms of SpO_2, HR, SBP, DBP and MAP values.

Cipolla (13) suggested that the decrease in the $ETCO_2$ and $PaCO_2$ values caused by hyperventilation can reduce the blood flow as a result of vasoconstriction of the cerebral vessels, thereby leading to cerebral oxygen desaturation. In our study, although $ETCO_2$ values established no significant difference between the groups, the lowest value was 29 mmHg and the highest was 35 mmHg. No hyper- or hypocapnia was observed in any patient. Moreover, no CrSO2 value reached the critical threshold; therefore, no intervention was performed for any patient.

Haemoglobin concentration is a key parameter affecting CrSO2. Previous studies indicated that CrSO2 significantly decreased at the haemoglobin levels <11 g dL^{-1}. Some other studies reported that CrSO2 decreased by 7%-9% with blood losses ranging between 400 and 1.800 mL (14-16). In our study, the mean preoperative haemoglobin level was 13 g dL^{-1} in both groups.

A previous study showed that an CrSO2 value <40% and a 25% relative increase from the baseline value can be the predictors of neurological events secondary to decreased cerebral oxygenation (5). Nevertheless, there are contradictory values reported for the normal ranges of CrSO2. Madsen et al. (17), for instance, evaluated 39 resting subjects with no cardiorespiratory disease and reported that the normal range of cerebral CrSO2 value was 55-78. Kim et al. (18), on the other hand, evaluated 39 healthy volunteers aged 20-36 years and found the baseline cerebral CrSO2 value as 71±6. In our study, the baseline cerebral CrSO2 values in both groups were statistically similar to each other (Group S, 67.5; Group D, 66.5), and no significant difference was found between the two groups. In addition, a 10% relative decrease from the baseline CrSO2 values was found in 18% of the patients in Group D and in 26% of the patients in Group S, whereas a relative 20% decrease from the baseline values was found in 10% of the patients in Group D and in 13% of the patients in Group S. Moreover, no patient had a decrease of more than 20%, and no baseline CrSO2 value was below 55% in any patient.

Fassoulaki et al. (19) also evaluated the effects of desflurane and sevoflurane on CrSO2 and reported that although equipotent concentrations of desflurane or sevoflurane resulted in similar CrSO2 values, higher concentrations of both anaesthetics resulted in increased CrSO2 values. In that study, bispectral index (BIS)monitoring was used, and the type of surgery was abdominal hysterectomy. In our study, however, we did not use the BIS monitoring, which can be considered as a limitation to our study.

Blood pressure and CrSO2 are known to vary between the surgeries performed in the sitting *vs.* semi-sitting position. Kim et al. (18) compared the effects of desflurane and propofol in patients undergoing shoulder surgery in the sitting position and found that desflurane preserved CrSO2 better than propofol. Similarly, we also found that desflurane preserved CrSO2 better than sevoflurane. Moreover, the MAP and both the right- and left-hemisphere CrSO2 values started to decrease during the positioning of the patient.

Conclusion

The measurements performed by NIRS monitoring indicated that desflurane and sevoflurane had similar effects in the preservation of CrSO2. Further studies are needed to provide substantial support to our findings.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Van Yüzüncü Yıl University Clinical Investigation Ethic Committee (Date: 25.04.2017; No. 07).

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

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – C.S.; Design – C.S., N.G.; Supervision – C.S., N.Y., L.A.; Resources – L.A., C.S., N.G., N.Y.; Materials – L.A.; Data Collection and/or Processing – L.A., C.S.; Analysis and/or Interpretation – L.A., C.S., N.G., N.Y.; Literature Search – L.A., C.S., N.G., N.Y.; Writing Manuscript – L.A., C.S., N.G.; Critical Review – L.A., C.S., N.G., N.Y.; Other – L.A., C.S., N.G., N.Y.

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

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