

Cerebral oxygenation in the beach chair position before and during general anesthesia

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ABSTRACT

Aim. Ischemic brain damage related to the beach chair position is a matter of concern. The current study was designed to evaluate whether the beach chair position before and during general anesthesia differentially induces changes in cerebral oxygenation as determined by near-infrared spectroscopy (NIRS) in surgical patients.

Methods. We evaluated brain tissue oxygen index (TOI) values using the NIRS monitor NIRO-200™ in the beach chair position the day before and during general anesthesia. Thirty patients with normal preoperative TOI values undergoing shoulder surgery were enrolled. The initial TOI measurement in the supine position after 10 min rest or 10 min after tracheal intubation was followed by measurements after 5 min each in the 30-degree and subsequently 60-degree head-up tilt positions. During general anesthesia, patients were mechanically ventilated to obtain normocapnia under inhalation of 1.5% sevoflurane in 50% oxygen. Mean blood pressure (MAP) was measured non-invasively in the arm at heart level and was maintained above 60 mmHg with phenylephrine.

Results. Preoperative TOI values and preoperative MAP were within the normal range in the study population. MAP decreased upon anesthesia but did not further change when the patient was placed in the 30- and 60-degree head-up tilt positions. Heart rate also decreased upon anesthesia. However, TOI values did not change with induction of general anesthesia or placement of the patients in the beach chair position.

Conclusion. Under general anesthesia, the beach chair position does not alter cerebral oxygenation in patients showing normal preoperative cerebral TOI values. (*Minerva Anesthesiol* 2010;76:485-90)

Key words: Anesthesia, general - Spectroscopy, near-infrared - Arthroscopy.

The beach chair position in arthroscopic shoulder surgery provides good surgical conditions for surgeons.¹ Compared with the lateral decubitus position, the beach chair position can reduce brachial plexus injury and allows surgeons to easily access the shoulder because the arm weight distracts the shoulder joint while maintaining intact intraarticular anatomy.² However, possible cerebral hypoperfusion related to this position has been suggested by the poor neurological outcomes in four middle-aged patients without high risk for

cerebrovascular events, although the exact mechanisms of the catastrophic complications remain to be determined.¹⁻³

Cerebral hypoxia/ischemia is a major contributor to poor neurological outcome in a variety of clinical scenarios, but its detection is still problematic.⁴ Near-infrared spectroscopy (NIRS) is a noninvasive and continuous technique that offers the potential for cerebral perfusion monitoring, in which cerebral oxygenation reflecting the balance between cerebral metabolic supply and

demand can be assessed.⁴ Indeed, recent studies have demonstrated that NIRS is capable of providing similar accuracy to transcranial Doppler sonography or stump pressure measurements for the detection of cerebral ischemia during carotid surgery.⁵ Among the cerebral NIRS parameters, the tissue oxygen index (TOI) appears to be reliable because it is not influenced by the tissue hemoglobin concentration, skull thickness or the area of the cerebrospinal fluid layer.⁶ However, changes in TOI values related to the beach chair position have not been evaluated both before and during general anesthesia.

Therefore, the present preliminary study was designed to evaluate, in surgical patients with normal preoperative TOI values, whether the beach chair position before and during general anesthesia differentially induces changes in cerebral TOI values as well as hemodynamics.

Materials and Methods

This study received institutional approval from Wakayama Medical University, and informed consent was obtained from 30 patients undergoing shoulder surgery. Patients with a history of syncope and/or redness or rash on their forehead at the time of admission were excluded from this study.

NIRS measurement

TOI (%) was measured using the NIRS device NIRO-200™ (Hamamatsu Photonics, Hamamatsu, Japan). The NIRO-200™ uses three wavelengths of near-infrared light (775, 810 and 850 nm), and the sensor contains a laser diode and two detectors placed at 3.7 and 4.3 cm from the source of emitting light. The monitor also adopts the spatially resolved spectroscopy methodology, which combines multi-distance measurements of optical attenuation.⁷ This methodology enables the NIRO-200™ to calculate TOI as a ratio of the oxyhemoglobin concentration to the total hemoglobin concentration in the tissue every 0.18 sec. The oximeter probes were placed on the bilateral forehead (the left and right TOIs) with the caudal border 1 cm above the eyelash, positioning the light source and sensors away from the frontal sinus.⁶

Protocol of measurements

During the measurements, a number of other parameters were monitored: blood pressure in the upper limb at heart level 1-min intervals (noninvasively), continuous heart rate by electrocardiogram, and pulse oximetry. Support stockings were placed on enrolled patients' lower extremities. Twenty-four hours before the induction of general anesthesia, an initial TOI was measured after ten min rest in the supine position, followed by additional measurements after five min in the 30-degree head-up tilt position and then after five min in the 60-degree head-up tilt position. Patients who did not show any abnormal preoperative TOI values (lower than 60% at any point)⁸ were enrolled for further evaluation during anesthesia. Thus, none of the patients in this study showed abnormal preoperative TOI values.

On the day of surgery, patients were allowed to take clear fluids freely until 6 hr before the induction of anesthesia. After arrival in the operating room, acetated Ringer's solution was administered at a rate of 10 mL/kg/h throughout the study period. Following setup of the monitoring devices mentioned above and preoxygenation, anesthesia was induced with propofol 1 mg/kg iv and butorphanol 10 µg/kg iv, followed by vecuronium 0.1 mg/kg iv. Butorphanol was not further added during anesthesia. After bag-mask ventilation with a facemask using 3% sevoflurane in 100% oxygen at a fresh gas flow of 6 L/min for 3 min, the patient's trachea was intubated with a reinforced endotracheal tube. After the intubation, patients were mechanically ventilated to maintain normocapnia (end-tidal carbon dioxide tension = 35-40 mmHg) under inhalation of 1.5% sevoflurane in 50% oxygen. Ten min after tracheal intubation, the initial TOI measurement was taken in the supine position, followed by an additional measurement after five min in the 30-degree head-up tilt position and then after five min in the 60-degree head-up tilt position. To avoid hypotension (mean blood pressure below 60 mmHg), 0.1 mg phenylephrine was intravenously administered as needed; a previous study documented that this vasoconstrictor agent does not directly affect intracranial hemodynamics in anesthetized patients.⁹

TABLE I.—*Clinical and procedural characteristics of the study population.*

	Characteristics (N=30)
Age (yr)	55.0±13.0
Gender (M/F)	20/10
BMI (kg/m ²)	25.0±4.0
Diabetes (N)	6
Hypertension (N)	8
Hypercholesterolemia (N)	11
Hb (g/dL)	14.0±1.8
Medications (N)	
ARB	4
Beta-blocker	2
Ca ²⁺ -blocker	6
Statin	3
Insulin	2

BMI indicates body mass index; ARB, angiotensin receptor blocker. Means±SD

Statistical analysis

Data are shown as mean±SD. Power calculations were done using Sample Power 2.0™ (SPSS Japan Inc., Tokyo, Japan) with decreases in TOI values and decreases in mean blood pressure in response to the beach chair position during anesthesia as the primary and secondary end points, respectively. We calculated that a sample size of 30 gave 80% power to detect changes of 3.7% in TOI and 11.1 mmHg in mean blood pressure at a significance level of 0.05 (SD = 5 or 15, respec-

tively). Statistical analysis was performed using repeated measures of analysis of variance, followed by the Student-Newman-Keuls test using StatView™ version 5.0 (SAS Institute Inc., Cary, NC).

Results

Table I shows the clinical and procedural characteristics of the study population. The population included patients with diabetes mellitus, hypertension and hypercholesterolemia, but preoperative blood pressure was well controlled in these patients (Figure 1).

Without general anesthesia, the beach chair (60-degree head-up tilt) position affected neither mean blood pressure nor heart rate (Figure 1). Under general anesthesia, mean blood pressure decreased compared to that before anesthesia but was not further altered upon assuming the beach chair position. In contrast, heart rate was not altered by general anesthesia but decreased in the beach chair position under anesthesia.

All patients demonstrated normal preoperative baseline TOI values and normal TOI values in response to the head-up tilt position before anesthesia (Figure 2). Irrespective of decreases in both blood pressure and heart rate in the beach chair position under general anesthesia, the left and right TOI values did not change throughout the

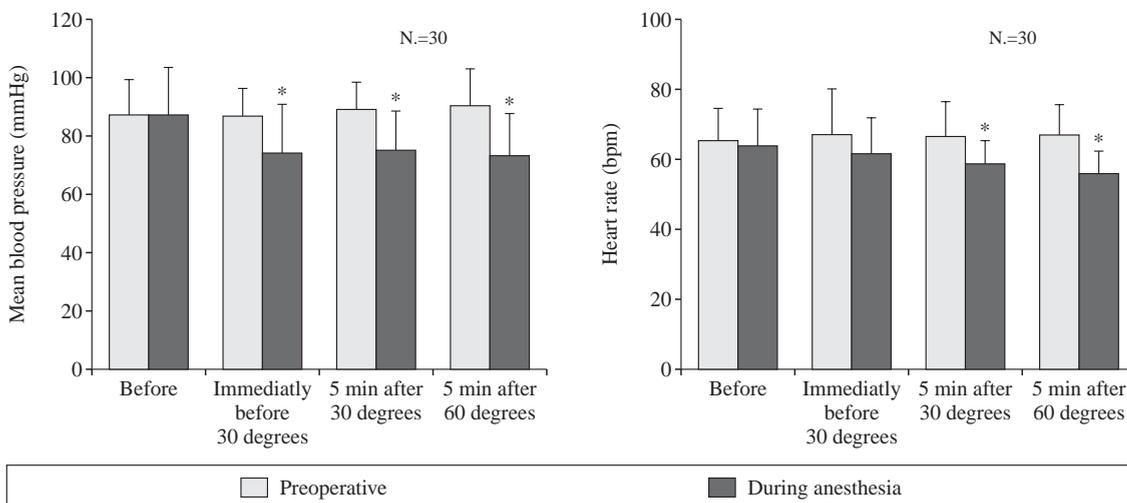


Figure 1.—Changes in mean blood pressure (A) and heart rate (B) in the 30- and 60-degree head-up tilt positions before and during general anesthesia. The values were significantly reduced compared with those before anesthesia. *P<0.05.

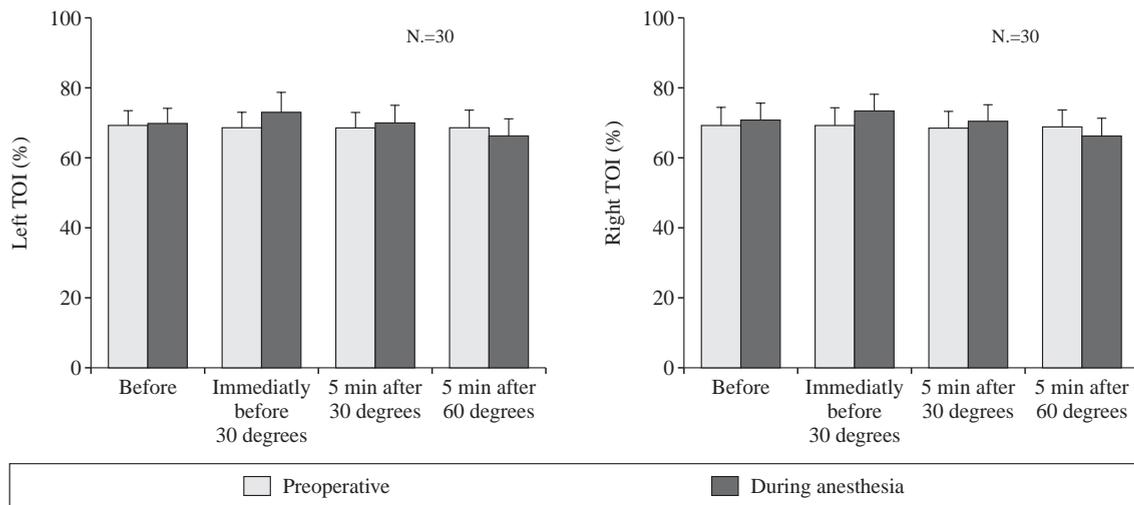


Figure 2.—Changes in left and right tissue oxygen indices (TOI; %) in the 30- and 60-degree head-up tilt positions before and during general anesthesia.

measurements (Figure 2). In each patient, TOI values did not show any significant changes throughout general anesthesia after assuming the 60-degree head-up tilt position (data not shown). No adverse postoperative outcomes were noted in these patients. The total phenylephrine dose used to avoid hypotension during the measurements under anesthesia was 0.04 ± 0.07 mg.

Discussion

This study is the first to evaluate hemodynamic changes in the beach chair (60-degree head-up tilt) position before and during general anesthesia with sevoflurane in surgical patients. Under general anesthesia, mean blood pressure decreased 16% relative to that before anesthesia but did not further decrease in the beach chair position. In contrast, heart rate was not altered by general anesthesia but did decrease in the beach chair position. Previous studies showed decreases in cardiac index, stroke volume or arterial pressure in the sitting (90-degree head-up tilt) position during anesthesia with nitrous oxide in combination with or without halothane, enflurane or opioids.^{10, 11} It appears that the anesthetics used in the current study (i.e., sevoflurane in combination with opioids but without nitrous oxide) did not alter hemodynamics in the beach chair position, but we do not have a clear explanation for this conclusion. We

speculate that the alpha-adrenergic receptor agonist phenylephrine, administered to avoid hypotension, had at least some effects, including a reactive decrease in heart rate. It is also crucial to note that previous studies demonstrated that hemodynamics were stable after 5 min in the sitting (90-degree head-up tilt) position under general anesthesia with 60% nitrous oxide in combination with enflurane, halothane or opioids.^{10, 11} Therefore, we decided to evaluate TOI as well as cardiovascular parameters 5 min after assuming the 30- and subsequently 60-degree head-up tilt positions to compare our data to these previous studies. In our study, in the 60-degree head-up tilt position without nitrous oxide, TOI values did not show significant changes until the end of general anesthesia, indicating that a delayed cerebral ischemia probably did not develop in our study population.

TOI values derived from the NIRS monitor NIRO™ reportedly represent the absolute cerebral oxygenation.⁷ Previous studies documented that TOI values measured by NIRO™ accurately reflect changes in cerebral tissue oxygenation as well as capillary oxygenation or mitochondrial oxygen tension in the brain with a high degree of sensitivity and specificity.^{12, 13} Normal TOI values in subjects without cerebrovascular diseases tend to be above ~60, but normal TOI values have not been exactly determined.⁸ In dis-

eased patients undergoing carotid endarterectomy, the threshold for cerebral ischemia appeared to be a 13% reduction in TOI relative to the baseline values.¹⁴ In the present study, irrespective of decreases in both blood pressure and heart rate during the beach chair position under general anesthesia, the left and right TOI values were not altered when mean blood pressure was maintained above 60 mmHg. In addition, TOI values after the measurements did not change throughout general anesthesia in each patient. These results may be consistent with previous studies demonstrating that dynamic cerebral autoregulation remains intact during prolonged orthostasis in nonsyncopal subjects without anesthesia.¹⁵ The beach chair position under general anesthesia with careful blood pressure management may not alter cerebral oxygenation in patients having normal preoperative TOI values. However, it is important to note that sevoflurane, compared with isoflurane, reportedly preserves dynamic cerebral pressure autoregulation in humans.¹⁶ Therefore, it seems possible that variable anesthetics differentially modify TOI values in the beach chair position during general anesthesia, although we did not evaluate this issue in the current study. Indeed, changes in position and the use of vasopressors in the current study may also affect the TOI measurements due to alterations in the proportion of hemoglobin-containing tissue and in the arterial-venous ratio.

Considering the catastrophic outcomes that have been associated with the beach chair position, Cullen and Kirby recommended that anesthesia personnel aggressively treat blood pressure values less than 80% of preoperative resting values in this position.² This recommendation is based on the concepts that the limits of cerebral autoregulation occur at mean arterial pressure values of approximately 70 to 150 mmHg and that blood pressure is lower in the brain than that in the heart or the arm if a patient is in the head-up tilt position.^{2, 17} However, this recommendation is in contrast with the following argument regarding the siphon to determine cerebral perfusion pressure.^{18, 19} The cerebral circulatory system is best described as a closed system, in which liquid is driven and returned to its original level through a series of tubes, without increased exposure to the atmos-

phere.^{18, 19} Therefore, these authors mention that the resistance to cerebral blood flow, but not the vertical distance above the heart, is the sole determinant of cerebral perfusion pressure.^{18, 19} This result implies that head elevation does not, by itself, decrease cerebral blood flow as long as mean arterial pressure at heart level is not allowed to change.²⁰ Indeed, previous studies demonstrated that in the sitting position, cerebral blood flow measured by the intravenous ¹³³Xenon technique does not decrease but rather increases in neurosurgical patients undergoing general anesthesia with 0.25% to 0.5% halothane in combination with 60% nitrous oxide.²¹ However, Drummond indicated that the available data support the concept that some patients may have lower limits of autoregulation that are much higher than expected.²² The implication for the clinical application of our data has been unclear because NIRO-200™ measures only a small area of the brain, and it is possible that cerebral ischemia may occur in areas that we are not capable of detecting by using this monitor.^{6, 7} In addition, the margin of safety in mean arterial pressure to prevent cerebral hypoperfusion in the beach chair position is still unknown; therefore, further studies are certainly needed to clarify this point.²³

Conclusions

The beach chair position under general anesthesia appears not to alter cerebral oxygenation as evaluated by NIRO-200™ in patients showing normal preoperative TOI values with mean blood pressure maintained above 60 mmHg. However, it is still unclear whether perioperative management using cerebral oxygenation monitoring contributes to preservation of cerebral perfusion in the beach chair position during general anesthesia.

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