ANESTHESIA FOR ARTHROSCOPIC SHOULDER SURGERY IN THE BEACH CHAIR POSITION: MONITORING OF CEREBRAL OXYGENATION USING COMBINED BISPECTRAL INDEX AND NEAR-INFRARED SPECTROSCOPY

Hiroaki Kawano* And Tomomi Matsumoto**

Abstract

Recent research has shown that cerebrovascular complications following shoulder surgery performed in the beach chair position under general anesthesia arise secondary to cerebral ischemia. Appropriate management of cerebral oxygenation is thus one of the primary goals of anesthetic management during such procedures. The present report describes the case of a 65-year-old male patient, in which both bispectral index (BIS) and near-infrared spectroscopy (NIRS) were used to monitor cerebral oxygenation. During the positioning, we observed an increased suppression ratio (SR) while BIS and regional cerebral oxygen saturation (rSO_2) were at adequate level. In view of the difference in blood pressure between the heart and the base of the brain, blood pressure was maintained to ensure adequate cerebral perfusion. Although intraoperative rSO_2 was at or around the cut-off point (a 12% relative decrease from baseline), no marked decrease in BIS or further increase in the SR was observed. Monitoring of cerebral perfusion using combined BIS and NIRS optimized anesthetic management during the performance of arthroscopic shoulder surgery in the beach chair position.

Key words: General anesthesia, Beach chair position, Cerebral oxygenation, Bispectral index, Near-infrared spectroscopy.

Introduction

Several reports have described serious complications secondary to general anesthesia for shoulder surgery performed in the beach chair position[1,2]. Recent research has identified a causal relationship between the beach chair position and cerebral hypoperfusion[3,4], and it is widely accepted that the beach chair position may be associated with a decrease in cerebral perfusion[5,6].

The present report describes optimal management of cerebral oxygenation during arthroscopic shoulder surgery performed in the beach chair position. This involved the monitoring of cerebral oxygenation using a combination of bispectral index (BIS) and near-infrared spectroscopy (NIRS).

* MD, PHD.
** MD.
Affiliation: Department of Anesthesiology and Clinical Research, National Hospital Organization Zentsuji Hospital, Zentsuji, Japan.
Corresponding author: Hiroaki Kawano, MD, PhD, Department of Anesthesiology and Clinical Research, National Hospital Organization Zentsuji Hospital, 2-1-1 Senyu, Zentsuji, Kagawa 765-8507, Japan. Tel: +81-877-62-2211, Fax: +81-877-63-1601. E-mail: hir.kawano@gmail.com

Case report

The 65-year-old male patient (166 cm, 67 kg) was admitted to our hospital for arthroscopic shoulder surgery. He had undergone arthroscopic rotator cuff repair in the lateral decubitus position 7 months before, but his symptoms had not improved. During the initial procedure, intraoperative monitoring included electrocardiography, noninvasive blood pressure monitoring, capnography and pulse oximetry, and the anesthetic management was successful with no complications. His medical history included insulin-dependent diabetes mellitus, hypertension and congestive heart failure.

No preanesthetic medication was administered prior to the arthroscopic procedure. On arrival in the operating room, his blood pressure was 161/72 mmHg, his heart rate was 68 beats/min, and his arterial oxygen saturation was 98% on room air. The patient was monitored with electrocardiography, capnography, and pulse oximetry. In addition to these routine monitoring procedures, an arterial catheter was inserted into the left radial artery to allow invasive blood pressure monitoring, and BIS monitoring was applied. At the same time, regional cerebral oxygen saturation (rSO_2) was measured using NIRS (INVOS 5100C; Covidien, Boulder, CO, USA). Throughout the procedure, the rSO_2 was recorded from the left ($LrSO_2$) and the right ($RrSO_2$) hemispheres using two probes, which were positioned on the left and right sides of the forehead respectively. Prior to induction, the LrSO2 and RrSO2 were 59% and 51%, respectively (baseline values). General anesthesia was induced with intravenous remifentanil (0.5 μg/kg/min), propofol (70 mg), and rocuronium (40 mg), and endotracheal intubation was performed. The patient was then placed in the beach chair position. The external auditory meatus, which represents the base of the brain, was positioned 40 cm above the atrial level. Thus, it was calculated that the blood pressure at the base of the brain would be approximately 30 mmHg lower than at the arm. To maintain the mean arterial pressure (MAP) above 80 mmHg, a continuous infusion of intravenous dopamine (2-5 μg/kg/min) was administered. In addition, all episodes of hypotension (defined as MAP< 80 mmHg) were treated with intravenous ephedrine (4 mg) or phenylephrine (0.1 mg). Anesthesia was maintained with oxygen (2 l/min), air (2 l/min), sevoflurane (1.0%), and remifentanil (0.2-0.3 μg/kg/min). Neuromuscular blockade was maintained with intermittent rocuronium. As postoperative analgesia, approximately 60 min before the end of the procedure, intravenous fentanyl (200 μg) was administered, and intravenous patient-controlled analgesia infusion (fentanyl 20 μg/ml; basal infusion 1 ml/h, bolus 1 ml, lockout time 10 min) was started.

In response to anesthetic induction, MAP decreased from 108 to 59 mmHg, which resulted in an increase of the suppression ratio (SR) to 19. At this point, the BIS and rSO_2 were stable. With intravenous administration of ephedrine (4mg), the MAP increased and the SR returned to 8. After the patient was placed in the beach chair position, the SR rapidly increased to 21. BIS and rSO_2 were in the 40-50 and 45-50 ranges, respectively, and signal quality index was more than 75%. The patient's MAP was 70 mmHg. This was treated with intravenous administration of ephedrine (8 mg), and the SR improved (Fig. 1). Thereafter, there was no further increase in the SR. The intraoperative systolic blood pressure was 90-160 mmHg, the MAP was 70-110 mmHg, the heart rate was 50-70 beats/min, and the end-tidal CO_2 was 35-40 mmHg. The total dose of ephedrine was 40 mg and that of phenylephrine was 0.5 mg. The BIS was stable at between 40 and 60, and there were no episodes of any marked decrease in BIS. The $LrSO_2$ was stable at around 52% (range 50-54%), and the $RrSO_2$ was also stable at around 52% (range 50-53%). Surgery was completed without complications, and the patient emerged from anesthesia uneventfully. Once the patient had regained consciousness and was able to follow simple commands, the neuromuscular blockade was reversed and his trachea was extubated. The duration of the surgical procedure and anesthesia were 8 h:11 min and 9 h:40 min, respectively. Intraoperative total blood loss was 250 ml, urine output was 1450 ml and total infusion volume was 1750 ml. The patient remained stable during the 1-month inpatient postoperative period, and no postoperative complications were evident.

Discussion

The beach chair position (30-90° above the horizontal plane) is widely used for orthopedic shoulder arthroscopy procedures as it offers advantages such as excellent intraarticular visualization and reduced brachial plexus strain. Although Tange et al.[7] reported that the use of the beach chair position under general anesthesia did not alter cerebral oxygenation, several studies have reported a causal relationship between the beach chair position and cerebral hypoperfusion[3,4]. According to a report by Murphy et al.[3], shoulder surgery in the beach chair position was associated with a significant reduction in cerebral oxygenation compared with the use of the lateral decubitus position. Therefore, maintenance of adequate cerebral perfusion should be ensured during shoulder surgery performed in the beach chair position, even in healthy patients who are not at increased risk of ischemic stroke. Strict cerebral oximetry monitoring was necessary in the present case, as the patient was at high risk of cerebrovascular events.

The BIS is widely used as an indicator of the level of consciousness during general anesthesia. In addition, several reports have suggested that the BIS allows detection of cerebral ischemia[8,9], since cerebral hypoperfusion decreases the BIS. Hayashida et al.[9] described five children in whom 14 episodes of a simultaneous decreases in rSO_2 and BIS occurred during episodes of acute hypotension within the course of cardiac surgery. In these patients, abrupt decreases in BIS in their patients associated with an acute slowing of the electroencephalogram (EEG), which is an early indication of cerebral hypoperfusion. In the present case, no marked reduction in BIS, a sign which may suggest cerebral hypoperfusion, was observed during the procedure.

In the present case, the SR increased to 21 following change of position from supine to beach chair position, while BIS and rSO_2 were in a normal range. This is similar to previously reported cases where an increased SR was observed despite BIS values at an adequate anesthetic level and the possible role of hypoxemia was suggested[10,11]. SR derived from BIS monitoring estimates the percentage of burst suppression EEG pattern or isoelectric activity. It occurs during deep anesthesia, but several reports suggest that SR could be related to hemodynamics[12] or metabolism such as hypothermia[13] or hypoxia[10]. A causal relationship between SR and cerebral hypoxemia has been suggested in animal studies[14]. Furthermore, it has been shown that the presence of SR in critically ill patients was associated with increased mortality[15]. Therefore, although it is obvious that BIS monitor is not designed to detect cerebral ischemia, it might be useful for detecting cerebral hypoperfusion. Because MAP decreased from 108 to 59 mmHg in response to anesthetic induction,

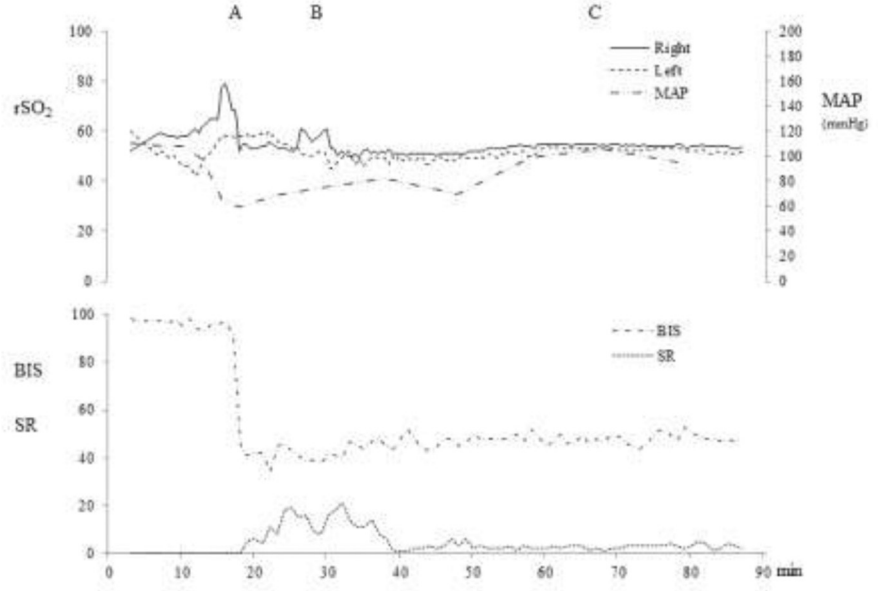

Fig. 1
Changes in regional cerebral oxygen saturation (rSO_2), mean arterial pressure (MAP), bispectral index (BIS), and suppression ratio (SR) during the anesthetic procedure. During the positioning, an increased SR was observed while BIS and rSO_2 were in a normal range. Although intraoperative rSO_2 was at or around the cut-off point, no marked decrease in BIS or further increase in the SR was observed. A, tracheal intubation; B, beach chair position; C, start of operation

and because hypoxia, hypocapnia, and anemia, all of which might cause cerebral hypoperfusion, were not present, the first episode of SR increase was thought to be due to hypotension. However, the second episode of SR increase in the present case may have been related to cerebral hypoperfusion associated with the beach chair position. It is well recognized that the beach chair position may be associated with a decrease in cerebral perfusion as mentioned above. In our patient, an elevation of the SR was a useful sign for the detection of the beach chair position-related cerebral hypoperfusion.

NIRS is a noninvasive technique for the continuous monitoring of rSO_2, and it has been used to detect cerebral ischemia and hypoxia in patients undergoing procedures such as cardiovascular surgery and carotid endarterectomy (CEA). Although various studies have investigated the optimal cut-off point for a decrease in rSO_2 in order to identify the occurrence of neurological complications in patients undergoing CEA[16,17], the rSO_2 threshold indicating cerebral ischemia ranges from a 12-20% relative decrease. It may therefore be difficult to judge whether pharmacological or physiological intervention is required when the rSO_2 is at or around the cut-off point like the present case. Furthermore, it has been shown that EEG and somatosensory evoked potentials (SEP) correlate directly with changes in cerebral blood flow, whereas no such data related to rSO_2 are currently available. Therefore relying on rSO_2 alone to monitor the adequacy of cerebral perfusion might be dangerous and inadequate in terms of avoiding neurological complications. Consequently, both BIS and rSO_2 were measured with NIRS. Hayashida et al.[18] reported that the combination of BIS and NIRS can be a convenient method of ischemic/anesthetic monitoring, i.e., that by monitoring both BIS and NIRS, it is possible to judge whether cerebral hypoperfusion, as indicated by a decrease in rSO_2, is at the saturation level at which cerebral dysfunction will occur.

In conclusion, appropriate management of cerebral oxygenation is essential during any surgical procedure performed in the beach chair position. We recommend the use of cerebral oximetry monitoring devices. In the present case, monitoring of cerebral oxygenation using a combination of BIS and NIRS optimized anesthetic management during the performance of shoulder surgery in the beach chair position.

Conflict of interest

None.

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Published with the written consent of the patient.

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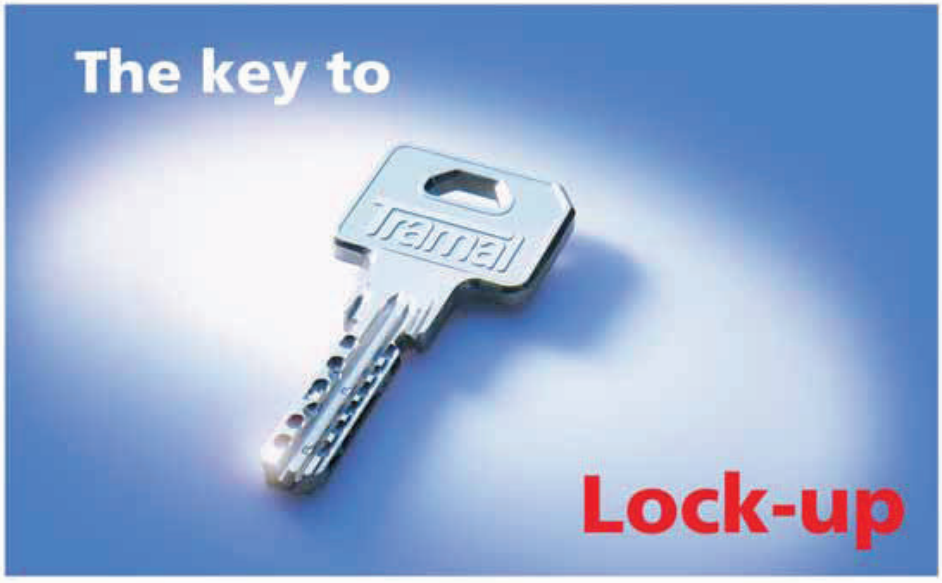

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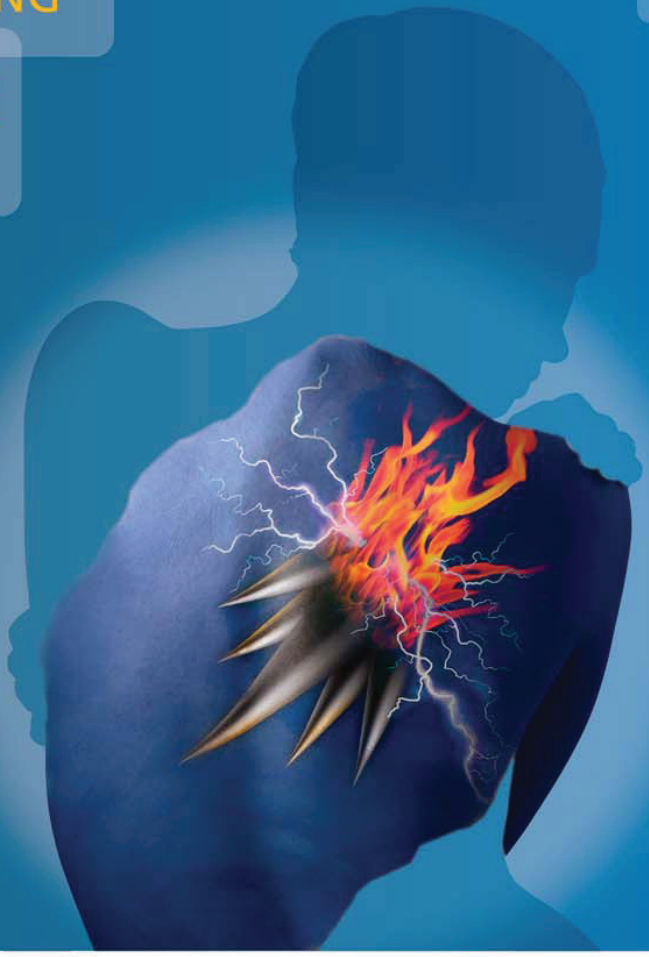

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* Train of four
† Post-tetanic counts
‡ Second twitch

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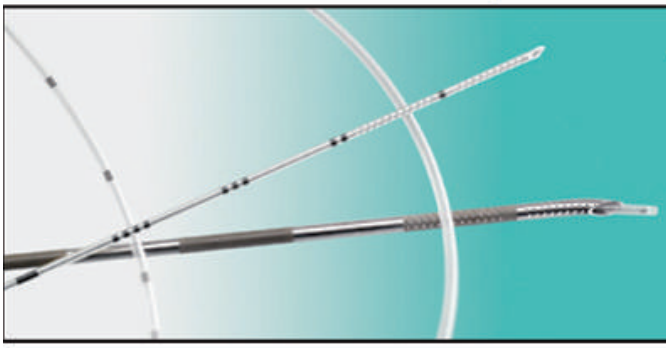

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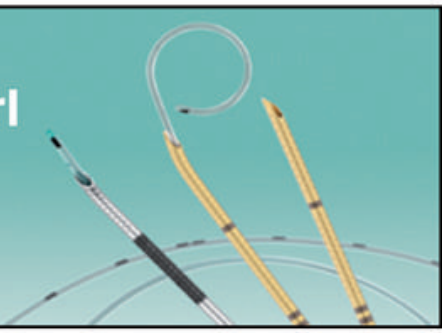

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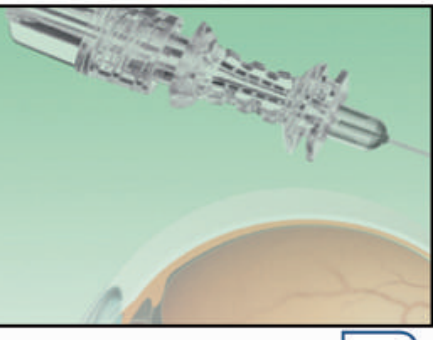

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