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ORIGINAL ARTICLE

The effectiveness of cerebral oxygenation monitoring during arthroscopic shoulder surgery in the beach chair position: a randomized blinded study

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Background: Beach chair positioning for shoulder surgery is associated with measurable cerebral desaturation events (CDEs) in up to 80% of patients. Near-infrared spectroscopy (NIRS) technology allows real-time measurement of cerebral oxygenation and may minimize the frequency of CDEs. The purpose of this study was to investigate the incidence of CDEs when anesthesiologists were aware of and blinded to NIRS monitoring and to determine the short-term cognitive effects of surgery in the beach chair position.

Methods: NIRS was used to monitor cerebral oxygenation saturation in 41 consecutive patients undergoing arthroscopic shoulder surgery in the beach chair position. Patients were randomized to 2 groups, anesthesiologists aware of or blinded to NIRS data. The Montreal Cognitive Assessment (MoCA) was used to assess cognitive function preoperatively, immediately postoperatively, and at 2 and 6 weeks postoperatively.

Results: Overall, 7 (17.5%) patients experienced a CDE, 5 (25%) in the aware group and 2 (10%) in the blinded group. There was no significant difference in MoCA scores between the aware and blinded groups preoperatively (27.9.1 vs. 28.2; $P = .436$), immediately postoperatively (26.1 vs. 26.2; $P = .778$), 2 weeks postoperatively (28.0 vs. 28.1; $P = .737$), or 6 weeks postoperatively (28.5 vs. 28.4; $P = .779$). There was a correlation of NIRS with systolic blood pressure ($r = 0.448$), diastolic blood pressure ($r = 0.708$), and mean arterial pressure ($r = 0.608$).

Conclusion: In our series, the incidence of CDEs was much lower than previously reported and was not lowered by use of NIRS. Patients did not have significant cognitive deficits after arthroscopic surgery in the beach chair position, and there was a correlation between NIRS and intraoperative brachial blood pressure.

Level of evidence: Level II; Randomized Controlled Trial; Treatment Study

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Keywords: Cerebral oxygenation; near-infrared spectroscopy; beach chair position; arthroscopic shoulder surgery; rotator cuff repair; capsular release

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Surgeons and anesthesiologists remain concerned about the increased risk of cerebral hypoperfusion that may occur in the beach chair position.¹² The reported incidence of cerebrovascular events in the beach chair position is <0.1%;

however, the reported incidence of cerebral desaturation events (CDEs) in the beach chair position ranges from 0% to 80.3% when general anesthesia is used.¹⁵ There is concern that CDEs could lead to ischemic brain or spinal cord injury, vision loss, and postoperative nausea and vomiting.^{1,2,4,12,15,16} It remains unclear whether the degree and duration of these CDEs are associated with short- or long-term cognitive deficits.^{1,10,19}

Current standard of care for patients undergoing shoulder surgery in the beach chair position does not involve any direct measurement of cerebral tissue oxygenation saturation. Instead, cerebral perfusion is estimated by measuring brachial blood pressure and adjusted by titrating the level of anesthesia and administering intravenous medications to maintain brachial blood pressure within a desired range. Near-infrared spectroscopy (NIRS) is a noninvasive method to measure regional cerebral tissue oxygenation (rSO₂). This technology has been studied during various surgical procedures, including orthopedic, transplant, cardiac, vascular, and abdominal surgery.^{3,7,12,19,24} In orthopedic surgery, this technology has been studied most extensively in patients undergoing shoulder surgery in the beach chair position.^{7,10,13,15} Another method to estimate cerebral tissue perfusion is estimated cerebral mean arterial pressure (eTMAP), measured with an arterial transducer at the temporal artery. Changes in eTMAP do not correlate well with changes in rSO₂ measured by NIRS during desaturation events but do correlate with brachial blood pressure.^{23,24} Alternatively, real-time intraoperative electroencephalography has been used to detect cerebral ischemia during shoulder surgery in the beach chair position; however, this method requires a neurophysiologist to be present to interpret the electroencephalography recordings.⁵ The use of NIRS to measure cerebral tissue oxygenation saturation may help anesthesia teams minimize the frequency and duration of CDEs during shoulder surgery in the beach chair position.

The primary purpose of this study was to determine whether NIRS monitoring decreases the incidence of CDEs during arthroscopic shoulder surgery in the beach chair position. Secondarily, we sought to quantify the effect of CDEs on short-term cognitive function. We hypothesize that patients in the blinded group would have a greater incidence of CDEs and worse postoperative cognitive function compared with the control group.

Materials and methods

Study design and patients

Patients between the ages of 18 and 85 years undergoing arthroscopic shoulder surgery in the beach chair position by the senior author (J.A.A.) were screened for eligibility. Preoperative diagnoses included rotator cuff tears, adhesive capsulitis, and glenohumeral arthritis. Procedures performed included rotator cuff repair (with or without acromioplasty and biceps tenodesis), capsular release, débridement, and chondroplasty. All procedures were performed at an outpatient surgery center. The exclusion criteria were minors, diagnosis of chronic neurologic conditions (ie, dementia, Parkinson

disease, multiple sclerosis), and preoperative Montreal Cognitive Assessment (MoCA) score <26. Eligible patients were contacted preoperatively by telephone for study inclusion. Informed written consent was obtained before surgery. Demographic data of the patients including age, gender, height, weight, and pre-existing medical conditions were recorded.

Randomization

All subjects underwent real-time regional cerebral tissue oxygenation saturation monitoring by NIRS during the surgical procedure. Patients were randomized into 1 of 2 groups by a computer random number generator. In the study group, the anesthesia staff was aware of the NIRS monitor recordings during surgery. In the control group, the anesthesia staff was blinded to the NIRS monitor recordings. The research staff, responsible for recording the NIRS monitor data and blood pressure readings, was aware of the randomization assignments.

Intraoperative monitoring and treatment

A Nonin Medical Inc. (Plymouth, MN, USA) SenSmart Model X-100 Universal Oximetry System was used to measure regional cerebral tissue oxygenation saturation. Two NIRS sensors (SenSmart 8004CB EQUANOX; Nonin Medical Inc.) were applied bilaterally to the frontotemporal area, with the medial margins approximately 0.5 cm from the midline of the forehead and the lower margins approximately 1 cm above the eyebrow (Fig. 1, A). Baseline rSO₂ values along with heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and arterial oxygenation saturation (SpO₂) were obtained in the preoperative holding area with the patient sitting upright in a hospital bed and breathing room air. These baseline values were obtained before any anesthetic medications were administered. The same measurements were recorded immediately after anesthesia induction in the operating room with the patient in the supine position and immediately after the patient was placed in the beach chair position. Frontal lobe oxygenation was continuously recorded every 4 seconds throughout the case, and SBP, DBP, and MAP were recorded at 5-minute intervals using a brachial automated sphygmomanometer. A CDE was defined as a decrease in rSO₂ of 20% or greater from baseline or an absolute rSO₂ <55% (Fig. 1, B).¹² A hypotensive event was defined as a drop in SBP below 90 mm Hg. The rSO₂, SBP, DBP, and MAP were recorded during each desaturation or hypotensive event. Events were categorized as CDEs isolated to the right or left side, bilateral CDEs, hypotensive only, or simultaneous CDE and hypotensive event. Treatment interventions for desaturation and hypotensive events were standardized to 5 mg of ephedrine or 80 µg of phenylephrine. The specific treatment administered was dependent on the patient's hemodynamics and at the discretion of the anesthesia team. Intraoperative hypertension was treated with 2.5 mg or 5 mg of metoprolol. At the end of each case, the surgeon was asked to rate the case difficulty and bleeding problems on a 10-cm visual analog scale.

Anesthesia protocol

The anesthesia protocol was standardized. All patients received an interscalene brachial plexus blockade using 31 mL of 0.5%

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