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Cerebral desaturation events during shoulder arthroscopy in the beach chair position: patient risk factors and neurocognitive effects

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Background: Patients undergoing shoulder surgery in the beach chair position may be at increased risk for serious neurocognitive complications due to cerebral ischemia. We sought to define the incidence, patient risk factors, and clinical sequelae of intraoperative cerebral desaturation events.
Methods: Regional cerebral tissue oxygen saturation (rSO2) was monitored intra-operatively using near-infrared spectroscopy (NIRS) on 50 consecutive patients. The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) was administered to each patient pre- and postoperatively. Intra-operative decreases in rSO2 of 20% or greater were defined as cerebral desaturation events (CDE). The association between intraoperative CDE and postoperative cognitive decline was assessed.
Results: The incidence of intraoperative CDE in our series was 18% (9/50). Increased body mass index (BMI) was found to have a statistically significant association with intraoperative CDE (mean BMI 37.32 vs 28.59, $P < .0001$). There was no statistical significance in pre- vs postoperative RBANS either in composite scores or any of the sub-indices in either group.
Conclusion: The degree and duration of cerebral ischemia required to produce neurocognitive dysfunction in this patient population remains undefined; however, cerebral oximetry with NIRS allows prompt identification and treatment of decreased cerebral perfusion decreasing the risk of this event. Increased BMI was found to be a statistically significant patient risk factor for the development of intra-operative CDE. The transient intra-operative CDEs were not associated with postoperative cognitive dysfunction in our patient series. We believe protocols aimed at detecting and reversing CDE minimize the risk of neurocognitive dysfunction and improve patient safety.
Level of evidence: Level IV, Case Series, Prognosis Study.

Keywords: Shoulder arthroscopy; beach chair; complications; cerebral desaturation; neurocognitive dysfunction

The beach chair position is commonly used for both arthroscopic and open shoulder surgery. Approximately two-thirds of shoulder surgeries performed in the United States utilize the beach chair position.[11,23] This technique

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positions the shoulder in an anatomic upright position, facilitating shoulder joint access and visualization.[38] The position also provides improved airway access, diminished bleeding, and reduced risk of brachial plexus injury.[32]

In spite of these advantages, there are multiple reports of significant neurologic complications including severe brain damage and death.[24] The definitive etiology of these complications remains unproven, but is hypothesized to occur secondary to cerebral ischemia.[22] The upright position is associated with hypotension leading to an increased risk of cerebral hypoperfusion.[34] Reduction in cerebral perfusion pressure below critical thresholds of duration and severity may result in permanent neurologic injury.[22] It has been recommended that patients undergoing surgery in the beach chair position be continuously monitored, and intraoperative cerebral oxygenation optimized to avoid potential neurologic complication.[7,10]

Near-infrared spectroscopy (NIRS), a noninvasive technique that allows continuous monitoring of cerebral oxygenation, has been demonstrated to accurately recognize desaturation episodes that would be undetected with conventional intraoperative monitoring.[22,25,26] This FDA approved technology is extensively used in patients undergoing procedures at high risk for adverse neurologic outcomes such as cardiac, vascular, transplant, and major abdominal surgery.[4] Multiple small case series and case reports have documented intraoperative cerebral desaturation episodes and rare catastrophic neurocognitive complications from shoulder surgery in the semi-upright position.[7,10,24,38] No current investigation has utilized NIRS to assess intraoperative cerebral perfusion deficits as they relate to postoperative cognitive changes.

The aim of this prospective cohort study is to investigate the incidence, and identify patient specific risk factors for episodes of intraoperative cerebral desaturation in subjects undergoing arthroscopic shoulder surgery in the beach chair position. In addition, we monitored the cognitive sequela of intraoperative cerebral hypoperfusion with the use of clinical pre- and postoperative neuropsychological testing.

Methods and materials

Enrollment

Following IRB approval, informed consent was obtained from all subjects. Fifty consecutive patients scheduled to undergo elective arthroscopic shoulder surgery in the beach chair position were enrolled. Exclusion criteria included age less than 18 years, carotid stenosis (90% occlusion), prior neck surgery, diagnosed cervical stenosis, cervical disc herniation, history of stroke, transient ischemic attack, prior neurologic event, syncope, myocardial infarction, spinal cord injury, or sudden vision loss. Patient demographic data, including age, gender, height, weight, smoking, and pre-existing medical conditions, were all recorded.

Preoperative cognitive testing

On the day of surgery, each subject was administered the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). The RBANS is a cognitive battery that consists of 5 indexes, with an administration time of between 20 and 30 minutes. The battery indexes include Immediate Memory, Visuospatial/Constructional, Language, Attention, and Delayed Memory. Each subject was randomized to receive 1 of 4 interchangeable versions of the exam (A, B, C, or D).

The raw scores from the subtests were scaled together to create index scores, which were summed for conversion to a total scale score. The cognitive assessments were conducted by research assistants trained in the administration of the RBANS. The preoperative RBANS score served as a personal cognitive baseline for each subject. After completion of the battery, patients were taken to the preoperative holding area.

Intra-operative monitoring

A standardized anesthesia protocol was used in all patients. An intravenous line was inserted in the preoperative holding area, and all patients were given midazolam (2-6 mg IV), titrated to effect and placed on 2 liters of continuous oxygen via simple facemask. After cleansing the forehead with an alcohol wipe, 2 noninvasive near-infrared spectroscopy sensors (INVOS 5100; Somanetics, Troy MI, USA) were applied bilaterally to the frontotemporal area, with the medial margin at the midline of the forehead and lower margin 1 cm above the eyebrow, thus avoiding the temporalis muscle. The INVOS system is designed specifically to measure oxygen in the blood of the brain in the area underlying the sensor, and uses 2 wavelengths, 730 and 810 nm, to measure changes in regional hemoglobin oxygen saturation by differentiating the absorption spectra of deoxygenated and oxygenated hemoglobin.[20] Frontal lobe oxygenation was continuously recorded every 5 seconds. After 1 minute, a preoperative regional cerebral tissue oxygen saturation (rSO2) baseline was obtained and recorded for both hemispheres.

Once the cerebral saturation baseline was established, an ultrasound guided interscalene block using 30 ml of 0.5% bupivacaine was performed on the side of the operative upper extremity. Bilateral sequential compression devices (AirCast VenaFlow; DJO Global, Vista, CA, USA) were used in all cases for DVT prophylaxis. Intraoperative monitoring consisted of electrocardiography, automatic arterial blood pressure assessment using a cuff placed on the nonoperative upper extremity, pulse oximetry, capnography, axillary temperature measurement, and cerebral tissue oxygen saturation via NIRS. Because cerebral oximetry values may be affected by depth of anesthesia, anesthesia protocols were standardized in terms of type of anesthetic administered, arterial carbon dioxide levels, inspired oxygen content, and mean arterial blood pressure,[9,19] study subjects.

Anesthesia was induced with 2.5-3.0 mg/kg of propofol. The airway was maintained using a laryngeal mask airway (LMA). Maintenance of anesthesia consisted of sevoflurane with N_2O and a fraction of inspired oxygen of 50%. For postoperative nausea and vomiting prophylaxis, nondiabetic patients were given dexamethasone 4 mg after induction and ondansetron 4 mg was given to all patients within 30 minutes of extubation. A lower body forced-air warming device (Bair Hugger; Augustine Medical,

Table I Comparison of dichotomous patient variables in the desaturation and nondesaturation patient groups

	Desaturation group	Nondesaturation group	*P* value
Number of patients	9	41	
Gender (Male/Female)	5 (55.6%)/4 (44.4%)	28 (68.3%)/13 (31.7%)	.467
Diabetes	3 (33.3%)	5 (12.2%)	.144
Smoker	2 (22.2%)	15 (36.6%)	.699
Hypertension	6 (66.7%)	14 (34.1%)	.13
Coronary artery disease	1 (11.1%)	3 (7.3%)	.56
Obstructive sleep apnea	3 (33.3%)	5 (12.2%)	.144
Pulmonary disease	1 (11.1%)	2 (4.9%)	.456

Data are expressed in number of patients (percentage).

Table II Comparison of continuous patient variables in the desaturation and non-desaturation patient groups

	Desaturation group	Nondesaturation group	Difference (95% CI)	*P* value
Age	53.22 ± 9.107	47.34 ± 14.150	−15.829 to 4.068	.24
Body mass index	37.322 ± 8.271	28.593 ± 5.671	−13.304 to −4.154	<.001

CI, confidence interval.
Data are expressed as mean ± standard deviation.

Minneapolis, MN, USA) was used to maintain core temperature above 35.0°C. After the airway was secured, head and neck positioning (flexion, extension, rotation, and lateral bending) was performed in the supine and semi-upright positions.

Intraoperative rSO2 data were collected continuously on a USB device. The patient was positioned into the semi-upright beach chair position (70° from horizontal) for the surgical procedure and the head was secured in the neutral position. Intraoperatively, the NIRS monitoring system was set to alarm with rSO2 decreases of 20% or greater from baseline. To avoid cerebral vascular injury, all such cerebral desaturation episodes were treated with a defined protocol that included ephedrine (5 mg), phenylephrine (80 μg), fluid bolus, and returning the patient to a supine position as clinically indicated. The type of intervention, the time, and mean arterial blood pressure for each CDE were recorded. All data were collected until extubation. All surgeries were performed by a single experienced surgeon (GM). Postoperatively, the patients were recovered in the post-anesthesia care unit in the usual fashion.

Postoperative cognitive testing

After meeting anesthesia criteria for discharge, each patient again underwent the RBANS exam. On the third postoperative day, subjects presented to the outpatient musculoskeletal clinic for routine follow-up and wound evaluation. At the completion of their outpatient visit, they were administered the RBANS for a third and final time. This version of the RBANS (version A, B, C, or D) was randomized such that it was dissimilar from their preoperative exam. Patients who underwent surgery on their dominant upper extremity were assisted by a blinded evaluator by writing on the patient's behalf during the Coding subtest. The pre- and postoperative RBANS were batched and scored by a board-certified clinical neuropsychologist. The grader was blinded to both patient identifying data and chronological sequence of all exams.

Results

Complete datasets were obtained from 50 consecutive patients who met the inclusion criteria. Based on CDE as the primary outcome variable, chi-square testing indicated a power of 99% ($P < .001$) using this sample size. The incidence of intraoperative CDE in our series was 18% (9/50). To investigate the association of CDE with patient risk factors, the dichotomous variables of gender, smoking, diabetes, hypertension, coronary artery disease, obstructive sleep apnea, peripheral vascular disease, and pulmonary disease were analyzed using Pearson chi-square and Fisher's exact tests. These data are presented in Table I. None of the nominal patient variables demonstrated a statistically significant difference between the desaturation group (9) and nondesaturation group (41); however, hypertension (67% vs 36%, $P = .130$), diabetes mellitus (33% vs 12%, $P = .144$), and obstructive sleep apnea (33% vs 12%, $P = .144$) all approached statistical significance.

The continuous variables of body mass index (BMI) and age were analyzed using a 2-tailed t test (Table II). The mean age of the patients who experienced CDE was 53.22, and 47.34 years in those who did not (mean difference −5.881, $P = .240$). The mean BMI among the subjects who experienced CDE was 37.32 vs 28.59 in those who did not (mean difference −8.72, $P < .001$). Subjects were analyzed with respect to a BMI cut-off of 34 or greater. Using this threshold, 78% of subjects experienced CDE vs 21% in patients with a BMI below 34. The odds-ratio for patients with a BMI of 34 or greater of experiencing an intraoperative CDE was calculated to be 12.4. Table III is

Table III Demographics, desaturation characteristics, and interventions for patients experiencing CDE

Age	Male	DM	Tob	HTN	CAD	OSA	COPD	PVD	BMI	Type of surgery undertaken	Duration of desaturation	Post-induction latency to CDE	Intra-operative intervention
63	Yes	No	No	Yes	No	No	Yes	No	34.9	Capsular release, SAD	2 min, 11 sec	17 min, 48 sec	Ephedrine 40 mgX2, ephedrine 50 mgX5
40	Yes	No	Yes	Yes	No	Yes	No	No	37.1	Distal clavicle excision, SAD	1 min, 35 sec 4 min, 48 sec 4 min, 14 sec 2 min, 9 sec	14 min, 32 sec 24 min, 11 sec 63 min, 53 sec 76 min, 42 sec	700 mL fluid bolus over 20 min, patient placed from upright to supine temporarily and started on phenylephrine gtt, turned inhaled anesthetic from 3 to 0 for remainder of case and used propofol for sedation
52	No	Yes	Yes	No	No	No	No	No	23.8	Capsular Release	1 min, 6 sec	0 min, 0 sec	Ephedrine 10 mg, ephedrine 5 mg, decreased inhaled anesthetic from 2 to 1.5
52	No	Yes	No	Yes	Yes	Yes	No	No	48.7	RCR, SAD	0 min, 32 sec	13 min, 52 sec	Ephedrine 10 mgX3, ephedrine 5 mg, decreased inhaled anesthetic from 2 to 1.5
60	Yes	Yes	No	Yes	No	No	No	No	38.0	RCR, SAD	3 min, 13 sec 5 min, 22 sec 8 min, 3 sec	13 min, 29 sec 35 min, 56 sec 71 min, 39 sec	5 mg ephedrine X3, decreased inhaled anesthetic from 2 to 1.4
45	No	No	No	Yes	No	No	No	No	46.9	RCR, SAD	4 min, 19 sec 2 min, 42 sec	10 min, 47 sec 18 min, 18 sec	Ephedrine 5 mgX5, ephedrine 10 mgX2, 800 mL of fluid in first 30 min of case
59	Yes	No	No	No	No	No	No	No	28.2	RCR, SAD	3 min, 14 sec	16 min, 45 sec	Decreased inhaled anesthetic from 1.4 to 0.8
43	No	No	No	No	No	No	No	No	44.0	SAD	1 min 4 sec	33 min, 22 sec	10 mg ephedrine
65	Yes	No	No	Yes	No	Yes	No	No	34.3	Debridement, RCR	1 min 36 sec 3 min 44 sec 2 min 9 sec	47 min, 10 sec 51 min, 59 sec 61 min, 4 sec	Phenylephrine 40 mcgX4

BMI, body mass index (calculated as weight in kg's divided by height); *CAD*, coronary artery disease; *CDE*, cerebral desaturation event; *COPD*, chronic obstructive pulmonary disease; *DM*, diabetes mellitus; *gtt*, drip; *HTN*, hypertension; male, patient's gender is male; *OSA*, obstructive sleep apnea; *PVD*, peripheral vascular disease; *RCR*, rotator cuff repair; *SAD*, sub-acromial decompression; *TOB*, patient is a current smoker.

a summary of the patient demographics, type of surgery, desaturation characteristics, and interventions for the 9 patients who experienced CDE.

Further analysis was performed to determine the impact of intraoperative CDEs on postoperative neurocognitive function. Neurocognitive function was tested using pre- and postoperative RBANS scores. The total score and scores of the individual sub-indices (List learning, Story Memory, Figure Copy, Line Orientation, Picture Naming, Semantic Fluency, Digit Span, Coding, List Recall, Story Recall, and Figure Recall) were compared between pre- and postoperative testing using a 2-tailed *t* test and the Mann-Whitney *U* test. There was no statistical difference in the overall RBANS scores or any of the specific indexes (Immediate Memory, Visuospatial/Constructional, Language, Attention, and Delayed Memory) between pre- and postoperative exams (Fig. 1). There was no statistical difference in the overall RBANS scores or any of the specific indexes between the subjects who had intraoperative CDE compared to those in the cohort who did not (Figs. 2 and 3).

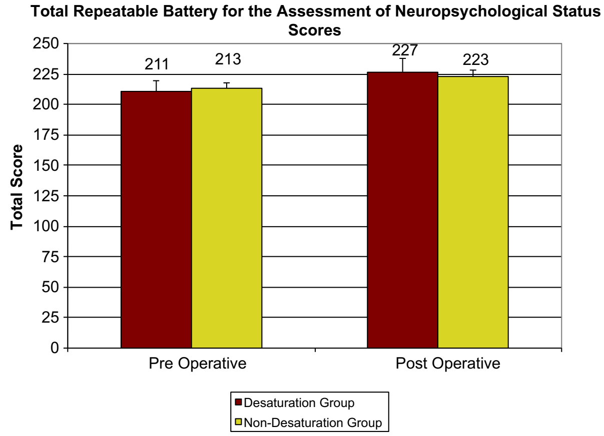

Figure 1 Comparison of mean preoperative and postoperative RBANS scores in the desaturation and nondesaturation patient groups. Data are expressed as mean total score + standard error margin. Desaturation group represented by the *dark bars*; nondesaturation group represented by the *light bars*.

Discussion

Beach chair positioning during surgical procedures has been associated with cerebral hypoperfusion.[22] Changes in cerebral perfusion pressure occur secondary to hemodynamic fluctuations as the patient is transitioned from supine to sitting.[34] In the normal physiologic state, the sympathetic nervous system is activated when assuming the seated position; causing increased systemic vascular resistance and heart rate alterations to maintain cardiac output and mean arterial pressure.[12] However, in anesthetized patients, the autonomic nervous system response is blunted by the vasodilating effects of intravenous and volatile anesthetics.[22] Decreases in cardiac output, mean arterial pressure, and cerebral perfusion pressure have been observed when the anesthetized patient is maneuvered from supine to sitting.[6,27] These changes can lead to detectable intraoperative CDE and potentially cerebral ischemia.[10]

Reports have described catastrophic complications in patients undergoing surgery in the sitting position including severe brain damage, ophthalmoplegia, and death.[1,23] Pohl and Cullen published a series of four relatively healthy middle-aged patients at extremely low risk for cerebrovascular events who sustained major brain injury during shoulder surgery in the upright position.[24] This landmark article exposed the need for improved means of identifying decreased cerebral perfusion in patients undergoing surgery in the beach chair position. It also highlighted the potentially dangerous practice of hypotensive anesthesia in the sitting position, secondary to the inaccuracy of noninvasive blood pressure monitoring in the upright position.[23] The overestimation of blood pressure at the level of the brain is caused by "the waterfall" effect.[21] The seated position creates a hydrostatic column of blood from the heart to the brain. As blood flows vertically, there is a reduction in arterial pressure directly related to the weight of the fluid column.[21] Thus blood pressure readings taken at the level of the brachial artery in the sitting position will over represent the blood pressure at the level of the brain.[22]

Several authors have recommended the use of cerebral oximetry using near-infrared spectroscopy (NIRS) to monitor the adequacy of cerebral perfusion and to guide intraoperative interventions.[7,10,25,26,38] A noninvasive technique, NIRS allows continuous monitoring and has been demonstrated to accurately recognize cerebral oxygen desaturation.[25,26] This technique is used extensively to monitor cerebral perfusion during cardiovascular surgery, neurosurgical procedures and carotid endarterectomy (CEA).[3,35] In awake subjects undergoing CEA, cerebral oxygen desaturation, detected using NIRS, correlated with development of clinical and EEG signs of cerebral ischemia during carotid cross-clamping.[30] The EEG signs and clinical findings of cerebral ischemia, including mental confusion, agitation and motor deficits of the upper extremity, rapidly resolved as the cerebral saturation returned to baseline values. This was accomplished by re-establishing cerebral perfusion via Javid shunt.[30] A 15% or greater reduction in rSO2 during carotid clamping test was associated with a 20-fold increase in developing overt signs and symptoms of cerebral ischemia.[30] Specific to arthroscopic shoulder surgery in the beach chair position, the incidence, patient risk factors, and clinical sequelae of intra-operative cerebral desaturation episodes remain undefined.

Evidence suggests that changes from baseline rather than absolute values are a more important predictor of cerebral ischemia, and that the trend of oxygen saturation has more clinical validity.[12,13,16,30] In conscious patients, a 20% reduction in frontal lobe oxygenation is associated with clinical manifestations of cerebral hypoperfusion, such

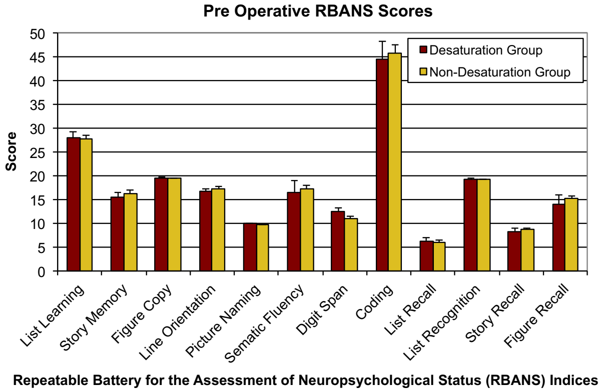

Figure 2 Comparison of mean preoperative RBANS indices in the desaturation and nondesaturation patient groups. Data are expressed as mean score + standard error margin. Desaturation group represented by the *dark bars*; nondesaturation group represented by the *light bars*.

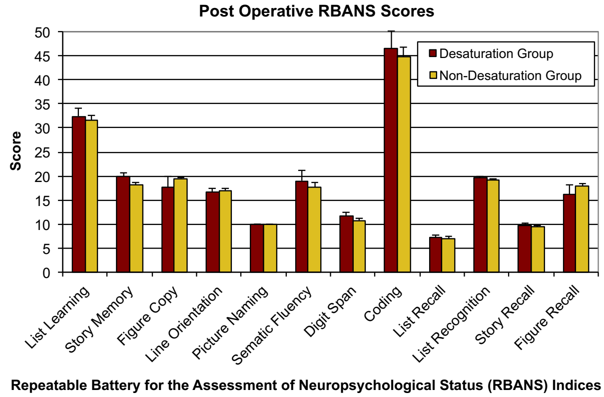

Figure 3 Comparison of mean postoperative RBANS indices in the desaturation and nondesaturation patient groups. Data are expressed as mean score + standard error margin. Desaturation group represented by the *dark bars*; nondesaturation group represented by the *light bars*.

as syncope.[20,31] Because cerebral oximetry values are affected by depth of anesthesia, type of anesthetic administered, arterial carbon dioxide concentration, inspired oxygen content, and mean arterial blood pressure, there is no consensus in the literature defining the optimal time point at which to measure a patient's baseline.[7,10,22,38] The goal of our protocol was to establish a reference point that most accurately represented the physiologic cerebral saturation unique to each subject. Thus we obtained baseline rSO2 readings in the supine position prior to intubation and positioning. In accordance with the standard of practice at our institution, we defined a CDE as a drop in rSO2 of 20% or greater from baseline for any time period and found that 18% (9/50) of the subjects in our cohort experienced intraoperative CDE.

In the only other prospective cohort study, Murphy et al found there were sizeable and frequent episodes of intraoperative cerebral desaturation in the seated position when compared to patients in the lateral decubitus position (80% beach chair vs 0% lateral decubitus), in a series of 124 patients undergoing elective arthroscopic shoulder surgery under general anesthesia.[22] Using NIRS, they defined a CDE as a decrease greater than or equal to 20% from baseline or absolute drop below 55% for 15 seconds in rSO2, and defined their rSO2 baselines as the mean value observed over a 1-minute period after induction. Several induction agents, including propofol, have been found to cause transient increases in rSO2 levels.[19] Because of this potential effect, the cerebral saturation assessment taken at the time of intubation, or shortly thereafter, could artificially inflate the rSO2 and would not correctly define the true baseline. This induction elevation effect could account for differences in the reported incidence of CDE in the 2 series.

Multiple series and case reports have confirmed the occurrence of CDEs in patients undergoing elective shoulder arthroscopy in the seated position, but to date none have established patient risk factors.[7,10,18,22,38]

In our series, increased BMI was found to have a statistically significant association with intraoperative CDE (mean BMI 37.32 vs 28.59, $P < .0001$). With respect to a BMI threshold of 34 or greater, 78% of subjects experienced CDE vs 21% in patients with a BMI below this cutoff. As well, patients with a BMI greater than 34 were calculated to have 12.4 times greater odds of intra-operative desaturation events.

Additionally, the presence of hypertension ($P = .130$) showed a strong trend toward statistical significance. This can be explained by the theory that chronic hypertension shifts the lower limit of autoregulation toward higher blood pressures, thus requiring a higher ratio of cerebral perfusion pressure to mean arterial pressure to ensure adequate perfusion.[10,24,37] In normotensive patients, autoregulation is considered to function adequately for mean arterial pressures above 50 mm Hg.[36] However, patients with chronic uncontrolled hypertension may experience cerebral ischemia at significantly higher pressures.[29,36] Animal studies have suggested that adequate antihypertensive medication may return the lower limit of autoregulation to normal; however, it is unknown if this occurs in humans.[15] In our series, 67% of the patients that had intraoperative CDE had a history of hypertension, compared to only 31% of the patients that did not experience a CDE. Preoperative blood pressure reducing agents may alter the intraoperative response to hemodynamic fluctuations. Thus it is possible that with a larger sample size or differentiation between uncontrolled hypertensive subjects and those controlled pharmacologically with antihypertensive medication, hypertension could have had an influence of statistical significance as a patient risk factor.

Prior to this study, the incidence of cognitive deficits after surgery in the beach chair position had not been assessed. Postoperative cognitive dysfunction after major surgery is a well-documented complication, particularly in the elderly. The incidence of postoperative cognitive deficits in cardiac surgery patients has been reported to be between 11% and 75%.[33] A recent study has demonstrated that in elderly patients intra-operative cerebral oxygen desaturation is associated with an increased risk of postoperative cognitive decline.[3] Originally thought to be isolated to major surgery, postoperative cognitive decline was demonstrated in approximately 7% of patients undergoing minor elective surgery.[2]

In our series, neurocognitive testing was performed pre- and postoperatively on all subjects to identify subtle cognitive deficits and their possible association with intraoperative CDE. The RBANS was employed, because it identifies and characterizes abnormal cognitive decline and has been proven to be sensitive enough to detect mild cognitive impairment.[5,8,14,28] Additionally, this exam has previously been utilized and validated to assess cognitive dysfunction in post-surgical patients.[17] The assessment yields scaled scores for 5 cognitive domains: immediate memory, visuospatial, language, attention, and delayed memory.[28] Because of the lingering effects of anesthesia and postoperative narcotic pain medication, the data from the RBANS given immediately postoperatively were excluded.

The results of the preoperative RBANS and the postoperative RBANS, administered 3 days after surgery, were compared. In our cohort, the RBANS studies did not demonstrate any measurable cognitive decline, and there is no statistically significant association between intraoperative CDE and postoperative cognitive dysfunction. We attribute this to early detection of CDE triggering rapid intervention to reverse the transient cerebral desaturation. We hypothesize that without continuous cerebral oximetry, detection and subsequent reversal of cerebral desaturation would have been delayed and thus could have led to cerebral ischemia. As our series is a clinical trial, patient safety required prompt intervention once an intraoperative CDE was identified. Thus, for this patient population, the severity and duration of desaturation that cause cerebral ischemia remain undefined. We do recognize, however, that the study was powered for the primary outcome of cerebral desaturation detection and thus could be underpowered for the additional outcomes of patient specific risk factors and detection of neurocognitive events.

Conclusion

In summary, reports of unanticipated cerebral ischemic events in low risk patients during shoulder surgery in the beach chair position demonstrate that arterial blood pressure monitoring alone does not guarantee adequate cerebral perfusion. In our prospective series of 50 consecutive patients, 18% of subjects experienced intraoperative CDE. We determined that an increased BMI ($P < .001$) was a statistically significant risk factor for intra-operative CDE. Cerebral oximetry with NIRS allows prompt identification and treatment of cerebral hypoperfusion. The degree and duration of cerebral ischemia required to produce neurocognitive dysfunction in this patient population remains unidentified. However, the transient intraoperative CDEs experienced by patients in this study group were not associated with postoperative cognitive dysfunction. We believe protocols aimed at detecting and reversing CDE minimize the risk of neurocognitive dysfunction and may thus improve patient safety during arthroscopic shoulder surgery performed in the beach chair position.

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