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ORIGINAL ARTICLE

The effect of the beach-chair position angle on cerebral oxygenation during shoulder surgery

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Background: Although the safety of the beach-chair position (BCP) is widely accepted, rare devastating neurologic complications have been reported and attributed to cerebral hypoperfusion. Cerebral oxygenation (regional oxygen saturation [rSO_2]) can be monitored noninvasively using near-infrared spectroscopy. The purpose of this study was to determine the effect of BCP angle on cerebral oxygenation in patients undergoing shoulder surgery in the BCP.

Methods: Fifty patients undergoing shoulder arthroscopy were prospectively enrolled to participate. Following induction of general anesthesia, each patient's rSO_2 was recorded at 0° of elevation and again at 30°, 45°, 60°, and 80° of elevation. Mean rSO_2 values and mean differences in rSO_2 were reported.

Results: An average total decrease of 5% in rSO_2 was seen when comparing 0° with 80° ($P < .001$). There were statistically significant differences in rSO_2 values at beach-chair angles of 0° versus 30° ($P < .001$), 30° versus 45° ($P = .007$), and 45° versus 60° ($P < .001$) but not between 60° and 80° ($P = .12$). The decrease in rSO_2 was similar between each progressive increase in the beach-chair angle, leading to a linear decline in rSO_2 as the BCP increased (regression slope of −0.060%/°, $P < .001$). No patient's cerebral oxygenation dropped greater than 20% from baseline. Neither body mass index nor American Society of Anesthesiologists score had a significant impact on the relation of rSO_2 to BCP angle.

Conclusions: The average drop in rSO_2 is significantly less than the threshold of 20% used as an identifier for a cerebral deoxygenation event. This study illustrates the direct effect the BCP angle has on cerebral oxygenation.

Level of evidence: Basic Science Study; Physiology

Keywords: Beach-chair position; cerebral oxygenation; shoulder arthroscopy; cerebral desaturation event; cerebral hypoperfusion; near-infrared spectroscopy

The beach-chair position (BCP) is commonly used for both open and arthroscopic shoulder surgical procedures. Skyhar et al[17] first described its use in shoulder arthroscopy in 1988. There has been continued debate on whether the BCP or the lateral decubitus position is superior for shoulder arthroscopy, but there is no evidence to suggest one is more efficient

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or efficacious.[12] Benefits of the BCP when compared with the lateral decubitus position include the ability to easily convert to an open approach, improved position for an examination under anesthesia, decreased traction on the brachial plexus, and a more anatomic position.[6,17] The most significant disadvantage as well as risk of the BCP is the potential for cerebral hypoperfusion and neurologic injury, although this is an extremely rare event with an estimated incidence of less than 0.005%.[3] Despite this, the 4 cases of ischemic brain and spinal cord injury presented by Pohl and Cullen[13] are devastating and were attributed to intraoperative cerebral hypoperfusion and hypotensive anesthesia used during shoulder surgery in the BCP.[11]

Near-infrared spectroscopy (NIRS) allows for noninvasive, continuous monitoring of cerebral oxygenation (regional oxygen saturation [rSO_2]). NIRS uses 2 infrared light sources that penetrate the thin, transparent skull to measure the hemoglobin level in the underlying brain tissue, arterial system, and venous system of the frontal lobe.[1] This technology provides the ability to determine when cerebral hypoperfusion and cerebral desaturation occur. A drop of 20% from the baseline readings on the NIRS monitor has been used as a predictor of neurologic compromise and termed a "cerebral desaturation event" (CDE).[10,14,16]

Although it has been demonstrated that patients in the BCP have significantly more CDEs than patients in the lateral decubitus position,[9] it is still unknown whether increasing the angle of the BCP increases the risk of having a CDE. In recent literature evaluating the effect of the BCP on cerebral oxygenation, recorded values of elevation have ranged from 30° to 90° and results have been inconsistent.[10]

The purpose of this study was to determine the effect of BCP angle on cerebral oxygenation in patients undergoing shoulder surgery in the BCP. We hypothesized that cerebral oxygen saturation would decline linearly with an increasing angle of the BCP.

Materials and methods

We enrolled a prospective cohort of 50 patients undergoing shoulder arthroscopy in this study. The inclusion criteria included all patients aged 18 to 90 years and any patient undergoing shoulder arthroscopy in the BCP. The exclusion criteria were patients with an American Society of Anesthesiologists (ASA) score of 4 or 5, women who were pregnant, and patients who refused to participate. No patients were excluded from this study, and no patients refused to participate. All surgical procedures were completed in a single outpatient surgical center from January to May 2016 by the senior author (S.A.). Patient demographic data were recorded, including age, sex, body mass index (BMI), and ASA score.

Because NIRS can be altered by anesthetic management (type and depth of anesthetic) and cardiopulmonary fluctuation (arterial carbon dioxide concentrations, inspired oxygen content, and systemic blood pressure), a standard anesthetic management was carefully selected. On arrival to the operating room, the patient was placed in the supine position and intraoperative monitors were applied prior to anesthetic induction. These monitors consisted of a noninvasive blood pressure cuff placed on the nonoperative upper extremity, electrocardiography, pulse oximetry, and capnography. An NIRS sensor applied to the frontotemporal region was used to continuously monitor cerebral oxygen saturation. Patients underwent preoxygenation with a fraction of inspired oxygen (FiO_2) of 1.0 for 3 to 5 minutes. Anesthesia was induced with propofol, 2.0 to 2.5 mg/kg; lidocaine, 60 to 80 mg; fentanyl, 100 μg; and a choice of muscle relaxant (rocuronium, 0.6-0.8 mg/kg, or succinylcholine, 1-1.5 mg/kg). Anesthesia was maintained with sevoflurane, 1% to 3%, in an oxygen-air mixture with the FiO_2 maintained at 40% or greater. Ventilation was controlled with target end-tidal carbon dioxide between 30 and 35 mm Hg. If necessary, 10- to 20-mg boluses of rocuronium were given to maintain a train-of-four count of 1 to 3. Boluses of fentanyl (50-100 μg) were administered throughout for perioperative analgesia. Patients' mean arterial pressure was maintained within 20% of the baseline value throughout the intraoperative period. If mean arterial pressure fell below 20% of baseline, a fluid bolus of phenylephrine (80 μg) and/or ephedrine (5 mg) was administered. A lower-body forced-air warming device was placed on each patient, and the core temperature was monitored with a nasal or esophageal temperature probe. Ondansetron, 4 mg, was prophylactically given 30 minutes before the end of surgery. If necessary, glycopyrrolate and neostigmine were administered for reversal of residual muscle relaxation.

Following anesthetic induction and placement of the NIRS sensor, each patient's rSO_2 was recorded in the supine position (0° of elevation), which served as the baseline rSO_2. In addition to the rSO_2, blood pressure and arterial oxygen saturation were measured at baseline while breathing air-oxygen admixture with an FiO_2 of 40% or greater. The head of the bed was then elevated to 30°, 45°, 60°, and 80° of elevation sequentially in the BCP, and the rSO_2 was recorded at each level. Patients were left at each angle about 30 seconds prior to recording of the value; during this time, the readings adjusted to the new angle, and recordings were taken after the monitor stopped changing and settled on a new value. These variables were recorded at each level prior to the start of the case. The threshold to stop increasing the BCP angle was a decline of 20% from the baseline rSO_2 on the NIRS. If a decline in rSO_2 of 20% or more was observed, the patient would be lowered to 0° to increase rSO_2 before the procedure proceeded.

Statistical analysis

SAS software (version 9.4; SAS Institute, Cary, NC, USA) was used for all statistical analyses. Continuous patient characteristics (age and BMI) were summarized as the average and range, whereas discrete patient characteristics (sex and ASA score) were summarized as number and proportion in each group. Data for cerebral oxygenation (rSO_2) were summarized by BCP angle as the mean, standard deviation, and range and were then analyzed using mixed-model analysis of variance (ANOVA) and mixed-model regression, each with an unstructured autocovariance matrix to accommodate the longitudinal nature of the data. The ANOVA post hoc analysis focused on estimating mean differences in rSO_2 between different beach-chair angles. All estimated mean differences in rSO_2 were accompanied by ±90% margins of error (MEs), as were the regression estimates. The same mixed-model ANOVA approach was also used to assess the impact of BMI group (≥30 vs <30) and ASA index (3 vs <3) on how the BCP angle affected the rSO_2 measures. All *P*