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Original Contribution

Cerebral oxygenation in the beach chair position for shoulder surgery in regional anesthesia: impact on cerebral blood flow and neurobehavioral outcome☆

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Abstract

Study objective: Beach chair position is considered a potential risk factor for central neurological events particularly if combined with low blood pressure. The aim of this study was to assess the impact of regional anesthesia on cerebral blood flow and neurobehavioral outcome.

Design: This is a prospective, assessor-blinded observational study evaluating patients in the beach chair position undergoing shoulder surgery under regional anesthesia.

Setting: University hospital operating room.

Patients: Forty patients with American Society of Anesthesiologists classes I-II physical status scheduled for elective shoulder surgery.

Interventions: Cerebral saturation and blood flow of the middle cerebral artery were measured prior to anesthesia and continued after beach chair positioning until discharge to the postanesthesia care unit. The anesthesiologist was blinded for these values. Controlled hypotension with systolic blood pressure ≤ 100 mm Hg was maintained during surgery.

Measurements: Neurobehavioral tests and values of regional cerebral saturation, bispectral index, the mean maximal blood flow of the middle cerebral artery, and invasive blood pressure were measured prior to regional anesthesia, and measurements were repeated after placement of the patient on the beach chair position and every 20 minutes thereafter until discharge to postanesthesia care unit. The neurobehavioral tests were repeated the day after surgery.

Main results: The incidence of cerebral desaturation events was 5%. All patients had a significant blood pressure drop 5 minutes after beach chair positioning, measured at the heart as well as the acoustic meatus levels, when compared with baseline values ($P < .05$). There was no decrease in either the regional cerebral saturation ($P = .136$) or the maximal blood flow of the middle cerebral artery ($P = .212$) at the same time points. Some neurocognitive tests showed an impairment 24 hours after surgery ($P < .001$ for 2 of 3 tests).

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Conclusions: Beach chair position in patients undergoing regional anesthesia for shoulder surgery had no major impact on cerebral blood flow and cerebral oxygenation. However, some impact on neurobehavioral outcome 24 hours after surgery was observed.

1. Introduction

Beach chair position (BCP) is commonly used for shoulder surgery compared with the lateral decubitus position (LDP) to facilitate shoulder joint access and optimal visualization [1]. However, these advantages are contrasted by challenging hemodynamic changes, and several case reports are blaming the BCP for devastating central neurologic complications [2] such as cranial nerve injury [3], visual loss [4], and cerebral infarction [5,6]. However, the real impact of BCP on these severe complications remains unclear [7,8].

Combining BCP and head fixation can lead to cerebral tissue hypoperfusion during surgery caused by mechanical obstruction of cerebral blood flow (CBF) due to the extreme rotation of the head in combination with the traction in the operated arm [9]. Additional risk factors for reduced CBF are the frequently used combination of general anesthesia and controlled hypotension for shoulder arthroscopy as well as open shoulder surgery [10]. Furthermore, congenital variations of the circle of Willis anatomy with incomplete expression have been described in 59% to 79% of adults [11,12]. These congenital variations present an additional risk for patients in the BCP undergoing shoulder surgery [13]. Near-infrared spectroscopy (NIRS) constitutes a useful tool to improve current monitoring by providing additional information regarding the regional cerebral tissue oxygenation [7]. Recent studies have shown that when NIRS is used for a cerebral oximetry monitoring, it reliably detects cerebral hypoperfusion during shoulder surgery in the BCP [14,15]. In 1 case, a cause and effect relation between regional cerebral (capillary) oxygen saturation ($rSco_2$), mean arterial pressure (MAP), and end-tidal CO_2 was reported. [15] Murphy et al. compared the incidence of cerebral desaturation during shoulder surgery under general anesthesia in the BCP vs the LDP, demonstrating a significant reduction of cerebral oxygen saturation in the BCP and highlighting the importance of this position in cerebral desaturation [14]. Recently, 2 studies have reported the importance of maintaining an adequately high systemic blood pressure in the BCP to allow for cerebral autoregulation and adequate CBF [16,17]. However, no study has described the correlation between CBF [18] and cerebral oxygenation in a controlled hypotension protocol for shoulder surgery in the BCP.

The aim of this prospective, observational, assessor-blinded study was to evaluate the prevalence of regional cerebral oxygen desaturation in American Society of Anesthesiologists (ASA) I-II patients undergoing shoulder surgery in the BCP under regional anesthesia with conscious sedation and a controlled hypotension protocol (systolic blood pressure 80-100 mm Hg at heart level) [19]. Our hypothesis was that NIRS reliably detects changes in cerebral oxygenation during regional anesthesia in the BCP and that the incidence of cerebral desaturation events (CDEs) would correlate with CBF impairment and neurobehavioral decline. Our primary outcome was the incidence of CDEs (expressed as a drop of absolute $rSco_2$ to a value <55% for >15 seconds of baseline and in relative terms as a decrease in $rSco_2 \geq 20\%$ compared with the baseline value) [5] during regional anesthesia with conscious sedation under controlled hypotension protocol.

Secondary outcomes were the effects of blood pressure (measured at heart level and at the level of the acoustic meatus) on $rSco_2$, the effects of the CDEs on the neurological and neurobehavioral outcome, as well as the effects of BCP on CBF and the correlations between CDEs, neurobehavioral, and CBF decline.

2. Materials and methods

The study was approved by the local Ethics Committee (Kantonale Ethikkommission Zürich, KEK-Zh-Nr: 2012-0112). Written informed consent was obtained from each patient. Forty ASA I-II adult patients scheduled for elective, unilateral shoulder surgery were included in this prospective, assessor-blinded, single-center cohort study. Exclusion criteria were a history of central neurological diagnosis (transient ischemic attack, stroke, bleeding, syncope, chronic headache, cervical disk herniation, spinal cord injury, recent vision impairment/loss, cerebral tumor or metastasis, orthostatic hypotension), recent myocardial infarction (<6 months), known relevant carotid stenosis (>40%) or known flow disturbance of vertebral arteries, pregnancy, allergies to any drug used for anesthesia, and known neurobehavioral disorders or baseline Minimental State Examination test result <24.

The evening prior to surgery, a standardized neurologic examination (pupil size and reaction, lateralization tests of both extremities, Glasgow Coma Scale, Minimental State Examination test) and neurobehavioral tests (Trail Making Test [TMT] A, TMT B, Grooved Pegboard) were conducted as baseline measurements by an anesthesiologist not involved in the further anesthetic management of the patient. TMT A and TMT B are neuropsychological tests focusing on visual attention and task switching. They consist of 2 parts in which the patient is instructed to connect a set of 25 dots (numbers in A, alternating numbers and letters in B) as fast as possible. They provide information about visual search speed, speed of processing, scanning, mental flexibility, as well as executive functioning. The Grooved Pegboard test assesses fine motor control and speed. Patients have to fit notched pegs into matching holes