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DOES THE ANESTHESIA TECHNIQUE AFFECT ARTERIAL PRESSURE AND REGIONAL CEREBRAL OXYGEN SATURATION DURING SHOULDER ARTHROSCOPY IN THE BEACH CHAIR POSITION?

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SUMMARY – This study aimed to investigate the impact of posture and anesthesia techniques on blood pressure changes, heart rate and regional cerebral oxygen saturation during shoulder arthroscopy in the beach chair position (BCP). Sixty patients were included in this prospective cohort study: 30 patients mechanically ventilated and subjected to general anesthesia (GA) and 30 patients subjected to interscalene block (ISB) without mechanical ventilation. Noninvasive blood pressure, heart rate (HR), peripheral blood oxygen saturation and regional oxygen saturation of the brain were measured in twelve predefined points during perioperative period. The GA group patients had significantly lower mean arterial pressure and heart rate values compared to patients in ISB group during BCP ($p<0.001$). There was a significant difference in regional cerebral saturation between the groups measured only in points of induction and emergence from anesthesia in favor of GA group when receiving 100% oxygen ($p<0.001$). Changes in the mean arterial pressure and regional cerebral oxygen saturation for both brain hemispheres correlated only at the 10th minute after setting up BCP in GA patients (right, $p=0.004$ and left, $p=0.003$). This correlation did not exist in the ISB group patients at any of the points measured. Cerebral desaturation events recorded in both groups were not statistically significantly different. Results of this study demonstrated that GA preserved regional cerebral oxygenation in a safe range during BCP despite changes in the arterial blood pressure and heart rate in comparison to ISB.

Key words: *Posture; Arthroscopy; Anesthesia, general; Arterial pressure; Spectroscopy, near-infrared; Hypoxia, brain; Croatia*

Introduction

It is well known that positioning of the patient from supine to sitting position as in so called beach chair position (BCP) during shoulder arthroscopy initiates physiologic changes for the cardiovascular system adaptation[1]. This adaptation is impaired during general anesthesia due to the effect of anesthetics on sympathetic activity and baroreceptor system dysregulation[2]. During this time, the patient is prone to hypotension, leading to hypoperfusion, mainly targeted to the brain.

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There are few case reports of catastrophic sequels after this procedure, including persistent vegetative state and brain death[3,4], as well as cardiac arrest[5].

The aim of this study was to investigate the impact of anesthesia techniques on blood pressure changes and regional cerebral oxygen saturation during shoulder arthroscopy in BCP. Two anesthesia techniques were applied: general anesthesia in one group of patients and interscalene block in the other group of patients. The study hypothesis was that general anesthesia leads to more hemodynamic instability during BCP and more cerebral oxygenation changes than the interscalene block technique, particularly during patient positioning from supine to sitting position.

Patients and Methods

This study was approved by the Ethics Committee of the Osijek University Hospital Centre, Osijek, Croatia, study number 25-1:5484-3/2013; date of approval May 27, 2013. Each patient provided his/her written informed consent for voluntary participation in the study. The duration of the study was one year (from February 2014 to February 2015).

The Ethics Committee insisted that, as part of the informed consent, patients be allowed to choose the anesthesia technique. According to the Committee decision, the patients in this non-randomized controlled trial[6] chose their group assignment upon arrival to the preoperative area, after careful explanation of the risks and benefits of each technique by the anesthesiologist who was not involved in data collection during the operation, to avoid any source of potential bias. Enrolment of the participants to the statistically predetermined number was performed consecutively in two groups: general anesthesia (GA group, N=30) and interscalene block (ISB group, N=30). All patients had the same preoperative preparation and measurement of baseline values of blood pressure, pulse and regional cerebral saturation in supine and sitting position. During the surgery, patients were placed in sitting position with 80° table tilt.

The patients that refused to take part in the study, patients assessed as American Society of Anesthesiologists (ASA) III (n=6) or higher, and patients with cerebrovascular or coronary disease, coagulopathy, hypersensitivity to local anesthetics or other contraindications to either anesthetic technique were not included in the study. The patients whose operation lasted for less than 20 minutes or longer than 90 minutes were excluded from the study (n=2), as well as those with unsuccessful ISB who needed conversion to GA (n=1).

Regional cerebral oxygen saturation was measured by near-infrared spectroscopy (NIRS; INVOS 5100, Somanetics Corp., Troy, Michigan, USA). The bispectral index (BIS) monitoring was used to estimate the depth of anesthesia and anesthetic effects (Bispectral Index, Aspect Medical System Inc., Norwood, MA, USA) in all patients. Blood pressure was measured non-invasively at the upper arm on the non-operative side.

Upon patient arrival in the preoperative room, a venous cannula was introduced and crystalloid fluid infusion started. Blood pressure, heart rate, peripheral blood oxygen saturation and regional cerebral oxygen saturation were measured in two positions, lying and sitting. These values were marked as baseline values. Patients did not receive supplemental oxygen during baseline value measurement. Then patients were premedicated with 3 mg of midazolam administered intravenously.

Routine noninvasive blood pressure (NIBP) measurements were done in 5-min intervals. Heart rate and peripheral blood oxygen saturation were monitored continuously throughout the operation and values were recorded every 5 min. If the systolic blood pressure was lower than 90 mm Hg, the patient received norepinephrine at a dilution of 1 μg/mL, at repeated intervals. If heart rate was lower than 50 beats *per* minute, atropine 0.5 mg was administered. In this study, heart rate was used as a marker of sympathetic responsiveness[7].

Regional cerebral oxygen saturation was measured by the INVOS system beneath two sensors for both hemispheres attached to the skin of the forehead above the eyebrows. Decline in values below 20% compared to baseline values (cerebral desaturation event) was considered important[8,9]. In this study, systolic pressure was interventional variable, and regional tissue oxygen saturation was dependent, non-interventional value.

Systolic blood pressure, diastolic blood pressure and mean arterial pressure (MAP), heart rate, peripheral blood oxygen saturation and regional cerebral oxygen saturation were recorded at twelve predefined points during the perioperative period. The mentioned values were recorded in the premedication area twice: while the patient was lying down (supine) (point 1) and in sitting position (point 2). Point 2 (patient in sitting position) was marked as the baseline value.

Then the same values were recorded upon arrival in the operating room, just before positioning the patient in BCP (point 3); immediately after BCP (point 4); five minutes after positioning (point 5); ten minutes after positioning (point 6); and throughout the operation (points 7-9). At the end of the surgery, the patient was repositioned to lying position, marked as point 10. At the end of the surgery, patients were transferred to recovery room for 60 minutes, and their values of heart rate, blood pressure, peripheral oxygen saturation, regional cerebral oxygen saturation and BIS were recorded at 30 minutes (point 11) and 60 minutes (point 12) after the end of the surgery.

The GA group patients were anesthetized using propofol 2 mg/kg, rocuronium 0.6 mg/kg and sufentanil 0.25 µg/kg. After intubation and setting mechanical ventilation, anesthesia was maintained with sevoflurane up to 1.5 minimal alveolar concentration (MAC) and mixture of oxygen 1 L/min and nitrous oxide 2 L/min, with additional boluses of sufentanil 5-10 µg for analgesia. Muscle relaxation was maintained with rocuronium. Exhaled values of CO_2 were kept at 35-45 mm Hg.

Patients in the ISB group were anesthetized by ultrasound guided interscalene block performed with 20 mL 0.5% levobupivacaine, after disinfection and preparation of the area. The success of the block was checked with temperature, sensation, pain and movement deprivation. During the surgery, if necessary, patients were additionally sedated with boluses of 3 mg midazolam, 5-10 µg sufentanil or 30-50 mg propofol, held awake with spontaneous breathing.

Statistical analysis

The study sample size was determined using a free online sample size calculator from Department of Statistics, Faculty of Science, The University of British Columbia, Vancouver, Canada (available at: http://www.stat.ubc.ca/~rollin/stats/ssize/n2.html). According to data from a pilot study[10], it is estimated that at least 26 subjects would be needed in each of the groups, with α level p=0.05 and the test power adjusted to 90%, to detect a statistically significant difference between the two groups (if it exists). Statistical analysis was performed using IBM SPSS Statistics 20 by the person blinded to group allocation. Discrete data were compared using χ^2-test and Fisher exact test. The normality of distribution of continuous data was assessed using Kolmogorov-Smirnov test. Ordinal data and continuous data that were not normally distributed were expressed as median and range. Mann-Whitney test was used to compare data differences between the two groups. Normally distributed continuous data were expressed as arithmetic mean and standard deviation (SD) or standard error of the mean (SEM). These data were compared using 2-factor analysis of variance with repeated measures on 1 factor, with least significant difference (LSD) method of post hoc analysis. The level of statistical significance of the observed differences was set at $p<0.05$.

Results

Demographic characteristics of the two patient groups are shown in Table 1. Patients having chosen GA were younger than ISB group, and there were more smokers (p=0.032). Baseline BIS values, arterial pressure, pulse and regional oxygen brain saturation (rsO_2) values in lying and sitting positions were not different between the two groups of patients while lying supine or sitting in BCP before application of any anesthesia type (Fig. 1). During GA, BIS values were maintained in the range between 40 and 60 (Fig. 1A).

Patients in the GA group had significantly lower MAP values compared to ISB group, measured at points 4-9 (points in BCP during the operation), as shown in Figure 1B. As for MAP, there was a statistically significant difference between the two groups both in systolic and diastolic blood pressure values measured at these points (2-factor analysis of variance with repeated measures, $F(6.9, 400.16)=20.74$, $p<0.001$ for systolic blood pressure; ($F(6.82, 395.49)=11.02$, $p<0.001$ for diastolic blood pressure; data not shown).

Patients in the GA group had higher heart rate values at points 1-4 and significantly lower heart rate values at points 5-10 (Fig. 1B) as compared to patients in the ISB group (2-factor analysis of variance with repeated measures, $F (6.92, 401.56) =9.51$, $p<0.001$). The GA group had significantly higher values of peripheral oxygen saturation (SpO_2) compared to ISB group during BCP from points 4 to point 9 ($p<0.001$). However, SpO_2 was in the safe range ≥94% at all measurement points in both groups (Fig. 1C).

Cerebral oxygen saturation was measured both on the left and the right side of frontal brain hemispheres. Since no differences were observed between the sides, mean values were presented for all points (Fig. 1C).

Table 1. Demographic characteristics of patients undergoing shoulder arthroscopy in beach chair position under two types of anesthesia

	GA	ISB	p
Number of patients	30	30	
Sex (male/female)	14 (46.7%)/16 (53.3%)	17 (56.6%)/13 (43.4%)	0.606
Age (yrs)	52 (21-63)	58 (37-73)	0.009
Weight (kg)	80 (55-108)	82 (53-140)	0.3516
Height (cm)	170 (151-185)	170 (157-187)	0.5692
BMI (kg/m^2)	26.5 (21.7-37.7)	27.3 (20.7-44.7)	0.2369
ASA (1/2)	9 (30%)/21 (70%)	3 (10%)/27 (90%)	0.104
Hypertension	12 (40%)	16 (53.3%)	0.437
Diabetes mellitus	2 (6.7%)	4 (13.3%)	0.671
COPD	0	0	-
Smoking	15 (50%)	7 (23.3%)	0.030

GA = general anesthesia; ISB = interscalene block; BMI = body mass index; ASA = American Society of Anesthesiologists, Physical Status Classification System; COPD = chronic obstructive pulmonary disease

Patients in the GA group had significantly higher values of rsO_2 for both hemispheres compared to the ISB group at points 3, 4 and 10 (rsO_2 values before positioning, immediately after positioning in BCP, and during awakening) ($p<0.05$). However, when the points of induction and emergence from anesthesia were excluded from analysis (points when GA group patients were ventilated with 100% oxygen), there was no significant difference in the right and left rsO_2 between the two groups (Fig. 1C).

Within-group analysis revealed that rsO_2 values dropped slightly in the ISB group at positioning from lying to BCP at the beginning of the surgery (point 3 and 4; $p\leq0.02$). In contrast, in the GA group, there was a significant increase in rsO_2 at repositioning from lying position to BCP at the beginning of the surgery, and at the end of the surgery after repositioning from BCP to lying position (points 3, 4 and 10), as shown in Figure 1C. This could be explained by using 100% oxygen at the beginning and at the end of general anesthesia.

Discussion

The aim of this study was to investigate the impact of anesthesia techniques on blood pressure changes and regional cerebral oxygen saturation during shoulder arthroscopy in BCP. The main findings of the present study were that GA patients had significantly lower intraoperative MAP and pulse values as compared to ISB group, which were not followed by cerebral desaturation events.

Although very rare, there are several case reports on devastating neurologic outcomes after BCP surgery, mostly in general anesthesia[3,11,12]. Cerebral monitoring techniques were the subject of previous studies aiming to elucidate critical points at which accidents can occur and to provide safe practice for these patients[13,14]. NIRS (INVOS in the present study) is a noninvasive method and can serve as a warning of impending global cerebral hypoxia. In the present study, as in the previous studies in general, the patients anesthetized by regional anesthesia techniques were found to be more hemodynamically stable as compared to patients under general anesthesia[10,15]. This is particularly emphasized with patient positioning to BCP[16]. MAP, systolic and diastolic arterial pressure were significantly lower after positioning to BCP and throughout the surgery in the GA group, which may indicate that the activation of the sympathetic autonomic system is preserved in the ISB group and blunted in the GA group.

There are several case reports on patients with ISB during BCP for shoulder surgery, which describe sudden profound bradycardia and hypotension with activation of so called Bezold Jarisch reflex, which could be the most likely mechanism to describe this event[17,18]. No such events were observed in our study, although retrospective analysis of 66 patients in BCP surgery in

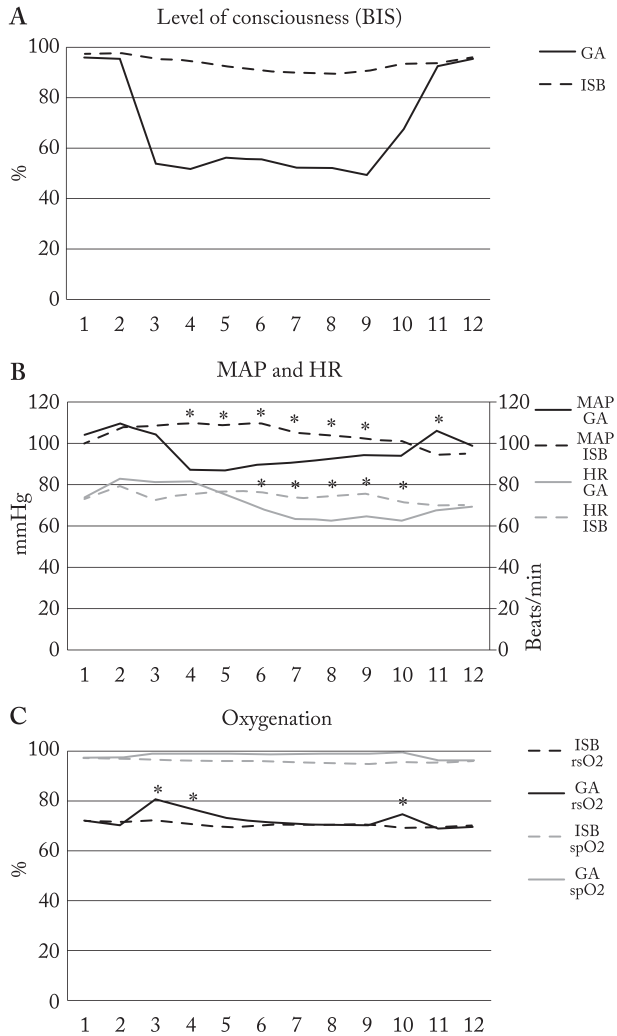

Fig. 1. Differences between two groups of patients undergoing shoulder arthroscopy in beach chair position (BCP): (A) depth of anesthesia as measured by BIS levels in patients in general anesthesia (GA) and in interscalene block (ISB); (B) differences in the mean arterial pressure (MAP) and heart rate values (HR); (C) cerebral oxygen saturation as measured by INVOS.

Points of measurement in the premedication area: point 1 – lying down (supine); point 2 – in sitting position; point 3 – upon arrival in the operating room before positioning the patient in BCP; point 4 – immediately after BCP, during the operation; point 5 – five minutes after positioning; point 6 – ten minutes after positioning; point 7 – fifteen minutes after positioning; point 8 – twenty minutes after positioning; point 9 – twenty-five minutes after positioning; point 10 – lodging the patient at the end of the surgery; point 11 – thirty minutes after the end of the surgery; point 12 – sixty minutes after the end of the surgery. Data were presented as mean values and compared using 2-factor analysis of variance with repeated measures; *statistically significant differences between the groups ($p<0.001$).

our hospital, anesthetized with either GA or ISB found this event described and recorded in four patients in the ISB group[10]. The heart rate changes in the current study, as shown in Figure 1B, may be connected to the stronger sympathetic activity, probably due to the higher preoperative level of anxiety in the group with more patients declared as smokers[19].

Peripheral oxygen saturation values were higher in GA group compared to ISB group because patients in the GA group had more stable oxygenation, with breathing frequency and tidal volume preset. Some authors suggest that ventilation strategies may have an impact on cerebral oxygenation[20]. Others suggest that patients under regional anesthesia who breathe spontaneously have higher pCO_2 blood values, which may improve brain perfusion and therefore they have better cerebral oxygenation[21].

For this reason, we aimed to investigate how much the MAP and rsO_2 values during the operation and BCP differed from baseline values measured in the preoperative setting. Unlike other researchers, we set sitting values before any anesthetic interventions as baseline and compared these values with BCP intraoperative points. In the ISB group patients, MAP was quite stable, whereas a significant decrease in MAP values compared to baseline was observed in the GA group. However, cerebral desaturation events recorded in both groups were not significantly different from baseline values, suggesting that higher oxygen concentration during GA may have compensated decrease in MAP. Increases in rsO_2 during GA could be attributed to inhaling 100% oxygen during the induction and awakening from anesthesia.

There is also the issue of BP value correction for height differences between the brain and the site of BP measurement[22]. Some authors propose that measurements should be taken at the level of the brain, due to the large hydrostatic gradient between the brain and the BP measurement site[11]. Accordingly, there is a decrease by approximately 2 mm Hg for every inch (2.54 cm) of height difference between the blood pressure cuff site and the brain, so the blood pressure measurement taken with cuff at the upper arm does not accurately reflect the actual values at the brain level[11]. In our study, BP values were not corrected, and no deliberate hypotensive anesthesia was used.

The significance of lower MAP throughout the operation in BCP in GA patients did not result in significant rsO_2 decline compared to baseline. This finding may suggest that cerebral autoregulation is functional despite significant declines of MAP even though the values measured in this study were not corrected to actual values. Therefore, the values of MAP measured at the brain level might be even lower.

Some recent studies tackled the issue of cerebral oxygen saturation during shoulder surgery in BCP, performed under general anesthesia[13,21], then during operation under general anesthesia in combination with interscalene block[9,23], as well as during shoulder surgery under regional anesthesia alone[24]. Yadeau *et al*. found that in patients undergoing this type of surgery in regional anesthesia, rsO_2 desaturation was uncommon despite deliberate controlled hypotension in the sitting position[24]. Koh *et al*. concluded that patients under regional anesthesia had almost no cerebral desaturation events, while avoidance of GA could reduce the risk of ischemic neurologic injury. They set baseline cerebral tissue oxygen saturation as measured in patient supine position in the operating room. In their study, after positioning, patients in the awake group (ISB) had oxygen nasal cannula applied at 3 L/min and propofol infusion for sedation[25].

In our study, patients in the ISB group did not receive supplemental oxygen at any time during the surgery and sedation was given in boluses, not continuously. The baseline value, which we compared with points when patients were positioned in BCP during the surgery, was set as sitting in the preoperative area. This approach may be granted for the lack of significant cerebral desaturation events in the present study.

Our study limitation was the lack of randomization[6]. Patients in GA group were older, smokers and more hypotensive, but had preserved brain tissue oxygenation even though having worse starting conditions. Accordingly, our findings suggest that GA with controlled oxygenation may be as safe as ISB even in unfavorable patient conditions.

Conclusion

The results of our study demonstrated that general anesthesia and posture significantly affected arterial pressure and heart rate in comparison to interscalene block during BCP. Despite decreased pulse and blood pressure values during GA, both techniques maintained sufficient cerebral oxygenation in patients during shoulder arthroscopy in BCP.

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Sažetak

UTJEČE LI ANESTEZIJSKA TEHNIKA NA ARTERIJSKI TLAK I REGIONALNU MOŽDANU PERFUZIJU TIJEKOM ARTROSKOPIJE RAMENA U SJEDEĆEM POLOŽAJU?

I. Haršanji Drenjančević, D. Drenjančević, E. Davidović-Cvetko, I. Drenjančević D. Gulam i *S. Kvolik*

Cilj ovoga istraživanja je bio ispitati povezanost postavljanja bolesnika u sjedeći položaj (engl. *beach chair position*, BCP) i vrste anestezijske tehnike s posljedičnim promjenama arterijskog tlaka i srčanih otkucaja, kao i njihovog utjecaja na regionalnu moždanu perfuziju tijekom artroskopije ramena. U studiju je bilo uključeno 60 bolesnika: prvu skupinu činilo je 30 bolesnika kod kojih je operacijski zahvat izveden u općoj anesteziji (OA) koji su bili mehanički ventilirani, a drugu skupinu 30 bolesnika kod kojih je operacijski zahvat izveden uz interskalenski blok (ISB) i spontano disanje. U 12 prethodno definiranih točaka tijekom perioperacijskog razdoblja mjerio se neinvazivno arterijski tlak, srčani otkucaji, periferna zasićenost kisikom i regionalna moždana zasićenost kisikom. Bolesnici u skupini OA imali su značajno niže vrijednosti srednjeg arterijskog tlaka i srčanih otkucaja u odnosu na bolesnike u skupini ISB tijekom BCP ($p<0{,}001$). Promjene srednjeg arterijskog tlaka i regionalne moždane zasićenosti kisikom za obje moždane hemisfere korelirale su samo u 10. minuti nakon postavljanja bolesnika u BCP kod skupine OA (desna $p=0{,}004$, lijeva $p=0{,}003$). Ova korelacija nije zabilježena kod bolesnika skupine ISB ni u jednoj od mjerenih točaka. Moždani desaturacijski događaji su zabilježeni u objema skupinama, ali nisu bili statistički značajni. Rezultati ovoga istraživanja ukazuju na to da je OA očuvala regionalnu moždanu zasićenost kisikom unutar sigurnog raspona u usporedbi sa skupinom ISB tijekom BCP, unatoč značajnim promjenama arterijskog tlaka i srčanih otkucaja.

Ključne riječi: *Položaj; Artroskopija; Anestezija, opća; Arterijski tlak; Infracrvena spektroskopija; Hipoksija, moždana; Hrvatska*