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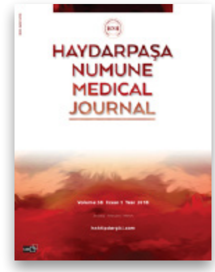

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ORIGINAL ARTICLE

Cerebral Oxygen Desaturation and Postoperative Cognitive Effects in Elderly Patients Operated in Beach Chair Position

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Abstract

Introduction: Elderly patients may be affected by some extreme positions during surgery. Upright positions may lead to systemic hypotension, cerebral circulation and oxygenation derangements, and postoperative cognitive dysfunction (POCD). Cerebral oxygen saturation monitored by near infrared spectroscopy (NIRS) in elderly patients undergoing arthroscopic shoulder operations in beach chair position (BCP) was assessed to see if this age group showed any failure to compensate for these positional hemodynamic effects and had POCD.

Methods: After pre-operative baseline mini mental state examination (MMSE) assessment, 105 patients were operated on in beach chair position and monitored using NIRS. Intraoperative data and postoperative cognitive functions were analyzed.

Results: Ninety-seven patients were included in the final analysis. Patients were cohort according to age: After Group ≥65-years old, n=43; Group <65-years old, n=54. In the group of elderly patients, the frequency, the maximum percentage of drop in hypotensive events were higher, the duration was longer ($p<0.02$, $p=0.018$); the maximum percentage of regional cerebral oxygen saturation drop, and the duration was larger. (AUC-R, median (IQR): 30 (0.274) versus 0 (0.21); ($p=0.014$). Three patients had a decline in cognitive function at 24 h that persisted at the 3-month follow-ups; in another 3 patients, cognitive dysfunction was detected 3-months following surgery ($p=0.016$).

Discussion and Conclusion: Elderly patients undergoing shoulder operations in BCP are at higher risk of serious cerebral hypotension, desaturation and peri-op- erative cognitive dysfunction than the younger patients.

Keywords: Cognitive dysfunctions; elderly; near infrared spectroscopy; beach chair position.

For surgical operations, different positions are sometimes used for surgical convenience and advantages. Arthroscopic shoulder procedures in the beach chair position (BCP) have several benefits, such as a lower incidence of traction neuropathies with reduced neurovascular complications, decrease in operation time, and better anatomical orientation[1]. However, the upright positioning of the patient's head can dramatically affect the cerebral circulation due to arterial hypotension and secondary cerebral hypo perfusion. The use of intentional hypotension during anesthesia to reduce intraoperative bleeding and provide improved intraoperative visibility can further aggravate the hydrostatic gradient between the heart and brain, leading to serious ischemic events and postoperative neurocognitive disorders[2-4].

Cerebral ischemia is a pathophysiological condition in

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which the oxygenated cerebral blood flow (CBF) is less than what is needed to meet cerebral metabolic demand. It is one of the most debilitating complications in the perioperative period and has serious clinical sequelae. It has a relatively high incidence. The monitoring and prevention of intraoperative cerebral ischemia are crucial because an anesthetized patient in the operating room cannot be neurologically assessed[5,6].

The number of patients above the age of 65 presenting for a variety of surgical procedures has dramatically increased. These patients are more prone to perioperative complications due to their numerous comorbidities and reduced physiologic reserve. Age has also been considered an independent risk factor for the impairment of vascular structures and their function. Intraoperative cerebral ischemia can be more deleterious in this patient group, causing a number of postoperative neurocognitive events ranging from delirium to cerebral stroke[7].

Near-infrared spectroscopy (NIRS) is a noninvasive technology that continuously monitors regional tissue oxygenation. It is used for the estimation of cerebral perfusion and CBF[8].

We aimed to assess the cerebral oxygen saturation using NIRS in elderly patients undergoing shoulder operations in BCP and see if patients over 65 years of age show any failure to compensate for the positional effects of BCP during shoulder operations in brain oxygenation and if there are any cognitive derangements as a result of that.

Materials and Methods

This prospective observational study was conducted in a university-affiliated training and research hospital between the years of 2018 and 2020. Approval from the hospital Ethics Committee (University of Health Sciences Ethic Committee of Scientific Studies; Approval number: HNHEAH-KAEK 2018/83-736) and patient consent were completed.

Patients over the age of 18 who were scheduled for arthroscopic shoulder surgery in the BCP were enrolled. During the preoperative assessment, a baseline Mini Mental State Examination (MMSE) was performed by the patients to assess their cognitive performance. Patients with any previous cerebral pathology (stroke, trauma, and mass lesion), carotid artery stenosis, psychiatric problems, or known cognitive problems were excluded from the study.

MMSE 24–30 was accepted as the baseline value for normal cognitive function,[9] but we adjusted MMSE for the age and education level of the patients (Score 20–24) (Tables 1 and 2)[10].

If the adjusted score was still below the cutoff point, these patients were accepted to have neurocognitive disorder and excluded too. After exclusions, a total of 105 patients were included in the study.

Two senior surgeons performed the shoulder operations, and anesthesia was provided by the same anesthesia group throughout the study. The expected duration for the operations was around 2–2.5 h.

Intraoperative monitoring consisted of electrocardiography, non-invasive arterial blood pressure (BP) measurement, capnography, pulse oximetry, and regional cerebral oxygen saturation ($rScO_2$) using NIRS (Covidien INVOS 5100c Cerebral Oximeter, Medtronic, Minneapolis, MN, USA). Cerebral oximeter sensors were applied bilaterally to each fronto-temporal area after cleansing the skin with al-

Table 1. Patien's age-educational level table

Age/Education	18–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85
0–4 years	22	25	25	23	23	23	23	22	23	22	22	21	20	19
5–8 years	27	27	26	26	27	26	27	26	26	26	26	25	25	23
High school	29	29	29	28	28	28	28	28	28	28	27	27	25	26
University higher	29	29	29	29	29	29	29	29	29	29	28	28	27	27

Table 2. The number of patients according to the age and education level

Age/Education	18–24 (n=3)	25–29 n=3	30–34 n=2	35–39 n=3	40–44 n=4	45–49 n=9	50–54 n=11	55–59 n=9	60–64 n=10	65–69 n=22	70–74 n=11	75–79 n=5	80–84 n=4	85 n=1
0–4 years	23	25	25	23	24	24	24	23	23	22	23	22	23	21
5–8 years	-	-	-	26	27	27	26	26	25	25	25	24	24	-
High school	29	29	-	29	29	29	27	27	25	26	26	24	25	-
University higher	30	30	29	29	29	29	29	28	27	27	26	28	25	-

cohol. Individual baseline values were obtained before the induction while the patient was breathing room air.

Anesthesia was induced with propofol 2–2.5 mg/kg, fentanyl 100 mcg, and rocuronium 0.6–0.8 mg/kg. Maintenance of anesthesia consisted of sevoflurane 1–3% (<1.5 minimum alveolar concentration [MAC]) in a 50% O_2 /air mixture. Anesthetic depth could not be monitored; in the upright position, the patient's head was fixed with a circular bandage covering the forehead; there was no space for both NIRS and bispectral index probes together, making the BIS monitoring unreliable. Ventilatory adjustments were made to maintain the $ETCO_2$ levels between 32 and 37 mmHg.

For the surgical procedure, the patient was first placed in the semi-beach chair, and then in the BCP (nearly 90°). The measured data were recorded 5 min after the patient was stabilized in each position and every 5 min during the operation.

Mean arterial BP was targeted to stay within 20% of baseline values. Hypotensive events were defined as a fall in the systolic BP (SBP) or mean arterial BP (MAP) below 30% of the baseline value or SBP under 90 mmHg.

A cerebral desaturation event (CDE) is defined as a >20% decrease from the baseline or an absolute value of <55% (the accepted normal value is 60–80 in the adult brain[11]) for >15 s in either hemisphere of the brain.

$rScO_2$ was continuously displayed on the INVOS monitor, automatically recorded on a secure USB drive attached to it, and then uploaded to a computer for analysis. During the defined cerebral desaturation attacks or hypotension episodes, accompanying SBP, MAP, or $rScO_2$ were also recorded.

In case of hypotensive events and/or if NIRS values showed cerebral desaturation, the management protocol consisted of:

First, verifying the head position to exclude flexion, extension, and rotations to the left or right side of the head[12].

And than,

1. Increasing MAP with a fluid bolus (defined as 250 mL in 5 min) repeated twice and/or ephedrine (5 mg) IV bolus
2. Increasing $ETCO_2$ up to 45–50 mmHg by decreasing minute ventilation (decreasing respiratory frequency or tidal volume) to achieve cerebral vasodilatation and increased blood flow
3. Increasing FiO_2 concentration (from 50% to 60–70%)

These steps were taken until the BP within 20% of baseline values or $rScO_2$ values returned to the normal values described.

The recordings of the data were concluded with the patient back in the supine position and extubated.

$rScO_2$ values were analyzed using the INVOS Analytics Tool (Medtronic, Minneapolis, MN, USA). Initial values were labeled as baseline, and desaturations were identified accordingly. Each patient's total area under the curve (AUC, $rScO_2$*min) value was automatically calculated by an analytical tool via a proprietary formula to quantify the degree of desaturation.

The MMSE was repeated postoperatively within 24 h and again at the patient's 3-month surgical follow-up visit. The results were compared with the pre-operative test scores. Any drop in the score was accepted as a decline in cognitive function.

This study was conducted in accordance with the Declaration of Helsinki.

Statistical Analysis

For this analysis, the cohort was divided into two groups defined primarily based on the patient's age: patients aged 65 years or older (the elderly group) and patients aged <65 years (the younger group).

The parameters were recorded as simple yes/no, according to the values being in the pre-defined limits of drop as in hypotension, CDEs, or MMSEs. Statistical comparisons between demographics, hemodynamic parameters, NIRS parameters, and mini-mental state changes for these groups were made by using the Wilcoxon rank-sum test, Fisher's exact test, and Pearson's Chi-square test of independence as indicated. Correlations between $rScO_2$, hypotension, and mini-mental state changes were evaluated with Pearson's r and Spearman's rho, as indicated.

All statistical analyses were performed using RStudio (version 3.6.3), and a value of $p<0.05$ was considered statistically significant.

Results

Ninety-seven patients out of 105 were included in the final analysis of the study (Group ≥65 years old, n=43; Group <65 years old, n=54). The data collection was incomplete in 7 patients, and the procedure was canceled in one patient.

The gender and body mass index (BMI) were not different between groups. The total number of preexisting comorbidities was significantly higher in the elderly, with HT being the most common comorbidity in this age group ($p<0.001$) (Table 3).

Table 3. Demographics and comorbidities of the groups

Characteristic	<65 years old, n=54	≥65 years old, n=43	Overall, n=97	p[1]
Age, Median (IQR)	50 (42, 57)	72 (68, 74)	58 (48, 68)	<0.001
Male Gender, n (%)	27 (50)	18 (41)	46 (47)	0.5
BMI, Median (IQR)	27.6 (25.0, 32.0)	29.1 (24.2, 32.0)	28.7 (24.7, 32.0)	0.9
Comorbidities, n (%)	30 (56)	43(100)	73 (72)	<0.001
DM, n (%)	9 (14)	12 (24)	21 (18)	0.3
HT, n (%)	14 (24)	28 (79)	42 (44)	<0.001
MI/CAD, n (%)	2 (2.0)	7 (10)	9 (5.1)	0.14
PVD, n (%)	2 (2.0)	3 (3.4)	5 (2.5)	>0.9
COPD, n (%)	0 (0)	3 (3.4)	3 (1.3)	0.4
Obesity, n (%)	26 (40)	18 (48)	44 (43)	0.5
Other, n (%)	11 (18)	14 (24)	25 (20)	0.5

[1]Wilcoxon rank sum test, Pearson's Chi-squared test, Fisher's exact test. BMI: Body mass index, DM: Diabetes mellitus, HT: Hypertension, MI/CAD: Myocardial infarction/coronary artery disease, PVD: Pulmonary vascular disease, COPD: Chronic obstructive pulmonary disease ($p<0.001$ statistically highly significant).

The duration of the operations was similar in both groups (127.5±19.15 min vs. 124.41±18.78 min, $p>0.05$). As one of the major advantages of the upright position is the minimal bleeding that permits arthroscopic intervention, the blood loss was negligible in all patients. Periferic oxygen saturation levels were similar (99.29±1.1 vs. 99.83±0.4; $p>0.05$).

The frequency of hypotensive events at the semi (45°) and full BCP (nearly 90°) were significantly higher in patients over 65 years of age after the induction and during the operation. The maximum percentage drop was higher, and the duration of the hypotensive episodes was longer again in the same group (Table 4).

When systemic BP drops, cerebral autoregulatory (CA) mechanisms are expected to preserve the cerebral perfusion pressure between the patient's specific limits of mean arterial pressure (MAP)[13]. If The MAP decreases below the individualized autoregulatory limits, failure of this autoregulatory mechanism may result in cerebral is chemia.

Although the hypotensive events compared to the elderly were much less in number, when these episodes occurred, cerebral desaturation attacks (drop in $rScO_2$ [NIRS] values) were similarly accompanied by systemic hypotension in younger patients (Table 4).

The maximum percentage of $rScO_2$ drop from the baseline was higher in the elderly (max % decrease [median: 26 [17.34] vs. 18 [11.26]) ($p=0.006$).

The area under the curve showed that the total duration of the $rScO_2$ decrease was again larger in the elderly group of patients. (AUC-R, median [IQR]: 30 [0.274] vs. 0 [0.21]; [$p=0.014$]) (Table 5).

No patient in the younger age group showed any minimental test score changes following the operation (0%). Whereas in the older group, 3 patients had a decline in

Table 4. Hypotensive episodes at PI, PInt, 45 and 90° (Beach-chair position), occurrence of coupling of Hypotension-$rScO_2$ drop, the number of episodes of coupling of Hypotension-$rScO_2$ drop. ($p<0.05$ statistically significant, $p<0.001$ statistically highly significant)

	<65 years old, n=54	≥65 years old, n=43	p[1]
Hypotension, total- n (%)	38 (70)	43 (100)	0.002
Bradycardia, n (%)	12 (22)	18 (41)	0.11
Hypotension-PI, n (%)	21 (39)	32 (76)	0.001
Hypotension-PInt, n (%)	9 (16)	7 (17)	>0.9
Hypotension-45°, n (%)	19 (36)	31 (72)	0.002
Hypotension-90°, n (%)	20 (38)	35 (83)	<0.001
HypoTA+_$rScO_2$ drop coupling, n (%)	22 (42)	26 (62)	0.085
HypoTA+$rScO_2$ drop, n, Median (IQR)	0.00 (0.00, 1.00)	1.00 (0.00, 3.00)	0.018
Hypotension-Max (%) Median (IQR)	42 (28.44)	54 (41.53)	<0.001

[1]Pearson's Chi-squared test; Fisher's exact test; Wilcoxon rank sum test, $rScO_2$: Regional cerebral oxygen saturation, PI: Postinduction, PInt: Postintubation.

Table 5. $rScO_2$ decrease and AUC values

	<65 years old, n=54	≥65 years old, n=43	p[1]
Max $rScO_2$ decrease (%), Median (IQR)	18 (11.2)	26 (17.3)	0.006
AUC-mean, Median (IQR)	3 (0.29)	23 (0.27)	0.049
AUC-L, Median (IQR)	0 (0.37)	8 (0.18)	0.10
AUC-R, Median (IQR)	0 (0.21)	30 (0.27)	0.014

[1]Wilcoxon rank sum test, $rScO_2$: Regional cerebral oxygen saturation.

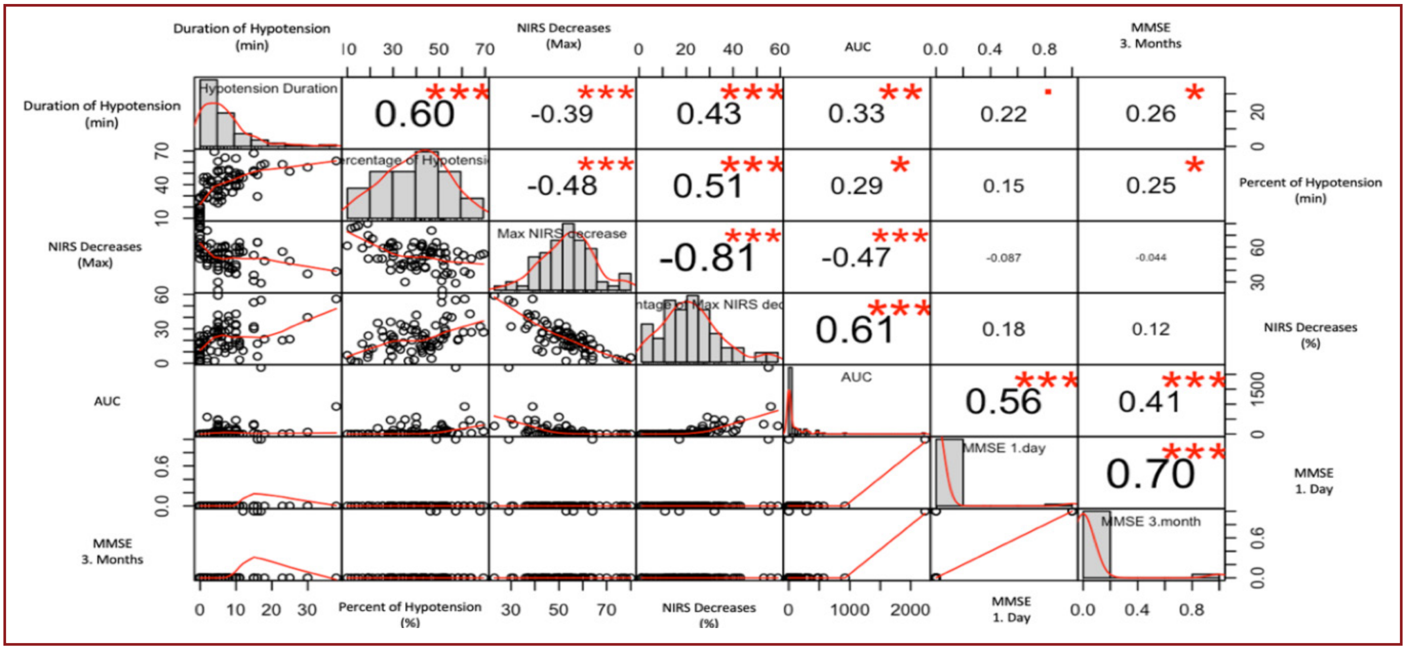

Figure 1. Associations between near infrared spectroscopy (NIRS) scores, hypotension and cognitive function. The mini mental state examination (MMSE) scores on the 1st day and the 3rd-month did not correlate with the levels of any NIRS scores (p>0.05 for all). The deterioration of blood pressure, elevated duration of hypotension, and hypotension percentage were significant (p<0.05) potential factors in cognitive function decline on the 3rd day. However, when comparing average cumulative saturation below the threshold of the baseline rSO_2 right and left (AUC), it positively correlated with the total MMSE scores (p<0.001). In the above plots: The distribution of each variable is shown on the diagonal. On the bottom of the diagonal: The bivariate scatter plots with a fitted line are displayed. On the top of the diagonal: the value of the correlation plus the significance level as stars. Each significance level is associated to a symbol: p-values (0, 0.001, 0.01, 0.05, 0.1, 1).

cognitive function at 24 h (7%; p=0.11) and this decline persisted at the 3-month follow-ups; in another 3 patients, the cognitive decline was observed not in the early phase but at the 3-month follow-up testing after surgery, making a total of 14% of the elderly group (p=0.013) (Fig. 1).

Discussion

It is known that age-related declines in cardiovascular function may impair CBF regulation, leading to the disruption of regional or global hypoperfusion[14,15]. We hypothesized that younger patients would compensate for these hypotensive episodes to an improved degree, so that cerebral desaturation episodes would not be seen as often as in elderly patients. Our study showed that when MAP drops, cerebral desaturation occurs similarly in conjunction with it, both in younger and elderly patients. But the frequency of hypotensive episodes and severity of cerebral desaturation attacks were significantly higher in patient's ≥65 years of age.

We also assessed the neurocognitive outcome in our elderly and younger patient groups to see if the CDEs affected the cognitive function to a different degree in these age groups.

With aging increases in wall thickening and stiffening of central elastic arteries, SBP and pulse pressure increase. This subsequently leads to an augmentation of CBF pulsatility. The elevated MAP, resulting from increased total peripheral resistance and endothelial dysfunction, may induce cerebrovascular remodeling to increase resistance and impedance[16].

While CA impairment is often implicated in the etiology of age-related disorders, e.g., falls, syncope, and brain aging, there is conflicting evidence on the effect of normal or healthy aging on cerebral autoregulation. According to a recent review, 60% of studies suggested that CA is preserved, while a smaller number of studies noted that CA is impaired or altered with age[17].

Although CA may not be affected by age, older adults have a marked reduction in cardiovagal-baroreflex sensitivity. The baroreflex controls BP by modulating heart rate, cardiac inotropy, and vascular tone in response to BP changes; therefore, this reduction very likely augments BP and CBF fluctuations. The augmented fluctuations in CBF during postural changes in older adults compared with younger adults have been shown in previous studies[18]. This finding was also demonstrated during repeated sit-stand maneuvers, indicating diminished cardiovascular regulatory capability in older adults and increased hemodynamic stress on the cerebral circulation with advanced aging[19]. Additional illnesses, including diabetes and cardiovascular diseases such as HT, can further dull the homeostatic response to postural changes[20]. Above all, it has been shown that among those ≥70 years old, carotid artery stenosis occurs at a prevalence of 12.5% (95% CI, 7.4–20.3%) in men and 6.9% (95% CI, 4.0–11.5%) in women. The pooled prevalence of severe stenosis is around 1.7% and is associated with poor cerebral reserve[21]. Clinically asymptomatic patients may have stenotic cerebral arteries and thus may require even higher perfusion pressures to achieve adequate blood flow[22].

Although autoregulation of cerebral perfusion is generally considered to function at an adequate level for MAP values of 50–150 mmHg, the actual range for humans might be higher and should be estimated individually based on the patient's resting MAP. In poorly controlled hypertensive patients, the autoregulation of CBF shifted to the right, requiring higher CPP/MAP to ensure cerebral perfusion[23]. The incidence of HT in our ≥65-year-old age group was 76%. All 29 patients experienced perioperative hypotension (100%). 62% of these episodes were associated with cerebral desaturation.

Age-related changes in CBF are also a well-known risk factor for cognitive dysfunction that has been widely studied and accepted as a multifactorial disease in older individuals[24,25].

Anesthetic agents affect the cerebral vasculature dynamics through direct effects on the vessels as well as through modulation of the endogenous regulatory mechanisms and by blunting baroreceptor responses. Vasodilation mediated by volatile anesthetics occurs independent of the anesthetic depth and is the result of a direct effect on the cerebral vasculature. Cerebral autoregulation remains intact during the administration of short-acting inhalational anesthetics at lower concentrations (1–1.5 MAC), but when it increases, the autoregulatory process collapses and becomes a direct function of the MAP[26-28]. This means that by increasing the MAP to within 20% of baseline during anesthesia, one may have increased CBF velocity, or vice versa, as autoregulation is absent. In humans, it is shown that both cerebral autoregulation and cerebral CO_2-reactivity were maintained at 1 MAC sevoflurane and better preserved during 1.5 MAC sevoflurane than isoflurane anesthesia[29].

We used 1–1.5 MAC (2–3%) of sevoflurane during the maintenance of anesthesia.

Putting all this knowledge together, it is predictable that moving the elderly patient from supine to BCP under general anesthesia may cause profound hypotension, and this may continue throughout the procedure. It is shown in the general population that during shoulder surgery in upright position, cerebral desaturation episodes can range from 1 min up to 1 h in length[30]. Nonetheless, the potential effects on the CBF and cerebral oxygenation generally are not directly monitored; this may actually be necessary under the above-mentioned circumstances.

NIRS is a non-invasive optical cerebral perfusion monitoring technology that has been extensively used for the management of silent cerebral ischemia in many surgical circumstances, including sitting or BCP[28]. a recent review of the current literature by Salazar et al.,[2] the incidence of intraoperative perfusion monitoring in patients undergoing shoulder arthroscopy in the BCP was reported to be 20%. The minimum incidence of intraoperative CDEs was between 0% and 57% in mostly small cohorts of patients. None of these studies reported the occurrence of CDEs in relation to age differences, which might be a remarkable factor.

We found less hypotensive episodes in the younger group, but when hypotension developed, CDEs were observed equally in both groups.

The maximum percentage of $rScO_2$ decrease and the duration of this desaturation (AUC) were higher in the older patient group (AUC-mean [both sides], median [IQR] 3 [0.29] vs. 23 [0.272]; p=0.049) (Table 4). The difference between the AUC-L and AUC-R values measured in the elderly group might be related to the low number of study patients. We did not detect any technical problems during the intra-operative period. This finding is encountered in some cardio-vascular surgery studies,[31] but we did not detect any postoperative findings related to that difference.

A total of 62% of the elderly group and 42% of the younger group showed cerebral desaturation ($rScO_2$ drop >20% of baseline; $p>0.05$). Seven (12.9%), 6 (11.1%), and 6 (11.1%) patients in the elderly, 3 (6.9%), 2 (4.6%), and 1 (2.3%) patients in the young group showed 30–40%, 40–50%, and 50–60% drops from the baseline values of $rScO_2$. The rescue therapies according to the protocol were applied accordingly.

Blood viscosity and hematocrit (Hct) levels may also influence CBF. Likewise, longer operation times and greater blood losses are recognized as possible predictors of cerebral oxygen desaturation[28]. Hct and hemoglobin levels are routinely checked before surgery in our institution, and a minimum level of 9–10 gr/dL Hb level is accepted for elective surgery that is applied to our patients. Arthroscopic shoulder surgery presents little or no risk for blood loss.

The meaningful endpoint of using cerebral oximetry is to protect central nervous system function. A previous systematic review of 24.701 cases reported the overall incidence of neurologic deficits after arthroscopy in the upright position to be 0.004%[32].

We assessed cognitive functions using the MMSE test, as it is a brief neuropsychological test that provides an overview of cognitive function.

Even though it is not suitable for diagnostic measures, it can be used to indicate the presence of cognitive impairment[9].

A senior anesthesia technician applied the test before and after the operation. The same person also administered the final test given at the 3rd postoperative month follow-up visit. Patients were questioned for any reason (operation, trauma, and falls) that might have affected their cognitive function since their last operation.

No patient in the young age group showed any cognitive dysfunction, neither 24 h nor 3 months after the operation.

Whereas in the elderly group, 3 patients showed a decline in cognitive function at 24 h, and this decline persisted after 3 months (6.9%). These patients were 73, 80, and 85 years old. The first one experienced a 57.2% drop in SBP and a 55% drop in $rScO_2$, and the AUC value was the highest of all (R/L-$rScO_2$*min=2986/1480). The 80- and 85-year-old patients had SBP drops of 49% and 51%, respectively, and the AUC values were also high ($rScO_2$ drops of 20–25%).

In 3 other patients of the same group, the cognitive decline was observed not in the early phase but at the second test, 3 months after surgery (6.9%). These three patients were 65, 73, and 79 years old. They had nearly 69%, 64%, and 60% drops in SBPs and 32%, 43%, and 25% drops in their baseline $rScO_2$ values during the operation, with a modest increase in AUC values. They did not have any reason to explain this cognitive regression within the past 3 months. In a systematic review to determine the incidence of post-operative cognitive dysfunction 3 months after non-cardiac surgery in adults, the pooled incidence of post-operative cognitive dysfunction at 3 months was found to be 11.7%, which was similar to our study (13.9%)[33].

The patient with the highest decline in $rScO_2$ values was a 77-year-old patient ($rScO_2$ drop 59%). His AUC values were modestly increased, and he showed no decline in cognitive function.

In the former review of Pant et al.,[34] the mean incidence of CDEs was found to be 28.8%. A strong positive correlation between CDEs and the degree of elevation in the BCP was found. They reported that the patients could be stratified on the basis of age, history of HT and stroke, BMI, diabetes mellitus, obstructive sleep apnea, and height, and defining the degree and duration of cerebral desaturation as measured by NIRS required a measurable neurocognitive decline postoperatively[4].

In the study of Cox et al.,[35] NIRS was monitored on 41 patients during artroscopic surgery done in the BCP. The Montreal Cognitive Assessment was used to assess cognitive dysfunction preoperatively, immediately, and 2, 4, and 6 weeks postoperatively. Similar to our findings, they found that there was a correlation between CDEs and intraoperative BP. The overall incidence of CDEs was 17.5%, and no patient experienced cognitive dysfunction at any time postoperatively. In this study, the mean age was around 55±12 years, which is comparable to our younger group of patients, and no one had significant comorbidities[5].

In another similar study by Lafham et al.,[36] the mean age of the patients in BCP (n=109) was 66±12, less than our elderly group (age, median: 72 [68–74]). They also had less comorbidities compared to our elderly patients. In this study, the patients were positioned in a 30–40° head-up position. They had cognitive testing before and after the operation. The authors found significant decreases in $rScO_2$ levels in BCP, but they did not report any difference in the composite cognitive outcome compared to the control group (lateral decubitus position)[6].

Our study had a relatively small number of patients. The statistical significance was found between the young and elderly groups in terms of MMSE score regression (0% vs. 14%) (p=0.016).

In the latest work of Salazar et al.,[2] a total of 1056 cases in 19 studies were reviewed. They concluded that multiple reports had failed to establish a correlation between the clinically significant thresholds of magnitude, duration, and frequency of intraoperative CDEs and postoperative neurocognitive deficits. None of these studies regarded the older patients as a separate group.

Our study showed the importance of monitoring cerebral oxygenation in patients with vulnerable cerebral circulation, both in terms of patients (age and comorbidities) and operational characteristics. To our knowledge, this is the first study that points out the differential situation of aging and implies the necessity of brain oxygenation in this group.

Our study has some weaknesses; it was not possible to identify the patients who had cerebral vascular problems, carotid artery stenosis, etc. Patients' preoperative volume status was not properly controlled, especially in the elderly population, as they were ordered NPO, which may have contributed to dehydration and hypotension to some degree. Also, rapid changes in cerebral perfusion pressures inducing transient (3–4 min.) alterations in CBF may be missed as the data were recorded only every 5 min, but AUC values were automatically recorded and were not missed.

Conclusion

During arthroscopic shoulder operations in the beach chair position, the head of the patient is nearly 90° elevated from the cardiac level. Regarding the comorbidities and systemic dysfunctions with aging, the elderly patients are prone to a greater risk for serious hypotension, cerebral desaturation, and post-operative cognitive dysfunction than the younger patients and therefore should be monitored for cerebral oxygenation.

Ethics Committee Approval: Approval from the hospital Ethics Committee (University of Health Sciences Ethic Committee of Scientific Studies; Approval number: HNHEAH-KAEK 2018/83-736) and patient consent were completed.

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Conflict of Interest: None declared.

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