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Changes in cerebral oxygenation at different beach chair position angles as a predictor of early postoperative neurocognitive disorders

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The beach chair position during shoulder surgery may lead to reduced cerebral oxygenation due to the hydrostatic gradient and anesthesia-induced vasodilation. Increasing the tilt angle potentially elevates the risk of cerebral hypoxia and early postoperative cognitive impairment. Objective. To investigate the effect of body tilt angle in the beach chair position on cerebral oxygenation parameters and the risk of early postoperative cognitive impairment. Methods. In this prospective randomized study, 75 ASA I–II patients undergoing shoulder surgery were assigned to a beach chair position at either 80° (n = 35) or 60° (n = 40). Regional cerebral oxygen saturation (rSO_2) was monitored using near-infrared spectroscopy (NIRS), along with hemodynamic parameters and BIS. Cognitive function was assessed using the MMSE preoperatively and 24 hours postoperatively. Quality of recovery was evaluated using the QoR-15 questionnaire, and discharge readiness using the Modified Aldrete score. Statistical analysis was performed using Student's t-test. Results. After positioning, mean rSO_2 was lower in the 80° group (71.9 ± 6.6 %) compared with the 60° group (83.3 ± 5.3 %; p < 0.001), with no significant differences in mean arterial pressure. At 24 hours, MMSE scores were lower in the 80° group (25.1 ± 1.5 vs 28.1 ± 1.3; p < 0.001). This group also demonstrated poorer QoR-15 scores and longer extubation time (p <0.001). Conclusions. A tilt angle of 80° is associated with greater reductions in rSO_2 and worse early cognitive outcomes.

Напівсидяче положення (НСП) пацієнта («пляжне крісло») під час операцій на плечовому суглобі може спричиняти зниження церебральної оксигенації внаслідок гідростатичного градієнта й анестезіологічної вазодилатації. Збільшення кута нахилу потенційно підвищує ризик мозкової гіпоксії та ранніх післяопераційних когнітивних порушень. Мета. Дослідити вплив кута нахилу тіла в НСП на показники церебральної оксигенації та ризик розвитку ранніх післяопераційних когнітивних порушень. Методи. У проспективне рандомізоване дослідження включено 75 пацієнтів (ASA I–II), яких розподілили на 2 групи: 1 — оперували в НСП під кутом 80° (n = 35), 2 — втручання виконано за 60° (n = 40). Проводили моніторинг rSO_2 (NIRS), гемодинаміки. Когнітивний статус оцінювали за шкалою MMSE до операції та через 24 години. Якість відновлення визначали за QoR-15, швидкість пробудження — за шкалою Альдрете. Результати. Після позиціювання в НСП середній показник rSO_2 нижчий у групі 80° ((71,9 ± 6,6) % порівняно з 60° (83,3 ± 5,3) %; p < 0,001) за відсутності достовірних відмінностей середнього артеріального тиску. Через 24 год значення MMSE нижче у групі 80° (25,1 ± 1,5 проти 28,1 ± 1,3; p < 0,001). У цій групі також відзначено гірші показники QoR-15 та більшу тривалість екстубації (p < 0,001). Висновки. Збільшення кута нахилу тіла до 80° порівняно з 60° асоціюється з вираженим зниженням rSO_2 та гіршими ранніми когнітивними результатами. Ключові слова. Напівсидяче положення, мозкова оксигенація, кут нахилу тіла.

Keywords. Beach chair position, cerebral oxygenation, body tilt angle

Introduction

The "beach chair" position (semi-sitting, SSP) utilized during shoulder joint surgeries has been linked to documented occurrences of cerebral desaturation episodes, with a reported incidence as high as 17.5 % according to published literature [1].

The use of near-infrared spectroscopy (NIRS) technology provides continuous real-time monitoring of cerebral oxygenation and is considered an effective tool for reducing the incidence of cerebral desaturation. Assessment of brain function during general anesthesia, along with monitoring of hemodynamics and appropriate levels of anesthesia, is one of the main tasks of anesthesiologic monitoring. This is attributed to the fact that hypoxic brain injuries are still among the most frequent and serious anesthesiologic complications [2]. Non-invasive monitoring of cerebral oximetry is a key method for controlling and protecting brain perfusion, especially in situations where there is a risk of iatrogenic brain ischemia. Numerous clinical studies suggest that, despite certain limitations, such monitoring is an important neuroprotective tool, especially in clinical situations associated with the risk of this impairment.

The SSP is routinely used during shoulder arthroplasty (SA) and arthroscopy; however, it is associated with the development of arterial hypotension, which can lead to reduced cerebral perfusion and, consequently, increase the risk of neurological injuries. Moreover, SA procedures are usually characterized by longer durations, which potentially increases the risk of brain hypoperfusion during the perioperative period. Cases of ischemic brain injury have been reported in healthy patients following surgery in the SSP due to hypoperfusion. Near-infrared spectroscopy is described as a non-invasive, continuous method for monitoring cerebral oxygen saturation; however, its impact on neurobehavioral outcomes remains underexplored [3]. Despite the existence of studies describing cerebral desaturation during surgeries, high-quality data on this topic remain limited. Analyzing 10 publications with a total sample of 24,701 patients, only one case of postoperative neurocognitive deficit was recorded, constituting 0.004 % of all observations. Additionally, 4 clinical reports, not included in the main studies, described 6 patients with catastrophic neurocognitive complications after SA in the SSP. The incidence of registered intraoperative cerebral desaturation cases varied from 0 to 100 %, with the average value being 41.1 % [4]. Monitoring and preventing intraoperative brain ischemia are crucial since a patient under anesthesia in the operating room cannot be neurologically assessed [5]. Most existing studies focus either on the frequency of cerebral desaturation or on hemodynamic parameters, without paying sufficient attention to the role of the specific angle of positioning as a modified risk factor. Data on threshold values of decreased rSO_2, which may be clinically significant for the development of cognitive impairments, also remain limited.

Purpose: To investigate the impact of body tilt angle in the "beach chair" position on cerebral oxygenation indicators and the risk of developing early postoperative cognitive impairments.

Materials and Methods

The study was carried out at the State Institution Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Medical Sciences of Ukraine. The study was approved by the local bioethics committee of the institution (protocol No. 257 dated 22.12.2025), conducted in compliance with the principles of Good Clinical Practice (ICH GCP), the Helsinki Declaration on Human Rights and Biomedicine (1977 edition), and the requirements of the current legislation of Ukraine. All patients involved in the study were properly informed about the purpose, plan, and conditions of the study and provided written informed consent to participate.

A prospective randomized study included 75 patients, who were divided into 2 groups: Group I (n = 35) — surgical intervention was performed in SSP at a tilt angle of 80°, and Group II (n = 40) — patients in SSP with a tilt angle of 60°. The average age of patients in Group I was (45.02 ± 13.55) years, and in Group II (44.87 ± 11.50).

Exclusion criteria: patients with arrhythmia, angina pectoris, respiratory failure, a history of acute cerebrovascular disorders, traumatic brain injury, transient ischemic attacks, or refusal to participate in the study.

The physical status of patients in the preoperative period was assessed using the American Society of Anesthesiologists (ASA) scale, with all patients being classified as ASA I–II. Initial patient positioning in both groups was in the standard position, i. e. lying on their back. After securing venous access, 12 ml/kg of volume loading was performed [6], and premedication included 75 mg pregabalin, 40 mg omeprazole before induction, and 10 mg diazepam. Induction consisted of 2 mg/kg of 1 % propofol solution, 0.2 mg of 0.005 % fentanyl solution, and muscle relaxation during tracheal intubation was ensured by administering 0.1 mg/kg of succinylcholine and,

thereafter, maintaining muscle relaxation with 0.3 mg/kg of atracurium besylate. After securing the airway and transitioning the patient to mechanical ventilation with the Drager Atlan A300 (pressure support mode), general anesthesia was maintained with 1 % propofol based on the bispectral index (BIS) values (propofol dosage ranged from 4.5 to 6.5 mg/kg/h). Analgesia was provided with a 0.005 % fentanyl solution. Ten minutes after induction, patients were positioned in SSP. Peripheral blood oxygen saturation (SpO2), non-invasive systolic arterial pressure (SAP), diastolic arterial pressure (DAP), and mean arterial pressure (MAP) were measured using the Mediana YM 6000 monitor. The first measurement was taken immediately upon arrival in the operating room and then every 5 minutes thereafter. BIS monitoring (COVIDEN) was used to control sedation depth and adjust the propofol infusion; according to the manufacturer's recommendations, the target BIS value for general anesthesia was between 40 and 60. The manufacturer indicates that the BIS has a processing delay of 5-10 seconds [7]. Given that CO_2 concentration affects cerebral vascular tone [8], end-tidal carbon dioxide ($ETCO_2$) was continuously measured in both groups and maintained within the range of 35–45 mm Hg. Cerebral oxygenation (rSO_2) was monitored using the INVOS 5100 Regional Oximeter. The speed of awakening was assessed using the Aldrete scale [9], extubation time, and Quality of Recovery-15 (QoR-15) were assessed 24 hours later. Cognitive impairments were evaluated preoperatively and 24 hours postoperatively using the Mini Mental State Examination. Early postoperative hemodynamic responses to position changes were analyzed.

Statistical Analysis

The obtained data were analyzed using IBM SPSS 9.0 software. Normal distribution of the samples was checked using the Kolmogorov-Smirnov test. The mean values and standard deviations were calculated. Differences between groups were evaluated using the Student's t-test.

Results

Patients in both groups were comparable in terms of age, duration of surgery, and blood loss (Table 1).

Assessment of changes in the main hemodynamic parameters of SBP, DBP, pulse, as well as non-invasive cerebral oxygenation monitoring (NIRS) showed no significant differences before positioning. After positioning, there was a statistically significant difference between the groups in terms of hemodynamic parameters and rSO_2: the average rSO_2 value in Group I was 71.97 ± 6.59, while in Group II it was 83.3 ± 5.26 ($p < 0.001$). No statistically significant differences were found in arterial pressure indicators; specifically, the average SAP in Group I was 102.91 ± 13.13, and in Group II it was 108.35 ± 12.57 ($p = 0.07$), while the DAP in Group I was 65.2 ± 10.90 and in Group II it was 68.97 ± 11.02 ($p = 0.14$). However, a significant difference was found in pulse rate, with the average pulse in Group I being 87.05 ± 11.79, while in Group II it was 80.9 ± 14.9 ($p < 0.001$). In Group I, two patients had minimal rSO_2 levels: a 81-year-old man had an rSO_2 of 68 %, and a 49-year-old had an rSO_2 of 61 %. The data obtained are summarized in Table 2.

During the assessment of cognitive functions before surgery, no significant differences were found between the study groups. However, their analysis 24 hours postoperatively revealed a significant difference between the groups, specifically the average Mini-Mental State Examination (MMSE) score in Group I was 25.17 ± 1.50, while in Group II it was 28.17 ± 1.35 ($p < 0.001$). The clinical picture was characterized by mild short-term memory disturbances (episodic forgetting of dates), attention reduction, and slower thinking and concentration processes. At the same time, the patients remained critically aware of their condition (Table 3).

The study of extubation duration from the end of the surgery revealed statistical significance: the average extubation time in Group I was 22.75 ± 11.20 minutes, while in Group II it was 14.17 ± 7.96 minutes ($p < 0.001$). Moreover, there was a difference in the incidence of orthostatic collapse: in Group I, postural hypotension occurred in 7 patients, while in Group II it was observed in 3 cases, making it 15.5 % and 8.57 %, respectively. Regarding the safety of transferring patients to the recovery unit, no statistical difference was found ($p = 0.49$).

A statistically significant difference was found between the groups on the QoR-15 scale: the average score in Group I was 130.82 ± 3.73, while in Group II it was 141.35 ± 3.64 ($p < 0.001$).

Table 1

Comparison of age, duration of surgical intervention, blood loss, and cognitive functions in patients of the study groups

Group	Age of patients	Blood loss (ml)	Duration of surgery (min)
I	45.02 + 13.55	235.85 + 62.13	119.02 + 15.03
II	44.87 + 11.50	231.28 + 55.11	120.,08 + 18.07

Discussion

This study examined the effect of body position, particularly the perioperative tilt angle in the BCP, on cerebral oxygenation and the development of cognitive dysfunctions in the early postoperative period. At a tilt angle of 80°, a significant reduction in cerebral oxygenation was observed, with the lowest rSO_2 value being 61 %. The clinical manifestations were limited to minimal cognitive changes, including slight reduction in operational memory, attention, and cognitive processing speed. It should be noted that 15.5 % of patients experienced orthostatic collapse after verticalization, with the average age of patients being (48.71 ± 6.57) years. The maximum decrease in rSO_2 was up to 22 % from baseline values of cerebral oximetry. Furthermore, a larger tilt angle was associated with worse recovery quality scores on the QoR-15 scale and longer extubation times. This may reflect the complex impact of positional factors on cerebral oxygenation, autonomic regulation, and early functional recovery. The incidence of postural hypotension was higher in Group I, which aligns with the physiological mechanisms of blood redistribution in the upright position.

According to the data obtained by R. M. Cox et al., after examining 41 patients who were divided into 2 groups based on the use of open NIRS monitoring, 7 episodes of cerebral desaturation were recorded, with 5 cases observed in the group with open NIRS monitoring and 2 in the control group. According to the results of cognitive function assessment using the MoCA scale, no cognitive disorders were detected in the early postoperative period, as well as at 2 and 6 weeks after surgery [1]. In the study by J. Chan et al., among 25 patients in the BCP at 30º, cerebral desaturation was recorded in 19 patients, and in 42 % of cases, it occurred specifically during positioning [10]. A. Özgültekin et al. studied the incidence of cognitive disorders and episodes of arterial hypotension in individuals operated on in the BCP at 45° and 90°, considering age-related characteristics. According to the MMSE scale assessment, cognitive changes were observed in 14 % of patients. In patients under 65 years of age, rSO_2 reduction was up to 18 % of the initial level, while in those older than 65, it was 26 % [11].

At the same time, J. A. Aguirre et al. noted that during the observation of 40 patients in the beach chair position, the frequency of cerebral desaturation cases was 5 %. In all subjects, a significant decrease in arterial pressure was recorded 5 minutes after positioning in the beach chair position compared to baseline values (pressure was measured at the forearm at heart level). There was no decrease in either rSO_2 or maximum blood flow in the middle cerebral artery. However, 24 hours later, cognitive dysfunction was found in the patients. It should be noted that the perioperative systolic arterial pressure (SiAT) was ≤ 100 mm Hg [12]. Overall, the frequency of rSO_2 occurrences was 28.8 %, with a strong positive correlation observed between the development of desaturation and the height of the patient's elevation in the beach chair position (p = 0.056). The level of evidence IV suggests the possibility of stratifying patients by age, presence of hypertension, previous stroke, body mass index, diabetes, obstructive sleep apnea, and height. At the same time, the issue of determining the critical degree and duration of cerebral desaturation

Table 2

Comparison of hemodynamic indicators and rSO_2 in two groups

Parameter	Indicator						Statistical significance
	primary		after induction		after positioning		
	I	II	I	II	I	II	
SBP (mmHg)	143.88 + 22.00	138.57 + 18.77	116.25 + 17.24	111.75 + 14.66	102.91 + 13.13	108.35 + 12.57	—
DBP (mmHg)	86.05 + 13.02	84.55 + 12.61	73.85 + 10.77	71.45 + 11.06	65.2 + 10.90	68.97 + 11.02	—
Pulse, min	84.31 + 14.49	85.15 + 12.81	82.11 + 13.38	85.67 + 14.04	87.05 + 11.79	80.9 + 14.9	p < 0.001
rSO_2	97.08 + 1.42	95.78 + 1.56	85.17 + 8.59	85.50 + 6.54	71.97 + 6.59	83.3 + 5.26	p < 0.001

Table 3

Comparison of cognitive function data in two groups

Parameter	Indicator				Statistical difference
	before operation		after operation		
	I	II	I	II	
MMSE (бал)	28.12 + 1.12	27.92 + 1.15	25.17 + 1.50	28.17 + 1.35	p < 0.001

measured by the NIRS method, which is necessary for the formation of postoperative neurocognitive deficit, remains unresolved. This emphasizes the need for further research to clarify the threshold values of desaturation and assess their clinical significance for postoperative neurocognitive prognosis [13]. The data obtained confirm that the perioperative body tilt angle is a clinically significant modified factor that affects cerebral oxygenation parameters and early cognitive outcomes. However, the study has limitations: a relatively small sample size, absence of long-term cognitive observation, and a lack of direct correlational analysis between the depth of desaturation and neurocognitive indicators.

Conclusions

The perioperative body tilt angle in the semi-sitting position is a significant factor affecting cerebral oxygenation levels and is one of the factors associated with the development of postoperative cognitive disorders.

Conflict of Interest. The authors declare no conflict of interest.

Perspectives for Further Research. Future studies should focus on determining individual threshold values for cerebral desaturation and limits of autoregulation associated with the development of postoperative cognitive disorders. Additionally, the development of personalized monitoring algorithms and optimization of hemodynamics to improve neurocognitive outcomes should be explored.

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CHANGES IN CEREBRAL OXYGENATION AT DIFFERENT BEACH CHAIR POSITION ANGLES AS A PREDICTOR OF EARLY POSTOPERATIVE NEUROCOGNITIVE DISORDERS

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