УДК 616.831-089.5-089.168:612.26](048.8)

DOI: http://dx.doi.org/10.15674/0030-59872026288-95

The role of noninvasive cerebral oxygenation monitoring in the detection of cerebral autoregulation impairment and cognitive dysfunction during dnesthesia in the beach chair position

K. I. Lyzohub, M. V. Lyzohub

Sytenko Institute of Spine and Joint Pathology National Academy of Medical Sciences of Ukraine, Kharkiv

The beach chair position, commonly used in shoulder surgery, is associated with a potential risk of cerebral hypoperfusion due to hydrostatic gradient and anesthesia-induced hypotension. The role of cerebral autoregulation in maintaining adequate cerebral oxygenation under these conditions remains incompletely understood. Objective. Assess the relationships between indicators of systemic hemodynamics, cerebral oximetry and cognitive functions in patients in the perioperative period in a beach chair position. Methods. A total of 80 patients were included. Mean arterial pressure (MAP), heart rate, and regional cerebral oxygen saturation were continuously monitored using near-infrared spectroscopy (NIRS). Cerebral autoregulation was assessed using the correlation between MAP and rSO_2 (cerebral oximetry index, COx). Cognitive function was evaluated using the Montreal Cognitive Assessment (MoCA). Results. Preserved cerebral autoregulation was observed in 75 patients (93.75 %), who demonstrated no clinically significant decrease in rSO_2 after positioning. Five patients (6.25 %) developed marked reductions in MAP and cerebral oxygenation. During surgery, the decrease in rSO_2 was significantly greater in these patients compared with the preserved autoregulation group (–15.2 ± 4.6 % vs. –1.07 ± 4.79 %; $p < 0.001$). Postoperatively, the impaired autoregulation group showed a significant decline in MoCA scores from 28.4 ± 0.5 to 26.4 ± 0.5 points ($p = 0.011$), whereas cognitive performance remained unchanged in the remaining patients. Conclusions. Cerebral autoregulation remained preserved in most patients undergoing surgery in the beach chair position. Impaired cerebral autoregulation was associated with greater decreases in cerebral oxygenation and postoperative cognitive decline. NIRS monitoring may facilitate early identification of patients at risk of cerebral hypoperfusion and perioperative neurological complications.

Напівсидяче положення, яке широко використовується під час нейрохірургічних та ортопедичних операцій, може супроводжуватися зниженням церебральної перфузії внаслідок гідростатичного градієнта й анестезіологічно індукованої гіпотензії. Роль церебральної ауторегуляції в підтриманні адекватної оксигенації мозку в цих умовах залишається недостатньо вивченою. Мета. Проаналізувати взаємозв'язок між показниками системної гемодинаміки, церебральної оксиметрії та когнітивних функцій у пацієнтів у періопераційному періоді у напівсидячому положенні (НСП). Методи. У проспективне дослідження включено 80 пацієнтів. Проводили моніторинг середнього артеріального тиску (САТ), частоти серцевих скорочень і регіональної церебральної оксигенації методом NIRS. Вивчення церебральної ауторегуляції здійснювали шляхом аналізу кореляції між САТ і rSO_2. Когнітивні функції оцінювали за шкалою MoCA. Результати. У 75 пацієнтів (93,75 %) під час переведення в напівсидяче положення не спостерігалося клінічно значущого зниження rSO_2, що свідчило про збережену церебральну ауторегуляцію. У 5 осіб (6,25 %) відзначалося виражене зниження САТ і rSO_2. Під час інтраопераційного моніторингу величина зниження rSO_2 становила –15,2 ± 4,6 проти (–1,07 ± 4,79) % у пацієнтів зі збереженою ауторегуляцією ($p < 0,001$). Післяопераційно у цій групі спостерігалося достовірне зниження показників MoCA з 28,4 ± 0,5 до (26,4 ± 0,5) бала ($p = 0,011$), тоді як у решти пацієнтів когнітивні функції залишалися стабільними. Висновки. У більшості прооперованих церебральна ауторегуляція в разі оперативних втручань у напівсидячому положенні залишається збереженою. ЇЇ порушення асоціюється зі значно вираженішим зниженням церебральної оксигенації та післяопераційним погіршенням когнітивних функцій. Моніторинг NIRS може бути корисним для раннього виявлення хворих із ризиком церебральної гіпоперфузії. Ключові слова. Напівсидяче положення, церебральна ауторегуляція, системна гемодинаміка.

Keywords. Beach chair position, cerebral autoregulation, hemodynamic

© Lyzohub K. I., Lyzohub M. V., 2026

PREVIEW

Introduction

Cerebral oximetry using near-infrared spectroscopy (NIRS) reflects regional oxygen saturation in the cerebral cortex and partially in the subcortical white matter of the frontal lobe. It serves as an indicator of the balance between oxygen delivery and consumption in brain tissue. NIRS values are largely dependent on cerebral blood flow, which in turn is determined by cerebral perfusion pressure (CPP), calculated as the difference between mean arterial pressure (MAP) and intracranial pressure (ICP).

The traditional concept of a lower limit of autoregulation of approximately 50–60 mmHg does not account for substantial inter-individual variability; in adults, this threshold may range from approximately 40 to 90 mmHg [1]. When cerebral autoregulation is intact, cerebral vessels maintain stable blood flow through changes in vascular tone; therefore, variations in MAP are not accompanied by significant changes in NIRS-derived values. Accordingly, within the autoregulatory plateau, no direct correlation between MAP and regional cerebral oxygen saturation (rSO_2) is observed.

In contrast, when cerebral autoregulation is impaired (e.g., in traumatic brain injury, hypoxia, sepsis, effects of anesthetics, hypocapnia, or increased ICP), cerebral blood flow becomes passively dependent on systemic arterial pressure. Under these conditions, a decrease in MAP leads to a reduction in CPP, cerebral blood flow, and consequently NIRS values, establishing a direct relationship between these parameters. Cerebral autoregulation plays a crucial role in various clinical settings, including the perioperative period. Autoregulatory dysfunction may result in cerebral ischemia due to hypoperfusion during low-flow states, or in vasogenic edema and hemorrhagic events during hyperperfusion. In addition, impaired autoregulation may exacerbate both primary and secondary brain injury [2, 3].

Since approximately 70–80 % of cerebral blood volume is contained within the venous compartment, NIRS values predominantly reflect venous oxygen saturation. There is also considerable intra- and inter-individual variability in baseline measurements. Normal NIRS values range from 60 % to 75 %, although physiological values of 55–60 % have been reported in patients with cardiac disease. Therefore, trends in NIRS values are considered more clinically relevant than absolute values [4]. A decrease in NIRS of 20 % from baseline or an absolute value below 50 % is generally regarded as clinically significant [5].

The semi-sitting position (SSP) is commonly used in upper limb surgery. Although this position offers several advantages, it also carries potential disadvantages, including rare but potentially serious neurological complications [6]. These complications are primarily attributed to the gravitational effects of the SSP, which may reduce cerebral perfusion.

The relevance of cerebral oxygenation monitoring during anesthesia in the SSP is underscored by the widespread use of shoulder arthroscopic procedures, during which there is a risk of cerebral hypoperfusion due to positional and hemodynamic changes [7].

Postoperative cognitive dysfunction (POCD) or delirium may represent adverse outcomes of procedures performed in the SSP and can be associated with intraoperative decreases in rSO_2 exceeding 20 % from baseline [8]. Reduced rSO_2 is considered an independent risk factor for the development of POCD [9]. Therefore, the identification of preoperative factors influencing the risk of perioperative cerebrovascular events remains an important clinical issue.

Aim: To analyze the relationship between systemic hemodynamic parameters, cerebral oximetry, and cognitive function in patients during the perioperative period in the semi-sitting position.

Materials and Methods

The study was conducted at the SI “Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Medical Sciences of Ukraine”. The protocol was approved by the institutional bioethics committee (Protocol No. 263, dated 4 May 2026) and performed in accordance with Good Clinical Practice (ICH GCP), the Declaration of Helsinki on Human Rights and Biomedicine (2024 revision), and current Ukrainian legislation.

A total of 80 patients scheduled for shoulder arthroscopic surgery in the semi-sitting position were prospectively screened. The mean age was 42.44 ± 11.51 years.

Exclusion criteria included cardiac arrhythmias, hepatic or renal failure, a history of neurosurgical interventions, and refusal to participate. The preoperative physical status was assessed using the American Society of Anesthesiologists (ASA) classification; all patients were classified as ASA I–II.

The study was conducted in three stages:

Stage 1 (preoperative assessment, 24 hours before surgery):

The cerebral oximetry index (COx) was calculated as the correlation coefficient between MAP and rSO_2

PREPRINT

measured by near-infrared spectroscopy (NIRS). This approach is based on the analysis of slow-wave correlations between systemic arterial pressure and cerebral oxygenation and is widely used for non-invasive assessment of cerebral autoregulation. COx values range from –1 to +1; values above 0 indicate impaired cerebral autoregulation, whereas negative values suggest intact autoregulation, reflecting pressure-independent cerebral blood flow regulation [10].

After a 5-minute stabilization period at rest, three consecutive measurements of MAP and rSO_2 were obtained at 3-minute intervals in the supine position. Following repositioning to the semi-sitting position and hemodynamic stabilization, three additional measurements were recorded using the same protocol. The mean value of the three measurements was used for statistical analysis in each position.

Based on changes in rSO_2 and hemodynamic parameters, patients were divided into two groups: Group I — preserved cerebral autoregulation (n = 75), and Group II — impaired cerebral autoregulation (n = 5).

In Group I, transition to the semi-sitting position did not result in significant changes in hemodynamic parameters or rSO_2. In contrast, Group II demonstrated a decrease in cerebral oxygenation and MAP during positional change.

Stage 2 (intraoperative assessment):

Patients were initially placed in the supine position. Anesthesia induction included propofol 1 % (2 mg/kg), fentanyl 0.005% (0.2 mg), and muscle relaxation for intubation with succinylcholine (1 mg/kg), followed by maintenance of neuromuscular blockade with atracurium besylate (0.3 mg/kg).

After airway management and initiation of mechanical ventilation using a Dräger Atlan A350 ventilator (pressure support mode), general anesthesia was maintained with propofol 1 % at 4.5–6.5 mg/kg/h, titrated according to BIS monitoring. Analgesia was provided with fentanyl 0.005 %.

Ten minutes after induction, patients were repositioned to the semi-sitting position. Peripheral oxygen saturation (SpO_2), non-invasive systolic (SBP), diastolic (DBP), and MAP were continuously monitored using a Mediana YM 6000 monitor. The first measurement was obtained immediately upon admission to the operating room, followed by measurements every 5 minutes. Depth of anesthesia and propofol infusion were guided by BIS monitoring (COVIDIEN system).

Monitoring of rSO_2 was performed using an INVOS 5100 Regional Oximeter system.

Stage 3 (postoperative cognitive assessment):

Cognitive function was assessed preoperatively and on postoperative day 3 using the Montreal Cognitive Assessment (MoCA) scale [11]. Postoperative results were compared with baseline preoperative values. Both the total MoCA score and the incidence of POCD were analyzed. The obtained data were compared between study groups.

Statistical analysis was performed using R software (R Foundation for Statistical Computing). The normality of continuous variables was assessed using the Shapiro–Wilk test and Q–Q plot inspection. For normally distributed data, results are presented as mean ± standard deviation (M ± SD).

Given that measurements were obtained at two time points (preoperatively and intraoperatively), individual changes were calculated for each patient as ΔrSO_2 and ΔMAP (mean arterial pressure). This approach allowed assessment of both the direction and magnitude of within-subject changes.

At the first stage, positional changes from supine to the semi-sitting position were calculated as:

$$\Delta rSO_2 = rSO_{2(\text{semi-sitting})} - rSO_{2(\text{supine})}$$

$$\Delta MAP = MAP_{(\text{semi-sitting})} - MAP_{(\text{supine})}$$

These parameters reflected the immediate physiological response of cerebral oxygenation and systemic hemodynamics to positional change.

To evaluate differences in physiological response between the preoperative and intraoperative periods, $\Delta(\Delta rSO_2)$ and Δ(ΔMAP) were calculated as the difference between intraoperative and preoperative responses:

$$\Delta(\Delta rSO_2) = \Delta rSO_{2(\text{intraoperative})} - \Delta rSO_{2(\text{preoperative})}$$

$$\Delta(\Delta MAP) = \Delta MAP_{(\text{intraoperative})} - \Delta MAP_{(\text{preoperative})}$$

Thus, $\Delta(\Delta rSO_2)$ reflected changes in the cerebral oxygenation response to the semi-sitting position under anesthesia compared with the preoperative state, while Δ(ΔMAP) represented corresponding changes in hemodynamic response. These indices allowed assessment not only of absolute rSO_2 and MAP values but also of changes in physiological reactivity under different clinical conditions (awake vs anesthetized state).

Within-group comparisons (supine vs semi-sitting position) were performed using a paired t-test. Effect sizes were calculated using Hedges' g with 95 % confidence intervals (95 % CI).

Due to the marked imbalance in group sizes and the small sample size in Group II, between-group comparisons were performed using a permutation Welch test. Effect sizes were also estimated using Hedges' g with 95 % CI [12].

Associations between quantitative variables were assessed using Spearman's rank correlation coeffi-

PREPRINT

cient (ρ), which does not assume normal distribution and is suitable for detecting monotonic relationships, particularly in small samples. Statistical significance was set at $p < 0.05$.

Results

Preoperative CO_x analysis

In Group I, transition to the semi-sitting position was not associated with significant changes in hemodynamic parameters or rSO_2. In contrast, patients in Group II demonstrated a decrease in both rSO_2 and mean arterial pressure (MAP) during positional change. Baseline values are presented in Table 1.

In Group I, mean rSO_2 showed a statistically significant decrease ($p = 0.003$) from 91.35 ± 3.77 % in the supine position to 90.96 ± 3.99 % in the semi-sitting position. In Group II, rSO_2 decreased from 89.00 ± 2.00 % to 87.20 ± 2.17 %, although this change did not reach statistical significance due to the small sample size ($p = 0.137$). Between-group comparison showed no significant difference in rSO_2 in the supine position ($p = 0.055$). However, after repositioning to the semi-sitting position, rSO_2 was significantly lower in Group II ($p = 0.013$), with a large effect size ($g = 0.95$).

In Group I, MAP decreased from 100.55 ± 7.76 to 98.03 ± 10.13 mmHg, without statistical significance ($p = 0.096$). In Group II, a pronounced and statistically significant decrease in MAP was observed after positional change, from 103.60 ± 2.97 to 87.60 ± 2.51 mmHg ($p = 0.002$), with a very large effect size ($g = 2.63$). No significant between-group differences in MAP were found in the supine position ($p = 0.092$). After transition to the semi-sitting position, MAP was significantly lower in Group II compared to Group I ($p < 0.001$), with a large effect size ($g = 1.04$).

To assess the physiological response to positional change 24 hours before surgery, ΔrSO_2 and ΔMAP were calculated as the difference between semi-sitting and supine positions (Table 2).

In Group I, transition to the semi-sitting position resulted in minimal decreases in ΔrSO_2 (–0.4 ± 1.1 %) and ΔMAP (–2.5 ± 12.9 mmHg). In Group II, the decrease was more pronounced, with ΔrSO_2 (–1.8 ± 2.2 %) and ΔMAP (–16.0 ± 4.8 mmHg). Between-group comparison showed a greater reduction in ΔrSO_2 in Group II; however, this difference did not reach statistical significance ($p = 0.267$), although a moderate effect size was observed ($g = 0.66$), suggesting a trend toward a more pronounced reduction in cerebral oxygenation response.

For ΔMAP, the between-group difference was statistically significant ($p = 0.0045$). Group II demonstrated a substantially greater decrease in MAP during positional change, with a large effect size ($g = 1.26$), indicating marked differences in hemodynamic response already at the preoperative stage.

Overall, 24 hours before surgery, patients in Group II exhibited a more pronounced decrease in MAP during transition to the semi-sitting position, whereas differences in ΔrSO_2 showed only a non-significant trend.

Intraoperative CO_x analysis

During surgery, rSO_2 and MAP were recorded in both groups in the supine position under general anesthesia and after transition to the semi-sitting position (Table 3).

In Group I, mean rSO_2 remained essentially unchanged during transition to the semi-sitting position ($p = 0.059$), decreasing from 91.49 ± 3.80 % to 90.42 ± 4.10 %. In Group II, a marked and statistically significant reduction in rSO_2 was observed ($p = 0.002$), from 92.60 ± 1.95% to 77.40 ± 3.97 %, accompanied by a very large effect size ($g = –2.63$). Between-group comparison showed no significant difference in rSO_2 in the supine position ($p = 0.296$), whereas after positioning in the semi-sitting position,

Table 1

rSO_2 and MAP values in the preoperative period

Indicator	Position		Within-group comparison (t; p)	Hedges' g (95 % CI)
	supine	semi-sitting		
rSO_2, %:				–0.36 [–0.59; –0.12]
– Group I;	91.35 ± 3.77	90.96 ± 3.99	t = –3.113; p = 0.003	–0.66 [–1.46; 0.19]
– Group II;	89.00 ± 2.00	87.20 ± 2.17	t = –1.857; p = 0.137	0.63 [–0.27; 1.53]
– between-group comparison	t = 2.361; p = 0.055	t = 3.498; p = 0.013		0.95 [0.04; 1.86]
CAT, мм рт. ст.:				–0.19 [–0.42; 0.03]
– Group I;	100.55 ± 7.76	98.03 ± 10.13	t = –1.685; p = 0.096	–2.63 [–4.51; –0.75]
– Group II;	103.60 ± 2.97	87.60 ± 2.51	t = –7.380; p = 0.002	–0.40 [–1.30; 0.50]
– between-group comparison	t = –1.899; p = 0.092	t = 6.408;	p < 0.001	1.04 [0.13; 1.95]

PREPRINT

rSO_2 was significantly lower in Group II compared to Group I (p = 0.001; g = 3.15).

During the intraoperative stage, mean arterial pressure (MAP) decreased significantly (p < 0.001) after positioning in the semi-sitting position in both groups. In Group I, MAP decreased from 163.23 ± 22.44 mmHg to 79.03 ± 9.38 mmHg, with a large effect size (g = –3.35). In Group II, MAP decreased from 154.47 ± 10.64 mmHg to 75.20 ± 4.58 mmHg, also with a very large effect size (g = –6.19).

Despite the pronounced intraoperative reduction in MAP in both groups, no statistically significant between-group differences were observed either in the supine position (p = 0.152) or after transition to the semi-sitting position (p = 0.146).

Thus, the main intergroup differences during the intraoperative period were not related to MAP levels but rather to a substantially more pronounced decrease in rSO_2 in Group II following positioning in the semi-sitting position. The results of intraoperative changes in ΔrSO_2 and ΔMAP are presented in Table 4.

In Group I, the mean decrease in ΔrSO_2 was –1.07 ± 4.79 %, whereas in Group II it was significantly greater at –15.20 ± 4.60 %, with a statistically significant between-group difference (p < 0.001) and a large effect size (g = 2.48). This indicates a markedly more pronounced reduction in rSO_2 in Group II during intraoperative positioning.

Changes in ΔMAP were substantial in both groups. In Group I, ΔMAP was –84.20 ± 24.91 mmHg, while in Group II it was –79.27 ± 10.22 mmHg, with no statistically significant between-group difference (p = 0.402).

Thus, during intraoperative transition to the semi-sitting position, both groups exhibited a comparable magnitude of MAP reduction. However, only patients in Group II demonstrated a significantly greater decrease in ΔrSO_2, suggesting insufficient compensation of cerebral perfusion under orthostatic stress during anesthesia.

To evaluate the effect of anesthesia on physiological responses to positioning, $\Delta(\Delta rSO_2)$ and Δ(ΔMAP) were analyzed, reflecting changes between preoperative and intraoperative responses (Table 5).

In Group I, the change in cerebral oxygenation response ($\Delta(\Delta rSO_2)$) was minimal (–0.68 ± 4.86 %), indicating relatively stable rSO_2 reactivity to the semi-sitting position both preoperatively and during anesthesia. In Group II, this parameter was markedly reduced (–13.40 ± 5.32 %), demonstrating a substantially greater intraoperative decrease in rSO_2 response compared to the preoperative state. The be-

Table 2

Assessment of changes in hemodynamic parameters 24 hours before surgery

Baseline values by group	24 hours before surgery	
	ΔrSO_2	ΔCAT
– I (M ± SD); – II (M ± SD)	–0.4 ± 1.1 –1.8 ± 2.2	–2.5 ± 12.9 –16.0 ± 4.8
Between-group comparison: – p; – g; 95 % CI	 0.2673 0.66; [–0.37; 1.63]	 0.0045 1.26; [0.49; 2.00]

Table 3

Baseline rSO_2 and MAP (CAT) values in the intraoperative period

Indicator	Position		Comparison between patient positions
	supine	semi-sitting	
rSO_2, % I II	91.49 ± 3.80	90.42 ± 4.10	t = –1.9162, p = 0.059 g = –0.22; [–0.45; 0.01]
	92.60 ± 1.95	77.40 ± 3.97	t = –7.3818; p = 0.002 g = –2.63; [–4.51; –0.75]
Between-group comparison: t, p g; 95 %CI	 –1.140; 0.296 –0.30; [–1.19; 0.60]	 7.074; 0.001 3.15; [2.12; 4.17]	—
MAP, мм,рт,ст	163.23 ± 22.44	79.03 ± 9.38	t = –29.082, p < 0.001 g = –3.35; [–3.93; –2.76]
I II	154.47 ± 10.64	75.20 ± 4.58	t = –17.351; p < 0.001 g = –6.19; [–10.38; –2.08]
Between-group comparison: t, p g; 95 %CI	 t = 1.614; p = 0.152 0.39; [–0.51; 1.29]	 t = 1.649; p = 0.146 0.41; [–0.49; 1.31]	—

PREVIEW

tween-group difference was statistically significant ($p < 0.001$) with a very large effect size ($g = 2.05$). These findings indicate that anesthesia in Group II was associated with a pronounced deterioration of rSO_2 responsiveness to positional change compared with Group I.

Analysis of Δ(ΔMAP) showed that in Group I the value was –81.67 ± 25.46 mmHg, whereas in Group II it was 63.27 ± 8.73 mmHg, with a statistically significant between-group difference ($p = 0.01756$) and a large effect size ($g = –0.89$).

Anesthesia substantially altered the physiological response to verticalization in both groups; however, the pattern of these changes differed. Patients in Group II demonstrated a more pronounced deterioration in rSO_2 during transition to the semi-sitting position, whereas differences in MAP between groups were less evident. These findings suggest that the observed differences in rSO_2 cannot be fully explained by systemic hemodynamic changes alone.

A correlation analysis was performed to assess the relationship between ΔrSO_2 and ΔMAP in the preoperative and intraoperative periods, as well as between-stage changes in the response to the semi-sitting position (Δ(ΔrSO_2) and Δ(ΔMAP)). Spearman's rank correlation coefficient (ρ) was used.

Twenty-four hours before surgery, no statistically significant correlation between ΔrSO_2 and ΔMAP was found. In Group I, the correlation was very weak ($\rho = 0.027$; $p = 0.821$), while in Group II a moderate negative correlation was observed but did not reach statistical significance ($\rho = –0.53$; $p = 0.362$). Similar results were obtained during the intraoperative period: no significant correlations were identified in either group (Group I: $\rho = 0.031$; $p = 0.787$; Group II: $\rho = 0.35$; $p = 0.553$).

Analysis of the relationship between changes in responses (Δ(ΔrSO_2) and Δ(ΔMAP)) also demonstrated no significant correlations. In Group I, $\rho = 0.012$ ($p = 0.911$), while in Group II a moderate negative correlation was observed ($\rho = –0.50$; $p = 0.391$). Given the very small sample size in Group II, these findings should be interpreted with caution.

Cognitive function was assessed using the Montreal Cognitive Assessment (MoCA) scale 24 hours before surgery and in the early postoperative period (Table 5).

In Group I, the mean MoCA score was 28.8 ± 1.0 preoperatively and 28.7 ± 0.8 postoperatively. The observed changes were minimal and not statistically significant ($p = 0.241$), with a small effect size ($g = 0.14$), indicating the absence of clinically relevant cognitive decline.

In Group II, the MoCA score decreased significantly from 28.4 ± 0.5 to 26.4 ± 0.5 ($p = 0.011$), with a large effect size ($g = 1.60$), indicating a clinically relevant deterioration in cognitive performance after surgery (Table 6).

Thus, cognitive function remained stable in Group I throughout the observation period, whereas patients in Group II demonstrated a statistically and clinically significant decline in MoCA scores, accompanied by the most pronounced intraoperative reduction in rSO_2. These findings may suggest a potential association between impaired intraoperative cerebral oxygenation and postoperative cognitive decline, manifested mainly as mild impairment of attention, slowed psychomotor responses, and subtle short-term memory difficulties without clinically significant neurological deficit.

Discussion

We found that in most patients, transition to the semi-sitting position was associated with a moderate decrease in arterial pressure without clinically relevant reductions in rSO_2, corresponding to functional physiological adaptation. The low correlation between arterial pressure and rSO_2 in Group II suggests preservation of cerebral autoregulatory mechanisms. This is consistent with the contemporary concept of CO_x as an indicator of pressure–passive cerebral perfusion: when autoregulation is intact, changes in

Table 4

Intraoperative changes in hemodynamic parameters

Group	Operative control	
	ΔrSO_2	ΔCAT
I	–1.07 ± 4.79	–84.20 ± 24.91
II	–15.20 ± 4.60 II	–79.27 ± 10.22
Between-group comparison: – p; – g; 95 % CI	 < 0.001 2.48; [0.76; 4.18]	 0.4018 –0.23; [–0.74; 0.29]

Table 5

Оцінка ефекту переведення в НСП між передта інтраопераційним етапами

Group	Operative control	
	Δ(ΔrSO_2)	Δ(ΔCAT)
I	–0.68 ± 4.86	–81.67 ± 25.46
II	–13.40 ± 5.32	–63.27 ± 8.73
Between-group comparison: – p; – g; 95 % CI	 < 0.001 2.05; [0.52; 3.54]	 0.012 –0.89; [–1.48; –0.27]

PREVIEW

MAP should not be accompanied by parallel changes in rSO_2, whereas a positive correlation indicates loss of compensatory vascular reactivity [13].

Notably, patients with lower intraoperative rSO_2 values also demonstrated lower MoCA scores, consistent with mild cognitive impairment. This aligns with findings reported by M. Aguirre et al., who demonstrated that under total intravenous anesthesia in the semi-sitting position, cerebral desaturation may occur in approximately 25 % of ASA I–II patients and is associated with impaired cerebral blood flow and early postoperative neurobehavioral dysfunction. However, the literature remains heterogeneous: while several studies support an association between cerebral desaturation and cognitive impairment, others have failed to demonstrate a definitive causal relationship [14].

An additional important factor is the hydrostatic gradient between the heart and the brain. In the semi-sitting position, cerebral perfusion pressure is lower than that measured at the level of the heart or arm, which may partly explain why "acceptable" systemic blood pressure values do not necessarily guarantee adequate cerebral perfusion.

In the literature, it is emphasized that controlled hypotension should be avoided during procedures performed in the semi-sitting position, and that the target mean arterial pressure should be higher in patients with hypertension or cerebrovascular disease [15]. Thus, our results are consistent with the current concept that systemic arterial pressure alone is not a sufficient marker of cerebral safety during surgical interventions in the semi-sitting position. The combined use of standard hemodynamic monitoring and NIRS enables timely identification of patients with potentially impaired cerebral autoregulation, in whom even a moderate decrease in arterial pressure may be associated with a clinically significant reduction in rSO_2 and poorer cognitive outcomes [16].

Limitations. The relatively small number of patients with confirmed impaired autoregulation limits the statistical power of between-group comparisons. In addition, NIRS reflects regional rather than global cerebral oxygenation, and the results may be partly influenced by measurement methodology, sensor type, and the chosen desaturation thresholds.

Table 6

Cognitive function (MoCA)

Group	Preoperative (M ± SD)	Postoperative (M ± SD)	Between-group comparison: t; p g, 95 % CI
I	28.8 ± 1.0	28.7 ± 0.8	1.1827; 0.241 0.14; [–0.09; 0.36]
II	28.4 ± 0.5	26.4 ± 0.5	4.472; 0.011 1.60; [0.30; 2.85]

Conclusions

In most patients, cerebral autoregulation remained preserved during transfer to the semi-sitting position and was not associated with a significant decrease in rSO_2.

Impaired cerebral autoregulation was associated with a more pronounced decrease in arterial pressure, cerebral oxygenation, and lower cognitive function scores.

Monitoring cerebral oxygenation using NIRS is an informative tool for early detection of cerebral desaturation and impaired cerebral autoregulation in patients undergoing surgical procedures in the semi-sitting position.

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

Prospects for further research. Optimization of perioperative management in the semi-sitting position during shoulder arthroscopy.

Funding information. No external funding was received for this study.

Author contributions. K. I. Lyzohub — data analysis; M. V. Lyzohub — study concept development.

References

1. Vu, E. L., Brown, C. H., Brady, K. M., & Hogue, C. W. (2024). Monitoring of cerebral blood flow autoregulation: Physiologic basis, measurement, and clinical implications. *British Journal of Anaesthesia, 132*(6), 1260–1273. https://doi.org/10.1016/j.bja.2024.01.043
2. Donnelly, J., Budohoski, K. P., Smielewski, P., & Czosnyka, M. (2016). Regulation of the cerebral circulation: Bedside assessment and clinical implications. *Critical Care, 20*(1). https://doi.org/10.1186/s13054-016-1293-6
3. Sarwal, A., Robba, C., Venegas, C., Ziai, W., Czosnyka, M., & Sharma, D. (2023). Are we ready for clinical therapy based on cerebral Autoregulation? A pro-con debate. *Neurocritical Care, 39*(2), 269–283. https://doi.org/10.1007/s12028-023-01741-1
4. Maillard, J., Sologashvili, T., Diaper, J., Licker, M., & Keli Barcelos, G. (2019). A case of persistence of normal tissue oxygenation monitored by near-infrared spectroscopy (NIRS) values despite prolonged perioperative cardiac arrest. *American Journal of Case Reports,* 20, 21–25. https://doi.org/10.12659/ajcr.911399
5. Seshan, J. R., Kapoor, I., Prabhakar, H., & Mahajan, C. (2022). An unexpected reduction in the value of near-infrared spectroscopy in a child with moyamoya disease. *Journal of Anaesthesiology Clinical Pharmacology, 38*(2), 336–337. https://doi.org/10.4103/joacp.joacp_117_20
6. Salazar, D., Sears, B. W., Aghdasi, B., Only, A., Francois, A., Tonino, P., & Marra, G. (2013). Cerebral desaturation events during shoulder arthroscopy in the beach chair position: Patient risk factors and neurocognitive effects. *Journal of Shoulder and Elbow Surgery, 22*(9), 1228–1235. https://doi.org/10.1016/j.jse.2012.12.036
7. Ozgultekın, A. (2023). Cerebral oxygen desaturation and postoperative cognitive effects in elderly patients operated in beach chair position. *Haydarpasa Numune Training and Research Hospital Medical Journal*. https://doi.org/10.14744/

PREVIEW

hnhj.2022.70446
8. Wu, X., Xu, W., Yu, Y., Han, L., Zhang, J., & Yang, L. (2017). Postoperative serum thioredoxin concentrations correlate with delirium and cognitive dysfunction after hip fracture surgery in elderly patients. *Clinica Chimica Acta,* 466, 93–97. https://doi.org/10.1016/j.cca.2017.01.009
9. Rivera-Lara, L., Geocadin, R., Zorrilla-Vaca, A., Healy, R., Radzik, B. R., Palmisano, C., Mirski, M., Ziai, W. C., & Hogue, C. (2017). Validation of near-infrared spectroscopy for monitoring cerebral Autoregulation in comatose patients. *Neurocritical Care, 27*(3), 362–369. https://doi.org/10.1007/s12028-017-0421-8
10. Mewes, C., Wei, P., Yang, Y., Kainz, E., Kahl, U., Beck, S., Graefen, M., Zöllner, C., & Fischer, M. (2025). Cerebrovascular autoregulation-based optimal mean arterial pressure during prostate surgery – A secondary analysis of a prospective cohort study. *Therapeutics and Clinical Risk Management,* 21, 757–767. https://doi.org/10.2147/tcrm.s505676
11. Evered, L., Silbert, B., Knopman, D. S., Scott, D. A., DeKosky, S. T., Rasmussen, L. S., Oh, E. S., Crosby, G., Berger, M., & Eckenhoff, R. G. (2018). Recommendations for the nomenclature of cognitive change associated with anaesthesia and surgery — 2018. *Anesthesiology, 129*(5), 872–879. https://doi.org/10.1097/aln.0000000000002334
12. Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for T-TesTs and ANOVAs. *Frontiers in Psychology,* 4. https://doi.org/10.3389/fpsyg.2013.00863
13. Bensaidane, M. R., Turgeon, A. F., Lauzier, F., English, S. W., Leblanc, G., & Francoeur, C. L. (2025). Neuromonitoring with near-infrared spectroscopy (NIRS) in aneurysmal subarachnoid hemorrhage: A systematic review and meta-analysis. *Critical Care, 29*(1). https://doi.org/10.1186/s13054-025-05701-3
14. Aguirre, J. A., Etzensperger, F., Brada, M., Guzzella, S., Saporito, A., Blumenthal, S., Bühler, P., & Borgeat, A. (2019). The beach chair position for shoulder surgery in intravenous general anesthesia and controlled hypotension: Impact on cerebral oxygenation, cerebral blood flow and neurobehavioral outcome. *Journal of Clinical Anesthesia,* 53, 40–48. https://doi.org/10.1016/j.jclinane.2018.09.035
15. Ensor, D., Gwilym, S. E., Imam, M., West, S., Elgebaly, A., & Baring, T. (2024). Should the beach chair position have national guidelines to reduce the risk of cerebrovascular complications? Results from a national survey of surgeons and anaesthetists. *Shoulder & Elbow, 17*(4), 459–465. https://doi.org/10.1177/17585732241269147
16. Laflam, A., Joshi, B., Brady, K., Yenokyan, G., Brown, C., Everett, A., Selnes, O., McFarland, E., & Hogue, C. W. (2015). Shoulder surgery in the beach chair position is associated with diminished cerebral Autoregulation but no differences in postoperative cognition or brain injury biomarker levels compared with supine positioning. *Anesthesia & Analgesia, 120*(1), 176–185. https://doi.org/10.1213/ane.0000000000000455

The article has been sent to the editors	Received after review	Accepted for printing
28.04.2026	22.05.2026	24.05.2026

THE ROLE OF NONINVASIVE CEREBRAL OXYGENATION MONITORING IN THE DETECTION OF CEREBRAL AUTOREGULATION IMPAIRMENT AND COGNITIVE DYSFUNCTION DURING ANESTHESIA IN THE BEACH CHAIR POSITION

K. I. Lyzohub, M. V. Lyzohub

Sytenko Institute of Spine and Joint Pathology National Academy of Medical Sciences of Ukraine, Kharkiv

✉ Kseniia Lyzohub, MD, PhD: kslizogub@gmail.com; https://orcid.org/0000-0001-9149-7208

✉ Mykola Lyzohub, MD, DMSci: nlizogub@gmail.com; https://orcid.org/0000-0003-4776-1635

PREPRINT