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COMPARATIVE ANALYSIS OF INFUSION THERAPY AND COMPLEX INTENSIVE THERAPY AFTER NEURO-ONCOLOGICAL SURGERY

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ABSTRACT. Neurooncological diseases represent one of the most complex clinical conditions, characterized by high mortality and disability rates. Although brain tumors account for only 1.5–2% of all cancers, their impact on functional and vital prognosis is substantial. Aim. To study the dynamics of cerebral blood flow and intracranial pressure (ICP) in patients undergoing neurooncological surgery and to evaluate the effectiveness of standard resuscitation protocols. Materials and Methods. A prospective observational study conducted at Samarkand State Medical University from 2023–2025 included 53 patients aged 18–73 years. Surgical approaches included craniotomy, stereotactic, and debulking resections. Resuscitation protocols incorporated sedation with propofol, midazolam, and dexmedetomidine; ventilation; and osmotherapy. Results. The study results demonstrated that perioperative ICP and hemodynamic parameters are directly dependent on the invasiveness of the surgery and the selected therapy. Propofol provided the most stable ICP reduction, hyperventilation resulted in short-term effects with increased ischemic risk, and combined osmotherapy offered the most effective pressure control.

Keywords: Neurooncological diseases, anesthesia, intracranial pressure, osmodiuretics

Neurooncological surgery requires careful control of intracranial pressure (ICP) and hemodynamic stability. Brain tumors affect brain physiology through two pathways, posing serious threats to safety during surgery and long-term neurological outcomes [1,2,4,14]. According to the Monro–Kellie principle, even minor changes in the volume of brain, blood, or cerebrospinal fluid (CSF) within the rigid skull can lead to a sharp increase in ICP and a decrease in cerebral perfusion pressure (CPP). In patients with brain tumors, this balance is already disrupted, necessitating regular monitoring of ICP and hemodynamics in the preoperative and postoperative periods [3,5,6,17].

Elevated ICP in neurosurgical and neurooncological practices is always associated with poor outcomes. Prolonged high pressure leads to cerebral ischemia, disrupts microcirculation, and increases the risk of herniation syndromes. The main challenges in neurooncological surgery involve not only tumor removal but also preventing secondary damage arising from these pathological changes [7,8,12]. Maintaining normal cerebral perfusion protects against ischemic damage, but excessive blood flow and hyperemia can exacerbate edema, resulting in increased ICP [9,10,11]. Cerebral blood flow and autoregulation are directly influenced by anesthetic agents, intraoperative blood loss, systemic hypotension, and arterial carbon dioxide levels [13,16]. For instance, intraoperative hypotension due to deep anesthesia or significant blood loss increases complication rates and is associated with poor outcomes [14,15]. Conversely, neuroanesthetic approaches incorporating targeted fluid therapy or transcranial Doppler ultrasound have been shown to significantly improve outcomes [18,19,20]. Thus, managing cerebral blood flow is of paramount importance, serving as a key factor determining surgical success and recovery.

Purpose of the study: To study the dynamics of cerebral blood flow and ICP in patients undergoing neurooncological surgery and to evaluate the effectiveness of standard resuscitation protocols.

Materials and Methods: This study was designed as a prospective observational clinical investigation. Patients who underwent neurooncological surgery for intracranial tumor removal were prospectively enrolled and monitored throughout the perioperative period. The final analysis included a total of 53 patients, ensuring adequate representation across age and gender groups. The study was conducted at the Neurosurgery and Anesthesiology Departments of the Multidisciplinary Clinic of Samarkand State Medical University from 2023–2025. All surgical procedures, perioperative monitoring, and postoperative treatment were performed in accordance with the hospital's existing protocols. In this study, demographic data, tumor histology and location, surgical procedure characteristics, and hemodynamic parameters were systematically analyzed. Additionally, dynamic indicators of cerebral hemodynamics and ICP were examined before and after various surgical approaches. Furthermore, the impact of standard resuscitation measures (osmotherapy, sedation, and ventilation) on cerebral hemodynamic stability and ICP was evaluated. During this study, a comprehensive monitoring approach was employed to assess cerebral hemodynamics and ICP in patients undergoing neurooncological surgery. Transcranial Doppler ultrasound was selected as the primary method, measuring blood flow velocities. Measurements were performed along the MCA, ACA, and PCA, with results recorded in cm/s. Based on these indicators, the Lindegaard index was calculated, serving as a key diagnostic criterion for differentiating changes due to vasospasm from those caused by hyperemia. ICP was determined using invasive and non-invasive methods. Monitoring was conducted before surgery and in the days following. This sequential observation allowed for dynamic documentation of hemodynamic changes and their systematic correlation with the invasiveness of the surgery. Sedation. Three medications were used during the study: propofol (50–150 μg/kg/min), midazolam (0.02–0.1 mg/kg/h), and dexmedetomidine (0.2–0.7 μg/kg/h). Ventilation. Two approaches were applied: normoventilation ($PaCO_2$ 35–40 mmHg) and hyperventilation ($PaCO_2$ ~32 mmHg). Osmotherapy. Three regimens were evaluated: mannitol (0.5–1 g/kg), hypertonic sodium chloride (2–5 ml/kg), and combined osmotherapy.

Statistical analysis of the study results was performed using the latest version of R software. Categorical variables were presented as absolute numbers and percentages, while continuous variables were expressed as mean (M) ± standard deviation (m). Categorical data, including gender distribution, tumor histological features, and perioperative complication frequencies, were evaluated using the χ^2 (chi-square) test. In all analyses, a p-value < 0.05 was considered statistically significant. Where appropriate, corrections were applied in repeated analyses to reduce the risk of Type I errors. Additionally, effect sizes and confidence intervals were provided alongside p-values to enhance clinical interpretation of the results.

Results and Discussion: The study group consisted of 53 patients, with a mean age of 46.8 ± 11.9 years, ranging from 18 to 73 years. In our study, the age distribution analysis showed that the majority of patients were in the middle-age group, i.e., 40–59 years, comprising 50.9% of the total. Younger patients (under 40 years) accounted for 28.3%, while elderly patients (60 years and older) made up 20.8%. These figures indicate that, although middle-aged individuals predominate, neurooncological diseases are also widely observed among younger and older patients (Table 1).

Table 1. Analysis of Demographic Indicators in Patients Undergoing Neurooncological Surgery

indicators	value
Number of patients	53
Mean age (years)	46,8±11,9 (18–73)
<40 years	15 (28,3%)
40–59 years	27 (50,9%)
≥60 years	11 (20,8%)
Males	29 (54,7%)
Females	24 (45,3%)

The most common tumor locations were the temporal lobe (26.4%) and parietal lobe (17.0%), together accounting for a significant portion of brain tumors. Infratentorial tumors were noted in 15.1% of patients, while basal brain regions and paranasal sinuses tumors were less common, at 7.5% and 3.8%, respectively (Table 2).

Table 2. Analysis of Tumor Location and Size in Patients Undergoing Neurooncological Surgery (n=53)

tumor location	Number of patients		% Average volume (cm^3)
Frontal lobe	16	30,2	31,5±11,2
Temporal lobe	14	26,4	30,9±11,1
Parietal lobe	9	17,0	29,8±9,5
Cerebellum	8	15,1	26,4±9,8
Basal lobes	4	7,5	29,7±13,6
Sinuses	2	3,8	20,2±6,4

When comparing tumor volumes across locations, the average tumor size in most areas was within a moderate range with no significant differences. Frontal lobe tumors had the largest volume, with a mean of 31.5 ± 11.2 cm³. Temporal (30.9 ± 11.1 cm³) and parietal (29.8 ± 9.5 cm³) lobe tumors also had similar volumes. Basal region tumors averaged 29.7 ± 13.6 cm³. The obtained results indicate no differences in tumor size indicators among the enrolled patients, regardless of superficial or deep brain structure location. Cerebellar tumors, despite their anatomically confined location, had an average volume of 26.4 ± 9.8 cm³ and were of high clinical significance. Sinus region tumors had the smallest volume, averaging 20.2 ± 6.4 cm³. Nevertheless, these tumors are diagnosed earlier due to the rapid onset of clinical symptoms.

The characteristics and indicators of surgical procedures performed on the study patients are presented in Table 3. This table includes data on the analysis of operative methods and various indicators used in treating brain tumors observed in the patients. The majority of patients (73.6%) underwent craniotomy with microsurgical resection, a standard approach worldwide for surgically amenable brain tumors. The average duration of these procedures was 232.3 minutes, with an average intraoperative blood loss of 487.2 ml. These indicators reflect the technical complexity and invasiveness of open neurosurgical resections.

Table 3. Analysis of Neurooncological Surgical Procedure Characteristics in Study Groups (n=53)

Indicator	Parts	Number of	Percentage (%)	Duration (min)	Intraoperative blood loss (ml)
Type of surgery	Craniotomy (microsurgical resection)	39	73,6	232,3±61,2	487,2±314,2

	Stereotactic procedure (minimally invasive resection)	8	15,1	77,6±23,9*	58,3±89,1*
	Debalking (partial resection)	6	11,3	162.3±57.3*	358,2±194,4

In 11.3% of the study patients, debulking (partial resection) was performed, a method used when complete or near-complete tumor removal is not feasible due to anatomical or functional risks. The average duration was shorter (198.5 minutes), with blood loss of 412.3 ml, indicating less invasiveness compared to full resections. Stereotactic resections were applied in 15.1% of cases, primarily for deep-seated or precisely localized tumors. These procedures had the shortest duration (175.4 minutes) and minimal blood loss (320.1 ml), highlighting the advantages of minimally invasive techniques in reducing surgical trauma. The analysis of cerebral hemodynamics and ICP before and after sedation revealed clear differences in effectiveness and clinical significance among the studied medications. Propofol group (n=15): Before sedation, MCA blood flow velocity was 66.0 ± 12.1 cm/s, Lindegaard index 2.3 ± 0.4, ICP 20.0 ± 5.0 mmHg. After sedation, these decreased to MCA 45.0 ± 9.2 cm/s, Lindegaard 1.9 ± 0.3, ICP 14.0 ± 4.0 mmHg—a 30% reduction. All changes were statistically significant ($p<0.05$), confirming propofol's high efficacy in reducing cerebral metabolism, hemodynamic load, and ICP.

Table 10. Analysis of Cerebral Hemodynamics Before and After Sedation

Group (n)	Dose Time	MOA	velocity (cm/s)	Lindegaard index MIB, mm.s.u MIB, %	index MIB, mm.s.u	MIB, %
Propofol (n=15)	50–150 µg/kg/min	Before	66.0±12.1	2.3±0.4	20.0±5.0	
		After	45.0±9.2*	1.9±0.3*	14.0±4.0*	**−30%**
Midazolam (n=12)	0.02–0.1 mg/kg/hours	Before	65.5±11.4	2.2±0.3	19.0±5.2	
		After	59.5±10.6	2.1±0.3	15.5±4.6	**−18%**
Dexmedeto midin(n=11)	0.2–0.7 µg/kg/hours	Before	64.8±10.9	2.2±0.3	18.5±4.8	-
		After	57.0±9.3*	2.0±0.2	15.0±4.2	**−19%**
Note: The indicators according to the types of neurosurgical procedures were compared using Mann-Whitney or ANNOVA criteria and the level of statistical significance was considered to be p<0.05 (*)						

Midazolam group (n=12): Before sedation, MCA 65.5 ± 11.4 cm/s, Lindegaard 2.2 ± 0.3, ICP 19.0 ± 5.2 mmHg. After, MCA 59.5 ± 10.6 cm/s, Lindegaard 2.1 ± 0.3, ICP 15.5 ± 4.6 mmHg—an 18% reduction, indicating a stable but less pronounced effect. Dexmedetomidine group (n=11): Before sedation, MCA 64.8 ± 10.9 cm/s, Lindegaard 2.2 ± 0.3, ICP 18.5 ± 4.8 mmHg. After, MCA 57.0 ± 9.3 cm/s, Lindegaard 2.0 ± 0.2, ICP 15.0 ± 4.2 mmHg—a 19% reduction. Changes were significant ($p<0.05$), showing notable but slightly less effective ICP reduction compared to propofol. Sedation significantly impacts cerebral hemodynamics postoperatively. Propofol was the most effective, reducing ICP by 30%. Midazolam and dexmedetomidine provided milder, stabilizing effects (18% and 19%, respectively). Analysis of cerebral hemodynamics before and after ventilation showed variations depending on ventilation type (Table 11).

Table 11. Analysis of Cerebral Hemodynamics Before and After Ventilation.

Group (n)	$PaCO_2$, mm.s.u	Time	MOA (sm/s)	Lindegaard indeks	MIB, mm.Hg.u	MIB, %
Normo ventilyatsiya (n=19)	35-40	Before	60.5±9.8	2.1±0.3	18.0±4.3	
	35-40	After	61.0±9.6	2.1±0.3	17.8±4.8	**-1%**
Giper ventilyatsiya (n=12)	**38-32**	Before	62.3±8.9	2.1±0.3	22.0±5.1	
	32	After	52.1±6.7*	2.4±0.4*	16.0±4.3*	**-27%**
Note: Indicators relative to ventilation types were compared using Mann-Whitney or ANNOVA criteria, and the level of statistical significance was considered p<0.05 (*).						

Normoventilation group (n=19), with PaCO2 35–40 mmHg: Before, MCA 60.5 ± 9.8 cm/s, Lindegaard 2.1 ± 0.3, ICP 18.0 ± 4.3 mmHg. After, MCA remained nearly unchanged at 61.0 ± 9.6 cm/s, Lindegaard stable at 2.1 ± 0.3, ICP slightly decreased to 17.8 ± 4.8 mmHg (−1%). This indicates normoventilation maintains hemodynamic stability without significant changes in cerebral blood flow or ICP.

Analysis of cerebral hemodynamics before and after osmotherapy confirms that osmotic agents significantly affect ICP levels but do not lead to major changes in cerebral blood flow velocities or Lindegaard index.

Table 12. Analysis of Cerebral Hemodynamics Before and After Osmotherapy

Number of patients	Dosa	Time	MOA (sm/s)	Lindegaard indeks	MIB, mm.Hg.u	MIB, %
		Before	60.0±10.1	2.1±0.3	22.0±5.6	

Mannitol (n=20)	0.5–1 g/kg	After	61.5±9.9	2.0±0.3	15.0±4.2*	**-32%**
Hypertonic solution (n=18)	2–5 ml/kg	Before	60.5±9.7	2.1±0.3	23.0±5.8	
		After	61.0±9.2	2.0±0.3	12.5±4.0*	**-46%**
Kombinatsion (n=8)		Before	60.8±9.5	2.1±0.3	24.0±6.0	
		After	60.2±9.1	2.0±0.3	12.0±3.8*	**-50%**
Note: The indicators relative to the types of osmotherapy were compared using Mann-Whitney or ANNOVA criteria, and the level of statistical significance was considered p<0.05 (*).						

Mannitol group (n=20): Before, MCA 60.0 ± 10.1 cm/s, Lindegaard 2.1 ± 0.3, ICP 22.0 ± 5.6 mmHg. After mannitol infusion (0.5–1 g/kg), MCA remained nearly unchanged at 61.5 ± 9.9 cm/s, Lindegaard decreased slightly to 2.0 ± 0.3. ICP significantly dropped to 15.0 ± 4.2 mmHg—a 32% reduction (p<0.05). This shows mannitol's efficacy in reducing ICP without major changes in cerebral blood flow dynamics. Hypertonic solution group (n=18): Baseline MCA 60.5 ± 9.7 cm/s, Lindegaard 2.1 ± 0.3, ICP 23.0 ± 5.8 mmHg. After treatment (2–5 ml/kg), MCA and Lindegaard remained stable (61.0 ± 9.2 cm/s and 2.0 ± 0.3), but ICP sharply decreased to 12.5 ± 4.0 mmHg—a 46% reduction (p<0.05). This confirms hypertonic solution's stronger ICP-reducing effect compared to mannitol while maintaining hemodynamic stability. Combined group (n=8): Baseline MCA 60.8 ± 9.5 cm/s, Lindegaard 2.1 ± 0.3, ICP 24.0 ± 6.0 mmHg. After treatment, MCA showed minimal change to 60.2 ± 9.1 cm/s, Lindegaard slightly decreased to 2.0 ± 0.3. ICP sharply dropped to 12.0 ± 3.8 mmHg—a 50% reduction (p<0.05). This indicates combined osmotherapy's synergistic effect for maximal ICP reduction.

Osmotherapy led to significant ICP reductions regardless of method, with minimal impact on cerebral blood flow velocities and Lindegaard index. Among the osmotherapy methods studied, hypertonic solution and combined treatment caused the greatest reductions (−46% and −50%), while mannitol resulted in a relatively smaller decrease (−32%). Thus, while mannitol and hypertonic solution are effective, their combined use proved highly efficient in reducing ICP.

Analysis of standard resuscitation measures (sedation, ventilation, and osmotherapy) showed these interventions have significant but independent effects on cerebral hemodynamics and ICP. Propofol stood out as the most effective agent, reducing ICP by 30%. Midazolam and dexmedetomidine provided clinically beneficial, relatively mild stabilizing effects (18% and 19%, respectively). Hyperventilation reduced ICP by 27% but increased vasoconstriction risk, while normoventilation maintained hemodynamic stability. Osmotherapy effectively reduced ICP in all cases, with hypertonic solution and combined methods achieving the greatest efficacy (−46% and −50%), and mannitol −32%. Overall, these data confirm that standard resuscitation measures are essential regulators of cerebral hemodynamics and ICP, emphasizing the need for individualized balance between safety and efficacy in their selection.

Conclusions:

Post-neurooncological surgery changes in cerebral hemodynamics and ICP are directly proportional to surgical invasiveness. Craniotomy resulted in higher cerebral artery blood flow velocities and vasospasm (46.2%) compared to stereotactic and debulking procedures. The most common complications post-neurooncological surgery were middle cerebral artery vasospasm (32.1%) and hypoperfusion (24.5%), primarily in craniotomy patients.

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