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ORIGINAL ARTICLE

Optical Nerve Sheath Diameter Correlates with ICU Length of Stay After Craniotomy

Artha Wahyu Wardana,[1,2] Reza Widianto Sudjud,[2] Ricky Aditya[2]
[1]Hermina Hospital Daan Mogot Jakarta Barat, Indonesia
[2]Department of Anesthesiology and Intensive Care, Faculty of Medicine Universitas Padjadjaran Dr. Hasan Sadikin General Hospital Bandung, Indonesia

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Corresponding Author:
Artha Wahyu Wardana
Hermina Daan Mogot Hospital
Jakarta Barat, Indonesia
E-mail:
arthaww@gmail.com

Abstract

Background: Elevated intracranial pressure (ICP) is a common complication after craniotomy, often causing decreased consciousness, ventilator dependence, and prolonged ICU stay. Invasive ICP monitoring carries risks, while non-invasive methods such as optic nerve sheath diameter (ONSD) measurement via ultrasonography offer a promising alternative. This study aimed to examine the correlation between ONSD and ICU length of stay (LOS) in post-craniotomy patients.

Methods: A prospective observational study was conducted at the ICU of Dr. Hasan Sadikin General Hospital, Bandung, from February to April 2024. Post-craniotomy patients admitted to the ICU were included. ONSD was measured 12–24 hours after ICU admission. Data collected included ONSD, demographics, preoperative clinical status, and ICU records. The relationship between ONSD and ICU LOS was analyzed using Pearson correlation and multivariable analysis.

Results: Thirty-three patients were included (mean age 48.2 years; 60.6% male). Median preoperative GCS was 10.8, and 54.5% were ASA III/IV. ONSD correlated positively with ICU LOS ($r = 0.636$, $p < 0.001$). Multivariable analysis showed that ONSD ≥ 5.0 mm was independently associated with prolonged ICU stay (≥7 days) after adjusting for GCS and postoperative complications.

Discussion: A larger ONSD, reflecting higher ICP, was moderately associated with longer ICU stay, suggesting that non-invasive ONSD measurement can serve as a useful marker for resource utilization. However, further studies with larger cohorts are needed to validate its predictive role.

Conclusion: ONSD measurement is a reliable non-invasive parameter that shows a significant correlation with ICU length of stay in post-craniotomy patients.

Keywords: Intracranial pressure, length of stay intensive care unit, optic nerve sheath diameter

Introduction

Intracranial pressure (ICP) monitoring is crucial in the management of post-craniotomy patients. ICP is a vital physiological parameter that aids in assessing cerebral status, diagnosing neurological complications, and ultimately improving patient outcomes following brain surgery. Furthermore, effective ICP monitoring provides essential information regarding the efficacy of surgical procedures and guides critical decisions on further interventions and therapeutic options in the Intensive Care Unit (ICU).[1]

In recent years, the need for non-invasive, repeatable, and accessible methods for ICP

assessment has led to the development of several alternative techniques. Measurement of the optical nerve sheath diameter (ONSD) using bedside ultrasonography (USG) has emerged as a promising tool for detecting intracranial hypertension. Extensive research has investigated the relationship between ONSD and elevated ICP. A study conducted in China demonstrated that ONSD measurements reflect real-time relative changes in ICP. This study found a strong positive correlation between ONSD and ICP variations in patients undergoing lumbar puncture, with 95% of subjects showing a decrease in ONSD corresponding to a reduction in cerebrospinal fluid pressure. Other studies have reported a sensitivity of 94% and a specificity of 96.08% for an ONSD cut-off value of ≥5.8 mm. The highest accuracy was observed at a cut-off of >0.58 cm in patients with positive CT scan findings. Consequently, ONSD serves as a viable screening tool for patients with suspected intracranial hypertension. Furthermore, a meta-analysis demonstrated excellent discriminative value with an AUROC of 0.94 for detecting elevated ICP via ONSD. Additionally, ONSD has been linked to a two-fold increase in hospital mortality. Linear regression analysis further indicates that ONSD is independently associated with increased ICP within the first 48 hours of hospital admission. The optic nerve sheath is continuous with the subarachnoid space, causing ICP fluctuations to directly transmit and distend the infraorbital portion of the sheath. Consequently, an increased ONSD is a widely accepted and reliable indicator of elevated ICP. The primary advantages of ONSD measurement include its non-invasive nature, portability, efficiency, and ease of performance.[2]

Timely identification of factors associated with a prolonged ICU length of stay (LOS) is essential for clinical decision-making, proper resource allocation, and identifying high-risk patients. Given that ONSD reflects ICP, and elevated ICP is known to worsen neurological outcomes, a potential link between ONSD and ICU LOS exists. While various studies have established the utility of ONSD in monitoring ICP and predicting outcomes in trauma and post-neurosurgery patients, the specific role of ONSD as an early predictor of ICU Length of Stay in post-craniotomy patients remains less explored. [3-4] Therefore, this study aims to investigate the correlation between ONSD measurement and ICU LOS in patients following craniotomy.[3–4]

Subjects and Methods

The study employed a prospective observational correlation design conducted at the Intensive Care Unit (ICU) of Dr. Hasan Sadikin General Hospital, Bandung, from February to April 2024. The study population comprised all post-craniotomy patients admitted to the ICU. Sampling utilized a consecutive sampling technique, enrolling all eligible patients until the calculated minimum sample size of 33 patients (accounting for a 10% dropout rate) was met. Inclusion criteria mandated ICU patients aged ≥18 years post-craniotomy, specifically those undergoing surgery for tumor, trauma, arteriovenous malformation (AVM), or hemorrhagic stroke. Exclusion criteria included patients unsuitable for Optical Nerve Sheath Diameter (ONSD) measurement due to local wounds or dressings, poor image quality, or the presence of co-morbidities (e.g., pneumonia, ARDS, shock) or pre-existing ocular conditions (e.g., optic neuritis, optic nerve glioma) that could independently affect ICU length of stay (LOS) or ONSD results. Patients who died during their ICU stay were categorized as dropouts.
Ethical approval for the protocol was secured from the Health Research Ethics Committee of Dr. Hasan Sadikin General Hospital (DP.04.03/D. XIV.6.5/137/2024). Written informed consent was obtained from all participants or their legally authorized representatives prior to enrollment. The research workflow involved performing the ONSD examination on admitted post-craniotomy patients 12–24 hours after ICU admission while the patient was clinically stable. The examination utilized

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a *GE Healthcare Logic F6* ultrasound machine and was conducted by a competent operator experienced in neurosonography. The ONSD was measured at least three times on each eyeball, and the largest recorded value was used for analysis. Following the ONSD measurement, the patient's ICU LOS (days from admission to discharge) was recorded. Data concerning ONSD, LOS, and standard ICU management protocols were meticulously documented in a dedicated Case Report File (CRF).

Data entry and statistical analysis were performed using IBM SPSS software version 22.0. Continuous data were tested for normality using the Shapiro-Wilk test. The correlation between ONSD and ICU LOS was analyzed using the Pearson product-moment test. To address potential confounding factors such as GCS and APACHE II scores, a multivariable linear regression model was employed to determine if ONSD remains an independent predictor of ICU LOS. Statistical significance was defined as a p-value <0.05.

Results

A total of 33 patients were included and analyzed in this study. Data collected encompassed ONSD measurements, ICU LOS, and details from pre-operative, pre-anesthetic, anesthesia, and ICU medical records.

The demographic and clinical characteristics of the study subjects are summarized in Table 1. The majority of participants were male (n=20, 60.6%), with a mean age of 48.2 years. The most common surgical indication was tumor (n=16, 48.5%), followed by CVA (n=9, 27.3%) and trauma (n=8, 24.2%). The most frequent operative procedure was craniotomy for hematoma evacuation (n=14, 42.4%). Regarding pre-operative status, 54.5% (n=18) of patients were classified as PS ASA III–IV. The mean APACHE II score upon admission was 12.7 and the mean Glasgow Coma Scale (GCS) score 24 hours post-operation was 10.8. Regarding complications, 66.7% (n=22) of patients were without ICU complications, while pneumonia (18.2%) was the most frequent complication observed.

The mean ONSD for all subjects was 5.67 mm, and the mean ICU LOS was 8.12 days. The correlation analysis between ONSD and ICU LOS, as detailed in Table 2 and visualized in the accompanying graph, showed a statistically significant positive correlation. The Pearson

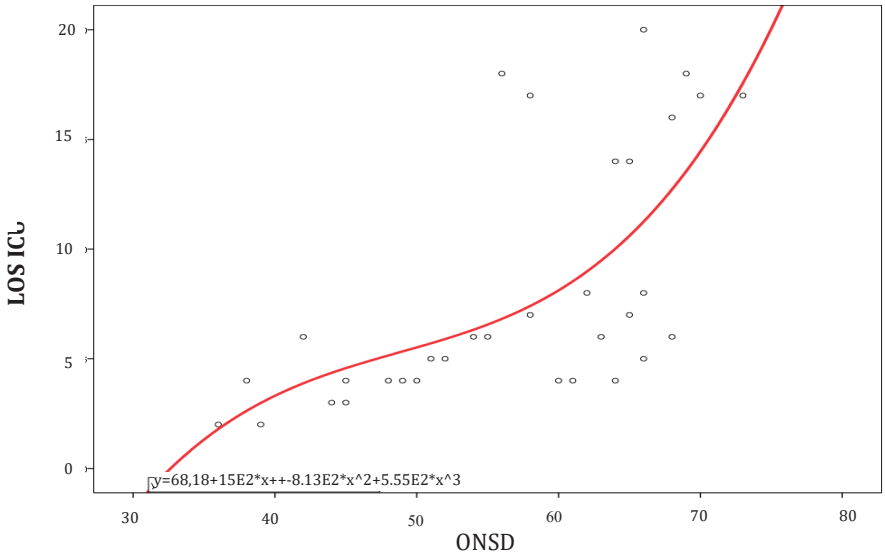

Figure 1 Scatter Plot Illustrating the Positive Correlation Between ONSD and LOS ICU in Post-Craniotomy Patients

Tabel 1 Characteristics of Study Subjects in Post-Craniotomy Patients

Characteristic	Frecuency n (%)	(mean ±SD)
Gender		
Male	20 (60.6)	
Female	13 (39.3)	
Age (years)		48,2 (±11,4)
Surgical indication		
Trauma	8 (24.2)	
Tumor	16 (48.5)	
CVA	9 (27.3)	
Type of operation		
Tumor craniotomy	12 (36.4)	
Hematoma evacuation craniotomy	14 (42.4)	
Decompressive cranectomy	3 (9.1)	
Transsphenoidal craniotomy	4 (12.1)	
PS ASA status		
PS ASA I-II	15 (45.5)	
PS ASA III-IV	18 (54.5)	
Skor APACHE II		12,7 (±3,8)
GCS 24 hours post-operation		10,8 (±2,9)
ICU care complication		
Withoutcomplication	22 (66.7)	
Pneumonia	6 (18.2)	
Sepsis	3 (9.1)	
ICU aquired weakness (ICU-AW)	2 (6.1)	

product-moment correlation coefficient was r=0.636, with a coefficient of determination r^2=0.404 (p <0.001). This indicates that ONSD has a moderately positive correlation with ICU LOS in post-craniotomy patients.

To evaluate the independent effect of ONSD on ICU LOS, we analyzed it alongside other clinical determinants (Table 3). While GCS≤8 and ICU complications were strongly associated with longer stays (p<0.001), ONSD≥5.0 mm remained a significant early predictor (p=0.009). This suggests that ONSD provides critical physiological information regarding intracranial pressure that can be assessed much earlier than the manifestation of secondary complications.

Tabel 2 Correlation of ONSD dengan Length Of ICU Length of Stay

Variable	Mean (±SD)	r	r^2	p-value
ONSD (mm)	5,67(±1.04)	0.636	0.404	<0,001
LOS ICU (days)	8,12(±5.65)			

Notes: *Uji Pearson product moment with p value <0.05

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Table 3 Analysis of Factors Associated with ICU Length of Stay (LOS)

Predictor Variable	Mean ICU LOS (Days)	p-value
ONSD Threshold		0.009
ONSD <5.0 mm	4.0±1.2	
ONSD ≥5.0 mm	9.8±6.2	
GCS 24 hours post op		<0.001
GCS >8	5.7±3.5	
GCS ≤8	14.7±5.2	
ICU Care complication		<0.001
Without complication	4.6±1.4	
With complications (pneumonia/sepsis/AW)	16.3±3.8	
PS ASA status		0.070
PS ASA I–II	4.8±1.9	
PS ASA III–IV	10.9±6.3	

Discussion

Intensive Care Unit Length of Stay (ICU LOS) is a critical parameter reflecting healthcare utilization and costs. Although various prognostic models have been employed in neurocritical patients, the factors directly influencing ICU LOS in this population remain largely underexplored. Monitoring and controlling intracranial pressure (ICP) is a pivotal component in neurocritical care management, yet its relationship with ICU LOS has not been fully elucidated. The identification of factors associated with prolonged ICU stay and insights into the ICP–LOS relationship are essential for risk stratification, clinical decision-making, and appropriate allocation of hospital resources.[4]

The mean APACHE II score 12,7±3,8 observed in this study subjects is relatively comparable to those reported in other brain surgery studies which are 16,56±5,95 and 13,68±4,34 for example. [5–6] The tendency towards a moderate APACHE II score can be explained by the fact that patients undergoing brain surgery, particularly elective procedures, are often in a more stable pre-operative physiological condition compared with patients undergoing brain surgery in an emergency setting. In this study, the mean ONSD was found to be 5,67±1,4 mm. This result contrasts with previous ONSD research reporting a mean ONSD of 4,4 ± 0,5 mm in the survival group.[7] This difference is likely due to population dissimilarities, as the previous study included ischemic stroke patients, who typically have lower ICP compared to post-craniotomy patients. [8]

Elevated ICP is the primary cause of secondary brain injury in patients with cerebral insults. Given that ONSD measurement demonstrates a positive correlation with standard invasive ICP measurement, ONSD serves as a valuable non-invasive tool for the early detection of ICP elevation. Currently, the need for non-invasive, repeatable, and accessible methods for ICP assessment has led to the development of several alternative techniques. Measurement of the ONSD using bedside USG has emerged as a promising tool for detecting intracranial hypertension. The ONSD measurement is practically useful in the setting where ICP monitoring is unavailable. [1, 9]

ONSD measurement has been proven to correlate positively (linearly) with standard invasive ICP measurements.[10] The finding of increased ICP in brain-injured patients frequently necessitates adjustments to therapeutic management, which may include surgical intervention, osmotic diuresis,

sedation, or cerebrospinal fluid drainage.[11, 12]

The principal finding of this study is the moderately positive correlation between ONSD and ICU LOS r=0,636, p<0,001). This indicates that elevated ONSD, which reflects higher ICP, is significantly associated with a prolonged recovery period and extended ICU stay. This result is consistent with the finding that ONSD measurement correlates positively (linearly) with standard invasive ICP measurement.[10] However, several prior studies reported that there was no significant association between ICP and ICU LOS p=0,468 dan 0,140).[11, 12]

This disparity can be accounted for by the inclusion of non-surviving patients in previous research; patients with extremely high ICP are at an elevated risk of early mortality, which can paradoxically shorten the calculated LOS. [11, 12] Conversely, sub-analyses of prior data align with our findings, demonstrating that survivors with low ICP experienced shorter ICU and hospital stays. [11, 12]

This research is further substantiated by the finding that patients with an ONSD ≥5,0 mm had a significantly increased risk (Relative Risk [RR]=3,75, p=0,009) of experiencing a prolonged ICU stay (≥7 days). The 5,0 mm threshold was selected because it reflects an increase in ICP ≥20 mmHg, a established clinical threshold. [13,14] The 7-day LOS cut-off was utilized due to its association with the increased risk of acquired ICU complications, such as infection, pneumonia, and ICU-Acquired Weakness (ICU-AW).[15] Our data affirm that ICU care complications significantly prolonged LOS (p <0,001), with patients diagnosed with ICU-AW exhibiting a mean LOS of 19,0 days, markedly longer than patients without complications (4.6 days).

The principal finding of this study is the moderately positive correlation between ONSD and ICU LOS (r=0.636, p<0.001), suggesting that elevated ICP, as reflected by ONSD, is a key determinant of resource utilization. Although patients with GCS ≤8 or those who developed pneumonia/sepsis had markedly longer stays, ONSD remains a superior early-warning tool. Our analysis demonstrated that 24-hour postoperative GCS and the presence of complications were significantly associated with ICU LOS. This is consistent with the pathophysiology of brain injury, where lower GCS scores often necessitate prolonged mechanical ventilation and intensive monitoring. Postoperative complications, such as infections or electrolyte imbalances, further delay recovery and extend resource utilization. Interestingly, ONSD remained a significant factor even after adjusting for these variables, suggesting that while clinical status and complications play major roles, the underlying intracranial pressure-as reflected by ONSD-provides additional objective data regarding the patient's neurological stability.

Furthermore, by shifting the analysis to a predictive framework, we established that an ONSD ≥5.0 mm is a significant predictor for prolonged stay (≥7 days). This reinforces the utility of ONSD not just as a monitoring tool, but as a triage instrument for hospital resource management.

Other established factors influencing ICU LOS in brain surgery patients include the size of the tumor, ASA physical status, pre-operative hydrocephalus, multiple procedures, intraoperative hypothermia, hyperglycemia, blood transfusion, intraoperative fluid management, duration of surgery, ICU admission time outside working hours, placement of external ventricular drainage (EVD), fever, hyperglycemia, and electrolyte disorders upon ICU admission.[17] Furthermore, various other literature sources indicate that predictive factors such as tumor severity score (assessed by midline location, mass effect, and midline shift), tumor type, diabetes, blood transfusion, advanced age, and re-exploration surgery are associated with prolonged ICU stay in post-craniotomy patients.[18–20]

Although some patients ultimately require intervention to manage airway compromise, the resulting prolonged ICU LOS due to acquired care complications was unavoidable. Consequently, the detection of post-operative ICP elevation is highly beneficial for evaluating the risk of ICU complications, allowing for the determination of early preventive measures such as airway management strategies and

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medical rehabilitation. Anesthesia and surgery duration also constitute predictors of ICU LOS in post-craniotomy patients.[21] Prolonged surgical duration may indicate a more invasive, difficult, or sophisticated procedure.[22] Extended operation and anesthesia duration are recognized as risk factors associated with delayed recovery.[23]

Furthermore, craniotomy lasting more than five hours is associated with post-operative pulmonary complications. This is consistent with previous research reporting that surgery exceeding six hours is a predictive factor for complications, mortality and ICU LOS.[24]

This study is subject to several limitations. First, as a single-center observational study, the generalizability of the findings may be restricted. Second, although ONSD is a reliable non-invasive proxy, the measurement was performed at a single time point (12–24 hours post-admission), which may not capture dynamic changes in ICP. Third, the relatively small sample size (n=33) limits the statistical power needed to detect weaker associations. Future research should explore serial ONSD measurements and their correlation with LOS. Furthermore, large-scale, prospective studies are warranted to validate the predictive value of the ONSD threshold (5.0 mm) for prolonged ICU LOS and to integrate these findings into standardized ICU protocols for risk stratification and resource management.

Conclusion

ONSD measurement exhibits a significant positive correlation with ICU LOS in post-craniotomy patients. An ONSD value ≥5.0mm significantly associated with prolonged ICU stays (≥7 days), independent of initial surgical indications.

AI Use Disclosure

Artificial intelligence (AI) tools (Gemini) were used to assist in language editing, and grammar correction during the preparation of this article. The authors have carefully reviewed and verified all content, and they take full responsibility for the accuracy, integrity, and originality of the final manuscript.

References

1. Nag DS, Sahu S, Swain A, Kant S. Intracranial pressure monitoring: Gold standard and recent innovations. World J Clin Cases. 2019;7(13):1535–46. doi:10.12998/wjcc.v7.i13.1535.
2. Ragland J, Lee K. Critical care management and monitoring of intracranial pressure. J Neurocrit Care. 2016;9(2):82–90. doi:10.18700/jnc.160101.
3. Kalim Z, Siddiqui OA, Nadeem A, Hasan M, Rashid H. Assessment of optic nerve sheath diameter and its postoperative regression among patients undergoing brain tumor resection in a tertiary care center. J Neurosci Rural Pract. 2022;13(2):221–7. doi:10.1055/s-0042-1744117.
4. Lazaridis C, Yang M, DeSantis SM, Luo ST, Robertson CS. Predictors of intensive care unit length of stay and intracranial pressure in severe traumatic brain injury. J Crit Care. 2015;30(6):1253–60. doi:10.1016/j.jcrc.2015.08.003.
5. Akavipat P, Thinkhamrop J, Thinkhamrop B, Sriraj W. Acute physiology and chronic health evaluation (APACHE) II score – the clinical predictor in neurosurgical intensive care unit. Acta Clin Croat. 2019;58(1):7–14. doi:10.20471/acc.2019.58.01.07.
6. Cardim D, Robba C, Bohdanowicz M, et al. Non-invasive monitoring of intracranial pressure using transcranial Doppler ultrasonography: Is it possible? Neurocrit Care. 2016;25(3):473–91. doi:10.1007/s12028-016-0258-6.
7. Lina Z, Qiuping H, Peijie H, Qi Z, Hui X, Ruilan W. Optic nerve sheath diameter and eyeball transverse diameter as a useful tool for the clinical prognosis in patients with stroke during hospitalization. Chin Crit Care Med. 2019;31(10):1052–8. doi:10.3760/cma.j.issn.2095-4352.2019.10.012.
8. Peeters W, van den Brande R, Polinder S, Brazinova A, Steyerberg EW, Lingsma HF,

et al. Epidemiology of traumatic brain injury in Europe. Acta Neurochir (Wien). 2015;157(10):1683–96. doi:10.1007/s00701-015-2512-7.
9. Avci Ozbalik B, Bingol Tanriverdi T, Ozcan HG, Gura Celik M. The clinical importance of optic nerve sheath diameter in patients with traumatic brain injury: Preliminary report. Medeni Med J. 2022;37(4):249–54. doi:10.4274/MMJ.galenos.2022.42966.
10. Maissan IM, Dirven PJAC, Haitsma IK, Hoeks SE, Gommers DI, Stolker RJ. Ultrasonographic measured optic nerve sheath diameter as an accurate and quick monitor for changes in intracranial pressure. J Neurosurg. 2015;123(3):743–8. doi:10.3171/2014.10.JNS141197.
11. Lazaridis C, Yang M, DeSantis SM, Luo ST, Robertson CS. Predictors of intensive care unit length of stay and intracranial pressure in severe traumatic brain injury. J Crit Care. 2015;30(6): 1258–62. doi: 10.1016/j.jcrc.2015.08.003
12. Zhang Y, Zhu S, Hu Y, Guo H, Zhang J, Hua T, et al. Correlation between early intracranial pressure and cerebral perfusion pressure with 28-day intensive care unit mortality in patients with hemorrhagic stroke. Eur Stroke J. 2024;27:648–57. doi:10.1177/23969873241232311.
13. Golshani K, Ebrahim Zadeh M, Farajzadegan Z, Khorvash F. Diagnostic accuracy of optic nerve ultrasonography and ophthalmoscopy in prediction of elevated intracranial pressure. Emerg (Tehran). 2015;3(2):53–9. doi:10.22037/emergency.v3i2.6105.
14. Trocha G, Bonilla A, Romero C, Palacios J, Molano-Gonzalez N. Ultrasound measurement of optic nerve sheath diameter in a healthy adult Colombian population. BMC Neurol. 2023;23(1):135. doi:10.1186/s12883-023-03062-4.
15. Loss SH, De Oliveira RP, Maccari JG, Savi A, Boniatti MM, Hetzel MP, et al. The reality of patients requiring prolonged mechanical ventilation: A multicenter study. Rev Bras Ter Intensiva. 2015;27(1):6–12. doi:10.5935/0103-507X.20150006.
16. Xu SS, Tian Y, Ma YJ, et al. Development of a prediction score for evaluation of extubation readiness in neurosurgical patients with mechanical ventilation. Anesthesiology. 2023;139:614–27. doi:10.1097/ALN.0000000000004721.
17. Sangtongjaraskul S, Lerdsirisopon S, Sae-Phua V, Kanta S, Kongkiattikul L. Factors influencing prolonged intensive care unit length of stay after craniotomy for intracranial tumor in children: A 10-year analysis from a university hospital. Indian J Crit Care Med. 2023;27(3):154–61. doi:10.5005/jp-journals-10071-24418.
18. Baalaaji M. Postoperative care of pediatric brain tumors: Let's work together. Indian J Crit Care Med. 2023;27(3):162–6. doi:10.5005/jp-journals-10071-24421.
19. Chu JK, Feroze AH, Collins K, McGrath LB, Young CC, Williams JR, et al. Variation in hospital charges in patients with external ventricular drains: Comparison between the intensive care and surgical floor settings. J Neurosurg Pediatr. 2019;24(1):29–37. doi:10.3171/2019.2.PEDS18545.
20. Mishra N, Rath GP, Rajagopalan V, Doddamani R, Chaturvedi A. Perioperative management of pediatric brain tumors: A retrospective analysis. Neurol India. 2022;70(3):721–7. doi:10.4103/0028-3886.349578.
21. Kayaalti S, Kayaalti O. Risk factors affecting the length of intensive care unit stay after brain tumor surgery. Indian Anaesth Forum. 2019;20(2):101–6. doi:10.4103/TheIAForum.TheIAForum_14_19.
22. Gaudet JG, Levy CS, Jakus L, et al. Early extubation after elective infratentorial craniotomy: Results of the international PRICE survey. J Neurosurg Anesthesiol. 2024;27(1):42–9. doi:10.1097/ANA.0000000000000894.
23. Misal U, Joshi S, Shaikh M. Delayed recovery from anesthesia: A postgraduate educational review. Anesth Essays Res. 2016;10(2):413–9. doi:10.4103/0259-1162.165506.
24. Hooda B, Chouhan RS, Rath GP, et al. Incidence and predictors of postoperative

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pulmonary complications in patients undergoing craniotomy and excision of posterior fossa tumor. J Anaesthesiol Clin Pharmacol. 2019;35(2):241–7. doi: 10.4103/joacp.JOACP_350_17.

25. Hooda B, Chouhan RS, Rath GP, et al. Incidence and predictors of postoperative pulmonary complications in patients undergoing craniotomy and excision of posterior fossa tumor. J Anaesthesiol Clin Pharmacol. 2019;35(2). doi: 10.4103/joacp.JOACP_350_17