

## POST-OPERATIVE PROTOCOL FOR BRAIN TUMOR SURGERY IN INTENSIVE CARE UNIT: A LITERATURE REVIEW

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### ABSTRACT

**Background:** Brain tumors represent a diverse group of neoplasms arising from intracranial tissues, posing significant clinical challenges and impacting public health globally. With primary brain tumors having an annual incidence of around 14 per 100,000 individuals and secondary brain tumors being even more prevalent, the burden on healthcare systems is substantial. Postoperative care, particularly in the intensive care unit (ICU), plays a crucial role in monitoring patients for early detection of complications and maintaining neurological and systemic homeostasis. This study aims to serve a literature review to examine post operative management in brain surgery operation in the ICU in literatures.

**Result and Discussion:** Protocols for ICU management post-brain tumor surgery are essential, with factors such as patient status, surgical site, and anticipated postoperative needs guiding decisions regarding ICU admission and monitoring. Neuroprotective strategies encompass physiological and pharmacological interventions aimed at mitigating adverse outcomes, with a multifaceted approach necessary for optimal neuroprotection.

**Conclusion:** A comprehensive understanding of the surgical and postoperative management of brain tumors along with the implementation of evidence-based protocols for ICU care are essential to improve patient outcomes and minimize complications. Continued advancements in surgical techniques, neuroprotective strategies, and critical care management are crucial in addressing the complex challenges posed by brain tumors and enhancing the quality of care for affected patients.

**Keyword:** Post-operative protocol, brain tumor surgery, intensive care unit

## INTRODUCTION

The fields of neurosurgery, neurooncology, neuroanesthesiology, and neurocritical care have shown significant advancements, but the morbidity and mortality rates of patients undergoing neurosurgery remain high. The patient profile undergoing neurosurgery varies from neonates to adults, and surgeries range from elective to emergent cases. Post-operative complications in neurooncology patients in the intensive care unit must be identified and managed appropriately.<sup>1,2</sup>

Postoperative management of neurosurgical patients involves prevention, early detection, and management of surgical complications. Close monitoring is required in the first 6-12 hours post-surgery as clinical deterioration is often the first sign of potential fatal complications. The primary goal of postoperative management is preventing secondary brain injury and maintaining major organ systems until the patient recovers from the primary issue.<sup>3,4</sup>

Major complications after intracranial surgery affect 13-27% of patients and can be neurological, hemodynamic, metabolic, or respiratory in nature.<sup>5</sup> These may include postoperative hematomas, cerebral edema, seizures, and minor events like postoperative nausea and vomiting, pain, and hyperglycemia. Following intracranial tumor surgery, admission to an intensive care unit (ICU) is common practice. ICU management during the postoperative period facilitates rapid detection of neurological deterioration and maintenance of systemic and neurological homeostasis.<sup>6,7</sup>

However, there can be correlating events where a moderate and treatable event may precede a more severe one, such as hypertension leading to postoperative hematoma. Acute physiological changes during anesthesia recovery such as sympathetic activation and increased cerebral blood flow may contribute to intracranial complications. Nevertheless, criteria for ICU admission post-surgery are unclear, considering the scarcity and expense of ICU resources, which may limit availability for emergency admissions. Careful patient selection for ICU admission post-surgery may help reduce hospital stays and costs.<sup>8,9</sup>

The impact of management strategies on patient outcomes remains uncertain. The utilization of ICU resources for postoperative care poses challenges due to their scarcity and cost, potentially limiting availability for emergency admissions and other neurosurgical procedures. Amidst constrained medical economics, traditional practices, including postoperative ICU management, are being scrutinized, with parallels drawn to changes seen in cardiac surgery practices.<sup>10</sup> This study aims to serve a literature review to examine post operative management in brain surgery operation in the ICU in literatures.

## METHODS

A systematic search was conducted across major electronic databases including PubMed, MEDLINE, Embase, and Google Scholar using keywords related to "post-operative protocol," "brain tumor surgery," and "intensive care unit." Additionally, reference lists of relevant articles and reviews were manually screened for additional studies.

Studies were included if they focused on post-operative protocols specifically for brain tumor surgery and their implementation in intensive care units. Articles written in English and published within the last 10 years were considered. Both quantitative and qualitative studies, including clinical trials, observational studies, systematic reviews, and meta-analyses, were eligible for inclusion. Studies not relevant to post-operative protocols for brain tumor surgery, protocols not implemented in the intensive care unit setting, and articles not available in English were excluded. Additionally, studies published more than 10 years ago and those lacking full-text availability were excluded.

Data extracted from selected studies included study design, sample size, patient demographics, post-operative protocols implemented, outcomes measured, and key findings related to protocol effectiveness and patient outcomes. Data were independently extracted by two reviewers and discrepancies were resolved through discussion. Findings from included studies were synthesized narratively, focusing on common themes related to post-operative protocols for brain tumor surgery in intensive care units. Key protocol components, variations in implementation, and reported outcomes were summarized.

## RESULT AND DISCUSSION

### Brain Tumor

Brain tumors are a group of neoplasms originating from intracranial tissues, including meninges (e.g., meningioma), exhibiting varying degrees of malignancy, ranging from benign to aggressive. Based on their tissue origin, brain tumors are divided into two types, namely primary and secondary brain tumor. Primary brain tumors originate from various intracranial tissues such as neurons, glial cells, astrocytes, and meninges. Secondary brain tumors are metastases from primary tumors elsewhere including solid aggressive tumors (such as lung cancer, breast cancer, melanoma, and kidney cancer) and hematologic malignancies (lymphoma, leukemia). Most primary and metastatic brain tumors are located in

the cerebral hemispheres. Gliomas, brain metastases, and convex meningiomas are the most commonly encountered types of brain tumors.<sup>1,11,12</sup>

Brain tumors pose a substantial clinical challenge, with newly diagnosed primary brain tumors having an annual incidence of around 14 per 100,000 individuals and a prevalence of 131 per 100,000. Secondary brain tumors, originating from metastases from other sites, are even more prevalent, comprising up to 170,000 cases annually in the USA alone. These statistics underscore the significant burden and impact of brain tumors on public health and healthcare systems globally.<sup>13</sup>

The posterior fossa is a common site for brain tumors and metastases, housing critical structures within the brain. Among the histopathological types frequently encountered in this region are acoustic neuroma, meningioma, glioma, ependymoma, and medulloblastoma. These tumors present unique challenges due to the complex anatomy of the posterior fossa and the presence of vital structures such as the brainstem, cranial nerve nuclei, and the reticular activating system. Surgical interventions in this area demand meticulous attention to avoid damaging these structures and to ensure optimal patient outcomes. Despite advancements in surgical techniques, postoperative complications remain a concern due to the narrow confines of the posterior fossa and the intricacies of the surrounding anatomy.<sup>14</sup>

A significant complication associated with tumors in the posterior fossa is the development of posterior fossa syndrome, particularly observed in pediatric patients with medulloblastoma. This syndrome manifests in 25%-40% of cases and can significantly impact patients' neurological function. Two distinct types of posterior fossa syndrome have been identified based on symptom severity. Type 1 presents with complete inability to speak, severe limitations in movement including walking, neurological deficits, abnormal eye movements, and involuntary movements. In contrast, Type 2 involves limited verbal ability and similar symptoms to Type 1 but with less severity. Managing posterior fossa syndrome poses a considerable challenge, requiring comprehensive rehabilitation strategies tailored to the individual patient's needs.<sup>14</sup>

Tumors occurring in the sellar region, such as pituitary adenoma, craniopharyngioma, and parasellar meningioma, present specific surgical challenges. The sellar region is anatomically intricate and poses difficulties in surgical access. However, advancements in endoscopic transsphenoidal techniques have improved surgical outcomes and reduced complications associated with accessing this region. Safe removal of tumors in the sellar region is generally more feasible for small to medium-sized tumors with specific growth patterns, such as infrasellar, laterosellar, and anterosellar. Conversely, large tumors that invade suprasellar structures pose greater surgical complexities and carry a higher risk of complications, including diencephalic damage and postoperative meningitis. Effective management of sellar region tumors requires a multidisciplinary approach involving neurosurgeons, endocrinologists, and other specialists to optimize patient outcomes and minimize postoperative morbidity.<sup>15,16</sup>

## **SURGICAL MANAGEMENT OF BRAIN TUMOR**

Brain tumor surgery involves a diverse array of pathologies and surgical techniques. Technological advancements have empowered neurosurgeons to safely and effectively operate on tumors located in various regions of the brain. However, the rapid pace of technological innovation has surpassed our capacity to rigorously evaluate whether these new techniques truly enhance patient outcomes. In elective cases, surgery allows for careful preoperative planning, including imaging studies to precisely locate the tumor, assess its size and relationship to surrounding structures, and formulate the surgical approach. This approach enables neurosurgeons to optimize surgical techniques and minimize the risk of complications during the procedure.<sup>17</sup>

Surgery plays a pivotal role in the treatment of brain tumors, serving as a primary therapeutic intervention to alleviate symptoms, achieve tumor removal, and potentially improve patient outcomes. While surgery is often planned as an elective procedure, there are circumstances where it becomes an emergency. Rapid deterioration may show up due to increased intracranial pressure. This pressure may result from the tumor's mass effect, causing compression of surrounding brain tissue and impeding normal cerebrospinal fluid circulation. Signs of increased intracranial pressure, such as severe headaches, neurological deficits, altered mental status, or signs of herniation may prompt immediate surgical intervention to relieve the pressure and prevent further neurological damage.<sup>18,19</sup>

Additionally emergency surgery may be required in cases of tumor-related hemorrhage or when the tumor causes obstructive hydrocephalus. Tumors located near blood vessels are prone to bleeding, leading to sudden neurological deterioration requiring urgent surgical evacuation of the hematoma. Similarly, tumors blocking the normal flow of cerebrospinal fluid within the ventricular system can lead to hydrocephalus, characterized by the accumulation of fluid within the brain's ventricles. Surgical placement of a shunt or endoscopic procedures to bypass the obstruction may be necessary to alleviate symptoms and prevent further complications.<sup>20</sup> Overall, while elective surgery allows for thorough preoperative planning and optimization, emergency surgery becomes essential in critical situations where prompt intervention is required to mitigate potentially life-threatening complications associated with brain tumors.<sup>18,21</sup>

## **INTENSIVE CARE MANAGEMENT POST BRAIN TUMOR SURGERY: IS IT NECESSARY?**

Postoperative complications following elective neurosurgical procedures are common during the early recovery period and encompass various issues such as respiratory events, pain, arterial hypertension, shivering, nausea, and vomiting. However, the incidence of severe complications necessitating ICU care is relatively low. Studies have reported that while all complications occurred in more than half of the patients overall, less than 6% experienced early neurologic complications. Notably, complications such as brain infarction, large subdural hematomas, and postoperative seizures have been documented within the first 24 hours after surgery in some cases.<sup>10,22</sup>

Postoperative intracranial hematoma is a common complication that occurs in a range between 0.8% and 2.2% of patients after elective brain surgery. Rates of neurologic events requiring possible intervention remain consistent with earlier findings. Interestingly, the time course of these complications plays a significant role in determining the optimal utilization of postoperative resources. Studies have shown that clinical deterioration typically occurs within a short timeframe post-surgery, with a majority of complications detected within the first few hours after craniotomy.<sup>10</sup>

In one study, nearly all postoperative events were identified within 2 hours of surgery, either in the operating room or in the post-anesthesia care unit (PACU). This underscores the importance of vigilant monitoring and prompt intervention in the immediate postoperative period to detect and address complications efficiently. Early detection and management of complications are crucial in optimizing patient outcomes and minimizing the need for active intervention, particularly in the ICU setting.<sup>10</sup>

ICU care during the postoperative period enables quick detection of neurological deterioration and helps maintain systemic and neurological homeostasis. Major complications following intracranial surgery affect 13-27% of patients and can manifest as neurological, hemodynamic, metabolic, or respiratory issues. Neurological complications, including postoperative hematomas, cerebral edema, and seizures, must be distinguished from minor events such as postoperative nausea and vomiting, pain, and hyperglycemia. There exists a potential relationship between these events, where a moderate and easily treatable event may precede a more severe one; for example, hypertension may lead to postoperative hematoma. Acute physiological changes during anesthesia recovery, such as sympathetic activation, increased cerebral blood flow and intracranial pressure, as well as shivering and coughing, may contribute to intracranial complications.<sup>23</sup>

## **PROTOCOL FOR INTENSIVE CARE MANAGEMENT POST BRAIN TUMOR SURGERY**

Monitoring and postoperative care decisions ideally should be determined during the preoperative period. The decision to manage patients in the ICU with mechanical ventilation or extubation in the operating room depends on several factors, which are preoperative patient status, surgical site, surgical factors such as bleeding and involvement of the brainstem, and anticipation of postoperative patient needs.<sup>1</sup>

Previous cohort study involving 358 patients admitted to the ICU after intracranial procedure identified predictors of postoperative complications, including failure of extubation in the operating room, duration of surgery exceeding 4 hours, and lateral positioning during surgery. Other risk factors such as advanced age, high anesthesia risk, prolonged surgery time, significant bleeding, and severe intraoperative complications are crucial considerations for patients upon ICU admission. Patients with posterior fossa tumors, large tumors regardless of location, sellar region tumors following transcranial resection, and those with risk factors indicate the need for ICU care after tumor resection.<sup>10</sup> Badenes, et al.<sup>24</sup> (2017) proposed a criteria for admission to ICU after elective craniotomy showed in Table 1. This admission criteria involved multiple factors in preoperative, intraoperative, and post operative state.

**Table 1. Proposed criteria for admission to ICU after elective craniotomy.<sup>24</sup>**

A preoperative	B intraoperative	C postoperative
ASA physical status: • >ASA 2 • >ASA 1 if any of B or C Karnofsky Index: - <70	Type of lesion: • Supratentorial: vascular tumours and malformations (AVM, aneurysms) • Infratentorial: any • Others if any of A or C Site of lesion: • Supratentorial: hypothalamic or thalamic • Infratentorial • Others if any of A or C	Major complications: • Radiological: rebleed, infarct/ischaemia, oedema, infection • Neurological: new focal deficit, deteriorating GCS, seizures, prolonged unconsciousness • Systemic: haemodynamic instability, worsening gas exchanges, electrolytes disturbances or any new or worsening organ or system dysfunction Minor complications: • All if any of A or B
Preoperative neurology: • GCS 14/15 • Fluctuating preoperative • Rapid progression of focal deficit • GCS 15 and no deficit but any of B or C	Surgery-related: • Intraoperative bleeding • Diabetes insipidus • Prolonged temporary clipping or permanent clipping of arteries • Intraoperative seizures (awake craniotomy) • Length of surgery >6h • None but any of A or C	Monitoring: • Tight blood pressure control • Tight glucose control • Seizures chart or continuous EEG monitoring • Close neurological observations • Invasive or noninvasive ventilation and gas exchange monitoring • None but any of A or B

ASA, Anaesthesiologists score; AVM, arteriovenous malformation; GCS, Glasgow Coma Scale.

### Monitoring After Elective Craniotomy

Neurosurgical patients are at risk of postoperative neurological complications and require specialized monitoring. A study comparing various assessment scales found that combined evaluation of pupils, Glasgow Coma Scale (GCS), Ramsay scale, Canadian Neurological Scale (CNS), Nursing Delirium Screening Scale (Nu-DESC), and bispectral index (BIS) improved early detection of postoperative neurological complications in the post-anesthesia care unit (PACU) after elective craniotomies.<sup>24</sup>

Clinical neuromonitoring postoperatively varies based on the surgery type but generally exhibits strength and sensitivity between 70 and 80%. However, there's significant variability in neurological monitoring practices due to the absence of guidelines, differing resources, and the surgical procedure's nature. Morning discharge huddles led by a neurosurgeon have been shown to reduce ICU days, laboratory costs, and pharmacy costs per patient while enhancing patient satisfaction. Interdisciplinary huddles facilitate communication and patient flow, resulting in substantial cost reductions and improved patient experiences. Additionally, clinical observation is deemed sufficient to predict early postoperative complications, and routine CT scans within 24 hours post-surgery are not recommended unless clinical deterioration occurs.<sup>24</sup>

### Physiological Neuroprotective Strategies

Physiological neuroprotective strategies in neurosurgery focus on monitoring and controlling blood pressure, cerebral oxygenation, and core body temperature to mitigate adverse outcomes. Maintaining adequate cerebral perfusion pressure (CPP) is crucial, as reduced CPP in patients with elevated intracranial pressure (ICP) correlates with poor prognosis. ICP control is vital to prevent decreased cerebral blood flow and subsequent ischemia, particularly in conditions like stroke and head injury. Reperfusion therapies, though beneficial in some cases of acute stroke, can lead to hemorrhagic transformation and increased bleeding. Elevated glucose levels pre- and post-ischemic events exacerbate neurological outcomes.<sup>25</sup>

### Neuroprotective Pharmacological Strategies

Neuroprotective pharmacological strategies encompass various drugs targeting neuronal cell death pathways. Nimodipine has shown efficacy in subarachnoid hemorrhage but lacks proven neuroprotective effects in head injury or stroke. Glutamate receptor antagonists are implicated in ischemic neuronal death, while free radicals like tirilazad mesylate have yielded inconclusive results in clinical trials.<sup>26</sup>

Erythropoietin demonstrates neuroprotective effects through its antiapoptotic, antioxidant, and anti-inflammatory actions. Statins reduce morbidity and mortality in stroke and cardiovascular events. Hypnotics like propofol and barbiturates may benefit severe traumatic brain injury (TBI) patients by reducing intracranial pressure.<sup>27</sup>

Mechanical ventilation strategies focus on preventing pulmonary complications in brain injury patients, while kinetic therapy enhances cerebral oxygenation and prevents atelectasis. Magnesium shows promise in vasospasm following subarachnoid hemorrhage. Antibiotic prophylaxis in neurosurgery aims to mitigate postsurgical infections, but optimal regimens remain uncertain.<sup>28</sup>



Managing cerebral edema, whether from tumors or trauma, involves various approaches including maintaining CPP within a certain range and avoiding aggressive therapies like osmotherapy and active cooling. Overall, a multifaceted approach combining physiological and pharmacological strategies is essential for neuroprotection in neurosurgical patients.<sup>29</sup>

Patients with primary brain diseases or injuries constitute a particularly vulnerable subgroup in critical care settings. Their condition along with the intensive care environment can disrupt sleep patterns. Recent studies have shown that even when not sedated, these patients may not exhibit typical sleep patterns observed in healthy individuals. Assessing sleep in such patients is challenging, and efforts to develop new sleep classifications have encountered difficulties. Sedatives, medications, and severe illness can further alter brain activity, making it challenging to identify normal sleep patterns and phenomena in these patients.<sup>30</sup>

## CONCLUSION

A comprehensive understanding of the surgical and postoperative management of brain tumors along with the implementation of evidence-based protocols for ICU care are essential to improve patient outcomes and minimize complications. Continued advancements in surgical techniques, neuroprotective strategies, and critical care management are crucial in addressing the complex challenges posed by brain tumors and enhancing the quality of care for affected patients.

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