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## **TRAUMATIC BRAIN INJURY: NEUROSURGICAL DECISION-MAKING AND INTRACRANIAL PRESSURE MONITORING IN CRITICAL CARE**

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### **NARRATIVE LITERATURE REVIEW**

#### **ABSTRACT**

Traumatic brain injury (TBI) remains a major cause of morbidity and mortality worldwide and requires complex decision-making in critical care. This narrative review analyzes current updates in neurosurgical management and intracranial pressure (ICP) monitoring in moderate and severe TBI. A literature review was conducted using PubMed, Scopus, Web of Science, and SciELO databases (2015–2026), focusing on clinical trials, observational studies, guidelines, and relevant reviews addressing neurosurgical interventions and neurocritical monitoring strategies. Contemporary TBI management prioritizes prevention of secondary brain injury through physiology-guided treatment. Continuous ICP monitoring plays a central role in guiding stepwise therapeutic interventions, including sedation optimization, ventilation control, osmotherapy, and hemodynamic adjustments aimed at maintaining cerebral perfusion pressure. Decompressive craniectomy remains an important option for refractory intracranial hypertension, demonstrating mortality reduction in selected patients, although functional outcomes remain heterogeneous and dependent on baseline prognosis and timing of intervention. The incorporation of multimodal neuromonitoring, including brain tissue oxygenation, microdialysis, and autoregulation assessment, has shifted neurocritical care from a reactive to a preventive approach, enabling earlier detection of cerebral hypoperfusion and metabolic distress. However, challenges persist regarding interpretation of monitoring data, definition of surgical timing, and availability of specialized resources. Overall, optimal management of TBI depends on integration of clinical evaluation, imaging findings, and physiological monitoring, supported by structured protocols and trained multidisciplinary teams.



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**Keywords:** traumatic brain injury; intracranial pressure monitoring; decompressive craniectomy; neurocritical care.

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## **1 INTRODUCTION**

Traumatic brain injury (TBI) represents one of the leading causes of morbidity and mortality worldwide, particularly among young adults, constituting a significant public health concern. It is characterized by structural lesions or functional alterations of the brain resulting from external forces, ranging from mild concussions to severe injuries with immediate risk of death. Beyond its impact on mortality, TBI is associated with a high burden of permanent disability, cognitive impairment, and behavioral changes, significantly affecting patients' quality of life and the healthcare system (Maas *et al.*, 2017).

The management of severe TBI is based on the prevention of secondary brain injury, a phenomenon related to hypoxia, hypotension, metabolic disturbances, and especially intracranial hypertension. In this context, standardized care protocols and clinical neuroprotective therapies represent the cornerstones of initial treatment (Carney *et al.*, 2017). Nevertheless, a considerable proportion of patients develops progressive neurological deterioration, requiring neurosurgical interventions and advanced monitoring strategies. The heterogeneity of lesions and the unpredictability of clinical progression continue to pose challenges to therapeutic decision-making (Aiolfi *et al.*, 2017).

In recent decades, technological advances have expanded the possibilities for pathophysiological assessment of the injured brain. Continuous intracranial pressure monitoring, combined with multimodal methods, has enabled earlier and more individualized interventions, while neurosurgical techniques have evolved with the aim of controlling refractory intracranial hypertension and preserving cerebral perfusion (Hutchinson *et al.*, 2016; Hutchinson *et al.*, 2019). However, controversies remain regarding indications, optimal timing of interventions, and the true impact of these strategies on clinical outcomes.

Given this context, this narrative review aims to analyze current updates in the neurosurgical approach and intracranial pressure monitoring in the management of traumatic brain injury, discussing their implications for clinical decision-making and the care of critically ill patients.

## **2 METHOD**

This study is characterized as a narrative literature review, a methodological approach appropriate for integrating and critically discussing heterogeneous evidence related to the clinical and surgical management of complex conditions. In the context of traumatic brain injury, this strategy allows the integration of clinical studies, international guidelines, systematic reviews, and observational research, enabling a practice-oriented understanding of care, particularly given the variability in clinical presentations, criteria for neurosurgical intervention, and different modalities of neurological monitoring (Ferrari, 2015).

The review was conducted based on the PICO strategy: Population (P) – adult patients with moderate or severe traumatic brain injury; Interest (I) – neurosurgical approach and intracranial pressure monitoring, including invasive and multimodal methods; Context (Co) – management in intensive care and neurological emergency settings, focusing on the prevention of secondary brain injury and clinical outcomes. From this structure, the following guiding question was formulated: what are the current updates in the neurosurgical approach and intracranial pressure monitoring in the management of traumatic brain injury? The PICO strategy is widely used in formulating questions in clinical reviews oriented toward healthcare practice (Aromataris; Munn, 2020).

The literature search prioritized publications from 2015 to 2026 in the PubMed, Scopus, Web of Science, and SciELO databases, combining controlled descriptors and free terms (traumatic brain injury; intracranial pressure monitoring; decompressive craniectomy; neurosurgical management; neurocritical care). Articles in English, Portuguese, and Spanish were included, encompassing clinical trials, observational studies, guidelines, and relevant reviews. Editorials, isolated case reports, duplicates, and studies not directly related to therapeutic decision-making were excluded. After critical appraisal, the selected studies were organized into thematic axes for narrative synthesis.

## **3 RESULTS**

The analyzed literature demonstrates that contemporary management of

traumatic brain injury has prioritized strategies aimed at preventing secondary brain injury, with intracranial pressure monitoring highlighted as a central tool in therapeutic decision-making (Carney *et al.*, 2017; Denchev *et al.*, 2023). Observational studies and international guidelines indicate that persistently elevated intracranial pressure values are associated with worse neurological prognosis, higher mortality, and longer hospital stays (Carney *et al.*, 2017; Cnossen *et al.*, 2017). In this context, the use of invasive monitoring devices, particularly ventricular catheters and intraparenchymal sensors, has come to guide stepwise interventions, including optimized sedation, ventilatory control, osmotherapy, and hemodynamic adjustments aimed at maintaining cerebral perfusion pressure (Carney *et al.*, 2017; Denchev *et al.*, 2023).

Concurrently, the neurosurgical approach has evolved with refinement of the indications for decompressive procedures, particularly decompressive craniectomy in cases of intracranial hypertension refractory to clinical treatment (Carney *et al.*, 2017; Denchev *et al.*, 2023). In addition, the incorporation of multimodal monitoring strategies, including cerebral oximetry, microdialysis, and continuous assessment of cerebral autoregulation, has contributed to more individualized therapeutic decisions (O'Donnell *et al.*, 2023). These methods enable early identification of hypoperfusion and cerebral metabolic distress, expanding the opportunity for intervention before irreversible neurological deterioration. The synthesis of the main thematic axes identified in the literature is presented in the table below.

**Table 1.** Summary of Evidence on Neurosurgical Management and Intracranial Pressure Monitoring in Traumatic Brain Injury

<b>Thematic Axis / Therapeutic Modality</b>	<b>Main Findings (Clinical Impact and Physiological Rationale)</b>	<b>Key Evidence (Author, Year)</b>
<b>Prevention of Secondary Brain Injury</b>	Contemporary TBI management prioritizes physiology-guided strategies aimed at preventing hypoxia, hypotension, metabolic dysfunction, and intracranial hypertension, reducing secondary cerebral damage.	Maas <i>et al.</i> , 2017; Carney <i>et al.</i> , 2017
<b>Intracranial Pressure (ICP) Monitoring as Central Strategy</b>	Continuous ICP monitoring guides stepwise interventions, including sedation optimization, ventilatory control, osmotherapy, and hemodynamic adjustments to maintain cerebral perfusion pressure (CPP).	Carney <i>et al.</i> , 2017; Denchev <i>et al.</i> , 2023
<b>Association Between Elevated ICP and Outcomes</b>	Persistently elevated ICP values are associated with worse neurological prognosis, increased mortality, and prolonged hospitalization.	Cnossen <i>et al.</i> , 2017; Carney <i>et al.</i> , 2017

<b>Invasive Monitoring Devices (EVD and Intraparenchymal Sensors)</b>	Ventricular catheters and intraparenchymal probes allow real-time monitoring and therapeutic CSF drainage, supporting targeted treatment decisions in neurocritical care.	Carney <i>et al.</i> , 2017; Zoerle, 2024
<b>Decompressive Craniectomy for Refractory ICP</b>	Decompressive craniectomy reduces mortality in selected patients with refractory intracranial hypertension; however, functional outcomes vary and require individualized decision-making.	Hutchinson <i>et al.</i> , 2016; Hutchinson <i>et al.</i> , 2019; Cooper <i>et al.</i> , 2020
<b>Timing of Neurosurgical Intervention</b>	Optimal timing remains controversial; decisions increasingly rely on physiological trends (ICP and CPP dynamics) rather than isolated imaging findings.	Carney <i>et al.</i> , 2017; Abdollahifard <i>et al.</i> , 2025
<b>Multimodal Neuromonitoring</b>	Brain tissue oxygen monitoring (PbtO <sub>2</sub> ), microdialysis, autoregulation indices, and cerebral oximetry enable earlier detection of hypoperfusion and metabolic distress, supporting preventive neuroprotection strategies.	Taccone, 2023; O'Donnell <i>et al.</i> , 2023; Bögli <i>et al.</i> , 2025
<b>High-Resolution Data Integration and Advanced Monitoring</b>	Integration of multimodal data and high-resolution analytics improves interpretation of complex physiological signals, although definitive impact on long-term outcomes is still under investigation.	Magnussen <i>et al.</i> , 2025; Sun <i>et al.</i> , 2026
<b>Protocolization and Multidisciplinary Care</b>	Effective implementation of neurosurgical and monitoring strategies requires structured institutional protocols, trained teams, and integration among intensivists and neurosurgeons.	Carney <i>et al.</i> , 2017; Denchev <i>et al.</i> , 2023
<b>Shift from Reactive to Preventive Neurocritical Care</b>	Neurocritical care is evolving from a reactive response model to a preventive, physiology-driven approach focused on preserving cerebral function and minimizing long-term disability.	Taccone, 2023; Zoerle, 2024

Source: Elaborated by the authors based on the analyzed literature (2015–2026).

#### 4. DISCUSSION

The analysis of the literature demonstrates that the management of traumatic brain injury has evolved from an approach predominantly based on clinical parameters to a physiologically oriented model centered on the prevention of secondary brain injury (Carney *et al.*, 2017; Taccone, 2023). In this context, the integration of intracranial pressure monitoring and neurosurgical interventions has become a fundamental decision-making component in the care of critically ill patients (Zoerle, 2024; Sun *et al.*, 2026). However, despite technological advances, controversies persist regarding indications, optimal timing of interventions, and long-term functional impact, reinforcing the need for individualized assessment and context-adapted protocols (Hutchinson *et al.*, 2016).

#### **4.1 Neurosurgical approach and control of intracranial hypertension**

Decompressive craniectomy remains a key strategy for controlling refractory intracranial hypertension, with evidence of reduced mortality in selected patients; however, functional outcomes vary across cohorts and trials, requiring individualized discussion regarding prognosis and post-survival quality of life (Hutchinson *et al.*, 2016; Hutchinson *et al.*, 2019). Follow-up studies emphasize that surgical decision-making should consider not only immediate survival but also potential functional dependency outcomes, guiding the judicious use of the technique in experienced centers with structured rehabilitation pathways (Cooper *et al.*, 2020; Thamilmaran, 2026).

The timing of intervention remains a central issue: very early procedures may expose recoverable patients to unnecessary surgical risks, whereas delayed surgical response may allow irreversible ischemic injury due to prolonged intracranial hypertension. Consequently, decision-making has shifted toward a model integrating physiological trends (e.g., ICP curves and cerebral perfusion pressure) with clinical and imaging data, enabling more precise and contextualized decisions (Carney *et al.*, 2017; Abdollahifard *et al.*, 2025).

Beyond craniectomy, procedures such as external ventricular drainage maintain both therapeutic and diagnostic roles, allowing immediate control of intracranial pressure and access to monitoring (e.g., fluid sampling and pressure reduction via drainage). The choice between EVD, intraparenchymal sensors, and other modalities depends on anatomical factors, infection risk, monitoring objectives, and institutional expertise; therefore, protocols and training are essential (Zoerle, 2024; Magnussen *et al.*, 2025).

#### **4.2 Intracranial pressure monitoring and neurocritical care**

Intracranial pressure monitoring has consolidated its role as a central axis in the management of severe TBI, enabling targeted and individualized interventions (Carney *et al.*, 2017). The emphasis has shifted from isolated absolute values to the interpretation of ICP temporal dynamics and its relationship with cerebral perfusion pressure, allowing physiology-guided therapeutic adjustments (TACcone, 2023; Zoerle, 2024).

The incorporation of multimodal monitoring, including brain tissue oxygen partial



pressure (PbtO<sub>2</sub>), cerebral oximetry, microdialysis, and autoregulation indices, has expanded the ability to identify hypoperfusion and metabolic dysfunction before sustained ICP elevation, creating windows for early neuroprotective interventions (TACcone, 2023; Bögli *et al.*, 2025). Recent trials and reviews have also investigated high-resolution integration and data-assisted algorithms to interpret complex signals, although evidence regarding definitive impact on global outcomes is still evolving (Magnussen *et al.*, 2025; Sun *et al.*, 2026).

From a care delivery perspective, the adoption of advanced technologies requires trained teams, clinical governance, and robust protocols to avoid misinterpretation and unnecessary interventions. Standardized protocols, integration among clinicians, neurosurgeons, and physiologists, and quality systems are essential to transform monitoring signals into decisions that effectively improve outcomes (Carney *et al.*, 2017).

## **5 CONCLUSION**

Recent advances in the management of traumatic brain injury reinforce the importance of a pathophysiology-oriented approach, in which the integration of neurosurgical interventions and intracranial pressure monitoring constitutes a central component of treatment. Evidence indicates that the use of stepwise strategies, combined with continuous assessment of cerebral perfusion, contributes to improved control of intracranial hypertension and reduced mortality in selected patients.

Beyond its impact on immediate clinical outcomes, the incorporation of advanced monitoring methods enables greater therapeutic individualization, allowing earlier and more targeted interventions. In this context, neurocritical care shifts from a reactive response to neurological deterioration toward a preventive model focused on preserving brain function and reducing functional sequelae.

However, challenges remain regarding the definition of the optimal timing of surgical interventions, the integrated interpretation of multimodal parameters, and the availability of specialized resources. Thus, the consolidation of these strategies depends not only on technological advances but also on well-structured care protocols and trained teams, and further studies are needed to refine indication criteria and long-term



functional impact.

## REFERENCES

ABDOLLAHIFARD, S. *et al.* Timing of intracranial pressure monitoring in traumatic brain injury: a systematic review and meta-analysis. **Clinical Neurology and Neurosurgery**, 2025. Available at: <https://www.sciencedirect.com>. Accessed on: Feb 10, 2026.

AIOLFI, A. *et al.* Brain Trauma Foundation guidelines for intracranial pressure monitoring: compliance and effect on outcome. **World Journal of Surgery**, v. 41, n. 6, p. 1543-1549, 2017. Available at: <https://doi.org/10.1007/s00268-017-3898-6>. Accessed on: Feb 10, 2026.

AROMATARIS, E.; MUNN, Z. (Eds.). JBI Manual for Evidence Synthesis. Adelaide: **Joanna Briggs Institute**, 2020. Available at: <https://synthesismanual.jbi.global>. Accessed on: Jan 10, 2026.

BÖGLI, S. Y. *et al.* Unlocking the potential of high-resolution multimodality neuromonitoring for traumatic brain injury management: lessons and insights. **Critical Care**, v. 29, 2025. Available at: <https://doi.org/10.1186/s13054-025-05360-4>. Accessed on: Feb 11, 2026.

CARNEY, N. *et al.* Guidelines for the management of severe traumatic brain injury, fourth edition. **Neurosurgery**, v. 80, n. 1, p. 6-15, 2017. Available at: <https://doi.org/10.1227/NEU.0000000000001432>. Accessed on: Feb 12, 2026.

CNOSSEN, M. C. *et al.* Variation in monitoring and treatment policies for intracranial hypertension in traumatic brain injury: a survey in 66 neurotrauma centers participating in the CENTER-TBI study. **Critical Care**, v. 21, p. 233, 2017. Available at: <https://doi.org/10.1186/s13054-017-1816-9>. Accessed on: Feb 11, 2026.

COOPER, D. J. *et al.* Patient outcomes at twelve months after early decompressive craniectomy for traumatic brain injury. **Journal of Neurotrauma**, 2020. Available at: <https://www.liebertpub.com>. Accessed on: Feb 12, 2026.

DENCHEV, K. *et al.* Traumatic brain injury: intraoperative management and intensive care unit multimodality monitoring. **Anesthesiology Clinics**, v. 41, n. 1, p. 39-78, 2023. Available at: <https://doi.org/10.1016/j.anclin.2022.11.003>. Accessed on: Feb 13, 2026.

FERRARI, R. Writing narrative style literature reviews. **Medical Writing**, v. 24, n. 4, p. 230-235, 2015.

HUTCHINSON, P. J. *et al.* Trial of decompressive craniectomy for traumatic intracranial hypertension. **New England Journal of Medicine**, v. 375, n. 12, p. 1119-1130, 2016. Available at: <https://doi.org/10.1056/NEJMoa1605215>. Accessed on: Feb 10, 2026.

HUTCHINSON, P. J. *et al.* Consensus statement from the International Consensus Meeting on the role of decompressive craniectomy in the management of traumatic brain injury. **Acta Neurochirurgica**, v. 161, p. 1261-1274, 2019.

HUTCHINSON, P. J. *et al.* Decompressive craniectomy for traumatic intracranial hypertension: long-term outcomes of the RESCUEIcp trial. **The Lancet Neurology**, v. 18, n. 7, p. 634-642, 2019. Available at: [https://doi.org/10.1016/S1474-4422\(19\)30195-3](https://doi.org/10.1016/S1474-4422(19)30195-3). Accessed on: Feb 12, 2026.



MAGNUSSEN, A. S. *et al.* Multimodal neuromonitoring in the Nordic countries: implementation and outcomes. **Acta Neurochirurgica Supplement**, 2025. Available at: <https://vbn.aau.dk>. Accessed on: Feb 12, 2026.

MAAS, A. I. R. *et al.* Traumatic brain injury: integrated approaches to improve prevention, clinical care, and research. **The Lancet Neurology**, v. 16, n. 12, p. 987-1048, 2017.

O'DONNELL, J. C. *et al.* Multimodal neuromonitoring and neurocritical care in brain trauma research. **Biomedicines**, v. 11, n. 5, p. 1336, 2023. Available at: <https://doi.org/10.3390/biomedicines11051336>. Accessed on: Feb 12, 2026.

SUN, X. *et al.* Evaluation of intracranial pressure in patients with severe brain injury: quantitative CEUS and other methods. **Neurocritical Care**, 2026. Available at: <https://doi.org/10.1007/s12028-026-02447-w>. Accessed on: Feb 11, 2026.

TACCONE, F. S. Multimodal neuromonitoring in traumatic brain injury patients: the search for the holy grail. **Annals of Intensive Care**, 2023. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10577936>. Accessed on: Feb 10, 2026.

THAMILMARAN, A. Optimal timing of cranioplasty post-decompressive craniectomy and long-term outcomes. **Journal of Neurosurgery/Neurotrauma Supplements**, 2026. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC12789150>. Accessed on: Feb 12, 2026.

ZOERLE, T. Intracranial pressure monitoring in adult patients with severe traumatic brain injury: indications and controversies. **Neuroscience Reviews**, 2024. Available at: <https://www.sciencedirect.com>. Accessed on: Feb 12, 2026.