Hyperosmolar Resuscitation in Severe Traumatic Brain Injury: Comparative Insights into Mannitol and Hypertonic Saline

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Abstract. Severe traumatic brain injury (sTBI) is a significant neurocritical condition associated with elevated morbidity and death rates stemming from heightened intracranial pressure (ICP) and the onset of secondary brain injury. Hyperosmolar resuscitation has emerged as a principal approach for managing ICP, with mannitol and hypertonic saline (HTS) being the predominant medications utilised in contemporary neurocritical care. This paper aims to evaluate the efficacy and safety of mannitol in comparison to hypertonic saline for patients suffering from severe traumatic brain injury, grounded in the most recent evidence and clinical protocols. The research utilised a systematic literature review methodology adhering to PRISMA criteria, with literature searches performed in the PubMed, Scopus, and Cochrane Library databases, encompassing papers from 2020 to 2026. The examined literature encompassed randomised controlled trials, cohort studies, systematic reviews, meta-analyses, and neurocritical care protocols pertaining to hyperosmolar treatment in severe traumatic brain injury. The compilation of evidence indicated that both agents were successful in lowering ICP; nevertheless, hypertonic saline generally exhibited a quicker onset of ICP reduction, a prolonged duration of ICP management, and superior preservation of cerebral perfusion pressure and haemodynamic stability relative to mannitol. Mannitol continues to be an efficient acute osmotherapy drug; however, it is increasingly linked to the hazards of hypotension, hypovolaemia, and renal impairment. This evaluation emphasises that the choice of hyperosmolar treatment must be tailored according to haemodynamic parameters, cerebral perfusion status, and patient safety considerations to enhance neurocritical care in cases of severe traumatic brain injury.

Keywords: Severe traumatic brain injury, mannitol, hypertonic saline.

1 Introduction

Traumatic brain injury (TBI) continues to be a significant global health issue, characterised by elevated morbidity and mortality rates, especially in young and economically active individuals. This disorder significantly influences fatalities associated with trauma and ranks as a primary contributor to enduring brain impairments globally. Severe traumatic brain injury (sTBI) is the most critical type of TBI, marked by significant

© The Author(s) 2026
F. Maulina and S. Wahyuni (eds.), *Proceedings of the 3rd Malikussaleh International Conference on Health and Disaster Medicine (MICOHEDMED 2026)*, Advances in Health Sciences Research 97,
https://doi.org/10.2991/978-94-6239-836-8_13

loss of consciousness, advancing neurological decline, and a heightened likelihood of neurocritical issues, including cerebral oedema, compromised cerebral autoregulation, brain tissue hypoxia, and increased intracranial pressure (ICP). Unregulated increases in intracranial pressure (ICP) may result in diminished cerebral perfusion pressure (CPP), subsequent cerebral ischaemia, brain herniation, and fatality if not addressed swiftly and correctly. In contemporary neurocritical care, the regulation of intracranial pressure (ICP) has emerged as a crucial element in the therapy of severe traumatic brain injury (sTBI), as it is closely linked to neurological outcomes and patient survival.

Recent epidemiological data indicate that the global burden of TBI continues to increase due to traffic accidents, occupational injuries, interpersonal violence, and sports-related trauma. Consequently, optimising neuroresuscitation strategies has become a critical priority in contemporary critical care services [1]. Furthermore, recent guidelines emphasise that effective ICP management is an essential component in preventing secondary brain injury among patients with severe neurotrauma [2]. A recent multicenter study also demonstrated that persistent ICP elevation is strongly associated with increased mortality and poor neurological outcomes in patients with severe TBI [3].

Hyperosmolar resuscitation therapy is the primary strategy used to control elevated intracranial pressure in severe traumatic brain injury. The principle of this therapy is to increase plasma osmolarity, thereby promoting the movement of fluid from cerebral tissue into the intravascular compartment through an osmotic gradient. This mechanism reduces cerebral oedema and intracranial pressure. Mannitol has long been considered the standard hyperosmolar agent in neurotrauma management because of its ability to reduce blood viscosity and improve cerebral blood flow. However, mannitol use has also been associated with several complications, including excessive osmotic diuresis, hypotension, hypovolaemia, electrolyte disturbances, acute kidney injury, and rebound intracranial hypertension in the setting of blood-brain barrier disruption [4].

In recent years, HTS has increasingly been utilised as an alternative and, in some cases, a preferred therapy because it can reduce ICP without causing excessive diuresis and may be more effective in maintaining haemodynamic stability and cerebral perfusion pressure [5]. Although numerous studies have demonstrated the effectiveness of HTS in ICP control, evidence regarding its superiority over mannitol in reducing mortality and improving long-term neurological outcomes remains heterogeneous [6]. Variations in solution concentration, treatment regimens, patient characteristics, and study designs have contributed to the lack of a definitive consensus regarding the optimal hyperosmolar agent for severe TBI [7]. Therefore, a comprehensive systematic review remains necessary to evaluate the effectiveness and safety of both agents based on the latest evidence and current neurocritical care guidelines.

The concept of hyperosmolar therapy in severe traumatic brain injury is closely linked to several major theoretical frameworks in neurocritical care, including the Monro–Kellie doctrine, cerebral perfusion theory, pathophysiology of intracranial hypertension, and osmotherapy. The Monro–Kellie doctrine states that the intracranial cavity has a fixed volume consisting of brain tissue, blood, and cerebrospinal fluid; therefore, an increase in one component without adequate compensation results in elevated intracranial pressure [8]. In severe TBI, cerebral oedema and impaired vascular

autoregulation increase intracranial volume, subsequently reducing CPP and triggering secondary brain injury.

According to cerebral perfusion theory, maintaining adequate cerebral perfusion pressure (CPP) is crucial for preserving cerebral oxygenation and preventing cerebral ischaemia [9]. In this context, osmotherapy with either mannitol or HTS aims to reduce cerebral oedema through osmotic mechanisms while preserving cerebral perfusion and haemodynamic stability in neurocritical patients [10]. Beyond their osmotic effects, hypertonic saline solutions have also been reported to exert immunomodulatory and anti-inflammatory properties that may contribute to reducing secondary brain injury in severe TBI [11]. The integration of these concepts provides an important theoretical foundation for understanding the effectiveness of hyperosmolar therapy in the modern management of severe neurotrauma.

Based on these considerations, this systematic literature review was conducted to analyse the effectiveness and safety of mannitol compared with hypertonic saline as hyperosmolar resuscitation therapy in patients with severe traumatic brain injury, based on the latest guidelines and scientific literature published between 2020 and 2026. Specifically, this review aims to explain the mechanisms underlying increased intracranial pressure in severe TBI, describe the mechanisms of action of mannitol and hypertonic saline in ICP management, analyse the effectiveness of both agents in reducing intracranial pressure, compare their advantages and limitations according to recent evidence, and evaluate recommendations from current neurocritical care guidelines regarding hyperosmolar therapy in severe TBI.

The research questions addressed in this study were as follows: How does hyperosmolar therapy control intracranial pressure? What is the effectiveness of mannitol and hypertonic saline according to the latest guidelines and evidence? How do the effectiveness and safety profiles of these two agents compare in the management of severe traumatic brain injury?

This review employed a systematic literature review approach based on the PRISMA guidelines and utilised data sources from PubMed, Scopus, and the Cochrane Library to provide a systematic and scientifically rigorous synthesis of evidence [12]. This article contributes to the scientific literature by providing a comprehensive synthesis of the use of mannitol and hypertonic saline in severe traumatic brain injury based on the most recent developments in modern neurocritical care. Unlike previous reviews that primarily focused on ICP reduction, this study integrates aspects of pathophysiology, cerebral perfusion, haemodynamic stability, safety profiles, and contemporary guideline recommendations into a single systematic analytical framework. The review also highlights emerging evidence supporting hypertonic saline as a potentially preferred therapy for patients with severe TBI accompanied by haemodynamic instability or refractory intracranial hypertension. Through a PRISMA-based systematic review approach and the inclusion of up-to-date literature, this article is expected to contribute to the advancement of evidence-based neurocritical care and provide clinicians with a scientific basis for decision-making regarding hyperosmolar therapy in patients with severe traumatic brain injury [13].

2 Methods

2.1 Study Design and Protocol Reporting

This investigation adopted a systematic literature review (SLR) framework to assess the efficiency and safety of mannitol relative to hypertonic saline in the context of hyperosmolar resuscitation therapy for patients with severe traumatic brain injury (sTBI). The selection of a systematic literature review is justified as it offers a methodical, clear, and reproducible framework for the synthesis of scientific evidence through organised methods of literature identification, selection, assessment, and analysis. This strategy allowed for the synthesis of insights from multiple studies on hyperosmolar therapy in neurocritical care, consequently yielding a thorough comprehension of its clinical effectiveness, safety considerations, and the development of current guideline recommendations for severe traumatic brain injury treatment. The evaluation was executed in alignment with the PRISMA 2020 framework to uphold methodological precision, reporting quality, and transparency throughout the review process [12] Additionally, the methodology of systematic reviews holds significant importance in neurocritical care, as it allows for the appraisal of varied clinical evidence and bolsters the establishment of evidence-based approaches in treating severe traumatic brain injury [14].

2.2 Search Strategy

The data sources consisted of primary clinical studies evaluating the use of mannitol and hypertonic saline in adult patients with severe traumatic brain injury. International clinical guidelines, systematic reviews, and meta-analyses were additionally re-viewed as supporting evidence to provide contextual interpretation of the findings. Significant literature was extracted from three primary electronic sources, namely PubMed, Scopus, and the Cochrane Library, which are esteemed for offering high-quality and recent evidence in the domains of neurocritical care, neurosurgery, and traumatic brain injury. To affirm that the review captured contemporary advancements in cerebral hypertension management and hyperosmolar therapy, the publication range was narrowed to publications issued from 2020 to 2026. Peer reviewed publications indexed in major scientific databases were prioritised to improve the reliability and quality of evidence synthesis. The utilisation of peer-reviewed literature from distinguished databases was recognised as imperative to strengthen the reliability of evidence synthesis and diminish information bias [14].

The systematic literature search utilised a strategic combination of keywords and Boolean operators designed to meet the study's aims. The principal search phrases featured "hyperosmolar resuscitation," "severe traumatic brain injury," "mannitol," "hypertonic saline," "intracranial pres-sure," and "cerebral perfusion pressure." These terms were integrated using Boolean operators such as AND and OR to optimise the retrieval of relevant research. Illustrations of search tactics featured ("severe traumatic brain injury" AND "hypertonic saline" AND "mannitol") beside ("intracranial pressure" AND "hyperosmolar therapy"). Each identified record was evaluated and chosen based on the PRISMA framework, which includes the steps of identification, screening,

eligibility, and inclusion. During the screening phase, duplicate records were discarded before the relevance of titles and abstracts to the research goals was evaluated. Full-text papers that conformed to the preliminary criteria were subsequently analysed using predetermined inclusion and exclusion parameters. The application of the PRISMA framework improved transparency in the selection methodology and mitigated the potential for selection bias in the review [15]. To facilitate literature management and duplicate identification, Mendeley and Microsoft Excel were utilised throughout the review process.

2.3 Eligibility Criteria

The inclusion criteria consisted of comparative clinical studies involving adult patients (≥18 years) with severe traumatic brain injury that evaluated hypertonic saline and mannitol as hyperosmolar therapies. Eligible study designs included randomised controlled trials, prospective cohort studies, and retrospective comparative observational studies. Studies were required to report outcomes related to intracranial pressure, cerebral perfusion pressure, mortality, neurological outcomes, or treatment-related adverse events. Articles published between 2020 and 2026, written in English, and available as full-text publications were considered eligible. Conversely, the exclusion criteria included systematic reviews, meta-analysis, guidelines, clinical protocols, and narrative reviews, as these sources were excluded from the final qualitative synthesis but considered as supporting evidence. Additional exclusions included studies that did not specifically address severe traumatic brain injury, paediatric population, animal studies, laboratory-based experimental research, editorials, letters to the editor, conference abstracts, expert opinions without empirical data, articles with inaccessible full texts, and studies with poor methodological quality or unclear outcome reporting. These criteria were established to maintain topic relevance and improve the validity of the evidence synthesis process [14].

2.4 Study Selection and Data Extraction

The analytical unit comprised comparative clinical studies assessing the efficacy and safety of hyperosmolar therapy using mannitol and hypertonic saline in adult individuals with severe traumatic brain injury. The study selection process was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.

All records identified from PubMed, Scopus, and the Cochrane Library were collected and screened after removal of duplicate records. Titles and abstracts were independently reviewed, followed by full-text assessment of potentially eligible studies. Studies were excluded if they involved paediatric populations, non-comparative designs, conditions other than severe traumatic brain injury, or did not directly compare mannitol and hypertonic saline. Systematic reviews, meta-analysis, guidelines, and clinical protocols were reviewed as supporting evidence but were not included in the final qualitative synthesis.

The examination concentrated on the operational mechanisms of hyperosmolar therapy, its efficacy in diminishing intracranial pressure, its influence on cerebral perfusion pressure and haemodynamic stability, neurological outcomes, mortality rates, and treatment-related adverse events. Data extracted from the eligible studies included study characteristics, patient population, intervention protocols, comparator therapy, outcome measures, and major findings.

The calibre of the incorporated studies was evaluated according to the research design, outcome consistency, techniques employed for intracranial pressure assessment, and general methodological integrity. Quality evaluation was deemed crucial to guarantee the reliability and clinical relevance of the compiled evidence [14]. The complete study selection process is illustrated in the PRISMA flow diagram (Figure 1).

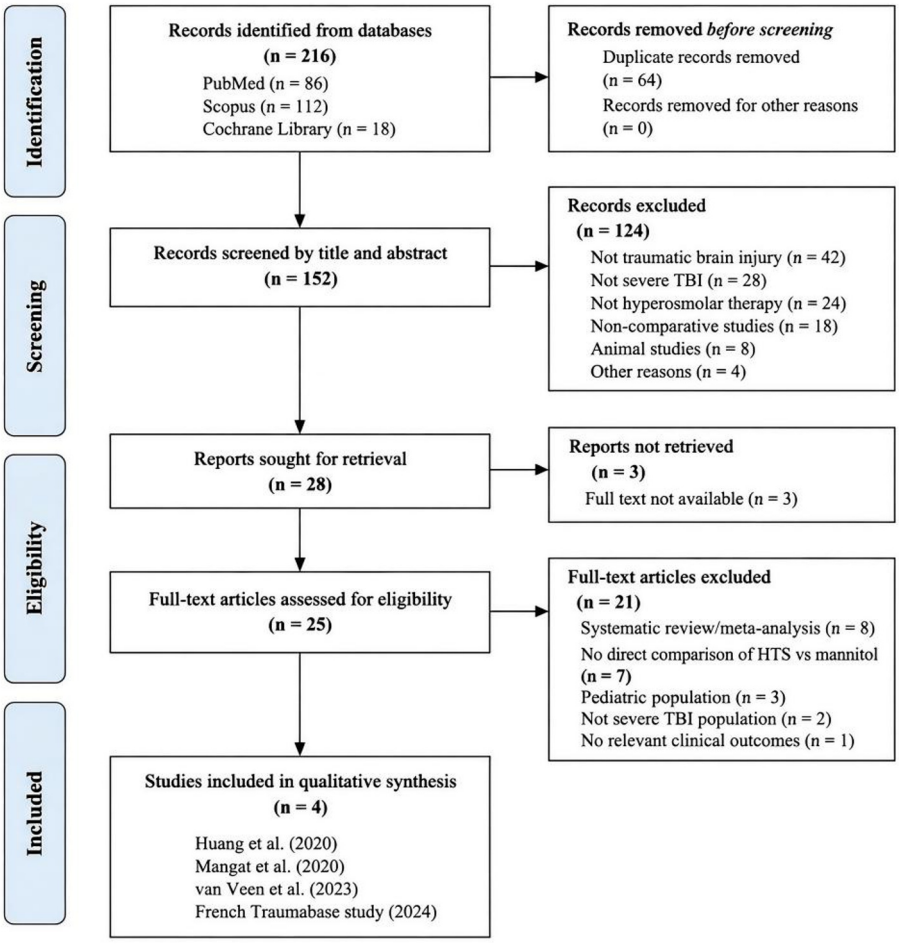


Fig. 1. PRISMA Style searching flowchart

2.5 Quality Appraisal

The quality evaluation was conducted to guarantee the reliability and clinical relevance of the compiled evidence. The calibre of the incorporated studies was evaluated according to research design, outcome consistency, techniques employed for intracra-nial pressure assessment, and general methodological integrity. Quality evaluation was deemed crucial to guarantee the reliability and clinical relevance of the compiled evidence [14].

2.6 Outcomes

A narrative synthesis technique was used for data analysis to consolidate findings from research marked by diversity in study design, patient demographics, hyperosmolar solution concentrations, and outcome assessments. The data obtained were organised according to the features of the study, the type of hyperosmolar treatment, its success in decreasing intracranial pressure, its effects on cerebral perfusion pressure, adverse reactions, and applicable guideline recommendations. The outcomes were then juxtaposed and meticulously scrutinised to uncover trends, similarities, and variations across the research. The selection of narrative synthesis is due to its capability to combine evidence from different study frameworks without the need for the statistical consistency essential for meta-analysis [16]. Moreover, conceptual analysis was applied to associate the outcomes with established theoretical frameworks, including the Monro–Kellie doctrine, cerebral perfusion theory, and osmotherapy, to furnish a detailed understanding of the effectiveness of hyperosmolar resuscitation in severe traumatic brain injury.

3 Results

3.1 Study Selection

A literature investigation conducted using PubMed, Scopus, and the Cochrane Library revealed research published from 2020 to 2026 that examined the efficacy of mannitol and hypertonic saline in severe TBI. The study selection process conformed to the PRISMA 2020 framework, which involved identification, screening, eligibility determination, and inclusion. The study selection process is illustrated in Figure 1. The eligible studies consisted of randomised controlled trials and comparative observational studies focused on adult patients with severe traumatic brain injury. Systematic reviews, meta-analyses, and neurocritical care recommendations were reviewed as supporting evidence but were not included in the final qualitative synthesis.

3.2 Characteristics of Included Studies

Four comparative studies involving adult patients with severe traumatic brain injury were included in the qualitative synthesis. The characteristics of the included studies are summarised in Table 1.

Table 1. Characteristics of Included Studies Evaluating Hypertonic Saline and Mannitol in Adult Patients with Severe Traumatic Brain Injury.

Study	Design	Population	Intervention	Comparator	Outcomes assessed	Main finding
Huang et.al. (2020)	Randomized controlled trial	Adult patients with severe traumatic brain injury and intracranial hypertension	Hypertonic saline 15%	Mannitol 20%	Intracranial pressure reduction and duration of ICP control	Both hypertonic saline and mannitol effectively reduced the ICP. Hypertonic saline demonstrated a longer duration of ICP-lowering effect, although the difference was not statistically significant
Mangat et al. (2020)	Retrospective comparative study	Adult patients with severe traumatic brain injury requiring hyperosmolar therapy	Hypertonic saline	Mannitol	ICP burden and cerebral perfusion pressure burden	Hypertonic saline was associated with a reduced cumulative ICP burden and improved combined ICP-CPP profile compared with mannitol.
Van Veen et al. (2023) (CENTER-TBI)	Prospective multicenter cohort study	Adult traumatic brain injury patients receiving hyperosmolar therapy in intensive care settings	Hypertonic saline preference	Mannitol preference	ICU mortality and neurological outcome at 6 month	No significant difference was observed between hypertonic saline and mannitol in terms of mortality or long-term neurological outcomes.
French Traumabase Study (2024)	Retrospective multicenter cohort study	Adult patients with severe traumatic brain injury and suspected brain herniation	Hypertonic saline	Mannitol	ICU mortality and clinical outcomes	Hypertonic saline showed potential benefits in selected patients with severe brain injury and suspected herniation after adjustment.

3.3 Comparative Effects of Hypertonic Saline and Mannitol

Recent publications have demonstrated an increasing trend toward evaluating hypertonic saline compared with mannitol, particularly regarding haemodynamic stability and multimodal neurocritical monitoring [17]. International guidelines have also increasingly recommended hypertonic saline for refractory intracranial hypertension in severe TBI [5]. Although the included studies showed considerable heterogeneity in study design, solution concentrations, dosing regimens, and outcome measures, most investigated hypertonic saline at concentrations of 3%, 7.5%, or 23.4%, while mannitol was commonly administered as a 20% solution. Frequently reported outcomes included ICP reduction, CPP improvement, mortality, Glasgow Outcome Scale (GOS), ICU length of stay, and treatment-related adverse effects.

3.4 Intracranial Pressure and Cerebral Perfusion Pressure Outcomes

Several comparative studies have consistently demonstrated the favourable physiological effects of hypertonic saline. Mangat et al. reported that hypertonic saline significantly reduced cumulative ICP burden compared with conventional mannitol therapy [18]. Stern-Nezer et al. reported that hypertonic saline produced faster ICP reduction and maintained CPP within the optimal range for a longer period [19]. However, randomised controlled trials indicated that both agents were similarly effective in treating acute ICP elevation, although hypertonic saline provided greater haemodynamic stability, especially in patients with hypotension or hypovolaemia [20].

Mannitol remains one of the most widely used hyperosmolar agents for elevated ICP. Evidence consistently shows that it lowers ICP through osmotic diuresis, reduced blood viscosity, and improved cerebral blood flow. Nates et al. demonstrated rapid ICP reduction following mannitol administration, particularly during the early phase of severe TBI [5]. Nevertheless, repeated or prolonged administration has been associated with hypotension, dehydration, hypovolemia, hyperosmolarity, electrolyte disturbances, acute kidney injury, and renal dysfunction, particularly in hemodynamically unstable patients [4]. Several studies also described rebound intracranial hypertension due to mannitol accumulation within brain tissue after severe blood–brain barrier disruption [8].

3.5 Clinical Outcomes and Safety Profile

Evidence supporting the use of hypertonic saline continues to increase because it effectively controls ICP while preserving systemic blood pressure and CPP without causing excessive osmotic diuresis. Ichai et al. demonstrated that hypertonic saline provides stable osmotherapy by increasing plasma osmolarity and intravascular volume without compromising systemic perfusion [11]. Similarly, a meta-analysis by Shi et al. found that hypertonic saline produced a faster onset and longer duration of ICP control than mannitol [6]. In addition, hypertonic saline may exert anti-inflammatory and immuno-

modulatory effects that reduce secondary brain injury [21], and prospective studies reported fewer episodes of refractory intracranial hypertension and reduced need for surgical intervention among patients receiving hypertonic saline [3].

Despite these physiological advantages, evidence regarding mortality and long-term neurological outcomes remains inconsistent. Most systematic reviews and meta-analyses have concluded that although hypertonic saline is more effective in controlling ICP, current evidence does not demonstrate clear superiority over mannitol in reducing mortality or improving long-term neurological recovery [6]. Some studies have reported improved Glasgow Outcome Scale scores with hypertonic saline in patients with severe TBI and haemodynamic instability; however, substantial heterogeneity in patient characteristics, injury severity, and outcome assessment limited definitive conclusions [22]. Furthermore, neurological outcomes are influenced by multiple factors, including patient age, severity of brain injury, timing of treatment, and multimodal neurocritical care strategies, rather than the choice of hyperosmolar agent alone [9].

Regarding safety, each hyperosmolar agent has a distinct adverse effect profile. Mannitol is more frequently associated with hypotension, osmotic diuresis, hypovolaemia, and renal dysfunction, whereas hypertonic saline is more commonly linked to hypernatremia, hyperchloremia, fluid overload, and osmotic demyelination syndrome if not carefully monitored. Therefore, regular monitoring of serum sodium and plasma osmolarity is recommended during hypertonic saline therapy [23]. Recent neurocritical care guidelines further emphasise that the choice of hyperosmolar therapy should be individualised according to the patient's haemodynamic status, intravascular volume, renal function, and target CPP. Although mannitol remains widely used, contemporary guidelines increasingly favour hypertonic saline for patients with severe TBI complicated by hypotension or refractory intracranial hypertension [13].

4 Discussion

The results of this comprehensive literature analysis suggest that hyperosmolar treatment is fundamental for managing ICP in individuals with severe traumatic brain injury (sTBI). Both mannitol and HTS are effective in decreasing ICP; although, HTS often achieves a more rapid reduction in ICP, offers prolonged control of ICP, and enhances the maintenance of cerebral perfusion pressure (CPP) and haemodynamic stability compared to mannitol. Mannitol remains valuable for acute intracranial hypertension but is associated with hypotension, hypovolaemia, and renal dysfunction, whereas HTS appears particularly beneficial in patients with haemodynamic instability or refractory intracranial hypertension because of its ability to expand intravascular volume while preserving CPP [11]. These findings suggest that the effectiveness of hyperosmolar therapy depends not only on ICP reduction but also on maintaining cerebral and systemic homeostasis.

These results are consistent with the Monro–Kellie doctrine and cerebral perfusion theory, which state that hyperosmolar agents reduce cerebral oedema by creating an osmotic gradient that shifts water from the brain tissue into the intravascular compart-

ment. Although mannitol lowers ICP through osmotic diuresis and reduced blood viscosity, excessive diuresis may compromise cerebral perfusion by causing hypovolaemia and hypotension [10]. In contrast, HTS increases plasma osmolarity and intravascular volume without excessive diuresis, thereby preserving the cerebral autoregulation. Recent evidence suggests that HTS may possess immunomodulatory and anti-inflammatory properties that reduce secondary brain injury [21, 23].

The evidence synthesis supports previous studies demonstrating the superiority of HTS in controlling intracranial hypertension. Meta-analysis and prospective studies have reported that HTS achieves faster and longer ICP reduction, reduced cumulative ICP burden, and decreased the need for additional interventions compared with mannitol [6, 20, 24]. However, evidence regarding mortality and long-term neurological outcomes remains inconsistent. While some studies reported improved Glasgow Outcome Scale scores with HTS, others found comparable mortality and neurological recovery between HTS and mannitol [19]. These differences are likely related to variations in study design, treatment protocols, and patient characteristics.

Despite the growing preference for HTS, mannitol continues to be an effective first-line therapy for acute intracranial hypertension, particularly when adequate haemodynamic monitoring is available [5]. Some studies have also found no significant differences between the two agents regarding mortality or long-term neurological recovery [4]. Therefore, hyperosmolar therapy should be individualised according to each patient's intravascular volume, renal function, haemodynamic stability, cerebral perfusion targets, and the overall neurocritical care strategy rather than applying a universal approach.

This review contributes by integrating recent evidence on ICP reduction, CPP preservation, haemodynamic stability, anti-inflammatory effects, and safety profiles into a comprehensive neurocritical care framework. The findings support contemporary recommendations favouring HTS in patients with hypotension or refractory intracranial hypertension, while emphasising the importance of multimodal monitoring, including ICP, cerebral oxygenation, and haemodynamic assessment, to optimise individualised treatment [25].

Several limitations should be acknowledged, including heterogeneity in study design, treatment regimens, HTS concentrations, mannitol dosages, monitoring techniques, and neurological outcome measurements. Most available studies also focused primarily on short-term physiological outcomes, with limited evidence regarding long-term neurological recovery and quality of life. Small sample sizes, observational study designs, and methodological variability further limit the generalisability of the current evidence. Nevertheless, the PRISMA-based methodology and inclusion of studies from reputable databases strengthen the reliability of this review [12].

Overall, the findings indicate that hyperosmolar therapy should be tailored to the patient's physiological and haemodynamic conditions. HTS may be preferred for patients with hypotension, hypovolaemia, or refractory intracranial hypertension because it better preserves CPP and systemic stability, whereas mannitol remains an important option for acute ICP elevation when fluid balance and renal function are closely monitored. Future research should focus on long-term neurological outcomes, standardised treatment protocols, optimal HTS concentration, timing of administration, target serum

osmolarity, and the integration of multimodal neurocritical care strategies to improve outcomes in patients with severe traumatic brain injury [12].

5 Conclusion

The use of hyperosmolar resuscitation is vital in neurocritical care for patients with severe traumatic brain injury, notably in managing heightened intracranial pressure and preventing subsequent brain damage. This methodical literature analysis reveals that mannitol and hypertonic saline are both successful in lowering intracranial pressure through osmotherapeutic mechanisms; however, each agent possesses distinct physiological characteristics, advantages, and limitations.

Mannitol remains an effective therapy for acute intracranial pressure reduction, although its use is associated with risks of excessive osmotic diuresis, hypotension, hypovolemia, and renal dysfunction. In contrast, hypertonic saline appears to provide more rapid ICP reduction, longer-lasting intracranial pressure control, and superior maintenance of cerebral perfusion pressure and hemodynamic stability.

Nevertheless, findings regarding mortality and long-term neurological outcomes remain inconsistent across studies; therefore, no definitive consensus exists regarding the absolute superiority of either hyperosmolar agent in the management of severe traumatic brain injury. This review provides both conceptual and practical contributions to the development of evidence-based neurocritical care by integrating the pathophysiology of intracranial hypertension, cerebral perfusion, haemodynamic stability, treatment safety profiles, and evolving guideline recommendations within a comprehensive analytical framework.

The results highlight that the choice of hyperosmolar therapy should be individualised rather than applied universally, taking into account the patient's clinical state, haemodynamic condition, renal performance, and desired cerebral perfusion pressure. Moreover, this analysis underscores the significance of multimodal neuroresuscitation approaches and effective neurocritical surveillance in enhancing outcomes for individuals with severe traumatic brain injury. Subsequent investigations should emphasise extensive randomised controlled trials utilising uniform treatment protocols to assess the impact of mannitol and hypertonic saline on prolonged neurological outcomes, patient well-being, and the efficacy of contemporary multimodal neurocritical care approaches.

In addition, updated evidence-based guidelines are needed to determine the optimal concentration of hypertonic saline, ideal monitoring parameters, and more specific algorithms for selecting hyperosmolar therapy according to the characteristics of individual patients with severe traumatic brain injury.

Acknowledgments. The authors thank all individuals and institutions who contributed to the completion of this study.

Disclosure of Interests. The authors declare that they have no competing interests relevant to the content of this article.

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