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**Original Research Article**

# 3% saline versus mannitol in the treatment of cerebral edema in children: a randomized controlled trial

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## ABSTRACT

**Background:** Cerebral edema with raised intracranial pressure is a pediatric neurological emergency associated with coma, herniation and death. Mannitol and hypertonic saline are commonly used osmotic agents, but comparative pediatric data remain limited and heterogeneous. To compare the efficacy and safety of 3% hypertonic saline with 20% mannitol in children aged 3 months to 12 years with cerebral edema.

**Methods:** This randomized controlled trial was conducted from 2023 to 2025 among 70 children with clinical or radiological evidence of cerebral edema. Eligible children were randomized equally into the mannitol group (n=35) and 3% saline group (n=35). Mannitol was administered as 20% mannitol at 1.5 ml/kg intravenously over 20 minutes every 8 hours, whereas 3% saline was administered at 5 ml/kg intravenously over 20 minutes every 8 hours. Other supportive management was standardized. Outcomes included early Glasgow Coma Scale improvement, time to recovery from coma, duration of ventilation, survival and treatment-related complications.

**Results:** Baseline age, sex, nutritional status, admission GCS, etiology and diagnostic features were comparable between groups. Early GCS improvement of at least 2 points within 6 hours occurred in 23 children (65.7%) in the 3% saline group compared with 13 children (37.1%) in the mannitol group (p=0.031). Coma duration ≤24 hours was observed in 18 children (51.4%) receiving 3% saline and 9 children (25.7%) receiving mannitol (p=0.026). Ventilation duration ≤24 hours was more frequent with 3% saline (14 (40.0%)) than mannitol (6 (17.1%)) (p=0.034). Survival was higher in the 3% saline group (32 (91.4%)) than in the mannitol group (26 (74.3%)), but this difference was not statistically significant (p=0.110). Hypernatremia was more frequent with 3% saline (9 (25.7%) vs 2 (5.7%); p=0.045), while renal dysfunction was numerically more frequent with mannitol (5 (14.3%) vs 1 (2.9%); p=0.198).

**Conclusions:** In children with cerebral edema, 3% hypertonic saline was associated with faster early neurological improvement and shorter coma and ventilation duration compared with mannitol, while mortality difference was not statistically significant. Hypernatremia requires close monitoring during hypertonic saline therapy.

**Keywords:** Cerebral edema, Children, Hypertonic saline, Mannitol, Pediatric intensive care, Randomized controlled trial, Raised intracranial pressure

## INTRODUCTION

Cerebral edema is an important final pathway in several acute pediatric neurological illnesses, including central nervous system infections, traumatic brain injury, metabolic encephalopathy, diabetic ketoacidosis and hypoxic-ischemic injury. The rigid cranial vault limits compensatory expansion; therefore, progressive accumulation of intracellular, extracellular or vasogenic fluid can rapidly increase intracranial pressure (ICP), reduce cerebral perfusion pressure and precipitate secondary brain injury. In children, timely recognition is especially important because clinical deterioration may be abrupt and invasive ICP monitoring may not always

be available in resource-limited settings. Hyperosmolar therapy remains one of the central components of acute management of cerebral edema. Mannitol lowers ICP by producing an osmotic gradient across the blood-brain barrier, reducing blood viscosity and promoting osmotic diuresis. However, its use may be limited by hypovolemia, hypotension, electrolyte disturbances, rebound intracranial hypertension and renal dysfunction, especially when repeated doses are required. Hypertonic saline produces osmotic movement of water from the cerebral interstitium into the intravascular space, expands plasma volume, may improve mean arterial pressure and cerebral perfusion and can be used even when diuresis is undesirable.[1]

Recent neurocritical care guidance supports hyperosmolar therapy for acute cerebral edema and suggests hypertonic sodium solutions over mannitol in selected traumatic brain injury contexts, while emphasizing that the certainty of evidence for long-term neurological outcome remains limited.[1] The Brain Trauma Foundation pediatric severe traumatic brain injury guideline recommends bolus 3% hypertonic saline for ICP control at 2-5 ml/kg over 10-20 minutes and also emphasizes safety limits for sustained hypernatremia.[2]

Pediatric comparative evidence is evolving: randomized studies in children with raised ICP have reported favorable ICP or clinical response with 3% saline compared with mannitol whereas recent pediatric meta-analyses and large observational cohorts indicate that mortality and long-term functional outcome differences remain uncertain.[3-10]

In settings where invasive ICP monitoring is unavailable or not feasible for every child, bedside neurological endpoints such as glasgow coma scale (GCS), pupillary response, abnormal posturing, ventilation requirement, survival and complications remain clinically relevant. The present randomized controlled trial was designed to compare 3% hypertonic saline with 20% mannitol in children with cerebral edema using clinically measurable outcomes and safety parameters.

## METHODS

### *Study design and period*

This was a randomized controlled trial conducted from 2023 to 2025. The trial compared 20% mannitol and 3% hypertonic saline in children with cerebral edema. The study was performed after approval from the institutional ethics committee and written informed consent was obtained from parents or legal caregivers before enrolment.

### *Study population*

Children aged 3 months to 12 years with suspected or confirmed cerebral edema were screened. A total of 70 eligible children were included and randomized equally into two groups: Group A received 20% mannitol (n=35) and Group B received 3% hypertonic saline (n=35).

### *Inclusion criteria*

Children aged 3 months to 12 years were included if they had cerebral edema of any etiology with GCS <8 and at least one additional clinical or radiological feature suggestive of raised ICP. Eligible features included persistent posturing after correction of hypoxemia and hypotension, unequal or non-reactive pupils, cranial nerve palsy, bradycardia with hypertension, abnormal respiratory pattern, papilledema or neuroimaging evidence of cerebral edema.

### *Exclusion criteria*

Children were excluded if they presented with shock, renal failure or intracranial hemorrhage at admission; had received osmotherapy before enrolment, had afebrile status epilepticus with complete clinical recovery within 6–8 hours or had neurological findings better explained by neuroparalytic disorders such as snake bite, Guillain–Barré syndrome, drug poisoning or other neuromuscular disorders.

### *Diagnostic criteria for cerebral edema*

Cerebral edema was diagnosed when a child had GCS <8 with one or more of the following: persistent posturing, abnormal pupils, third or sixth cranial nerve palsy, Cushing response, abnormal respiration, papilledema or radiological features such as effaced basal cisterns, slit-like ventricles, obliterated cortical sulci, midline shift, temporal lobe herniation or tonsillar herniation.

### *Randomization and intervention*

After enrolment, children were randomized using a computer-generated random allocation sequence. Allocation concealment was maintained using sealed opaque envelopes. Baseline clinical data, etiology, neurological findings, fundus examination, ventilation requirement, laboratory values and CT findings were recorded before osmotherapy. Children in Group A received 20% mannitol at 1.5 ml/kg intravenously over 20 minutes every 8 hours. Children in Group B received 3% hypertonic saline at 5 ml/kg intravenously over 20 minutes every 8 hours. Supportive care was otherwise identical in both groups and included airway stabilization, oxygenation, mechanical ventilation when required, antiepileptic treatment, antipyretic therapy, fluid and electrolyte correction and disease-specific therapy according to standard pediatric critical care practice.

### *Monitoring and stopping criteria*

Serial monitoring included GCS, pupillary size and reaction, posture, heart rate, blood pressure, respiratory

pattern, urine output and requirement for mechanical ventilation. Laboratory monitoring included serum sodium, potassium, urea, creatinine and serum osmolality. In the 3% saline group, serum sodium was targeted at 145–155 mEq/l. Osmotherapy was discontinued when GCS improved to >8 and clinical signs of cerebral edema resolved or earlier if complications requiring treatment cessation developed. The maximum planned duration of osmotherapy was 72 hours.

### *Outcome measures*

The primary outcome was early neurological response, defined as GCS improvement of at least 2 points within 6 hours of therapy. Secondary outcomes included GCS >8 within 48 hours, duration of coma, duration of mechanical ventilation, survival, death and treatment-related complications including hypernatremia, hypokalemia, renal dysfunction, high serum osmolality, pulmonary edema and discontinuation of therapy due to adverse events.

### *Statistical analysis*

Categorical variables were expressed as frequency and percentage. Between-group comparisons were performed using the Chi-square test or Fisher's exact test as appropriate. Continuous variables were summarized descriptively; where required, comparison was performed using independent sample t test or Mann–Whitney U test depending on distribution. A p value<0.05 was considered statistically significant.

## RESULTS

A total of 70 children were included in the analysis, with 35 children allocated to the mannitol group and 35 children allocated to the 3% saline group. There was no post-randomization exclusion. The two groups were comparable for demographic characteristics, presenting features, clinical diagnostic criteria and baseline severity. The baseline characteristics were comparable between the two treatment groups.

The most common age group was 1–5 years, observed in 15 children (42.9%) in the mannitol group and 16 children (45.7%) in the 3% saline group. Male children were slightly more common in both groups, with 20 males (57.1%) in the mannitol group and 18 males (51.4%) in the 3% saline group. Severe neurological impairment with GCS≤5 was present in 14 children (40.0%) and 13 children (37.1%), respectively, with no statistically significant difference (Table 1).

CNS infection was the most frequent underlying cause of cerebral edema, present in 17 children (48.6%) in the mannitol group and 18 children (51.4%) in the 3% saline group. Fever was present in 20 children (57.1%) and 22 children (62.9%), respectively. Seizures were observed in 19 children (54.3%) in the mannitol group and 17 children (48.6%) in the 3% saline group. The distribution of etiology and presenting symptoms was statistically comparable between groups (Table 2).

Posturing was noted in 16 children (45.7%) in the mannitol group and 15 children (42.9%) in the 3% saline group. Abnormal pupillary findings were present in 10 children (28.6%) and 8 children (22.9%), respectively. Radiological evidence of cerebral edema was found in 25 children (71.4%) in the mannitol group and 26 children (74.3%) in the 3% saline group. No significant baseline difference was observed in diagnostic features (Table 3).

A GCS improvement of at least 2 points within 6 hours was observed in 13 children (37.1%) in the mannitol group compared with 23 children (65.7%) in the 3% saline group, showing a statistically significant difference (p=0.031). Coma duration was shorter in the 3% saline group, with recovery within 24 hours in 18 children (51.4%) compared with 9 children (25.7%) in the mannitol group (p=0.026). Survival was higher in the 3% saline group, 32 children (91.4%), compared with 26 children (74.3%) in the mannitol group, although this difference did not reach statistical significance.

Hypernatremia was more frequent in the 3% saline group, occurring in 9 children (25.7%) compared with 2 children (5.7%) in the mannitol group and this difference was statistically significant (p=0.045). Hypokalemia was more common in the mannitol group, seen in 8 children (22.9%) compared with 3 children (8.6%) in the 3% saline group. Renal dysfunction occurred in 5 children (14.3%) receiving mannitol and 1 child (2.9%) receiving 3% saline, but this difference was not statistically significant.

**Table 1: Baseline demographic and clinical characteristics of the study groups.**

| Baseline variables | Mannitol group, n=35 | 3% saline group, n=35 | P value |
|---|---|---|---|
| **Age category (in years)** | | | |
| 3 months -≤ 1 | 8 (22.9%) | 7 (20.0%) | 0.952[NS] |
| 1–5 | 15 (42.9%) | 16 (45.7%) | |
| 6–12 | 12 (34.3%) | 12 (34.3%) | |
| **Gender** | | | |
| Male | 20 (57.1%) | 18 (51.4%) | 0.811 [NS] |
| Female | 15 (42.9%) | 17 (48.6%) | |

Continued.

| Baseline variables | Mannitol group, n=35 | 3% saline group, n=35 | P value |
|---|---|---|---|
| **Underweight nutritional status** | 14 (40.0%) | 12 (34.3%) | 0.805 NS |
| GCS ≤5 at admission | 14 (40.0%) | 13 (37.1%) | 1.000 NS |
| GCS 6–8 at admission | 21 (60.0%) | 22 (62.9%) | |

The values are shown as frequency (%); Chi Square test; NS- Non-Significant.

**Table 2: Etiology and presenting symptoms among children with cerebral edema.**

| Variables | Mannitol group, n=35 | 3% saline group, n=35 | P value |
|---|---|---|---|
| **CNS infection** | 17 (48.6%) | 18 (51.4%) | 0.986 NS |
| **Traumatic brain injury** | 8 (22.9%) | 7 (20.0%) | 0.653 NS |
| **Diabetic ketoacidosis** | 5 (14.3%) | 4 (11.4%) | 0.752 NS |
| **Hepatic/metabolic encephalopathy** | 3 (8.6%) | 4 (11.4%) | 0.432 NS |
| **Other causes** | 2 (5.7%) | 2 (5.7%) | - |
| **Fever** | 20 (57.1%) | 22 (62.9%) | 0.808 NS |
| **Seizures** | 19 (54.3%) | 17 (48.6%) | 0.811 NS |
| **Vomiting** | 12 (34.3%) | 13 (37.1%) | 1.000 NS |
| **Headache/irritability** | 11 (31.4%) | 12 (34.3%) | 1.000 NS |
| **Altered sensorium** | 35 (100.0%) | 35 (100.0%) | — |

The values are shown as frequency (%); Chi Square test; NS- Non-Significant.

**Table 3: Clinical and radiological features used for diagnosis of cerebral edema.**

| Diagnostic features | Mannitol group, n=35 | 3% saline group, n=35 | P value |
|---|---|---|---|
| **Persistent posturing** | 16 (45.7%) | 15 (42.9%) | 1.000 NS |
| **Unequal/dilated/non-reactive pupil** | 10 (28.6%) | 8 (22.9%) | 0.785 NS |
| **Cranial nerve palsy** | 5 (14.3%) | 4 (11.4%) | 1.000 NS |
| **Bradycardia with hypertension** | 7 (20.0%) | 6 (17.1%) | 1.000 NS |
| **Abnormal respiratory pattern** | 9 (25.7%) | 8 (22.9%) | 1.000 NS |
| **Papilledema** | 4 (11.4%) | 5 (14.3%) | 1.000 NS |
| **CT evidence of cerebral edema** | 25 (71.4%) | 26 (74.3%) | 1.000 NS |

The values are shown as frequency (%); Chi Square test; NS- Non-Significant.

**Table 4: Treatment response and clinical outcomes.**

| Outcome variables | Mannitol group, n=35 | 3% saline group, n=35 | P value |
|---|---|---|---|
| **GCS improvement ≥2 points within 6 hours** | 13 (37.1%) | 23 (65.7%) | 0.031 NS |
| **GCS >8 within 48 hours** | 21 (60.0%) | 29 (82.9%) | 0.063 NS |
| **Coma duration (in hours)** | | | |
| ≤24 | 9 (25.7%) | 18 (51.4%) | |
| 25–48 | 12 (34.3%) | 12 (34.3%) | 0.026* |
| >48 | 14 (40.0%) | 5 (14.3%) | |
| **Ventilation duration (in hours)** | | | |
| ≤24 | 6 (17.1%) | 14 (40.0%) | 0.034* |
| 25–48 | 13 (37.1%) | 14 (40.0%) | |
| >48 | 16 (45.7%) | 7 (20.0%) | |
| **Survived** | 26 (74.3%) | 32 (91.4%) | 0.110NS |
| **Death** | 9 (25.7%) | 3 (8.6%) | |

The values are shown as frequency (%); Chi Square test; NS- Non-Significant; * indicates significant (p<0.05).

**Table 5: Treatment-related complications.**

| Complications | Mannitol group, n=35 | 3% saline group, n=35 | P value |
|---|---|---|---|
| **Hypernatremia >155 mEq/l** | 2 (5.7%) | 9 (25.7%) | 0.045* |
| **Hypokalemia** | 8 (22.9%) | 3 (8.6%) | 0.188 NS |
| **Renal dysfunction** | 5 (14.3%) | 1 (2.9%) | 0.198 NS |
| **Serum osmolality >320 mOsm/kg** | 7 (20.0%) | 2 (5.7%) | 0.151 NS |
| **Pulmonary edema** | 2 (5.7%) | 1 (2.9%) | 1.000 NS |
| **Therapy stopped due to adverse event** | 5 (14.3%) | 2 (5.7%) | 0.428 NS |

The values are shown as frequency (%); Chi Square test; NS- Non-Significant; * indicates significant (p<0.05).

## DISCUSSION

The present randomized controlled trial compared 3% hypertonic saline with 20% mannitol in 70 children with cerebral edema. The principal finding was that 3% saline produced a significantly better early neurological response: GCS improvement of at least 2 points within 6 hours occurred in 23 children (65.7%) in the 3% saline group compared with 13 children (37.1%) in the mannitol group (p=0.031).

Clinically important recovery endpoints also favored 3% saline, including coma duration <=24 hours in 18 children (51.4%) versus 9 children (25.7%) in the mannitol group (p=0.026) and ventilation duration <=24 hours in 14 children (40.0%) versus 6 children (17.1%) (p=0.034). Mortality was lower in the 3% saline group (3 deaths (8.6%)) than in the mannitol group (9 deaths (25.7%)), but this difference was not statistically significant (p=0.110). Therefore, the present study supports a stronger early clinical effect of 3% saline, while it should not be interpreted as proving a definitive survival benefit.

The early neurological advantage observed in the present study is in agreement with the randomized clinical trial by Rameshkumar et al which compared 20% mannitol with 3% hypertonic saline in children with raised ICP due to acute CNS infections. Their study reported that 3% hypertonic saline achieved greater ICP reduction than 20% mannitol and was associated with better modified Glasgow Coma Scale improvement at 72 hours, shorter duration of mechanical ventilation and PICU stay and less severe neurodisability at discharge.[3] The present study shows the same direction of benefit, although our primary endpoint was bedside GCS improvement rather than directly measured ICP. The similarity is important because CNS infection was also the most common etiology in our cohort, affecting 17 children (48.6%) in the mannitol group and 18 children (51.4%) in the 3% saline group.

The findings also resemble the earlier Indian pediatric randomized comparative study by Upadhyay et al which included approximately 200 children with raised intracranial pressure and concluded that 3% hypertonic saline was a safe and effective alternative to mannitol.[4] In that study, serum sodium and chloride increased significantly in the hypertonic saline arm but remained within acceptable limits and mortality did not differ significantly between the groups.

The results are concordant: hypernatremia was more frequent with 3% saline (9 children (25.7%) vs 2 children (5.7%), p=0.045), but the mortality difference did not reach statistical significance. This supports the interpretation that 3% saline may provide better early ICP-related clinical response, provided sodium is actively monitored. More recent smaller pediatric comparative studies also support the direction of the present findings. Upadhyay et al, 17 reported improvement in 19 of 21 children (90.5%) treated with 3% hypertonic saline compared with 15 of 19 children (78.9%) treated with mannitol, although the difference was not statistically significant. Kochar et al 18 reported GCS improvement of >=2 points at 1 hour in 67% of children receiving 3% hypertonic saline compared with 53% receiving mannitol, they also observed hypernatremia in 22% of the saline group, hypokalemia in 12% of the mannitol group, renal dysfunction in 5.5% versus 11.8% and lower mortality in the saline group. The present study shows a very similar early response rate with hypertonic saline (65.7%) and a similar pattern of complications, but it demonstrated a larger treatment separation for early GCS response than these smaller reports.

The present results should be viewed in the context of mixed conclusions from systematic reviews. Mishra et al, 5 performed a pediatric meta-analysis of randomized trials and reported no statistically significant overall difference between hypertonic saline and mannitol for reduction of elevated ICP in children, emphasizing the limited number of trials and low-certainty evidence. In contrast, Ortiz reported that two randomized pediatric studies showed statistically significant evidence favoring 3% hypertonic saline for ICP reduction, while mortality remained comparable between agents.[19]

Afroze et al reviewed pediatric cerebral edema studies and noted that several studies showed significant ICP reduction with hypertonic saline, including one reporting coma resolution, but highlighted the small evidence base and heterogeneity of outcomes.[10] Thus, our significant early GCS response is consistent with studies favoring hypertonic saline, whereas our non-significant mortality difference is consistent with pooled analyses showing insufficient evidence for a survival advantage.

The 2023 pediatric TBI systematic review by Rodrigues et al, identified six studies comparing mannitol and hypertonic saline in children with traumatic brain injury and concluded that both agents lower ICP, but available evidence is heterogeneous and insufficient to make strong conclusions regarding superiority.[9] Similarly, the 2024 systematic review and meta-analysis by Choudhury et al in non-traumatic brain injury emphasized that both 20% mannitol and 3% hypertonic saline are effective osmotic agents, but heterogeneity in etiologies, dosing schedules and ICP monitoring methods limits certainty.[6] The present study contributes clinical outcome data from a mixed-etiology pediatric population, but the same limitation applies: infection, trauma and metabolic etiologies may respond differently to osmotherapy.

Although the present study included mixed etiologies rather than only traumatic brain injury, comparison with large pediatric TBI datasets is useful because they provide stronger physiologic evidence. The ADAPT comparative effectiveness study by Kochanek et al analyzed approximately 2500 bolus administrations of

3% hypertonic saline and mannitol among children with severe TBI and found that hypertonic saline was associated with greater ICP reduction, especially during higher ICP crises, while both agents had broadly similar observed effects on cerebral perfusion pressure.[7] This supports the physiological plausibility of our observed faster neurological improvement with 3% saline. It also suggests that the main advantage of hypertonic saline may be rapid ICP control rather than guaranteed improvement in all downstream outcomes.

The largest recent clinical outcome comparison is the 2025 multicenter cohort by Chong et al which included 445 children with moderate to severe TBI. Mortality was 7.1% in the 3% hypertonic saline-only group and 11.0% in the mannitol-only group (p=0.34) and adjusted analyses found no significant difference in mortality, discharge pediatric cerebral performance category scores or 3-month glasgow outcome scale-extended pediatric version outcomes.[8] This closely parallels the present study: mortality numerically favored 3% saline but was not statistically significant. Therefore, our findings should be framed as demonstrating improved early neurological and ventilatory recovery, not as definitive evidence of better survival or long-term neurodevelopmental outcome.

Other pediatric physiologic studies also support the ICP-lowering effect of hypertonic saline. Wellard et al observed that effective bolus hyperosmolar therapy after pediatric TBI was associated with decreased ICP and changes in arterial blood pressure, with pretreatment cerebrovascular pressure reactivity potentially influencing response.[11] Zipfel et al reported that hypertonic saline significantly lowered ICP in children with severe TBI and that a greater and longer-lasting ICP reduction was associated with favorable outcome.[12] These studies provide mechanistic support for our bedside observation of faster GCS improvement in the saline group, although they also reinforce the need for direct ICP monitoring in future trials.

The safety profile in the present study was consistent with known pharmacology and previous studies. Hypernatremia >155 mEq/L was significantly more common with 3% saline (9 children (25.7%)) than with mannitol (2 children (5.7%), p=0.045). Hypernatremia has also been described in pediatric comparative studies and in systematic reviews and it is an expected effect of sodium-based osmotherapy.[4,10,14,18]

The brain trauma foundation guideline specifically recommends avoiding sustained serum sodium >160 mEq/l and >170 mEq/l because of potential complications such as deep vein thrombosis, thrombocytopenia and anemia.[2] In the present protocol, serum sodium was targeted to 145-155 mEq/l, treatment duration was limited to 72 hours and therapy was stopped or modified if serious complications developed. This may explain why hypernatremia was frequent but clinically manageable.

In contrast, hypokalemia, renal dysfunction and high serum osmolality were numerically more common in the mannitol group. Hypokalemia occurred in 8 children (22.9%) receiving mannitol compared with 3 children (8.6%) receiving 3% saline, while renal dysfunction occurred in 5 children (14.3%) and 1 child (2.9%), respectively. Although these differences did not reach statistical significance, they are clinically meaningful because mannitol depends on renal clearance and produces osmotic diuresis.

Neurocritical care guidance and systematic reviews caution that mannitol may worsen hypovolemia, hypotension, renal dysfunction and serum osmolality when repeated doses are used, particularly in critically ill or hemodynamically unstable children.[1,9,13-16] The present pattern therefore supports careful selection of mannitol when renal function, volume status or serum osmolality is borderline.

The clinical relevance of the present trial lies in its pragmatic endpoints. In many pediatric intensive care settings, invasive ICP monitoring is not available for all children, particularly those with infection-related or metabolic cerebral edema. Under such circumstances, serial GCS, pupillary reaction, posturing, ventilation requirement, CT findings, serum sodium, serum osmolality, renal function and urine output become important bedside indicators. The significant improvement in early GCS response and shorter ventilation duration observed with 3% saline suggests that it may be preferred when rapid neurological recovery and avoidance of diuresis are priorities. However, mannitol remains appropriate in selected patients, particularly when baseline hypernatremia, fluid overload or concern for excessive sodium load is present.

Overall, the present findings agree with the major theme of contemporary literature: 3% hypertonic saline is at least comparable to mannitol and may be superior for rapid ICP-related physiological response, while evidence for mortality and long-term functional superiority remains uncertain.[5-10,15,16,20,21] The results therefore support using 3% saline as an effective first-line or early osmotherapy option for pediatric cerebral edema, provided that serum sodium, chloride, osmolality and renal parameters are closely monitored. Larger multicenter randomized trials with standardized ICP monitoring, uniform etiological subgroups, sedation-adjusted neurological assessment and long-term neurodevelopmental follow-up are needed before definitive outcome superiority can be claimed.

The study included a relatively small sample of 70 children, which limited statistical power for mortality and subgroup analyses. Cerebral edema was diagnosed using clinical and radiological criteria and direct invasive ICP

monitoring was not performed in all children. The study population included mixed etiologies of cerebral edema, which may have influenced treatment response and outcome. Long-term neurological and neurodevelopmental outcomes after discharge were not assessed.

## CONCLUSION

In children with cerebral edema, 3% hypertonic saline was associated with significantly better early GCS improvement, shorter coma duration and shorter ventilation duration compared with 20% mannitol. Mortality was lower in the 3% saline group, but the difference was not statistically significant. Hypernatremia was significantly more common with 3% saline and requires structured electrolyte monitoring. Mannitol was associated with numerically higher hypokalemia, renal dysfunction and high serum osmolality. The findings support 3% saline as an effective and practical osmotherapy option for pediatric cerebral edema, while emphasizing individualized treatment selection and careful safety surveillance.

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