Section: Pediatrics

Original Research Article

COMPARATIVE EVALUATION OF 3% HYPERTONIC SALINE VERSUS 20% MANNITOL FOR RAISED INTRACRANIAL PRESSURE IN A PEDIATRIC ICU: A PROSPECTIVE STUDY

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ABSTRACT

Background: Raised intracranial pressure (ICP) is a critical emergency [8] in pediatric care. This study compares the efficacy and safety of 3% hypertonic saline (NaCl) and 20% mannitol.

Materials and Methods: This was a prospective observational study conducted from July to December 2024 in a tertiary pediatric ICU. Thirty-five children with raised ICP were enrolled: 18 received 3% NaCl and 17 received mannitol. Primary outcome was clinical improvement in ICP features within 1 hour.

Results: Clinical improvement was observed in 67% of the NaCl group vs 53% of the mannitol group. Hypernatremia occurred in 22% of the NaCl group; hypokalemia in 12% of the mannitol group. Mortality was lower in the NaCl group (no mortality) compared to mannitol (5.9%).

Conclusion: 3% hypertonic saline may be a more effective and safer alternative to mannitol in managing raised ICP in pediatric,[5] patients.

Keywords: Hypertonic saline, Mannitol, Intracranial pressure, Pediatric ICU, Osmotherapy, Neurocritical care, Raised ICP

INTRODUCTION

Raised intracranial pressure (ICP) in children represents a critical neurologic emergency [8] that, if not recognized and managed promptly, can lead to irreversible brain injury and death. The etiologies of raised ICP in pediatric populations are diverse and include central nervous system (CNS) infections, traumatic brain injury, posterior reversible encephalopathy syndrome (PRES), and hepatic encephalopathy, among others. The cornerstone of early management involves reducing intracranial pressure through a combination of supportive care and osmotic therapy. While 20% mannitol has been a mainstay of osmotherapy for decades,[1] concerns around rebound intracranial hypertension,[3] dehydration, and renal impairment,[7] have led to increasing interest in 3% hypertonic saline. The latter is thought to offer sustained ICP control with favorable hemodynamic profiles. However, pediatric comparative data remains limited, particularly from resource-constrained settings. This prospective observational study was conducted to compare the efficacy and safety profiles of these two agents in the real-world context of a tertiary-care pediatric,[5] ICU.

MATERIALS AND METHODS

Study Design: This was a prospective observational study conducted over six months (July to December 2024) in the Pediatric Intensive Care Unit (PICU) of Dr. S.S. Tantia Medical College, a tertiary-care teaching hospital in North India. All children aged between 1 month and 16 years presenting with clinical and/or radiologic evidence of raised ICP were screened for inclusion.

Inclusion Criteria: Patients were eligible if they exhibited at least two of the following indicators of raised ICP: altered level of consciousness (GCS <8 or drop by ≥2), abnormal pupillary reactivity, decerebrate/decorticate posturing, bulging anterior fontanelle (in infants), Cushing's triad (hypertension,

bradycardia, irregular respiration), or radiological signs of cerebral edema or midline shift on CT.

Exclusion Criteria: Children were excluded if they had pre-existing renal dysfunction, severe hypotension, or succumbed within 6 hours of ICU admission.

Intervention: Based on clinical discretion and availability, enrolled children received either 3% NaCl (3-5 mL/kg over 20-30 minutes) or 20% Mannitol (0.5–1 g/kg IV bolus). No crossover was allowed. Follow-up clinical evaluation was conducted at 1 hour and 6 hours post-administration.

Data Collection: Demographics, primary diagnosis, baseline and post-treatment GCS, pupil reactivity, electrolyte trends, duration of ICP control, complications, and final outcomes were documented using a structured case proforma.

Statistical Analysis: Data were analyzed using descriptive and inferential statistics. Continuous variables were expressed as medians and compared using the Mann-Whitney U test. Categorical variables were presented as percentages and analyzed using the Chi-square test or Fisher's exact test as appropriate. A p-value < 0.05 was considered statistically significant.

Sampling Technique: A convenience sampling method was used. All eligible children presenting to the PICU during the study period who met the inclusion criteria and whose guardians provided informed consent were enrolled consecutively until the sample size was reached.

RESULTS

A total of 35 children were enrolled during the study period. Of these, 18 children received 3% hypertonic saline and 17 received 20% mannitol. The median age of participants was 6.8 years (range: 2 months to 14 years), and 54% were male. The most common etiologies were CNS infections (34%), traumatic brain injury (29%), and postoperative neurosurgical complications (20%).

Table 1: Baseline Characteristics of Patients in Each Group

Variable	3% Hypertonic Saline (n=18)	20% Mannitol (n=17)	p-value
Number of patients	18	17	-
Median age (years)	6.5	7.1	0.71
Gender (Male %)	55%	53%	0.89
Most common etiology - CNS infections	33%	35%	0.83
Traumatic Brain Injury	28%	29%	0.94
Postoperative neurosurgical cases	22%	18%	0.65

Initial GCS scores ranged from 4 to 9. Clinical response, defined as an improvement of ≥2 points in GCS within one hour, was seen in 67% of children in the hypertonic saline group compared to 53% in the mannitol group. Hypernatremia occurred in 22% of NaCl cases; hypokalemia in 12% of mannitol recipients. Renal dysfunction was observed in 5.5% of children in the hypertonic saline group and 11.8% in the mannitol group. The need for escalation to second-line ICP control strategies such as ventilation or decompressive surgery was notably lower in the NaCl group. No mortality was observed in 3% NaCl group whereas 1 child passed away in the mannitol (5.9%) group.

Table 2: Comparative Outcomes between the Two Groups

Outcome Measure	3% Hypertonic Saline	20% Mannitol	p-value
GCS improvement ≥2 points at 1 hour	67%	53%	0.44
Hypernatremia incidence	22%	0%	0.04*
Hypokalemia incidence	0%	12%	0.10
Renal dysfunction	5.5%	11.8%	0.62

DISCUSSION

This prospective study supports growing evidence that 3% hypertonic saline may offer superior clinical efficacy in managing raised ICP in pediatric,[5] patients compared to traditional 20% mannitol therapy. The higher early response rate in the hypertonic saline group suggests a more rapid and sustained reduction in intracranial tension, possibly due to its dual effect of plasma expansion and osmotic gradient-driven cerebral dehydration.

Hypernatremia, though more common in the saline group, remained within manageable levels and did not necessitate therapy discontinuation. Conversely, hypokalemia and renal dysfunction were notable concerns with mannitol, aligning with known adverse profiles from adult and pediatric literature. Importantly, the lower requirement for second-line escalation in the saline group underscores its potential as a first-line agent.

Limitations of the study include a small sample size, non-randomized allocation, and absence of invasive ICP monitoring, which reflects the pragmatic constraints of resource-limited settings. Nevertheless, the data mirror real-world clinical decision-making and provide an impetus for larger randomized controlled trials.

CONCLUSION

3% hypertonic saline demonstrated favorable outcomes in terms of early ICP control, safety, and mortality profile compared to 20% mannitol in our prospective pediatric cohort. While both agents remain valuable in acute neurocritical care, hypertonic saline may be a more suitable first-line osmotherapy in resource-constrained pediatric,[5] ICUs. Future multicenter trials should aim to validate these findings and explore long-term neurological outcomes.

Ethical Considerations

This study was conducted following approval from the Institutional Ethics Committee (Approval No: IEC/2024/07, dated 30th June 2024). Assent was obtained from children older than 7 years when applicable, and informed consent was obtained from all guardians. Informed consent was obtained from guardians of all participants.

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Conflict of Interest

None declared.

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