Original Research Paper

Volume - 13 | Issue - 03 | March - 2023 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Pediatrics

FLUID THERAPY IN MECHANICALLY VENTILATED CRITICALLY ILL CHILDREN: THE SODIUM, CHLORIDE AND WATER BURDEN OF FLUID CREEP"

Chapay Soren	Professor, Department of Pediatrics, SVS Medical College and Hospital Mahabubnagar, Telangana, India
Deepthi .D*	Assistant Professor, Department of Pediatrics, SVS Medical College and Hospital Mahabubnagar, Telangana, India*Corresponding Author
Jyothi. K	Junior Resident, Department of Pediatrics, SVS Medical College and Hospital Mahabubnagar, Telangana, India
Latha. B	Junior Resident, Department of Pediatrics, SVS Medical College and Hospital Mahabubnagar, Telangana, India
Laxmi. P	Junior Resident, Department of Pediatrics, SVS Medical College and Hospital Mahabubnagar, Telangana, India
Saraswathi. K	Junior Resident, Department of Pediatrics, SVS Medical College and Hospital Mahabubnagar, Telangana, India

ABSTRACT **Aim:** To quantify the burden of sodium, chloride and water in fluid creep among critically ill mechanically ventilated children. **Method:** All critically ill children between1year to 15 years of age on mechanical ventilation admitted in PICU were included in the study. The cause for PICU admission will be categorized into respiratory failure, sepsis and neurological disease. The amount of resuscitation, replacement, and maintenance fluid will be calculated. Maintenance fluid calculated by Holliday—Segar formula, in addition measure the amount of sodium, chloride and water in infusions, transfusions, vehicle for drug administration and flush. **Result:**The major source of water input was fluid creep followed by fluid maintenance. The quantitative role of fluid boluses/fluid resuscitation was minor and quantitatively similar to blood components. Fluid creep represented the major source of sodium and chloride followed by maintenance fluids, resuscitation fluid and blood components, **Conclusion:** Fluid creep is quantitatively the most relevant fluid in the PICU and future research and clinical efforts should address this topic in order to improve the quality of care of critically ill children.

KEYWORDS : Pediatric intensive care unit, Fluid creep, Volume overload, Strong ion difference.

Introduction

Water constitutes to be the main component of human body. Its distribution depends upon age, body weight and sex.1 In new-born infants the proportion of body water in relation to weight is as high as 80%, which declines with age. Fluid balance is more delicately balanced in young infants and children because of variable reasons such as greater insensible losses because of higher basal metabolic rate and large surface area and urinary losses because of immature concentrating ability of nephrons.[2]

Total body water is distributed in such a way that 40% of it constitutes intracellular fluid and 20% constitutes extracellular fluid (15% - interstitial and 5% - intravascular).

Regarding electrolytes composition, Sodium and chloride are the dominant cation and anion in ECF respectively and Potassium is the most abundant cation in the ICF. Fluid and electrolytes disturbances are common in critically ill children.[3] Therefore, optimal fluid therapy remains the most important aspect of treatment in PICU to improve the outcome. Critically ill children need intravenous fluid administration for resuscitation, replacement of loss, and daily maintenance.[4]

In addition, a substantial amount of water and electrolyte is administered in the form of transfusions, infusions (vehicle for medicines), flushes and total parenteral nutrition. These frequently neglected administered fluids termed as fluid creep.[4] Isotonic saline (0.9% sodium chloride) is the classical fluid creep which is mostly used.

This extra amount of fluid and electrolytes are needed to be adjusted with the daily requirements of the child to maintain the normal homeostasis.5 I hereby did this study in order to know the burden of electrolyte disturbances which occur with the inadvertent usage of fluid in emergency situations and its impact on the outcome of the child.

Materials and Method: All critically ill children between1year to 15 years of age on mechanical ventilation admitted in PICU were included in the study after obtaining ethical clearance and after obtaining informed consent from the parent. Patients on Renal replacement therapy, plasmapheresis, parenteral nutrition were excluded from the study.

The demographic data which included age, gender, body weight, presence and type of co-morbidities were recorded. The cause for PICU admission will be categorized into respiratory failure, sepsis and neurological disease. The amount of resuscitation, replacement, and maintenance fluid will be calculated. Maintenance fluid calculated by Holliday—Segar formula, in addition measure the amount of sodium, chloride and water in infusions, transfusions, vehicle for drug administration and flush. Data was entered in excel sheet. Qualitative variables were expressed as proportion; quantitative variables calculated as per the contents of various fluids were converted into categories and again expressed in proportion. Statistical significance was considered when the p value was < 0.05.

NORMAL ELECTROLYTE VALUES :
SODIUM –
Newborn – 133–146mEq/L Infant – 139-146 mEq/L Child – 138-145 mEq/L Adult – 136-145 mEq/L CHLORIDE – Newborn – 98-113 mEq/L Child – 98 – 107 mEq/L

RESULTS:
A total of 73 patients were included in this study after considering inclusion and exclusion criteria.

Almost 50% of the patients included in this study were aged above 10 years. About 24 (32.9%) between 1-5 years, 15 (20.5%) between 6-10 years while 34 (46.6%) between 11-15 years.

About 60.3% of the patients were male and 39.7% were female.

Regarding the weight distribution, the mean weight was 22.21kg with a standard deviation of 14.86. About 26% fall below 10kg, 31.5% between 11-20kg, 16.4% between 21-30kg, 11% between 31-40kg,

9.6% between 41-50kg and 5.5% between 51-60kg. About 76.7% of the diagnosis were Neurological, 6.8% were respiratory failure and 9.6% were septic shock and others included drowning, MISC, unknown bites and ethylene glycol poisoning. (Table 1)(Figure 1)

On average, a daily dose of 1540 ± 191 ml (178 ± 44 ml/kg/day) of water was administered. The major source of water input was fluid creep (121 ± 22 ml/kg/day, 60.6%) followed by fluid maintenance (57±14 ml/kg/day, 29.5%). The quantitative role of fluid boluses/fluid resuscitation was minor (6.1%) and quantitatively similar to blood components (3.8%). (Table 2)(Figure 2)

The daily dose of sodium for was 73.99 ± 96.24 mEq (23.81 ± 24.86 mEq/kg/day). Fluid creep represented the major source of sodium (7.45 ± 3.03 mEq/kg/day, 66% of total sodium input), followed by maintenance fluids (25.2%), Resuscitation Fluid (5.3%) and Blood Components (3.5%).

The daily dose of chloride was 66.7 ± 98.36 mEq (23.71 ± 26.31 mEq/kg/day), slightly lower than sodium. Fluid creep represented the major source of chloride (5.81 ± 2.17, 63% of total chloride input), followed by maintenance fluids (29.9%), Resuscitation Fluid (6.3%) and Blood Components (0.7%). (Figure 3)

Discussion:

The present study conducted in young (1-15yrs) critically ill mechanically ventilated children by considering the four days of their hospital stay. The findings are (i) the overall extremely high sodium, chloride and water load and (ii) predominant role of fluid creep.

The major source of water input was through fluid creep accounting for 66% followed by maintenance fluid accounting for 25.2% of total fluid administration which was calculated as per Holliday and Segar.

As stated by other authors like Van Regenmortel N et al.6 and Bihari S et al.[7], the quantitative role of resuscitation fluid and blood components was minimal when compared to other types of fluids. Alobaidi R et al.[8] updated that the positive fluid balance could be a marker of disease and severity of illness rather than a pure iatrogenic or preventable problem. In fact, poor resuscitation brought on by inadequate fluid supply can result in organ failure, particularly in the early stages of disease.

According to Namitha R et al.[9] the fluid creep quantity and composition represented the major source of sodium (66% of total sodium input). Overall, the sodium burden was more than 10 times the advised sodium intake. It is likely recommended sodium inputs might not be sufficient for critically ill children with altered vascular permeability because of relative hypovolemia. Although, the administration of the 66% of this overload was inadvertent i.e., in the form of fluid creep as vehicle for intravenous drugs and to maintain the patency of the intravenous catheters. It is therefore conceivable that this sodium load was not a therapeutic choice, but rather a side effect of other therapies. According to Bihari S et al. [10] daily sodium administration was 225.5mmol. The median daily net fluid balance was 351mL and median daily fluid intake was 2352mL. Daily sodium administered correlated with net fluid balance.

According to Choo WP et al.[11] fluid balances were positive and did not differ from normonatremia on most days in the presence of slightly higher plasma creatinine and more frequent administration of furosemide, at higher doses, in hypernatremia than in normonatremia. The total chloride load was slightly lower than sodium. This is because the presence of sodium in medicines and blood components. Fluid creep in particular and the high chloride load associated with fluid therapy could both lead to the development of hyperchloremia and its associated side effects, such as hyperchloremic metabolic acidosis. According to Van Regenmortel N et al.[6] the most significant sources of salt and chloride were maintenance and replacement fluids, which made up 24.7% of the average daily total fluid volume, significantly outpacing resuscitation fluids (6.5%). A startling 32.6% of the average daily total fluid volume was made up of fluid creep. Instead of using a balanced resuscitation method, using a hypotonic maintenance strategy can reduce chloride levels more successfully. According to Langer et al.[4] The majority of the patients' daily fluid intake, or 1004± 284 ml (153 ±36 ml/kg/day), came from enteral (39%), creep (34%) and maintenance (24%) fluids. Patients got 13.6±4.7, and 14.4±4.8, respectively, mEq/kg/day of chloride and sodium. The majority of sodium and chloride (56 and 58%) came via fluid creep. Total salt intake was correlated with daily fluid balance, which was 417± 221 ml (64 ±30 ml/kg/day) (r2 = 0.49, p< 0.001).

List of Tables and Figures

Table – 1: Categorization of the disease based on the cause for PICU admission

Diagnosis	Frequency	Percentage
Neurological	56	76.7%
Respiratory Failure	5	6.8%
Septic Shock	7	9.6%
Others	5	6.8%
Total	73	

Table – 2: Comparison of Fluid Creep among three Groups

FLUID CREEP	Sodium		Chloride		Water		P - Value
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	
DAY-1	151.989	50.482	120.850	40.149	784.740	260.707	0.001
DAY-2	166.625	58.399	125.097	45.997	812.315	298.681	0.001
DAY-3	122.763	54.886	103.908	51.066	684.097	324.047	0.001
DAY-4	75.347	44.263	65.005	43.548	440.200	274.521	0.001

Figure – 1: Pie chart depicting categorization of diseases

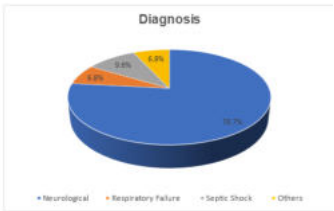


Figure – 2: Comparison of Fluid Creep among three Groups during four days of hospital stay

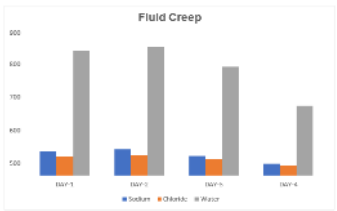
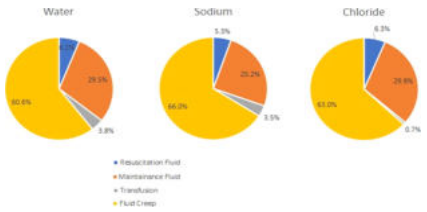


Figure – 3: Pie charts summarizing the percentage contribution of different fluid categories to water, sodium and chloride load.



Conclusion

In conclusion, our study examined the clinical procedures for administering fluids to critically sick, mechanically ventilated patients aged 1 to 15 years who were receiving care at our PICU. In our unit, we had established protocols for drug dilution that did not always use the highest concentration. Because of this, our current therapeutic practices and routines unquestionably result in an unintentional and excessive water, salt, and chloride load, which may have a substantial impact on patients' outcomes and the development of edema. Future studies and clinical initiatives should focus on fluid creep since it is quantitatively the most important fluid in the PICU and can help provide better care for children who are critically unwell.

REFERENCES

1. Mittal K, Aggarwal HK, Damke S, Wagha J. Clinical Update-Practical Guidelines on Fluid Therapy in Children. J Pediatr Crit Care 2019;6(2): 59-64.
2. Outcome of public consultations on the Scientific Opinions of the EFSA Panel on Nutrition, Novel Foods and Food Allergens (NDA) on Dietary Reference Values for sodiumandchloride, EFSASupporting Publications, 10.2903/sp.efsa.2019.EN-1679, 16, 9, (2019).
3. Gupta R, Rosen D. Paediatric mechanical ventilation in the intensive care unit. BJA Education. 2016;16(12):422-426. doi:10.1093/bjaed/mkw025
4. Langer T, D'Oria V, Spolidoro GCI, et al. Fluid therapy in mechanically ventilated critically ill children: the sodium, chloride and water burden of fluid creep. BMC Pediatr.

2020;20(1):424. doi:10.1186/s12887-020-02322-3
5. Danziger J, Zeidel ML. Osmotic Homeostasis. CJASN. 2015;10(5):852-862. doi:10.2215/CJN.10741013
6. Van Regenmortel N, Verbrugghe W, Roelant E, Van den Wyngaert T, Jorens PG. Maintenance fluid therapy and fluid creep impose more significant fluid, sodium, and chloride burdens than resuscitation fluids in critically ill patients: a retrospective study in a tertiary mixed ICU population. Intensive Care Med. 2018;44(4):409–17.
7. Bihari S, Festa M, Peake SL, Seppelt IM, Williams P, Wilkins B, et al. Sodium administration in critically ill paediatric patients in Australia and New Zealand: a multicentre point prevalence study. Crti Care Resusc. 2014;16(2): 112–8.
8. Alobaidi R, Morgan C, Basu RK, Stenson E, Featherstone R, Majumdar SR, et al. Association between fluid balance and outcomes in critically ill children: in critically ill children: A systematic review and meta-analysis. JAMA Pediatr 2018;172:257-68.
9. Namitha R, Ramachandran R, Ponnarmeni S, Subramanian M. Retrospective study on 48 hours fluid balance and outcome in mechanically ventilated children. J Ped Crit Care 2020;7:174-178.
10. Bihari S, Ou J, Holt AW, Bersten AD. Inadvertent sodium loading in critically ill patients. Crti Care Resusc. 2012;14(1):33–7.
11. Choo WP, Groeneveld AB, Driessen RH, Swart EL. Normal saline to dilute parenteral drugs and to keep catheters open is a major and preventable source of hypernatremia acquired in the intensive care unit. J Crit Care. 2014;29(3):390–4.