Fluid overload among critically ill children with acute kidney injury: A tertiary care experience of Western Odisha

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Abstract

Introduction: Acute Kidney Injury (AKI) is a frequent clinical complication in paediatric critically ill patients who often develop Fluid Overload (FO).

Objectives: To study the occurrence of FO among critically ill patients admitted to Pediatric Intensive Care Unit (PICU) with AKI and study its association with age, sex, stages of AKI and duration of hospitalization.

Materials and Method: A cross-sectional study was conducted in the PICU of a tertiary care hospital of Western Odisha enrolling 140 patients by simple consecutive sampling with inclusion criteria being critically ill children admitted for 24 hrs or more in PICU in the age group of one completed month to 14 completed years having AKI as per pRIFLE criteria; and patients with pre-existing renal diseases, less than 1-month age were excluded. FO percentage was calculated using equation [{Total fluid in (in ltrs) – Total fluid out (in ltrs)}/Admission body weight (in kgs) X 100]. A score of 10% or more was considered to be indicative of fluid overload (FO ≥10%). All the cases were followed up till discharge and / or death & the relevant data including demographic characters like age, sex, body weight at admission and stages of AKI were collected and analysed in SPSSv24.

Results: The association between age group and FO≥10% is significant. The occurrence of FO ≥10% in male children (75.3%) is significantly higher than that in case of females (58.8%). There is no significant difference in mean duration of hospitalisation in days between three stages of AKI (Risk, Injury and Failure).

Conclusion: Duration of hospitalisation in PICU does not alter with the various stages of AKI may it be Risk or Injury or Failure. It's the fluid overload in the pre-ICU setting before getting admitted to PICU predicts the outcome.

Keyword: Fluid Overload, Critically Ill, Acute Kidney Injury.

Introduction

Fluid management is incredibly vital within the management of critically ill kids. Fluid management is important to keep up the intravascular volume and organ perfusion.[1,2] One important consequence of fluid given in critically sick kids is fluid overload (FO).[1-4] Fluid balance becomes quickly positive in the critically ill, likely due to initial required resuscitation and increased capillary leak leading to interstitial FO in the organs. FO is not only a consequence of fluid therapy but also occurs during severe sepsis secondary to the release of complement factors, cytokines and prostaglandin products and altered organ microcirculation.[5] FO recognition and assessment requires an accurate documentation of intakes and outputs; yet, there is a wide difference in how it is evaluated, reviewed and utilized. Fluid balance can be calculated on a daily basis or on cumulative basis. Daily fluid balance refers to the distribution of all fluid intake and output in one single day, together with insensible water losses (IWL). The accumulative fluid balance refers to fluid balance over a period of time. The percentage of fluid accumulation can be calculated from the cumulative fluid balance divided by body weight when the patient enters the intensive care unit, using the formula developed by Goldstein et al.[6]

Fluid overload among critically ill patients and its relationship with various organ dysfunctions have been studied recently of which one of the important organ dysfunction is AKI. AKI commonly occurs in critically ill patients in the Pediatric Intensive Care Unit (PICU). Fluid balance in critically ill patients at risk for or with AKI remains controversial.[7] The overall volume balance may play a pivotal role in the development of, and outcome from, AKI. In keeping with the spectrum of changes seen in AKI, a diagnostic classification scheme was developed known by the acronym RIFLE, where each letter means a level of severity of AKI (R = Risk of renal dysfunction, I = Injury to the kidney, F= Failure of kidney function, L= Loss of function, E= End-stage kidney disease).[8] A pediatric modification of this criteria came into use for being applicable to children known as pRIFLE criteria, which is based on the estimated creatinine clearance(eCCl) and/or urine output.

The relationship between FO and AKI has been understudied and needs further exploration. The factors which may affect development of fluid overload in children with AKI have been sparsely studied. Keeping in view, all these issues, this cross-sectional study was undertaken to study the factors associated with FO in critically ill children with AKI in the PICU.

Materials and Methods

This was a prospective observational and analytical study conducted at the 7 bedded Pediatric Intensive

Care Unit (PICU) of Department of Pediatrics, Veer Surendra Sai Institute of Medical Sciences and Research (VSSIMSAR), Burla, which is a 750-bedded tertiary care centre of Western Odisha after getting approval from institutional ethics committee. This study spanned over a period of two years from December of 2015 to November of 2017 out of which first one year was dedicated for data collection and subsequent year for data analysis and interpretation. The inclusion criteria being all the critically ill patients admitted for 24 hrs or more in the PICU falling in the age group of 1 completed month to 14 completed years having AKI (as defined by pRIFLE criteria). All patients with chronic kidney disease, whether on dialysis or not were excluded along with all patients admitted with acute on chronic renal failure. As per the previous admission records of our PICU, it was observed that the prevalence of AKI in our PICU was around 10% among critically ill patients. Based on this data and with an absolute precision of 5% and with a confidence interval (CI) of 95%, the needed sample size was calculated to be 139 using n Master v2 (BRTC, Bagayam, CMC, Vellore). A total number of 590 patients were admitted to the PICU of VSSIMSAR within a period of one year from December of 2015 to November of 2016. As per the predesigned inclusion and exclusion criteria, total 154 children were enrolled for this study out of which parents of 14 children did not give their consent. Systematic random sampling technique was applied for selection of study subjects. The target population here and the study population both are the same, being those children who satisfied the inclusion criteria.

The study variables were age (continuous), sex (categorical), body weight (continuous) at the time of admission to PICU, stages of AKI (categorical) and duration of hospitalisation (continuous). The outcome variable was fluid overload [FO] (categorical). Here age (in years), sex, body weight (in kgs) and duration of hospitalisation (in days) of the children were recorded from the patient admission case tickets in a prescribed case proforma. Duration of hospitalisation was taken to be the time (in days) spent by the patient since the day of admission to PICU till discharge from PICU or death whichever was earlier. The stages of AKI were assigned using pRIFLE criteria to each study subject based on the estimated creatinine clearance and/or urine output. The estimated creatinine clearance (eCCl) was calculated using Cockcroft and Gault formula. Monitoring of the fluid balance was done by calculation and recording of the daily fluid intake and daily fluid output. Fluid Intake included the amount of fluid that entered the body orally or by intravenous infusion. Fluid Intake included all medication and fluids taken orally, medication and fluids given intravenously even intravenous flushes, and all fluids administered via any other tube including blood and blood products. Fluid output included the amount of fluid that leaves the body by means of urine, drainage, blood loss, vomitus, stools and nasogastric tube secretions. Insensible losses could not be taken into account. Fluid intake and output prior to PICU admission were not available due to practical constraints. Fluid overload percentage was calculated using the formula: Fluid overload (FO) % = [{Total fluid in (in ltrs) – Total fluid out (in ltrs)}/Admission body weight (in kgs) X 100].[6] A $FO_{\geq 10\%}$ was considered as significant fluid overload.[9]

Various parametric tests like chi-square test, independent t test, one-way ANOVA were done by using SPSS v24(IBM, New York). The p-value if less than 0.05 was considered as statistically significant.

Results

The age of all children was categorised into two age groups – a) age less than 10 years and b) age more than 10 years for chi-square analysis (Table 1). The association between age group and $FO_{\geq 10\%}$ is significant as evidenced by Pearson chi-square = 5.081(1), p = 0.024. The strength of this association is however weak as evidenced by phi = 0.190, p = 0.024. The occurrence of $FO_{\geq 10\%}$ in male children (75.3%) is significantly higher than that in case of females (58.8%) as evidenced by Pearson chi-square =4.13(1), p = 0.04 (Table 2). The strength of this association is however weak as evidenced by phi = -0.172, p = 0.042. The mean duration of hospitalisation in days in children with $FO_{\geq 10\%}$ is significantly higher (5.34 ± 1.45) when compared to children without fluid overload (3.93 ± 1.17) as evidenced by t = 5.613(138, 98.50), p = 0.000. There is no statistically significant difference in mean duration of hospitalisation in days between three stages of AKI (Risk, Injury, Failure) as evidenced by F = 0.428 (2,137), p = 0.653. After doing Tukey's post hoc analysis, it is found that there is no significant relationship in mean duration of hospitalisation in days within three stages of AKI (Risk, Injury and Failure). The association of $FO_{\geq 10\%\ \text{between}}$ three stages of AKI (Risk, Injury, Failure) is significant as evidenced by Pearson chi-square = 74.324(2), p = 0.000. The strength of this association is strong as evidenced by Cramer's V = 0.73, p = 0.000.

Table 1

Variable		Frequency % (n)	Variable	Mean (SD)
Age	< 10 years	28(39)	Age (in years)	8.3 (2.05)
	> 10 years	72(101)	Duration of Hospitalization (in days)	4.9 (1.51)
Sex	Male	64(89)		
	Female	36(51)		
FO	≥10%	69(97)		
	< 10%	31(43)		
Stages of AKI	Risk	30(42)		
	Injury	39(54)		
	Failure	31(44)		

Table 2: Association of sex of patients & fluid overload

		Fluid overload		Total
		< 10%	≥10%	
Sex of patients	Male	22 (24.7%)	67 (75.3%)	89
	Female	21 (41.2%)	30 (58.8%)	51
Total		43 (30.7%)	97 (69.3%)	140

Discussion

There are few pre-existing supportive data regarding fluid overload among patients who are critically ill and have AKI; and judicious fluid management does play a vital role in their prognosis.[10] This data is mostly from studies based on adult age group and there are only few studies belonging to the pediatric age group. A study done in the United Kingdom suggested that every 1 in 5 patients may have deleterious effects due to inadvertent fluid therapy.[11] In our study 1 in 11 have the deleterious effects due to fluid overload. A recent systematic review and meta-analysis studied the association between fluid overload and renal outcome in patients with AKI with 12 cohort studies published from 2008 to 2014 with a total of 5095 study subjects which found no significant association between fluid overload and kidney recovery (OR: 0.66; 95%CI 0.37-1.15).[12] In our study, there is a significant and strong association of $FO_{\geq 10\%}$ between three stages of AKI (Risk, Injury, Failure). Another cohort study namely 'Program to Improve Care in Acute Renal Disease' (PICARD),[13] demonstrated that fluid overload >10% of hospital admission weight contributed to prolonged hospitalization. In our study, the mean duration of hospitalisation in days in children with $FO_{\geq 10\%}$ is significantly higher than that in children without fluid overload. No previous studies suggested any age or sex predilection for developing fluid overload in critically ill patients with AKI.

Our study limitations are limited target population because of which the results cannot be generalised to others, unknown fluid balance status prior to admission because of which we had to assume euvolemic at the time of admission, we had to ignore the insensible losses due to practical constraints and finally it is a single centre study.

Conclusion

From this study, we may conclude that the duration of hospitalisation in PICU does not alter with the various stages of AKI may it be Risk or Injury or Failure or in other words the stages of AKI does not affect the morbidity. So, we can say that the fluid balance status or fluid overload in the pre-ICU setting before getting admitted to PICU predicts the outcome here. So further future studies on this regarding fluid overload as a predictor of outcome irrespective of the AKI status of children needs to be encouraged.

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Author's Contribution

KP, SCM & NRM done study designing, NRM done data analysis, BKN done data validation. All the authors have done proof reading.

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