Scholars Journal of Applied Medical Sciences (SJAMS)
Abbreviated Key Title: Sch. J. App. Med. Sci.
©Scholars Academic and Scientific Publisher
A Unit of Scholars Academic and Scientific Society, India
www.saspublishers.com

ISSN 2320-6691 (Online)
ISSN 2347-954X (Print)

Pediatrics

To Study the Frequency and Outcome of AKI in Children Using Paediatric RIFLE Criteria

Dr. P. Srinivas[1], Dr. B.Koteshwar[2*], Dr. M. Venkat Kumarreddy[3], Dr. A.Aparna[4]
[1]Associate Professor of Pediatrics, Niloufer hospital, OMC, Hyderabad, Telangana, India
[2]Associate Professor of Pediatrics, Niloufer hospital, OMC, Hyderabad, Telangana, India
[3]Post graduate student of Pediatrics, Niloufer hospital, OMC, Hyderabad, Telangana, India
[4]Professor of Pediatrics, Niloufer hospital, OMC, Hyderabad, Telangana, India

Original Research Article

***Corresponding author**
Dr. B.Koteshwar

Article History
Received: 01.10.2018
Accepted: 09.10.2018
Published: 30.10.2018

DOI:
10.36347/sjams.2018.v06i10.036

Abstract: To study the frequency and outcome of AKI in children using paediatric rifle criteria. Prospective observational study. All children admitted in PICU over six months' period, from August 2016 to January 2017, in age group of >1 month to 13 years are taken as study group according to the inclusion criteria. All the children of the study group were assigned baseline creatinine clearance value of 100ml/min/1.73m^2. Creatinine clearance of every child is calculated by using Revised Schwartz formula. For children with deranged creatinine clearance at admission in to PICU or during stay in hospital, pRIFLE class is established. Maximum pRIFLE strata attained by children is documented, outcomes were noted and studied. Primary outcome (mortality) and secondary outcome (morbidity) is measured by Length of stay (LOS) in PICU. A total of 26 children of entire study population are dead (26/200, 13%).12 children with AKI are died (12/58, 20.68%). Death rate in children with AKI is 2.09 times more than Non AKI group. Deaths among AKI were analyzed, Of the Injury category 4 children died (4/18, 22.22%).6 children from failure category were dead (6/14, 42.85%). LOS in PICU in children with AKI group is high with a mean LOS of 7.89+/-3.49(95% CI of 0.91< 2-18>) compared to LOS of non AKI patients 4.34+/-1.86(95% CI of 0.30<1-12>).When LOS in hospital is evaluated AKI children had mean of 12.43+/-5.29(95% CI 1.39 <2-30>) compared to non AKI children 8.17+/-3.29(95% CI 0.54<1-30>), which is significant (P<0.05).. SCr and UOP seem to be late markers of renal injury, use of classification systems and other serum biomarkers are required to detect AKI earlier to prevent AKI in children prior to a rise in SCr concentration. 2. AKI had increased LOS in PICU, and increased mortality.

Keywords: AKI, LOS, PICU, pRIFLE.

INTRODUCTION

Acute renal failure is a frequent clinical complication in critical care that is constituted by an acute drop in renal function, with manifestations ranging from minimal elevation of serum creatinine concentration to Anuric renal failure. This dysfunction causes abnormal regulation of fluid, electrolytes, blood pressure and removal of waste products. In addition growing evidence shows that the kidneys play a key role in the development and regulation of inflammatory process which occurs in multi-organ failure [1]. Recognising the need for a more uniform definition, The Acute Dialysis Quality Initiative Group, has established a system for classification of acute renal failure severity. Through this work group, the term Acute Kidney Injury (AKI) was introduced, a newer classification system termed the RIFLE criteria was proposed for use in critically ill adult patients [2]. RIFLE (acronym for Risk, Injury, Failure, Loss of function, End stage renal disease) stratifies patients based on changes in serum creatinine (SCr) levels from base line and / or a decrease in urine output (Uop).

Prospective paediatric studies of AKI are limited. Ackan- Arikan et al developed a modified version of the RIFLE criteria called pRIFLE [3]. This criterion is based on a decrease in estimated creatinine clearance (eCCl) and in urine output based on weight.

The use of changes in function markers such as serum creatinine (SCr) is not ideal as SCr concentrations may not change until 25-50% of kidney function has already been lost and thus it may take a few days after an injury before a significant rise in SCr is seen [5,6]. At lower GFR, SCr will overestimate renal function due to tubular secretion of Creatinine. SCr varies by muscle mass, hydration status, sex, age, and gender and method of estimation [7]. Once a patient receives dialysis, SCr can no longer be used to assess kidney function because SCr is easily dialyzed.

Despite these concerns about definitions of AKI, SCr based classification definitions of AKI have allowed for valuable comparisons among different studies. Using these definitions many have shown that AKI is an independent predictor of mortality in critically ill children [8-10]. Even small changes in serum creatinine values which were previously ignored, are associated with poor outcomes [11, 12]. This present study is carried out to study the incidence and outcome of AKI in children admitted to PICU of our hospital.

Table1: PRIFLE classification [4]

Category	Estimated creatinine clearance	Urine output
Risk (R)	Decrease by 25%	<0.5 ml/kg/hr for 8hr
Injury (I)	Decrease by 50%	<0.5 ml/kg/hr for 16 hr
Failure (F)	Decrease by 75% or <35ml/min/1.73 m2	,0.3 ml/kg/hr for 24 hr or Anuric for 12 hr
Loss (L)	Loss of renal function >4 weeks	
End stage (E)	Persistent failure for >3 months	

Aims and objectives

To study the incidence and outcome (mortality and morbidity) of AKI in children by pRIFLE criteria

Study design

Prospective observational study

Study setting

PICU at Niloufer Hospital, Osmania Medical College, Hyderabad. Children aged >1 month to 13 years admitted into PICU as per hospital protocol are included in the study.

Study period: 6Months, from August 2016-January 2017

Sample size: 210 children

Inclusion criteria

All the children who were admitted to PICU as per the institute protocols during the study period

Exclusion criteria

Children Left Against Medical Advise. 2) Children, whose parents have not given consent. 3) Children with underlying Chronic Kidney Disease (CKD/ESRD).

Statistical analysis

Results are entered using Microsoft office Excel 2007. Statistical analysis was done using STATA 16.0 version. Continuous variables are expressed as mean (SD), Categorical variables as proportions (%). Continuous variables are compared using analysis of variance and Student's t-test. The outcomes examined are mortality, length of stay in PICU, Hospital, Requirement of Renal Replacement therapy. P value of <0.05 is considered significant.

Data collection

Informed consent was obtained from parents before start of the study. Anthropometry (Height/Length) of the study population was documented at the entry into PICU. All the children of the study were assigned baseline creatinine clearance value of 100 ml/min/1.73m2. Creatinine clearance of every child is calculated using Revised Schwartz estimate.

Revised Schwartz formula

Estimated Creatinine clearance = 0.413*Height(cm)/Serum Creatinine (mg/dl)

For children with deranged clearance of creatinine at admission in to PICU or during stay in hospital, PICU, pRIFLE class is established. Maximum pRIFLE strata attained by children is documented and outcomes were noted. Outcomes studied are 1.Primary outcome- Mortality, 2.Secondary outcome- LOS in PICU, Hospital, Requiring RRT.

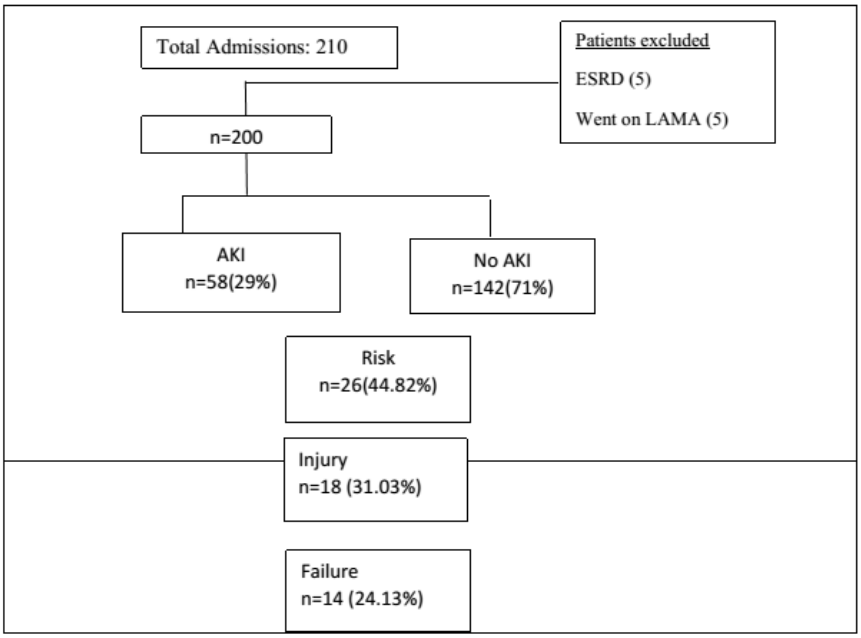
OBSERVATION AND RESULTS

A total of 210 children were studied during 6 months, of which 5 went on LAMA, 5 belong to ESRD, hence excluded from our study. 200 children were evaluated. 58 children had AKI by pRIFLE classification of AKI in children. Mean age group of children with AKI is 4.84+/-2.25 years (95% CI 0.59 range of 1-11). Mean age group of non AKI is 5.95+/-3.023 years (95% CI 0.50 range of 1-13). Children in AKI group are younger when compared to children from non AKI group (p 0.005).

Table-2: The admission diagnoses of all children included in the study were classified according to aetiology

Disease category	Total n=200 (100%)	AKI(n=58) (29%)	Non AKI n=142 (71%)
Respiratory	66(33)	14(24.1)	52(36.6)
Cardiovascular	54(27)	22(37.9)	32(22.5)
Sepsis/MODS/Shock	25 (12.5)	11(18.9)	14(9.9)
Neurologic	37(18.5)	8(13.7)	29(20.4)
Others	18(9)	3(5.1)	15(10.5)

Flow Diagram showing the distribution of AKI in study population



Acute Kidney Injury was diagnosed in 58(29%) children admitted in PICU using the pRIFLE score. Non AKI children are 142 (71%) out of 200 children. Out of 58 children with AKI, 26(44.82%) patients has reached the maximum pRIFLE strata of Risk (R), 18(31.03%) met the Injury criteria and 14(24.13%) met the Failure criteria.

Of the total of 58 children who developed AKI, 30(51.72%) children had AKI at admission by pRIFLE classification.

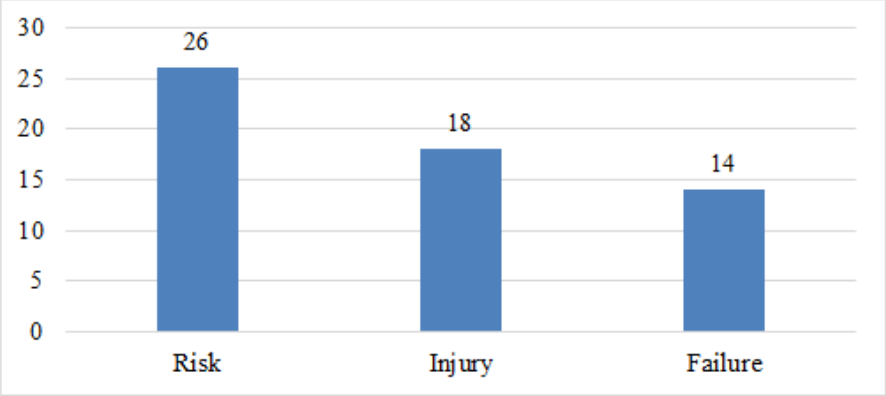


Diagram-1: Bar diagram showing pRIFLE strata

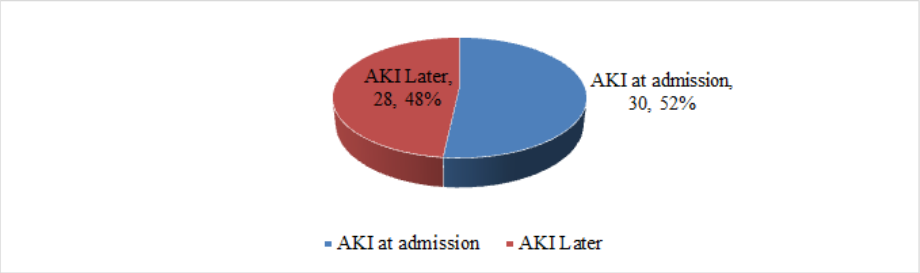


Diagram-2: Pie diagram showing AKI at admission and later

Of these 30 children with AKI at admission 14(46.66%), 9(30%), 7(23.33%) met the criteria for Risk, Injury, Failure respectively (Diagram-2).

15(50%) of this children who had AKI at admission were recovered within 48 hours (Early reversal) of admission into PICU. The remaining children who were not recovered were classified as children with persistent AKI (AKI present even after 48 hours) (Diagram-3).

Early reversal was more likely to occur in Risk group (8/14, 57.14%) than in Injury group (4/9, 44.44%) or Failure group (3/7, 23.33%).

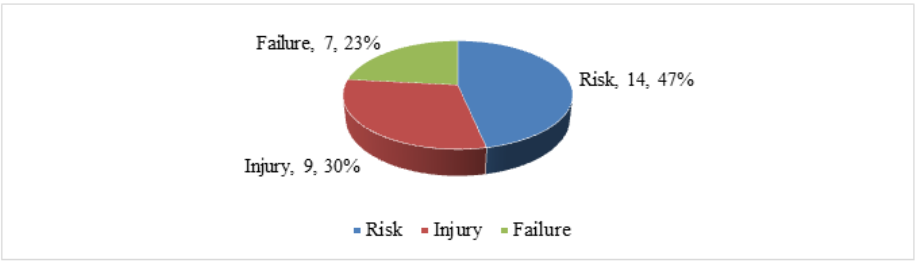


Diagram-3: Pie diagram showing AKI at admission

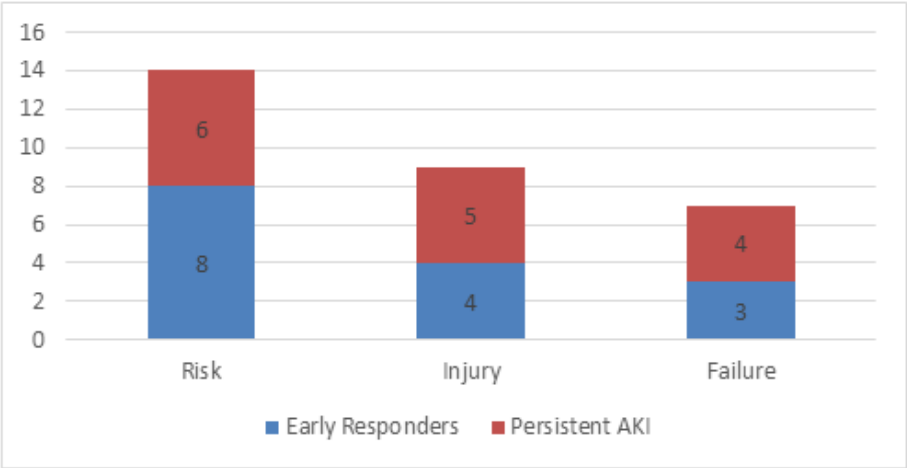


Diagram-4: Bar diagram showing early reversal

46(80% of 58) children developed AKI within 1 week of admission into PICU (including AKI at admission)

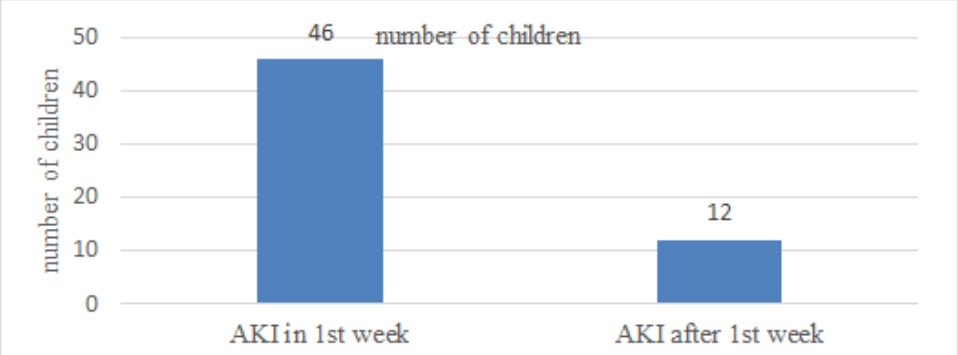


Diagram-5: Bar diagram comparing total number of children who developed AKI during 1st week of admission and children who developed AKI after 1st week:

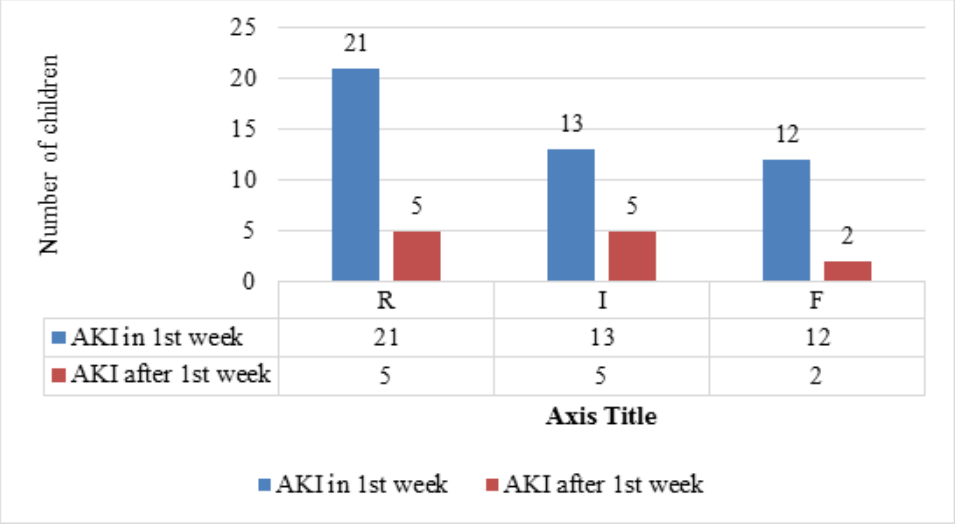


Diagram- 6: Bar chart (clustered column) showing distribution of occurrence of AKI in various strata

Mean length of stay (LOS) in PICU, Hospital in children with AKI is 7.89 (3.49) days, 12.43 (5.29) days respectively, whereas the mean LOS in PICU, Hospital in children without AKI is 4.34 (1.86) days, 8.17 (3.29) days respectively.

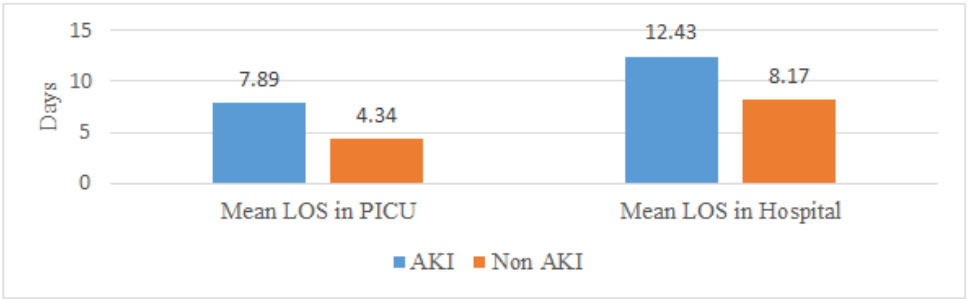


Diagram-7: Comparison of LOS in children with AKI and without AKI

OUTCOMES

Outcome of the study was evaluated as primary outcome (mortality) and secondary outcome (morbidity) which is measured by Length of stay in PICU, Hospital, Need for Renal Replacement Therapy).

A total of 26 children of entire study population were dead (26/200, 13%), 174 were alive (174/200, 87%).12 children with AKI are dead (12/58, 20.68%). The rest 14 dead children doesnot have renal failure during the study period.

Table-3: comparing deaths among children with and without AKI

	Total	Dead	% of Deaths
AKI	58	12	20.68%
Non AKI	142	14	9.85%

Death rate in children with AKI is 2.09 times more when compared to deaths in Non AKI group. When deaths among AKI were analysed, 2 children died (2/26, 7.69%) from the R group, 4 children died (4/18, 22.22%) from the injury category, 6 children died from Failure category (6/14, 42.85%). Of the total deaths (12) among children with AKI, 5 deaths occurred in children with AKI at admission (2 from injury group, 3 from Failure group). Of the Children who had AKI during the 1st week of admission into PICU (46), 11 were dead, 3 children required RRT. When the length of stay (LOS) in PICU was evaluated the children in AKI group had a mean LOS of 7.89+/-3.49(95% CI of 0.91< 2-18>) compared to LOS of non AKI patients 4.34+/-1.86(95% CI of 0.30<1-12>). Children in AKI group had significantly longer PICU LOS when compared to children without AKI (P=0.05).When LOS in hospital is evaluated AKI children had mean of 12.43+/-5.29(95% CI 1.39 <2-30>) compared to non AKI children 8.17+/-3.29(95% CI 0.54<1-30>). Children with kidney disease has a significantly longer length of stay in hospital as compared to children without AKI. (P<0.05).

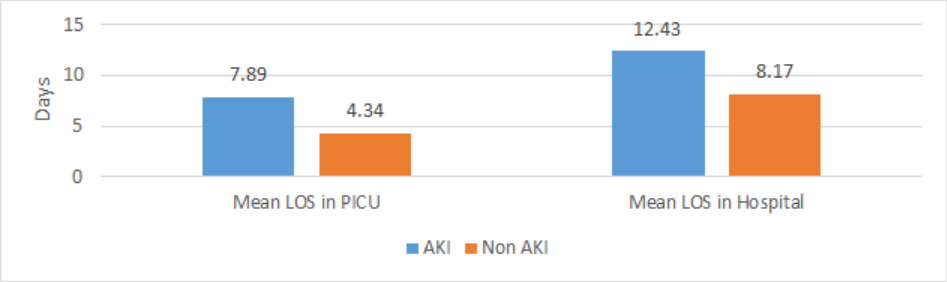


Diagram-8: Comparison of LOS in children with AKI and without AKI

DISCUSSION

This study attempts to study the incidence and the mortality, morbidity of children with AKI in a PICU set up. All categories of children with medical ailments (both ventilated and non-ventilated) are included in this study. The mean age of children with AKI is 4.84+/-2.25 in this study. When compared to children of Non AKI group (5.95+/-3.02), children with Kidney injury are younger in age (p=0.005).This is comparable to many paediatric studies on AKI in PICU.

Table-4: comparing the Mean age group of children across various studies:

	Shweta naik *et al.*[14]	Sheetal Gupta *et al.* [15]	Soler *et al.* [18]	Present study
Avg age AKI(SD)	2.35(3.24)Years	47.42(49.04)months	3.5(5.1) years	4.84(2.25)Years
Non AKI	3.95(4.04) years	53.48(57.15) months	8.4(5.8) years	5.95(3.02) years

Table-5: Incidence of AKI in various studies

	Mehta *et al.*[16]	Krishnamurthy *et al.* [17]	Soler *et al.*	Sheetal gupta *et al.*	Akcan-Arikan *et al.* [9]	This study
Incidence	38.1%	25.1%	27.4%	42.9%	82%	29%
Study population	PICU	PICU	PICU	PICU	PICU(Only mechanically ventilated children)	PICU

Incidence of AKI is 29% in this study. We have used baseline creatinine clearance value of 100 ml/min/1.73 m^2, the fall in creatinine clearance from baseline (e CCl is measured by revised Schwartz formula) was used to classify children into their respective p RIFLE strata, in defining AKI. Several studies from India and abroad have shown variable incidence ranging from 10% to 82% depending on the study population characteristics, base line creatinine clearance values. The differences in incidence of AKI is explained by the differences of the study population, Criteria used to define AKI, base line creatinine clearance used.

In the study of "Ascertainment and epidemiology of AKI varies with Definition Interpretation", Michael Zappitielli *et al.* has shown that incidence of AKI significantly varies when using different criteria. (12% if admission creatinine is used for baseline creatinine clearance versus 87.8% if norms

minimum is used, they have also shown that the incidence using Cr CL of 120ml/min/1.73m^2 is associated with higher incidence when compared to 100 ml/min/1.73 m^2). Hence it can be assumed that the incidence in the present study as calculated using baseline creatinine clearance of 100 ml/min/1.73m2, might underestimate the actual incidence. But since baseline creatinine value is not available for many of the children, we have used a uniform creatinine clearance for all children. It is likely that, children whose average creatinine clearance is less than 100 ml/min/1.73m^2, may be labelled as AKI as per this study. However many children in our study were older than 6months, for which group average GFR (a practically estimated by Cr CL) is above 100 ml/min/1.73m^2.

In this present study RIFLE classes were established using only the creatinine clearance values and Uop criteria for defining AKI is not used. In a study by Shweta naik *et al*. which is a retrospective study they have used only the creatinine clearance criteria for defining AKI as it was a retrospective study and urine output of children was not documented. They have used a baseline creatinine clearance value of 120ml/min/m^2 and have reported an incidence of 40.9%.

In the study of Soler *et al*, 89% of children with AKI, met the criteria based on e CCl (estimated creatinine clearance) while 11% met the criteria for AKI, using Uop criteria. In the study of Akcan-Arikan of the 123 children with AKI, 22(17.86 %) met the criteria for AKI based only on Uop criteria. 58(47.15%) met the criteria for AKI based only on creatinine clearance value. As per these details this study underestimates the incidence of AKI in children admitted to PICU.

The incidence of AKI diagnosed at admission in the present study is 51.72%, which is comparable to the admission incidence of AKI in the study of Sheetal gupta *et al*. (50%), 56.66% in the study of Frans B. plotz *et al*. in their study of paediatric AKI in ICU.

Table-6: Comparison of Incidence of AKI during 1st week across studies:

Shweta naik *et al*.[14]	Bailey *et al*.[22]	Schneider *et al* [10]	Sheetal gupta *et al.* [15]	Present study
90.2% within 72 hours	84% at admission	75% by 1st week	90.4% in 72 hours	85.71% in 1st week

This data also support previous paediatric studies demonstrating that children develop their maximum number of organ failures early in the ICU course, unlike the observation in adult patients who develop organ dysfunction late [13].

Table-7: Comparison of Severity grading of AKI across studies

pRIFLE class	Tina Palmieri *et al*. [20]	Soler *et al.*	Sheetal Gupta *et al*.	Ackan-Arikan	Present study
R	32%	42.5%	49.1%	48.78%	44.82%
I	50%	37.0%	29.5%	26.01%	31.03%
F	18%	20.5%	21.3%	25.20%	24.13%

This study has shown the severity grading of AKI as R (44.82%, n=26), I as (31.03%, n=18), F (24.13%, n=14). It is showing that many children with AKI are falling into R strata. This distribution is comparable with many studies.

Table-8: Comparison of results of AKI at admission

	Ackan-Arikan		Present study	
pRIFLE	Total	Early responders	Total	Early responders
R	16	10(62.5%)	14	8(57.1%)
I	21	8(38.1%)	9	4(44.44%)
F	15	4(26.7%)	7	3(42.85%)

Of the children with AKI at admission (n=30), the maximum number of children belong to R (46.66%, n=14), followed by I (30%, n=9), followed by F (23.33%, n=7). Of these children with AKI at admission, 15 (50%) children recovered from AKI within 48 hours. These children are labelled as Early Reversal (ER). Those children who were having AKI even after 48 hours are labelled as Persistent AKI. In the study by Ackan –Arikan AKI at admission was categorised as R (30.08%), I (40.4%), F (28.8%).

It is clear from above table that number of Persistent AKI increases as the RIFLE class increases. This classification of AKI into early reversal and persistent AKI is significant in that, children with pre renal azotaemia, where there is no significant damage to kidney recovers quickly with appropriate fluid

management. The remaining children who went into Persistent AKI can be assumed as suffered greater kidney injury due to prolonged hypoxia (ATN). This assumption is supported by the results, that children in R group had maximum early reversal (57.1%).

Table-9: Comparison of percentage of children dead with and without AKI across various studies

Study	Percentage children dead		
	AKI	Non AKI	Ratio
Soler *et al*.	12.3%	6.2%	1.98
Frans B. plotz [19]	25%	5%	5
Sheetal Gupta *et al*.	46.03%	18.62%	2.47
Shweta naik *et al*.	16%	8.2%	1.95
Present study	20.68%	9.85%	2.09

Total 26 (13%) children are dead in the entire study population. Mortality among AKI (n=12, 20.68%) is clearly more, when compared to mortality among non AKI children (n=14, 9.85%). Various studies have documented such correlation when regression analysis was not done. In the study by Frans B. plotz, mortality in AKI (25%) is documented as 5 times higher when compared to mortality in non-AKI (5%). Such correlation of higher mortality was noticed in studies by Soler *et al*. Ackan-Arikan *et al*. etc.

This table shows that the crude mortality in children with AKI is more compared to non AKI children. The death rate in children with AKI is 2.09 times that of death rate in children without AKI. However when adjusted for Age and Disease characteristics, many studies have failed to show a significant correlation.

Table-10: Mortality % among various study groups when analysed for p RIFLE class

Study	R	I	F
Shweta naik *et al*.	5.1%	16.2%	29.6%
Sheetal gupta *et al*.	31.19%	53.03%	77.08%
Ostermann *et al*.[21]	20.90%	45.61%	56.80%
Present study	7.69%	22.22%	42.85%

When deaths among different RIFLE classes were compared class F (n=6, 42.85%) has shown a significantly high death rates than I(n=4, 22.22%), R (n=2, 7.69%).It is clearly evident from above contingent table that, as the pRIFLE class increases the rate of deaths increases. This correlation was significant in few studies, but there is a definite linear correlation.

When all the deaths in AKI group are analysed to time of occurrence of AKI, 11(91.66%) deaths occurred in children with AKI onset during the 1st week of admission.

Table-11: Comparing the LOS in PICU across various studies

Study	Length of stay in PICU(SD) days	
	AKI	Non-AKI
Ackan-Arikan et al.	18(24.3)	10.1(6.2)
Shweta Naik et al.	3	2
Sheetal Gupta	4.75(1.99)	3.75(2.06)
Present study	7.89(3.49)	4.38(1.86)

Length of stay in PICU of children with kidney failure as per the present study is 7.89 days (3.49), compared to length of stay of children without AKI 4.38 days (1.86).

From the above table it is evident that Children with AKI have longer PICU LOS when compared to children without AKI and the present study shows the same (p=0.005). The length of stay in PICU in Akan-Arikan is significantly higher when compared to other study groups because all the children in this study group are mechanically ventilated and may be very ill when compared to children from other groups.

The LOS of children with AKI in present study is 12.41(5.29) days, and is longer significantly when compared to hospital LOS of Non AKI children 8.17(3.29) days. ($p<0.05$). Review of other studies also shows the same. In the present study 3 children required RRT (Renal replacement therapy). The decision for Renal Replacement therapy is taken by Nephrologist. Requirement for RRT is not based on deranged creatinine values, but is made on clinical grounds. 2 children from Injury group and 1 child from Failure group required RRT. All three children had peritoneal dialysis and all are recovered. These three children had AKI at admission. It was seen in many studies, that the

requirement for RRT will be higher for children with AKI at admission, and children who developed AKI after 1st week rarely required RRT.

Table-12: Comparing the LOS in Hospital across various studies

Study	Length of stay in Hospital(SD) days	
	AKI	Non-AKI
Ackan-Arikan et al.	36.61(40.1)	20.5(16.6)
Shweta Naik et al.	8	6
Sheetal Gupta	9.15(3.11)	6.63(2.38)
Present study	12.41(5.29)	8.17(3.29)

CONCLUSIONS

- AKI classification and stratification systems such as p RIFLE can serve well in early detection of kidney injury by the small change in serum creatinine concentration.
- As SCr and Uop seem to be late markers of renal injury, use of classification systems will be essential to assess the potential utility of urine and other serum biomarkers to detect AKI earlier and direct therapies to prevent AKI in children prior to a rise in SCr concentration.
- Through this prospective study, it is clear that children with AKI had increased LOS in PICU, Hospital and increased mortality. Implementation of p RIFLE scoring in every PICU admission may provide clinicians with an additional tool to develop preventive and early therapeutic interventions in critically ill children at risk of AKI.

LIMITATIONS OF THE STUDY

- A potential limitation of this study is that it assumes a baseline creatinine clearance of 100ml/min/1.73m2. This could lead to increased incidence of AKI in infants by Schwartz formula.
- The predictors of mortality are not identified in this study.

REFERENCES

1. Liu M, Liang Y, Chigurupati S, Lathia JD, Pletnikov M, Sun Z, Crow M, Ross CA, Mattson MP, Rabb H. Acute kidney injury leads to inflammation and functional changes in the brain. Journal of the American Society of Nephrology. 2008 Jul 1;19(7):1360-70.
2. Bellomo R, Ronco C, Kellum JA, Mehta RL. Acute renal failure-definition, outcome measures, animal models, fluid therapy and information technology needs: the second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. Crit Care. 2004 Aug;8(4):R204-12.
3. Akcan-Arikan A, Zappitelli M, Loftis LL, Washburn KK, Jefferson LS, Goldstein SL. Modified RIFLE criteria in critically ill children with acute kidney injury. Kidney international. 2007 May 2;71(10):1028-35.
4. Nelson textbook of pediatrics 20th edition. Page no. 2539. Table no.535-1.
5. Brion LP, Fleischman AR, Schwartz GJ. A simple estimate of glomerular filtration rate in low birth weight infants during the first year of life: noninvasive assessment of body composition and growth. J Pediatr.1986 Oct; 109(4):698-707.
6. Nelson textbook of pediatrics 20th edition. Page no. 2491. Chapter 508.2 Glomerular Filtration
7. Rajs G, Mayer M. Oxidation markedly reduces bilirubin interference in the Jaffe creatinine assay. Clin Chem. 1992 Dec;38(12):2411-3.
8. Chertow GM, Levy EM, Hammermeister KE, Grover F, Daley J. Independent Association between Acute Renal Failure and Mortality following Cardiac Surgery 12. The American journal of medicine. 1998 Apr 1;104(4):343-8.
9. Akcan-Arikan A, Zappitelli M, Loftis LL, Washburn KK, Jefferson LS, Goldstein SL. Modified RIFLE criteria in critically ill children with acute kidney injury. Kidney international. 2007 May 2;71(10):1028-35.
10. Schneider J, Khemani R, Grushkin C, Bart R. Serum creatinine as stratified in the RIFLE score for acute kidney injury is associated with mortality and length of stay for children in the pediatric intensive care unit. Critical care medicine. 2010 Mar 1;38(3):933-9.
11. Zappitelli M, Bernier PL, Saczkowski RS, Tchervenkov CI, Gottesman R, Dancea A, Hyder A, Alkandari O. A small post-operative rise in serum creatinine predicts acute kidney injury in children undergoing cardiac surgery. Kidney international. 2009 Oct 2;76(8):885-92.
12. Portilla D, Dent C, Sugaya T, Nagothu KK, Kundi I, Moore P, Noiri E, Devarajan P. Liver fatty acid-binding protein as a biomarker of acute kidney injury after cardiac surgery. Kidney international. 2008 Feb 2;73(4):465-72.
13. Lassnigg A, Schmid ER, Hiesmayr M, Falk C, Druml W, Bauer P, Schmidlin D. Impact of minimal increases in serum creatinine on outcome in patients after cardiothoracic surgery: do we have to revise current definitions of acute renal failure?. Critical care medicine. 2008 Apr 1;36(4):1129-37.
14. Basu RK, Devarajan P, Wong H, Wheeler DS. An update and review of acute kidney injury in pediatrics. Pediatric Critical Care Medicine. 2011 May 1;12(3):339-47.

15. Naik S, Sharma J, Yengkom R, Kalrao V, Mulay A. Acute kidney injury in critically ill children: Risk factors and outcomes. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2014 Mar;18(3):129.
16. Gupta S, Sengar GS, Meti PK, Lahoti A, Beniwal M, Kumawat M. Acute kidney injury in pediatric intensive care unit: incidence, risk factors, and outcome. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2016 Sep;20(9):526.
17. Mehta P, Sinha A, Sami A, Hari P, Kalaivani M, Gulati A, Kabra M, Kabra SK, Lodha R, Bagga A. Incidence of acute kidney injury in hospitalized children. Indian pediatrics. 2012; 49(7):537-42.
18. Krishnamurthy S, Mondal N, Narayanan P, Biswal N, Srinivasan S, Soundravally R. Incidence and etiology of acute kidney injury in Southern India. Indian J Pediatr. 2013;80:183–9.
19. Soler YA, Nieves-Plaza M, Prieto M, García-De Jesús R, Suárez-Rivera M. pRIFLE (Pediatric Risk, Injury, Failure, Loss, End Stage Renal Disease) score identifies Acute Kidney Injury and predicts mortality in critically ill children: a prospective study. Pediatric critical care medicine: a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies. 2013 May;14(4):e189.
20. Plötz FB, Bouma AB, van Wijk JA, Kneyber MC, Bökenkamp A. Pediatric acute kidney injury in the ICU: an independent evaluation of pRIFLE criteria. Intensive care medicine. 2008 Sep 1;34(9):1713-7.
21. Palmieri T, Lavrentieva A, Greenhalgh DG. Acute kidney injury in critically ill burn patients. Risk factors, progression and impact on mortality. Burns. 2010 Mar 1;36(2):205-11.
22. Ostermann M, Chang RW. Acute kidney injury in the intensive care unit according to RIFLE. Critical care medicine. 2007 Aug 1;35(8):1837-43.
23. Bailey D, Phan V, Litalien C, Ducruet T, Mérouani A, Lacroix J, Gauvin F. Risk factors of acute renal failure in critically ill children: A prospective descriptive epidemiological study. Pediatric Critical Care Medicine. 2007 Jan 1;8(1):29-35.