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Prevalence of acute renal failure in pediatrics admitted to the emergency department

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ABSTRACT

Introduction: Causes of acute renal failure in children vary in developed and developing countries. Prevention plays an important role in reducing the complications of acute renal failure (ARF), while changes in fluid therapy management and infection control can reduce the incidence and severity of renal failure.

Objectives: The aim of this study was to investigate the prevalence and causes of ARF in children.

Patients and Methods: A prospective descriptive-analytical study was conducted in Ali-Ibn-Abitaleb hospital in Zahedan during a period of one year from April to March 2017 in patients aged one month to 15 years who were admitted to the pediatric emergency department.

Results: Among 201 patients with acute kidney injury (AKI), the highest number was 112 patients (28.3%) between one month and one year, followed by 80 patients (7.9%), one year to five years, and 9 patients (3.1%) above 5 years. Gender did not play a significant role in the development of acute kidney disease. The most common causes of AKI were sepsis (87.2%), underlying renal disease (64.9%), heart disease (37.5%), and gastrointestinal disease (19.5%), respectively. The most common laboratory findings in patients with AKI were hypokalemia (56.7%) and hypernatremia (57.1%).

Conclusion: ARF is one of the most problems in medical system, but its exact cause is not well established. Knowing ARF epidemiology by standard definitions can help to measure high-risk pediatrics, as the first step for treatment and improving outcomes. A future study may benefit from better identification of risk factors and early detection of AKI using novel biomarkers to prevent the progression of AKI.

Implication for health policy/practice/research/medical education:
This prospective descriptive-analytical study was designed for determining the causes of ARF in children. Among 201 patients with AKI, the most common causes of AKI were sepsis, underlying renal disease, heart disease, and gastrointestinal disease, respectively.

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Introduction

Acute renal failure (ARF) is characterized by a reversible increase in blood creatinine and urea concentrations due to the inability of the kidney to properly regulate fluids and electrolyte homeostasis (1,2). ARF is a common clinical condition among patients admitted to hospitals. The condition is associated with both increased short-term and long-term mortality. With the development of a standardized definition for acute kidney injury (AKI) and the acknowledgment of the impact of AKI on patient outcomes, there has been increased recognition of AKI (3). ARF is divided into three groups; pre-renal, renal and post-renal ARF (4).

Worldwide epidemiological data on AKI are indeed limited, as most studies in children are from developed countries (5-7), while available data from developing countries, especially most Asian countries, are scarce (8,9).

Causes of ARF in children vary in developed and developing countries. In some countries, such as Argentina, the leading cause of ARF in children is uremic hemolytic

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syndrome. In most developing countries, despite acute control of diarrhea due to gastroenteritis, acute tubular necrosis due to dehydration is still a major cause (10). Children with ARF are variable and depend entirely on the nature of the underlying disease process rather than on renal failure itself. The prognosis for improved kidney function also depends on the disorder that caused the ARF (4). Given the high cost of advanced treatments such as hemodialysis in developing countries, prevention seems to play an important role in reducing the complications of ARF and changes in fluid therapy management and infection control can reduce the incidence and severity of renal failure.

Objectives

The aim of this study was to investigate the prevalence and causes of ARF in children.

Patients and Methods

Study design

This prospective descriptive analytical study in Ali-Ibn-Abitaleb hospital, belonging to Zahedan University of Medical Sciences in the southeastern region of Iran, after approval by the ethics committee of the university and obtaining informed consent from patients' parents during one year period was conducted from April 2017 to March. We enrolled all patients aged one month to 15 years who were admitted to the pediatric emergency department of Ali-Ibn-Abitaleb hospital and patients who had kidney failure criteria and did not have exclusion criteria were included in the case group and other patients in the control group (Figure 1). Patients with chronic renal failure and congenital kidney disease were excluded from this study. The degree of ARF was determined based on acute kidney injury network (AKIN) criteria as follows:

- *Stage 1:* 1.5-fold increase in serum creatinine relative to baseline
- *Stage 2:* doubling of serum creatinine compared to baseline values
- *Stage 3:* 3-fold increase in serum creatinine compared to baseline

Normal creatinine was considered 0.2-0.4 mg/dL for one month to one year, 0.3-0.7 mg/dL for 1 to 12 years and 0.5-1 mg/dL for age over 12 years.

The required information was obtained through history, clinical examinations and laboratory tests. During hospitalization, patients were evaluated for their general condition, blood pressure, urine volume, and edema and consider in one of three stages according to AKIN criteria. Patients were followed up until discharge and their final diagnosis was recorded. All patient information in both case and control groups including age, gender, creatinine (Cr), Na, K stage of renal failure and final diagnosis were recorded in information forms.

Data analysis

Data were analyzed by SPSS software version 21 and the results were expressed as mean, percentage and standard deviation and all demographic and laboratory information were compared and analyzed between the two groups of ARF and non-ARF (P value < 0.05).

Results

In the present study, out of 1889 children admitted to the pediatric emergency department of Zahedan teaching hospital in a period of one year, 1502 (79.5% of the total patients) patients were treated with a diagnosis other than kidney disease and were taken as the control group. Of these, 387 (20.5% of all patients) were treated for kidney failure. Among patients diagnosed with renal failure, 186 (48% of all patients diagnosed with renal failure) were excluded from the study with chronic kidney disease and congenital kidney disease and 201 (52% of all patients diagnosed with renal failure) patients were diagnosed with AKI as a case group (Figure 1).

To facilitate the work, patients were classified into age groups of one month to one year, one year to five years and over 5 years. Among 201 patients with AKI, the highest

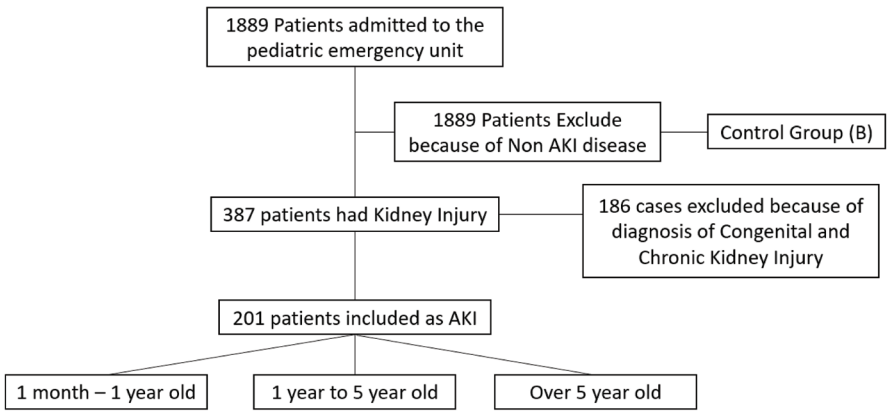

Figure 1. Patient's Selection Steps.

number was 112 patients (28.3%) between one month and one year, followed by 80 patients (7.9%), one year to 5 years, and 9 patients (3.1%) above 5 years. As can be seen, the percentage of patients is calculated based on each age group. In the two groups of one month to one year and one year to 5 years, the highest number of patients were in the second stage of the disease, which included 51 (56.04%) and 37 cases (40.66%), respectively. In the age group over five years, the highest number of patients in the third stage was four cases (5.48%) (P <0.005).

Of the total patients, 757 were male and 946 were female. Among men, 103 patients (13.6%) had AKI and among women, 98 patients (10.4%) had AKI. Comparison of the number and percentage of the two groups shows that gender did not play a significant role in the development of acute kidney disease (P value <0.005). The highest number of infected men (44 cases; 48.35%) and the highest number of infected women (47%-51.65%) were in the second stage (P <0.005).

To investigate the causes and etiology of acute kidney disease in the studied patients, diseases were classified as heart, hematological, neurological, renal, sepsis, respiratory, gastrointestinal and other diseases. It was observed that out of 12 hematological patients, all of them (100%) had AKI and therefore were not evaluated in the final conclusion because the information and results were not distorted. The most common causes of AKI are calculated according to OR and include sepsis (87.2%), underlying renal disease (64.9%), heart disease (37.5%) and gastrointestinal diseases (19.5%), respectively (P < 0.005). Most patients in cardiac (5.49%), hematological (6.59%), neurological (8.79%), sepsis (18.68%) and gastrointestinal (38.46%) groups were in the second stage of the disease and most of the patients with congenital renal disease (34.25%) and respiratory disease (4.11%) were in the third stage of the disease (CI: 95% and P < 0.005).

In the study of laboratory findings, the most common laboratory findings in patients with AKI were hypokalemia (56.7%) and hypernatremia (57.1%; P < 0.005). All the data presented above are summarized in Tables 1 and 2.

Discussion

This article is one of the most important articles in the field of kidney diseases and in the field of etiology and laboratory findings of AKI patients in Iran. In this study, the incidence of AKI in the population of high-risk children aged one month to 15 years in the southeastern region of Iran, as one of the main medical centers in the country, was about 11.8% (with 95% confidence interval) compared to other regions. The world has a lower incidence; therefore in several studies, the range of 3 to 60% for the incidence of the disease in different parts of the world has been noted (11,12). So far, no study has been conducted in this region of the country to see the difference in the incidence of this disease between different years.

In our study, all 12 hematological patients admitted to the emergency department had AKI and we did not have any

Table 1. Demographics, disease and laboratory findings of AKI and non-AKI hospitalizations

Factor		AKI (%)	Non AKI (%)	*P* value	Univariate unadjusted OR (95% CI)	*P* value	Multivariate adjusted OR (95% CI)
Age	1 month-1 year	112 (28.3)	284 (71.7)	-	1.0	-	1.0
	1-5 years	80 (7.9)	936 (92.1)	0.000	**0.217 (0.158, 0.297)**	0.000	**0.244 (0.144, 0.414)**
	>5 years	9 (3.1)	282 (96.9)	0.000	**0.081 (0.040, 0.163)**	0.000	**0.099 (0.037, 0.264)**
Gender	Male	103 (13.6)	654 (86.4)	-	1.0	-	1.0
	Female	98 (10.4)	848 (89.6)	0.040	**0.734 (0.546, 0.985)**	0.002	**0.479 (0.303, 0.758)**
Disease	Heart	6 (37.5)	10 (62.5)	-	1.0	-	1.0
	Hematologic	12 (100)	0 (0)	0.999	2.692E9 (0.000,-)	0.998	2.503E9 (0.000, -)
	Neurologic	10 (2.3)	423 (97.7)	0.000	**0.039 (0.012, 0.130)**	0.008	**0.128 (0.028, 0.588)**
	Renal	48 (64.9)	26 (35.1)	0.049	**3.077 (1.005, 9.421)**	0.000	**14.933 (3.463, 64.391)**
	Sepsis	34 (87.2)	5 (12.8)	0.001	**11.333 (2.850, 45.070)**	0.000	**5.494 (1.036, 29.130)**
	Respiratory	5 (9)	531 (99.1)	0.000	**0.016 (0.004, 0.060)**	0.000	**0.022 (0.004, 0.108)**
	Gastrointestinal	74 (19.5)	306 (80.5)	0.088	0.403 (0.142, 1.144)	0.000	**1.246 (0.327, 4.744)**
	Other	12 (5.6)	201 (94.4)	0.000	**0.100 (0.031, 0.320)**	0.000	**0.661 (0.149, 2.937)**
K	Hypokalemia	38 (56.7)	29 (43.3)	0.000	**14.089 (8.419, 23.577)**	0.000	**8.381 (3.803, 18.468)**
	Normal	133 8.5)	1430 (91.5)	-	1.0	-	1.0
	Hyperkalemia	30 (41.1)	43 (58.9)	0.000	**7.501 (4.555, 12.355)**	0.002	**3.979 (1.637, 9.673)**
Na	Hyponatremia	24 (40.7)	35 (59.3)	0.000	**8.334 (4.796, 14.482)**	0.000	**20.798 (7.720, 56.033)**
	Normal	117 (7.6)	1422 (92.4)	-	1.0	-	1.0
	Hypernatremia	60 (57.1)	45 (42.9)	0.000	**16.205 (10.541, 24.912)**	0.000	**9.233 (4.464, 9.673)**

OR: odds ratio; CI: confidence interval; AKI: acute kidney injury.
Significant values are bolded (significant at the level of P < 0.005).

Table 2. Demographics, disease and laboratory findings of AKI and non-AKI hospitalizations based on disease stages

Factor		Stage I (The reference category)			Stage II			StageIII		
		Frequency	P value	Multinomial Adjusted OR (95%CI)	Frequency	*P* value	Multinomial Adjusted OR (95% CI)	Frequency	*P* value	Multinomial Adjusted OR (95% CI)
Age	1m-1Y	13 (35.14)	-	1.0	51 (56.04)	-	1.0	48 (65.75)	-	1.0
	1-5Y	22 (59.46)	-	1.0	37 (40.66)	**<0.001**	**16.880 (5.208, 54.715)**	21 (28.77)	**0.000**	**11.915 (4.240, 33.484)**
	5Y<	2 (5.41)	-	1.0	3 (3.30)	**0.030**	**3.176 (1.137, 12.142)**	4 (5.48)	0.404	1.582 (0.538, 4.646)
Gender	Male	18 (48.65)	-	1.0	44 (48.35)	-	1.0	41 (56.16)	-	1.0
	Female	19 (51.35)	-	1.0	47 (51.65)	0.370	1.214 (0.795, 1.854)	32 (43.84)	**0.036**	**1.661 (1.035, 2.667)**
Disease	Heart	0 (0.00)	-	1.0	5 (5.49)	-	1.0	1 (1.37)	-	1.0
	Hematologic	5 (13.51)	-	1.0	6 (6.59)	**<0.001**	**4.416e-9 (2.849e-10, 6.844 e-8)**	1 (1.37)	**0.000**	**7.808e-9 (6.569e-10, 9.281e-8)**
	Neurologic	1 (2.70)	-	1.0	8 (8.79)	**<0.001**	**4.499e-8 (1.964e-9, 1.272 e-6)**	1 (1.37)	**0.000**	**1.017e-7 (4.903e-9, 2.111e-6)**
	Renal	14 (37.84)	-	1.0	9 (9.89)	**<0.001**	**2.605e-9 (2.119e-10, 3.202 e-8)**	25 (34.25)	**0.000**	**6.932e-8 (2.287e-8, 2.101e-7)**
	Sepsis	4 (10.81)	-	1.0	17 (18.68)	**<0.001**	**1.489e-8 (1.081e-9, 2.052 e-6)**	13 (17.81)	**0.000**	**5.153e-8 (1.132e-8, 2.347e-7)**
	Respiratory	0 (0.00)	-	1.0	2 (2.20)	1.000	0.607 (0.000,-)	3 (4.11)	1.000	9.229 (0.000, -)
	Gastrointestinal	10 (27.3)	-	1.0	35 (38.46)	**<0.001**	**1.481e-8 (1.556e-9, 1.410 e-7)**	29 (39.73)	-	1.019e-7 (1.019e-7, 1.019e-7)
	Other	3 (8.11)	-	1.0	9 (9.89)	**<0.001**	**1.067e-8 (7.241e-10, 1.573 e-7)**	0 (0.00)	0.993	3.73e-16 (0.000,-)
K	Hypokalemia	6 (16.22)	-	1.0	16 (17.58)	**<0.001**	**0.120 (0.063, 0.229)**	16 (21.92)	0.000	1.141 (0.067, 0.298)
	Normal	26 (70.27)	-	1.0	60 (65.93)	-	1.0	47 (64.38)	-	1.0
	Hyperkalemia	5 (13.51)	-	1.0	15 (16.48)	0.289	1.582 (0.678, 3.691)	10 (13.70)	0.066	2.372 (0.946, 5.952)
Na	Hyponatremia	5 (13.51)	-	1.0	15 (16.48)	**<0.001**	**0.073 (0.041, 0.129)**	4 (5.48)	**0.000**	**0.059 (0.033, 0.106)**
	Normal	19 (51.35)	-	1.0	53 (58.24)	-	1.0	45 (61.64)	-	1.0
	Hypernatremia	13 (35.13)	-	1.0	23 (25.27)	0.661	0.839 (0.382, 1.841)	24 (32.88)	**0.008**	**0.214 (0.068, 0.675)**

OR: odds ratio; CI: confidence interval; AKI: acute kidney injury.
Significant values are bolded (significant at the level of $P < 0.005$).

non-AKI hematological patients among them, therefore, according to Table 1, *P* value and odds ratio (OR) are not reliable. Therefore, we did not consider hematologic diseases in comparison with other diseases to examine the etiology of AKI and eliminated it. In this study, the most common causes of AKI were calculated according to OR and included sepsis, underlying renal disease, heart disease and gastrointestinal disease, respectively. The most common laboratory findings in these patients were hypokalemia and hypernatremia. There was no significant difference in the incidence of the disease between men and women, but the highest incidence of AKI was in the age range of one month to one year, followed by one year to five years and above five years, respectively.

In a 2014 study by Sadeghi et al, at the same center, among the 303 pediatric patients admitted to PICU, the most common causes of AKI were neurological (28.05%), cardiac (17.18%), and respiratory diseases (10.23%), respectively (13).

In a 2020 study by Bjornstad et al in Malawi, the incidence of AKI in hospitalized pediatric patients was estimated at 4 to 10%, among the etiologies leading to AKI, the most common cause was burn injury followed by multiple injuries and the use of recent herbal medicines, respectively (14). According to the study and its comparison with our study, the incidence of AKI in the two studies was almost the same, but the most common causes of AKI in our study were different from this study and included sepsis, renal and gastrointestinal.

In another study conducted by Krishnamurthy et al in 2012 in a level 3 hospital in southern India, the incidence of AKI was 23.2% in 2376 children admitted to the pediatric ward and 25.1% in PICUover a one-year period (15). This rate was almost half of the incidence rate calculated in our study. The most common causes of AKI were infection (55.4%), glomerulonephritis (16.9%), heart disease (4.8%) and poisoning (4.2%), respectively. The findings are dramatically exactly in line with the findings of our study on the factors leading to AKI.

Another study by Peerapornratana et al, sepsis-associated acute kidney injury (S-AKI) is a frequent complication of the critically ill patient and is associated with unacceptable morbidity and mortality. Prevention of S-AKI is difficult because its etiology is multi factorial. Thus, early recognition is crucial to provide supportive treatment and limit further evaluations (16).

In another study, Sutherland et al found that the incidence of AKI in hospitalized children aged one month to 18 years was 3.9-6.6 per 1000 hospitalizations. The most common diseases resulting AKI were shock and septicemia, respectively (17). According to the statistics obtained in our study and compared with other studies, it has been shown that this prevalence is higher in Iran. The prevalence of AKI-related diseases was almost consistent with the Sutherland et al study, and the most common cause in our study was sepsis.

Additionally the reviewed study by Parameswaran et al according to studies around the world, community-acquired AKIs are more likely to be caused by infections, animal, plant or chemical toxins, or obstetric complications compared with AKI, which was the prevalence of sepsis and diagnostic and therapeutic interventions such as contrast imaging, respectively (18). The findings of this study also indicate the prevalence of AKI in South Asia at about 7.5%, which is different from our study. Regarding the prevalence of causes of AKI, this study was in line with our study and the most common cause of both was sepsis. In another study in China, among children admitted to 25 medical hospitals over a two-year period in 2015, Xu et al estimated the incidence of AKI at 28%, which was much higher than the global incidence. The most common causes of AKI in these patients were gastrointestinal (diarrhea) and sepsis, respectively (19). The difference between this finding and our study is in the order of the prevalence of gastrointestinal diseases, hence in our study, gastrointestinal diseases were prevalent after sepsis.
Another study in New Zealand in 2006 conducted a six-year study by Ball et al, which estimated the prevalence of AKI in hospitalized pediatric patients at four per 100 000, much lower than our results. The most common causes of AKI after heart surgery were uremic hemolytic syndrome (HUS), sepsis, and glomerulonephritis (20). Due to the lack of examination of surgical complications in our study, the most common cause of sepsis in general pediatric diseases has been suggested, which is consistent with ours. It has been calculated that the above findings are completely inconsistent with our study to the extent that it shows that in the emergency department of the same center, the most common causes of AKI include sepsis, underlying renal disease, heart and gastrointestinal diseases, respectively.

Conclusion

ARF is one of the most problem in medical system, but its exact cause is not well established. Knowing ARF epidemiology by standard definitions can help to measure high-risk pediatrics, as the first step for treatment and improving outcomes. A future study may benefit from better identification of risk factors and early detection of AKI using novel biomarkers to prevent the progression of AKI.

Limitations of the study

The empirical results reported herein should be considered in light of some limitations. Patients 'lack of cooperation during treatment and families' dissatisfaction with participating in the study can be mentioned.

Authors' contribution

Conceptualization: SSB and GS. Methodology: SSB. Validation: GS, SSB and Zahedan University of Medical

Sciences (ZaUMS). Formal Analysis: SHSM. Investigation: GS, SSB and SY. Resources: GS and SS. Data Curation: SY. Writing—Original Draft Preparation: SHSM. Writing—Review and Editing: SHSM and SY. Visualization: SSB and GS. Supervision: SSB. Project Administration: GS. Funding Acquisition: ZaUMS.

Conflicts of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Ethical issues

The research followed the tenets of the Declaration of Helsinki. The Ethics Committee of Zahedan University of Medical Sciences approved this study. The institutional ethical committee at Zahedan University of Medical Sciences approved all study protocols (IR.ZAUMS.REC.1398.446). Accordingly, written informed consent was taken from all participants before any intervention. This study was extracted from M.D, thesis at this university (Thesis #9759). Moreover, ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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