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Changing epidemiology of community-acquired acute kidney injury in developing countries: analysis of 2405 cases in 26 years from eastern India

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Abstract

Background. The epidemiology of acute kidney injury (AKI) differs from country to country and varies from center to center within a country. Owing to the absence of a central registry, data on overall epidemiology of AKI are scanty from India.

Methods. This study aimed at describing changes in epidemiology of community-acquired AKI (CAAKI) over a time span of 26 years in two study periods, namely, 1983–95 and 1996–2008.

Results. We studied 2405 (1375 male and 1030 female) cases of AKI in the age range 1–95 (mean: 40.32) years. The incidence of CAAKI in 1983–95 and 1996–2008 was 1.95 and 4.14 per 1000 admission, respectively ($P < 0.01$). Obstetrical AKI has decreased because of the declining number of post-abortal AKI. Surgical AKI decreased from 13.8% in 1983–95 to 9.17% in 1996–2008($P < 0.01$). Malarial AKI increased significantly from 4.7% in the first half of the study to 17% in the later period ($P < 0.01$). Diarrhea-associated AKI had significantly decreased from 36.83% in 1983–95 to 19% in 1996–2008 ($P < 0.01$). Sepsis-related AKI had increased from 1.57% in 1983–95 to 11.43% in 1996–2008 ($P < 0.01$). Nephrotoxic AKI showed an increasing trend in recent years ($P < 0.01$) and mainly caused by rifampicin and NSAIDs. Liver disease-related AKI increased from 1.73% in 1983–95 to 3.17% in 1996–2008 ($P < 0.01$). Myeloma-associated acute renal failure (ARF) accounted for 1.25% of the total number of ARF cases in the period 1996–2008. HIV infection contributed to 1.65% of ARF of the total number of AKI cases in the second period (1996–2008). Incidence of renal cortical necrosis (RCN) decreased significantly from 5.8% in 1983–95 to 1.3% in 1996–2008 of the total number of ARF cases ($P < 0.01$). However, during the same period ARF due to acute tubular necrosis, acute glomerulonephritis and acute interstitial nephritis remained unchanged. The mortality rate from AKI decreased significantly from 20% in 1983–95 to 10.98% in 1996–2008 ($P < 0.01$).

Conclusions. The epidemiological characteristics of CAAKI have changed over the past three decades. There has been an increase in the overall incidence of ARF with the changing etiology of AKI in recent years. Incidences of obstetrical, surgical and diarrheal AKI have decreased significantly, whereas those of AKI associated with malaria, sepsis, nephrotoxic drugs and liver disease have increased. RCN has decreased significantly. In contrast to developed nations, community-acquired AKI is more common in developing countries. It often affects younger individuals and is caused by single and preventable diseases.

Keywords: acute kidney injury; changing epidemiology; community-acquired AKI; hospital-acquired AKI; mortality

Introduction

The incidence of acute kidney injury (AKI) has increased over the past few decades and the reported incidence of AKI in different regions of the world is quite variable [1–5]. In developed countries, AKI is seldom a community-acquired disease, while in developing countries AKI is commonly caused by community-acquired diseases [6–9]. The cultural, economic and geographical differences determine the epidemiology of AKI in different places. Thus, epidemiology of AKI differs from country to country and also varies from center to center within the same country [10–15]. Owing to the absence of a central registry, data on overall epidemiology of AKI are very limited for India and what is available often originates

from a single center of urban location. This article describes the changing epidemiology of community-acquired AKI (CAAKI) over a time span of 26 years divided into two 13-year periods, namely; 1983–95 and 1996–2008 from a single center of eastern India.

Materials and methods

Subjects

All patients admitted with AKI during the study period were subjected to urine analysis, hemogram, blood biochemistry (urea, creatinine, electrolytes, uric acid, calcium and phosphorus) and ultrasound scan of the abdomen. Renal biopsy was done in selected cases with prolonged duration of acute renal failure (ARF) (>4 weeks) and unexplained ARF and in those with features suggestive of systemic and glomerular diseases. The diagnosis of ARF was based on standard criteria (history, physical examination, laboratory value and clinical course). Immunological assays, such as hepatitis B surface antigen, anti hepatitis C virus, antinuclear antibody, anti double-stranded DNA, anti-neutrophil cytoplasmic antibody and anti-glomerular basement membrane antibody, were done in selected cases.

Definitions

ARF was defined as an acute reduction in renal function with a >2 mg percentage rise in serum creatinine in the presence of normal size kidneys. CAAKI was defined as renal failure developing outside the hospital. Hospital-acquired ARF was defined as renal failure that developed during hospitalization for non-renal problems in patients whose serum creatinine was normal at the time of admission. Chronic kidney disease (CKD) was defined as per the K/DOQI guidelines. Full recovery of renal function was defined as the normalization of serum creatinine within a period of 12 weeks from the onset of AKI. Partial recovery was defined as persistent dialysis-independent renal dysfunction.

Data collection

Data were collected from the case record of patients with AKI and were analyzed for age, gender, etiology, clinical features, course and outcomes. All patients included in the study had CAAKI. Patients with underlying CKD (acute-on-chronic renal failure) were excluded from the study. The results of our observation were compared with respect to the epidemiology of AKI in two periods, namely: 1983–95 and 1996–2008.

Statistical data analysis

The data were analyzed using SPSS 10.0 version. The results are expressed as mean ± SD. The Chi-square test, 'Z' test and Student's *t*-test were used for statistical analysis. A P-value of <0.05 was taken as the point of statistical significance.

Results

This retrospective study included 2405 (1375 male and 1030 female) patients of ARF from July 1983 to December 2008. The study was divided into two 13-year periods: 1983–95 (638 cases) and 1996–2008 (1767 cases). Their age ranged from 1 to 95 (mean: 40.32) years. The incidence of medical and obstetric categories of AKI remained unchanged in the two periods with declining incidence of surgical AKI. The incidence of CAAKI significantly increased from 1.95 per 1000 admissions in 1983–95 to 4.19 per 1000 admissions in 1996–2008 ($P < 0.01$). The demographic data of AKI in the two periods are shown in Table 1. AKI due to diarrheal disease has decreased significantly ($P < 0.001$) and AKI related to malaria, sepsis, drugs and liver diseases has increased in recent years. Post-abortal ARF declined, while ARF in the peri-partum and post-partum period increased. The changing patterns of etiology of AKI in the two-study periods are shown in Table 2. The main features and outcomes of patients with renal cortical necrosis (RCN) of all cases of AKI in the two 13-year periods are shown in Table 3. The incidence of RCN of all cases of AKI had significantly decreased from 5.8% in 1983–95 to 1.3% in 1996–2008. Similarly, RCN related to obstetric ARF of total ARF cases decreased up to 0.45% in 1996–2008 from an initial high incidence of 4.08% in 1983–95. The mortality rate of patients with RCN decreased to 17.39% in 1996–2008 from 70% in 1983–95. With improvement in survival, nearly 50% of cases of RCN progressed to end-stage renal disease. We observed a partial recovery of renal function in 34.78% of cases of RCN in 1996–2008 in comparison with 13.61% of cases in 1983–95.

Discussion

Geographical, etiological, cultural and economic differences determine dissimilarities among many characteristics of AKI in different regions of the world. Discernment of the true epidemiological characteristic of CAAKI has been hampered by the lack of a generally accepted definition of AKI. Difficulties also arise because of variation in catchment population and the method used for case ascertainment. Taking into account these issues, the aim of this paper is to compare the changes in the

Table 1. Demographic data of AKI in two periods: 1983–95 and 1996–2008

	Study period		Statistical analysis	
Parameters	1983–95	1996–2008	Z-value	P-value
Total number of AKI	638	1767		
Number of AKI per 1000 hospital admissions	1.95	4.19	17.75	<0.001
Male: female ratio	368:270	1007:760		
Mean age (years)	39.23	40.71		
Dialyzed, *n* (%)	523 (81.9)	1381 (78.15)	2.11	<0.05
Medical AKI *n* (%)	470 (73.69)	1396 (79)	2.27	<0.05
Surgical AKI, *n* (%)	88 (13.79)	162 (9.16)	2.46	<0.05
Obstetrical AKI, *n* (%)	80 (12.8)	209 (11.83)	0.47	>0.05
Lost to follow-up, *n* (%)	40 (6.26)	161 (9.11)	2.41	<0.05

Table 2. Etiological pattern of AKI in two periods: 1983–95 and 1996–2008

Etiology of AKI	Study period				Statistical analysis	
	1983–95 ($n = 638$)		1996–2008 ($n = 1767$)			
	Total number	Percentage (%)	Total number	Percentage (%)	Z-value	P-value
Malaria	30	4.70	302	17.09	10.10	<0.001
Diarrheal diseases	235	36.83	338	19.13	8.32	<0.001
Sepsis	10	1.57	202	11.43	10.92	<0.001
Hemolytic uremic syndrome	6	0.94	34	1.93	1.95	<0.05
Nephrotoxic drugs	28	4.39	27	1.52	3.31	<0.001
Liver disease related	11	1.73	56	3.17	2.18	<0.001
Vasculitis	0	0.00	5	0.28	2.23	<0.05
Multiple myeloma	0	0.00	20	1.13	4.49	<0.001
Obstructive uropathy (surgical AKI)	66	10.35	124	7.02	2.46	<0.05
Post-abortal	57	8.9	126	7.1	1.476	>0.05
Eclampsia	5	0.78	22	1.24	0.658	>0.05
HIV infection	0	0.00	29	1.65	3.71	<0.0002

Table 3. Comparative data: main features and outcomes of patients with renal cortical necrosis of all cases of acute kidney injury in two 13-year periods: 1983–95 and 1996–2008

Parameters	Study periods				Statistical analysis	
	1983–95 ($n = 638$)		1996–2008 ($n = 1767$)			
	n	%	*n*	%	Z-value	P-value
Obstetric AKI	80	12.54	209	11.83	0.47	>0.05
Total number of RCN	37	5.80	23	1.30	4.67	<0.001
Obstetric RCN	26	4.08	8	0.45	4.53	<0.001
Non-obstetric RCN	11	1.72	15	0.85	1.56	>0.05
Outcome of RCN	($n = 37$)		($n = 23$)		Chi-square test[a]	
Mortality	26	70.27	4	17.39	6.91	<0.001
Progression to ESRD	6	16.22	11	47.83	2.75	>0.05
Partial recovery of renal function	5	13.61	8	34.78	1.32	>0.05

[a]With continuity correction factor.

epidemiology of CAAKI during the past 26-year period from a single center of eastern India in two periods, namely 1983–95 and 1996–2008.

The reported incidence of AKI in different regions of the world is widely variable [1, 2]. In developed countries, AKI primarily develops in hospitalized patients, while it is mainly community-acquired in developing countries [6]. Data on CAAKI from the developing world are scanty because different definitions of AKI are used in different regions, and it often originates in a single center of an urban location. It is, therefore, likely that the apparently lower incidence of AKI in the developing world is the result of gross under-reporting [1, 10, 11]. The number of reported CAAKI has increased in recent years. The incidence of CAAKI in two studies, one from Saudi Arabia and another from India, was 2.3/1000 and 6.6/1000 admission, respectively [9, 13]. We observed that the incidence of CAAKI increased to 4.19/1000 admissions in 1996–2008 from 1.95/1000 admissions in 1983–95. In contrast, CAAKI in the USA and developed nations is less frequent but reported [14]. The overall incidence of AKI seems to have increased over the past few decades and thus, supports our observations, similar to other studies [3–5, 9, 15]. AKI in developing countries is commonly caused by community-acquired diseases, such as malaria, leptospirosis, gastroenteritis and hemolytic uremic syndrome (HUS) in young and otherwise healthy individuals [16]. The incidence of CAAKI has wide variation in different parts of the world depending upon the definition of AKI accepted in that region [1–4]. True estimation of CAAKI in developing countries is difficult to make because most patients do not go to urban hospitals, where they would have been included in incidence estimation. Among developed countries, such as the USA, Kaufman *et al.* [14] reported that community-acquired AKI accounts for 1% of hospital admissions. A study of AKI in an African American population revealed that CAAKI is 3.5 times more common than hospital-acquired AKI in this population (0.55 versus 0.15% of hospital discharge, respectively) [17]. Several studies of CAAKI in the developed world (diagnosis made on the basis of hospital) have shown an apparently steady increase in incidence [10, 18]. We have found a 2.15 times increase in the incidence of CAAKI in 1996–2008 in comparison with 1983–95. Comparative incidences of CAAKI from different centers of developing countries are shown in Table 4. The incidence of CAAKI from Chandigarh (India) was 6.6/1000 hospital admissions [9]. These data suggest an increasing incidence of community-acquired ARF in all centers of our country.

The age of people that develop AKI differs markedly between developed and developing countries. In the developed world, elderly patients predominate [3, 4], but in the developing world AKI is generally a disease of the young; 46% of patients were <40 years in one Nigerian series [19] and a study from India had an average patient age of 34 years [20]. The mean age of patients with AKI in the present study was 40.32 years. The gender discrimination of patients with AKI is an important problem in the developing world. Most reports on the epidemiology of AKI in the developed world indicate a male-to-female ratio of close to 1:1. We observed a male-to-female ratio of 1.33:1 in the present study. This gender difference is not due to different incidences of AKI, but rather reflects that males access treatment centers much more frequently than females in developing countries.

The causes of AKI in our study in the two periods, namely 1983–95 and 1996–2008 have shown some changes. Some causes are slowly becoming less prevalent, while other etiologies are becoming more important factors in the genesis of AKI. Diarrhea-related AKI had significantly decreased ($P < 0.001$) in 1996–2008 compared with 1983–95. We also noted that obstructive uropathy had decreased to 7% in 1996–2008 from 10.35% in 1983–95. The AKI related to malaria, sepsis and liver diseases had increased in the second half of the study

Table 4. Comparative incidence of community-acquired AKI in the developing world[a]

Authors	Location	Incidence	Change in incidence over time
Abraham *et al.* [7]	Kuwait	4.1/100 000 of population per year	NA
Seedat and Nathoo (1993) [51]	Durban, South Africa	20/million population	No significant change since 1980s
Anochie and Eke [8]	Nigeria	11.7/million children each per year	NA
Al-Homramy [13]	Saudi Arabia	2.3/1000 admission	NA
Kohli *et al.* [9]	Chandigarh, India	6.6/1000 admission	NA
Wang *et al.* [32]	Peking, China	0.54/1000 admission	NA
Prakash *et al.* (1983–2008) (present study)	Varanasi, India	1.95/1000 admission (1983–95) 4.19/1000 admission (1996–2008)	2.15-fold increase

[a]Table is modified from Cerda *et al.* [10].

period (1996–2008). Worldwide, the incidence of AKI caused by malaria varies from 0.6 to 60% depending on the geographical region [21]. In endemic areas, the incidence of malaria-related AKI is up to 4%. We reported that 13% of the total number of AKI cases were due to malaria in our previous study [22]. Naqvi *et al.* [23] reported that 5.9% of ARF was related to malaria (*Plasmodium falciparum* or *Plasmodium vivax*) and 79.8% required renal replacement therapy. Age, oliguria, central nervous system involvement and presence of disseminated intravascular coagulation are poor prognostic factors in univariate analysis. ARF is a serious complication of malaria, with a reported mortality rate of 15–45%. Both *P. falciparum* and *P. vivax* malaria can cause AKI [23, 24]. However, *P. falciparum* malaria is a more common cause of AKI than *P. vivax* malaria. Leptospirosis is a common cause of AKI in tropical and subtropical areas, and is the leading cause of AKI in Thailand and Singapore [25–27]. We did not see any case of AKI due to leprospirosis over a period of 26 years. The AKI related to hemolytic uremic syndrome (HUS) had increased to 1.93% in 1996–2008 from 0.94% in 1983–95 in the present study. We observed mainly D-ve (not related to diarrhea) HUS in our adult population causing AKI. However, HUS is currently the main cause of AKI among children in northern India [28]. The proportion of AKI cases related to HUS increased to 36% from the 1970s to 1990 in children in India [29, 30]. Thus, prevalence and severity of HUS and malaria are increasing in developing countries. Acute glomerulonephritis (GN) remains an important cause of AKI in developing countries. The incidence of AKI due to acute GN had not changed over the past three decades. Acute GN accounts for 9–10% cases of total AKI and are mostly post-infectious in origin [31]. The etiology of drug-related ARF has changed. In the past, antibiotics were the most common causes, followed by analgesics and contrast media. The incidence of ARF due to antibiotics had since declined while other new causal agents have emerged including NSAIDs, ACEI, chemotherapeutic and antiviral medications. The trends in developed countries are toward an increasing incidence of ARF in hospitalized patients because of drugs, infections and surgery, and it has also been observed in developing countries [32–33]. Our present study revealed that NSAIDs and rifampicin are the major cause of drug-induced AKI. Rifampicin-related AKI was seen in 1.8% of the total number of ARF cases in our previous study [34].

Obstetric AKI declined because of decreasing number of post-abortal AKI cases (11.8% in 1996–2008 versus 12.5% in 1983–95). The incidence of obstetric-related ARF also decreased in other parts of India [35,36]. However, it is still high in certain developing countries, such as Ghana, Pakistan and Nepal [37–39]. The incidence of cortical necrosis due to obstetric AKI significantly decreased ($P < 0.001$) from 4% in 1983–95 to 0.45% in 1996–2008 of the total number of AKI cases. The mortality related to cortical necrosis in obstetric AKI significantly decreased ($P < 0.001$) to 17.39% in 1996–2008 from 70% in 1983–95. The rate of progression to ESRD increased to 47.83% in 1996–2008 from 16.22% in 1983–95 mainly because of better survival of patient. These favorable outcomes of obstetrical ARF are due to improvements in health care and better management of obstetrical complications. Volume-responsive AKI is more common in developing countries, which causes acute tubular necrosis (reversible form of AKI) in most of the cases [40–42]. Moreover, volume-responsive AKI is rapidly reversible when volume contraction has corrected. However, AKI from obstetrical complications and HUS can cause irreversible renal damage due to cortical necrosis—a condition that is extremely rare in developed countries [43, 44]. In developed nations, RCN accounts for <2% of all causes of AKI in adults and for 15–20% of AKI cases during the third trimester of pregnancy. Improving prenatal care has dramatically decreased the incidence of cortical necrosis in India as well [45, 46].

In contrast to the high mortality associated with AKI in developed nations, AKI-associated mortality seems to be lower in developing countries between 10 and 40% [47, 48]. This is because of the fact that AKI often affects younger individuals and is caused by a single disease (i.e. less commonly associated with multiple organ failure). But the mortality of AKI associated with a specific disease such as severe malaria that is often complicated with multiple organ failure is very high [49, 50]. In summary, AKI is commonly caused by community-acquired single diseases such as malaria, HUS, diarrhea, septic abortion and poisoning. Thus, many cases of AKI in developing countries can be prevented by community-based interventions (e.g. oral re-hydration or malaria prevention).

Conclusion

Several factors have changed the epidemiology of ARF over the past three decades in developing countries and they include: absolute increase in the incidence of ARF, increase in the percentage of elderly patients with ARF, emerging newer infections and drugs causing AKI and AKI developing in patients with several comorbidities. In addition, causes of AKI have changed; some causes

(such as diarrhea and septic abortion) are becoming less prevalent while other factors (such as malaria, HIV infection, rifampicin and antiretroviral drugs) are becoming more common etiologies of AKI.

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Conflict of interest statement. None declared.

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