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Original Article

Acute renal failure in the ICU setting: A prospective observational study

Col Shivinder Singh^{a,*}, Sqn Ldr A.K. Patra^b, Maj Barun Patel^c,
Brig G.S. Ramesh (Retd)^d, Brig V.K. Sharma^e,
Lt Gen V. Ravishankar, VSM (Retd)^f, D. Bassannar^g

^aSenior Adviser (Anaesthesiology & Critical Care), Command Hospital (Western Command), Chandimandir, Haryana, India

^bGraded Specialist (Anaesthesiology), 12 Air Force Hospital, Gorakhpur, UP, India

^cDADH, 71 Mtn Div, C/o 99 APO, India

^dDirector, Cardiac & Transplant Anaesthesia, Jaypee Hospital, Noida, UP, India

^eProfessor & Head (Anaesthesiology & Critical Care), Army Hospital (R&R), Delhi Cantt 110010, India

^fChief of Operation & Senior Consultant, Cardio Thoracic Surgery, Lilavati Hospital, Bandra West, Mumbai, India

^gScientist 'F', Department of Community Medicine, Armed Forces Medical College, Pune 411040, India

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ABSTRACT

Background: Acute renal failure (ARF) is a common entity in the intensive care unit (ICU) setting. There is scanty data regarding acute kidney injury (AKI) in ICUs from our country and no data from the service setting.

Methods: All patients admitted to the ICU of a tertiary care teaching hospital for six months were included in the study. They were divided into two groups: surg gr (admitted in surgical ICU) and med gr (admitted in medical ICU). During the stay in ICU, patients were observed for the development of AKI depending on the creatinine values and hourly urine output. Staging was done based upon the Risk Injury Failure Loss and End stage kidney (RIFLE) criteria. Relevant data associated with development of AKI was collected for correlation.

Results: 17.15% patients developed AKI after admission to the ICU 40% patients admitted with sepsis developed AKI. An increased susceptibility to develop AKI was found on day 4 of admission in both the groups. Of the patients who developed AKI, the surg gr of patients had a higher sequential organ failure assessment (SOFA) score both on day of admission (7.85 vs 5.65) and on the day of development of AKI (9.47 vs 6.18) as compared to the medical group. **Conclusion:** The incidence of ARF in our study was 17.2% with the patients of polytrauma/MODS being of major concern. The initial 3–4 days are the most critical and susceptible patients must be intensive monitored during this time for prevention of ARF. Medical ICU patients develop ARF at a low SOFA score in comparison to surgical ICU patients and thus need greater attention.

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* Corresponding author. Tel.: +91 07837109056.

E-mail address: sshivinder@hotmail.com (S. Singh).

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Introduction

Acute renal failure (ARF) has remained one of the major concerns in the intensive care unit (ICU) since time immemorial. In the recent past, it has been the subject of research in different parts of the world because of its impact on the morbidity and mortality of patients. The spectrum of ARF ranges from mild to severe and has various definitions. There are many studies directed at the incidence, probable risk factors, morbidity and treatment approaches of ARF; however, Indian studies are few and data from the service setting non-existent. We therefore carried out a prospective observational study to find out the incidence, risk factors and to measure the burden of ARF in our setup, which would help in identifying the possible areas of intervention.

Materials and methods

The study was carried out in the ICU of a tertiary care teaching hospital over a period of six months from March 2012 to August 2012. A total of 576 patients were admitted during the same period and all of them were screened. Patients who stayed in the ICU for less than 24 h or patients who were not catheterised were excluded from the study. Paediatric and cardiothoracic patients were managed in separate ICUs and were not included in our study.

The presence of comorbid diseases and organ system already compromised differ depending on the duration and severity of the comorbid disease and thus were considered separately. The presence of sepsis, whether they were on ventilator at admission and whether they had a past history of dialysis was also noted. Presence of sepsis was diagnosed as per the standard definitions.¹ Patients who were admitted with invasive airway in situ or who required mechanical ventilation on their initial evaluation were considered in the group of “on ventilatory support at admission”. During the stay in ICU, patients were observed for hourly urine output and daily creatinine levels and staging of ARF was done as per Risk Injury Failure Loss and End stage kidney (RIFLE) criteria.² The progress of the patients was noted using the sequential organ failure assessment (SOFA) score.³ All the patients were followed till their discharge from ICU; in case a patient developed ARF, he was followed till the 28th day following ARF development. The aim of the study was to find out the proportion of patients who develop ARF, potential risk factors and the outcome of such patients. Primary outcome of the study was the development of ARF.

Institutional ethics committee approval was obtained prior to starting the study. Data was collected and collated in excel sheet and was analysed using SPSS 20. Frequency, mean, chi square, independent t test and multiple regressions were used for measuring various outcomes and associations. On carrying out multiple regression analysis, the explained variation in the dependent variable based on our model, ranged from 24% to

The patients were divided into two groups: surg gr (patients admitted in surgical ICU) and med gr (patients admitted in medical ICU). The following data were collected with respect to every patient: age, sex, primary disease of admission, comorbidities, organ systems already compromised on admission and the morbidity scores. The patients were further divided into two groups: age less than or more than 60.

40%. This model predicted 97.1% of the ARF episodes correctly with a goodness-of-fit, as per the Hosmer and Lemeshow test with a *p* value of 0.14, which indicates that there was an agreement between the number of cases predicted and those actually observed.

Limitations of the study: Being a simple observational study, all the patients included in the study were those who fulfilled

the inclusion criteria during the 6-month period. Therefore, the study was not actually conducted based on sample size calculation. Secondly, we did not measure the time frame of development of ARF and death, so were unable to calculate Cox proportional hazard model to determine death. Also we measured the 28-day mortality of patients who developed ARF but did not take the renal replacement therapy instituted into comparison.

Results

548 patients were accepted for the study. 17.2% patients developed ARF (Fig. 1). There was a significant association, $p = 0.016$ (OR 0.52) of type of ICU for development of ARF. We found that there was a 48% less chance of Surgical ICU patients as compared with medical ICU patients to develop ARF. Neither age nor gender made any difference in the development of ARF in ICU patients (Table 1).

Table 2 shows the association of the primary disease of the patients with the development of ARF. It was found that most of the patients admitted had diseases related to the central nervous system (172 out of 548) or gastrointestinal system (164 out of 548). Though patients with renal system abnormality contributed to only a small number (40 out of 548), such patients were significantly associated (OR 3.62) with the development of ARF. Also, patients with multi-organ dysfunction syndrome (MODS) or poly-trauma had a significantly (OR 3.72) greater association with ARF. It was found that the patients having hepatitis (OR 7.40), more than one comorbid disease (OR 2.03) or more than one compromised organ at admission (OR 2.44) were strongly associated with development of ARF. Moreover, the presence of sepsis, requirement of mechanical ventilation and history of dialysis were strongly associated with development of ARF. Multiple regression analysis of the data revealed that there was a significant chance of development of ARF if there was organ dysfunction of any organ at admission (Table 3). A value below 0.05 denotes that the covariate is significantly associated with the dependent variables (ARF) if other factors are constant.

Outcome analysis (Fig. 2) of the ARF patients showed that 48.9% of patients who developed ARF expired by day 28. The association is statistically significant ($p < 0.05$; OR = 1.95). SOFA score of med gr patients was found to be high both on the day of admission and on the day of ARF development. Most of the patients developed ARF on day 4 of admission (Fig. 3).

Distribution of ARF cases

Fig. 1 – Distribution of ARF cases.

Outcome analysis

Fig. 2 – Outcome analysis of ARF cases.

Discussion

Different definitions have been used to define acute renal failure.⁴ Moreover, renal functional derangement has also been described as acute renal failure (ARF), acute kidney injury (AKI) or acute kidney insufficiency.⁵ The Acute Kidney Injury Network (AKIN) and the RIFLE criteria are the most widely used presently for definition and staging of ARF. We used the term acute renal failure to describe kidney dysfunction as per the RIFLE criteria.

The incidence of renal dysfunction varies from 6.3% to 20%.⁶ This wide variation may be due to the use of varied definitions applied to define the condition, basic underlying disease needing ICU care, presence of different coexisting diseases and the treatment strategy of the ICU being analysed. Advancing age has been considered as a significant risk factor for the development of ARF⁷ and a preventive strategy is always recommended to prevent ARF in the elderly admitted to the ICU.⁵ We did not find a significant association of ARF in patients above the age of 60 years.

Acute renal failure is multi-factorial. Clear associations have been found between diabetes, heart failure, hypovolemia, liver

Table 1 – Association of ARF with patient profile.

		PT without ARF	PT with ARF	p value	Chi-square value	OR	95% CI of OR	
ICU	Medical	228	60	0.016	5.78	0.52	0.36	0.91
	Surgical	226	34					
Age	<60 years	272	50	0.228	1.45	1.32	0.84	2.055
	>60 years	182	44					
Gender	Male	266	52	0.559	0.34	0.875	0.559	1.369
	Female	188	42					

Table 2 – Association of ARF with different factors.

		PT without ARF	PT with ARF	p value	Chi-square value	OR	95% CI of OR	
Primary disease on admission								
CVS	Absent	376	82	0.293	1.11	0.71	0.367	1.355
	Present	78	12					
CNS	Absent	316	60	0.272	1.21	1.29	0.814	2.067
	Present	138	34					
GI	Absent	314	70	0.307	1.05	0.77	0.464	1.274
	Present	140	24					
RESP	Absent	414	86	0.925	0.009	0.96	0.435	2.130
	Present	40	8					
Renal system	Absent	416	92	0.034	4.485	3.62	0.926	14.16
	Present	38	2					
MODS/polytrauma	Absent	434	80	0.000	14.72	3.79	1.842	7.828
	Present	20	14					
Associated comorbidities								
DM	Absent	410	90	0.090	2.88	0.41	0.15	1.18
	Present	44	4					
HTN	Absent	388	86	0.120	2.42	0.55	0.25	1.18
	Present	66	8					
CAD	Absent	426	92	0.117	2.46	0.33	0.078	1.41
	Present	28	2					
CKD	Absent	426	90	0.472	0.52	0.68	0.23	1.97
	Present	28	4					
Hepatitis/cirrhosis	Absent	438	74	0.000	39.98	7.40	3.68	14.93
	Present	16	20					
>1 comorbidity	Absent	418	80	0.033	4.55	2.03	1.05	3.94
	Present	36	14					
Organ already compromised on admission								
Heart	Absent	420	88	0.708	0.14	0.84	0.34	2.07
	Present	34	6					
Lungs	Absent	424	90	0.389	0.74	0.63	0.22	1.83
	Present	30	4					
GI	Absent	376	70	0.058	3.58	1.65	0.98	2.79
	Present	78	24					
Brain	Absent	366	74	0.674	0.17	1.12	0.65	1.94
	Present	88	20					
Kidney	Absent	422	84	0.234	1.42	1.57	0.74	3.32
	Present	32	10					
>1 organ compromised	Absent	398	70	0.001	10.87	2.44	1.42	4.18
	Present	56	24					
Miscellaneous								
Sepsis on ADM	Absent	412	66	0.000	29.47	4.16	2.42	7.17
	Present	42	28					
On ventilator on admn	Absent	376	68	0.018	5.56	1.843	1.103	3.08
	Present	78	26					
H/O dialysis	Absent	450	90	0.013	6.16	5.000	1.228	20.36
	Present	4	4					

failure, rhabdomyolysis and open-heart surgery and ARF.⁸ In our study, the association of ARF with diabetes was not significant though there was a significant association with hepatitis. The association of system involved because of the primary disease at ICU admission with ARF was analysed. Multiple regression analysis clearly shows that patients with multiple organ system dysfunction were independently associated with ARF. It also showed that patients having multiple comorbid diseases had a strong association with development of ARF. Also, if at admission the patient was found to have an organ already compromised, then they were independently susceptible to develop ARF. Association of sepsis⁹ and mechanical ventilation¹⁰ with ARF and increased morbidity and

mortality has been demonstrated in literature, this is similar to our results. Moreover, our study also brought out the fact that patients with a past history of dialysis were associated with ARF (OR 5.0) but following multiple regression analysis it was evident that it was not actually so. In fact, in an elegant study, the authors have brought out that patients with ARF who did or did not require dialysis had poorer outcomes than patients of end stage renal disease (ESRD) who were dialysis-dependant.¹¹

The morbidity of the patients in the ICU was noted as per SOFA score. On comparing the SOFA score (Fig. 3) of patients who developed ARF, it is evident that surg gr patients had a higher score both on the day of admission and on the day of development of ARF. This difference may be due to the impact

Table 3 – Multiple regression analysis.

(a) Variables in the equation									
		B	S.E.	WALD	DF	Sig.	Exp(B)		
Step 0	Constant	−1.575	0.113	193.132	1	0.000	0.207		
(b) Hosmer and Lemeshow test									
Step	Chi-square			DF			Sig.		
1	19.090			8			0.014		
(c) Variables in the equation									
		B	S.E.	WALD	DF	Sig.	Exp(B)	95% C.I. for exp (B)	
								Lower	Upper
Primary disease on admission									
CVS		−0.704	0.748	0.887	1	0.346	0.495	0.114	2.141
CNS		−1.407	0.768	3.360	1	0.067	0.245	0.054	1.102
Gastro intestinal		−0.741	0.730	1.029	1	0.311	0.477	0.114	1.995
Respiratory system		−0.610	0.853	0.510	1	0.475	0.544	0.102	2.895
Renal system		0.686	1.078	0.405	1	0.525	1.986	0.240	16.431
MODS/poly trauma		−2.729	0.867	9.912	1	0.002	0.065	0.012	0.357
Associated co-morbidities									
Diabetes mellitus		0.656	0.593	1.223	1	0.269	1.927	0.603	6.163
Hypertension		0.227	0.477	0.228	1	0.633	1.255	0.493	3.197
CAD		0.600	0.802	0.560	1	0.454	1.822	0.379	8.770
CKD		19.579	7351.054	0.000	1	0.998	318,483,730.598	0.000	−
Hepatitis/cirrhosis		−2.700	0.472	32.659	1	0.000	0.067	0.027	0.170
More than one co morbidity		−1.510	0.436	11.991	1	0.001	0.221	0.094	0.519
Organ already compromised on admission									
Heart		−1.253	0.628	3.978	1	0.046	0.286	0.083	0.978
Lungs		−1.906	0.751	6.443	1	0.011	0.149	0.034	0.648
Gastro intestinal system		−2.306	0.492	21.937	1	0.000	0.100	0.038	0.262
Brain		−2.199	0.499	19.382	1	0.000	0.111	0.042	0.295
Kidney		−2.323	0.588	15.588	1	0.000	0.098	0.031	0.310
>1 organ compromised		−2.653	0.503	27.803	1	0.000	0.070	0.026	0.189
Miscellaneous									
Sepsis on admission		−1.867	0.358	27.146	1	0.000	0.155	0.077	0.312
On ventilator on admission		−0.750	0.341	4.845	1	0.028	0.472	0.242	0.921
H/O dialysis		−21.763	7351.054	0.000	1	0.998	0.000	0.000	−
Constant		20.281	4.922	16.981	1	0.000	642,848,116.552

Fig. 3 – The morbidity score.

of the chronic effects of medical diseases on the renal function. Also, the study showed that patients were more susceptible on day 4 of admission for the development of ARF in both the groups.

Conclusion

The incidence of ARF in our study was 17.2% with the patients of polytrauma/MODS being of major concern. Presence of multiple illnesses, sepsis and requirement of mechanical ventilation on admission may be independent predictors for the development ARF. The initial 3–4 days are the most critical and susceptible patients must be intensive monitored during this time for prevention of ARF. Surgical ICU patients had a 48% less chance of developing ARF as compared to Medical ICU. Medical ICU patients develop ARF at a low SOFA score in comparison to surgical ICU patients and thus need greater attention.

Conflicts of interest

The authors have none to declare.

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