Original Research Article

KDIGO Classification in Predicting the Outcomes of Acute Kidney Injury in Patients in Intensive Care Units of a Tertiary Care Centre

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Abstract

Background: Acute kidney injury (AKI) is a common occurrence in intensive care units. Mortality is more for patients with AKI than those without AKI. KDIGO classification system is a recent tool to stage AKI. Outcomes of AKI depend on stage of the disease, underlying aetiologies and interventions. Objectives were to study the ability of KDIGO classification in predicting the outcomes of acute kidney injury in patients admitted to the intensive care units of a tertiary care centre, to predict the mortality among acute kidney injury patients admitted for intensive care and to study the clinical and etiological profile of acute kidney injury in such patients.

Materials and methods: 153 subjects from Medical ICUs admitted with AKI were included. The period of study was from 1st January 2016 to 31st December 2016. After getting proper consent, details were taken in proforma. Patients coming under exclusion criteria were excluded. Data of 153 patients entered in excel sheet and with various statistical tools the data were analysed**.**

Results: Globally subjects with AKI in ICU, the mortality is about 40 to 60%. Duration of ICU stay among Stage III patients were comparatively longer than those in stage II and stage I ($p<0.05$). Patients undergoing RRT hold higher mortality. AKI patients who need HD or PD as Renal replacement had comparatively higher rates of mortality than those doesn't require RRT ($p<0.05$). There was no significant association between age of the patients and mortality ($P>0.05$). There was no significant association between mortality and gender. Binary logistic regression model for mortality was performed to predict the independent risk factors of mortality. The regression analysis revealed

that staging according to KDIGO, sepsis, hypertension and diabetes has independent predictability in mortality.

Conclusion: We concluded that higher the stage of AKI, the higher will be the mortality and also staging can predict mortality. So staging AKI patients with KDIGO classification holds statistical significance.

Key words

Acute Kidney Injury, Intensive care unit, Mortality.

Introduction

Among kidney diseases, acute kidney injury (AKI) comprises a major portion, which complicates 5 to 7 % of admissions in hospitals [1, 2] and around 30% of ICU admissions [3-5]. AKI is important in socio economic aspects also in view of the cost of care, worse outcomes and diminished quality of life after its occurrence [6]. The prognosis varies with the disease, AKI severity, co morbidities and geographical location. By using evidence from studies and observations, AKI detection tools are modified from time to time with more precision. Around 40 criterias are there to define AKI [7-11], resulting in great discrepancy in the incidence of AKI. For more precision, early detection of cases and to prevent the fatalities, experts have developed newer classification tools. It is proven from the collective data all around the globe that newer criteria hold definite edge over the previous ones and also the detection rates become more accurate.

Incidence of AKI is increasing globally. Mortality in patients of ICU is high. Patients with AKI also have higher mortality [12-14]. Data regarding mortality among ICU patients with AKI vary as newer and newer detection tools are introduced. As the mortality is directly related to stage of AKI, as stage advances out comes also becomes worse.

Those who require renal replacement therapy (RRT), mortality is around 50-70% [15, 16]. RRT is an independent risk factor in patients with AKI, with reference to mortality. Newer classification systems of AKI (RIFLE, AKIN, and KDIGO) changed the epidemiology of AKI and improve the sensitivity and specificity in diagnosis of AKI and stratification of the illness. In 2012 international authorities developed KDIGO Classification system, which is the most recent one. Among ICU admitted patients, mortality variability, effects of early institutions of interventions and various aetiologies of AKI are thoroughly studied to date. Sepsis [17] is the most important risk factor for AKI in ICU. Other risk factors include Diabetes mellitus, Hypertension, CKD, Mechanical Ventilation and medications like vasopressors.

KDIGO classification system is one of the most recent practices in defining AKI and by using that large number of studies has been done globally. We adopted KDIGO classification in predicting the outcomes in patients having AKI, admitted to the ICUs of a tertiary care centre.

Such studies are very few in our place. We decided to study the overall mortality of patients with AKI in ICU, statistical comparison of mortality in AKI according to the stages of kidney injury, duration of ICU stay, contributory factors and etiological profiles. We took data from 153 AKI patients admitted in ICU and applying KDIGO classification the degree of renal injury was staged and statistically analysed the outcomes such as mortality, length of stay, and various co morbidities and its statistical significance.

Objectives

- To study the ability of KDIGO classification in predicting the outcomes of acute kidney injury in patients

admitted to the intensive care units of a tertiary care centre.

- To predict the mortality among acute kidney injury patients admitted to intensive care units
- To study the clinical and etiological profile of patients with acute kidney injury admitted to the Intensive care units.

Materials and methods

All the patients with acute kidney injury, admitted to the intensive care units of our hospital during the period of one year from January 2016 to December 2016, who satisfy the inclusion criteria, were taken into the study. It was a Hospital based prospective cohort study; the diagnostic evaluations were conducted in Govt. Medical College Thiruvananthapuram.

Inclusion criteria

- Patients having acute kidney injury admitted to the intensive care units.
- Age more than 14 years.

Exclusion criteria

- Patients of established Chronic Kidney Disease and End Stage Renal Disease.
- Pre renal factors like volume depletion, correctable within 48 hours
- Discharge against medical advice.
- Adverse outcomes due to other obvious causes

Sample size

$$n = \frac{Z^2_{1-\alpha/2} p(1-p)}{(S+C-1)^2 d^2}$$

p = proportion of mortality = 30%

d = relative position = 20% of p = $\frac{20 \times 30}{100} = 6$

confidence interval = 95%

n = $\frac{3.84 \times 30 \times 70}{0.64 \times 36} = 150$

s = sensitivity of KDIGO = 90%

c = specificity of KDIGO = 90%

Study variables

- Exposure variables like serum creatinine, urine output and blood urea in pre admission and post admission periods.
- Outcome variables like death, End Stage Renal Disease and duration of hospital stay
- Variables like age and sex
- Other clinical and laboratory parameters like serum potassium, platelet count, serum bilirubin and total leucocyte count.
- Mode of treatment
- Time of intervention

Data Analysis

The ability of KIDGO classification in predicting the mortality, outcomes of Acute Kidney Injury in patients in ICU and its statistical significance were assessed. Data entered in to Microsoft excel sheet and analyzed using SPSS package.

Results

Age wise distribution

Study subjects were grouped in to various age groups for analysis. Majority were in the age group of 51 to 60 years (26%). As paediatric population comes under exclusion we included subjects of age more than 14 years only. Average age of the study population was 48.6 years, which is the most productive average age. So AKI holds economic impacts in society (**Table – 1**).

Table – 1: Age wise distribution.

Age (Years)	Frequency	%
<= 20	9	5.9
21 - 30	21	13.7
31 - 40	18	11.8
41 - 50	28	18.3
51 - 60	40	26.1
61 - 70	26	17.0
71+	11	7.2
Total	153	100.0

Average age of the study population was 48.6±16.8 years and age ranges from 14 to 93 years and the median age 51 years (**Table – 2**).

In the present study, males were 58.2% and females were 41.8% (**Figure – 1**).

We had total 153 study subjects, all having acute kidney injury defined by KDIGO classification. Out of 153 subjects 51% died the during study period.

Globally mortality in subjects with AKI in ICU holds about 40 to 60% (**Table – 3**).

Table – 2: Age - mean and median.

	N	Mean age	SD	Minimum age	Maximum age	Median
Age	153	48.6	16.8	14	93	51.0

Figure – 1: Gender distribution.

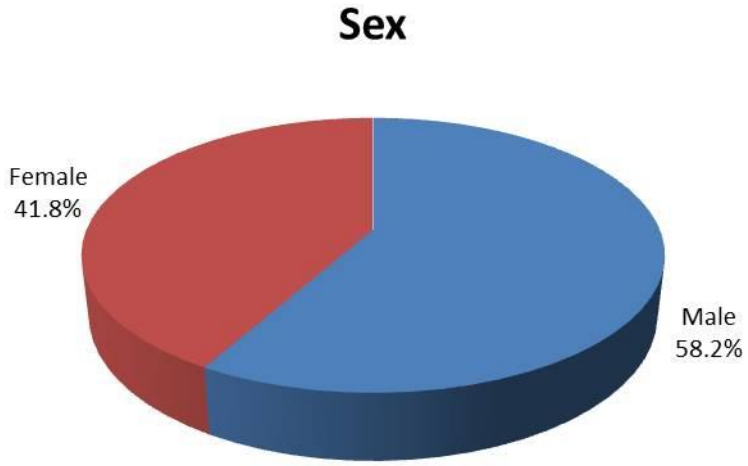

Table – 3: Mortality and AKI.

Mortality	Frequency	Percentage
Yes	78	51.0
No	75	49.0
Total	153	100.0

Table – 4: Duration of Hospital Stay.

	N	Mean	SD	Minimum	Maximum	Median	Q1	Q3
Duration of hospital stay in days	153	6.4	3.2	3	23	6.0	4.0	7.0

Table - 4.a: Duration of hospital stay in days.

	Duration of hospital stay in days							
	N	Mean	S D	Minimum	Maximum	Median	Q1	Q3
Stage 3	88	6.9	3.1	3	22	6.0	5.0	8.0
Stage 2	29	5.7	2.5	3	16	5.0	4.0	6.0
Stage 1	36	5.9	3.7	3	23	5.0	4.0	6.0

p=0.028

Mean duration of ICU stay among AKI patients in Stage III, Stage II and Stage I was 6.9±3.1 days, 5.7±2.5 days and 5.9 ±3.7 days respectively. Duration of ICU stay among Stage III patient was comparatively longer than stage II and stage I ($p<0.05$).It holds statistical significance (**Table – 4, 4.a**).

Renal replacement therapy

50.4% of the patients underwent renal replacement therapy. 47.1% had haemodialysis and 3.3% had peritoneal dialysis, i.e. about half underwent RRT (**Figure – 2**).

37.3% of the patients had both renal and hepatic impairment. Around 24% of subjects had leptospirosis and sepsis. 22% subjects had ARDS and 15.7% of subjects had short fever (**Figure – 3**).

Figure – 2: RRT.

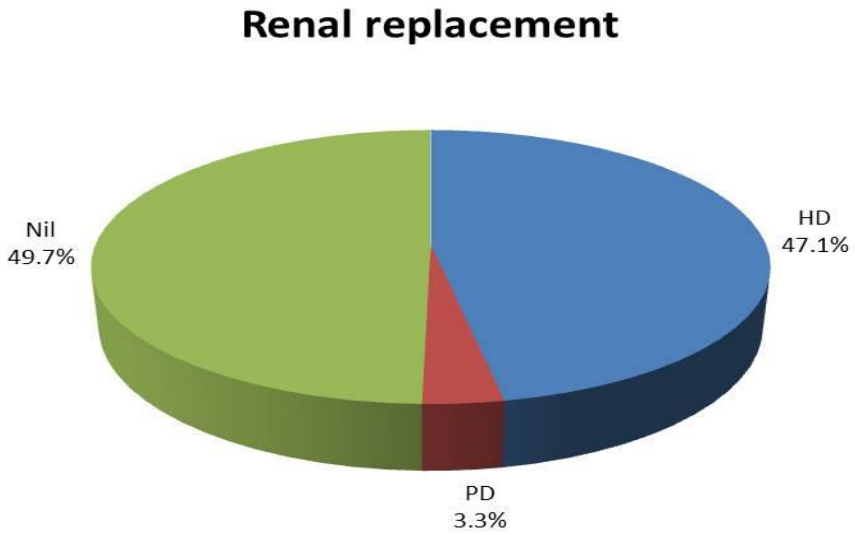

Figure – 3: Etiologies of AKI.

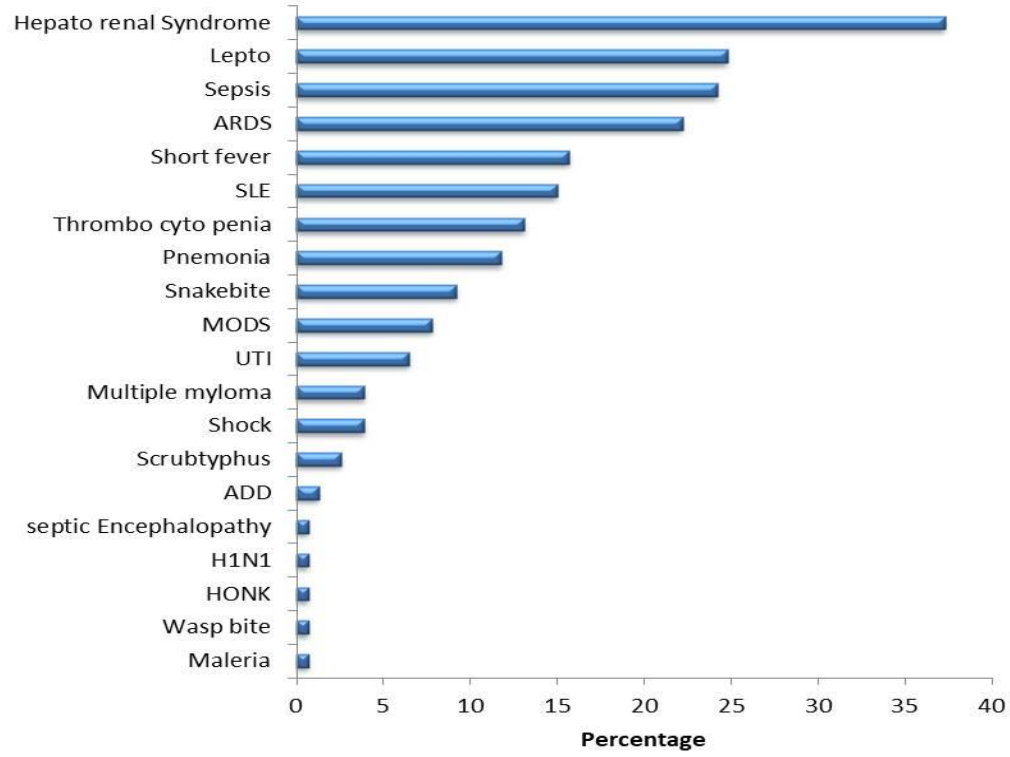

Figure – 4: Stage of AKI.

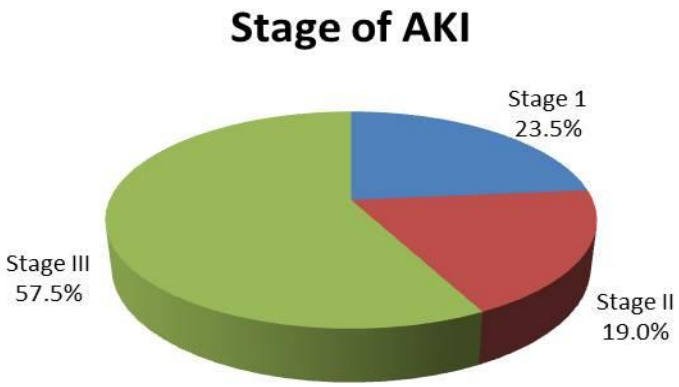

Table – 5: Mortality and stages.

Stage	Mortality				Total	
	Yes		No			
	N	%	N	%	N	%
Stage I	7	19.4	29	80.6	36	100
Stage II	15	51.7	14	48.3	29	100
Stage III	56	63.6	32	36.4	88	100
Total	78	51	75	49	153	100

χ^2 = 19.973 df= 2 P<0.001

Table - 6: Duration of ICU stay.

Stage	Duration of ICU stay				Total	
	>5 days		≤5 days			
	N	%	N	%	N	%
Stage I	30	83.3	6	16.7	36	100.0
Stage II	23	79.3	6	20.7	29	100.0
Stage III	47	53.4	41	46.6	88	100.0
Total	100	65.4	53	34.6	153	100.0

χ^2 = 13.180 df= 2 P=0.001

57.7% of study subjects were included under stage 3 of AKI, according to KDIGO Classification, 23.5 % in Stage 1 and 19% in stage 2 (**Figure – 4**).

19.4 % of the AKI patients in Stage I, 51.7% of the AKI patients in Stage II and 53.6% of the AKI patients in Stage III, expired. Mortality rate among patients in Stage III of AKI was significantly higher than that of the lower stages ($p<0.05$) as shown in **Table - 5**.

83.3% of the AKI patients in Stage I, 79.3 % of the AKI patients in Stage II and 53.4 % of the AKI patients in Stage III had > 5 days of ICU stay. Longer duration of ICU stay was observed among patients in Stage I of AKI, which was significantly higher than that of Higher stages of AKI ($p<0.05$) as in **Table - 6**.

Binary logistic regression model for mortality was performed to predict the independent risk factors of mortality. The regression analysis revealed that staging according to KDIGO, sepsis, hypertension and diabetes had independent predictability in mortality (**Table – 7**).

Table - 7: Binary logistic Regression.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	3.016	7	.884

	B	S.E.	Wald	df	p.	OR	95% C.I. for OR	
							Lower	Upper
DM	.330	.425	3.603	1	.043	1.391	.605	3.199
HTN	1.165	.573	4.126	1	.042	3.205	1.042	9.860
Sepsis	1.063	.440	5.821	1	.016	2.894	1.221	6.862
Stage of AKI II & III	1.644	.484	11.544	1	.001	5.178	2.005	13.370
Constant	-6.602	1.411	21.876	1	.000	.001		

Discussion

We had total 153study subjects. All had acute kidney injury defined by KDIGO classification. Our primary objective was to study the ability of KDIGO system in predicting the outcomes. The important outcome variables studied were mortality, duration of hospital stay and renal replacement therapy.

According to our study, the mortality among stage I, Stage II and stage III of AKI was 19.4 %, 51.7% and 63.6% respectively. Mortality rate among higher stages of AKI patients was comparatively higher than that of the patients in lower stages of AKI ($p<0.05$). This hold statistical significance. We found similar results in lot other studies also but most of which are with other classification systems. Only few studies were there based on KDIGO classification. Thacker, et al. [18], in their study showed almost similar findings with ours. In their study acute kidney injury patients with sustained elevation of creatinine value had higher mortality than those survived.

Out of 153 subjects 51% died during study. That is our mortality rate with AKI, in our ICU is found to be 51%. Globally, in subjects with AKI in ICU, the mortality is about 40 to 60 %. Lots of reference studies are there regarding mortality in patients admitted in ICU with AKI. Chertow, et al. [19] studied various aspects of AKI such as mortality, cost and duration of stay, showed significance in each parameter according to the staging.

In Levy, et al. [20] study, the mortality rate was 34% in patients with AKI versus 7% in patients without AKI. Odds ratio of death was increased by 5.5-fold in the AKI group. In another study, this increase in the odds ratio was 6.3-fold among 643 patients with amphotericin B–associated AKI [21]. Association between very small changes in serum creatinine (S. Cr) was studied by Krumholz, et al. [22, 23], showed that small changes in serum creatinine concentration had been associated with increased mortality and extended (>10 days) length of hospital stay. Recently, Lassnigg, et al. [24] showed a two-fold increase in the risk for death in patients who experienced no change or a small increase (<0.5 mg/dl) in S. Cr at 48 hours. In a similar population, Loef, et al. [25] showed an association between increase in S.Cr and mortality. Our study also showed a statistically significant relationship between mortality in AKI.

Our study subjects were grouped in to various age groups for analysis. Majority were in the age group of 51 to 60 years (26%). We found that the average age of study population is 48.6 years, which is the most productive average age. So AKI holds economic impacts in society.

In some studies there is a relationship between age and AKI related mortality. In our study, 57.1% of the patients in > 50 years of age and 44.7 % of the patients in <50 years had mortality. There was no significant association between age of the patient and mortality (P>0.05) in this study.

We could not demonstrate any association of age with outcomes in contrast to the results of some other studies, the reasons may be that in other studies they used more of younger population, like trauma victims (most are young). In our study we had subjects from 14 years to 93 years.

Our next outcome variable was the duration of ICU stay. Mean duration of ICU stay among AKI patients in Stage III, Stage II and Stage I was 6.9±3.1 days, 5.7±2.5 days and 5.9 ±3.7 days respectively. Duration of ICU stay among Stage III patients were comparatively longer than stage II and stage I (p<0.05) which holds statistical significance. Among the expired, 100% the patients in Stage I, 73.3% of the patients in Stage II and 60.7% of patients in Stage III had to spend more than 5 days in ICUs. In live group also we got a statistically significant relationship between stage AKI and duration of ICU stay. Wijewickrama, et al. [26] studied on duration of stay and mortality and their results are almost similar with ours. Eswarappa, et al. [27], in their study among south Indian population, brought out the significance of the duration of the ICU stay and AKI stage, with average duration of ICU stay being 5.6 days.

Renal replacement therapy and stages were studied in detail and 50.4% of our patients underwent renal replacement therapy, 47.1% had haemodialysis and 3.3%, peritoneal dialysis, i.e.; about half underwent RRT. Of these, 68.1% patients with HD and 80% of patients with PD expired; the p value being <0.005 and this shows that patients with AKI undergoing RRT hold higher mortality, than those doesn't require renal replacement (p<0.05). Monique, et al. [28] also showed similar results. Mehta, et al. [29] and Tolwani, et al. [30], demonstrated that mortality among ICU patients with AKI requiring RRT, is as high as 80%. These results are in line with ours and a lot other studies. Global data also support this.

The co morbidities of the patients admitted to ICU with AKI also were studied in detail and analysed statistically. We found a significant relationship between mortality in subjects with sepsis, short fever, diabetes mellitus and hypertension.

65.4% of the expired patients with AKI had diabetes and on analysis, p value was found to be less than 0.05 which is significant. 65.4% of the diabetic patients had mortality whereas only 43.6% in non-diabetic patients. B. Thijs, et al. [31] studied about vascular complications of diabetes mellitus and found out the relationship between diabetes and AKI but our results are contrary to theirs.

77.8% of the hypertensive study subjects expired as per our study. There is a statistically significant association between hypertension and kidney diseases and it holds a vice versa relationship, i.e.; hypertension can accelerate kidney injury and kidney injury can lead to secondary hypertension. But it needs further detailed independent studies to establish a definite association. Lynda, et al. [32] showed such relationship in their study.

Sepsis associated mortality was 73% in our study group. Mortality among Sepsis patients was significantly higher than that of patients without sepsis (p<0.05). Alobaidi, et al. [33] in their study showed that development of AKI during an episode of sepsis is associated with worse clinical outcome as well as increased mortality (76.5 vs. 61.5% in early AKI).

52.8 % of males and 48.4% of females expired during our study period. The observed difference in mortality was not statistically significant (p>0.05). There was no significant association between mortality and gender according to this study which is similar to the global data.

Like sepsis, short fever also had statistically significant relationship with AKI outcomes as per our study. It is again similar to the global data.

We studied various aetiologies and complications associated with AKI in ICU patients and statistically analysed their relationship to outcomes. Sepsis, diabetes mellitus, short fever, and hypertension were associated with significance in outcomes. Age, gender, occupation or habits failed to show any significant relationship with AKI outcomes. Wasp bite, thrombocytopenia, leptospirosis, malaria, pneumonia, coronary artery diseases, thyroid illness, COPD, asthma, malignancy, chronic liver diseases, readmission, ARDS, acute diarrhoeal diseases, Scrub typhus, HONK, shock, SLE, multiple myeloma, H1N1, MODS etc., in our study did not hold any statistically significant association with outcome variables like mortality. There are lot of studies showing relationship between AKI mortality and some of the above described variables. While considering each variable separately the number of subjects studied was very few in each category in our case and that may be the reason for the contradictory results. Leptospirosis, malaria, ARDS and acute diarrhoeal diseases were extensively studied by many others and shown association. One study showed positive association regarding AKI and malaria. In our study there was no significant association between malaria and mortality. We had only one patient with malaria. There was no significant association between mortality and ARDS, may be because of equal number of subjects in death and recovery groups. There was no significant association between leptospirosis and mortality ($P>0.05$) Out of the 78 expired patients, 17 had leptospirosis but 21 survived patients also had leptospirosis. That means equal incidence in death and live group. So in an outcome measure like mortality, leptospirosis doesn't hold any statistical significance.

Limitations

- We could not identify the exact duration of the illness as we collected data from ICU admissions only. In our setting patients are first admitted in general ward and then only transferred to the ICUs.
- We ruled out chronic kidney diseases by history and using biochemical variables, the chances of missing CKD is there, even then.
- We could not follow up patients for more than the duration other than ICU stay.
- Most of our female subjects gave their occupation as no occupation even though they were busy home makers, which might have affected the analysis regarding occupation.
- Number of subjects with many of the etiological variables was very minimal and it leads to contrary results in comparison to the global data.

Conclusion

We conclude that the higher the stage of AKI, the higher will be the mortality and also staging can predict mortality. So staging AKI patients with KDIGO classification holds statistical significance.

References

1. Kaufman J, Dhakal M, Patel B, Hamburger R. Community-acquired acute renal failure. Am J Kidney Dis., 1991; 17(2): 191-198.
2. Nash K, Hafeez A, Hou S. Hospital-acquired renal insufficiency. Am J Kidney Dis., 2002; 39(5): 930-936.
3. C. V. Thakar, A. Christianson, R. Freyberg, P. Almenoff, M. L. Render. Incidence and outcomes of acute kidney injury in intensive care units: a Veterans Administration study. Critical Care Medicine, 2009; 37(9): 2552–2558.
4. M. Ostermann, R. W. S. Chang. Acute kidney injury in the intensive care unit according to RIFLE. Critical Care Medicine, 2007; 35(8): 1837–1843.

5. H. Gammelager, C. F. Christiansen, M. B. Johansen, et al. One-year mortality among Danish intensive care patients with acute kidney injury: a cohort study. Critical Care, 2012; vol. 16, article R124.
6. Ethgen O, Schneider AG, Bagshaw SM, Bellomo R, Kellum JA. Economics of dialysis dependence following renal replacement therapy for critically ill acute kidney injury patients. Nephrol Dial Transplant., 2015 Jan; 30(1): 54-61.
7. Roy AK, McGorrian C, Treacy C, Kavanaugh E, Brennan A, Mahon NG, et al. A Comparison of Traditional and Novel Definitions (RIFLE, AKIN, and KDIGO) of Acute Kidney Injury for the Prediction of Outcomes in Acute Decompensated Heart Failure. Cardiorenal Med., 2013 Apr.; 3(1): 26-37.
8. Hui WF, Chan WK, Miu TY. Acute kidney injury in the paediatric intensive care unit: identification by modified RIFLE criteria. Hong Kong Med J., 2013 Feb.; 19(1): 13-9.
9. Ratanarat R, Skulratanasak P, Tangkawattanakul N, Hantaweepant C. Accuracy of RIFLE and Acute Kidney Injury Network (AKIN) criteria for predicting Clinical hospital mortality in critically ill patients with multi-organ dysfunction syndrome. J Med Assoc Thai., 2013 Feb.; 96 Suppl 2: S224-31.
10. Ricci Z, Ronco C. Neonatal RIFLE. Nephrol Dial Transplant, 2013 Apr 25.
11. Kellum JA, Levin N, Bouman C, et al. Developing a consensus classification system for acute renal failure. Curr Opin Crit Care, 2002; 8: 509–514
12. Liano F, Pascual J. Epidemiology of acute renal failure: a prospective, multicenter, community-based study. Madrid Acute Renal Failure Study Group. Kidney Int., 1996; 50: 811–818.
13. Brivet FG, Kleinknecht DJ, Loirat P, et al. Acute renal failure in intensive care units - causes, outcome, and prognostic factors of hospital mortality; a prospective, multicenter study. French Study Group on Acute Renal Failure. Crit Care Med., 1996; 24: 192–198.
14. Uchino S, Kellum JA, Bellomo R, et al. Acute renal failure in critically ill patients: a multinational, multicenter study. JAMA, 2005; 294: 813–818
15. Mehta RL, Pascaul MT, Soroko S, Savage DR, Himmelfarb J, Ikizler TA, et al. Spectrum of acute renal failure in the intensive care unit:the PICARD experience. Kidney Int., 2004; 66: 1613–21.
16. Tolwani A. Continuous renal-replacement therapy for acute kidney injury. N Engl J Med., 2012; 367: 2505–14.
17. Bagshaw SM, Uchino S, Bellomo R, et al. Septic acute kidney injury in critically ill patients: clinical characteristics and outcomes. Clin J Am SocNephrol., 2007; 2: 431–439.
18. Thakar CV, Christianson A, Freyberg R, Almenoff P, Render ML. Incidence and outcomes of acute kidney injury in intensive care units: A Veterans Administration study. Crit Care Med., 2009; 37: 2552–2558.
19. Glenn M. Chertow, Elisabeth Burdick, Melissa Honour, Joseph V. Bonventre, David W. Batest. Acute Kidney Injury, Mortality, Length of Stay, and Costs in Hospitalized Patients. J Am Soc Nephrol., 2005; 16: 3365–3370.
20. Levy EM, Viscoli CM, Horwitz RI. Effect of acute renal failure on mortality. A cohort analysis. JAMA, 1996; 275: 1489 –1494.
21. Bates DW, Su L, Yu DT, Chertow GM, Seger DL, Gomes DRJ, Platt R. The mortality and costs of acute renal failure associated with amphotericin B therapy. Clin Infect Dis., 2001; 32: 686 –693.
22. Gottlieb SS, Abraham W, Butler J, Forman DE, Loh E, Massie BM, O'Connor CM, Rich MW, Stevenson

LW, Young J, Krumholz HM. The prognostic importance of different definitions of worsening renal function in congestive heart failure. J Card Fail., 2002; 8: 136 –141.

23. Smith GL, Vaccarino V, Kosiborod M, Lichtman JH, Cheng S, Watnick SG, Krumholz HM. Worsening renal function: What is a clinically meaningful change in creatinine during hospitalization with heart failure? J Card Fail., 2003; 9: 13 –25.
24. Lassnigg A, Schmidlin D, Mouhieddine M, Bachmann LM, Druml W, Bauer P, Hiesmayr M. Minimal changes of serum creatinine predict prognosis in patients after cardiothoracic surgery: A prospective cohort study. J Am Soc Nephrol., 2004; 15: 1697 –1705.
25. Loef BG, Epema AH, Smilde TD, Henning RH, Ebels T, Navis G, Stegeman CA. Immediate postoperative renal function deterioration in cardiac surgical patients predicts in-hospital mortality and long-term survival. J Am Soc Nephrol., 2005; 16: 195 –200.
26. Wijewickrama ES, Ratnayake GM, Wikramaratne C, Sheriff R, Rajapakse S. Incidences and clinical outcomes of acute kidney injury in ICU: a prospective observational study in Sri Lanka. , 2014 May 19; 7: 305.
27. Eswarappa M, Gireesh MS, Ravi V, Kumar D, Dev G. Spectrum of acute kidney injury in critically ill patients: A single center study from South India. Indian J Nephrol., 2014 Sep; 24(5): 280-5.
28. Monique M Elseviers, Robert L, Patricia Vander Niepen, Eric Hoste, Manu L Malbrain, Pierre Damas, Jacques Devriendt. The SHARF investigators are an independent risk factor for mortality in critically ill patients with acute kidney injuryRenal replacement therapy. Critical Care, 2010; 14: R221.
29. Mehta RL, Pascaul MT, Soroko S, Savage DR, Himmelfarb J, Ikizler TA, et al. Spectrum of acute renal failure in the intensive care unit: the PICARD experience. Kidney Int., 2004; 66: 1613–21.
30. Tolwani A. Continuous renal-replacement therapy for acute kidney injury. N Engl J Med., 2012; 367: 2505–14.
31. Thijs T. W. van Herpt, Roosmarijn F. H. Lemmers, Mandy van Hoek, Janneke G. Langendonk, Ronald J. Erdtsieck, Bert Bravenboer, Annelies Lucas, Monique T. Mulder, Harm R. Haak, Aloysius G. Lieverse, Eric J. G. Sijbrands. Introduction of the DiaGene study: clinical characteristics, pathophysiology and determinants of vascular complications of type 2 diabetes. Diabetology & Metabolic Syndrome, 2017; 9: 1.
32. Lynda A, Christipher B Granger, Joseph F Dasta. Acute kidney injury and cardiovascular outcomes in acute severe hypertension. circ.ahajournels.org 2183-2191,2010
33. Alobaidi R, Basu RK, Goldstein SL, Bagshaw SM. Sepsis-associated acute kidney injury. Seminars in Nephrology, 2015; 35: 2-11.