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A HOSPITAL BASED OBSERVATIONAL STUDY OF CLINICAL PROFILE, OUTCOME AND PROGNOSTIC FACTORS OF ACUTE KIDNEY INJURY

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ABSTRACT

BACKGROUND: Acute kidney injury (AKI) is an important cause of in-hospital mortality especially in critically ill patients. The clinical presentation is varied. A comprehensive understanding of AKI is essential to identify potential areas of intervention. Early diagnosis and treatment of AKI in potentially reversible stage prevent progression of renal disease.

METHODS: This was a hospital based observational study. After applying necessary inclusion and exclusion criteria, the study population was assessed. The clinical profile of AKI including etiology, symptoms, signs and blood investigations were assessed. The stage and outcome of AKI was determined. An attempt was made to find out factors which affect outcome of AKI and which help in monitoring a patient with AKI. Associations were made out using chi square test and Kruskal Wallis tests.

RESULTS: The clinical profile of study population was found comparable to other studies. Intrinsic renal failure was most common type and sepsis, most common etiology. Significant association was detected with eGFR, number of days of stay in hospital and KDIGO stage of AKI with outcome. Need for inotrope support, ventilator and hemodialysis were associated with poor outcome. Best prognostic factors were 24 hour urine output, blood urea and serum creatine.

CONCLUSIONS: Any patient admitted in hospital should be kept on an input-output chart and should be closely monitored for decrease in urine output. Sepsis and hypotension must be promptly managed. As for all diseases prevention is better than cure in AKI and conservative treatment is the best treatment option for the same.

KEYWORDS : Acute kidney injury, 24 hour urine output, blood urea, serum creatine, hemodialysis, sepsis

INTRODUCTION

Acute kidney injury (AKI), previously known as acute renal failure is characterized by sudden impairment of renal function resulting in retention of nitrogenous and other waste products which are normally cleared by kidneys. AKI implies the concept that renal damage is a continuous process with a broad range from mild to severe forms. The recent KDIGO definition and classification based on objective parameters such as urine output and creatine levels has improved uncertainties in epidemiology and clinical management of AKI.[1] AKI is common in hospitalized patients and especially in critically ill and the incidence and mortality rates has a wide variation globally, the former 1-31% and the later 28-82%.[2] It is no longer an innocent bystander reflecting co-existent pathologies, but a major risk factor for mortality in intensive care unit.

The general causes of AKI can be divided to three categories, prerenal (caused by decreased renal perfusion, mainly because of volume depletion), intrinsic renal (caused by injury to kidney itself) and postrenal (caused by obstruction to urine flow). It may either be community acquired or hospital acquired. While fluid loss due to diarrhea and vomiting, drugs and distal obstructions are the major causes for the former, the same for later differs significantly which are sepsis, surgeries, heart or liver failure, contrast administration and drugs. The causes differ significantly from country to country and a few region specific etiologies seen in this part of country are envenomation, leptospirosis and malaria. [3]

Early detection and aggressive management of AKI is necessary to bring down mortality. In a country like India the true epidemiological picture of AKI is still not well understood due to late presentation to tertiary care centers and lack of documentation of health care and these are the principal reasons of initiating this study. This study may help in detection of AKI in early and reversible stages and prevent the progression to complete renal shutdown and even death. This study also presents a bird's eye view of important prognostic markers to be watched over, once a patient is in early renal failure as to avoid renal damage.

The objectives of this study were to assess the clinical profile of acute kidney injury including etiologies and to determine prognostic factors and outcome of the same.

MATERIALS AND METHODS

The study was a hospital based non-interventional observational descriptive study conducted in Department of Medicine, Darbhanga Medical College and Hospital, Laheriasarai, Bihar from January 2021 to December 2021.

INCLUSION CRITERIA: All the people more than fifteen years of age presented to MES Medical College during the period of study with an acute increase in serum creatine of 0.3 mg/dl or more from the baseline within 48 hours of admission or those with serum creatine at least 50% greater than baseline within one week of admission or those with oliguria (reduction in urine output <0.5 ml/kg/hour for more than 6 hours) were included in study.

EXCLUSION CRITERIA: The people excluded from study were 1) those with known kidney disease, 2) established diabetic or hypertensive nephropathy, 3) those with connective tissue disorders like systemic lupus erythematosis, 4) those who did not give consent to be a part of study.

Sample size: Total 90 patients were included in the analysis. Significant sample size calculated and statistically validated was 75 for this study.

Data collection technique and tools: Patients were introduced to study after getting an informed consent. They were evaluated by face to face interview sessions based on a statistically validated proforma that was giving emphasis to meticulous history, clinical investigations and relevant investigations. Interview and investigations were carried out on same day without any discomfort to the study population.

After examination staging of AKI was done as per KDIGO guidelines. Probable etiology was determined and classified to prerenal, intrinsic renal and postrenal as well as to community acquired and hospital acquired. Usually two management options were given after complete diagnosis – conservative and hemodialysis – based on severity of disease. The indications for hemodialysis were anuria, refractory rapidly worsening renal failure, hyperkalemia, refractory metabolic acidosis, uremic pericarditis and uremic encephalopathy. All patients were daily followed up with 24 hour urine output, blood urea and serum creatine values. The in-hospital outcomes of AKI considered were mortality, partial recovery and full recovery of renal functions. The outcome and factors affecting that were studied in detail and an attempt was made to make outsome prognostic indicators for outcome in AKI.

STATISTICAL METHODS:

The entire collected data was entered in Microsoft excel 2018 and analyzed with the help of appropriate statistical tools. Kruskal Wallis test and Chi-square test with p value <0.05 were taken as significant association.

RESULTS

Total sample size of the study was 90. Mean age of the study population was 58.39 years with a standard deviation of 18 years and only 16 persons were aged less than 40. Fifty three out of ninety (58.9%) were males. Forty patients were in medicine Intensive care unit that accounted to 44.4% of study population and thirty was from medicine wards (33.3%). From surgery ICU and wards 8 and 12 patients were included respectively. The most common symptom was fever which was seen in 44 (48.8%) of sample population and the mean duration of fever was 4 days. Symptoms of study population with duration are given below in table 1.

Table 1 : Symptoms of AKI with duration

Symptom	Frequency (%)	Duration in days (mean±SD)
Fever	44(48.8%)	4.36±3.56
Oliguria	33(36.6%)	2.61±1.99
Vomiting	22(24.4%)	3.95±9.93
Edema	22(24.4%)	5.27±6.54
Breathlessness	21(23.3%)	3.43±2.95
Altered sensorium	20(22.2%)	1.60±2.08
Abdominal pain	15(16.6%)	4.40±2.55
Dysuria	5(5.5%)	9.33±4.61

43% of study population had pallor and 43% had pitting pedal edema. Mean systolic blood pressure was 135.89 ± 37.98 millimeters of mercury and mean diastolic blood pressure was 83.11 ± 18.338 millimeters of mercury. The mean pulse rate was 91.86 ± 17.227 beats per minute and respiratory rate 21.49 ± 4.71 per minute. Bilateral basal crepitations were noted in 26.6% which was another significant sign. The mean values of first day blood investigations are mentioned below in table 2.

Table 2 : First day blood investigation

Investigation	Mean	Standard Deviation
Hemoglobin (gm/dl)	11.279	2.04
WBC count (cells/cumm)	14310.56	8134.82
Platelet count (cells/cumm)	240762.22	113026.28
ESR (mm after 1 hour)	43.61	24.14
Blood urea (mg/dl)	70.94	46.95
Serum creatinine (mg/dl)	3.079	2.9479
Blood sugar (mg/dl)	128.78	63.23
eGFR	34.7147	22.6133
Total bilirubin (mg/dl)	1.218	0.972
Direct bilirubin (mg/dl)	0.329	0.67
SGPT (IU)	80.64	95.82
SGOT (IU)	68.11	42.097
ALP (IU)	96.7	82.342
Albumin (mg/dl)	3.12	0.68
Globulin (mg/dl)	3.08	0.62
Sodium (mEq/L)	129.38	15.54
Potassium (mEq/L)	4.098	0.92
Calcium (mg/dl)	8.043	0.8946
Phosphorous (mg/dl)	4.541	1.801

28 patients out of 90 (31.1%) had 1+ albuminuria, 14 had 2+ and 7 had 3+ albuminuria. Only 13 patients (14.4%) had no albumin in urine routine. Hematuria was present in 20 patients (22.2%). Metabolic acidosis was detected in 57 patients which accounted to 63.3% of study population which was the single most common acid base disorder noticed. Hypocalcemia was detected in 75.5% of study population, followed by hyponatremia in 66.67%, hypokalemia in 26.67%, hyperphosphatemia in 22.2% and hyperkalemia in 13.33%.

Seventy percent of study population had intrinsic renal failure, 23.3% had pre-renal failure and 6.7% had postrenal failure. The same was found out applying clinical data and calculating fractional excretion of sodium. 44 out of 90 patients (48.9%) had stage 3 AKI, 28 (31.1%) had stage 2 and 18 (20%) had stage 1 AKI. 92.2% of AKI was community acquired in this study and only 8 patients had hospital acquired AKI, 3 due to vancomycin use, 2 due to aminoglycosides and 3 due to significant diarrhea in hospital. 43 patients had sepsis (47.7%) which was the single most common cause for AKI in this study, also proven by relative increase in total leukocyte count in blood investigations furnished above. Among those with infections, 21.1% had urinary tract infections, 14.4% had respiratory tract infections, 8.8% had cellulitis, skin and soft tissue infections. Acute glomerulonephritis produced AKI in 7.8% and accelerated hypertension caused the same in 5.6%.

The outcome of AKI can assessed as expired, partial recovery, full recovery. 16 out of 90 (17.8%) succumbed to illness, 39 (43.3%) had partial recovery and 35 (38.9%) recovered fully. Eighty four percent of patients were treated conservatively and only fourteen patients needed hemodialysis during hospital stay. Antibiotics were used in 79 (87.8%) patients. Inotropes support were needed in 14 (15.6%) and ventilator support in 13 (14.4%). Out of fourteen patients who underwent hemodialysis five expired, eight had partial recovery and long term maintenance hemodialysis and only one had full recovery.

The following table (table 3) shows the follow up, the mean 24 hour urine output, mean blood urea and mean serum creatine of all patients for first five days.

An attempt was made to find out association between different variables and outcome of AKI which was the main part of this study so as to look for a suggestive prognostic factor. Age, sex, premorbidities like hypertension, diabetes and addictions showed no relationship to the outcome of AKI. Similarly elevated blood counts, liver function tests and serum electrolyte values had no relation to the outcome. Significant association was seen between a few variables to outcome which were consolidated as table 4 below.

Table 3 : Follow up of the study population

Urine output	Mean (ml/day)	Standard Deviation
Day 1	1067.96	611.75
Day 2	1222.137	701.50
Day 3	1300.462	665.69
Day 4	1211.191	585.40
Day 5	1241.522	705.99
Blood urea	Mean (mg/dl)	Standard Deviation
Day 1	71.75	50.21
Day 2	71.03	51.12
Day 3	68.21	48.71
Day 4	71.94	53.45
Day 5	70.64	55.98
Serum Creatinine	Mean (mg/dl)	Standard Deviation
Day 1	3.097	2.94
Day 2	3.092	2.43
Day 3	2.849	2.04
Day 4	2.923	1.86
Day 5	2.74	1.77

Table 4 : Association of various factors to outcome of AKI

Factor	Outcome			p-value
	Expired (mean±SD)	Partial recovery (mean±SD)	Complete recovery (mean±SD)	
Mean hospital stay in days	7.94±3.24	10.69±6.35	6.86±3.566	0.01*
eGFR	34.0±20.78	29.09±26.68	41.30±16.44	0.002*
Stage of kidney disease	Expired N(%)	Partial recovery N(%)	Complete recovery N(%)	Chi square/ p-value
Stage 1	0(0%)	3(16.66%)	15(83.3%)	42.730 */ 0.0001*
Stage 2	2(7.1%)	10(35.7%)	16(57.7%)	
Stage 3	14(31.8%)	26(66.67%)	4(9%)	

Statistically significant data

So significant association were seen for the hospital stay duration, eGFR and stage of acute kidney injury with the outcome. Out of 21 patients with AKI, 5 expired 4 had partial recovery and 12 had complete recovery. Out of 63 patients with intrinsic renal disease 8 expired, 32 had partial recovery and 23 had full recovery. Out of 6 patients with post renal AKI, 3 expired and 3 had partial recovery. Of the patients admitted with sepsis, which was the most common cause, 9 expired, 8 partially recovered and 11 recovered fully. Out of the 74 patients who were managed conservatively, 44.7% fully recovered, 40.7% partially recovered and 14.4% succumbed to illness. May be the group of patients taken for hemodialysis were more sick than the conservatively managed group; outcome of the former was also bad. Out of 14 patients taken for hemodialysis only one had complete recovery, 8 had partial recovery and 5 succumbed to illness.

Regarding monitoring of AKI patients; when Kruskal Wallis test was applied for mean 24 hour urine output values and daily blood urea and serum creatine values, all three were found to have statistically significant association with the outcome of disease which is shown in table number 5 below. So progressive decline in urine output and progressive increase in blood urea and serum creatine are poor prognostic factors in AKI.

Table 5 : Symptoms of AKI with duration

Variable	Expired (mean±SD)	Partially recovered (mean±SD)	Fully recovered (mean±SD)	p-value
Urine output Day 1 (ml)	964.188±473.73	982.967±621.63	1210±643.87	0.262
Urine output Day 2 (ml)	1020.063±541.9	1142.213±720.66	1403.571±720.21	0.163
Urine output Day 3 (ml)	935±483.11	1310.092±735.58	1456.8±603.46	0.014*
Urine output Day 4 (ml)	839.286±426.37	1186.766±702.64	1492.857±298.61	0.004*
Urine output Day 5 (ml)	872.222±487.07	1041.170±686.4	1852.417±484.19	0.002*
Blood Urea Day 1 (mg/dl)	82.725±62.69	75.51±55.96	62.54±34.18	0.667
Blood Urea Day 2 (mg/dl)	105.38±81.72	73.46±44.47	52.63±27.79	0.019*
Blood Urea Day 3 (mg/dl)	112.56±73.36	66.97±40.06	49.31±27.34	0.001*
Blood Urea Day 4 (mg/dl)	139.77±79.17	61.00±24.27	45.05±18.70	0.001*
Blood Urea Day 5 (mg/dl)	152.14±96.90	62.74±22.04	38.25±9.17	0.001*
Serum creatinine day 1 (mg/dl)	2.37±1.26	4.126±3.64	2.283±2.22	0.02*
Serum creatinine day 2 (mg/dl)	3.35±1.60	4.144±2.97	1.80±1.20	0.01*
Serum creatinine day 3 (mg/dl)	3.963±1.68	3.646±2.28	1.45±0.69	0.01*
Serum creatinine day 4 (mg/dl)	4.43±1.65	3.438±1.69	1.29±0.58	0.01*
Serum creatinine day 5 (mg/dl)	4.81±1.27	3.056±1.53	0.97±0.09	0.01*

DISCUSSION

This study was done in 90 hospitalized patients with AKI. The mean age 58 which was comparable to study conducted by Turney et al and a similar study conducted in India by Prakash et al.[4,5] The mean age of expired patients were significantly higher than that of recovered though no statistical correlation was attained. But advancing age has shown to affect AKI outcome in a similar study conducted in Spain.[6] Males were detected to have higher incidence of AKI in this study which is similar to many studies.[7] There may be unknown genetic aspects influencing the development of AKI. Patients were included from medicine and surgery departments in this study and 62 out of 90 are from intensive care units. This may be due to increased co-morbidities like hypotension and infections. Fever was found to be the most common presenting symptom in this study. Most of the studies all over the world project oliguria as the commonest symptom of AKI.[8] The disparity here may be due to the fact that sepsis is the most common etiology identified here. 43% of this study population had anemia. This factor is previously highlighted by a Canadian study, where 53 out of 56 patients with AKI had anemia at some point during their hospital stay.[9]

Anemia was multifactorial since in nearly one-third patients, it preceded onset of renal failure. Anemia may be a pointer to underlying chronic kidney disease or other chronic diseases. Most of the systemic examination findings were due to volume overload. Bilateral basal crepitations may be due to acute pulmonary edema and abdominal distension may be due to fluid accumulation in peritoneum. Presence of co-morbid illness like diabetes, hypertension did not reveal a significant association to incidence, progression or outcome of AKI.

Neutrophilic leukocytosis was the most common finding in routine hemogram apart from anemia. Both luekocytosis and leukocytopenia are associated with increased mortality though no similar findings were obtained here.[10] Most of the patients had very minimal proteinuria in this study. The urine microscopy was helpful in identifying AKI in this study. However there was no association between microscopy findings and outcome of AKI. Previously Bagshaw and colleagues had collected blood and urine samples of 83 critically ill patients with sepsis of whom 52%had AKI. They had derived a urine microscopy score based on observed quantification of renal tubular epithelial cells and granular casts in sediments and showed that septic AKI was associated with greater urine microscopy evidence of kidney injury than non-septic AKI despite similar severity of both.[11] A higher urine microscopy score was also predictive of worsening AKI. Various electrolyte abnormalities were seen in this study associated with AKI, the commonest being hypocalcemia which was present in 75.5% of study population. It was followed by hyponatremia, hyperphosphatemia, hypokalemia and hyperkalemia. No significant association was made out between electrolyte abnormality and outcome of AKI. Hypocalcemia hyperphosphatemia and increase in immunoreactive parathyroid hormone are very common metabolic derangements seen of which calcium and parathyroid abnormalities persist into the diuretic phase of AKI. [12]

There were studies where hyperkalemia was commonest electrolyte abnormality followed by hyponatremia and hypocalcemia only abnormality detected in liver function tests was hypoalbuminemia. Hypoalbuminemia may casually contribute to the development of AKI and administration of human albumin solution has shown some potential in preventing AKI. [13]

The patients were divided to stage 1, 2 and 3 of AKI based on the highest they had reached during stay in hospital. This study had clearly showed increasing stage of disease significantly affect the outcome. The stage of AKI had shown to correlate with the short term and long term outcomes of AKI. In a Brazilian study, the same Kidney Disease Improving Global Outcomes (KDIGO) criteria used here was found to be a powerful predictor of 30 day mortality in patients who had elevated post operative serum creatine who underwent cardiac surgeries. [14] The studies available highlight even transient perturbations in kidney function increases mortality. 70% of the study population had intrinsic renal failure, 23% had prerenal failure and the rest postrenal failure. Community acquired causes were accounted for in 92.2% of the study population and sepsis was the most common etiology for the same. Common causes and risk factors of AKI significantly differed in developing and developed countries. In contrast to trauma, industrial accidents, drugs, cardiogenic causes, renal transplant rejection in developed countries, acute tubular necrosis due to community acquired infections remain the most common cause in the tropics. Sepsis, hypotension, aminoglycosides were the main culprits of AKI in India. [15] These are the different scenarios where we should be cautious of renal status of the patient.

Coming to the management part, of the conservatively managed 76 patients, 11 (14.4%) succumbed to the illness, 31 had partial recovery and 34 recovered completely. IV fluids were the main stay of treatment of AKI but were administered judiciously with strict monitoring of urine output as to avoid pulmonary edema. Antibiotics were another important part of treatment especially in sepsis patients. A few patients of study population needed inotrope support and ventilator. These two requirements may be taken as a poor prognostic sign as seven out of fourteen patients who required inotrope and eight out of thirteen patients who required ventilator succumbed to their illness. Antibiotics whenever used must be in a calculated dose based on creatine clearance that should be individually calculated for each patient. Another common medication used in conservative management of AKI was diuretics. However it was told using diuretics on patient with AKI was like whipping a dying horse. The same was shown in studies which demonstrated diuretics to be ineffective in preventing AKI as well as improving outcome of the same.[16] Despite decades of research, no specific therapy for AKI other than supportive care exists currently. May be due to increased severity of disease and increased stage of AKI, patients initiated on hemodialysis had a worse outcome than conservative management. Of the 14 patients initiated on dialysis only one person had full recovery, eight had to be maintained on hemodialysis and five patients had expired. In SHARF (Stuivenberg Hospital Acute Renal Failure) study mortality was 58% among those AKI patients who had undergone hemodialysis and the same was 43% among those conservatively managed. So a critical approach is warranted in initiating renal replacement therapy in AKI.

Discussion will not be complete without mentioning about monitoring and prognostication factors of AKI. Daily urine output, blood urea and serum creatine were found to be excellent tools to monitor and predict outcome of AKI in this study. It was found out oliguric AKI had far worse prognosis than non-oliguric AKI. [17] Similarly worsening blood urea and creatine value despite optimum conservative management showed poor survival outcomes in this study. So these are the three most important predictors of outcome of AKI according to this study and we strongly advice monitoring these in critically ill patients so as to pick up AKI very early and prevent worsening of the same. Regarding final outcome, only in-hospital outcomes were considered in this study. 17.8% of study population passed away in hospital, 43.3% had partial recovery and 38.9% had complete recovery. The majority in partial recovery group are those patients who had responded to treatment but had not returned to baseline creatine during the period of study. The reported hospital mortality of AKI patients had varied between 13.3% to 49.1%.[18] A prospective study of AKI in India in ICU patients found out a mortality of 52% down the line.[19] Studies showed most of the deaths in AKI occur within 60 days and hence follow up for 60 to 90 days would be adequate for a reliable analysis of mortality rate.[20]

CONCLUSION

Acute Kidney Injury is a clinical syndrome with several different etiologies, pathophysiologies and prognostic factors. Fever and oliguria are the main clinical features. Sepsis is the most common cause of AKI. Most common type of AKI was intrinsic renal failure. Premorbidities like hypertension, diabetes did not affect the outcome of AKI. The factors affecting outcome were eGFR, KDIGO stage of AKI, duration of hospital stay, need for inotrope support, ventilator, hemodialysis. Conservative management was the best time tested approach in treating AKI where antibiotics and intravenous fluid are the pillars. Monitoring of AKI patient can be done by assessing daily 24 hour urine output, blood urea and serum creatine.

REFERENCES

1. Kidney Disease: Improving Global Outcomes (KDIGO) Acute Kidney Injury Work Group. KDIGO Clinical Practice Guideline for Acute Kidney Injury. Kidney Int. 2012;2:1–138.
2. Ali T, Khan I, Simpson W, Prescott G, Townend J, Smith W, et al. Incidence and outcomes in acute kidney injury: a comprehensive population-based study. J Am Soc Nephrol. 2007 Apr 1;18(4):1292–8.
3. Kaufman J, Dhakal M, Patel B, Hamburger R. Community-acquired acute renal failure. Am J Kidney Dis. 1991Feb;17(2):191–8.
4. Turney, Obialo CI, Crowell AK, Okonofua EC. Acute renal failure mortality in hospitalized African Americans: age and gender considerations. J Natl Med Assoc 2002 Mar;94(3):127–34.
5. Prakash J, Murthy a S, Vohra R, Rajak M, Mathur SK. Acute renal failure in the intensive care unit. J Assoc Physicians India. 2006;54(October):784–8.
6. Coca SG. Acute kidney injury in elderly persons. Am J Kidney Dis.2010 Jul;56(1): 122–31.
7. Basu G, Chrispal A, Boorugu H, Gopinath KG, Chandy S, Prakash JAJ, et al. Acute kidney injury in tropical acute febrile illness in a tertiary care centre--RIFLE criteria validation. Nephrol Dial Transplant.2011 Feb 1;26(2):524–31.
8. Nagamani R, Sudarsi K, Amaravati KS, Khan M, Sakuntala P. A Study on Clinical Profile of Acute Kidney Injury. Int J Sci Res Publ 2014;5(7):2250–3153.
9. Hales M,Solez K KC. The anemia of acute renal failure: association with oliguria and elevated blood urea. - PubMed - NCBI. Ren Fail.1994;16(1):125–31.
10. Han SS, Ahn SY, Ryu J, Baek SH, Kim K, Chin HJ, et al. U-shape relationship of white blood cells with acute kidney injury and mortality in critically ill patients. Tohoku J Exp Med 2014;232(3):177–85.
11. Bagshaw SM, Haase M, Haase-Fielitz A, Bennett M, Devarajan P, Bellomo R. A prospective evaluation of urine microscopy in septic and non-septic acute kidney injury. Nephrol Dial Transplant.2012 Feb 1;27(2): 582–8.
12. Uchino S, Bellomo R, Goldsmith D. The meaning of the blood urea nitrogen/creatinine ratio in acute kidney injury. Clin Kidney J.2012 Apr 1;5(2):187.
13. Wiedermann CJ, Wiedermann W, Joannidis M. Causal relationship between hypoalbuminemia and acute kidney injury. World J Nephrol 2017 Jul 6;6(4):176–87.
14. Machado MN, Nakazone MA, Maia LN. Acute kidney injury based on KDIGO (Kidney Disease Improving Global Outcomes) criteria in patients with elevated baseline serum creatinine undergoing cardiac surgery. Rev Bras Cir Cardiovasc 2014;29(3):299–307.
15. Schor N. Acute renal failure and the sepsis syndrome. Kidney Int 2002;61:764–76.
16. Mehta RL, Pascual MT, Soroko S, Chertow GM, PICARD Study Group. Diuretics, mortality and nonrecovery of renal function in acute renal failure. JAMA 2002 Nov 27;288(20):2547–53.
17. Singh TB, Rathore SS, Choudhury TA, Shukla VK, Singh DK, Prakash J. Hospital-acquired acute kidney injury in medical, surgical, and intensive care unit: A comparative study. Indian J Nephrol 2013 Jan;23(1):24–9.
18. Ostermann M, Chang RWS. Acute kidney injury in the intensive care unit according to RIFLE. Crit Care Med 2007 Aug;35(8): 1837–43.
19. Bhadade R, De'Souza R, Harde MJ, Mehta KS, Bhargava P. A prospective study of acute kidney injury according to KDIGO definition and its mortality predictors. J Assoc Physicians India. 2016;64 (December):22–8.
20. Bell M, Liljestam E, Granath F, Fryckstedt J, Ekbom A, Martling C-R. Optimal follow-up time after continuous renal replacement therapy in actual renal failure patients stratified with the RIFLE criteria. Nephrol Dial Transplant 2005 Feb 1;20(2):354–60.