MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.36478/makrjms.2024.11.44.50

OPEN ACCESS

Key Words
Kidney Injury, kidney function, sociodemographic data

Corresponding Author
Mulagapaka Vinusha,
Department of General Medicine, PES Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh, India, 571425

Author Designation
[1,5,6]Junior Resident
[2]Senior Resident
[3]HOD and Professor
[4]Professor

Received: 6 September 2024
Accepted: 9 October 2024
Published: 11 October 2024

Citation: Mulagapaka Vinusha, P.V.L. Sahithi, M.A. Uma, P.E. Dhananjaya, Shikara Reddy Kundavaram and Kandula Venkata Sai Raghavendra, 2024. Etiology, Risk Factors, Clinical Course and Outcome of Acute Kidney Injury in Geriatric Patients. Res. J. Med. Sci., 18: 44-50, doi: 10.36478/makrjms. 2024.11.44.50

Etiology, Risk Factors, Clinical Course and Outcome of Acute Kidney Injury in Geriatric Patients

[1]Mulagapaka Vinusha, [2]P.V.L. Sahithi, [3]M.A. Uma, [4]P.E. Dhananjaya, [5]Shikara Reddy Kundavaram and [6]Kandula Venkata Sai Raghavendra
[1-6]Department of General Medicine, PES Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh, India, 571425

ABSTRACT
Acute Kidney Injury (AKI), formerly known as acute renal failure, is a sudden and often reversible decline in kidney function, characterized by an abrupt increase in serum creatinine levels or a decrease in urine output. The study's objectives are to examine the causes, risk factors and consequences of Acute Kidney Injury (AKI) in the older population. The study conducted was an Observational cross-sectional study in the Department of General Medicine, PES College, Kuppam from October 2022 to October 2023. The sample size was 50. The data was collected using a pretested questionnaire which contains sociodemographic data, presenting complaints, clinical examination and investigation details (CBC, RFT, Serum electrolytes, Urine analysis, USG abdomen and pelvis). Data was entered in Excel and Imported to SPSS for further analysis. Out of a total of 50 individuals, 32 (64%) were male, while 18 (36%) were female. There was a higher percentage of males (64%) compared to females (36%). The lactate levels, procalcitonin were higher among the death group than compared to the patients who were discharged. Inotrope and ventilatory support requirement was more in patients whose outcome was death. This difference was statistically significant (p-value<0.05). verall, the conclusion of this study is the major causes for AKI among the geriatric population are cardiovascular system and respiratory system etiologies. There were 13 (26%) deaths reported in the study and 37 (74%) survived. The main risk factors and parameters that were statistically significantly associated with consequences were elevated creatinine levels, inotrope support, ventilator support, lactate levels, duration of hospital stay.

INTRODUCTION

Acute Kidney Injury (AKI), formerly known as acute renal failure, is a sudden and often reversible decline in kidney function, characterized by an abrupt increase in serum creatinine levels and a decrease in urine output.

The Kidney Disease: Improving Global Outcomes (KDIGO) guidelines have given a widely accepted definition and staging system for AKI based on serum creatinine levels and urine output. According to KDIGO, AKI is classified into three stages based on the severity of kidney dysfunction. An increase in serum creatinine by ≥0.3mg/dL (≥26.5μmol/L) within 48 hours, or an increase in serum creatinine to ≥1.5 times baseline, which is known or presumed to have occurred within the prior 7 days, or urine volume <0.5 mL/kg/hour for 6 hours is the definition according to KDIGO[1]. Along with the definition, severity grading is also given which helps the clinicians classify AKI severity and guide management decisions, emphasizing the importance of timely recognition and intervention in AKI cases. AKI is classified into 3 stages from mild to severe form.

AKI is of clinical concern as it is associated with increased risk of morbidity, mortality and high expenditure. AKI patients develop various complications such as electrolyte imbalances, fluid overload , organ pathologies other than kidney. The need for long hospital stays, renal replacement therapy (RRT) and long-term adverse outcomes like chronic kidney disease (CKD)makes AKI an important disease to be studied and researched.

Globally AKI is a common and serious condition, affecting millions of people every year. The exact prevalence and incidence rates might vary across different regions and populations. Various studies have shown that AKI occurs in up to 20% of hospitalized patients and is even more prevalent in critical individuals[3]. The global incidence of AKI has gone up over the years, partly due to advancements in technologies and healthcare which has led to increased recognition and diagnosis of AKI cases. A meta-analysis done on the world incidence of AKI revealed that the pooled incidence rates of AKI were 21.6% [95% confidence interval (CI) -19.3-24.1] and 33.7% (95% CI -26.9-41.3) in adults and children respectively[2]. A study done on global epidemiology and outcome of AKI estimated a prevalence range from <1%-66%[3]. In a study on pediatric population admitted to tertiary care hospital with trauma, deaths were significantly high in study population associated with AKI[4]. This study particularly focuses on examining the causes, risk factors and consequences related to Acute Kidney Injury (AKI) in the older population.

MATERIALS AND METHODS

The study was conducted at the Department of General Medicine, PES Hospital, Kuppam from October 2022 to October 2023. This study had study subjects aged more than 60 years of age with Acute Kidney injuries admitted to the General Medicine Ward and medical ICU of PES Hospital, Kuppam. The sample size was calculated to be 42 based on the study done by Soren B(5), considering the prevalence as 20% and precision of 12%. However, it was decided to round it off to 50. The data was collected using a pretested questionnaire which contains sociodemographic data, presenting complaints, clinical examination and investigation details (CBC, RFT, Serum electrolytes, Urine analysis, USG abdomen and pelvis). Informed consent was taken from the patient or the patient attendees. Demographic details were noted. A thorough history was taken regarding fever, vomiting, loose stools, decreased urine output, shortness of breath, burning micturition, poisoning, unknown bite, use of nephrotoxic drugs, trauma and surgeries. A detailed clinical examination was done which included a vitals examination and a general examination included pallor, icterus, cyanosis, clubbing, generalized lymphadenopathy and pedal edema. Detailed systemic examination included signs of uremic encephalopathy, signs of fluid overload and signs of sepsis. The data was entered into MS Excel 2019 version and further analyzed using SPSS (version 26.0., SPSSInc. Chicago IL, USA).

RESULTS AND DISCUSSIONS

During the study period of 12 months, 250 patients were admitted with acute kidney injury in medical wards and intensive care units. Among them, patients who already have CKD and patients who were lost to follow-up and not willing to the study have been excluded. Hence a sample of 50 patients has been included in the study.

Table 1: Distribution of Study Participants Based on Gender

Gender	Number	Percentage
Female	18	36
Male	32	64
Total	50	100

Out of a total of 50 individuals, 32 (64%) were male, while 18 (36%) were female. There was a higher percentage of males (64%) compared to females (36%).

Table 2: Distribution of Study Participants Based on Hospital Stay

Hospital stay (Days)	Number	Percentage
1-7	24	48
8-14	19	38
> 15	7	14
Total	50	100

A significant portion of patients (86%) had a hospital stay of up to 14 days, with nearly half of them staying for 1-7 days. About 14% of them stayed for more than 15 days.

Table 3: Distribution of the Study Participants Based on Outcome

Final outcome	Number	Percentage
Death	13	26
Discharge	37	74
Total	50	100

Table 4: Association Between Diagnosis and Level of Urea at Peak among the Study Participants

Level of Urea at Peak Diagnosis n (%)	Central Nervous System	Cardio vascular System	Gastro Intestinal System	Others	Renal	Respiratory System	Total	P-value
	0	0	1	1	0	0	2	
<40	(0%)	(0%)	(50%)	(50%)	(0%)	(0%)	(100%)	
40-	1	6	4	11	0	9	31	
100	(3.2%)	(19.3%)	(12.9%)	(35.5%)	(0%)	(29.0%)	(100%)	0.155
	0	5	1	3	4	4	17	
>100	(0%)	(29.4%)	(5.9%)	(17.6%)	(23.5%)	(23.5%)	(100%)	
	1	11	6	15	4	13	50	
Total	(2%)	(22%)	(12)	(30)	(8)	(26)	(100)	

Table 5: Association Between Diagnosis and Level of Creatinine at Peak among the Study Participants

Level of creatinine at Peak Diagnosis n (%)	Central Nervous System	Cardio Vascular System	Gastro Intestinal System	Others	Renal	Respiratory System	Total	P-value
	1	11	5	14	1 12	44		
<4	(2.3%)	(25%)	(11.4%)	(31.8%)	(2.3%)	(27.2%)	(100%)	
	0	0	1	1	3 1	6	0.004	
>4	(0%)	(0%)	(16.7%)	(16.7%)	(50%)	(16.8%)	(100%)	
	1	11	6	15	4 13			
Total	(2)	(22)	(12)	(30)	(8)	(26)	50	

Table 6: Association of Level of eGFR with Ventilatory Support among the Study Participants

	Ventilatory Support			
Level of eGFR (mL/min)	Y Number (%)	N Number (%)	Total Number (%)	P-value
<15	6 (66.67)	3 (33.33)	9	0.924
15-30	7 (53.85)	6 (46.15)	13	
30-60	13 (56.52)	10 (43.48)	23	
60-90	0 (0)	0 (0)	0 (0)	
>90	2 (50)	2 (50)	4	
Total	28 (56)	22 (44)	50 (100)	

Table 7: Association of Level of eGFR with Inotrope Support among the Study Participants

	Inotrope Support		
eGFR	Yes Number (%)	No Number (%)	P-value
<15	5 (55.56)	4(44.44)	0.172
15-30	9 (69.23)	4(30.77)	
30-60	8 (34.78)	15(65.22)	
60-90	0(0)	0(0)	
>90	1(25)	3(75)	
Total	23(46)	27(54)	

Table 8: Comparison of Electrolytes among the Discharge and Death Groups

Electrolytes	Outcome		
	Death Mean ± SD	Discharge Mean ± SD	P-value
Sodium	129.0538±8.33	133.4811±5.86	0.0420*
Potassium	4.7070±1.11	4.120±0.72	0.0344*
Chloride	101.61±9.12	101.29±7.99	0.9058
Calcium	13.11±18.94	8.42±0.79	0.1319
Magnesium	1.69±0.33	1.82±0.39	0.2884
Phosphate	4.01±1.09	3.38±0.86	0.0403*
pH	7.29±0.096	7.36±0.14	0.0870
Bi-carbonate	14.192±7.48	18.31±5.01	0.0304*

Table 9: Association Between Total Count and Etiology of AKI

	Etiology of AKI				
Total count (cells/mm)	Post renal	Pre renal	Renal	Total	P-value
<4000	0 (0)	2 (50)	2 (50)	4 (100)	0.708
4000-10000	0	1 (9.09)	10 (90.91)	11 (100)	
10000-20000	1 (3.33)	6 (20)	23 (76.67)	30 (100)	
>20000	0	1 (20)	4 (80)	5 (100)	
Total	1 (2)	10 (20)	39 (78)	50 (100)	

Table 10: Association Between Inotrope Support and Outcome

	Outcome		
Inotrope support	Death Number(%)	Discharge Number(%)	P-value
No	0(0)	26 (100)	<0. 001*
Yes	13 (52.17)	11 (47.83)	
Total	13 (24.49)	37 (75.51)	

Table 11: Association Between Ventilator Support and Outcome

	Outcome		
Ventilator support	Death Number(%)	Discharge Number(%)	P-value
No	0(0)	21 (100)	<0. 001*
Yes	13 (42.86)	16 (57.14)	
Total	13 (24.49)	37 (75.51)	

Table 12: Association Between Duration of Hospital Stay and Outcome

	Outcome		
Duration of hospital stay (in days)	**Death N(%)**	**Discharge N(%)**	**P-value**
1-7	10 (41.67)	14 (58.33)	0.026*
8-14	1 (5.26)	18 (94.74)	
>15	2 (28.57)	5 (71.43)	
Total	13 (26.00)	37 (74)	

Table 13: Association Between Levels of Lactate at Admission and Outcome

	Outcome		
Level of lactate at admission (mmol/L)	**Death Number (%)**	**Discharge Number (%)**	**P-value**
2-10	0(0)	12 (100)	0.019*
>10	13 (34.21)	25 (65.79)	
Total	13 (26.00)	37 (74)	

Table 14: Association Between Level of Procalcitonin and Outcome

	Outcome		
Level of procalcitonin (ng/ml)	**Death Number (%)**	**Discharge Number (%)**	**P-value**
<0.8	1 (100)	0(0)	0.202
>0.8	8 (36.36)	14 (63.64)	
Total	9 (39.13)	14 (60.87)	

This study recorded 26% (13/50) of deaths and 74% of the study participants were discharged. The urea at peak levels between 40-100mg/dl was majorly (35.5%) seen among the other diagnoses. A level of 100mg/dl and more was seen in renal and respiratory diagnoses (23.5% each). The association between the level of urea at peak and the diagnosis was not found to be statistically significant (p-value=0.155). A creatinine level of more than 4mg/dl was seen in renal (50%), Gastrointestinal system, respiratory system involvement and other diagnoses (16.7% each). The association between level of creatinine at peak and the diagnosis was found to be statistically significant (p value=0.004).

About 66.7% of the study participants required ventilator support who had an eGFR of <15ml/min, similarly 53.9% and 56.5% of them required ventilator support who had 15-30mmHg and 30-60mmHg respectively. The association between level of creatinine at peak and the diagnosis was found to be statistically significant (p value=0.004). Study subjects who had eGFR of less than 15ml/min, required more (55.6%) inotrope support. Similar result was seen in eGFR of 15-30 ml/min. The relationship between eGFR and inotrope support was not statistically significant (p value=0.172).

The electrolytes, sodium and bi-carbonate were high among the discharged group than compared to the patients who died. This difference was statistically significant (p value<0.05). Similarly, potassium and phosphate were low among the discharged patients than compared to the patients who died which showed a significant difference.

A total count of 10,000 to 20000 cells/mm was majorly seen among all etiologies with the highest among the renal etiology (23/30, 76.7%). About 90.9% (10/11) of the patients with renal etiology had a total count of 4000-10000 cells/mm. There was no statistically significant association found between total count and etiology.

Inotrope support was used in 75.5% of the study subjects. Among the subjects where inotrope was used 52.17% subjects died. The relationship between inotrope support and outcome was statistically significant (p value<0.05) .

Ventilatory support was used in 75.5% of the study subjects. Among the patients who received ventilator support, 42.86% died. The relationship between ventilator support and outcome was highly statistically significant (p-value <0.05).

Majority (24/50,48%) of the study population stayed in the hospital for 1-7 days. Out of the 13 deaths, 10 study subjects hospital stay was less than a week. The association between duration of hospital stay and outcome was found to be statistically significant (p value <0.05).

Among the 38 study subjects whose level of lactate was above 10mmol/L, 34.2% of them did not survive. All the 12 subjects with normal lactate levels survived. The association between lactate levels and the final outcome was found to be statistically significant (p value <0.05).

Among the 22 study subjects whose level of procalcitonin was above 0.8ng/ml, 36.4% of them did not survive. The association between lactate levels and the final outcome was not statistically significant.

This study was conducted in a tertiary care hospital situated in a tri-state junction area. It is a 700 bedded hospital with hemodialysis services available. This hospital caters to the rural population mainly. Studies indicate that there is an increased burden on the health care services in India due to AKI and its complications. For example, a study by Prakash *et al.* (2016) reported a rise in AKI cases in tertiary care hospitals in North India[6].

The economic burden of AKI is significant, considering the costs associated with hospitalizations, dialysis, medications and long-term care for AKI survivors[7,8]. The burden of AKI among the elderly is very common. Studies like the one by Coca *et al.* (2009) have shown that older people, especially those aged 65 and above, are more likely to have AKI. This happens because their kidneys change with age and they often have other health problems that make AKI more likely for them[9]. AKI in the elderly is associated with poorer outcomes, including higher mortality rates and increased healthcare utilization. Therefore, it is very important to examine the causes, risk factors and consequences related to Acute Kidney Injury (AKI) in the older population. This study was a hospital-based observational cross-sectional study carried out for 1 year. This study was done among the 50 elderly population aged more than 60 years of age with AKI admitted in the General Medicine Ward. Age less than 60 years were excluded because the definition of elderly in India is considered as 60 years and above according to the Ministry of Statistics and Programme Implementation, Government of India[10]. According to the National Kidney Foundation (NKF), AKI is defined as a sudden episode of kidney failure or damage that occurs within a few hours or a few days. It highlights the rapid onset characteristic of AKI and therefore patients with CKD, on hemodialysis were omitted from the study. Also, patients with abnormal kidney size and abnormal corticomedullary differentiation were excluded because research by Guo *et al.* (2019) found that abnormal kidney size, particularly smaller kidney size, was associated with a higher risk of AKI[11]. And also patients who have undergone renal transplants were excluded.

All the demographic details were noted. A thorough history was taken regarding fever, vomiting, loose stools, decreased urine output, shortness of breath, burning micturition, poisoning, unknown bite, use of nephrotoxic drugs, trauma and surgeries. The most common symptoms in AKI were compiled using various literature to take this history. These symptoms can vary in severity depending on the underlying cause and stage of AKI. Early recognition and management of AKI symptoms are crucial for improving patient outcomes. It was important to know the various causes for AKI among the elderly and therefore a thorough literature search was done on the causes of AKI which included decreased blood flow to the kidneys, kidney obstruction, direct kidney damage, systemic illnesses and toxic exposures[12-15].

This study was done particularly among a total of 50 elderly population, out of which 32 (64%) were male, while 18 (36%) were female. Acute Kidney Injury (AKI) can show differences in incidence, causes and outcomes based on gender. Research has shown that there are differences in the incidence, outcomes and responses to treatment of AKI between males and females. These differences are influenced by a variety of factors, including biological, hormonal and social determinants. A study by Chao[15]. found that males had a higher risk of developing AKI compared to females which was a similar finding to this study. A significant portion of patients (86%) had a hospital stay of up to 14 days, with nearly half of them staying for 1-7 days. About 14% of them stayed for more than 15 days. Acute Kidney Injury (AKI) is closely associated with prolonged hospital stays and this relationship is well-supported by research. A study by Silver *et al.*(2017) found that AKI was associated with a significant increase in hospital length of stay across various patient populations[16]. A meta-analysis by Coca et al highlighted that AKI, especially when severe, was associated with increased hospital length of stay and higher healthcare costs[9]. AKI often leads to longer hospital stays due to the need for close monitoring, specialized care and management of complications associated with kidney dysfunction.

Smoking is a significant risk factor for various health conditions, including Acute Kidney Injury (AKI). The relationship between smoking and AKI is multifaceted, involving direct and indirect effects on kidney function. It was found that 96% of the study population did not have a smoking habit. The association between AKI and tobacco use has been studied, particularly in the context of how tobacco exposure can contribute to kidney damage. Studies have shown that exposure to nicotine and carbon monoxide can lead to inflammation, oxidative stress and endothelial dysfunction in the kidneys, contributing to AKI[17]. Tobacco use is a well-known risk factor for hypertension and vascular diseases. Chronic hypertension can lead to renal artery stenosis and decreased renal perfusion, increasing the risk of AKI, especially in situations where there is additional stress on kidney function, such as during surgery or acute illness. In this study, we did not have many tobacco users, maybe because the study subjects would had a co-morbidity earlier to AKI, which would have forced them to reduce or stop the usage of tobacco. More research is needed to fully understand the mechanisms by which smoking contributes to AKI and to identify potential therapeutic targets. Studies exploring the benefits of smoking cessation on kidney outcomes in patients at risk for AKI are also essential. In summary, smoking is a significant risk factor for AKI due to its effects on oxidative stress, inflammation, endothelial dysfunction and renal hemodynamics[18].

Acute Kidney Injury (AKI) can present with various symptoms, depending on the underlying cause, severity of kidney dysfunction and presence of comorbidities. The various symptoms of AKI are decreased urine output, fluid retention and edema. Electrolyte imbalances are a common and significant issue in patients with Acute Kidney Injury (AKI). The kidneys play a critical role in maintaining electrolyte balance and when their function is impaired, it can lead to various imbalances. The relationship between AKI and eGFR is significant as AKI can lead to a temporary or permanent reduction in eGFR. Monitoring eGFR is crucial in assessing kidney function, diagnosing kidney disease and guiding treatment decisions, especially in patients with a history of AKI. This study showed that about 92% of the study participants had an eGFR less than 60ml/min. Study subjects who had eGFR of less than 15ml/min, required more (55.6%) inotrope support. A similar result was seen in eGFR of 15-30ml/min. The relationship between eGFR and inotrope support was not statistically significant (p-value = 0.172). In a study done by Horie R *et al*, which included 1,495 patients showed that 468 (31%) had an eGFR <60mL/min/1.73m^2 which was in contrast to the current study finding due to small sample size maybe[19]. A strong correlation was observed between estimated Glomerular Filtration Rate (eGFR) and critical illness, which was defined as a combination of outcomes including death or need for intensive care unit (ICU) admission, hospitalization, death, ICU admission and requirement for renal replacement therapy. The odds ratios (with 95% confidence intervals) were 1.72 (1.45-2.05), 1.36 (1.16-1.59), 1.66 (1.39-2.00), 1.73 (1.32-2.28) and 2.71 (1.73-4.24) for every 10mL/min/1.73m2 decrease in eGFR, respectively. About 66.7% of the study participants required ventilator support and had an eGFR of <15 ml/min, similarly 53.9% and 56.5% of them required ventilator support and had 15-30 mmHg and 30-60 mmHg respectively. Therefore, eGFR is one of the important parameters for monitoring the elderly with AKI.

Electrolyte imbalances are frequently observed in patients diagnosed with Acute Kidney Injury (AKI). In patients with Acute Kidney Injury (AKI), hyponatremia has been consistently linked to a poorer clinical outcome. However, the association between abnormal sodium levels and AKI is not consistently reported across studies. Hyperkalemia and variability in potassium levels are often predictive of AKI. Interestingly, the relationship between serum calcium levels and the risk of AKI follows a U-shaped pattern, indicating that both low and high calcium levels may be associated with an increased risk of AKI. This study calculated the mean and standard deviation of all different electrolytes-sodium, potassium, chloride, calcium, magnesium and phosphate which was 132.33±6.79, 4.273±0.86, 101.38±8.20, 9.642±9.62, 1.792±0.38 and 3.548±0.96 respectively. The electrolytes, sodium and bi-carbonate were higher among the discharged group than compared to the patients who died. This difference was statistically significant (p-value<0.05). Similarly, potassium and phosphate were low among the discharged patients compared to the patients who died which showed a significant difference. One of the studies by Hu J *et al.* showed the serum electrolytes among AKI to be sodium 141.0 (139.0-143.0), potassium 4.0 (3.7-4.7), chloride 103.0 (100.0-105.0), calcium 2.27(2.15-2.15), magnesium 0.90 (0.84-0.84) and phosphate 1.10 (0.94-1.94) which is almost similar to this current study[20].

Among the 38 study subjects whose level of lactate was 74 above 10mmol/l, 34.2% of them did not survive. All the 12 subjects with normal lactate levels survived. The association between lactate levels and the final outcome was found to be statistically significant (p value<0.05). Assessing lactate levels is a valuable tool for clinicians in determining the likelihood of Acute Kidney Injury (AKI). Among the AKI patients, lactate levels were 3.9 (2.6-5.5) in one of the study conducted in China[21].

Hematolysis is a critical renal replacement therapy (RRT) used in the management of Acute Kidney Injury (AKI) when conservative measures are insufficient to maintain homeostasis. Hemodialysis is indicated in AKI patients for several reasons: Severe electrolyte imbalances-hyperkalemia, severe acidosis, or hyponatremia, Volume overload-unresponsive to diuretics, causing pulmonary edema or hypertension, Uremia-elevated blood urea nitrogen (BUN) levels leading to symptoms like encephalopathy, pericarditis or bleeding diathesis, Drug toxicity: When certain toxins or medications are implicated in AKI and can be removed via dialysis. Hemodialysis is a life-saving intervention in AKI patients, providing critical support to manage severe metabolic imbalances and fluid overload. While it carries risks, careful management and monitoring can mitigate complications and support recovery in patients with acute renal failure[22].

CONCLUSION

Overall the conclusion of this study is the major causes for AKI among the geriatric population are cardiovascular system and respiratory system etiologies. There were 13 (26%) deaths reported in the study and 37 (74%) survived. The main risk factors and parameters which were statistically significantly associated with consequences were elevated creatinine levels, inotrope support, ventilator support, lactate levels, duration of hospital stay.

REFERENCES

1. John, A.K., L. Norbert, A. Peter and S. B. Rashad, *et al.* 2012. Kidney disease: Improving global outcomes (KDIGO) acute kidney injury work group. KDIGO clinical practice guideline for acute kidney injury. Kidn Int. Suppl., 2: 1-138.
2. Susantitaphong, P., D.N. Cruz, J. Cerda, M. Abulfaraj, F. Alqahtani, I. Koulouridis and B.L. Jaber, 2013. World Incidence of AKI. Clin. J. Am. Soc. Nephrology, 8: 1482-1493.
3. Hoste, E.A.J., S.M. Bagshaw, R. Bellomo, C.M. Cely and R. Colman et al., 2024. Epidemiology of acute kidney injury in critically ill patients: The multinational aki-epi study. Inten Care Med., 41: 1411-1423.
4. Bjornstad, E.C., W. Muronya, Z.H. Smith, K. Gibson and A.K. Mottl *et al.,* 2020. Incidence and epidemiology of acute kidney injury in a pediatric

Malawian trauma cohort: A prospective observational study. BMC Nephrology, Vol. 21 .10.1186/s12882-020-01755-3 1-10.0.

5. Soren, B., A. Papareddy, S. Kommareddy, R. Meriga, N. Midathala and G. Sarikonda, 2019. Clinical profile of acute kidney injury in patients admitted to medical wards in a tertiary care setting. Int. J. Med. Sci. Public Health, Vol. 8 .10.5455/ijmsph.2019.0927727102018 1-10.0.
6. Prakash, J., T.B. Singh, B. Ghosh, V. Malhotra, S.S. Rathore and R. Vohra *et al.*, 2013. Changing epidemiology of community-acquired acute kidney injury in developing countries: analysis of 2405 cases in 26 years from Eastern India. Clin Kidney J 6: 1-10.0.
7. Lameire, N., W.V. Biesen and R. Vanholder, 2006. The changing epidemiology of acute renal failure. Nat. Clin. Pract. Nephrology, 2: 1-10.0.
8. Monard, C., T. Rimmelé, E. Blanc, M. Goguillot, S. Bénard and J. Textoris, 2023. Economic burden of in-hospital AKI: A one-year analysis of the nationwide French hospital discharge database. BMC Nephrology, Vol. 24 .10.1186/s 12882-023-03396-8 1-10.0.
9. Coca, S.G., B. Yusuf, M.G. Shlipak, A.X. Garg and C.R. Parikh, 2009. Long-term Risk of Mortality and Other Adverse Outcomes After Acute Kidney Injury: A Systematic Review and Meta-analysis. Am. J. Kidney Dis., 53: 1-10.0.
10. Guo, J., X. Zeng and C. Wang, *et al.,* 2019. Association between abnormal renal size and risk of acute kidney injury in critically ill patients: a multicenter cohort study. Crit Care Vol. 23, No. 1 .0 1-10.0.
11. Nath, K.A. and S.V. Shah., 2004. Oxidative stress and endothelial cell dysfunction in kidney failure. Kidney Int Suppl., Vol. 66 .0 1-10.0.
12. Singer, M., C.S. Deutschman, C.W. Seymour, M. Shankar-Hari and D. Annane *et al.,* 2016. The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). JAMA, 315: 801-810.
13. Rewa, O. and S.M. Bagshaw, 2014. Acute kidney injury-epidemiology, outcomes and economics. Nat. Rev. Nephrology, 10: 1-10.0.
14. Chao, C.T., V.C. Wu, C.F. Lai, C.C. Shiao and T.M. Huang *et al.,* 2012. Advanced age affects the outcome-predictive power of RIFLE classification in geriatric patients with acute kidney injury. Kidney Int., 82: 1-10.0.
15. Silver, S.A. and G.M. Chertow, 2017. The Economic Consequences of Acute Kidney Injury. Nephron, 137: 1-10.0.
16. Chen, M., N. Ding, M.E. Grams, K. Matsushita and J. Ishigami, 2024. Cigarette Smoking and Risk of Hospitalization With Acute Kidney Injury: The Atherosclerosis Risk in Communities (ARIC) Study. Am. J. Kidney Dis., 83: 1-10.0.
17. Fu, Y.C., Z.L. Xu, M.Y. Zhao and K. Xu, 2022. The Association Between Smoking and Renal Function in People Over 20 Years Old. Front. Med., Vol. 9 .10.3389/fmed.2022.870278 1-10.0.
18. Horie, R., Y. Endo and K. Doi, 2021. Estimated glomerular filtration rate may be an independent predictor for clinical outcomes regardless of acute kidney injury complication in the emergency department. PLOS ONE, Vol. 16 .10.1371/j ournal.pone.0258665 1-10.0.
19. Hu, J., Y. Wang, X. Geng, R. Chen and X. Xu *et al.,* 2017. Metabolic acidosis as a risk factor for the development of acute kidney injury and hospital mortality. Exp. Ther. Med., 13: 1-10.0.
20. Wang, R., S. Wang, J. Zhang, M. He and J. Xu, 2022. Serum Lactate Level in Early Stage Is Associated With Acute Kidney Injury in Traumatic Brain Injury Patients. Front. Surg., Vol. 8 .10.3389 /fsurg.2021.761166 1-10.0.
21. Murdeshwar, H.N. and F. Anjum 2024. Hemodialysis. [Updated 2023 Apr 27]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. 0 1-10.0.