RESEARCH ARTICLE

Frequency of acute kidney injury and its short-term effects after acute myocardial infarction

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Abstract

Objective: To find out the frequency of acute kidney injury and its short-term effects after acute myocardial infarction.

Methods: This descriptive, cross-sectional study was conducted at the cardiology department of Lady Reading Hospital's Postgraduate Medical Institute, Peshawar, Pakistan, from January to June 2016, and comprised acute myocardial infarction patients. Non-probability consecutive sampling technique was used. SPSS 20 was used for data analysis.

Results: Of the 207 patients, 154(74.7%) were male and 53(25.6%) were female. The overall mean age was 59.09±8.6 years. At admission, the mean baseline creatinine was 0.97±0.23, the mean glomerular filtration rate was 83.30±25.4 mL/min, and 30(14.4%) patients had an estimated glomerular filtration rate<60 mL/min. Moreover, 43(20.7%) patients developed acute kidney injury. Post-myocardial infarction in-hospital complications were higher in patients with acute kidney injury (p<0.05).

Conclusion: In-hospital, short-term effects including acute heart failure, cardiogenic shock and arrhythmias were higher in acute kidney injury patients after acute myocardial infarction.

Keywords: Acute kidney injury, Acute myocardial infarction, Short-term effects. (JPMA 67: 1693; 2017)

Introduction

Acute kidney injury (AKI) is common in patients hospitalised with an acute myocardial infarction (AMI), developing in 13-16%.[1,2] In high-risk patients, such as those hospitalised for congestive heart failure, sepsis, and those who have undergone cardiac surgery, the incidence of AKI is high, ranging from 10% to 25%.[3] The AKI incidence in patients in the coronary care unit has been reported to vary from 9.6% to 27%, with mortality ranging from 20% to >50%.[4]

Acute kidney injury is a complication that affects hospitalised patients with various clinical conditions, with an estimated incidence of 5%.[5] In this setting, AKI is associated with health-care costs, evolution to chronic kidney disease (CKD) and long-term mortality at up to 10 years of follow-up.[6] In patients presenting with AMI, the incidence of AKI ranges from 10% to 30% during the hospital stay.[1,7,8] Moreover, AKI has long-term implications in AMI patients, being associated with CKD progression, recurrent AMI, heart failure progression and long-term mortality.[6,9] Hospitalised patients with AMI are subject to several procedures and complications related to AKI, like coronary artery bypass grafting (CABG), catheterisation, heart failure and drugs nephrotoxicity.[4,10] In each of these situations, AKI-associated risk factors have already been explored. Previous CKD, diabetes mellitus, volume depletion, haemodynamic instability and low cardiac output are risk factors that are constantly present in such studies.[11,12]

The current study was planned to find the frequency of AKI and its short-term effects after AMI.

Patients and Methods

This descriptive, cross-sectional study was carried out in the cardiology department of the Postgraduate Medical Institute at Lady Reading Hospital, Peshawar, Pakistan, from January to June 2016, and comprised AMI patients. The sample size was calculated using 16%[1,2] proportion of AKI after AMI with 95% confidence level and 5% margin of error under World Health Organisation (WHO) software for sample size determination.[16] Non-probability consecutive sampling technique was used as the sampling method. Both male and female patients with ages 30-75 years who presented within 12 hours of symptoms were included in the study. Their creatinine and other baseline characteristics were measured and then repeated after 48 hours. Patients with chronic renal failure diagnosed by raised serum creatinine (SCr) of more than 1.2mg/dl or patients requiring chronic peritoneal or haemodialysis were excluded.

The study was conducted after approval from the institutional research committee. Mean and standard

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deviation (SD) were calculated for numerical variables like age, and serum creatinine and estimated glomerular filtration rate (eGFR) which was calculated using Modification of Diet in Renal Disease (MDRD) equation. Frequencies and percentages were calculated for categorical variables like gender, major bleeding, cardiogenic shock, arrhythmias, and acute heart failure. Short-term effects were stratified among age and gender and AKI was stratified among age, gender and baseline characteristics to see effect modification. Chi-square test was applied. $P \leq 0.05$ was considered significant. SPSS 20 was used for data analysis.

Results

Of the 207 patients, 154(74.7%) were male and 53(25.6%) were female. The overall mean age was 59.09±8.6 years. Moreover, 107(51.69%) patients had ST elevation myocardial infarction (STEMI) and 100(48.3%) had non-ST elevation myocardial infarction (NSTEMI). Besides, 5(2.41%) patients were in age range 30-40 years, 34(16.42%) were aged 41-50 years, 90(42.9%) patients 51-60 years, 61(29.46%) patients 61-70 years and 17(8.21%) patients were more than 70 years old (Table-1).

Table-1: Showing Baseline Characteristics (N=207).

Baseline characteristics	Frequency	Percent
Mean Age (years)	59.09±8.6	
Men	154	74.70%
BMI kg/cm^2	22.1±2.61	
Killip Classification		
Killip I	115	55.60%
Killip II	47	22.70%
Killip III	30	14.50%
Killip IV	15	7.20%
Hypertension	114	55.10%
Diabetes	75	35.60%
Dyslipidaemia	75	36.20%
Current Smokers	46	22.22%
Obesity	32	15.50%
STEMI	107	51.69%
NSTEMI	100	48.30%
Symptoms Time Hours	7.1±4.82	
Drug History		
ACE inhibitors/ARB's	69	33.34%
Insulin	18	8.60%
β-Blockers	25	12.07%
Oral Hypoglycaemic Drugs	19	9.17%
Streptokinase for STEMI	98	47.30%

BMI: Body mass index
STEMI: ST-segment elevation myocardial infarction
NSTEMI: Non-ST-segment elevation myocardial infarction
ACE: Angiotensin converting enzyme
ARB: Angiotensin receptor blocker.

Regarding baseline renal function, the mean eGFR was 83.30±25.4 ml/min, mean baseline creatinine was 0.97±0.23 mg/dl, and baseline eGFR was <60ml/min in 30(14.4%) patients.

Table-2: Renal functions profile by acute kidney injury status.

Renal Functions Profile	Acute kidney injury(AKI) (n=43)	No Acute Kidney Injury (n=164)	P-Value
Baseline Creatinine mg/dl	0.95±0.17	0.96±0.22	0.16
Baseline eGFR ml/min	78.86±22.8	85.2±25.2	0.45
Baseline eGFR<60ml/min	13(30.2)	17(10.3)	0.05
Creatinine after 48 HRS mg/dl	1.67±0.37	1.09±0.2	0.0001
eGFR after 48 HRS ml/min	44.7±15.02	71.42±20.3	0.2
Change in creatinine mg/dl	0.72±0.33	0.13±0.06	0.0001
Change in eGFR ml/min	36.1±12.5	13.82±10.5	0.26

BMI: Body mass index
STEMI: ST-segment elevation myocardial infarction
NSTEMI: Non-ST-segment elevation myocardial infarction
ACE: Angiotensin converting enzyme
ARB: Angiotensin receptor blocker
eGFR: Estimated glomerular filtration rate.

Table-3: Baseline characteristics according to Acute Kidney Injury Status. (n=207).

Baseline characteristics (n=207)	Acute Kidney Injury (AKI) (n=43)	No Acute Kidney Injury (No AKI) (n= 164)	P Value
Mean Age (years)	61.67±9.02	58.41±8.4	0.04
Men	33(76.7)	118(71.9)	0.60
Mean BMI kg/cm^2	22.05±2.8	22.12±2.6	0.5
Killip Classification			
Killip I	5(11.6)	110(67.0)	
Killip II	5(11.6)	42(25.6)	0.0001
Killip III	18(41.9)	12(7.4)	
Killip IV	15(34.9)	0(0)	
Hypertension	37(86.04)	77(46.9)	0.0001
Diabetes	19(44.2)	56(34.1)	0.18
Dyslipidaemia	15(34.8)	60(36.6)	0.79
Current Smokers	8(18.6)	38(23.17)	0.49
Obesity	9(20.93)	23(14.01)	0.28
STEMI	21(48.8)	87(53.0)	0.6
NSTEMI	22(51.1)	77(46.5)	0.8
Symptoms Time Hours	10.07±4.9	6.34±4.5	0.0001
Drug History n %			
ACE inhibitors/ARB's	31(72.0)	58(35.3)	
Insulin	00(00)	18(10.9)	0.0001
β-Blockers	8(18.6)	18(10.5)	
Oral Hypoglycaemic Drugs	6(13.9)	31(18.9)	

BMI: Body mass index
STEMI: ST-segment elevation myocardial infarction
NSTEMI: Non-ST-segment elevation myocardial infarction
ACE: Angiotensin converting enzyme
ARB: Angiotensin receptor blocker

Table-4: Showing Short Term Clinical Effects of Patients (n=207).

Short Term Effects	Acute Kidney Injury(AKI) (n=43)	No Acute Kidney Injury (No AKI) (n= 164)	P-value
Major Bleeding			
Intra cranial Bleed	03(6.97%)	01(0.60%)	0.001
Per Rectal Bleed	01(2.32%)	0(0)	
Per Vaginal Bleed	02(4.65%)	0(0)	
Upper Gastrointestinal Bleed	0(0)	01(0.60%)	
Cardiogenic shock	16(37.2%)	04(2.5%)	0.0001
Arrhythmias			
Atrial Fibrillation(AF)	12(27.90%)	14(8.53%)	0.0001
Complete Heart Block(CHB)	4(9.30%)	5(3.04%)	
Ventricular tachycardia(VT)	9(20.93%)	13(7.92%)	
Ventricular Fibrillation(VF)	0(0)	53.04%)	
Acute Heart Failure	17(39.5%)	25(15.2%)	0.0001

During the hospital stay, 43(20.8%) patients developed AKI while 164(79.2%) did not develop it. The number of patients with STEMI who developed AKI was 21(10.14%) in and those with NSTEMI was 22(10.62%) (Table-2).

The patients with AKI were older, more likely to have co-morbidities like hypertension 37(86.04%), had reduced eGFR at presentation (<60ml/min) 13(30.2%) and had a higher cardiac enzyme peak. At admission, patients who had a history of beta blockers, angiotensin-converting-enzyme (ACE) inhibitors and angiotensin II receptor blockers(ARBs) for the treatment of hypertension, had longer symptom time and had higher Killip classification developed AKI during the hospital stay. They also had a greater left ventricular end diastolic volume (p=0.01). Linear regression analysis showed fractional shortening (p=0.0001) and higher Killip class (p=0.0001) as independent predictors for the development of AKI during the hospital stay (Table-3).

Patients those with AKI experienced a more complicated in-hospital clinical course, with higher rates of major adverse clinical events. Besides, 8(3.8%) patients had major bleeding, 20(9.7%) had cardiogenic shock, 62(29.9%) had brady or tachy arrhythmia and 42(20.2%) had heart failure.

When stratified according to AKI status, 6(13.9%) of the AKI patients (p=0.001) had major bleeding during the hospital stay. Also, 16(37.2%) AKI patients and 4(2.4%) non-AKI patients (p=0.0001) had cardiogenic shock. Arrhythmia during the hospital stay was stratified according to the AKI status and was 24(55.8%) in the AKI group as compared to the non-AKI group 37(22%) (p=0.0001). The most common arrhythmia was atrial fibrillation (AF) in the AKI 12(27.9%) and non-AKI 14(8.5%) group, followed by ventricular tachycardia, i.e. 9(20.9%) versus 13(7.9%).

Moreover, 17(39.5%) patients with AKI had acute heart failure compared to 25(15.2%) patients in the non-AKI group (p=0.0001) (Table-4).

Discussion

The major findings of the study were that AKI is a frequent complication of AMI, occurring in 20.7% of patients, and is associated with a parallel and striking increase of in-hospital complications. Several factors can contribute to AKI development in patients with AMI, including haemodynamic instability, the use of contrast agents, major bleeding, atheroembolic disease, acute hyperglycaemia, and drug toxicity.[13,14]

Patients suffering an AMI are at high risk for developing AKI. The risk factors for developing AKI are related to morbidities (high prevalence of hypertension and CKD), procedures (contrast, CABG) and cardiac complications (haemodynamic instability, heart failure). All these factors are associated with AKI development and risk factors for the development of AKI in each specific situation have already been studied extensively.[4,15,16] Our study showed that increasing age, worsened Killip class, longer symptom time, medication use like beta blockers and an ACE inhibitors/ARB's were risk factors for AKI. Also, patients who developed AKI had low fractional shortening and increased left ventricular end diastolic volume. When early reperfusion is performed, there is less myocardial damage, heart failure and haemodynamic instability.[7] Almost similar results were obtained in the present study; patient who presented early and had shorter symptom time did not develop AKI.

The new interest in AKI after AMI is due to the association between AKI with in-hospital complications and mortality. These studies identify a new concern regarding the prevention of AKI after AMI.

We in this study also recorded the short-term effects after AMI in the form of major bleeding, cardiogenic shock, arrhythmias and acute heart failure. AKI patients had more frequent major bleeding (13.6%) despite the fact that patient with AKI did not undergo percutaneous coronary intervention. The most common major bleeding was intracranial bleeding occurring in STEMI patients. The reason for this is unclear and may be related to worsening AKI and the relationship between kidney and platelet dysfunction. Fox et al. found that major bleeding ranged from 8.4%-32.7% according to worsening renal functions. Marenzi et al. showed similar results in which 03-21% of the patients had major bleeding depending on the

severity of AKI. Thus patients with AKI were substantially at high risk for bleeding despite lower rates of invasive strategies.[1,2] Therefore, when treatment algorithms are planned worsening renal functions should be considered in the AMI setting, especially when doses of renally cleared medications, including anticoagulants and anti-platelet agents are prescribed.

Studies show that when AMI is complicated by cardiogenic shock AKI affects more than 50% of the patients. The widely variable results are due to a lack of consensus criteria to define AKI occurrence and severity. Our study showed that cardiogenic shock occurred in 37.2% of the patients who had AKI. In a single-centre study of 97 STEMI patients who were haemodynamically unstable and required intra-aortic balloon pump, the AKI-associated mortality rate was 50%, with an in-hospital mortality relative risk of 12.3.[4] Similarly, at a medical centre in Israel, in a total of 1,038 patients who were admitted with STEMI, worsening renal function (defined as an increase in SCr of at least 0.5 mg/dL) was associated with an 11.4-fold increased risk of in-hospital haemodynamic instability leading to mortality.[9] Our results complement these findings showing an increased risk of haemodynamic compromise among patients admitted with myocardial infarction (MI) complicated by AKI.

We also evaluated arrhythmias in AMI patients who had AKI. In patients with AKI, many reasons can be present to cause cardiac arrhythmias, whereas cardiac arrhythmias can also cause disturbances in haemodynamics leading to AKI.[17] Disturbances in electrolyte balance are frequent during AKI and are not an uncommon cause of arrhythmias. These disturbances can be related not only to accumulation, but also to compartmental shifts of electrolytes.[17] The present study recorded AF as the most common arrhythmia after AMI in AKI patients. Many studies have shown increased incidence of AF after AMI in the presence of acute heart failure, AKI and left ventricular dysfunction and worse outcomes for these patients.[5,18,19] The second commonest arrhythmia was ventricular tachycardia in the AKI patients. AMI patients with AKI are at a high risk of acute heart failure. In our study, 39.5% of the patient who had heart failure had AKI.

In our study, we identified some independent predictors of AKI. Age, left ventricular fractional shortening, left ventricular end diastolic volume, longer symptoms time, hypertension and medications like ACE inhibitors or ARBs were associated with AKI occurrence. Thus, a risk score can be developed and can have wide applicability and can be easily calculated in the initial hours of hospital presentation to predict the risk of AKI. Several studies have shown that small increases in SCr levels during hospitalisation are associated with a worse prognosis for the patient.[20] Many clinical trials have shown that decreased renal function is an independent predictor of adverse outcomes in AMI patients.[21,22] Moreover, even minor increases in SCr level are associated with longer hospital stay and higher cost. In patients with acute MI with AKI, in-hospital complications have been reported as atrial fibrillation 25%, ventricular tachycardia 16%, brady arrhythmias 11%, acute heart failure 42%, cardiogenic shock 26%, and major bleeding 14%.[2]

There were some limitations of our study as well. Our baseline SCr measures were obtained on admission. The admission SCr cannot be considered a true baseline value in patients with AMI because haemodynamic impairment secondary to myocardial ischaemia could have already led to an increase in SCr. This may have led to underestimation of AKI in our sample and may have biased our findings. Secondly, modified version of the Acute Kidney Injury Network (AKIN) criteria[8] was used to define AKI because information on urinary output was not available in our study sample.

We could not assess from our data the temporal relationship between AKI and in-hospital short-term effects. Finally, patients whose SCr was not collected (and hence excluded from our analysis) were less healthy and died within the first 48 hours. Also we did not include patients who were discharged before repeat SCr samples were taken. Thus, the true incidence of AKI was underestimated.

Conclusion

AKI was found to be a common complication after AMI. In-hospital short-term effects, including major bleeding, acute heart failure, cardiogenic shock and arrhythmias, were higher in acute kidney injury patients. The data provided from the study can be used as an initiative towards preventing AKI. However, this analysis could not distinguish whether there is any causal association between acute kidney injury and adverse outcomes or AKI is just a risk marker. Further work towards understanding and preventing this important complication can define ways to reduce morbidity and early mortality from AMI.

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