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Cardiac arrhythmia following acute myocardial infarction: a retrospective analysis of 27,648 hospitalized patients in a tertiary heart hospital

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Abstract

Arrhythmia frequently complicates acute myocardial infarction (AMI) and contributes to high morbidity and mortality. We aimed to investigate the prevalence, risk factors, and impact of cardiac arrhythmias in AMI patients at a tertiary heart hospital. This retrospective observational study included AMI patients who were admitted between January 1991 and May 2022. Patients' data were analyzed and compared according to the absence or presence of cardiac arrhythmias post-AMI. We hypothesized that arrhythmias are associated with higher mortality following AMI. During the study, 27,648 patients were hospitalized with AMI, of whom 2118 (7.7%) developed arrhythmia. Patients who developed arrhythmia had a higher average age compared to those without arrhythmia (57.2 *vs.* 54.8 years, p=0.001), and a larger proportion were male compared to female patients (85.2% *vs.* 14.8%, p=0.001). Atrial fibrillation was observed in 383 patients (18.1%). Ventricular tachycardia was found in 461 (21.8%), and ventricular fibrillation occurred in 526 patients (24.8%). Complete heart block was developed in 286 (13.5%) patients, 1st-degree atrioventricular (AV) block in 36 (1.7%), 2nd-degree AV block in 138 (6.5%), left bundle branch block in 81 (3.8%), and right bundle branch block in 118 (5.6%). The rate of β-blocker use has increased in the arrhythmias group at discharge compared to the on-admission rate (55.7% *vs.* 32.5%). However, it remained sub-optimal. Arrhythmias were associated with longer hospital stays and five times higher hospital mortality than the non-arrhythmia group. Multivariable logistic regression analysis indicated that arrhythmia was associated with increased mortality risk three times following AMI (adjusted odds ratio 3.01; 95% confidence interval 2.42-3.75, p=0.001). Almost one-tenth of patients hospitalized with AMI in Qatar developed arrhythmia with variable outcomes; however, the in-hospital mortality remained high. Addressing the risk factors and optimizing the prevention and treatment of AMI and arrhythmias is crucial to improving clinical outcomes. This study may underestimate the incidence of arrhythmias post-AMI as it did not report all types.

Key words: arrhythmias, acute myocardial infarction, coronary, outcome, heart.

Introduction

Arrhythmias (dysrhythmia) frequently occur as complications following an acute myocardial infarction (AMI) and could contribute to increased morbidity and mortality [1]. Despite significant advances in medical therapy, arrhythmia continues to have an adverse impact on the prognosis and outcomes [2]. In addition, arrhythmia associated with AMI often puts a tremendous burden on healthcare systems and patients [1,3]. Most AMI-related deaths attributed to arrhythmias encompass bradyarrhythmia, supraventricular tachyarrhythmias, and ventricular arrhythmias (VA) [4]. The reopening of an infarct-related artery in the acute phase of AMI further escalates the likelihood of significant arrhythmia as part of reperfusion injury, compounding the mortality risk [5].

Multiple studies in the past have investigated the prevalence of cardiac arrhythmia in AMI patients and found variable results depending on the patient population, studying the extent of myocardial damage and other risk factors involved [4,6]. Among the lethal arrhythmias, ventricular arrhythmias are the most feared complication that can initiate or worsen cardiac failure or result in sudden cardiac death, and they tend to manifest in the first 48 hours following the onset of AMI [7-9]. Numerous risk factors, including advanced age and pre-existing cardiac conditions, hypertension, diabetes mellitus, and multivessel disease, have been associated with the occurrence of cardiac arrhythmias [4,10]. Additionally, the timing and efficacy of reperfusion therapy, with failure or delayed reperfusion, has been linked to a higher incidence of arrhythmias [1, 11].

The underlying causes of cardiac arrhythmias in AMI patients are intricate and multifaceted. Electrical instability, cardiac tissue heterogeneity, and changes in ion channel function are all effects of ischemia-induced myocardial damage that result in the development of a proarrhythmic substrate [12]. These electrophysiological abnormalities result in various arrhythmias, including ventricular tachycardia and ventricular fibrillation, which can exacerbate symptoms related to AMI and cause sudden cardiac death (SCD) [13, 14].

Early identification and effective management of arrhythmias are critical for reducing complications and improving the overall prognosis of patients with AMI. A multidisciplinary approach is needed, involving prompt and early diagnosis, risk stratification, and timely intervention. Antiarrhythmic drugs, including beta-blockers, amiodarone, and lidocaine, are commonly employed to control arrhythmias during the acute phase [15]. Additionally, early revascularization through percutaneous coronary intervention (PCI) or thrombolytic therapy is used to restore coronary blood flow and limit myocardial injury [16,17,18]. The implantation of cardioverter-defibrillators (ICDs) for high-risk patients is warranted to prevent SCD in selected cases [19].

Although patients remain susceptible to cardiac arrhythmias and sudden death, the recovery phase following AMI has garnered less attention [4]. There is a significant link between early post-hospital mortality and the occurrence of arrhythmias during the hospital stay [20]. Hence, there is an urgent need for more proactive identification and management of cardiac arrhythmias in individuals experiencing AMI. Understanding and addressing the risk factors helps the risk stratification and devising targeted interventions to improve patient outcomes, ultimately reducing the burden of cardiac arrhythmia in AMI patients. Therefore, this study aims to investigate the prevalence, risk factors and impact of cardiac arrhythmias in AMI patients at a tertiary heart Hospital. We hypothesized that arrhythmias are associated with higher mortality following AMI.

Materials and Methods

Sample population

The study used retrospective cohort data of patients in the coronary care unit (CCU) registry at the Heart Hospital in Qatar. The CCU data registry with cardiovascular diseases is approved by IRB, Medical Research Center, Hamad Medical Corporation (HMC) (MRC#11355/11). A detailed description of the registry is given elsewhere [21]. Data were collected between Jan 1991 to May 2022. The Heart Hospital at HMC (a governmental, not-for-profit institution) is a tertiary hospital that caters to more than 95% of the cardiac inpatient and outpatient medical and surgical care needs of nationals and residents of Qatar.

The patients' physicians collected data from each patient at the time of discharge on a predefined coded record form (CRF). Recorded data were checked and validated by a research coordinator in the department. Approximately 40% of Qatar's population are Arabs, including Qatari nationals, and 60% are non-Arabs. The CRF included history, along with information regarding risk factors for CHD, indication for coronary angiography, and the angiographic findings of each patient. The presence of diabetes mellitus was determined by the documentation in the patient's previous or current medical record of a diagnosis of diabetes mellitus that had been treated with medication or insulin. The presence of hyperlipidemia was determined by fasting cholesterol >5.2 mmol/L in the patient's medical record or any history of hyperlipidemia treatment by the patient's physician. The presence of hypertension was determined by documentation in the medical record of hypertension or by determining whether the patient was receiving treatment from their physician. The diagnosis of acute coronary syndrome, including AMI, was based on the final decision of the assigned consultants based on clinical, electrocardiographic, laboratory, and echocardiographic data [22]. The study included all adult male and female patients admitted to the cardiology department with AMI documented on admission. Patients with incomplete data were excluded. The type of arrhythmia was documented as bradyarrhythmia (sinus bradycardia or any AV block), tachyarrhythmia including atrial, supraventricular, and ventricular arrhythmia [1].

Statistical analysis

Descriptive statistics were calculated for categorical variables and interval variables in the form of frequency with percentages for categorical variables and mean, standard deviation (SD), or Interquartile range (IQR) for interval variables in the study. Chi-square tests were used to see the association of categorical variables between the arrhythmia vs non-arrhythmia group. Student t-tests or Mann-Whitney U tests were applied to see significant mean/median level differences between the two groups for interval variables. Multivariate binary logistic regression was used to find the risk of arrhythmia patients for in-hospital mortality with other important risk factors. ROC curve analysis of the predictive regression model for in-hospital mortality in acute myocardial infarction patients. A two-tailed p-value (<=0.05) was considered at a statistically significant level. SPSS 29.0 statistical package was used for the analysis.

Results

Overall findings

During the study period, 27,648 patients were hospitalized with AMI, of whom 2118 (7.7%) developed arrhythmias**.** Table 1 describes the demographic and risk factors associated with cardiac arrhythmia in patients with AMI. Patients who developed arrhythmia post-AMI had a higher average age compared to those without arrhythmia (57.2 years vs. 54.8 years, p=0.001), and a larger proportion of males developed arrhythmia compared to females (85.2% vs. 14.8%, p=0.001).

Risk factors such as DM, hypertension, family history, obesity, and CRF were not found to be significant between patients with arrhythmia and those without arrhythmia. Hospital deaths and median days of hospital stay were significantly higher in arrhythmia patients than in non-arrhythmia patients (p=0.001). Other cardiac conditions, such as aortic insufficiency (AI), aortic stenosis (AS), and mitral regurgitation (MR), showed mixed results, with some differences being statistically significant. Congestive Heart Failure (CHF) was more common in patients with arrhythmia compared to those without arrhythmia (11.9% vs 6.7%, p=0.001). Table 2 shows the differences in various lab parameters and procedures between AMI patients with and without arrhythmia. Notable differences were observed with hemoglobin, BNP, and CK-MB levels, suggesting potential associations with arrhythmia development in AMI patients. However, no significant differences were found in fasting blood sugar, creatinine, triglycerides, and ejection fraction percentages between the two groups.

Types of arrhythmias

Atrial Fibrillation (AF) was observed in 383 patients, accounting for 18.1% of the sample. Ventricular Tachycardia (VT) was observed in 461 (21.8%), and ventricular fibrillation (VF) occurred in 526 patients (24.8%) (Table 3). Complete heart block happened in 286 (13.5%), 1st-degree AV block in 36 (1.7%), 2nd-degree AV block in 138 (6.5%), Left bundle branch block (LBBB) in 81 (3.8%), and Right bundle branch block (RBBB) in 118 (5.6%).

Medications

Tables 2 and 4 show various procedures and treatments for patients with AMI, categorized by the presence or absence of arrhythmia. On-admission medications such as beta-blockers, calcium channel blockers, ACE/ARB, aspirin, clopidogrel, and LMWH were less frequently administered to patients with arrhythmia upon admission, reflecting variations in initial treatment strategies tailored to the presence or absence of arrhythmia in AMI patients.

At discharge, Betablocker (77.6%), calcium channel blocker (12.4%), ACE (Angiotensin-Converting Enzyme Inhibitor) / ARB (Angiotensin Receptor Blocker) (52.9%), aspirin (92.6%), clopidogrel (58.9%), and statins (70.8%) were significantly higher in AMI with arrhythmia patients than those who were not having arrhythmia whereas warfarin (3.1%), and diuretics (19.6%) were less in the arrhythmic group.

Predictors of mortality

Table 5 reveals the results of a multivariate logistic regression analysis to identify factors associated with in-hospital mortality in AMI patients. Patients who have experienced arrhythmia have a significantly higher risk of in-hospital mortality after adjusting to other independent variables. The adjusted odds ratio of 3.01 indicated that these patients have more than three times the odds of in-hospital mortality compared to those without arrhythmia. ROC (Figure 1) demonstrated a high discriminative ability with Area under the curve of (AUC: 0.86; 95% CI: 0.85 – 0.87, p=0.001), suggesting that the model effectively distinguishes between patients who will survive and those who will not during their hospitalization.

Discussion

This study describes the incidence, types, and outcomes of dysrhythmias following acute myocardial infarction in a large-scale population. This is a unique study from the Arab Middle Eastern countries that is characterized by high cardiovascular risk factors such as DM, hypertension, obesity, and dyslipidemia [23,24]. Also, the incidence of AMI in Qatar is high [25]. This study showed that dysrhythmias occur in almost 8% of post-AMI cases and are associated with longer hospital stays and a 5 times higher hospital mortality rate than the non-dysrhythmia group. However, this study may underestimate the incidence of arrhythmia post-AMI as it did not report all types, such as PVCs. The rate of receiving beta-blockers has increased in the arrhythmias group at discharge compared to the on-admission rate (55.7% vs. 32.5%). However, it remains sub-optimal. The most common type of dysrhythmias was VF (25%), VT (22%), AF (18%), and CHB (13.5%). The occurrence of dysrhythmia post-MI was an independent predictor of mortality with an odds ratio of 3.0. The true incidence of arrhythmia post-AMI is broadly varying in literature because of the definition of arrhythmias used in the study, the timing of the event in relation to the onset of AMI, reperfusion therapy used, and fatality of arrhythmias (lethal vs. non-lethal), medications on admissions and whether sinus tachycardia or bradycardia were included and data documentation. This study also showed an association between age and the development of post-AMI arrhythmia, as patients who experienced arrhythmias were older than those without arrhythmia. These results align with the findings of previous studies that have identified age as a significant risk factor for arrhythmias in various cardiac conditions [26-29]. Gender differences also showed an association as a larger proportion of male patients developing arrhythmias compared to female patients [26,27]. The prevalence of arrhythmia was higher among Qatari patients with AMI compared to others.

Although the differences were not significant, comorbidities such as diabetes mellitus, obesity, and chronic renal failure were found more frequently in AMI patients with arrhythmia than in those who had no arrhythmia. However, paradoxical results were found in AMI patients with hypertension and a family history of AMI. Furthermore, dyslipidemia was significantly more common in AMI patients without arrhythmia, highlighting the need for a better understanding of the unique risk factors relevant to the specific patient population [30,31].

In this study, we also found that patients with arrhythmia experienced significantly higher rates of congestive heart failures, hospital deaths, and longer median hospital stays compared to those without arrhythmia [32-34]. On exploring the relationship between arrhythmias and other cardiac conditions, such as aortic insufficiency, aortic stenosis, and mitral regurgitation, these conditions were more common in patients with arrhythmia compared to those without, which intricates interconnections between various cardiac conditions and arrhythmias and brings out the significance of a holistic approach in managing post-MI patients with arrhythmias.

Our study showed that AF occurred in 18.1% of cases, VT in 21.8%, VF in 24.8%, and complete heart block in 13.5% of patients. These results align with existing literature emphasizing the association between arrhythmia and MI and its contribution to increased morbidity and mortality [35,36]. Some studies highlighted the clinical significance of heart blocks in this population, and the presence of 1◦ and 2◦ blocks constitute the spectrum of conduction disturbances observed in AMI patients [37]. In addition, RBBB was found more than LBBB. RBBB is associated with more severe symptoms and higher incidents of complete occlusion of infarct-related artery (IRA) and had primary PCI treatment compared with LBBB [38].

We also analyzed the relationship between the laboratory parameters and found significantly lower hemoglobin levels and reduced EF in AMI patients with arrhythmia. Lower hemoglobin levels have been associated with adverse cardiovascular events [39], and reduced EF is a risk factor for arrhythmia post-AMI [40]. B-type Natriuretic Peptide (BNP) levels are elevated in AMI patients with arrhythmia than those without arrhythmia. CK-MB elevation has been linked to larger infarct sizes and adverse cardiac events [41], whereas elevated BNP is associated with increased cardiovascular events and mortality in AMI patients [42-45].

Patients without arrhythmias received coronary interventions more frequently than those with arrhythmias, which probably benefits these patients from early revascularization in reducing arrhythmia and improving overall prognosis in AMI patients [46,47].

The AMI patients without arrhythmia received significantly more beta-blockers, calcium channel blockers, ACE inhibitors/ARBs, aspirin, clopidogrel, and low-molecular-weight heparins (LMWHs) during admission and discharge. Beta-blockers have traditionally been used to lower the myocardial oxygen demand and enhance outcomes after AMI [48]. These medications are known for their antiarrhythmic properties and cardiovascular benefits and are fundamental in post-AMI management [49,50]. Due to their proven effects on the cardiovascular system, ACE inhibitors are helpful in post-AMI management, especially in reducing mortality and arrhythmia post-AMI [51-53]. Early use of Beta-blockers, statins and ACE-I/angiotensin receptor blocker (if no contraindication), treatment of electrolyte imbalance, and early revascularization are important targets after AMI [54]. Although it is out of the study scope, the role of catheter ablation for ventricular arrhythmias as a therapeutic strategy is of interest and exploring its utility in reducing arrhythmia burden and improving survival rates would add depth to the therapeutic considerations. Most ablations are performed post-MI and for intractable, drug-refractory arrhythmias (after treating the underlying ischemia), this will reduce the recurrence rate of ventricular arrhythmias [55].

In this study, we also observed that advanced age, diabetes mellitus, hypertension, and chronic renal failure are associated with a higher risk of in-hospital mortality in patients with AMI. On adjusting all other factors, multivariate logistic regression analysis showed that arrhythmia had a three-fold higher risk of in-hospital mortality in AMI patients. Shah et al. [56] reported that the incidence of arrhythmia within 24 hours of hospitalization is high in patients with AMI, even in those who undergo primary PCI, and is associated with an increased rate of in-hospital mortality (15%). Chronic renal failure and arrhythmia are also identified as significant predictors of in-hospital mortality, which highlights the importance of managing comorbidities to improve outcomes in AMI patients [57,58]. Furthermore, the pathophysiological mechanism of arrhythmias is of value for management; for example, intramural re-entry causes arrhythmia during ischemia event while triggered activity is the main mechanism during the reperfusion stage [55]. The role of Strain imaging, cardiac MRI and nuclear imaging in stratifying arrhythmic risk and decision making is of currant interest. Radionuclide imaging helps visualization and quantification of underlying pathophysiological processes of dysrhythmias [59]. Moreover, cardiac autonomic innervation imaging is a promising tool for directly evaluating the arrhythmic risk [59].

Limitations

The risk of selection bias limits the retrospective design of this study. Moreover, being a single-center study limits the generalizability of the findings. Other limitations include lack of documentation of time from the onset of AMI, time to treat AMI, time of the onset of arrhythmia, and coronary culprit arrhythmia correlation. Also, the incidence of arrhythmia in each type and location of AMI and follow-up are not captured. The study did not include all kinds of dysrhythmia; however, it documented the most common and important types.

Conclusions

Almost one-tenth of patients hospitalized with AMI in Qatar developed arrhythmias with variable outcomes; however, in-hospital mortality remained high. Addressing the risk factors and optimizing the prevention and treatment of AMI and arrhythmias is crucial to improving clinical outcomes. However, this study may underestimate the incidence of arrhythmia post-AMI as it did not report all types, such as PVCs.

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Table 1. Demographic, risk factors, and outcome of cardiac arrhythmia in AMI patients.

Variable	Category	No Arrhythmia 25530(92.3%)	Arrhythmia 2118(7.7%)	P value
Age in years	--	54.8±12.2	57.2±13.2	0.001
Gender	Male	22515(88.2)	1803(85.2)	0.001
	Female	3014(11.8)	314(14.8)	
Nationality	Qatari	5309(20.8)	559(26.4)	0.001
STEMI	Yes	12192(51.3)	1401(70.6)	0.001
NSTEMI	Yes	11597(48.7)	583(29.4)	0.001
Diabetes mellitus	Yes	11332(44.4)	981(46.3)	0.09
Hypertension	Yes	11105(43.5)	885(41.8)	0.13
Dyslipidemia	Yes	3577(14.0)	245(11.6)	0.002
Family History	Yes	792(3.1)	51(2.4)	0.07
Obesity	Yes	1062(4.2)	100(4.7)	0.22
Chronic renal failure	Yes	1309(5.1)	123(5.8)	0.18
Smoking	Yes	12558(49.2)	1004(47.4)	0.001
Aortic insufficiency	Yes	38(0.1)	7(0.3)	0.05
Aortic stenosis	Yes	746(2.9)	69(3.3)	0.38
Mitral stenosis	Yes	150(0.6)	22(1.0)	0.01
Hospital death	Yes	1058(4.1)	455(21.5)	0.001
Hospital length of stay days (IQR)	-	4(3 – 6)	6(4 – 11)	0.001

IQR= Inter Quartile Range

Table 2. Lab parameters and procedures in AMI patients.

Variable	No Arrhythmia 25530(92.3%)	Arrhythmia 2118(7.7%)	P value
Hemoglobin level (IQR)	13.9(12 – 15)	13(11 – 14.7)	0.001
Fasting blood sugar	7(6 – 10)	7(6 – 10.7)	0.31
Serum Creatinine	88(75 – 105)	96(81 – 128)	0.09
BNP value	267(23 – 1564)	760(54 – 3703)	0.002
CK-MB	47.8(11.3 – 160)	93(15 – 311)	0.001
LVEF%	47(40 – 54)	42(33 – 50)	0.05
Coronary Angiogram	3786(14.8)	341(16.1)	0.12
Swan Ganz	109(0.4)	55(2.6)	0.001
PTCA/PCI	6472(25.4)	455(21.5)	0.001
Holter monitoring	274(1.1)	85(4.0)	0.001
Echocardiography	12078(47.3)	984(46.5)	0.45

Table 3. Type of arrhythmia in AMI patients

Type of Arrhythmia	N (%)
Atrial fibrillation	383(18.1%)
Ventricular tachycardia	461(21.8%)
Ventricular fibrillation	526(24.8%)
Complete Heart Block	286 (13.5%)
1^0 heart Block	36 (1.7%)
2^0 heart Block	138 (6.5%)
LBBB	81 (3.8%)
RBBB	118 (5.6%)

Table 4. Medications of AMI patients.

Variable	No Arrhythmia 25530(92.3%)	Arrhythmia 2118(7.7%)	P value
Admission medications			
Beta-blocker	12471(48.8)	688(32.5)	0.001
Calcium Channel	3606(14.1)	185(8.7)	0.001
ACEI/ARB	10497(51.0)	624(38.4)	0.001
Aspirin	24065(94.3)	1865(88.1)	0.001
Clopidogrel	16074(63.0)	1129(53.3)	0.001
Warfarin	290(1.1)	41(1.9)	0.001
LMW Heparin	7771(30.4)	397(18.7)	0.001
Discharge medications			
Beta-blocker	19819(77.6)	1180(55.7)	0.001
Calcium Channel Blocker	3154(12.4)	172(8.1)	0.001
ACEI/ARB	13493(52.9)	885(41.8)	0.001
Aspirin	23653(92.6)	1549(73.1)	0.001
Clopidogrel	15039(58.9)	922(43.5)	0.001
Warfarin	793(3.1)	140(6.6)	0.001
Diuretics	4997(19.6)	520(24.6)	0.001
Statins	18072(70.8)	1135(53.6)	0.001

Table 5. Multivariate logistic regression analysis for in-hospital mortality in AMI patients.

Variable	Odds Ratio	95% Confidence interval	P value
Age in years	1.05	1.04 – 1.06	0.001
Sex Male	0.58	0.48 – 0.72	0.001
Nationality Qatari	2.05	1.71 – 2.47	0.001
Diabetes mellitus	1.25	1.02 – 1.53	0.03
Hypertension	1.35	1.10 – 1.66	0.006
Dyslipidemia	0.80	0.64 – 0.98	0.03
Obesity	1.10	0.77 – 1.56	0.62
Chronic Renal Failure	1.62	1.30 – 2.0	0.001
LVEF%	0.94	0.93 – 0.95	0.001
Arrhythmia	3.01	2.42 – 3.75	0.001

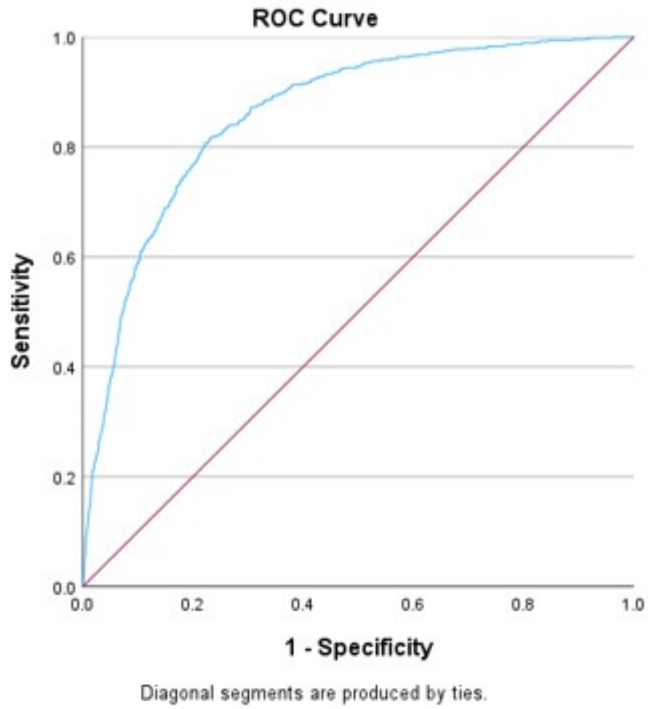

Figure 1. ROC curve for in-hospital mortality in acute myocardial infarction patients and its C-statistics.