Comparative Study of Predictive Value for Different Risk Scores for Predicting Contrast Induced Nephropathy and Short Outcome after Primary Percutaneous Coronary Intervention

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Abstract

Background: Meticulous risk stratification for contrast-induced nephropathy (CIN) is important for patients with ST-segment elevation myocardial infarction (STEMI) and treated with primary percutaneous coronary intervention (PPCI).

Aim of the work: To compare between different risk scores for predicting contrast-induced nephropathy (CIN) and short outcome after primary percutaneous coronary intervention in patients with ST segment elevation myocardial infarction.

Materials and methods: We prospectively enrolled 100 patients who presented with STEMI and treated with Primary PCI. Mehran, Gao, Chen, ACEF or AGEF (age, serum creatinine, or glomerular filtration rate, and ejection fraction); and GRACE (Global Registry for Acute Coronary Events) risk scores were calculated for each patient. The predictive accuracy of the 6 scores for CIN, in-hospital death and major adverse clinical events (MACEs) were assessed by Receiver operating characteristics (ROC) curve. CIN was defined as an absolute increase of serum creatinine by ≥ 0.5 mg/dl or a relative increase of serum creatinine by ≥ 25% from baseline value, at 48-72 h following the exposure to contrast media (CM). The data was analyzed using Chi-square test using SPSS (Statistical package for social science) software.

Results: All risk scores had relatively good predictive accuracy for CIN (Area under the curve (AUC) ranged from 0.671 to 0.829) and performed well for prediction of in-hospital death (AUC ranged from 0.838 to 0.973) and MACEs (AUC ranged from 0.815 to 0.926). The Mehran and Gao risk scores had better predictive accuracy for CIN. While Mehran and GRACE risk scores had better predictive accuracy for in-hospital death and MACEs.

Conclusion: Risk scores for predicting CIN perform well in stratifying the risk of CIN, in-hospital death and MACEs in patients with STEMI undergoing PPCI. The Gao, Mehran risk scores appear to have greater predictive value for CIN. While GRACE and Mehran scores had highest predictive accuracy for in hospital death and MACEs than the other risk scores.

Keywords: Primary PCI; Contrast induced nephropathy; Risk scores

Introduction

Contrast-induced nephropathy (CIN) or Contrast-induced acute kidney injury (CI-AKI) is the term given to iatrogenic renal dysfunction following intravascular (Intravenous or intra-arterial) administration of radiographic contrast media, occurring in absence of any other identifiable cause [1]. CIN is defined as either a greater than 25% increase of serum creatinine or an absolute increase in serum creatinine of 0.5 mg/dl from baseline value, at 48-72 h following the exposure to CM [2].

CIN is normally a transient process, with renal functions reverting to normal within 7-14 days of contrast administration. Less than one-third patients develop some degree of residual renal impairment [3]. CIN continues to be one of the most common major adverse side effects of cardiac catheterization, and is associated with short- and long-term morbidity and mortality [4]. This is particularly true in the population presenting with acute ST-elevation myocardial infarction (STEMI) which was significantly higher compared with patients undergoing non-emergent catheterization [5].

Patients undergoing primary PCI, however, are at high risk of CIN, a complication that has a serious impact on in-hospital outcome and may partially affect the overall benefit of primary PCI. Indeed, in-hospital mortality has been shown to be 20 times higher in patients who experience CIN after primary PCI as compared with those without this complication [6].

Identification and intervention for patients with STEMI with a high risk of CIN are crucial to improve clinical outcomes. Furthermore, last guidelines recommended risk stratification before treating patients with myocardial revascularization, with an evidence level of II b [7]. Therefore, many risk scores have been established for risk assessment of CIN in patients undergoing PCI.

The Mehran risk score was the first to be developed and was derived from a cohort of 8,357 patients treated with PCI. This score, when proposed, was observed to have a c-statistic of 0.67 but excluded patients treated with PPCI and patients in shock [8] However, the Mehran risk score was later tested for patients with STEMI who underwent primary PCI and showed a strong predictive value for CIN (c-statistic: 0.80 to 0.84) [9].

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Ando et al., demonstrated that the ACEF risk score which include Age, serum crat is useful to predict CIN in patients with STEMI, while also demonstrating that the modified ACEF (AGEF) score has a similar discriminative ability for CIN [10,11]. In addition, Raposeiras-Roubin et al., [12] reported that the GRACE score is useful for predicting CIN in patients n a cohort of Chinese patients undergoinwith acute coronary syndrome with normal renal function [13]. The Gao and Chen risk scores were established based og PCI, without discrimination based on the underlying condition. They have good discriminative power for CIN in the validation data set [13-15].

Although none of those risk scores were established specifically to identify the risk of poor outcomes in patients with STEMI. Liu et al., [16] showed that the all 6 scores, in addition to prediction of CIN, had been proved to predict the in hospital outcomes [16].

Patients and Methods

This was a prospective observational study that was conducted from October 2016 to April 2017 and included 100 patients who presented to the emergency department of the National Heart Institute (NHI) with acute ST-elevation myocardial infarction and were treated with primary PCI. We enrolled patients presented, within 12 hours from symptoms onset mainly with typical chest pain lasting for at least 30 minutes not responsive to nitrates, with ECG showing ST-segment elevation of at least 0.1 mV in 2 or more contiguous leads, or development of new left bundle-branch block. Acute myocardial infarction was diagnosed in patients according to ESC guidelines 2014 [7].

Exclusion criteria were patients who not amenable for primary PCI and had recent exposure to radiographic contrast within one week before procedure. Patients on regular peritoneal or hemodialysis treatment, and who died during PCI were excluded.

The study protocol was approved by Al-Azhar University, Faculty of Medicine. A chart review was perform-ed, and data were collected including patient demographics, medical history, examination, ECG, echocardiography and primary PCI.

History was taken including age, gender, smoking was recognized as a lifetime history of >100 cigarettes in their entire life and had continued smoking in the last 6 months was considered a positive smoking history) 17while ex-smokers were defined having history of smoking at least 100 cigarettes in their entire life and had completely stopped smoking for at least 6 months) [17], Current diabetes mellitus was recognized as having history of DM on admission with the use of oral anti-hyperglycemic full agents or any extended release insulin and confirmed by laboratory HbA1c on admission if more than 6.5% [18], dyslipidemia was defined by total cholesterol ≥ 220 mg/dl, triglyceride ≥ 150 mg/dl, high-density lipoprotein (HDL cholesterol) ≥ 40 mg/dl or current use of anti-hyperlipdemic drug [19-21], hypertension was defined as systolic/diastolic blood pressure ≥ 140/90 mmHg or patients having history of hypertension and current use of any antihypertensive medications [22], Family history of premature coronary artery disease was defined as fatal or non-fatal events in first degree relatives men<55 or women <60 years [19], previous PCI procedures and previous CABG, other co-morbid conditions such as previous cerebrovascular stroke, renal impairment and the presence of peripheral vascular disease.

Serum creatinine was measured before the procedure and at 48 h after the procedure. The eGFR was calculated at the time of admission and at 48 hours after the procedure, using the 4-variable modification of diet in renal disease equation (MDRD) (mL/min/1.73 m^2): 186 × (serum creatinine mg/dl) -1.154 × (age) - 0.203 × (0.742 for women) × (1.212 if black) [15]. It worth to be noted that MDRD equation had been validated extensively between the ages of 18 and 70 years old.

Serum creatinine kinas, creatinine kinas-MB, troponin I, complete blood count and electrolytes were measured at admission. Serum level of lipid profiles (low density lipoproteins, high density lipoproteins, total cholesterol and triglycerides) and basal liver functions were measured after the procedure. The left ventricular EF (LVEF) was evaluated by echocardiography in all patients within 24 h after admission.

There are many risk scores that have been established for risk assessment of CIN in patients undergoing PCI. Risk scores were calculated from the initial clinical history, laboratory values, and PCI procedure. A full clinical examination included vital signs, cardiac examination to assess the Killip classification for each patient, patients were ranked by Killip class in the following way: Killip class I (included individuals with no clinical signs of heart failure), Killip class II (included individuals with rales or crackles in the lungs, an S3, and elevated jugular venous pressure), Killip class III (described individuals with frank acute pulmonary edema), and Killip class IV (described individuals in cardiogenic shock or hypotension and evidence of peripheral vasoconstriction (oliguria , cyanosis or sweating) [7]. Hypotension was defined as systolic blood pressure ≤ 90 mmHg requiring inotropic support with medications or intra-aortic balloon pump (IABP). Heart failure included advanced congestive heart failure (New York Heart Association functional class III/IV) or acute heart failure (Killip class II–IV) [7].

All patients were given 600 mg clopidogrel, 300 mg aspirin, UFH/LMWH (low-dose unfractionated heparin, 50 U/kg (regardless of use of glycoprotein IIb /IIIa antagonists), while the standard-dose of unfractionated heparin is 85 U/kg (60 U/kg with Glycprotein IIb/IIIa antagonists) [7]. During the procedure and continued during hospital stay unless contraindicated, in addition to the conventional anti-ischemic and anti-anginal treatment as nitrates.

Hydration with intravenous normal saline solution was initiated during the procedure and maintained until 6 to 12 hours after completion of the procedure. The hydration rate was 1 ml/kg/hour or 0.5 ml/kg/hour if the LVEF was <40% for patients with eGFR< 60 ml/min/1.73 m^2. Coronary angiography was performed as soon as possible, upon arrival of the on-call team. We started, by catheterization of the artery of the non-infract region, followed by the culprit one. PCI stenting of the culprit lesion(s) was done.

The primary study end point was the occurrence of CIN, defined as either a greater than 25% increase of serum creatinine or an absolute increase in serum creatinine of 0.5 mg/dl from baseline value, at 48-72 h following the exposure to procedure [2]. The secondary end point was the occurrence of in hospital death and in hospital major adverse cardiac (MACEs) which include cardiac death, presence of reinfarction, the onset of heart failure and major bleeding.

For comparison of differences among risk scores, we classified patients into risk categories according to the data presented in Liu et al., [16] who defined patients as low-, moderate- and high-risk for CIN [17].

Reinfarction was defined as the appearance of new myocardial ischemic symptoms or electrocardiographic ischemic changes accompanied by re-elevation of cardiac biomarkers (cTnI). Major bleeding was defined as the composite of intracranial or intraocular bleeding, access site hemorrhage requiring intervenetion, reduction in hemoglobin of 4 g/dl without or 3 g/dl with an overt bleeding source,

reoperation for bleeding or blood product transfusion during the follow up.

Data were analyzed using Statistical program for social science (SPSS) version 20.0. Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage. Independent samples t-test of significance was used when comparing between two means. Chi-square (X2) test of significance was used in order to compare proportions between two qualitative parameters. Receiver operating characteristic (ROC curve) analysis was used to find out the overall predictively of parameter in and to find out the best cut-off value with detection of sensitivity and specificity at this cut-off value.

Results

This was a prospective cross sectional observational study that involved 100 patients who presented to the emergency department of the National Heart Institute (NHI) with acute ST- elevation myocardial infarction and treated with primary PCI, within the period between October 2016 and May 2017.

All patients were subjected to history taking and full clinical examination, venous samples were withdrawn, coronary angiography was recorded and intervention was done, then they were followed during hospital stay.

The mean age of study group was 54.69 ± 11.77 years (ranged from

	Variable	Score
Mehran	Age ≥ 75 years	4
	Anemia	3
	Diabetes mellitus	3
	Chronic heart failure	5
	Intra-aortic balloon pump	5
	Hypotension	5
	CM material 1 for each 100 cc	
	eGFR ≤ 20 ml/min/1.73 m²	6
	eGFR 20- 40 ml/min/1.73 m²	4
	eGFR 40-60 ml/min/1.73 m²	2
CHEN	Age >70 years	4
	History Of MI	5
	Diabetes mellitus	4
	Hypotension	6
	LV EF ≤ 45%	4
	Anemia*	3
	eGFR <60 ml/min/1.73 m²	7
	HDL <1 mmol/L	3
ACEF	Age /Left ventricular EF (%)	Yrs/EF%
	if serum creatinine >2.0 mg/dl	Add 1
AGEF	Age /Left ventricular EF (%)	Yrs/EF%
	If eGFR ≤60 mL/min/1.73 m²	Add 1
Gao	Age >60 years	2
	Hypertension	2
	Acute myocardial infarction	2
	Heart failure	2
	Use of intra-aortic balloon pump	4
	eGFR 89 to 70 ml/min/1.73 m²	1
	eGFR69 to 50 ml/min/1.73 m²	2
	eGFR49 to 30 ml/min/1.73 m²	3
	eGFR<30 ml/min/1.73 m²	6
	Contrast volume 100 to 300 ml	1
	Contrast volume >300 ml	3

*Anemia was defined as hemoglobin (HB%) <12 gm/dl [16]

	variable	Score
GRACE	**Age**	
	<30	0
	30-39	8
	40-49	25
	50-59	41
	60-69	58
	70-79	75
	80-89	91
	>90	100
	Heart rate (beats/min)	
	<50	0
	50-69	3
	70-89	9
	90-109	15
	110-149	24
	150-199	38
	>200	46
	Systolic BP(mm Hg)	
	<80	58
	80-99	53
	100-119	43
	120-139	34
	140-159	24
	160-199	10
	>200	0
	Creatinine(mg/dl)	
	0-0.39	1
	0.4-0.79	4
	0.8-1.19	7
	1.2-1.59	10
	1.6-1.99	13
	2-3.99	21
	>4	28
	Killip's classification	
	I	0
	II	20
	III	39
	IV	59
	Cardiac arrest at admission 39	
	Increased cardiac markers	14
	ST Segment deviation	14

Abbreviations; **CM**=contrast media; **EF**=ejection fraction, **eGFR**=Estimated glomerular filtration rate; **Yrs**=years; **HDL**=high density lipoproteins, **MI**=myocardial infarction

Table 1: Variables in risk scores evaluated.

Risk score	Low	Moderate	High
Mehran	<7.8	7.8-11.99	≥ 12
Chen	<7	7-12.99	≥ 13
GRACE	<141	141-159.9	≥ 160
ACEF	<0.99	0.99-1.29	≥ 1.30
AGEF	<1.0	1.0-1.36	≥ 1.37
Gao	<5	5.-8.0	≥ 8.0

Table 2: definition of low, moderate and high risk patients for CIN according to different risk scores.

28 -82 years), the number of patients who are seventy or older was 11 (11%), while the number of patients who are below seventy was 89 (89%). Males represented 84% (84 patients) of the study population and the male to female ratio was (5.25:1). Thirty two percent of study group (32 patients) were diabetic, while 41% (41 patients) were hypertensive and 64% (64 patients) were smokers. 5% of study group (5 patients) were dyslipidemic and one patient had family history of premature coronary artery disease. Regarding the past history, 5% of study group (5 patients) had history of prior PCI, 8% of patients had history of prior MI and one patient had history of CABG (Tables 1 and 2).

As regard clinical examination, the mean of heart rate of study group was 89.76 ± 16.06 bpm, while the mean of systolic blood pressure was 118 ± 29 mmHg and the mean of diastolic blood pressure was 72 ± 17 mmHg. Concerning Killip class at presentation, 6 % of patients presented with Killip class IV, while 3% of patients presented with Killip class III and 91% of patients presented with Killip class I.

All patients presented with typical chest pain, 2% presented with diabetic ketoacidosis (DKA) and 3% (3 patients) presented with cardiac arrest and had successful cardiopulmonary resuscitation (CPR) receiving DC shock. Two patients presented with 2nd degree heart block and one patient presented with complete heart block. Majority of patients presented with anterior STEMI 61% (Table 3).

In the present study, serum creatinine level on admission was ≤ 1.4 mg/dl in a quite high proportion of patients (92.0%) and the eGFR on admission was ≥ 60 mL/min/1.73 m^2 in 80% of study population.

The infarct related artery (culprit artery) was right coronary artery (RCA) in 29 patients, left anterior descending artery (LAD) in 63 patients and left circumflex (LCX) in 5 patients, obtuse marginal (OM1) in 3 patients. We had 48% (48 patients) with single vessel disease, 34% (34 patients) with two vessel disease and 18% (18 patients) with multivessel disease (Tables 4 and 5).

Regarding contrast volume used and radiation exposure time, we used 221.80 ± 64.2 ml of contrast and the mean of exposure to radiation time was 51.4 ± 10.8 minutes. We used one stent in 69% of study group (69 patients), two stents in 30% (30 patients) and three stents only in one patient. Two interventions complicated with dissections and 6% with no-reflow. One patient had stroke and another had successful CPR in cath lab. Glycoprotein IIb IIIa antagonists were used in 17% of study population. Twenty seven percent of study group were recommended for elective PCI for non-culprit in another session and 3% (3 patients) for CABG.

Complete inhospital follow up during was achieved in 100% of patients with mean 3.81 ± 2.24 days (range 1-21 days). The incidence of CIN in was 10%, the patients with CIN had poor in-hospital outcome. Their hospital stay was significantly prolonged with a mean 5.2 ± 2.4 days. The incidence of in hospital MACEs was 7% and 6% for in hospital death. Only one patient underwent dialysis.

Demographic data	
Sex	
Female	16 (16.0%)
Male	84 (84.0%)
Age (years) Range	28-82 (54.69 ± 11.77)
Diabetes	32 (32 %)
Hypertension	41 (41%)
Smoker	64 (64 %)
Dyslipidemia	5 (5 %)
Family history of IHD	1 (1 %)
Past history	
Prior PCI	5 (5%)
Prior MI	8 (8 %)
Prior CABG	1 (1%)
Examination	
Heart Rate (bpm)	40-140 (89.76 ± 16.06)
Systolic blood pressure (mmHg)	60-220 (118.24 ± 29.21)
Diastolic blood pressure (mmHg)	40-120 (72.79 ± 17.16)
Killip class	
I	91 (91%)
II	0 (0%)
III	3 (3%)
IV	6 (6%)
Presentations	
Onset of chest pain in hours–Range	1-12 (6.59 ± 3.21)
Chest pain	100 (100%)
DKA	2 (2.0%)
DC Shock(tachyarrhythmia)	3 (3.0%)
Brady arrhythmia	3 (3.0%)
Cardiac arrest	3 (3.0%)
ECG	
Anterior STEMI	61 (61.0%)
Lateral STEMI	3 (3.0 %)
Inferior STEMI	35 (35.0%)
Septal STEMI	1 (1.0 %)
Laboratory before PCI	
Serum creatinine (mg/dl)	0.4-2.1 (0.94 ± 0.31)
eGFR (mL/min/1.73 m^2)	26.13-180.64 (90.95 ± 33.61)
Serum urea (mg/dl)	11-95 (34.50 ± 15.59)
Hemoglobin % (gm/dl)	9.6-17.5 (13.39 ± 1.56)
RBS (mg/dl)	90-600 (201.77 ± 122.67)
Labs after 48 h	
Serum creatinine (mg/dl)	0.4-4.1 (1.10 ± 0.63)
eGFR (ml/min/m^2)	15.34-180.64 (81.38 ± 30.45)
Serum urea (mg/dl)	15-143 (40.62 ± 20.0)
Lipid Profile	
Total cholesterol (mg/dl)	139-280 (205.40 ± 25.63)
Triglycerides (mg/dl)	85-616 (184.05 ± 71.24)
HDL (mg/dl)	21-50 (37.03 ± 6.04)
LDL (mg/dl)	14-212 (135.26 ± 25.72)
Ejection fraction	25-65 (46.16 ± 8.69)

Table 3: Baseline characteristics of the study population.

For CIN, there was statistical significant relation between CIN according to serum creatinine ≥ 2 mg/dl at admission (p value=0.003), with serum urea (p value<0.001), systolic blood pressure <90 mmHg at admission (p value=0.007), with Killip class at admission (p value<0.001), with anterior STEMI (p value =0.049), with contrast volume used ≥ 200 ml (p value =0.048) and radiation exposure time (p value=0.042) (Table 6 and Figure 1).

Culprit vessel (s)	
LAD	63 (63%)
Isolated	57
With other	6
RCA	29 (29%)
Isolated	27
With other	2
LCX	5 (5 %)
Isolated	4
With other	1
OM Vessel disease	
Single vessel disease	48 (48%)
Two vessel disease	34 (34 %)
Three vessel	18 (18%)
Total revascularization	57 (57%)
Femoral Approach	100 (100%)
Number of stents	
One	69 (69%)
Two	30 (30%)
Three	1 (1%)
Total	100 (100%)
Time to vascular access (Secs) Range	1-4 (1.37 ± 0.65)
Contrast volume (ml) Range	100-400 (221.80 ± 64.52)
Radiation Exposure Time(min) – Range	30-90 (51.40 ± 10.83)
Complications	
Dissection	3 (3%)
Stroke	1 (1%)
No-Reflow	6 (6%)
CPR 10 minutes	1 (1%)
No complications	89 (89%)
Glycoprotein II b III a antagonists use	
No	83 (83 %)
Yes	17 (17%)
Total	100 (100%)
Decisions after PCI	
For Elective PCI to non-culprit vessel(s)	31 (31%)
For CABG after viability test	3 (3%)
Medical TTT Only	66 (66 %)
Total	100 (100%)

Table 4: Technical data of primary PCI.

Follow up (days) Range [Mean ± SD]	2-21[3.81 ± 2.24]
CIN	
No	90 (90%)
Yes	10 (10%)
Total	100 (100%)
Hospital stay mean ± SD	5.2 ± 2.4 days
Time to CIN mean ± SD	2 ± 0.63 days
MACE(s)	
No	93 (93%)
Yes	7 (7 %)
Total	100 (100%)
All in hospital MACE(s) [N=7]	
Death	6 (6%)
Re-infarction	1 (1%)
Time to MACES (days) Range	2-21(7.57 ± 6.8)
Death	
No	94 (94%)
Yes	6 (6%)
Total	100 (100%)
Time to death (days) Range [Mean ± SD]	2-21(7.71 ± 7.3)
Time to vascular access (Secs) Range	1-4 (1.37 ± 0.65)
CIN and Dialysis	
No	99 (99%)
Yes	1 (1%)
Total	100 (100%)
Time to dialysis	6 days

Table 5: Follow up and in hospital outcomes
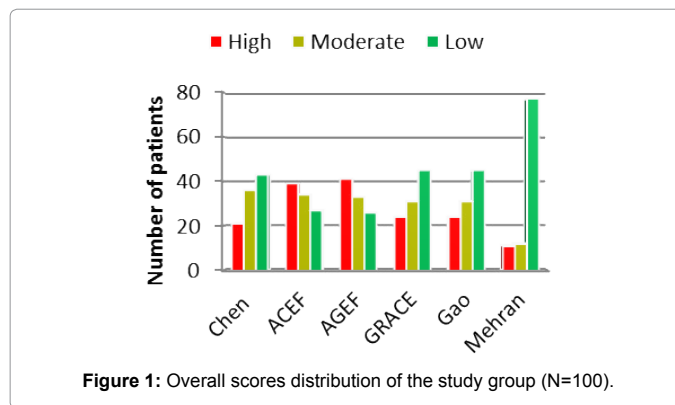
Figure 1: Overall scores distribution of the study group (N=100).

On the other hand, there was no significant relation with Age ≥ 70 years, presence of diabetes, history of hypertension, prior MI, prior PCI, EF<45%, RBS >300 mg/dl, eGFR<60 ml/min/1.73 m², lipid profile (LDL, HDL, total cholesterol and triglycerid- es), time to vascular access, heart rate on admission, number of stents used and total revascularization (Tables 6 and 7).

Our study demonstrated that there was statistically significant difference between CIN [No or Yes] according to level of all 6 risk scores (Table 8 and Figure 2).

In this study, there was statistically significant difference between MACE(s) [No or Yes] according to level of all risk scores (Table 9 and Figure 3).

There was statistically significant difference between death [No or Yes] according to level of all risk scores (Table 10 and Figure 4).

All risk scores showed relatively good predictive accuracy for CIN (ranged from 82.9%-67.1%). Mehran score has the highest predictive accuracy for CIN (82.9%) with 100% sensitivity and 46% specificity (Tables 11-13 and Figures 5-7).

All 6 risk scores showed high predictive accuracy for in hospital MACEs (ranged from 92.6 to 81.5%). Mehran risk score showed highest predictive accuracy in hospital with 100% sensitivity and 77% specificity.

All 6 risk scores showed high predictive accuracy for in hospital death (ranged from 97.3% to 83%). GRACE risk score showed the highest predictive accuracy for in hospital death with 100% sensitivity and 91% specificity.

Discussion

This was a prospective observational study conducted in the National Heart Institute (NHI) and involved 100 patients who presented with acute STEMI that was treated using primary PCI.

The present study aimed to compare between different risk scores for predicting CIN and short outcome after primary PCI in patients with STEMI. In addition to prediction of CIN, we demonstrated that

Variables	CIN		Chi-square test	
	No [n=90]	Yes [n=10]	x^2	p- value
Age (years)				
≤ 70 years	82 (91.1%)	9 (90.0%)	0.014	0.907
>70 years	8 (8.9%)	1 (10.0%)		
Age (years)				
<60 years	61 (67.8%)	6 (60%)	0.246	0.62
>60 years	29 (32.2%)	4 (40%)		
Hypertension				
No	54 (60%)	5 (50%)	0.372	0.542
Yes	36 (40%)	5 (50%)		
Diabetes				
No	63 (70.0%)	5 (50.0%)	1.654	0.198
Yes	27 (30.0%)	5 (50.0%)		
Prior PCI				
No	86 (95.6%)	9 (90.0%)	0.585	0.444
Yes	4 (4.4%)	1 (10%)		
Prior MI				
No	83 (92.2%)	9 (90%)	0.06	0.806
Yes	7 (7.8%)	1 (10%)		
Level of heart rate (bpm)				
≤ 100	62 (68.9%)	7 (70.0%)	0.005	0.943
>100	28 (31.1%)	3 (30.0%)		
Systolic blood pressure (mmHg) admission				
<90	9 (10.0%)	4 (40.0%)	7.162	**0.007**
≥ 90	81 (90.0%)	6 (60.0%)		
Killip class				
1	85 (94.4%)	6 (60.0%)	13.655	**<0.001**
3	2 (2.2%)	1 (10.0%)		
4	3 (3.3%)	3 (30.0%)		
Random blood sugar >300 mg/dl				
<300	64 (71.1%)	6 (60%)	0.529	0.467
>300	26 (28.9%)	4 (40%)		
Serum urea	32.13 ± 12.88	55.80 ± 21.75	25.96	**<0.001**
Serum Creatinine (mg/dl)				
≤ 2	90 (100.0%)	9 (90.0%)	9.091	**0.003**
>2	0 (0.0%)	1 (10.0%)		
eGFR ml/min/1,73m²				
<60	16 (17.8%)	4 (40.0%)	2.778	0.096
>60	74 (82.2%)	6 (60.0%)		
HDL[(mg/dl)	37.10 ± 6.14	36.40 ± 5.25	0.12	0.73
LDL (mg/dl)	137.9 ± 24.58	134.97 ± 25.96	0.367	0.716
T. cholesterol	203.6 ± 27.26	205.6 ± 25.6	0.239	0.812
TGs (mg/dl)	164.4 ± 24	186.23 ± 74.43	1.248	0.219
HB% (mg/dl)	12.79 ± 1.95	13.46 ± 2.07	1.054	0.299
Ejection Fraction<45%				
<45%	33 (36.7%)	6 (60%)	2.06	0.151
>45%	57 (63.3%)	4 (40%)		
Type of STEMI				
Anterior	54 (60%)	7 (70%)	12.621	**0.049**
Lateral	0%	0 (0%)		
Inferior	32 (35.6%)	3 (30%)		
Septal	1 (1.1%)	0 (0%)		
Time to vascular access (min)				
1	65 (72.2%)	6 (60.0%)	0.92	0.821
2	19 (21.1%)	3 (30.0%)		
3	5 (5.6%)	1 (10.0%)		
4	1 (1.1%)	0 (0.0%)		

Number of stents				
1	63 (70.0%)	6 (60.0%)	0.612	0.736
2	26 (28.9%)	4 (40.0%)		
3	1 (1.1%)	0 (0.0%)		
Complications				
CPR	1 (1.1%)	0 (0%)	0.741	0.946
Dissection	2 (2.2%)	0 (0%)		
No complications	81 (90%)	9 (90%)		
No-Reflow	5 (5.6%)	1 (10%)		
Stroke	1 (1.1%)	0 (0%)		
Contrast volume (ml)				
<200	26 (28.9%)	0 (0.0%)	3.904	**0.048**
≥ 200	64 (71.1%)	10 (100.0%)		
Total revascularization				
No	39 (43.3%)	4 (40.0%)	0.041	0.84
Yes	51 (56.7%)	6 (60.0%)		
Radiation exposure Time (min)				
	50.67 ± 10.84	58.00 ± 8.56	4.265	**0.042**

p-value <0.05 **S**; p-value <0.001 **HS**; p-value >0.05 **NS**

Table 6: Relation between CIN (Yes and No) and potential predictor variables.

Scores	No.	%
Chen		
High	21	21.0
Moderate	36	36.0
Low	43	43.0
Range (Mean ± SD)	0-27 (7.97 ± 5.55)	
ACEF		
High	39	39.0
Moderate	34	34.0
Low	27	27.0
Range (Mean ± SD)	0.6-2.31 (1.24 ± 0.38)	
AGEF		
High	41	41.0
Moderate	33	33.0
Low	26	26.0
	0.6-3.2 (1.43 ± 0.62)	
GRACE		
High	24	24.0
Moderate	31	31.0
Low	45	45.0
Range (Mean ± SD)	86-268 (145.08 ± 33.73)	
GAO		
High	31	31.0
Moderate	31	31.0
Low	38	38.0
Range (Mean ± SD)	4-13 (6.26 ± 2.28)	
Mehran		
High	11	11.0
Moderate	12	12.0
Low	77	77.0
Range (Mean ± SD)	1-22 (5.67 ± 4.24)	

Table 7: Overall Scores distribution of the study group (N=100).

those different risk scores performed well for predicting in hospital MACEs and death.

The observed incidence of CIN after primary PCI differs greatly among various studies, largely because of varying definitions and associated variable risk factors. Not surprisingly, the frequency of CIN in our study was about 10%, which is lower than the results observed

Level of Scores	CIN		Chi-square	
	No (n=90)	Yes (n=10)	x^2	p-value
Chen score				
High	17 (18.9%)	4 (40.0%)		
Moderate	30 (33.3%)	6 (60.0%)	8.466	**0.015***
Low	43 (47.8%)	0 (0.0%)		
ACEF				
High	32 (35.6%)	7 (70.0%)		
Moderate	32 (35.6%)	2 (20.0%)	6.568	**0.042***
Low	26 (28.9%)	1 (10.0%)		
AGEF				
High	35 (38.9%)	6 (60.0%)		
Moderate	30 (33.3%)	3 (30.0%)	5.103	**0.035***
Low	25 (27.8%)	1 (10.0%)		
GRACE				
High	18 (20.0%)	6 (60.0%)		
Moderate	28 (31.1%)	3 (30.0%)	9.028	**0.011***
low	44 (48.9%)	1 (10.0%)		
GAO				
High	24 (26.7%)	7 (70.0%)		
Moderate	28 (31.1%)	3 (30.0%)	9.677	**0.008***
Low	38 (42.2%)	0 (0.0%)		
Mehran				
High	8 (8.9%)	3 (30.0%)		
Moderate	9 (10.0%)	3 (30.0%)	8.622	**0.013***
Low	73 (81.1%)	4 (40.0%)		
p-value <0.05 **S***; p-value <0.001 **HS***; p-value >0.05 **NS**.				

Table 8: Comparison between CIN (No and Yes) according to level of scores.

Figure 2: Comparison between CIN [Yes and No] according to level of scores.

Level of Scores	MACE (s)		Chi-square	
	No (n=93)	Yes (n=7)	x^2	p-value
Chen				
High	16 (17.2%)	5 (71.4%)		
Moderate	34 (36.6%)	2 (28.6%)	12.467	**0.002***
Low	43 (46.2%)	0 (0.0%)		
ACEF				
High	32 (34.4%)	7 (100.0%)		
Moderate	34 (36.6%)	0 (0.0%)	11.773	**0.003***
Low	27 (29.0%)	0 (0.0%)		
AGEF				
High	34 (36.6%)	7 (100.0%)		
Moderate	33 (35.5%)	0 (0.0%)	10.831	**0.004***
Low	26 (28.0%)	0 (0.0%)		
GRACE				
High	18 (19.4%)	6 (85.7%)		
Moderate	30 (32.3%)	1 (14.3%)	16.010	**<0.001'**
low	45 (48.4%)	0 (0.0%)		
GAO				
High	25 (26.9%)	6 (85.7%)		
Moderate	30 (32.3%)	1 (14.3%)	10.807	**0.005***
Low	38 (40.9%)	0 (0.0%)		
Mehran				
High	6 (6.5%)	5 (71.4%)		
Moderate	12 (12.9%)	0 (0.0%)	28.182	**<0.001***
Low	75 (80.6%)	2 (28.6%)		
p-value <0.05 **S***; p-value <0.001 **HS***; p-value >0.05 **NS**.				

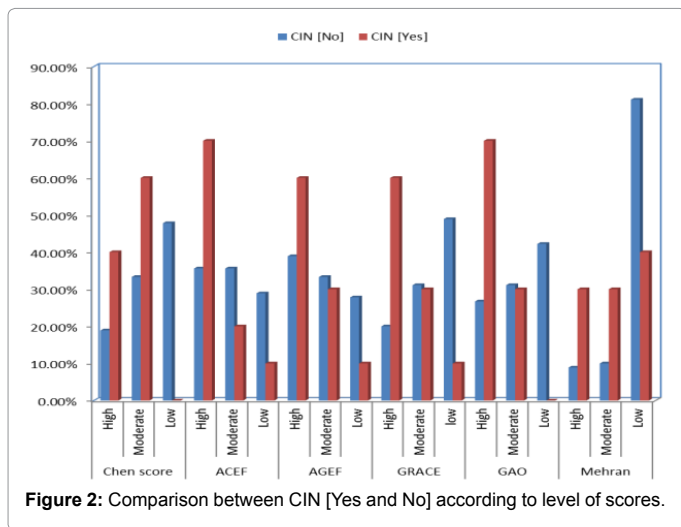**Table 9:** Comparison between MACE (s) (No and Yes) according to level of scores.
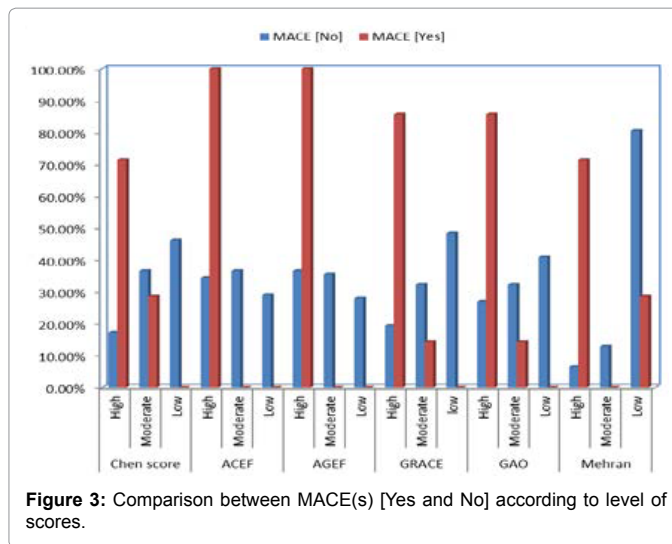
Figure 3: Comparison between MACE(s) [Yes and No] according to level of scores.

by Marenzi et al., [4], who studied 208 consecutive patients admitted to coronary care unit for STEMI who were treated with primary PCI. CIN was observed in approximately 19% of STEMI patients who underwent primary PCI. Our data may be related to the close collaboration with the local nephrologist in our institution that may have reduced the risk of CIN development as the result of a prompt activation of the hydration protocol.

However, Raposeiras-Roubin et al., [12] studied 202 consecutive patients presented with acute myocardial infarction (STEMI and NSTEMI) and with normal kidney function (eGFR>60/mL/min/ 1.7 m^2) undergoing coronary angiography and follow up during hospital stay. The incidence of CIN was 6% which was lower than our study, as

we did not exclude patients presented with renal dysfunction from the study as 20% of our study population presented with renal dysfunction (eGFR<60 ml/min/1.73 m^2).

In this study only 1% of patients who had CIN underwent dialysis and this was concordant with McCullough et al., [20], who demonstrated that the occurrence of acute renal failure requiring dialysis after coronary intervention is rare (1%).

This study showed that, in STEMI patients undergoing primary PCI, CIN was a significant and independent predictor of poor in-hospital outcome. This was concordant with Liu et al., [16], who

Level of Scores	Death		Chi-square	
	No (n=94)	Yes (n=6)	x^2	p-value
Chen				
High	16 (17.0%)	5 (83.3%)		
Moderate	35 (37.2%)	1 (16.7%)	15.217	<0.001*
Low	43 (45.7%)	0 (0.0%)		
ACEF				
High	33 (35.1%)	6 (100.0%)		
Moderate	34 (36.2%)	0 (0.0%)	9.984	0.007*
Low	27 (28.7%)	0 (0.0%)		
AGEF				
High	35 (37.2%)	6 (100.0%)		
Moderate	33 (35.1%)	0 (0.0%)	9.185	0.010*
Low	26 (27.7%)	0 (0.0%)		
GRACE				
High	18 (19.1%)	6 (100.0%)		
Moderate	31 (33.0%)	0 (0.0%)	20.213	<0.001*
low	45 (47.9%)	0 (0.0%)		
GAO				
High	26 (27.7%)	5 (83.3%)		
Moderate	30 (31.9%)	1 (16.7%)	8.488	0.014*
Low	38 (40.4%)	0 (0.0%)		
Mehran				
High	6 (6.4%)	5 (83.3%)		
Moderate	12 (12.8%)	0 (0.0%)	34.144	<0.001*
Low	76 (80.9%)	1 (16.7%)		

p-value <0.05 **S***; p-value <0.001 **HS***; p-value >0.05 **NS**

Table 10: Comparison between died and survived according to level of scores.
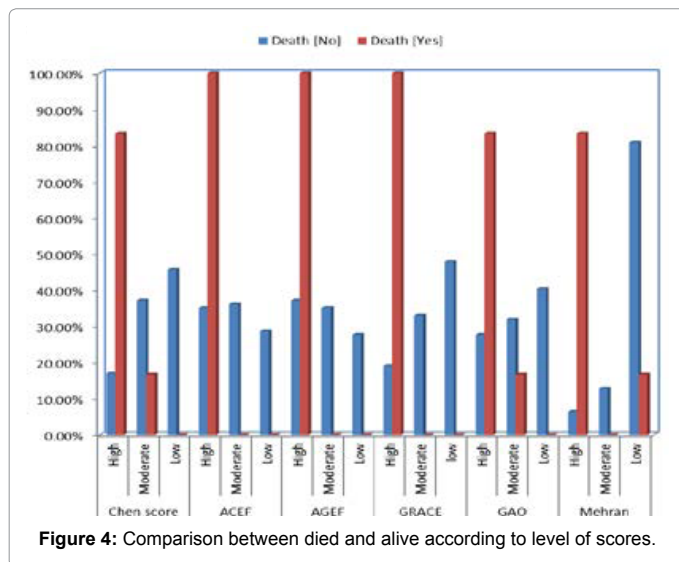

Figure 4: Comparison between died and alive according to level of scores.

Score	Cut-off	Sen.	100-spec.	Spe.	PPV	NPV	AUC	Accuracy
Chen	>8	80%	32%	68%	22%	97%	0.777	77.7%
ACEF	>1.7	50%	10%	90%	36%	94%	0.697	69.7%
AGEF	>1.7	60%	24%	76%	21%	94%	0.671	67.1%
GRACE	>149	90%	30%	70%	25%	98%	0.780	78.0%
GAO	>5	100%	54%	46%	17%	100%	0.798	79.8%
Mehran	>5	90%	34%	66%	23%	98%	0.829	82.9%

AUC: area under the curve, **spe**: specificity, **sens**: sensitivity, **PPV**: positive predictive value, **NPV**: negative predictive value.

Table 11: Performance of scores in discrimination of CIN (No and Yes).

Score	Cut-off	Sen.	100-spe	Spe.	PPV	NPV	AUC	Accuracy
Chen	>7	100%	37%	63%	17%	100%	0.863	86.3%
ACEF	>1.4	100%	27%	73%	22%	100%	0.849	84.9%
AGEF	>1.7	60%	24%	76%	21%	94%	0.815	81.5%
GRACE	>171	86%	9%	91%	43%	99%	0.915	91.5%
GAO	>6	100%	35%	65%	18%	100%	0.899	89.9%
Mehran	>6	100%	23%	77%	25%	100%	0.926	92.6%

AUC: area under the curve, **spe**: specificity, **sens**: sensitivity, **PPV**: positive predictive value, **NPV**: negative predictive value.

Table 12: Performance of scores in discrimination of MACEs (No and Yes).

Score	Cut-off	Sen.	100-spec	Spe.	PPV	NPV	AUC	Accuracy
Chen	>9	100%	30%	70%	18%	100%	0.900	90.0%
ACEF	>1.4	100%	28%	72%	19%	100%	0.856	85.6%
AGEF	>1.4	100%	35%	65%	15%	100%	0.838	83.8%
GRACE	>171	100%	9%	91%	43%	100%	0.973	97.3%
GAO	>6	100%	38%	64%	15%	100%	0.885	88.5%
Mehran	>11	83%	6%	94%	46%	99%	0.949	94.9%

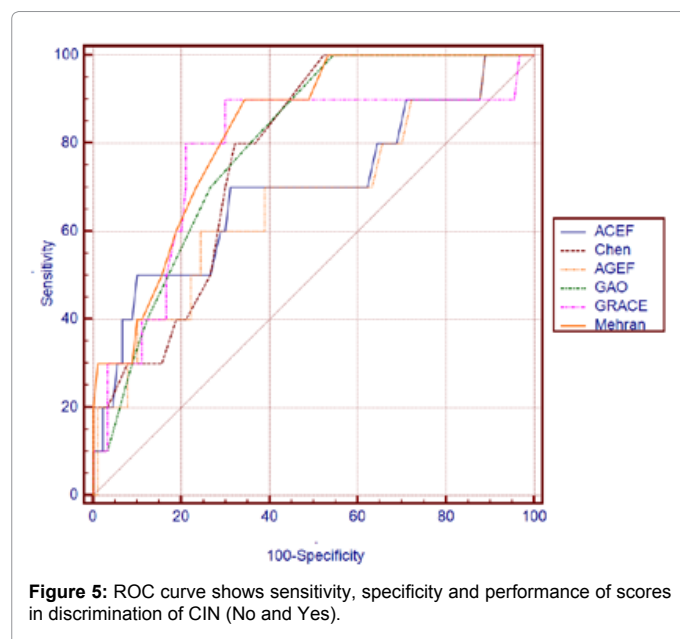**Table 13:** Performance of scores in discrimination of Death (No and Yes).

Figure 5: ROC curve shows sensitivity, specificity and performance of scores in discrimination of CIN (No and Yes).

may be the first to compare between those 6 risk models for CIN in patients with STEMI, prospectively enrolled 422 consecutive patients with STEMI undergoing primary PCI and showed that CIN was a highly significant predictor for in hospital mortality (p value=0.001).

In this study, the incidence of in-hospital death was 6% of study population while Liu et al., [16], who showed that the incidence of in hospital death was 4%. Our data may due to late presentation of study population.

MACEs occurred in 7% of our study population while Liu et al., [16] showed that the incidence of MACEs was 17% of study population. This was due they enrolled major adverse cardiac and non-cardiac events in their study.
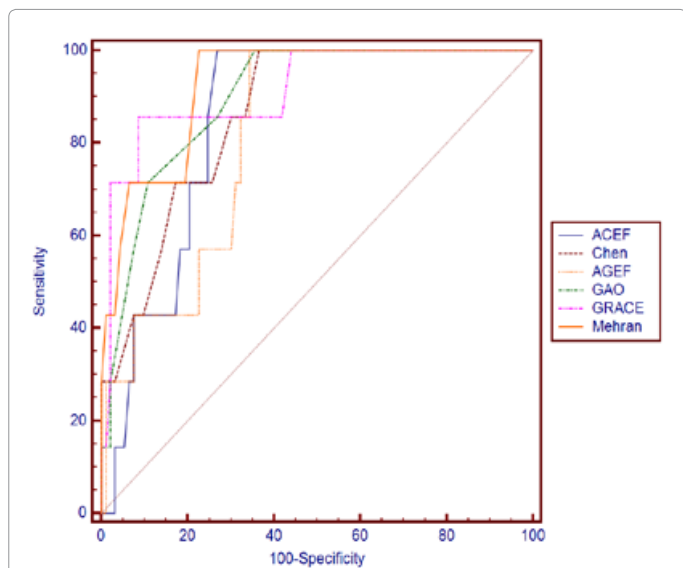
Figure 6: ROC curve shows sensitivity, specificity and performance of scores in discrimination of MACE(s) (No and Yes).
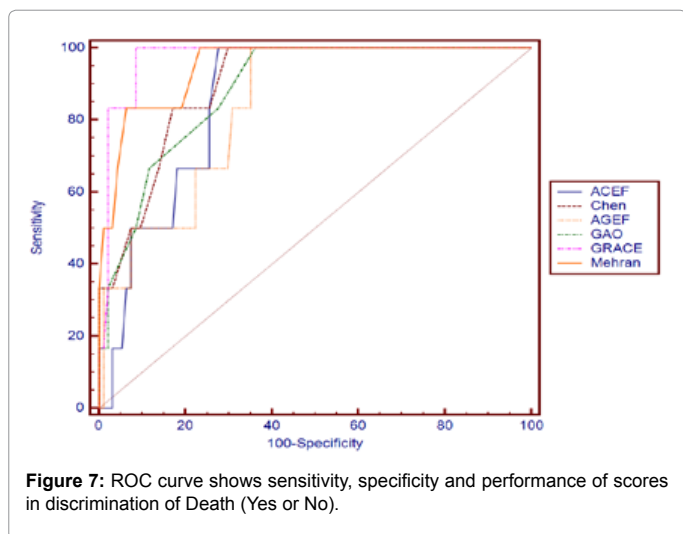

Figure 7: ROC curve shows sensitivity, specificity and performance of scores in discrimination of Death (Yes or No).

Univariate Analysis between Different Potential Predictor Variables and in Hospital Outcomes

CIN:

Our study concluded that there was statistically significant relation between CIN and following predictor variables:

Baseline serum creatinine ≥ 2 mg/dl at admission (p value=0.003), which was concordant with Ando et al., 10 who studied 481 patients with STEMI underwent primary PCI including patients with cardiogenic shock and demonstrated that baseline Serum creatinine ≥ 1.5 mg/dl was highly significant predictor for CIN (p value ≤ 0.001).

Systolic blood pressure <90 mmHg at admission (p value=0.007), which was concordant with Chen et al., [13], who retrospectively studied 1500 consecutive Asian patients who underwent PCI for ACS and demonstrated that the hypotension at admission was a highly significant predictor for CIN (p value ≤ 0.001).

Killip class at admission (p value ≤ 0.001), which was concordant with Raposeiras-Roubín et al., [12], who showed that Killip class >I at admission was highly significant predictor for CIN (p value=0.001).

Contrast volume used ≥ 200 ml (p value=0.048), which was consistent with Gao et al., [14], who retrospectively studied 3945 Asian patients undergoing coronary angiography or PCI and demonstrated that the contrast volume used >200 mL was associated with a significantly higher risk of CIN and the CIN risk would be increased with the increment of contrast volume.

Anterior STEMI (p value=0.049), this was concordant with Marenzi et al., [4] who found a that patients presented with anterior STEMI were at a higher risk for CIN (p value=0.0015).

In-hospital stay (p value 0.03), this was consistent with study Ando et al., [11], who found that patients with CIN had a significant prolonged in-hospital stay (p value ≤ 0.001).

On the other hand, we found that there was no statistically significant relation of the following factors and CIN:

Age ≥ 70 years (p value=0.907), which was in disagreement with Chen et al., [13], who found that the age of >70 years was an independent predictor of CIN because a number of structural and functional degenerative changes in kidneys could make old persons prone to CIN. Our data may due to the fact that we had only 11% of our study population with age of seventy or older. However, Raposeiras-Roubín et al., [12] found that Age ≥ 75 years was not a significant risk factor for CIN (p value= 0.365).

Diabetes (p value= 0.198), this was discordant with Chen et al., [13], who found that diabetes was a predictor of CIN (p value ≤ 0.001). But In 2006, the CIN Consensus Working Panel stated that it is not clear whether the risk of CIN is significantly increased in patients with diabetes who do not have renal impairment and the updated contrast Media Safety Committee (CMSC) of European Society of Urogenital Radiology guidelines published in 2011 also hold the same opinion [2].

The eGFR<60 ml/min/ 1.73 m^2 at admission (p value=0.096), which was inconsistent with Gao et al., [14], who found that the baseline renal function was one of the strongest predictors for CIN development. This may be due to the renal function in a quite high proportion of our patients (80.0%) was normal (i.e., eGFR >60 mL/min/1.73 m^2). Because the compensatory capacity of kidney diminished in the patients with renal insufficiency, it is easier to develop acute kidney injury affected by nephrotoxic agents, including contrast media.

Heart rate >100 bpm at admission (p value=0.943), which was consistent with Ando et al., [10], who found that heart rate at admission was not a predictor of CIN (p value=0.06).

Depressed EF <45% (p value=0.151), which was concordant with Raposeiras-Roubín et al., [12] who demonstrated that depressed EF was not a predictor of CIN (p value=0.541).

History of HTN (p value=0.542), which was consistent with Gao et al., [14], who demonstrated that history of hypertension was significant predictor of CIN (p value=0.001)

Patients who had multivessel disease and this was discordant with Gao et al., [14], who found that patients with multivessel disease were at high risk for CIN (p value=0.002).

History of prior PCI and prior CABG and this was concordant with Gao et al., [14], who found that patients with past history of CABG or PCI were not at risk for CIN (p value =0.529).

Number of stents used (p value=0.736).

Patients who underwent total revascularization (p value=0.840).

Death and MACEs

Our study concluded that there was significant relation between in hospital outcomes and the following predictor variables:

CIN which was an independent predictor for in hospital death. This was concordant with Ando et al., [10], who found that CIN was a significant risk predictor for in hospital mortality as 66% of deaths had CIN.

Heart rate ≥ 100 bpm (p value=0.004), SBP<90 mmHg (p value ≤ 0.001) and Killip class on admission (p value ≤ 0.001). This consistent with previous study [12].

On the other hand, our study showed that there was no significant relation between in hospital death and the following; Age ≥ 70 years (this was inconsistent with Valente et al., [23], who demonstrated that age ≥ 75 years was a predictor of death in patients presented with STEMI complicated with cardiogenic shock treated with primary PCI with p value=0.002), presence of diabetes, history of hypertension (this was discordant with Valente et al., [23], who demonstrated that history of HTN was a predictor of death with p value=0.003), prior MI, prior PCI, serum creatinine >2 mg/dl at admission (this was discordant with Valente et al., [23], who demonstrated that serum creatinine >1.5 mg/dl at admission was a predictor of death with p value=0.003), random blood sugar (RBS) >300 mg/dl at admission (this was discordant with Valente et al., [23], who demonstrated that RBS >200 mg/dl was a predictor of death with p value=0.002), eGFR<60 ml/min/1.73 m² on admission, HDL level, time to vascular access, number of stents used, total revascularization and with complications of PCI

Comparison between Different Risk Scores Predicting in Hospital Outcomes:

Receiver operating characteristic curve (ROC) analysis was used to find out the overall predictivity of parameter in and to find out the best cut-off value with detection of sensitivity and specificity at this cut-off value.

CIN

This study demonstrated that all six risk scores showed relatively good predictive accuracy for CIN (ranged from 82.9%-67.1%), which was concordant with Liu et al., [16], who showed that the predictive accuracy of all six scores for CIN were ranged from 87.6%-74.6%.

Our study showed that Mehran score had the highest predictive accuracy for CIN (82.9%), with 90% sensitivity and 66% specificity. while The ACEF and AGEF score showed the lowest predictive accuracy for CIN (69.7%, 67.1% respectively). On the other hand, Liu et al., [16], who demonstrated that Gao, ACEF and AGEF scores had the highest predictive accuracy for CIN-narrow (87.6%, 87.3% and 87.1% respectively). While Chen score had the lowest predictive value for CIN (74.6%) [16].

In hospital MACEs

Our Study demonstrated that the All six risk scores showed high predictive accuracy for in hospital MACEs (ranged from 92.6 to 81.5%), which was higher than the results published by Liu et al., [16] in which predictive accuracy for MACEs was ranged from 76.3% to 68.5%. [16].

This study showed that Mehran risk score showed the highest

predictive accuracy for MACEs with 100% sensitivity and 77% specificity. While the ACEF and AGEF score showed the lower predictive accuracy for MACEs (84.9%, 81.5% respectively). On the other hand, Liu et al., [16] showed that the ACEF and AGEF scores had the highest predictive accuracy for MACEs (76.3%, 75.8% respectively) and Mehran showed the lowest predictive accuracy for MACEs 68.5% [16].

In hospital death

This study demonstrated that All six risk scores showed high predictive accuracy for in hospital death (ranged from 97.3% to 83%), which was concordant with Liu et al., [16], who showed that the predictive accuracy of all 6 scores for in hospital death was ranged from 93.6 % to 78.4% [16].

This study showed that GRACE risk score had the highest predictive accuracy for in hospital death with 100% sensitivity and 91% specificity. While the ACEF and AGEF score had the lowest predictive accuracy (85.6%, 83.8% respectively for MACEs). On the other hand, Liu et al., [16] demonstrated that ACEF and AGEF had the highest predictive accuracy for in hospital death (92.5%, 93.6% respectively), while Chen score had the lowest predictive accuracy 78.4% [16].

Conclusion

Risk scores for predicting CIN perform well in stratifying the risk of CIN and in-hospital death or MACEs in patients with STEMI undergoing PPCI. In this study, the Mehran and Gao scores was observed to have the higher predictive accuracy for CIN than the other risk scores, all of which are exclusive of procedural factors. While GRACE and Mehran scores had highest predictive accuracy for in hospital death and MACEs than the other risk scores.

Recommendations

This study recommends risk stratification for CIN before treating patients with myocardial revascularization using different risk scores especially Mehran and Gao risk scores as identification and intervention for patients with STEMI with a high risk of CIN are crucial to improve clinical outcomes.

This study recommends starting hydration before and after PCI, as well as an optimized choice of contrast medium, for the prevention of CIN. On the other hand, renal function should always be monitored in patients with AMI after catheterization, even in patients with GFR >60 mL/min/1.73 m.

The observed different predictive values were exclusive to patients with STEMI, and we recommend to do a research for other patients who undergoing elective PCI.

Study Limitations

This study had several potential limitations. First, the study was performed at a single center with a relatively small study population; thus, results should be interpreted with caution. Second, the different predictive values observed were exclusive to patients with STEMI, and caution should be taken in generalizing the findings for other patient populations. Third, we did not include all risk scores developed for CIN because we believe that those risk scores not included are excessively complicated or have been proved in other patient populations.

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