Chronic Kidney Disease, But Not Diabetes, Can Predict 30-Day Outcomes in Patients with ST-Elevation Myocardial Infarction after Primary Percutaneous Coronary Intervention: A Single-Center Experience

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Background: Patients with acute coronary syndrome and impaired renal function have been shown to have high mortality. However, there is scarce literature to date addressing the impact of diabetes mellitus (DM) and renal function on clinical outcomes of ST elevation myocardial infarction (STEMI) in Taiwan.

Method: This study enrolled 512 STEMI patients who received primary percutaneous coronary intervention. Patients were divided into 4 groups including group 1: patients without DM or CKD (nDM-nCKD); group 2: patients with DM but without CKD (DM-nCKD); group 3: patients with CKD but without DM (nDM-CKD); group 4: patients with DM and CKD (DM-CKD). Patients were also classified into four groups based on their estimated glomerular filtration rates (eGFR): stage 1 (eGFR $\geqq$ 90 ml/min/1.73 m^2, n = 163), stage 2 (eGFR = 89-60 ml/min/1.73 m^2, n = 171), stage 3 (eGFR = 59-30 ml/min/1.73 m^2, n = 136), and stage 4 (eGFR < 30 ml/min/1.73 m^2, n = 42). The complication rates, length of hospital stay, and 30-day outcomes were analyzed.

Results: The patients in both the nDM-CKD group and DM-CKD group had higher incidences of hypotension, intra-aortic balloon counterpulsation use, and respiratory failure ($p < 0.005$). They had significantly longer hospital stay and 30-day mortality rates ($p < 0.001$). The patients with CKD stage 3 and 4 had longer hospital stay and higher 30-day mortality rates ($p < 0.001$). However, DM was not an independent factor on the length of hospital stay and 30-day mortality rates.

Conclusions: STEMI patients with impaired renal function, but not DM, had significantly longer hospital stay and higher 30-day mortality rates.

Key Words: Chronic kidney disease • Diabetes mellitus • Mortality • Primary percutaneous coronary intervention • ST-segment elevation myocardial infarction

Received: June 6, 2013 Accepted: July 24, 2013

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This study was supported by the Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan, Grant No. VGHKS 101-104, 101-043, 102-054, 102-008, and the National Science Council, Taiwan, NSC 101-2314-13-075B-008.

INTRODUCTION

ST-segment elevation myocardial infarction (STEMI) is a major cause of morbidity and mortality worldwide, and is now becoming increasingly more common in developed countries.[1] Partial or total occlusion of the coronary artery by acute coronary thrombosis or embolization results in STEMI. The coronary artery is filled with lipid-rich core after atherosclerosis plaque rupture, which triggers the formation of unstable platelet aggre-

gates, following intermittent reduction in coronary flow and distal embolization.[1,2] STEMI patients have high mortality rates, and medical evidence has shown that rapid coronary reperfusion reduces mortality.[3] Moreover, it has become increasingly clear that percutaneous coronary intervention (PCI) is the preferred method of reperfusion if it can be performed in a timely manner.[3-5]

Renal impairment is a worldwide public health issue, with increasing incidence, expense and adverse outcomes.[6] Patients with chronic kidney disease (CKD) are at high risk for developing atherosclerosis and cardiovascular events.[7,8] There is also evidence that CKD is a key determinant of poor health outcomes of hypertension and diabetes mellitus (DM), and also one of the strongest cardiovascular risk factors. Furthermore, the presence of CKD can be used to assess 30-day outcomes in acute coronary syndrome patients.[9-15] Besides, patients with end-stage renal disease have higher incidence of acute coronary syndrome and mortality rate.[16]

DM is a strong risk factor for cardiovascular disease.[17] Recent studies show that it is a relative risk for the incidence of cardiovascular events in patients with CKD. Previous studies have shown that the incidence of CKD was higher in patients with DM and hypertension, which suggested that diabetes was an independent risk factor for the development of CKD.[9] Furthermore, renal insufficiency is an independent risk factor for the development of cardiovascular complications.[7,8] Given these findings, the presence of CKD and DM may indicate adverse clinical outcomes in patients with STEMI. Some studies proposed that DM was an independent risk factor for 30-day outcomes in STEMI patients,[17-20] but authors in several other studies reached different conclusions.[21-23] However, limited data are available on the prognostic value of CKD in combination with DM in patients with STEMI.[23] How DM affects the relationship between CKD and STEMI remains unclear. Therefore, this study investigates the impact of DM and CKD on 30-day outcomes in patients with STEMI who received primary PCI.

MATERIALS AND METHODS

Patients

Five hundred thirty consecutive patients who were diagnosed with acute STEMI and received primary PCI from Jan. 2008 through Dec. 2011 were enrolled in this study. Diagnosis of STEMI was made on the basis of typical angina lasting more than 30 minutes, new electrocardiographic change that included ST-segment elevation 0.2 mV in 2 contiguous electrocardiographic leads or other ST/T changes lasting more than 12 hours, biochemical evidence of peak creatine kinase more than 2 times the upper limit of normal, and wall motion abnormalities by echocardiography.[18,24] The criteria for exclusion were normal coronary arteriogram and patients who received coronary artery bypass surgery rather than angioplasty. Fifteen patients were excluded due to normal coronary arteriogram; three patients were excluded because they received coronary artery bypass surgery rather than angioplasty. Therefore, 512 patients were included in the study (Figure 1). The data was collected retrospectively, including basic data such as hypertension or DM. The previous cardiovascular events included previous stroke or myocardial infarction history. The Human Research Committee of our hospital approved the study protocol.

All patients with STEMI received primary PCI immediately. Aspirin 300 mg and clopidogrel 300 mg were prescribed at the emergency room, with heparin 5000 IU infusion. Angiogram was performed via the radial or femoral approach. The angiogram was performed via Philips MultiDiagnost Eleva interventional radiography/fluoroscopy system (The Netherlands). Following balloon dilatation, stent deployment with bare-metal stent or drug-eluting stent was done according to the operator's decision.

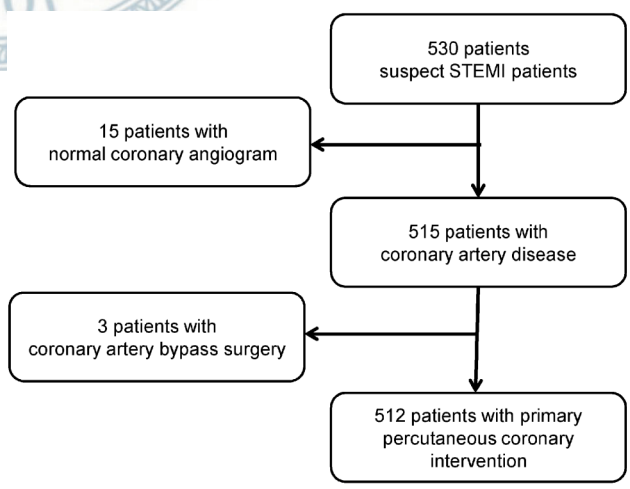

Figure 1. *Enrollment algorithm. STEMI, ST elevation myocardial infarction.*

DM definition

Patients were classified to have DM according to medical history. Newly detected DM was diagnosed by the following criteria: first, fasting plasma glucose level was more than or equal to 126 mg/dL twice; secondly, symptoms of hyperglycemia and non-fasting plasma glucose more than or equal to 200 mg/dL; third, glycated hemoglobin (HbA1c) greater than or equal to 6.5%.[25]

CKD definitions

The patients were divided into four stages by estimated glomerular filtration rate (eGFR).[8] The definitions of staging were as follows: stage 1: the eGFR was more than 90 mL/min/1.73 m^2; stage 2: the eGFR was between 89 to 60 mL/min/1.73 m^2; stage 3: the eGFR was between 59 to 30 mL/min/1.73 m^2; stage 4: the eGFR was less than 30 mL/min/1.73 m^2.

CKD was defined as kidney damage or GFR < 60 mL/min/1.73 m^2 after calculation.[7,8] GFR was estimated from calibrated serum creatinine and estimating equations. In this study, the Cockcroft-Gault formula was applied.[7]

Angiographic definitions

Coronary artery disease was diagnosed by more than 70% stenosis in 3 main coronary arteries.[17] The stenotic rate was measured by quantitative coronary angiographic analysis. At least one cardiologist who didn't know the patient's underlying disease identified the infarct-related vessel by the ST segment elevation leads on electrocardiogram. The infarct-related vessels were divided into right coronary artery, left circumflex artery, and left anterior descending artery, respectively.

Clinical evaluation and outcomes

Peripheral blood samples were drawn while patients visited the emergency room, or after admission. Heart rate and systolic blood pressure were measured at emergency room as well. Before intervention, complete blood counts and serum biochemical data were drawn, including non-fasting glucose, sodium, and potassium, but lipid profile and HbA1c were measured after intervention in fasting status. Complications included hypotension, intra-aortic balloon pump use, complete atrio-ventricular block, ventricular tachycardia, and respiratory failure. The post myocardial infarction left ventricular function (post-MI LV function) was estimated by echocardiogram. Length of hospital stay was defined by medical record, and 30-day outcome was defined as cardiogenic cause of death in 30 days after STEMI event.

Statistics

Parameters were summarized with mean and standard deviation where appropriate for continuous data, and counts or percentages for categorical data. For comparability between groups, a Chi-square test was used for categorical variables and analysis of variance (ANOVA) was adopted for continuous variables. All statistical analyses were performed with SPSS, version 18.0 (SPSS Inc, Chicago, Illinois, USA), and a value of $p < 0.05$ with two-sided testing was considered as statistically significant. The significant items were further analyzed with multivariate analysis to evaluate independent risk factor to 30-day mortality.

RESULTS

Patient population

Five hundred and twelve patients with STEMI who received primary PCI were enrolled in our study. Group 1 (nDM-nCKD, n = 249, 48.6%) enrolled patients without DM or CKD. Group 2 (DM-nCKD, n = 85, 16.6%) enrolled patients with DM only. Group 3 (nDM-CKD, n = 115, 22.5%) enrolled patients with CKD only, and group 4 (DM-CKD, n = 63, 12.3%) enrolled patients with both DM and CKD.

Patients in group 3 (nDM-CKD) and group 4 (DM-CKD) were older than group 1 (nDM-nCKD) (group 3 vs. group 1: 74.0 $\pm$ 10.7 vs. 52.9 $\pm$ 11.3, $p < 0.001$; group 4 vs. group 1: 70.8 $\pm$ 10.4 vs. 52.9 $\pm$ 11.3, $p < 0.001$, Table 1), but no difference was shown between group 3 and group 4 ($p = 0.32$, Table 1). Four hundred and fifty-one patients (88.1%) were male, and a gradual increasing trend in female gender from group 1 (nDM-nCKD) to group 4 (DM-CKD) was shown. Patients without DM or CKD in group 1 had higher body weight than those in group 3 and 4 (group 1 vs. group 3: 74.9 $\pm$ 11.7 vs. 61.0 $\pm$ 10.4, $p < 0.001$; group 1 vs. group 4: 74.9 $\pm$ 11.7 vs. 61.2 $\pm$ 10.4, $p < 0.001$, Table 1). Compared to group 1, there was a higher prevalence of hypertension in group

4 (group 1 vs. group 4: 45.8% vs. 81%, p < 0.001, Table 1). The incidence of smokers was significantly higher in group 1 than group 4 (group 1 vs. group 4: 63.5% vs. 33.3%, p < 0.001, Table 1). The prevalence of previous cardiovascular events was higher in group 4 patients (group 1 vs. group 4: 4% vs. 17.5%, p < 0.001, Table 1).

Presenting characteristics and laboratory data

Total cholesterol and low-density lipoprotein were lower in group 4 (p < 0.001, Table 1), as was hemoglobin (group 1 vs. group 4: 15.1 ± 1.7 vs. 12.1 ± 2.4, p < 0.001, Table 1). No difference was shown in high-density cholesterol, uric acid, alanine transaminase, and sodium

Table 1. Baseline characteristics of four groups which were divided by DM and CKD

	Total (N=512)	Group 1 (nDM-nCKD) (n = 249, 48.6%)	Group 2 (DM-nCKD) (n = 85, 16.6%)	Group 3 (nDM-CKD) (n = 115, 22.5%)	Group 4 (DM-CKD) (n = 63, 12.3%)	p value
Patient characteristics						
Age (years)	60.6 ± 14.2	52.9 ± 11.3	57.4 ± 10.3	74.0 ± 10.7	70.8 ± 10.4	< 0.001
Body weight (kilogram)	69.7 ± 12.8	74.9 ± 11.7	72.8 ± 10.6	61.0 ± 10.4	61.2 ± 10.4	< 0.001
Male gender	451 (88.1%)	231 (92.8%)	75 (88.2%)	98 (85.2%)	47 (74.6%)	< 0.001
Hypertension	281 (54.9%)	114 (45.8%)	58 (68.2%)	58 (50.4%)	51 (81%)	< 0.001
Smoking	273 (53.3%)	158 (63.5%)	44 (51.8%)	50 (43.5%)	21 (33.3%)	< 0.001
Previous cardiovascular events	32 (6.3%)	10 (4%)	4 (4.7%)	7 (6.1%)	11 (17.5%)	0.001
Laboratory data						
Total cholesterol (mg/dl)	182.4 ± 43.9	192.5 ± 43.3	186.5 ± 41.6	166.5 ± 43.9	165.9 ± 36.7	< 0.001
HDL (mg/dl)	36.0 ± 10.3	34.9 ± 9.3	37.5 ± 10.3	36.3 ± 12.3	37.6 ± 10.1	0.12
LDL (mg/dl)	108.8 ± 34.0	116.3 ± 35.7	110.7 ± 34.6	99.8 ± 28.0	93.1 ± 27.1	< 0.001
Uric acid (mg/dl)	6.1 ± 1.8	6.2 ± 1.7	5.8 ± 1.5	6.1 ± 2.0	6.4 ± 2.0	0.13
ALT (U/L)	55.2 ± 108.9	53.0 ± 40.7	39.5 ± 24.5	78.0 ± 217.9	43.4 ± 38.9	0.05
Hemoglobin (g%)	14.2 ± 2.2	15.1 ± 1.7	14.5 ± 1.8	13.1 ± 2.0	12.1 ± 2.4	< 0.001
Sodium (mmol/L)	139.0 ± 6.6	139.2 ± 3.2	139.8 ± 3.4	138.2 ± 11.9	138.6 ± 6.2	0.33
Potassium (mmol/L)	4.2 ± .6	4.2 ± .6	4.1 ± .5	4.3 ± .7	4.4 ± .6	0.03
Complication						
Hypotension	120 (23.4%)	30 (12%)	15 (17.6%)	47 (40.9%)	28 (44.4%)	< 0.001
IABP use	41 (8%)	7 (2.8%)	3 (3.5%)	21 (18.3%)	10 (15.9%)	< 0.001
CAVB	23 (4.5%)	6 (2.4%)	1 (1.2%)	8 (7%)	8 (12.7%)	< 0.001
Ventricular tachycardia	24 (4.7%)	5 (2%)	3 (3.5%)	9 (7.8%)	7 (11.1%)	0.01
Respiratory failure	66 (12.9%)	8 (3.2%)	10 (11.8%)	26 (22.6%)	22 (34.9%)	< 0.001
Initial presentation						
Heart rate	79.4 ± 23.2	77.6 ± 19.4	79.7 ± 23.9	79.8 ± 26.9	84.8 ± 27.9	0.18
SBP (mmHg)	133.0 ± 34.7	136.6 ± 30.7	134.9 ± 35.3	126.7 ± 38.0	127.7 ± 40.9	0.02
Killip classification	1.97 ± 1.34	1.6 ± 1.00	1.76 ± 1.06	2.50 ± 1.35	2.62 ± 1.21	0.02
Infarct-related vessels						
Right coronary artery	228 (44.5%)	110 (44.2%)	35 (41.2%)	50 (43.5%)	33 (52.4%)	0.57
Left circumflex artery	29 (5.7%)	11 (4.4%)	5 (5.9%)	11 (9.6%)	2 (3.2%)	0.19
Left anterior descending artery	255 (49.8%)	128 (51.4%)	45 (52.9%)	54 (47%)	28 (44.4%)	0.64
Triple-vessel disease	34 (6.7%)	15 (6.0%)	5 (5.9%)	7 (6.1%)	7 (11.1%)	0.75
Post-MI LV function	50.3 ± 11.1	53.2 ± 10.8	50.9 ± 12.5	48.7 ± 10.5	46.3 ± 12.2	0.06

Values are mean ± SD or number (%).

ALT, alanine aminotransferase; CAVB, complete atrioventricular block; HDL, high density lipoprotein; IABP, intra-aortic balloon pump; LDL, low density lipoprotein; Post-MI LV function, post-myocardial infarction left ventricular function; SBP, systolic blood pressure.

The group 1 (nDM-nCKD) means patients without DM or CKD. The group 2 (DM-nCKD) means patients with DM only. The group 3 (nDM-CKD) means patients with CKD only. The group 4 (DM-CKD) means patients with DM and CKD both. Previous cardiovascular events included stroke and myocardial infarction.

level among these 4 groups. Furthermore, there was also no difference in heart rate and infarct-related vessel among these 4 groups (Table 1). Systolic blood pressure was lower in group 3 and 4 (p = 0.02, Table 1), and Killip classification had higher class in group 3 and group 4 (p = 0.02, Table 1).

Percentage of cardiovascular complications

The percentage of complications increased in group 3 (nDM-CKD) and group 4 (DM-CKD) significantly compared to group 1 or 2, respectively, including hypotension (p < 0.001), intra-aortic balloon pump support (p < 0.001), complete atrioventricular block (p < 0.001), ventricular tachycardia (p = 0.01), and respiratory failure (p < 0.001). There was no difference in complication rates between group 3 and group 4 (Table 1). Also, there was no difference in the prevalence of triple-vessel disease between the four groups (p = 0.75, Table 1), and the post-MI LV function had no difference as well (p = 0.06, Table 1).

The impact of DM and CKD on clinical outcome

Compared to group 1, longer hospital stay was shown in group 3 and 4 (group 1 vs. group 3, p = 0.001; group 1 vs. group 4, p < 0.001; Figure 2), but post-hoc analysis showed no difference between group 1 and 2 (p = 0.58) or between group 3 and 4 (p = 0.68). Group 3 and 4 patients had higher 30-day mortality rates compared to group 1 or 2 (group 1 vs. group 3, p < 0.001; group 1 vs. group 4, p < 0.001; Figure 3), but no difference was shown between group 1 and 2 (p = 0.38) or between group 3 and 4 (p = 0.49). Multivariate logistic analysis revealed that CKD stage, systolic blood pressure, and Killip classification were independent risk factors of 30-day mortality rates (Table 2).

The impact of CKD stage on clinical outcome

Table 3 showed that patients were divided into four stages by eGFR. Patients with CKD stage 3 and 4 were older, and had a higher prevalence of hypertension, DM, and previous cardiovascular events (p < 0.001). Patients in CKD stage 1 and 2 had higher body weight (p < 0.001, Table 3). There were fewer smokers in group 3 and 4 (p < 0.001, Table 3). Compared with stage 1 and 2, the total cholesterol concentration, low density lipoprotein, hemoglobin, and potassium levels were significantly different in CKD stage 3 and 4 (p < 0.001, Table 3). Patients with CKD stage 3 and 4 had higher incidence of hypotension (p < 0.001), intra-aortic balloon pump support (p < 0.001), complete atrioventricular block (p = 0.002), ventricular tachycardia (p = 0.009), and respiratory failure (p < 0.001) than those patients in normal renal function stages (Table 3). Systolic blood pressure was lower in the CKD stage 3 and 4 (p = 0.02), and advanced CKD stage had higher Killip classification (p = 0.03, Table 3). Regarding the prevalence of triple-vessel disease, there was no difference between the four stages. (p = 0.86,

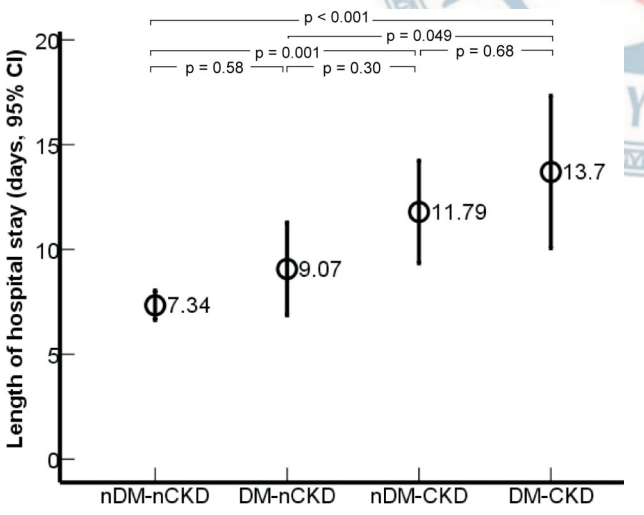

Figure 2. *The length of hospital stay stratified by DM-CKD groups. The DM-CKD group had longer hospital stay compared to nDM-nCKD (p < 0.05). The p value was significant between group 1 and 3, group 2 and 4, and group 1 and 4. These data showed mean ± standard deviation in four groups.*

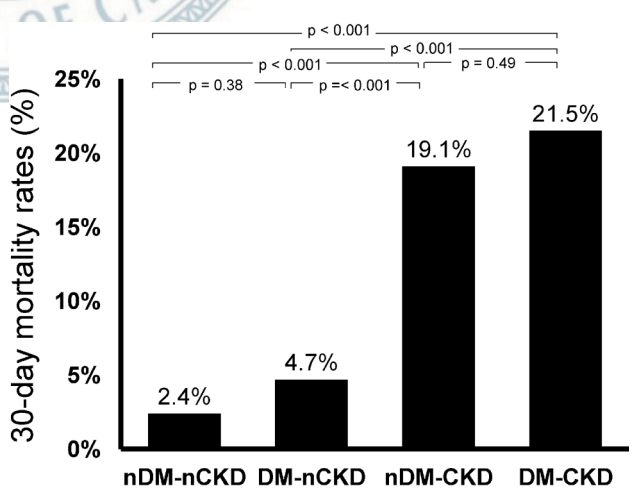

Figure 3. *The percetange at 30-day mortality rates stratified by DM-CKD groups. Patients with CKD had significantly higher 30-day mortality rate.*

Table 2. Multivariate analysis of 30-days mortality stratified by presenting characteristics

	Overall population	OR (95% CI)	p value
Patient characteristics			
Age (years)			
> 65 years	0.84	0.26-2.69	0.06
Body weight (kilogram)			
< 50 kg	1.79	0.66-4.85	0.77
Male gender	1.23	0.45-3.41	0.69
Risk factor ≧ 1 (Hypertension, dyslipidemia, smoking, family history)	0.48	0.15-1.51	0.21
Chronic kidney disease	7.05	2.34-21.19	0.001
Diabetes mellitus	1.51	0.69-3.34	0.31
Previous cardiovascular event	3.02	0.99-9.16	0.05
Presentation			
Heart rate < 60 or > 100	2.24	1.02-4.93	0.05
SBP < 100 mmHg	4.64	3.28-13.07	< 0.001
Killip classification	4.73	4.17-11.89	< 0.001
Infarct-related vessels			
Right coronary artery	0.51	0.11-2.34	0.39
Left circumflex artery	0.97	0.12-3.17	0.55
Left anterior descending artery	1.22	0.27-5.45	0.79

SBP, systolic blood pressure.

Table 3), and the post-MI LV function also had no difference (p = 0.05, Table 3). Longer hospital stay was shown in stage 3 and 4 patients (group 1 vs. group 3, p < 0.001; group 1 vs. group 4, p < 0.001; Figure 4), but no difference was shown between the two stages (p = 0.55). The CKD stage 3 and 4 had higher 30-day mortality rates compared to stage 1 or 2 (group 1 vs. group 3, p < 0.001; group 1 vs. group 4, p < 0.001, Figure 5), but no difference between stage 1 and 2 (p = 0.95) or between stage 3 and 4 (p = 0.99).

DISCUSSION

This study evaluated the impact of DM and CKD on 30-day mortality rates in STEMI patients receiving primary PCI in Taiwan. The most important finding was that STEMI patients with CKD had more cardiovascular events, longer hospital stay, and higher 30-day mortality rates when compared to non-CKD patients. This study showed that increased mortality rates may relate to higher complication rates in STEMI patients with poor renal function. After adjustment for other factors, multivariate logistic analysis revealed that mortality was independently associated with CKD stage, systolic blood pressure, and Killip classification. In this study, DM was not an independent factor of 30-day mortality.

Published data reported that DM had less impact on 30-day mortality in STEMI patients treated with primary PCI,[18-20] but other reports presented opposite opinions.[21-23] This study showed similar results with previous data concerning DM as not being an independent risk factor for 30-day mortality rates in STEMI patients.[21-23] The p value between group 3 (nDM-CKD) and group 4 (DM-CKD) was 0.49. A recent study by Hasin et al. showed that DM was not an independent risk factor for 30-day mortality in acute coronary syndrome patients, which may be due to the advancement in treatment.[21] Kowalczyk et al. showed that among all DM patients with STEMI, only those with GFR < 60 mL/min/1.73 m^2 on admission belong to the high-risk group, and our result was consistent with these studies.[23] Prior study concerned DM as not an independent risk factor for 30-day mortality in STEMI patients, while renal dysfunction was incorporated into multivariate analyses.[23] However, there have been limited studies aimed at determining the relationship of increased cardiovascular events and 30-day outcomes. In this study, the poor renal function groups had higher cardiovascular event rates and mortality rates.

The results of several studies revealed that patients with CKD had significantly higher mortality, including

Table 3. Baseline characteristics of 4 stages of chronic kidney disease

	Total (N = 512)	CKD stage 1 (n = 163)	CKD stage 2 (n = 171)	CKD stage 3 (n = 136)	CKD stage 4 (n = 42)	p value
Patient characteristics						
Age (year)	60.6 ± 14.2	47.6 ± 8.9	60.1 ± 9.6	73.3 ± 9.4	71.7 ± 14.2	< 0.001
Body weight (kilogram)	69.7 ± 12.8	78.5 ± 11.2	70.3 ± 10.3	61.5 ± 10.5	59.5 ± 10.1	< 0.001
Male gender	451 (88.1%)	153 (93.9%)	153 (89.5%)	116 (85.3%)	29 (69%)	< 0.001
Hypertension	281 (54.9%)	71 (43.6%)	101 (59.1%)	79 (58.1%)	30 (71.4%)	0.002
Diabetes mellitus	148 (28.9%)	34 (20.9%)	51 (29.8%)	43 (31.6%)	20 (47.6%)	0.01
Current smoking	273 (53.3%)	106 (65%)	96 (56.1%)	59 (43.4%)	12 (28.6%)	< 0.001
Previous cardiovascular event	35 (6.8%)	5 (3%)	10 (5.8%)	14 (10.3%)	6 (3.7%)	0.02
Laboratory data						
Total cholesterol concentration (mg/dl)	182.4 ± 43.9	196.1 ± 44.8	186.1 ± 40.5	164.9 ± 42.1	171.1 ± 39.2	< 0.001
HDL (mg/dl)	36.0 ± 10.3	34.7 ± 8.9	36.4 ± 10.3	37.0 ± 11.6	35.9 ± 11.6	0.26
LDL (mg/dl)	108.8 ± 34.0	117.7 ± 36.3	112.2 ± 34.5	97.0 ± 28.2	98.7 ± 26.8	< 0.001
Uric acid (mg/dl)	6.1 ± 1.8	6.0 ± 1.5	6.2 ± 1.7	6.0 ± 1.9	6.8 ± 2.2	0.08
ALT (U/L)	55.2 ± 108.9	55.6 ± 38.9	43.8 ± 35.7	70.4 ± 199.1	50.8 ± 68.5	0.21
Hemoglobin (g%)	14.2 ± 2.2	15.4 ± 1.5	14.5 ± 1.8	13.2 ± 2.1	11.4 ± 2.0	< 0.001
Sodium (mmol/L)	139.0 ± 6.6	139.3 ± 3.3	139.4 ± 3.3	138.3 ± 11.3	138.4 ± 5.9	0.41
Potassium (mmol/L)	4.2 ± 0.6	4.2 ± 0.6	4.1 ± 0.6	4.2 ± 0.6	4.6 ± 0.8	< 0.001
Complication						
Hypotension	120 (23.4%)	15 (9.2%)	30 (17.5%)	58 (42.6%)	17 (40.5%)	< 0.001
IABP use	41 (8%)	3 (1.8%)	7 (4.1%)	22 (16.2%)	19 (21.4%)	< 0.001
CAVB	23 (4.5%)	2 (1.2%)	5 (2.9%)	11 (8.1%)	5 (11.9%)	0.002
Ventricular tachycardia	24 (4.7%)	5 (3.1%)	3 (1.8%)	12 (8.8%)	4 (9.5%)	0.009
Respiratory failure	66 (12.9%)	4 (2.5%)	14 (8.2%)	35 (25.7%)	13 (31%)	< 0.001
Initial presentation						
Heart rate	81.9 ± 25.7	82.7 ± 17.0	77.7 ± 27.5	83.3 ± 27.1	88.2 ± 29.9	0.44
SBP (mmHg)	133.0 ± 34.7	137.1 ± 27.3	135.3 ± 35.8	125.2 ± 35.7	123.0 ± 47.9	0.02
Killip classification	1.97 ± 1.34	1.52 ± 0.91	1.85 ± 1.41	2.49 ± 1.46	2.46 ± 1.42	0.03
Infarct-related vessels						
Right coronary artery	228 (44.5%)	68 (41.7%)	77 (45%)	65 (47.8%)	18 (42.9%)	0.76
Left circumflex artery	29 (5.7%)	8 (4.9%)	8 (4.7%)	11 (8.1%)	2 (4.8%)	0.56
Left anterior descending artery	255 (49.8%)	87 (53.4%)	86 (50.3%)	60 (44.1%)	22 (52.4%)	0.44
Triple-vessel disease	34 (6.7%)	11 (6.7%)	16 (9.3%)	10 (7.4%)	4 (9.5%)	0.86
Post-MI LV function	50.3 ± 11.1	53.1 ± 12.9	51.6 ± 13.0	48.7 ± 12.1	47.0 ± 10.9	0.05

Values are mean ± SD or number (%).

ALT, alanine aminotransferase; CAVB, complete atrio-ventricular block; HDL, high density lipoprotein; IABP, intra-aortic balloon pump; LDL, low density lipoprotein; Post-MI LV function, post-myocardial infarction left ventricular function; SBP, systolic blood pressure.

Stage 1: eGFR ≧ 90 mL/min/1.73 m^2; stage 2: 90 > eGFR ≧ 60 mL/min/1.73 m^2; stage 3: 60 > eGFR ≧ 30 mL/min/1.73 m^2; stage 4: eGFR < 30 mL/min/1.73 m^2.

acute coronary syndrome.[9-15] Our study showed that when eGFR < 60 mL/min/1.73 m^2, there was a strong independent predictor of 30-day mortality in patients with STEMI undergoing primary PCI, and no difference was shown between stage 3 (eGFR between 59 to 30 mL/min/1.73 m^2) and stage 4 (eGFR less than 30 mL/min/1.73 m^2). Tsai et al. reported that CKD was the strongest risk factor of 30-day and 1-year mortality in patients with STEMI.[15] In our studies, stage 3 and stage 4 had higher complication rates, and this could have been the cause of high 30-day mortality rate, consistent with prior study.[9-15]

It remains a challenging issue to precisely evaluate patient mortality rate before primary PCI. The serum

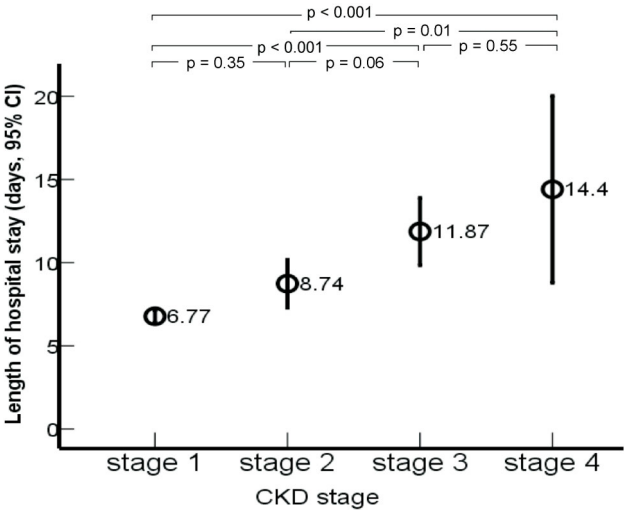

Figure 4. *The length of hospital stay in CKD stage. Patients with CKD stage 3 and 4 had longer hospital stay.*

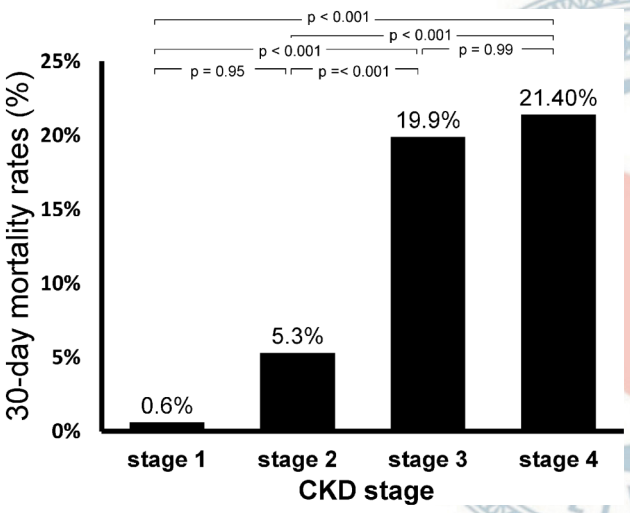

Figure 5. *The percentage at 30-day mortality rates stratified by CKD stages. Patients with CKD stage 3 and 4 had significantly higher 30-day mortality rate.*

creatinine level could serve as a non-invasive and rapid method to predict the 30-day mortality rate in STEMI patients, and high serum creatinine could remind us to be more aggressive when managing STEMI patients.

Study limitations

This study has the following limitations. First, the eGFR was assessed only in a single calculation,[7,8] but the eGFR still had a good relation to creatinine clearance rate. Second, because this was a single-center study, the study included relatively small number of patients, especially in group 4 (DM-CKD) and CKD stage 4. Third, this study focused on 30-day outcomes, but long-term follow-up is needed for further investigation.

CONCLUSIONS

This study demonstrated that patients with CKD have higher 30-day mortality rates, which may relate to high percentage of cardiovascular complications. CKD could accurately evaluate 30-day mortality rates in STEMI patients receiving primary PCI. However, DM was not an independent factor of 30-day mortality rates in STEMI patients.

ACKNOWLEDGEMENTS

The authors wish to thank Hwong-Ru Hwang and Tong-Chen Yeh for patient scanning, Tao-Yu Lee and Hsiang-Chiang Hsiao for patient preparation, and Research assistants Tonia Ko for data management.

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