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Original Article

Emergency department critical care unit for critically ill cardiovascular patients: An observation study

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Abstract

Background: We investigated an intensive care model for acute critically cardiovascular emergency patients in the emergency department (ED) as compared with those in the coronary care unit (CCU) after ED visits.
Methods: We performed a retrospective cohort analysis of patients with acute cardiovascular emergency admitted to the intensive care unit in the ED (EICU) or CCU from January 1, 2010 to March 31, 2011 in an university-affiliated medical center. All clinical characteristics or predictors possibly related to in-hospital mortality were documented, completed, and measured via electronic medical records review. The clinical independent variables with $p < 0.1$ in univariate analysis were further analyzed by using multiple logistic regression. Survival analysis of the predictors for hospital mortality was assessed by Kaplan–Meier survival curves.
Results: A total of 964 patients were recruited in this study. Of all patients, 328 were enrolled in the EICU group, whereas 636 were enrolled in the CCU group. Multiple regression analysis of both EICU and CCU mortality demonstrated that Acute Physiology and Chronic Health Evaluation II scores were common predictors of mortality in both groups of patients. Based on these scores, Kaplan–Meier survival curves showed no statistically significant differences of cumulative survival rates in both the 7-day and in-hospital survival between both groups.
Conclusion: Our study demonstrated a feasible and qualified model of intensive care delivery accomplished by collaboration of emergency physicians and cardiologists for acute critically ill cardiovascular emergency patients after initial ED management. Our results suggest that an expanded multicenter study should be conducted to further test and confirm this intriguing model.

Keywords: coronary care unit; emergency department; intensive care unit

1. Introduction

For acute critically ill patients visiting the emergency department (ED), initial resuscitation and stabilization, followed by continuously provided specific critical care treatment are mandatory in modern medical systems. ED visits increasing,[1–3] and the challenges of ED care are numerous, including overcrowding, increased length of stay (LOS) and boarding time, even leading to some critically ill patients receiving delayed admission to the intensive care unit (ICU).[4,5] Increased hospital LOS and higher ICU and hospital mortality are associated with delayed transfer of critically ill patients from the ED to the ICU.[6,7] Therefore, providing a continuously high quality of critical care to manage acute

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critically ill patients from ED visits through ICU care is one of the core contents of emergency medicine practice.

The care or intervention provided during the ED stay for critically ill patients significantly impacts the progression of hospital outcomes.[8] Svenson and colleagues[9] reported that critically ill patients received critical care procedures commonly performed in the ED while waiting for ICU admission. A significant proportion of critical care[10] and typical ICU procedures[11] were performed in the ED for critically ill patients. For patients with acute cardiogenic pulmonary edema, hypoxia, and severe respiratory distress or failure, noninvasive positive pressure ventilation may not only improve outcomes[12,13] but also help to avoid intubation and ICU admission.[14] However, there still remains a high risk of clinical deterioration in patients with acute cardiovascular emergency, with few if any signs of improvement during their short stay in the ED. Having a continuously monitoring system and interventions for acute critically ill patients has become imperative, especially for patients with acute cardiovascular emergency.

The main purpose for establishing an ICU in the ED (EICU) was to meet the need of quality care for critically ill patients, who might deteriorate rapidly or progressively in an overcrowded ED with prolonged boarding time. In addition, a lack of specialty ICU beds for acute critically ill patients, either from inpatient units or ED, would be associated with increased ED LOS and a delay of quality care.[15–17] Thirdly, to improve acute critically ill patient outcome by reconstructing an observation unit into an EICU setting that were equipped by a monitoring and intervention system, and intensivists, including reasonable collaboration with other specialists to be responsible for the care of all critically ill patients while waiting admission.

In a previous report on patients with cardiovascular diseases, the leading diagnoses of patients staying at an observation unit are described.[18] Early implementation of intensive monitoring and therapies, such as short-term noninvasive positive pressure ventilation for ED patients with acute cardiogenic pulmonary edema may improve outcome.[12–14,19] Our previous article demonstrated that cardiovascular emergency patients occupied approximately 13.3% of EICU admissions in a 1-year study period.[20] However, the detailed clinical characteristics and outcomes of patients admission to the EICU as compared to those admissions to the coronary care unit (CCU) still require elucidation. Few articles have aimed to investigate the care model of ICU settings in ED, especially focusing on cardiovascular emergency patients. The hypothesis addressed by this study was that providing continuous EICU for patients with acute critical cardiovascular emergencies had a similar quality of care compared with those patients admitted to the CCU.

2. Methods

2.1. Study design

This study was a retrospective analysis of prospectively registered patients aged ≥ 18 years, with cardiovascular emergency admissions to either the EICU or CCU by way of an ED visit. The Taipei Veterans General Hospital, a 3000-bed, university-affiliated medical center had an annual ED mean ± standard deviation census of 85,500 ± 4520 during the past 10 years. The hospital's institutional review board approved this study with a waiver of patient's consent (VGHIRB Number: 2012-02-024AC).

2.2. Study setting and population

Our study recruited patients with acute cardiovascular emergencies who visited the ED, and thereafter needed continuous ICU admission between January 1, 2010 and March 31, 2011. To verify and avoid missing potential participants, charts were cross-checked for coding with the International Classification of Diseases, 9th Revision, clinical modification coding numbers: 398 (rheumatic heart disease); 401–405 (hypertension); 410–413 (myocardial infarction); 414 (coronary artery disease); 415–417 (acute pulmonary heart disease); 421 (acute and subacute endocarditis); 421 (valvular heart disease); 425 (cardiomyopathy); 426 (conduction disorders); 427 (cardiac arrhythmia); 428 (heart failure); 429 (cardiovascular disease); 441 (aortic aneurysm); 458.9 (hypotension); 785 (symptoms involving cardiovascular system); and 972 (poisoning by cardiotonic glycosides and drugs of similar action). Medical charts of the patients were comprehensively and extensively reviewed. Exclusion criteria included the following: age < 18 years; those who died in ED before hospital admission; those with do-not-attempt-resuscitation orders; and charts lacking certain important information (e.g., 7-day and hospital discharge status). Patients with acute cardiovascular emergencies were initially resuscitated, diagnosed, and treated by emergency physicians (EPs) in the ED and were simultaneously consulted with cardiovascular physicians, who collaborated with the on-duty EP to conduct emergency cardiovascular interventions and hospital admissions based on individual patient clinical necessities and hospital admission resources.

2.3. Both EICU and CCU settings

The primary goal of the EICU setting was to implement continuous emergency and critical quality of care for critically ill patients who cannot be admitted to a specialized CCU immediately after initial ED resuscitation and stabilization. The EICU contained 13 beds, was located within the ED, and had been operated since 1994, complying with the regulations for an ICU setting issued from the Ministry of Health and Welfare. All EICU patients are limited to ED patient admissions only. The EICU was staffed by EPs, collaborating with other specialty physicians who thereafter will be in charge of subsequent patient care. All the staffed EPs are board-certificated intensivists accredited by the Joint Committee of Intensive Care Medicine in Taiwan. The staffed EP performed a clinical round every day for all the patients in the morning. At night, the on-duty EP also performed rounds for all patients at the beginning of their shift and then worked in an adjacent area in the ED. These scheduled rounds occurred twice daily, with dedicated round time taken for patients' medical needs. After rounds, the EP was available to reevaluate patients and make dispositions as needed. Both on-duty residents and nurses collaboratively facilitated patient care around-the-clock. Nurses staffed the unit at an average ratio of one nurse for every two patients. EICU patients were re-evaluated frequently, and a first priority transfer to up-floor specialty intensive care units was performed if a bed was available. On admission to the EICU, a routine data sheet was prospectively maintained for all patients, which included patient identification number, age, sex, admission diagnosis, and subsequent disposition (including transferred to other specialty critical care units or inpatient units, expired in EICU, or against-advice discharge under critical condition). The operative system in our EICU is a semi-open model that both EPs and cardiologists cooperatively take care of all patients with cardiovascular emergencies. The CCU is completely supervised by cardiologists, with a similar operation system, including medical personnel and equipment, fitting critical unit regulation by the Ministry of Health and Welfare.

2.4. Study protocol

Once the patient's data entry was started for both EICU and CCU registrations, all patients were registered in a hospital patient database. These data were then entered into a Microsoft Excel database for later analysis. Variables possibly related to cardiovascular emergencies and variables needed for this study were defined before abstracting data from the data bank and medical charts. Two trained research authors blindly entered the abstracted data into the new data bank used for study analyses. The patients' characteristics that could be collected shortly after ED arrival were abstracted as variables for determining prognostic significances. The variables used for comparison between EICU and CCU admissions included age, sex, Taiwan Triage and Acuity Scales, mean blood pressure, Glasgow Coma Scale (GCS), admission time, admission day (weekdays or weekends), Charlson comorbidity index, Acute Physiology and Chronic Health Evaluation II score (APACHE II score),[21] main diagnosis at admission, ED LOS, hospital LOS, 7-day hospital mortality, and in-hospital mortality. Based on hospital outcome—survival or mortality—we further compared all documented clinical characteristics, possible predictors for outcomes, within the individual group and also between groups.

2.5. Statistical analysis

Statistical analysis was performed using SPSS software version 15.0 (SPSS Inc., Chicago, IL, USA). Statistical tests were two-sided, and the significance level was set at $p < 0.05$. Data are presented as mean ± standard deviation for continuous variables and as a number (%) for categorical variables. The distribution of the data was assessed with the Kolmogorov−Smirnov test. Comparisons of numerical variables were performed using an unpaired t test (parametric data) or the Mann−Whitney U test (nonparametric data). Comparisons of categorical variables were done by Chi-square or Fisher exact test. Cox proportional hazard model was applied to assess clinical predictors of in-hospital mortality. Variables with $p < 0.1$ in univariate analysis were further analyzed using multiple logistic regression. We performed survival analysis to assess the association between APACHE II scores and the 7-day and in-hospital mortality rates using Kaplan−Meier survival curves.

3. Results

3.1. Clinical characteristics of study patients in both groups

A total of 964 patients were recruited in this study. Of all patients, 328 were enrolled in the EICU group, and 636 in the CCU group (Fig. 1). Table 1 presents the demographic and clinical characteristics of both groups. Compared with patients in the CCU group, patients in the EICU group were older; with significantly higher initial APACHE II scores, Charlson comorbidity index, and longer ED and hospital LOS. Patients in the EICU group also had higher percentages of non-ST-segment elevation myocardial infarction (non-STEMI), congestive heart failure complicated with acute pulmonary edema, pneumonia, acute respiratory failure, and chronic obstructive lung diseases with acute exacerbation, respectively, ($p < 0.05$). Patients in the CCU group had a significantly higher percentage of weekend admissions, STEMI, arrhythmia, complete atrial−ventricular block, and acute renal failure ($p < 0.05$). There is no statistical significance in 7-day hospital mortality between groups of patients, whereas the EICU group patients had a higher percentage of in-hospital mortality than the CCU group, ($p < 0.05$). The average EICU LOS was 34.0 ± 38.5 hours, about 1.4 days. Up to 56.7% (186/328) of patient admissions to the EICU were transferred to CCU, 9.8% (32/328) of the EICU patients were transferred to medical ICU, and 31.7% (104/328) of the patients were transferred to inpatient units when their clinical conditions stable. Of all the EICU patients, 1.8% (6/328) had died during the EICU admission.

3.2. Outcome-based analysis

Based on patient outcomes, in-hospital survival, or mortality, we applied univariate analyses of clinical characteristics in patients admitted to both EICU and CCU. Table 2 showed clinical predictors to in-hospital mortality in patient admissions to the EICU, including elderly, poor GCS, higher initial APACHE II scores, higher Charlson comorbidity index, higher percentage of congestive heart failure (CHF) complicated with acute pulmonary edema, pneumonia, and acute respiratory failure, respectively, ($p < 0.05$). Table 3 presents predictors to in-hospital mortality in patient admissions to CCU, including the elderly, had higher initial APACHE II scores and Charlson comorbidity index, poor GCS lower mean blood pressure at ED and a longer hospital LOS, higher percentage of CHF

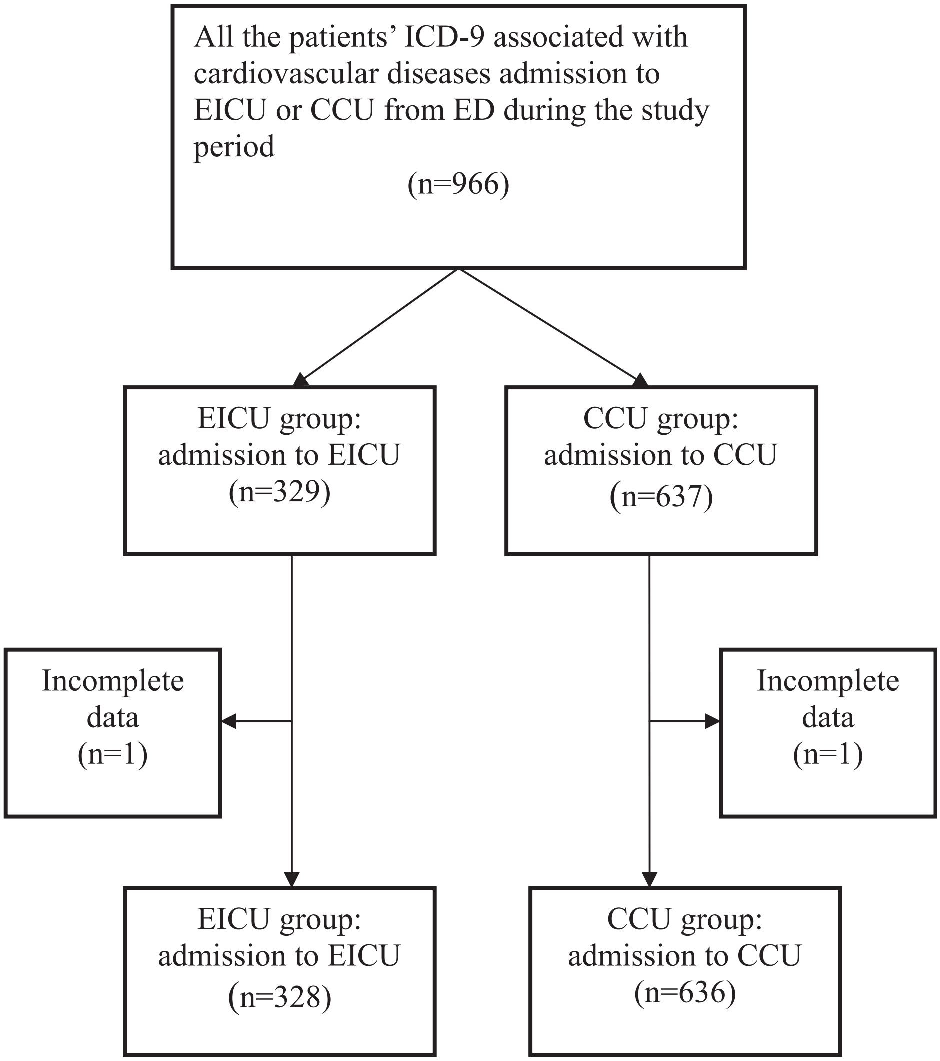

Fig. 1. Flowchart of study patients. CCU = coronary care unit; EICU = emergency intensive care unit.

complicated with acute pulmonary edema, pneumonia, cardiogenic shock, out of hospital cardiac arrest, acute respiratory failure, STEMI, and acute renal failure ($p < 0.05$).

To further identify clinical factors associated with survival and mortality, we compared all clinical characteristics between both groups. Table 4 demonstrated that survival patient admission to the EICU were more elderly, had a higher initial APACHE II scores, Charlson comorbidity index, a longer ED stay time, and a longer hospital LOS. They also had a higher percentage of weekday admission, Non-STEMI or unstable angina, CHF with acute pulmonary edema, pneumonia, acute respiratory failure, chronic obstructive pulmonary disease with acute exacerbation, and urinary tract infection, respectively, than those survival admissions to the CCU ($p < 0.05$). Table 5 shows that mortality patient admissions to the EICU had a higher initial mean blood pressure and a longer ED stay time; a higher percentage of CHF with acute pulmonary edema, and chronic obstructive pulmonary disease with AE, respectively, than those mortality admissions to the CCU ($p < 0.05$), but had a lower percentage of STEMI ($p < 0.05$).

The multiple logistic regression demonstrated that the APACHE II score was the only common predictor for mortality in both groups of patients. In addition, both older age and acute respiratory failure were outcome predictors for patients admitted to the EICU (Table 6). In-patient admission to CCU with STEMI, cardiogenic shock, pneumonia, and higher Charlson comorbidity index were related to poor prognosis (Table 7). After further analysis of the relationship between stratified APACHE II and both groups, Kaplan−Meier survival curves showed no statistically significant differences of cumulative survival rates in both the 7-day and in-hospital survival between three different APACHE II scales[21,22] (Fig. 2).

4. Discussion

In this study, we evaluated the outcomes of patients with acute cardiovascular emergency beginning in the ED with admission to the EICU compared with those patients admitted to the CCU. In terms of outcome assessment, we demonstrated that there is no statistical significance in 7-day hospital mortality between the patient groups. In addition, by Kaplan–Meier survival analysis of the stratification of APACHE II scores, which was the only common predictor for outcomes in both groups of patients, we demonstrated no statistical significances in 7-day and in-hospital mortality between groups. A short-term didactic ED-based critical care, which is delivered in a collaborative and integrated manner by both EPs and cardiologists, can provide comparable critical care quality as a temporary alternative unit for acute critically ill cardiovascular patients.

Table 1
Comparisons of clinical characteristics between patient admissions to emergency intensive care unit (EICU) and coronary care unit (CCU).

Variable	EICU ($n = 328$)	CCU ($n = 636$)	*p*
Age (y)*	76.5 ± 13.5	72.8 ± 14.8	<0.001
Male	218 (66.5)	452 (71.1)	0.162
TTAS			0.440
1	80 (24.4)	138 (21.7)	
2	191 (58.2)	381 (60.0)	
3	48 (14.6)	88 (13.9)	
4	9 (2.7)	29 (4.6)	
Glasgow coma scale	13.7 ± 3.1	13.7 ± 3.6	0.401
APACHE II score at admission*	15.3 ± 7.2	13.2 ± 8.2	<0.001
0–14	151 (46.0)	421 (66.2)	
15–24	142 (43.3)	152 (23.9)	
> 24	35 (10.7)	63 (9.9)	
Charlson comorbidity index*	3.7 ± 2.1	3.3 ± 2.6	<0.001
Mean blood pressure at ED (mmHg)	99.5 ± 24.5	93.3 ± 28.6	0.107
Admission time (h)			0.194
0–8	60 (18.3)	103 (16.2)	
8–16	150 (45.7)	330 (51.9)	
16–24	118 (36.0)	203 (31.9)	
Admission d*			<0.001
Weekdays	249 (75.9)	408 (64.2)	
Weekends	79 (24.1)	228 (35.8)	
Main diagnosis at admission			
Acute coronary syndrome*	174 (53.0)	393 (61.8)	0.011
STEMI*	10 (3.0)	160 (25.2)	<0.001
Non-STEMI*	149 (45.4)	182 (28.6)	<0.001
Unstable angina	15 (4.6)	51 (8.0)	0.061
CHF with APE*	157 (47.9)	182 (28.6)	<0.001
Arrhythmias*	68 (20.7)	203 (31.9)	<0.001
Ventricular fibrillation	11 (3.4)	39 (6.1)	0.091
Bradycardia	12 (3.7)	36 (5.7)	0.231
Atrial fibrillation	28 (8.5)	69 (10.8)	0.309
Complete AV block*	14 (4.3)	56 (8.8)	0.015
PSVT	3 (0.9)	3 (0.5)	0.415
Cardiogenic shock	16 (4.9)	38 (6.0)	0.580
OHCA	3 (0.9)	14 (2.2)	0.238
Great vessel diseases			
Pulmonary embolism	5 (1.5)	7 (1.1)	0.383
Aortic dissecting	5 (1.5)	8 (1.3)	0.772
Aortic aneurysm	3 (0.9)	6 (0.9)	1.000
Digoxin intoxication	2 (0.6)	13 (2.0)	0.153
Respiratory system diseases			
Pneumonia*	77 (23.5)	77 (12.1)	<0.001
Acute respiratory failure*	53 (16.2)	62 (9.7)	0.005
Acute COPD exacerbation*	33 (10.1)	29 (4.6)	0.002
Neurological system diseases			
Stroke	2 (0.6)	4 (0.6)	1.000
Seizure*	1 (0.3)	4 (0.6)	0.025
Acute renal failure*	38 (11.6)	110 (17.3)	0.001
Others			
Urinary tract infection	31 (9.5)	26 (4.1)	0.062
Gastrointestinal bleeding	24 (7.3)	27 (4.2)	0.095
Anemia	21 (6.4)	24 (3.8)	1.000
DIC	0 (0)	1 (0.2)	1.000
ED length of stay (h)*	6.4 ± 9.2	5.3 ± 10.8	<0.001
Hospital length of stay (h)*	402.7 ± 407.8	315.2 ± 403.5	<0.001
7-d hospital mortality	21 (6.4)	30 (4.7)	0.339
In-hospital mortality*	52 (15.9)	67 (10.5)	0.023

Results expressed as number (%) for categorical variables and mean (± standard deviation) for numerical variables.
*$p < 0.05$ means statistical significance in Mann–Whitney *U* test or Chi-square analysis.
ACS = acute coronary syndrome; APACHE = acute physiological and chronic health evaluation; APE = acute pulmonary edema; AV = atrioventricular; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; DIC = disseminated intravascular coagulation; ED = emergency department; OHCA = out of hospital cardiac arrest; PSVT = paroxysmal supraventricular tachycardia; STEMI = ST-segment elevation myocardial infarction; TTAS = Taiwan triage and acuity scale.

In Taiwan, overcrowding and prolonged ED LOS are very common in tertiary medical centers, especially those in larger public and university-affiliated hospitals, which is detrimental to ED patients' quality of care.[7,17,23] Undoubtedly, the admission priority for patients with acute cardiovascular emergencies was first in the CCU, but alternatively the EICU if no CCU bed was available in the hospital admission system.[20] The average boarding time for those ED patients waiting for hospital admission was approximately 21 hours in our ED. To intensify care quality for relatively high-risk patients with a compulsory longer waiting and boarding time, we immediately set up the EICU for critical patients who cannot be admitted to special critical care.[20] In this study, we highlighted that patients admitted to EICU were associated with more complicated clinical diagnosis, severity (evaluated by APACHE II score), and multiple comorbidities accompanied with patients being more elderly (Table 1). A recent study demonstrated that in a third of hospitals surveyed, care for critically ill cardiovascular patients is provided in a general ICU,[24] and only 16% of the cardiac ICUs had an attending cardiologist of record with a critical care focus. An updated meta-analysis study demonstrated high-intensity staffing is associated with reduced ICU and hospital mortality in critically ill patients.[25] However, within high-intensity staffing models, 24-hour in-hospital intensivist coverage did not reduce hospital or ICU mortality compared with day-time-only intensivist coverage.[25,26] Our operative system and strategy of EICU would be more likely found in a general ICU that was staffed with 24-hour EPs in close collaboration with the cardiologist and can continuously provide both diagnostic studies and therapeutic interventions for multiple varieties and complexities patients.[20]

It was imperative to make patients a first priority who had a definitive diagnosis needing immediate, timely, and effective

Table 2
Univariate analysis of clinical characteristics related to survival and mortality among patient admission to emergency intensive care unit (EICU).

EICU ($n = 328$)					
Variable	Survival ($n = 276$)	Mortality ($n = 52$)	Crude OR	95% CI	*p*
Age (y)*	75.4 ± 13.9	82.4 ± 9.3	1.056	(1.022−1.090)	0.001
Males	184 (66.7)	34 (64.4)	0.944	(0.506−1.762)	0.857
TTAS					
4	8 (2.9)	1 (1.9)	Reference		—
3	40 (14.5)	8 (15.4)	1.600	(0.175−14.631)	0.677
2	168 (60.9)	23 (44.2)	1.095	(0.131−9.161)	0.933
1	60 (21.7)	20 (38.5)	2.667	(0.314−22.655)	0.369
Glasgow coma scale*	14.0 ± 2.7	12.1 ± 4.4	0.851	(0.788−0.920)	< 0.001
APACHE II score at admission*	14.4 ± 6.9	20.1 ± 6.7	1.117	(1.069−1.167)	< 0.001
0−14	140 (50.7)	11 (21.2)	Reference		—
15−24*	113 (40.9)	29 (55.8)	3.266	(1.563−6.825)	0.002
> 24*	23 (8.3)	12 (23.1)	6.640	(2.622−16.820)	< 0.001
Charlson comorbidity index*	3.6 ± 2.1	4.5 ± 2.3	1.197	(1.050−1.364)	0.007
Mean blood pressure at ED (mmHg)	100.6 ± 24.3	93.6 ± 25.3	0.986	(0.972−1.001)	0.069
Admission time (h)					
0−8	50 (18.1)	10 (19.2)	Reference		—
8−16	122 (44.2)	28 (53.8)	1.148	(0.519−2.537)	0.734
16−24	104 (37.7)	14 (26.9)	0.673	(0.280−1.621)	0.377
Admission d					
Weekdays	208 (75.4)	41 (78.8)	Reference		—
Weekends	68 (24.6)	11 (21.2)	1.219	(0.593−.502)	0.590
Main diagnosis at admission					
Acute coronary syndrome	149 (54.0)	25 (58.1)	0.789	(0.436−1.428)	0.434
STEMI	9 (3.3)	1 (1.9)	0.582	(0.072−4.692)	0.611
Non-STEMI	128 (46.4)	21 (40.4)	0.783	(0.429−1.431)	0.427
Unstable angina	12 (4.3)	3 (5.8)	1.347	(0.367−4.949)	0.654
CHF with APE*	124 (44.9)	33 (63.5)	2.129	(1.154−3.927)	0.016
Arrhythmia	61 (22.1)	7 (13.5)	0.548	(0.235−1.277)	0.164
Ventricular fibrillation	8 (2.9)	3 (5.8)	2.051	(0.526−8.002)	0.301
Bradycardia	12 (4.3)	0 (0)	—		1.000
Atrial fibrillation	26 (9.4)	2 (3.8)	0.385	(0.088−1.673)	0.203
Complete AV block	12 (4.3)	2 (3.8)	0.880	(0.191−4.052)	0.870
PSVT	3 (1.1)	0 (0)	—		1.000
Cardiogenic shock	11 (4.0)	5 (9.6)	2.563	(0.852−7.712)	0.094
OHCA	1 (0.4)	2 (3.8)	11.000	(0.979−123.62)	0.052
Great vessel diseases					
Pulmonary embolism	3 (1.1)	2 (3.8)	3.640	(0.593−22.341)	0.163
Aortic dissecting	5 (1.8)	0 (0)	—		1.000
Aortic aneurysm	3 (1.1)	0 (0)	—		1.000
Digoxin intoxication	2 (0.7)	0 (0)	—		1.000
Respiratory system disease					
Pneumonia*	59 (21.4)	18 (34.6)	1.947	(1.027−3.692)	0.041
Acute respiratory failure*	35 (12.7)	18 (34.6)	3.645	(1.861−7.141)	<0.001
Acute COPD exacerbation	25 (9.1)	8 (15.4)	1.825	(0.774−4.306)	0.169
Neurological system diseases					
Stroke	1 (0.4)	1 (1.9)	5.392	(0.332−86.603)	0.236
Seizure	1 (0.4)	0 (0)	—		1.000
Acute renal failure	28 (10.1)	10 (19.2)	2.109	(0.955−4.659)	0.065
Others					
Urinary tract infection	24 (8.7)	7 (13.5)	1.633	(0.664−4.016)	0.285
Gastrointestinal bleeding	19 (6.9)	5 (9.6)	1.439	(0.512−4.043)	0.490
Anemia	17 (6.2)	4 (7.7)	1.270	(0.409−3.938)	0.679
DIC	0 (0)	0 (0)	—		—
ED length of stay (h)	5.9 ± 7.9	8.7 ± 14.1	1.026	(0.999−1.052)	0.055
EICU length of stay (h)	32.8 ± 38.3	40.1 ± 39.6	1.004	(0.997−1.010)	0.236
Hospital length of stay (h)	398.7 ± 372.7	424.0 ± 562.3	1.000	(0.999− 1.001)	0.682

Results expressed as number (%) for categorical variables and mean (± standard deviation) for numerical variables.
*$p < 0.05$ statistical significance in Mann−Whitney *U* test or Chi-square analysis.
ACS = acute coronary syndrome; APACHE = acute physiological and chronic health evaluation; APE = acute pulmonary edema; AV = atrioventricular; CHF = congestive heart failure; CI = confidence interval; COPD = chronic obstructive pulmonary disease; DIC = disseminated intravascular coagulation; ED = emergency department; OHCA = out of hospital cardiac arrest; OR = odds ratio; PSVT = paroxysmal supraventricular tachycardia; STEMI = ST-segment elevation myocardial infarction; TTAS = Taiwan triage and acuity scale.

Table 3
Univariate analysis of clinical characteristics related to survival and mortality among patient admissions to coronary care unit (CCU).

	CCU ($n = 636$)				
Variable	Survival ($n = 569$)	Mortality ($n = 67$)	Crude OR	95% CI	p
Age (y)*	72.1 ± 15.0	79.0 ± 11.8	1.041	(1.018−1.064)	0.001
Males	398 (69.9)	54 (80.6)	1.785	(0.949−3.356)	0.072
TTAS					
4	25 (4.4)	4 (6.0)	Reference		
3	81 (14.2)	7 (10.4)	0.540	(0.146−1.997)	0.356
2	358 (62.9)	23 (34.3)	0.402	(0.129−1.251)	0.116
1	105 (18.5)	33 (49.3)	1.964	(0.637−6.054)	0.240
Glasgow coma scale*	13.8 ± 3.4	12.5 ± 4.7	0.914	(0.861−0.971)	0.003
APACHE II score at admission*	12.3 ± 7.5	21.0 ± 9.7	1.106	(1.076−1.137)	< 0.001
0−14	401 (70.5)	20 (29.9)	Reference		
15−24*	126 (22.1)	26 (38.8)	4.137	(2.234−7.663)	< 0.001
> 24*	42 (7.4)	21 (31.3)	10.025	(5.029−19.986)	< 0.001
Charlson comorbidity index*	3.1 ± 2.5	5.2 ± 3.1	1.265	(1.162−1.377)	< 0.001
Mean blood pressure at ED (mmHg)*	95.2 ± 27.3	75.4 ± 34.0	0.980	(0.972−0.989)	< 0.001
Admission time (h)					
0−8	89 (15.6)	14 (20.9)	Reference		
8−16	301 (52.9)	29 (43.3)	0.612	(0.310−1.209)	0.158
16−24	179 (31.5)	24 (35.8)	0.852	(0.421−1.728)	0.658
Admission d					
Weekdays	365 (64.1)	43 (64.2)	Reference		
Weekends	204 (35.9)	24 (35.8)	1.001	(0.591−1.698)	0.996
Main diagnosis at admission					
Acute coronary syndrome	347 (61.0)	46 (68.7)	1.401	(0.814−2.412)	0.223
STEMI*	135 (23.7)	25 (37.3)	1.914	(1.125−3.256)	0.017
Non-STEMI	163 (28.6)	19 (28.4)	0.986	(0.562−1.729)	0.961
Unstable angina	49 (8.6)	2 (3.0)	0.327	(0.078−1.374)	0.127
CHF with APE*	153 (26.9)	29 (43.3)	2.075	(1.237−3.482)	0.006
Arrhythmia	188 (33.0)	15 (22.4)	0.585	(0.321−1.066)	0.080
Ventricular fibrillation	33 (5.8)	6 (9.0)	1.598	(0.644−3.966)	0.313
Bradycardia	33 (5.8)	3 (4.5)	0.761	(0.227−2.553)	0.659
Atrial fibrillation	63 (11.1)	6 (9.0)	0.790	(0.328−1.902)	0.599
Complete AV block	56 (9.8)	0 (0)			1.000
PSVT	3 (0.5)	0 (0)			1.000
Cardiogenic shock*	26 (4.6)	12 (17.9)	4.557	(2.178−9.532)	< 0.001
OHCA*	9 (1.6)	5 (5.5)	5.018	(1.630−15.445)	0.005
Great vessel disease					
Pulmonary embolism	7 (1.2)	0 (0)			1.000
Aortic dissecting	8 (1)	0 (0)			1.000
Aortic aneurysm	6 (1.1)	0 (0)			1.000
Digoxin intoxication	13 (2.3)	0 (0)			1.000
Respiratory system diseases					
Pneumonia*	57 (10.0)	20 (29.9)	3.822	(2.118−6.899)	< 0.001
Acute respiratory failure*	43 (7.6)	9 (28.4)	4.842	(2.616−8.961)	< 0.001
Acute COPD exacerbation	27 (4.7)	2 (3.0)	0.618	(0.144−2.657)	0.518
Neurological system diseases					
Stroke	4 (0.7)	0 (0)			1.000
Seizure	3 (0.5)	1 (1.5)	2.859	(0.293−27.877)	0.366
Acute renal failure*	90 (15.8)	20 (29.9)	2.265	(1.281−4.003)	0.005
Others					
Urinary tract infection	21 (3.7)	5 (7.5)	2.104	(0.766−5.778)	0.149
Gastrointestinal bleeding	22 (3.9)	5 (7.5)	2.005	(0.733−5.483)	0.175
Anemia	20 (3.5)	4 (6.0)	1.743	(0.577−5.261)	0.324
DIC	1 (0.2)	0 (0)			1.000
ED length of stay (h)	5.1 ± 8.8	6.6 ± 21.3	1.009	(0.992−1.027)	0.294
CCU length of stay (h)*	101.2 ± 90.1	165.3 ± 207.5	0.996	(0.994-0.998)	< 0.001
Hospital length of stay (h)*	299.6 ± 371.8	448.1 ± 596.8	1.001	(1.006−1.001)	0.010

Results expressed as number (%) for categorical variables and mean (± standard deviation) for numerical variables.
*$p < 0.05$ means statistical significance in Mann-Whitney U test or Chi-square analysis.
ACS = acute coronary syndrome; APACHE = acute physiological and chronic health evaluation; APE = acute pulmonary edema; AV = atrioventricular; CCU = coronary care unit; CHF = congestive heart failure; CI = confidence interval; COPD = chronic obstructive pulmonary disease; DIC = disseminated intravascular coagulation; ED = emergency department; OHCA = out of hospital cardiac arrest; OR = odds ratio; PSVT = paroxysmal supraventricular tachycardia; STEMI = ST-segment elevation myocardial infarction; TTAS = Taiwan triage and acuity scale.

interventions, including primary coronary intervention (PCI), permanent pacemaker implantation, and were most likely to be admitted to CCU postprocedurally (Table 1). In this study, one of the most important indicators to review and confirm timely and effective quality of care would be management of patients with STEMI. For STEMI patients, the recommendation of PCI as the preferred reperfusion strategy should be made in a timely fashion to improve outcomes.[27,28] In this study, of all the STEMI patients, 85.9% (146/170) patients were treated using PCI, with subsequent admission to the CCU. Those patients who did not undergo PCI were mainly personally reluctant, or declined due to old age. Among those who underwent primary PCI, 87.7% (128/146) patients had a door-to-balloon time of < 90 minutes during the study period. About 5.9% of patients (10/170) admitted to the EICU initially did not appear to fit the clinical diagnostic criteria of STEMI, which was diagnosed after sequential electrocardiogram changes and elevation of cardiac enzymes. By using the Taiwan National Health Insurance Research Database (1999–2008), Lee et al[29] demonstrated that the in-hospital mortality rate of patients with acute myocardial infarction decreased from 15.9% in 1999 to 12.3% in 2008. The overall mortality of acute myocardial infarction patients in this study was 13.2% (66/501), which was slightly higher than the value in 2008. In detailed analysis, an objective measurement in our study patients' mean age of 74.1 years was significant higher than the 66.3 years in that study's patients pool. After adjusting for an average age of 66 years, we generated a mortality rate 9.8%, lower than the 12.3% found in the previous article. Furthermore, our study found that there was no association with increased mortality between non-STEMI patients admitted to EICU or CCU.[30]

In scrutinizing univariate analysis of clinical characteristics comparing survival to mortality among patients admitted to each EICU or CCU, respectively, in this study (Tables 2 and 3), we found that old age, poor GCS, higher APACHE II scores and Charlson comorbidity index, CHF with acute pulmonary edema, pneumonia, and acute respiratory failure were common predictors associated with in-hospital mortality. Besides, patient admissions to CCU had more specific predictors of mortality, including STEMI, out-of-hospital cardiac arrest, lower mean blood pressure, and acute renal failure, which were related to poor prognosis. It can be speculated that out of hospital cardiac arrest or STEMI patients with cardiogenic shock and poor perfusion resulting in acute renal failure would be admitted to the CCU with first priority. By comparison, there was also evidence of clinical characteristics in survivals

Table 4
Univariate analysis of clinical characteristics among survival patient admissions to emergency intensive care unit (EICU) and coronary care unit (CCU).

Variable	EICU Survival (*n* = 276)	CCU Survival (*n* = 569)	*p*
Age (y)*	75.4 ± 13.9	72.1 ± 15.0	0.001
Male	184 (66.7)	398 (69.9)	0.375
TTAS			0.550
1	60 (21.7)	105 (18.5)	
2	168 (60.9)	358 (62.9)	
3	40 (14.5)	81 (14.2)	
4	8 (2.9)	25 (4.4)	
Glasgow coma scale	14 ± 2.7	13.8 ± 3.4	0.733
APACHE II score at admission*	14.4 ± 6.9	12.3 ± 7.5	<0.001
0–14	140 (50.7)	401 (70.5)	
15–24	113 (40.9)	126 (22.1)	
> 24	23 (8.3)	42 (7.4)	
Charlson comorbidity index*	3.6 ± 2.1	3.1 ± 2.5	<0.001
Mean blood pressure at ED (mmHg)	100.6 ± 24.3	95.2 ± 27.3	0.182
Admission time (h)			0.059
0–8	50 (18.1)	89 (15.6)	
8–16	122 (44.2)	301 (52.9)	
16–24	104 (37.7)	179 (31.5)	
Admission d*			<0.001
Weekdays	208 (75.4)	365 (64.1)	
Weekends	68 (24.6)	204 (35.9)	
Main diagnosis at admission			
Acute coronary syndrome	149 (54.0)	347 (61.0)	0.062
STEMI*	9 (3.3)	135 (23.7)	<0.001
Non-STEMI*	128 (46.4)	163 (28.6)	<0.001
unstable angina*	12 (4.3)	49 (8.6)	0.024
CHF with APE*	124 (44.9)	153 (26.9)	<0.001
Arrhythmia*	60 (21.7)	188 (33.0)	<0.001
Ventricular fibrillation	8 (2.9)	33 (5.8)	0.095
Bradycardia	12 (4.3)	33 (5.8)	0.473
Atrial fibrillation	25 (9.1)	63 (11.1)	0.436
Complete AV block*	12 (4.3)	56 (9.8)	0.007
PSVT	3 (1.1)	3 (0.5)	0.398
Cardiogenic shock	11 (4.0)	26 (4.6)	0.834
OHCA	1 (0.4)	9 (1.6)	0.179
Great vessel disease			
Pulmonary embolism	3 (1.1)	7 (1.2)	1.000
Aortic dissecting	5 (1.8)	8 (1.4)	0.767
Aortic aneurysm	3 (1.1)	6 (1.1)	1.000
Digoxin intoxication	2 (0.7)	13 (2.3)	0163
Respiratory system disease			
Pneumonia*	59 (21.4)	57 (10.0)	< 0.001
Acute respiratory failure*	35 (12.7)	43 (7.6)	0.022
Acute COPD exacerbation*	25 (9.1)	27 (4.7)	0.022
Neurological system disease			0.695
Stroke	1 (0.4)	4 (0.7)	1.000
Seizure	0 (0)	3 (0.5)	0.555
Acute renal failure*	28 (10.1)	90 (15.8)	0.034
Others			
Urinary tract infection*	24 (8.7)	21 (3.7)	0.004
Gastrointestinal bleeding	19 (6.9)	22 (3.9)	0.081
Anemia	17 (6.2)	20 (3.5)	0.114
DIC	0 (0)	1 (0.2)	1.000
ED length of stay (h)*	5.9 ± 7.9	5.1 ± 8.8	< 0.001
Hospital length of stay (h)*	398.7 ± 372.7	299.6 ± 371.8	< 0.001

Results expressed as number (%) for categorical variables and mean (± standard deviation) for numerical variables. *$p < 0.05$ means statistical significance in Mann-Whitney *U* test or Chi-square analysis.
ACS = acute coronary syndrome; APACHE = acute physiological and chronic health evaluation; APE = acute pulmonary edema; AV = atrioventricular; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; DIC = disseminated intravascular coagulation; OHCA = out of hospital cardiac arrest; PSVT = paroxysmal supraventricular tachycardia; STEMI = ST-segment elevation myocardial infarction; TTAS = Taiwan triage and acuity scale.

between groups (Table 4), which supports the proposition that patients with STEMI, arrhythmia, or complete atrial−ventricular block would be likely to be admitted to CCU ($p < 0.05$). We found old age, more complicated clinical diagnoses, and multiple comorbidity features for survival among those admitted to the EICU (Table 5), in comparison to

Table 5
Univariate analysis of clinical characteristics among in-hospital mortality patient admissions to emergency intensive care unit (EICU) and coronary care unit (CCU).

Variable	EICU mortality ($n = 52$)	CCU mortality ($n = 67$)	P
Age (y)	82.4 ± 9.3	79.0 ± 11.8	0.124
Male	34 (64.4)	54 (80.6)	0.096
TTAS			0.306
1	20 (38.5)	33 (49.3)	
2	23 (44.2)	23 (34.3)	
3	8 (15.4)	7 (10.4)	
4	1 (1.9)	4 (6.0)	
Glasgow coma scale	12.1 ± 4.4	12.5 ± 4.7	0.753
APACHE II score at admission	20.1 ± 6.7	21.0 ± 9.7	0.979
0−14	11 (21.2)	20 (29.9)	
15−24	29 (55.8)	26 (38.8)	
> 24	12 (23.1)	21 (31.3)	
Charlson comorbidity index	4.5 ± 2.3	5.2 ± 3.1	0.258
Mean blood pressure at ED (mmHg)*	93.6 ± 25.3	75.4 ± 34.0	0.012
Admission time (h)			0.485
0−8	10 (19.2)	14 (20.9)	
8−16	28 (53.8)	29 (43.3)	
16−24	14 (26.9)	24 (35.8)	
Admission d			0.124
Weekdays	41 (78.8)	43 (64.2)	
Weekends	11 (21.2)	24 (35.8)	
Main diagnosis at admission			
Acute coronary syndrome*	25 (48.1)	46 (68.7)	0.037
STEMI*	1 (1.9)	25 (37.3)	<0.001
NSTEMI	21 (40.4)	19 (28.4)	0.237
Unstable angina	3 (5.8)	2 (3.0)	0.652
CHF with APE*	33 (63.5)	29 (43.3)	0.045
Arrhythmia	7 (13.5)	15 (22.4)	0.314
Ventricular fibrillation	3 (5.8)	6 (9.0)	0.730
Bradycardia	0 (0)	3 (4.5)	0.256
Atrial fibrillation	2 (3.8)	6 (9.0)	0.463
Complete AV block	2 (3.8)	0 (0)	0.189
PSVT	0 (0)	0 (0)	—
Cardiogenic shock	5 (9.6)	12 (17.9)	0.308
OHCA	2 (3.8)	5 (7.5)	0.466
Great vessel disease			
Pulmonary embolism	2 (3.8)	0 (0)	0.189
Aortic dissecting	0 (0)	0 (0)	—
Aortic aneurysm	0 (0)	0 (0)	—
Digoxin intoxication	0 (0)	0 (0)	—
Respiratory system disease			
Pneumonia	18 (36.4)	20 (29.9)	0.723
Acute respiratory failure	18 (34.6)	19 (28.4)	0.550
Acute COPD exacerbation*	8 (15.4)	2 (3.0)	0.020
Neurological system disease			0.695
Stroke	1 (1.9)	0 (0)	0.437
Seizure	1 (1.9)	1 (1.5)	1.000
Acute renal failure	10 (19.2)	20 (29.9)	0.267
Others			
Urinary tract infection	7 (13.5)	5 (7.5)	0.441
Gastrointestinal bleeding	5 (9.6)	5 (7.5)	0.746
Anemia	4 (7.7)	4 (6.0)	0.728
DIC	0 (0)	0 (0)	—
ED length of stay (h)*	8.7 ± 14.1	6.6 ± 21.3	0.003
Hospital length of stay (h)	424 ± 562.3	448.1 ± 596.8	0.742

Results expressed as number (%) for categorical variables and mean (± standard deviation) for numerical variables.
*$p < 0.05$ statistical significance in Mann−Whitney U test or Chi-square analysis.
ACS = acute coronary syndrome; APACHE = acute physiological and chronic health evaluation; APE = acute pulmonary edema; AV = atrioventricular; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; DIC = disseminated intravascular coagulation; ED = emergency department; OHCA = out of hospital cardiac arrest; PSVT = paroxysmal supraventricular tachycardia; STEMI = ST-segment elevation myocardial infarction; TTAS = Taiwan triage and acuity scale.

Table 6
Independent predictors of emergency intensive care unit (EICU) mortality by using multiple regression model.

	EICU ($n = 328$)				
Variables	Survival ($n = 276$)	Mortality ($n = 52$)	Adjust OR	95% CI	p
Age (y)*	75.4 ± 13.9	82.4 ± 9.3	1.053	(1.015−1.091)	0.005
Acute respiratory failure*	35 (12.7)	17 (32.7)	3.344	(1.628−6.871)	0.001
APACHE II score at admission*					
0−14	140 (50.7)	11 (21.2)	Reference		
15−24	113 (40.9)	29 (55.8)	2.191	(1.016−4.724)	0.045
> 24	23 (8.3)	12 (23.1)	4.193	(1.590−11.055)	0.002

Results expressed as number (%) for categorical variables and mean (± standard deviation) for numerical variables.
*$p < 0.05$ statistical significance in multiple regression analysis.
APACHE = acute physiological and chronic health evaluation; CI = confidence interval; OR = odds ratio.

Table 7
Independent predictors of coronary care unit (CCU) mortality by using multiple regression model.

	CCU ($n = 636$)				
Variables	Survival ($n = 569$)	Mortality ($n = 67$)	Adjust OR	95% CI	p
STEMI*	135 (23.7)	25 (37.3)	3.528	(1.859−6.695)	<0.001
Cardiogenic shock*	26 (4.6)	12 (17.9)	2.732	(1.149−6.498)	<0.023
Pneumonia*	57 (10.0)	20 (29.9)	2.518	(1.284−4.939)	0.007
APACHE II score at admission*					
0−14	401 (70.5)	20 (29.9)	Reference		
15−24	126 (22.1)	26 (38.8)	2.539	(1.258−5.123)	0.009
> 24	42 (7.4)	21 (31.3)	5.417	(2.456−11.948)	<0.001
Charlson comorbidity index*	3.1 ± 2.5	5.2 ± 3.1	1.187	(1.078−1.308)	0.001

Results expressed as number (%) for categorical variables and mean (± standard deviation) for numerical variables.
*$p < 0.05$ statistical significance in multiple regression analysis.
APACHE = acute physiological and chronic health evaluation; CI = confidence interval; OR = odds ratio; STEMI = ST-segment elevation myocardial infarction.

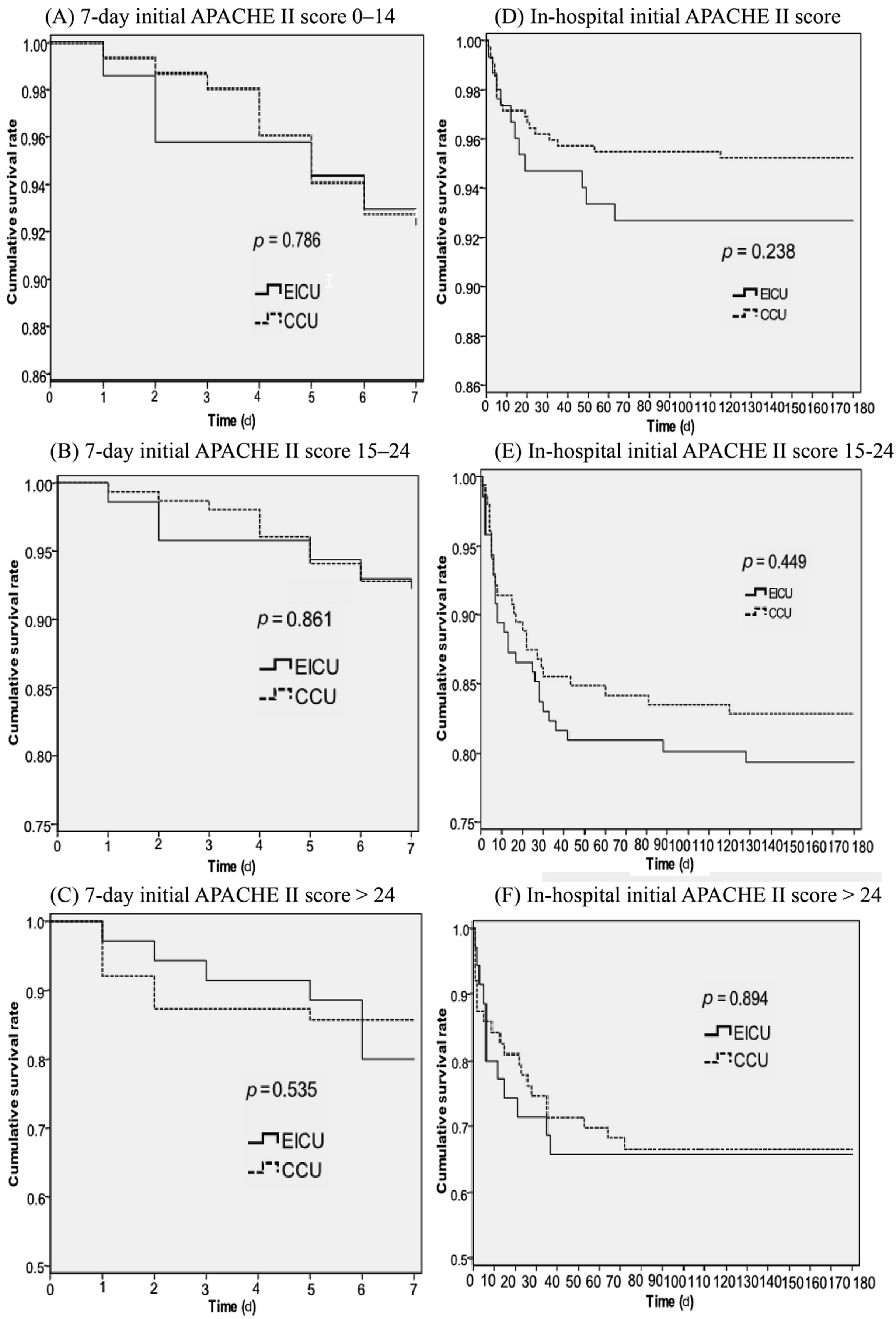

Fig. 2. Comparisons of 7-day and in-hospital survival rates by initial Acute Physiology and Chronic Health Evaluation (APACHE) II scores between patient admissions to the intensive care unit in the emergency department (EICU) and coronary care unit (CCU).

those survivals admitted to CCU similar to those patients with significant characteristics (Table 1). The phenomenon could be explained by our ED treating nontrauma patients with an average age of 54.1 ± 25.8 years, and around 51% of these patients were older than 65 years. In the meantime, the average occupancy rate of CCU was around 93%, which could dramatically delay admission time and increase ED length of stay.[16] In addition, our EICU had a lower occupancy rate of 74%, an average of 34-hour short-term LOS (Table 2), and greater flexibility for critical patient admissions. It is very intriguing to find that undifferentiated elderly patients with multiple comorbidity and organic dysfunction required more dedicated and complex diagnostic procedures or management, including specialist consultations. This might account for this study's finding of both longer ED and hospital LOS for EICU patients rather than CCU patients (Table 1). In this study, the EICU care model can continuously provide an effective diagnostic process and monitor therapeutic effects, for patients without leaving the ED, to mitigate possible complications for patients with older age, multiple organic insufficiency, and comorbidities.

In terms of outcome-based assessments, we analyzed the primary outcomes in both the 7-day and in-hospital mortality, to evaluate further whether the cause of death would be related to acute illness or chronic comorbidities, and furthermore to ensure care quality in both units. Illness severity and therapeutic intervention at admission to ICU were predictors of short-term mortality, whereas comorbidity was the strongest predictor for long-term mortality.[31] There was no statistical significance in 7-day hospital mortality between the groups, indicating that both units provided equivalent care quality for acute illness management, in spite of higher initial APACHE II Score in the EICU group. The significantly higher in-hospital mortality rate in the EICU group rather than in the CCU group of patients could be attributed to a higher comorbidity index, and multiple chronic comorbidities, infections, and complications in EICU patients. In this study, APACHE II score was identified as the only common predictor of both EICU and CCU mortality by multiple regression analysis. Further stratification of APACHE II score demonstrated no statistical significances in both the 7-day and in-hospital survival by Kaplan−Meier analysis (Fig. 2). This result indicates that, in elderly patients with cardiovascular emergency requiring ICU admission, APACHE II score remains an important predictor for mortality.[8]

Our study had several limitations. Firstly, the study design is a retrospective analysis, and thus subject to the limitations of all retrospective studies. Secondly, the potential for selection and outcomes bias exists, despite the fact that all admission decisions are the consensus of EPs and cardiologist. Thirdly, we did not comprehensively study all the ED patients admitted to the EICU, without the International Classification of Diseases diagnoses of inclusion criteria. Fourthly, this study was carried out in a single center study at a tertiary teaching medical center. The results may not be generalizable to other settings with differing admission demographics, diseases characteristics, or management practice. Multicenter studies are also needed to evaluate the proposed caring model, focusing on the efficacy and safety in ED settings. This observational study design has introduced a context for hospital-based preadmission criteria: patients with multiple comorbidities were admitted to EICU rather than CCU due to complex chronic diseases exacerbated by acute illness leading to higher mortality. All decisions focusing on where patients were subsequently transferred depended on both the patients' clinical condition and the judgment of in-charge physicians. Therefore, there would be a probable confounding effect on patient survival. However, we did our best to identify any possible clinical factors with regard to the survival duration between groups (Tables 2−5). To avoid this bias, we used logistic regression models to take into account factors that had some biological plausibility and scientific rationale. A prospective study of two or more centers with similar protocols and managed as a closed unit, but staffed either by ED physicians or non-ED physicians would be informative to address the need for a suitable care model in our health care system.

In conclusion, our study demonstrated there is a feasible model of intensive care delivery by through a combination of EPs and cardiologists for acute cardiovascular emergencies patients after initial ED management. However, further investigation is necessary to confirm a "gold standard" care system for elderly patients with multiple comorbidities requiring immediately invasive interventions, e.g., cardiac catheterization angioplasty and bypass surgery.

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