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Impact of a cardiac intensivist on mortality in patients with cardiogenic shock

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ABSTRACT

Background: This study aimed to evaluate the association between high-intensity staffing by a dedicated cardiac intensivist and clinical outcomes in CS.
Methods: We enrolled 2923 consecutive patients admitted to a cardiac care unit (CCU) from January 1, 2012 to December 31, 2015. In January 2013, the CCU changed from a low-intensity to high-intensity staffing unit managed by a dedicated cardiac intensivist. Patients were eligible if they required inotropes or vasopressors to maintain a systolic blood pressure > 90 mm Hg, and had serum lactate ≥ 2.0 mmol/L. Eligible patients (n = 513) were treated by low-intensity CCU (n = 352) or high-intensity CCU (n = 161). The primary outcome was CCU mortality.
Results: CCU mortality occurred in 49 patients (30.6%) of the low-intensity group versus 62 patients (17.6%) of the high-intensity group (adjusted odds ratio [aOR] 0.44, 95% confidence interval [CI] 0.25–0.75, $p < 0.001$). In-hospital mortality was not significantly different between the groups (33.1% vs 24.4%, aOR 0.75, 95% CI 0.43–1.29, $p = 0.29$). Among 135 patients treated with extracorporeal membrane oxygenation, the high-intensity model was associated with lower CCU mortality (54.5% vs 22.5%, aOR 0.24, 95% CI 0.07–0.77, $p = 0.02$) and in-hospital mortality (57.6% vs 29.4%, aOR 0.28, 95% CI 0.10–0.81, $p = 0.02$).
Conclusion: High-intensity staffed CCU managed by a dedicated cardiac intensivist was associated with a significant reduction of CS-related mortality.

1. Introduction

Although the hospital prognosis of patients with cardiogenic shock (CS) is improving, the mortality rate remains high at approximately 40% [1,2]. Worse still, refractory CS, which refers to a persistent shock despite appropriate volume resuscitation or use of inotropes or vasopressors, is lethal in more than half of hospitalized patients despite mechanical circulatory support [3]. In general, patients with CS are older and have higher rates of comorbidities, such as hypertension or diabetes, than patients without CS [4]. Also, since end-organ hypoperfusion due to inadequate cardiac output can lead to multi-organ system dysfunction and has a major impact on prognosis, adequate decision-making and optimal treatment based on hemodynamic monitoring in the cardiac care unit (CCU) is crucial [5].

Several previous studies demonstrated that high-intensity intensive care unit (ICU) physician staffing, which is regarded as a closed ICU or mandatory intensivist consultation, is associated with a significant reduction of ICU and in-hospital mortality in patients admitted to general medical and surgical ICUs [6,7]. However, in the CCU setting, the impact of the ICU staffing model on clinical outcome for the treatment of CS has been not studied. We investigated whether the implementation of high-intensity staffing setting involving management by a dedicated cardiac intensivist would be associated with a reduction of mortality in patients with CS.

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2. Methods

2.1. Study design

A total of 2923 consecutive patients over 18 years of age admitted to the CCU of Samsung Medical Center, Seoul, Korea, between January 1, 2012 and December 31, 2015 were screened in a single-center registry. We excluded 492 patients who were not diagnosed with any cardiovascular disease. Patients were eligible if they presented with CS regardless of the etiology. We defined as CS if the following two conditions were satisfied: (1) state that required inotropes or vasopressors support to achieve a systolic blood pressure > 90 mm Hg and (2) serum lactate ≥ 2.0 mmol/L to reflect tissue hypoperfusion. Of the 513 eligible patients, those treated from January 2012 to December 2012 (n = 161) were treated when the CCU was a low-intensity managed facility. Beginning in January 2013, the CCU became a high-intensity facility. From January 2013 to December 2015, 352 patients were treated using the high-intensity CCU model (Supplementary File 1). Clinical, laboratory and outcome data were retrospectively collected by a trained study coordinator from a review of the electronic medical records. The level of pharmacologic support for the first 48 h after shock was quantified using the maximum vasoactive inotropic score (VIS). The VIS is dopamine dose ([mcg/kg/min] + dobutamine dose [mcg/kg/min] + 100 × epinephrine dose [mcg/kg/min] + 10 × milrinone dose [mcg/kg/min] + 10,000 × vasopressin dose [unit/kg/min] + 100 × norepinephrine dose [mcg/kg/min]) [8]. Acute Physiology and Chronic Health Evaluation (APACHE) II scores were calculated to compare the severity between two groups. The Institutional Review Board at Samsung Medical Center approved the study protocol and waived the requirement for informed consent.

2.2. CCU setting

Our CCU is a twelve-bed ICU. To provide comprehensive critical care to patients with all kinds of cardiovascular disease and complex comorbidities, our CCU is equipped with noninvasive and invasive devices used to assess and monitor the hemodynamic status of the patients and provide cardiovascular support. These include intraaortic balloon pump (IABP), extracorporeal membrane oxygenation (ECMO) and ventricular assist devices, as well as mechanical ventilation and continuous renal replacement therapy (CRRT). Cardiac surgeon support is readily accessible. The nurse-to-patient ratio was maintained at 1:2. In January 2013, the CCU at Samsung Medical Center was converted to a high-intensity staffing model managed by a dedicated cardiac intensivist. Before implementing an intensivist-directed CCU, patients had been admitted or transferred to a CCU managed by only their individual physicians. Following the establishment of an intensivist-directed CCU, the cardiac intensivist assessed all patients admitted to the CCU and had responsibility for all aspects of patient care. The cardiac intensivist was a cardiologist who was board certified in interventional cardiology and critical care medicine. During the day, the CCU was covered by a general cardiology fellow, a critical care medicine fellow and three senior residents of internal medicine who were in the hospital. Therefore, the physician-to-patient ratio was also maintained at 1:2. Intensivist-led multidisciplinary team rounds were performed along with a nutrition support team that included a dietitian, pharmacist and respiratory care practitioner. Night-time coverage of the CCU comprised of in-house senior residents and a general cardiologist. The cardiac intensivist was accessible during the night at home by phone and text message. During the study period, there were no major changes in admission and discharge criteria, treatment guidelines, equipment advancement or nursing staffing, except for the level of intensity of ICU care. The primary outcome of this study was CCU mortality. Secondary outcomes included in-hospital mortality, mortality during follow-up, CCU and hospital readmission and CCU and hospital length of stay.

2.3. Statistical analyses

To compare characteristics and clinical outcomes between the low-intensity group and high-intensity group, continuous variables were presented as mean ± standard deviation or median with interquartile ranges (IQR). The *t*-test or Wilcoxon rank-sum test was used when applicable. Categorical variables were described as numbers and percentages, and compared using χ^2 test or Fisher's exact test. There were two patients who had no information on height and weight. For them, we imputed missing values with the group's median value. One patient was identified as an influential outlier, and thus was excluded to conduct a robust analysis on primary and secondary outcomes. To estimate the odds ratio (OR) of the type of ICU staffing model and identify risk factors for the prediction of mortality, logistic regression analyses were performed. Variables that appeared to be related in the univariate analysis ($p < 0.20$) were considered in multivariate regression models and an enter method was used to determine predictors of mortality. The OR of each variable is reported with their 95% confidence interval (CI). Survival curve were constructed

Table 1
Baseline and treatment characteristics.

Variables	Overall			ECMO		
	Low-intensity (n = 161)	High-intensity (n = 352)	*p* value	Low-intensity (n = 33)	High-intensity (n = 102)	*p* value
Age, years	67 (57–77)	67 (56–76)	0.76	59 (46–72)	58 (43–64)	0.11
Male	90 (55.9)	212 (60.2)	0.38	19 (57.6)	66 (64.7)	0.46
Cormobidities						
Body mass index, kg/m^2	22.4 (19.8–24.7)	23.0 (20.6–25.9)	0.03	24.0 (7–25.2)	24.2 (21.6–27.1)	0.60
Diabetes mellitus	58 (36.0)	125 (35.5)	0.91	9 (27.3)	38 (37.3)	0.30
Hypertension	70 (43.5)	186 (52.8)	0.05	8 (24.2)	39 (38.2)	0.14
Cerebrovascular disease	9 (5.6)	50 (14.2)	0.005	1 (3.0)	16 (15.7)	0.07
Chronic renal failure	34 (21.1)	53 (15.1)	0.09	4 (12.1)	8 (7.8)	0.49
Malignancy	12 (7.5)	40 (11.4)	0.17	2 (6.1)	7 (6.9)	0.00
Cause of admission			0.64			0.19
Acute coronary syndrome	71 (44.1)	150 (42.6)		13 (39.4)	46 (45.1)	
Heart failure	62 (38.5)	139 (39.5)		14 (42.4)	43 (42.2)	
Arrhythmia	15 (9.3)	43 (12.2)		3 (9.1)	11 (10.8)	
Acute aortic syndrome	6 (3.7)	8 (2.3)		0 (0.0)	0 (0.0)	
Pericardial disease	4 (2.5)	3 (0.9)		3 (9.1)	1 (1.0)	
Pulmonary thromboembolism	1 (0.6)	4 (1.1)		0 (0.0)	1 (1.0)	
Infective endocarditis	2 (1.2)	5 (1.4)		0 (0.0)	0 (0.0)	
Post-cardiac arrest	33 (20.5)	77 (21.9)	0.72	13 (39.4)	41 (40.2)	0.94
APACHE II score	18 (13–25)	18 (14–25)	0.70	23 (17–27)	22 (17–28)	0.74
Lactic acid, mmol/L	3.5 (2.5–6.5)	3.1 (2.3–5.6)	0.07	6.7 (3.7–10.5)	5.1 (3.0–9.0)	0.21
Left ventricle ejection fraction, %	36 (24–54)	37 (25–55)	0.49	30 (20–52)	35 (20–52)	0.43
Inotropes or vasopressors						
Dopamine	100 (62.1)	108 (30.7)	<0.001	22 (66.7)	24 (23.5)	<0.001
Norepinephrine	108 (67.1)	246 (69.9)	0.52	27 (81.8)	74 (72.5)	0.29
Dobutamine	78 (48.4)	163 (46.3)	0.65	21 (63.6)	63 (61.8)	0.85
Vasopressin	24 (14.9)	39 (11.1)	0.22	12 (36.4)	21 (20.6)	0.07
Epinephrine	8 (5.0)	38 (10.8)	0.03	3 (9.1)	21 (20.6)	0.13
Milrinone	4 (2.5)	20 (5.7)	0.11	1 (3.0)	11 (10.8)	0.29
Vasoactive inotrope score	37 (12–115)	21 (10–50)	0.001	73 (33–249)	31 (15–84)	0.001
Intra-aortic balloon pump	52 (32.3)	53 (15.1)	<0.001	13 (39.4)	10 (9.8)	<0.001
Extracorporeal membrane oxygenation	33 (20.5)	102 (29.0)	0.04	–	–	–
Mechanical ventilation	83 (51.6)	188 (53.4)	0.70	31 (93.9)	78 (76.5)	0.03
Continuous renal replacement therapy	52 (32.3)	97 (27.6)	0.27	17 (51.5)	39 (38.2)	0.18

APACHE II indicates Acute Physiology and Chronic Health Evaluation II; ECMO, extracorporeal membrane oxygenation. Values are mean ± standard deviation and median with interquartile range or n (%).

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