Characteristics and Outcomes of Patients Activated by Rapid Response Team Who Transferred to the Intensive Care Unit

Song-I Lee

Chungnam National University Hospital <https://orcid.org/0000-0001-8372-4511>

Jeong suk Koh

Chungnam National University Hospital

Yoon-joo Kim

Chungnam National University Hospital

Da Hyun Kang

Chungnam National University Hospital

Jeong Eun Lee (✉ jelee0210@cnu.ac.kr)

Chungnam National University Hospital <https://orcid.org/0000-0001-6173-2748>

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Abstract

Background:

The utilization of a Rapid response team (RRT) has influenced patient's clinical outcomes in the general ward. However, characteristics of RRT-screened patients admitted in the ward or transferred to the intensive care unit (ICU) is unknown. Therefore, this study aimed to evaluate these factors.

Methods:

We conducted a retrospective study using patient's data in a tertiary medical center in Korea between January 2016 and December 2017.

Results:

Total 1,096 patients were included; 389 patients were transferred to the ICU, and 707 patients stayed in the ward. The ICU group was more likely to be admitted for medical reasons, hepatobiliary disease, and high heart rate. More interventions were performed, hospital stays were longer, and 28-day and in-hospital mortality were higher in the ICU group. Multivariate logistic regression analyses showed that the risk factors affecting ICU admission were Sequential Organ Failure Assessment (SOFA) score, and National Early Warning Score (NEWS), platelet and lactate level. Transfer to the ICU was not associated with in-hospital mortality.

Conclusions:

Among RRT-activated patients, those with higher SOFA, NEWS scores, and lactate levels were more likely to transfer to the ICU. Therefore, these patients should be closely monitored and considered for ICU transfer.

Background

A rapid response for general ward patients suffering from acute deterioration may be impossible because of missing symptoms and the presence of vital signs. However, regular monitoring and introduction of automatic alarm systems aid the emergency medical team, which operates 24 hours or part-time a day, to implement treatment and reduce mortality [1–3]. General ward patients (up to 10% of cases) experience unexpected events [4], and 7.3% of patients suffer from fatal events [5]. Rapid response team (RRT) activation is usually triggered by several factors, such as vital sign monitoring, pre-rounding, and direct calls from attending physicians, nurses, and family members [3, 5].

Having a rapid response team in the hospital is associated with increased intensive care unit (ICU) admission and less severe patients transfer from the ward. However, RRT intervention did not improve the disease severity and outcome of patients transferred from ward [6]. These studies are usually compared before and after the RRT intervention. Patients transferred to the ICU after RRT activation and the

prognostic factors of the activated patient group are unknown. Thus, this study investigated the characteristics and outcomes of patients transferred to the ICU among patients activated by RRT.

Methods

Study design and patient selection

This was a retrospective observational study of patients admitted to the Chungnam National University Hospital, a 1200-bed tertiary academic hospital in South Korea, between January 2016 and December 2017. The electronic medical record (EMR)-based National Early Warning Score (NEWS) system was established in November 2013 and is used for adult patients admitted to the general ward. Admitted patients' vital signs were checked regularly by registered nurses. Seven physiological variables were entered into the NEWS at the nurses' discretion, and the NEWS data were stored in the EMRs. After a 6-month trial, the RRT introduced a track-and-trigger system in May 2014. A rapid response team began operation for adult patients at our hospital on a part-time basis (from 7 AM to 11 PM daily on weekdays) in 2014.

Data collection

All study data were retrieved from electronic medical records (C&U Care, Daejeon, Republic of Korea). A total of 1,218 patients were screened by RRT between February 1, 2016, and December 31, 2017. The study enrolled 1096 patients, excluding 122 patients due to the Do-Not-Resuscitate instruction. Demographic, clinical, and radiological information, as well as laboratory and imaging data, were collected.

Sequential Organ Failure Assessment (SOFA) scores based on Vincent et al. were assessed to predict mortality during the first 24 hours of ICU admission [7]. The worst value was chosen for each organ system every 24 hours to calculate the score [7]. NEWS2 is NEWS latest version, first produced in 2012 and updated in December 2017. It advocates a system to standardize acute illness assessment and response.

Ethics

This study was approved by the institutional review board (IRB) (IRB No: CNUH 2019-06-030), and the requirement for informed consent was waived because of the retrospective nature of the study.

Statistical Analysis

All values were expressed as mean $\pm$ standard deviation for continuous variables and percentages for categorical variables. Student's t-test or the Mann-Whitney U test was used for continuous data, and Pearson's chi-squared test or Fisher's exact test was used for categorical data analysis. Predictors of disease severity were identified by univariate logistic regression analysis. Multivariate logistic regression analyses with a backward elimination procedure, including all predictors with $p\text{-value} \leq 0.05$, in the univariate analysis, were performed to obtain the adjusted odds ratio (OR) along with 95% confidence

interval (CI) and to determine the variables independently associated with disease severity. All p-values were two-tailed, and p-value < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS software (version 22.0; IBM Corporation, Somers, NY, USA).

Results

Patients' baseline characteristics

The characteristics of 1,096 patients are presented in Table 1. More patients were admitted for medical reasons (75.8% vs. 70.3%, $p = 0.050$) among the patients admitted to ICU (ICU group). Chronic lung disease (9.3% vs. 15.4%, $p = 0.004$) was less and chronic hepatobiliary disease (12.1% vs. 7.8%, $p = 0.019$) was more common underlying diseases in the ICU group. There were no significant differences in other underlying diseases.

Vital sign before RRT activation showed the heart rate was faster in the ICU group (107 ± 26 vs. 102 ± 23 , $p = 0.002$). Laboratory findings showed that platelet count was lower (185 ± 114 vs. 203 ± 116 , $p = 0.018$), and T-bilirubin (1.8 ± 3.9 vs. 1.3 ± 3.3 , $p = 0.018$), creatinine (1.64 ± 1.66 , vs. 1.31 ± 1.76 , $p = 0.002$), and C-reactive protein (CRP) levels (11.5 ± 9.7 vs. 10.7 ± 9.3 , $p < 0.001$) were higher in the ICU group. The SOFA score (5.3 ± 3.2 vs. 3.5 ± 2.2 , $p < 0.001$) and NEWS score (8 ± 3 vs. 7 ± 3 , $p < 0.001$) were higher in the ICU group. Other vital signs and laboratory findings showed no statistical significance differences (Table 1).

Intervention and Outcomes

Table 2 shows the interventions and outcomes implemented after RRT activation. RRT activation was less due to sepsis and more due to septic shock, respiratory distress, and cardiogenic shock in the ICU group. RRT interventions were more frequent in the ICU group, except for extracorporeal membrane oxygenation, renal replacement therapy, application of high-flow nasal cannula, and ultrasonography. Hospital length of stay (LOS) was longer (53.3 ± 56.0 vs. 44.1 ± 58.9 , $p = 0.011$) and 28 day-mortality (22.6% vs. 14.6%, $p = 0.001$) and in-hospital mortality (29.8% vs. 20.1%, $p < 0.001$) were higher in the ICU group.

Factors associated with transfer to ICU

The multivariate analysis showed the factors associated with ICU transfer (Table 3). After adjusting for confounders, the independent predictors of ICU transfer included the SOFA score (OR, 1.281; 95% CI 1.184–1.386; $p < 0.001$), NEWS score (OR, 1.065; 95% CI, 1.006–1.128; $p = 0.032$), platelet count (OR, 1.002; 95% CI, 1.001–1.004; $p = 0.002$), and lactate (OR, 1.161; 95% CI, 1.074–1.255; $p < 0.001$).

Factors associated with patients' in-hospital mortality

The multivariate analysis showed factors associated with in-hospital mortality in Table 4. The independent predictors of in-hospital mortality included age (OR, 1.029; 95% CI, 1.013–1.045; $p < 0.009$), screened due to medical reason (OR, 1.799; 95% CI, 1.115–2.904; $p = 0.016$), SOFA score (OR, 1.119; 95% CI, 1.042–1.202; $p = 0.002$), solid tumor (OR, 1.676; 95% CI, 1.065–2.638; $p = 0.026$), hematologic

malignancy (OR, 3.166; 95% CI, 1.483–6.760; $p = 0.003$), T-bilirubin (OR, 1.055; 95% CI, 1.006–1.106; $p = 0.027$), lactate (OR, 1.166; 95% CI, 1.078–1.261; $p < 0.001$), and CRP (OR, 1.027; 95% CI, 1.008–1.046; $p = 0.005$) after adjusting for confounders.

Discussion

In this study, 35.5% of the RRT-activated patients were transferred to the ICU. Patients admitted for medical reasons with an underlying chronic hepatobiliary disease or a higher SOFA score or NEWS score were more likely to be admitted to the ICU when RRT was activated. Patients admitted to the ICU had longer hospital LOS and higher 28-day in-hospital mortality rates. SOFA score, NEWS score, and platelet and lactate levels were associated with ICU transfer. ICU admission was not associated with in-hospital mortality.

RRT has been implemented in several hospitals to facilitate early recognition and treatment of deteriorating patients in wards [3, 8]. Most RRT activation leads to one or more interventions in patient, including additional diagnostic testing, obtaining a venous or central access line, applying oxygen, intubation, vasopressor use, or supporting cardiopulmonary resuscitation [3, 9, 10]. Interventions were often performed in patients admitted to the ICU in this study because they were more likely to have activated RRT due to septic shock, respiratory distress, and cardiogenic shock. Therefore, more interventions are thought to be required.

According to a recent review, RRT interventions have improved patient safety [2, 11]. RRT performance was generally measured in terms of heart attack, unexpected ICU hospitalization, and mortality [12]. Patients with RRT activation tended to have more ICU admissions and experienced a relatively high mortality rate [13]. The in-hospital mortality rate of RRT-activated patients was 23.5% in this study. The mortality rate has been variously confirmed, ranging from 10.6–42.2% [2, 5, 14, 15]. Several studies have shown that RRT intervention reduces mortality in hospitals [2, 3, 11, 16]. However, some studies have shown that RRT intervention did not affect mortality [9]. In the Medical Early Response Intervention and Therapy study [17], the medical emergency team system did not substantially affect cardiac arrest incidence, unplanned ICU admissions, or unexpected death. Maharaj et al. showed that RRS implementation was associated with an overall hospital mortality reduction in adult patients (relative risk [RR] 0.87, 95% CI 0.81–0.95, $p < 0.001$) and was also associated with a reduction in cardiopulmonary arrests in adults (RR 0.65, 95% CI 0.61–0.70, $p < 0.001$) [2]. Chan et. al. showed that RRT activation in adults was associated with a 33.8% reduction in cardiopulmonary arrest rates outside the ICU (RR 0.66, 95% CI, 0.54–0.80) but was not associated with lower hospital mortality rates (RR, 0.96; 95% CI, 0.84–1.09) [16]. Therefore, while these results remain controversial, a rapid response team can improve meaningful outcomes. Thus, understanding the group of patients admitted to the ICU and the prognosis can help increase RRT effectiveness.

In this study, high SOFA score, NEWS score, lactate level, and low platelet count were factors related to ICU admission. High SOFA score [18–20] and NEWS score [21, 22] are well-known factors related to

patient severity. Higher scores indicate severe disease in patients; thus, it may have been associated with the patient's ICU admission. Lactate is known to be related to the severity of systemic hypoperfusion, and its high level is known to be associated with disease severity[23].

Acute deterioration after more than 7 days of hospitalization, septic shock was an independent risk factor for in-hospital mortality and ICU transfer [1, 24]. Age, screening for medical reasons, SOFA score, solid tumor, hematologic malignancy, T-bilirubin, lactate, and CRP were associated with in-hospital mortality in this study. Among these factors, SOFA score and lactate level are also related to the ICU admission factor. Therefore, more careful treatment when patients with these conditions are activated on RRT may help patients' prognosis.

This study had several limitations. First, this was a retrospective study performed at a single medical center. Second, the possibility of selection bias cannot be ruled out because many patients with missing variables were excluded. However, most of the missing variables were oxygen saturation or level of consciousness. This means that nurses did not use these variables for decision-making since the patients appeared to be mentally alert or did not require oxygen. Therefore, these patients may have had less severe disease and low in-hospital mortality risk. Third, since the RRT was not activated for 24 hours, the patient groups at the time when the RRT was not activated were not included in the study.

Conclusions

In this study, it was confirmed that 35.5% of patients were admitted to ICU after RRT activation. Factors associated with ICU admission were high SOFA score, NEWS score, platelet count, and lactate level. Therefore, close monitoring and transport to the ICU should be considered when these patients are activated on RRT.

Abbreviations

RRT: Rapid response team, ICU: Intensive care unit, EMR: Electronic medical record, NEWS: National Early Warning Score, SOFA: Sequential Organ Failure Assessment, IRB: Institutional review board, OR: Odds ratio, CI: Confidence interval, CRP: C-reactive protein, RR: Relative risk

Declarations

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Authors' contributions

Conceptualization: S.I.L., J.E.L., Data curation: S.I.L., Formal analysis: S.I.L., J.E.L., Investigation: S.I.L., J.E.L., Methodology: J.E.L., Supervision: J.E.L., Validation: S.I.L., J.E.L., Visualization: J.E.L., Writing—original draft: S.I.L., J.S.K., Y.J.K., D.H.K., J.E.L., Writing—review and editing: S.I.L., J.E.L.

Ethics approval and consent to participate

This study was approved by the institutional review board (IRB) of chungnam national university hospital (IRB No: CNUH 2019-06-030), and the requirement for informed consent was waived because of the retrospective nature of the study.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1. Patient’s characteristics

	All (n = 1096)	Ward (n = 707)	ICU (n = 389)	P- value
Age	67.4 ± 14.7	67.8 ± 14.8	66.5 ± 14.6	0.145
Male	675 (61.6)	428 (60.5)	247 (63.5)	0.335
BMI	22.5 ± 4.4	22.5 ± 4.4	22.7 ± 4.3	0.551
Medical	792 (72.3)	497 (70.3)	295 (75.8)	0.050
Surgical	304 (27.7)	210 (29.7)	94 (24.2)	0.050
Underlying disease				
Solid tumor	182 (16.6)	123 (17.4)	59 (15.2)	0.342
Hematologic malignancy	54 (4.9)	41 (5.8)	13 (3.3)	0.072
Chronic lung disease	145 (13.2)	109 (15.4)	36 (9.3)	0.004
Chronic heart disease	231 (21.1)	145 (20.5)	86 (22.1)	0.535
Chronic hepatobiliary disease	102 (9.3)	55 (7.8)	47 (12.1)	0.019
Cerebrovascular disease	182 (16.6)	120 (17.0)	62 (15.9)	0.660
Chronic kidney disease	116 (10.6)	68 (9.6)	48 (12.3)	0.161
Diabetes	339 (30.9)	213 (30.1)	126 (32.4)	0.438
Transplantation	3 (0.3)	2 (0.3)	1 (0.3)	0.938
Most recent vital sign				
MBP, mmHg	87.6 ± 21.4	87.3 ± 19.9	88.1 ± 23.9	0.568
HR, bpm	104 ± 24	102 ± 23	107 ± 26	0.002
RR, /min	25 ± 7	25 ± 6	26 ± 7	0.325
BT, °C	37.5 ± 0.9	37.5 ± 0.9	37.4 ± 0.9	0.238
SpO2, %	93 ± 9	94 ± 8	93 ± 10	0.238
Laboratory findings				
WBC, x10 ³ /uL	11.9 ± 11.2	11.5 ± 11.5	12.7 ± 10.6	0.100
Hb, g/dL	10.5 ± 2.2	10.5 ± 2.1	10.4 ± 2.4	0.448
Platelet, x10 ³ /uL	196 ± 115	203 ± 116	185 ± 114	0.018
T-bilirubin, mg/dL	1.5 ± 3.6	1.3 ± 3.3	1.8 ± 3.9	0.018

Creatinine, mg/dL	1.43 ± 1.73	1.31 ± 1.76	1.64 ± 1.66	0.002
Lactate, mEq/L	2.6 ± 2.4	2.1 ± 1.7	3.2 ± 2.9	0.213
CRP, mg/dL	11.0 ± 9.5	10.7 ± 9.3	11.5 ± 9.7	<0.001
SOFA score	4.2 ± 2.8	3.5 ± 2.2	5.3 ± 3.2	<0.001
NEWS score	8 ± 3	7 ± 3	8 ± 3	<0.001
Hospitalization period prior to RRT activation (Days)	13.4 ± 25.5	12.8 ± 26.9	14.6 ± 22.9	0.268

Data are presented as mean ± standard deviation or number (%), unless otherwise indicated.

ICU, intensive care unit; BMI, body mass index; MBP, Mean blood pressure; HR, heart rate; RR, respiratory rate; BT, body temperature; SpO2, saturation by pulse oximetry; WBC, white blood cell; Hb, hemoglobin; C-reactive protein; SOFA, sequential organ failure assessment; NEWS, national early warning score; RRT, rapid response team

Table 2. RRT activation, intervention and outcomes

	All (n = 1096)	Ward (n = 707)	ICU (n = 389)	P-value
Reason for RRT activation				
Sepsis	834 (76.1)	606 (85.7)	228 (58.6)	<0.001
Septic shock	126 (11.5)	48 (6.8)	78 (20.1)	<0.001
Respiratory distress	85 (7.8)	39 (5.5)	46 (11.8)	<0.001
Cardiogenic shock	51 (4.7)	14 (2.0)	37 (9.5)	<0.001
RRT intervention				
ACLS	41 (3.7)	9 (1.3)	32 (8.2)	<0.001
ECMO	3 (0.3)	1 (0.1)	2 (0.5)	0.258
Renal replacement therapy	17 (1.6)	10 (1.4)	7 (1.8)	0.622
Intubation	142 (13.0)	13 (1.8)	129 (33.2)	<0.001
Ventilator	49 (4.5)	6 (0.8)	43 (11.1)	<0.001
HFNC	124 (11.3)	99 (14.0)	25 (6.4)	<0.001
A-line insertion	14 (1.3)	3 (0.4)	11 (2.8)	0.001
C-line insertion	35 (3.2)	6 (0.8)	29 (7.5)	<0.001
USG	100 (9.1)	64 (9.1)	36 (9.3)	0.911
Vasopressors	83 (7.6)	22 (3.1)	61 (15.7)	<0.001
Outcomes				
Hospital LOS	47.3 ± 85.0	44.1 ± 58.9	53.3 ± 56.0	0.011
28day mortality	191 (17.4)	103 (14.6)	88 (22.6)	0.001
In-hospital mortality	258 (23.5)	142 (20.1)	116 (29.8)	<0.001

Data are presented as mean ± standard deviation or number (%), unless otherwise indicated.

RRT, rapid response team; ICU, intensive care unit; ACLS, advanced cardiovascular life support; ECMO, extracorporeal membrane oxygenation; HFNC, high flow nasal cannula; A-line, arterial line; C-line, Central line; USG, ultrasonography; LOS, length of stay

Table 3. Multivariate Logistic Regression Analysis of Factors Associated With transfer to ICU

	Univariate analysis			Multivariate analysis		
	OR	95% CI	P-value	OR	95% CI	P-value
Age	0.994	0.986 – 1.002	0.146			
Male	1.134	0.878 – 1.464	0.335			
BMI	1.009	0.979 – 1.040	0.551			
Medical	1.326	1.000 – 1.759	0.050	1.045	0.731 – 1.493	0.811
SOFA score	1.297	1.226 – 1.371	<0.001	1.281	1.184 – 1.386	<0.001
NEWS score	1.117	1.068 – 1.167	<0.001	1.065	1.006 – 1.128	0.032
Vital sign						
MBP	1.002	0.996 – 1.008	0.547			
HR	1.009	1.003 – 1.014	0.001	1.005	0.997 – 1.012	0.210
RR	1.010	0.991 – 1.029	0.301			
Underlying disease						
Solid tumor	0.849	0.605 – 1.191	0.343			
Hematologic malignancy	0.562	0.297 – 1.061	0.076			
Chronic lung disease	0.560	0.375 – 0.834	0.004	0.742	0.458 – 1.202	0.225
Chronic heart disease	1.100	0.814 – 1.487	0.535			
Chronic hepatobiliary disease	1.629	1.080 – 2.457	0.020	1.189	0.708 – 1.998	0.512
Cerebrovascular disease	0.927	0.663 – 1.297	0.660			
Chronic kidney disease	1.323	0.894 – 1.958	0.162			
Diabetes	1.111	0.851 –	0.438			

	1.450					
Laboratory findings						
WBC	1.010	0.997 – 1.022	0.128			
Hb	0.977	0.923 – 1.034	0.426			
Platelet	0.999	0.998 – 1.000	0.018	1.002	1.001 – 1.004	0.002
T-bilirubin	1.047	1.005 – 1.090	0.026	0.975	0.936 – 1.016	0.224
Creatinine	1.115	1.037 – 1.198	0.003	0.918	0.828 – 1.018	0.104
Lactate	1.251	1.164 – 1.345	<0.001	1.161	1.074 – 1.255	<0.001
CRP	1.009	0.995 – 1.022	0.213			

ICU, intensive care unit; OR, Odds ratio; CI, Confidence interval; BMI, body mass index; SOFA, sequential organ failure assessment; NEWS, national early warning score; MBP, Mean blood pressure; HR, heart rate; RR, respiratory rate; WBC, white blood cell; Hb, hemoglobin; C-reactive protein

Table 4. Multivariate Logistic Regression Analysis of Factors Associated With In-Hospital Mortality

	Univariate analysis			Multivariate analysis		
	OR	95% CI	P-value	OR	95% CI	P-value
Age	1.020	1.010 – 1.031	<0.001	1.029	1.013 – 1.045	<0.001
Male	1.246	0.931 – 1.668	0.140			
BMI	1.015	0.982 – 1.050	0.376			
Medical	2.262	1.580 – 3.237	<0.001	1.799	1.115 – 2.904	0.016
SOFA score	1.235	1.169 – 1.305	<0.001	1.119	1.042 – 1.202	0.002
NEWS score	1.139	1.083 – 1.197	<0.001	1.064	0.996 – 1.138	0.067
Underlying disease						
Solid tumor	2.075	1.474 – 2.923	<0.001	1.676	1.065 – 2.638	0.026
Hematologic malignancy	2.993	1.719 – 5.211	<0.001	3.166	1.483 – 6.760	0.003
Chronic lung disease	1.333	0.901 – 1.973	0.150			
Chronic heart disease	1.252	0.899 – 1.745	0.184			
Chronic hepatobiliary disease	1.475	0.943 – 2.307	0.088			
Cerebrovascular disease	0.934	0.639 – 1.365	0.724			
Chronic kidney disease	1.271	0.824 – 1.961	0.278			
Diabetes	0.981	0.725 – 1.328	0.902			
Laboratory findings						
WBC	1.004	0.993 – 1.016	0.477			
Hb	0.911	0.853 – 0.973	0.006	1.001	0.919 – 1.091	0.974
Platelet	0.997	0.995 –	<0.001	0.999	0.3997 –	0.223

		0.998			1.001	
T-bilirubin	1.106	1.049 – 1.166	<0.001	1.055	1.006 – 1.106	0.027
Creatinine	1.040	0.963 – 1.123	0.314			
Lactate	1.252	1.173 – 1.338	<0.001	1.166	1.078 – 1.261	<0.001
CRP	1.029	1.014 – 1.044	<0.001	1.027	1.008 – 1.046	0.005
Transfer to ICU	1.691	1.272 – 2.247	<0.001	1.042	0.704 – 1.542	0.836

OR, Odds ratio; CI, Confidence interval; BMI, body mass index; SOFA, sequential organ failure assessment; NEWS, national early warning score; MBP, Mean blood pressure; HR, heart rate; RR, respiratory rate; WBC, white blood cell; Hb, hemoglobin; C-reactive protein; ICU, intensive care unit

Figures

Figure 1

Patient flow chart RRT, rapid response team; DNR, do not resuscitate; ICU, intensive care unit.