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Original Article

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The Impact on Patient Prognosis of Changes to the Method of Notifying Staff About Accepting Patients With Out-of-Hospital Cardiac Arrest

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Abstract

Background: Our hospital is a designated emergency hospital and accepts many patients with out-of-hospital cardiac arrest (OHCA). Previously, after receiving a direct call from emergency services to request acceptance of an OHCA patient, the emergency room (ER) chief nurse notified medical staff. However, this method delayed ER preparations, so a Code Blue system (CB) was introduced in which the pending arrival of an OHCA patient was broadcast throughout the hospital.

Methods: In this study, we retrospectively analyzed the impact of introducing CB at our hospital on OHCA patient prognosis to examine whether the introduction of CB is clinically meaningful. We compared consecutive cases treated before introduction of the CB (March 3, 2022, to March 22, 2023) with those treated afterwards (March 23, 2023, to July 23, 2024).

Results: A total of 30 cases per group were included. The mean number of medical staff present at admissions increased significantly from 5.4 ± 0.6 to 15.0 ± 3.0 (P < 0.001). Although not statistically significant, the introduction of the CB increased the return of spontaneous circulation (ROSC) rate from 20% to 30%, survival to discharge rate from 3% to 10%, and social reintegration rate from 0% to 3%. ROSC occurred in 15 patients. Among OHCA patients with cardiac disease, the ROSC rate tended to increase from 0% to 43% (P = 0.055). In addition, in OHCA patients with cardiac disease whose electrocardiogram initially showed ventricular fibrillation or pulseless electrical activity, the ROSC rate increased from 0% to 100%. ROSC tended to be influenced by the total number of staff and physicians present and the number of staff such as medical clerks, clinical engineers, and radiology technicians (P = 0.095, 0.076, 0.088, respectively).

Conclusions: Introduction of a CB may increase the ROSC rate and the number of patients surviving to discharge. It also appears to improve the quality of medical care by quickly gathering all necessary medical staff so that they can perform their predefined roles.

Keywords: Emergency room; Cardiopulmonary resuscitation; Return of spontaneous circulation; Out-of-hospital cardiac arrest

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Introduction

Our hospital is an emergency hospital that accepts about 100 out-of-hospital cardiac arrest (OHCA) cases per year. Previously, when an emergency ambulance was headed for the emergency room (ER), the ER chief nurse first received a direct call from emergency services and then used a personal handy phone system (PHS; a low-powered wireless communication service phone used in Japan) to contact the emergency duty physician and medical clerks (Fig. 1a). The medical clerk then informed other relevant staff members via the loudspeaker of the in-hospital landline phone. Although staff were informed within 1 min of the emergency services call, it sometimes took more than 2 to 3 min for staff to arrive in the ER, depending on the situation. Furthermore, if the involved staff members were not near the loudspeaker, they may not have heard the announcement. For these reasons, when expecting a critically ill patient such as one with OHCA, the ER nurse also used their

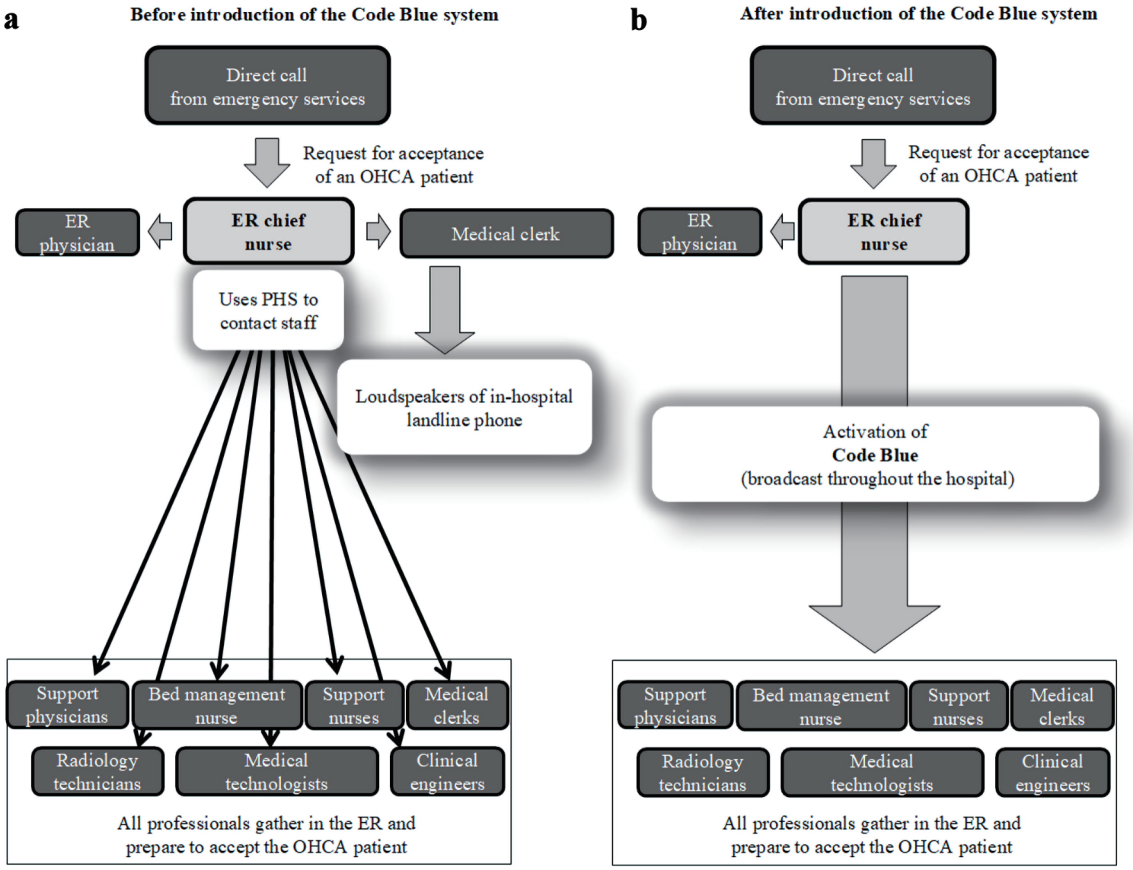

Figure 1. Comparison of communication systems used to gather staff in the ER in preparation for accepting OHCA patients. (a) Situation before introduction of the Code Blue system. (b) After the introduction of the Code Blue system. For example, if a patient with OHCA will arrive in 10 min, the ER nurse will twice broadcast "Code Blue, Code Blue, 10 minutes" via the Code Blue system. ER: emergency room; OHCA: out-of-hospital cardiac arrest; PHS: personal handy phone system.

PHS to call each relevant staff member in advance. However, OHCA patients usually arrive within 3 to 7 min after the direct call from emergency services. Therefore, if the notification system did not work smoothly, OHCA patients would arrive without sufficient staff being present. The arrival of staff was often delayed because the ER nurse had to concentrate on calling all staff individually. Our hospital is a medium-sized facility (with approximately 200 beds), so unlike large, critical care centers, it is not able to continuously have enough stand-by staff in the ER.

To provide advanced medical care in an ER, a system is required that enables staff to convene quickly, which in turn allows them to perform tasks according to their expertise and profession. Therefore, in March 2023, we introduced a Code Blue system (CB) at our hospital to improve the method for quickly convening staff from various departments in preparation for the arrival of an OHCA patient. We expected that the introduction of this system would improve the quality of medical care, because medical staff would be assembled more quickly and able to take on their predefined roles. However, it remained unclear whether introduction of the CB actually improved patient prognosis. Although many reports have been published on in-hospital emergency response systems, such as medical emergency teams [1] and rapid response systems [2], there is surprisingly little literature on developing systems for accepting OHCA patients, even though the development of such a system can be expected to have a major impact on clinical practice. Therefore, we retrospectively investigated the changes in prognosis of OHCA patients after the introduction of the CB at our hospital to examine whether the introduction of CB was clinically meaningful.

Materials and Methods

Details of the CB

On March 23, 2023, the method used to convene staff when accepting OHCA patients was changed from PHS calls and broadcast via the loudspeaker of the in-hospital landline phone to a CB, i.e., a hospital-wide broadcast (Fig. 1b). The CB was activated by the ER chief nurse during the day shift after they received a direct call from emergency services about an incoming OHCA patient, including those with return of spontaneous circulation (ROSC) after cardiac arrest and those with post-resuscitation shock. However, the system was not activated if patients had already signed a do-not-resuscitate order. During

Table 1. Main Roles of Medical Staff When the CB Is Activated

	Main roles
Emergency physician	Tracheal intubation, blood sampling, ultrasound examination, sheath insertion into arterial and venous line
Support physicians (non-emergency physicians, who are not in the ER when CB activated)	Tracheal intubation, blood sampling, ultrasound examination, sheath insertion into arterial and venous line
ER chief nurse	Timekeeper, chest compression device attachment, family contact/response
ER nurses	Recording, drug preparation/administration, drip route creation, intravenous line insertion
Support nurses	Tracheal intubation assistance, sheath insertion assistance, drug administration
Bed management nurse	Preparation for securing bed, support for families
Clinical engineers (medical engineers)	Priming, connecting, and setting up of arterial line
Radiology technicians	Portable X-ray preparation, computed tomography preparation
Medical technologists	COVID-19 antigen test, ultrasound examination, direct counter shock preparation, blood collection assistance, specimen transportation
Medical clerks	Reception support, administrative liaison, family support

The general roles of these staff members have been clarified in advance. ER: emergency room; CB: Code Blue system; COVID-19: coronavirus disease 2019.

non-day shift hours, the conventional method continued to be used to gather staff, as it was not possible to broadcast information to the entire hospital at night, and there were few staff members in the hospital to begin with.

When the CB was activated, the following staff members convened in the ER: emergency and support physicians; ER chief nurses; ER, support, and bed management nurses; clinical engineers (medical engineers); radiology technicians; medical technologists; and medical clerks. This system ensured that at least 10 staff members were present in the ER when emergency services arrived with an OHCA patient. The general roles of these staff members had been clarified in advance (Table 1). The staff members performed the initial treatment, and once their respective duties were completed, they returned to their usual tasks. The ever-changing patient information, treatment details, and progress were recorded on a whiteboard and shared among the staff.

Study population

Participants were consecutive OHCA patients (including patients with ROSC before arrival at the hospital), who were admitted to our hospital after the introduction of the CB (After CB group), and the same number of consecutive OHCA patients admitted before the introduction of the CB (Before CB group). Both groups were limited to cases who visited the hospital during the day shift (Fig. 2).

The study protocol was approved by Fukuoka University Medical Ethics Review Board (approval no. C24-03-003) and the Ethics Review Board of Imamura Hospital (approval no. 6-3). The study was performed in compliance with the ethical standards of the responsible institution on human subjects and with the Declaration of Helsinki. Patients were informed about the study by notices posted in the hospital and were able to opt out via the hospital website.

Outcomes

The main outcome was the ROSC rate during the day shift. The ROSC rate was the percentage of patients who achieved ROSC even once during the period from the onset of cardiac arrest till treatment in the ER to those who were transported due to OHCA.

Sample size estimation

The ROSC rate during day shifts was assumed to be 5% in the Before CB group and 30% in the After CB group. This rate of Before CB group was assumed by calculation from previous discharge summaries at our hospital. Assuming a 70% probability of detecting significance at the 5% level, a total of 52 patients were required. These values were calculated by "sealed envelope TM".

Exclusion criteria

Exclusion criteria were defined as patients for whom the response policy in the case of an emergency was decided in advance as "do not attempt resuscitate", patients who expressed their intention to refuse the use of existing information, and patients who were transported during non-day shift hours.

Statistical analysis

Statistical analyses were performed with the EZR application (version 1.61) [3]. To analyze differences between the two groups, the Student's *t*-test was performed if normality was present and the Levene test indicated equal variance, and the

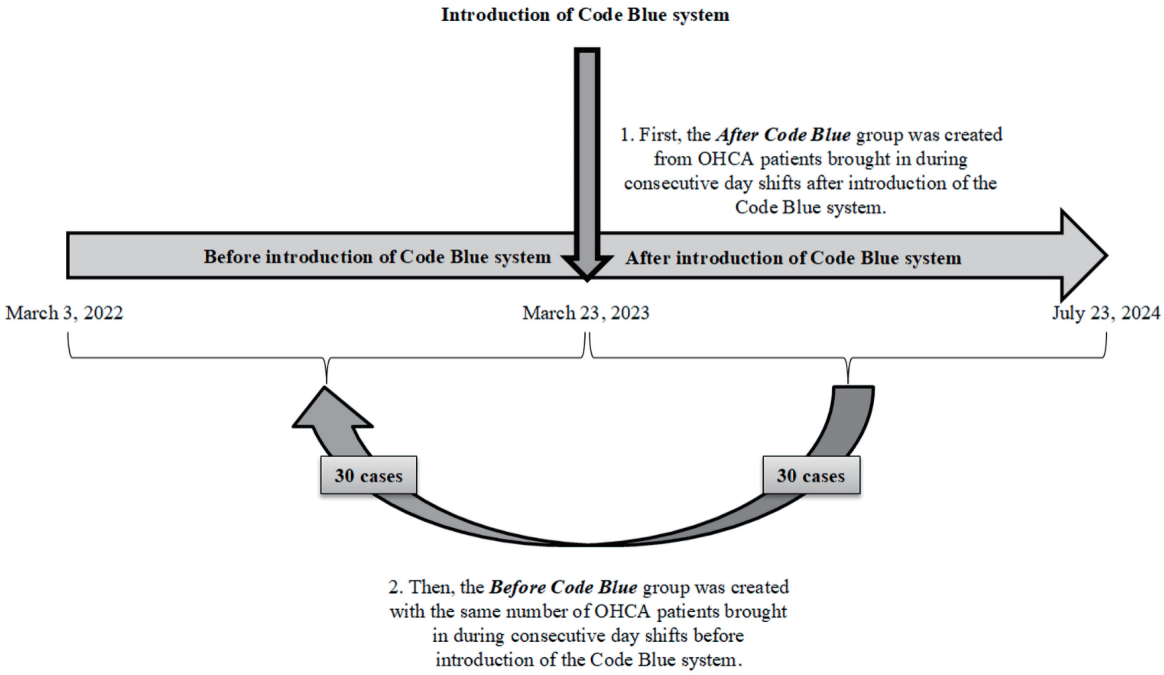

Figure 2. Patient enrollment. Participants were consecutive OHCA patients (including patients with return of spontaneous circulation before arrival at the hospital) who were admitted to our hospital before and after introduction of the Code Blue system. All participants were admitted during the daytime shift. Patients in the After CB group (n = 30) were admitted from March 23, 2023, to July 31, 2024, and patients in the Before CB group were admitted from March 30, 2022, to March 22, 2023. OHCA: out-of-hospital cardiac arrest.

Welch test was performed if the Levene test did not indicate equal variance. If normality was not present, the Mann-Whitney test was used. To analyze changes over time, paired *t*-test was used if normality was confirmed, and Wilcoxon single-rank test was used if it was not. The Chi-square test was used to analyze associations between categories. Numerical results were expressed as mean (standard deviation (SD)), median (interquartile range (IQR)), or number (frequency or proportion). A P value of less than 0.05 was considered statistically significant.

Results

The After CB group comprised 30 consecutive OHCA patients who were treated during the daytime shift from March 23, 2023, to July 31, 2024, and the Before CB group comprised 30 consecutive OHCA patients who were treated during the daytime shift from March 30, 2022, to March 22, 2023 (Fig. 2). Table 2 compares the patient characteristics between the Before and After CB groups. There were no significant differences in basic characteristics, bystander cardiopulmonary resuscitation (CPR), or adrenaline administration in the emergency ambulance.

Although the time from arrival at the hospital to administration of adrenaline did not change after the introduction of the CB, the amount of adrenaline used in the ER tended to decrease.

Figure 3 shows the changes in the total number of medical staff and in the number of physicians, nurses, and co-medical staff (i.e., medical clerks, clinical engineers, and radiology technicians) gathered in the ER. After the introduction of the CB, the total number of medical staff and the number of staff from each professional group increased significantly.

Figure 4 shows the changes in the ROSC rate, survival to discharge rate, and social reintegration (patients with a Cerebral Performance Category of 1 or 2 were defined as having social reintegration) rate from before to after introduction of the CB [4, 5]. Although the changes were not statistically significant, all three rates increased.

Table 3 shows the change in the ROSC rate after introduction of the CB according to the location, pre-hospital care, cause, and electrocardiogram (ECG) findings at onset of each OHCA patient. Introduction of the CB did not lead to a change in ROSC rate according to the location of OHCA onset or whether or not pre-hospital care was provided. When analyzing the data on the cause of OHCA, the ROSC rate showed a nonsignificant increase in patients with OHCA due to cardiovascular disease. There was no significant change in ROSC rate among patients whose ECG at first contact showed asystole, pulseless electrical activity (PEA), or ventricular fibrillation (VF). However, when limited to patients whose ECG at first contact showed PEA or VF due to cardiovascular disease, the ROSC rate changed from 0% to 100% after the introduction of the CB.

Table 4 compares patients with and without ROSC. Factors influencing ROSC tended to include the total number of medical staff and the numbers of physicians and co-med-

Table 2. Characteristics of Patients With OHCA Admitted Before and After Introduction of the Code Blue System

	Before CB group[a], N = 30	After CB group[a], N = 30	P
Age (years), mean (SD)	81 (10)	79 (13)	0.456
Sex, male, n (%)	17 (57)	17 (57)	1.000
Hypertension, n (%)	22 (73)	24 (80)	0.549
Diabetes mellitus, n (%)	17 (57)	17 (57)	1.000
Cardiovascular disease, n (%)	5 (17)	5 (17)	1.000
Brain disease, n (%)	8 (27)	7 (23)	0.770
Dementia, n (%)	16 (53)	14 (47)	0.613
Treatment before arriving at the hospital			
Bystander CPR, n (%)	5 (17)	5 (17)	1.000
Adrenaline administration in the ambulance, n (%)	0 (0)	2 (7)	0.155
Amount of adrenaline used in ER (mg), median (IQR)	5.0 (3.0 - 7.0)	4.0 (3.0 - 5.0)	0.053
Time from arrival at hospital to administration of adrenaline (min), median (IQR)	4.0 (3.0 - 4.75)	3.0 (3.0 - 5.0)	0.588

[a]Patients in the After CB group (n = 30) were admitted from March 23, 2023, to July 31, 2024, and patients in the Before CB group, from March 30, 2022, to March 22, 2023. CB: Code Blue system; CPR: cardiopulmonary resuscitation; IQR: interquartile range; SD: standard deviation; OHCA: out-of-hospital cardiac arrest.

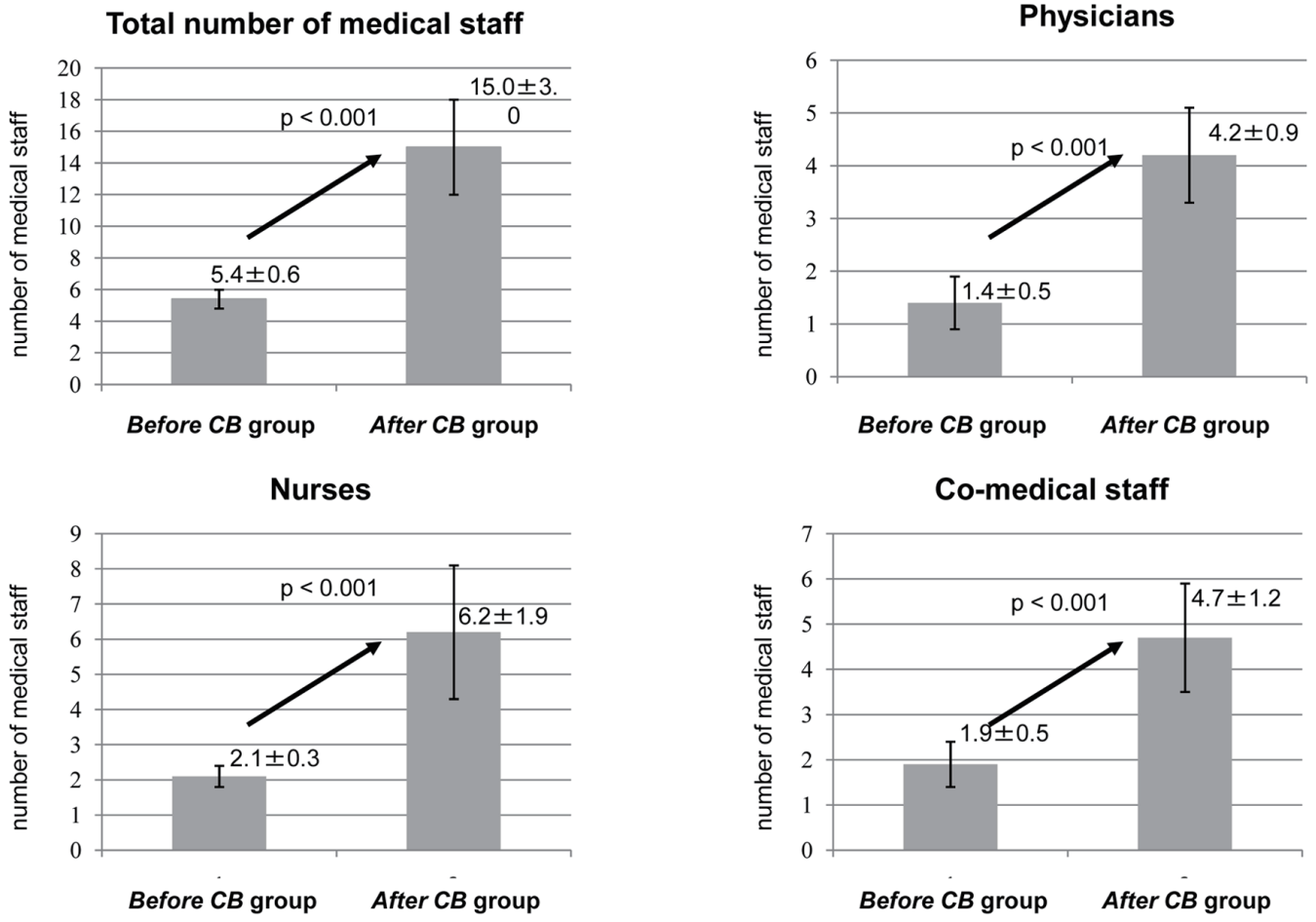

Figure 3. Changes in the number of medical staff present in the emergency room when out-of-hospital cardiac arrest patients arrived. CB: Code Blue system.

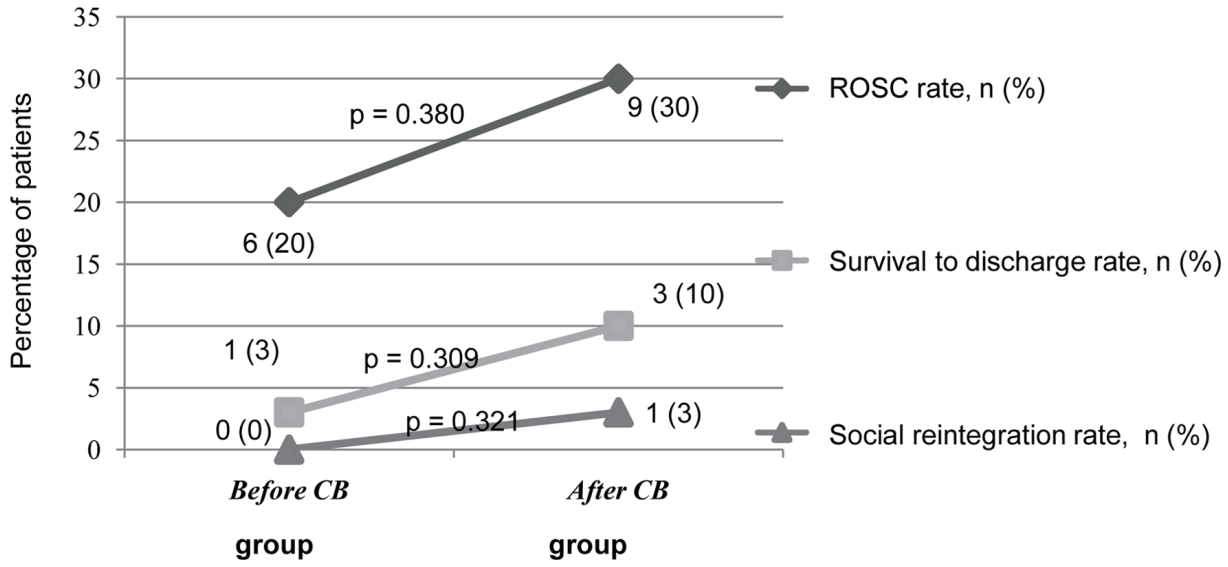

Figure 4. Changes in ROSC, survival to discharge, and social reintegration rates after introduction of the CB. ROSC: return of spontaneous circulation; CB: Code Blue system.

ical staff. Significantly less adrenaline was administered in patients with ROSC than in those without. An analysis of the 15 cases with ROSC showed that the amount of adrenaline administered in the ER tended to decrease after introduction of the CB (Table 5). In the analysis of the 45 cases without ROSC, the introduction of the CB tended to shorten

Table 3. Changes in ROSC Rate With the Introduction of the CB According to the Patients' Location at Onset of OHCA, the Presence or Absence of Pre-Hospital Care, the Causes, and ECG Findings

	ROSC rate for each condition		P
	Before CB group[a]	After CB group[a]	
Location at onset of OHCA			
Outdoors (n = 9), n (%)	0/3 (0)	2/6 (33)	0.316
Elderly care facility (n = 15), n (%)	2/10 (20)	1/5 (20)	1
At home (n = 36), n (%)	4/17 (24)	6/19 (32)	0.603
Pre-hospital care			
Bystander CPR (n = 10), n (%)	1/5 (20)	2/5 (40)	0.545
Adrenaline administration in the ambulance (n = 2), n (%)	0/0 (0)	1/2 (50)	-
Cause of OHCA			
Aspiration (n = 8), n (%)	1/3 (33)	4/5 (80)	0.244
Cardiovascular disease (n = 14), n (%)	0/7 (0)	3/7 (43)	0.055
Pulmonary disease (n = 12), n (%)	2/6 (33)	1/5 (20)	0.662
Cerebrovascular disease (n = 3), n (%)	0/0 (0)	0/3 (0)	-
Suicide, self-harm (n = 6), n (%)	1/4 (25)	0/2 (0)	0.541
Others (n = 17), n (%)	1/9 (11)	1/8 (13)	-
ECG findings at the time of OHCA detection			
Asystole (n = 45), n (%)	3/22 (14)	5/23 (22)	0.489
PEA (n = 13) or VF (n = 2), n (%)	3/8 (38)	4/7 (57)	0.483
Cardiovascular disease-related PEA (n = 3) or VF (n = 2), n (%)	0/0 (0)	5/5 (100)	-

[a]Patients in the After CB group (n = 30) were admitted from March 23, 2023, to July 31, 2024, and patients in the Before CB group, from March 30, 2022, to March 22, 2023. CB: Code Blue system; ECG: electrocardiogram; OHCA: out-of-hospital cardiac arrest; CPR: cardiopulmonary resuscitation; PEA: pulseless electrical activity; ROSC: return of spontaneous circulation; VF: ventricular fibrillation.

Table 4. Factors Affecting ROSC in Patients With OHCA

	ROSC (+), N = 15	ROSC (-), N = 45	P
Age (years), mean (SD)	83 (10)	79 (12)	0.265
Sex, male, n (%)	11 (73)	23 (51)	0.137
Number of staff in the ER			
Total, mean (SD)	12.2 (5.9)	9.6 (5.0)	0.095
Physicians, mean (SD)	3.4 (1.6)	2.6 (1.6)	0.076
Nurses, mean (SD)	4.9 (2.9)	3.9 (2.3)	0.194
Co-medical staff, mean (SD)	3.9 (1.9)	3.1 (1.5)	0.088
Pre-hospital care			
Bystander CPR, n (%)	3 (20)	7 (16)	0.695
Adrenaline administration in the ambulance, n (%)	1 (7)	1 (2)	0.415
Care in ER			
Amount of adrenaline used (mg), median (IQR)	2.0 (1.5 - 3.0)	5.0 (4.0 - 6.0)	< 0.001
Time from arrival at hospital to administration of adrenaline (min), median (IQR)	3.0 (2.5 - 4.0)	4.0 (3.0 - 5.0)	0.188

CPR: cardiopulmonary resuscitation; OHCA: out-of-hospital cardiac arrest; ROSC: return of spontaneous circulation; ER: emergency room; IQR: interquartile range; SD: standard deviation.

the time from arrival at the hospital to confirmation of death (Table 6).

Discussion

This retrospective study on the influence of introduction of a CB revealed that the introduction of the CB significantly increased the total number of medical staff, and the number of physicians, nurses, and co-medical staff present in the ER when the emergency ambulance arrived with an OHCA patient. Although not statistically significant, it also increased the ROSC, survival to discharge, and social reintegration rates. There was no change in the time from arrival at hospital to administration of adrenaline. The amount of adrenaline used in the ER tended to decrease. Furthermore, it tended to increase the ROSC rate in patients with OHCA due to cardiac disease. Before introduction of the CB, ROSC did not occur in any of

Table 5. Comparison of Patients With OHCA and ROSC Who Were Treated Before and After the Introduction of the CB

ROSC cases (n = 15)	Before CB group[a] (n = 6)	After CB group[a] (n = 9)	P
Amount of adrenaline used until ROSC (mg), mean (SD)	4.5 (4.3)	1.9 (1.1)	0.098
Time from arrival at hospital to ROSC (min), median (IQR)	11.5 (10.25 - 28.5)	11.0 (4.0 - 12.0)	0.287
Time from arrival at hospital to administration of adrenaline (min), median (IQR)	3.5 (3.0 - 4.0)	3.0 (1.0 - 5.0)	0.763

[a]Patients in the After CB group (n = 30) were admitted from March 23, 2023, to July 31, 2024, and patients in the Before CB group, from March 30, 2022, to March 22, 2023. CB: Code Blue system; OHCA: out-of-hospital cardiac arrest; ROSC: return of spontaneous circulation; IQR: interquartile range; SD: standard deviation.

Table 6. Comparison of Patients With OHCA and Non-ROSC Who Were Treated Before and After the Introduction of the Code Blue System

Non-ROSC cases (n = 45)	Before CB group[a] (n = 24)	After CB group[a] (n = 21)	P
Amount of adrenaline used until confirmation of death (mg), median (IQR)	5.3 (2.2)	4.8 (2.1)	0.382
Time from arrival at hospital to confirmation of death (min), median (IQR)	49.5 (31.0 - 62.5)	30.0 (20.0 - 49.0)	0.053
Time from arrival at hospital to administration of adrenaline (min), median (IQR)	4.0 (3.0 - 5.25)	4.0 (3.0 - 5.0)	0.694

[a]Patients in the After CB group (n = 30) were admitted from March 23, 2023, to July 31, 2024, and patients in the Before CB group, from March 30, 2022, to March 22, 2023. CB: Code Blue system; OHCA: out-of-hospital cardiac arrest; ROSC: return of spontaneous circulation; IQR: interquartile range; SD: standard deviation.

the patients with VF or PEA on ECG at first contact and cardiac disease, but after introduction of the system, all patients achieved ROSC. The factors that influenced ROSC tended to include the total number of medical staff and the number of physicians and co-medical staff. Significantly less adrenaline was administered in patients with ROSC than in those without it. In cases with ROSC, the amount of adrenaline administered tended to decrease after introduction of the CB. In cases without ROSC, the time to confirmed death tended to decrease after introduction of the CB.

The introduction of the CB enabled rapid notification of staff, reduced the time the ER chief nurse spent with communication tasks, and enabled adequate preparation and response. These changes can be expected to improve the ROSC rate because systemic management, including coronary artery assessment and temperature and circulatory management, contributes to outcomes after ROSC [6-9]. The introduction of a CB was found to improve the transition to integrated post-cardiac arrest care [9]. In the present analysis of 60 cases, although the introduction of the CB led to the presence of more staff in the ER and to an increase in ROSC, survival to discharge, and social reintegration rates, these changes were not statistically significant. However, the number of registered cases was small, so the study may have been underpowered.

Although the rate of social reintegration of OHCA patients is generally very low, the presence of a witness at the onset of cardiac arrest predicts a good outcome [10]. Favorable prognostic factors for unwitnessed cardiac arrest are younger age, ROSC during transport, chest compressions by the person who found the patient, and an indication of adaptation of electrical defibrillation on the initial ECG. If a Cerebral Performance Category of 1 or 2 at 30 days after the onset of OHCA is considered to be a good neurological prognosis [4, 5], in the present study, only one patient who was transported after bystander CPR and defibrillation with an automated external defibrillator (AED) fell into this category. However, the introduction of the CB was unlikely to be directly related to this result. Although only 17% of patients underwent bystander CPR, we found no change in ROSC rate with the introduction of the CB. The Hypothermia after Cardiac Arrest Study (HACA) study, which served as the basis for hypothermia therapy for OHCA patients, found high rates of around 50% for survival to hospital discharge and of good neurological prognosis [11]. These rates may have been the result of early withdrawal of CPR after neurological outcome assessment [12].

The geographic region covered by our facility does not have any advanced emergency medical facilities, and our hospital accepts a fairly large number of OHCA cases; however, the results of this study must be considered with the understanding that patients with VF or pulseless ventricular tachycardia and young patients tend to be transported to an emergency center approximately 10 km away that can perform extracorporeal CPR.

A secondary effect of introducing the CB was that support staff from departments other than the ER were able to regularly experience basic life support and advanced cardiac life support, which provided training in responding to emergencies within the hospital. Because nurse education progresses through stages such as noticing, interpreting, responding, and reflecting [13], education that includes hands-on experience through the CB was found to be effective. Additionally, members of the emergency ambulance staff commented that the fact that our hospital now has sufficient personnel waiting to accept OHCA patients gives them a sense of security.

The disadvantage of the CB is that when it is activated, other departments may be left with too few staff, which could disrupt normal operations. Furthermore, gathering too many staff can cause confusion, so a leader needs to take control. Another issue is that the CB is currently only used during day shifts, and during non-day shift hours, staff are still called to the ER by the traditional method. One study reported that organizing a medical emergency team in advance to respond to emergencies within a hospital is effective in reducing the number of in-hospital cardiac arrests and mortality rates [1]. It appears to be effective also for OHCA, but this approach is difficult for a medium-sized hospital like ours because establishing such a team requires a more flexible working system to ensure that a team is present at all times.

This study found no significant effect of adrenaline administration in the ambulance on the ROSC rate. Early administration of adrenaline is generally recommended in patients with non-shockable rhythms, and early administration of adrenaline to patients with OHCA before arrival at the hospital has been reported to improve life and neurological prognosis [14-16], although some studies found that it improves the ROSC rate but not neurological prognosis [17, 18]. Furthermore, a prolonged stay at the location where the OHCA occurs worsens patient prognosis [19, 20]. Ideally, a hospital is found quickly, and patients are rapidly transported there; however, it is not always possible to immediately find a hospital that will accept a patient. In any case, it is advisable that adrenaline is administered as soon as possible after the patient arrives at the hospital. In this study, introduction of the CB did not shorten the time from arrival at the hospital to administration of adrenaline, but this may have been because the time was already sufficiently short (3.3 min). However, we assume that introduction of the CB and the associated increase in available manpower allowed simultaneous securing of peripheral blood vessels and central lines for administering adrenaline. The CB may also improve early advanced airway management, which in turn may improve neurological outcome [21]; although the present study did not consider airway management, the introduction of the CB may have made endotracheal intubation smoother.

In this study, bystander CPR was performed in 17% of OHCA patients and more frequently in patients in elderly care facilities (40%) than in those where the OHCA occurred outdoors or at home (9%; $P < 0.005$; data not shown). There was no significant difference in ROSC rate between patients with and without bystander CPR. A smooth chain of care is necessary to save the life of someone experiencing OHCA [20], and as the first step, bystander CPR is crucial. This study found that although bystander CPR was performed more frequently in elderly care facilities than in the outdoors or at home, the rate was not high enough in view of the fact that such facilities have paramedical staff. The reason for this may be that these facilities house elderly people with chronic diseases, so staff members have insufficient awareness of and ability to respond to OHCA. In addition, the age of the OHCA patients at the

facilities (89.7 ± 6.5) was higher than that of patients who experienced OHCA outdoors or at home (76.9 ± 11.0), and staff at the facilities may have been hesitant to resuscitate patients (data not shown). However, elderly care facilities generally do not have a system such as a rapid response system [2] for treating patients whose condition suddenly worsens. In fact, current policies for dealing with sudden changes in patients' conditions are often not widely known and are unclear within elderly care facilities.

The survival rate of OHCA patients is high when the public has access to an AED [22], and it has improved with the widespread use of AED [23]. Furthermore, verbal instructions from telecommunicator CPR were found to be an effective means of increasing the rate of bystander CPR [24]. In addition to providing resuscitation training to the general public, there is a need to increase opportunities for self-learning [25], focus on early recognition of OHCA [26], and provide training in chest compression-only CPR [27].

The analysis of cases without ROSC found that introduction of the CB tended to shorten the time from arrival at the hospital to confirmation of death. We considered that introduction of the CB enabled the decision to terminate resuscitation to be made more quickly, since more physicians and staff members were present and able discuss the situation. In OHCA cases, conditions such as the absence of witnesses, no indication for defibrillation on the initial ECG, defibrillation not being performed, and absence of ROSC before arrival at the hospital were reported to indicate a very poor prognosis and require consideration of termination of resuscitation [28-32].

Unfortunately, most of the OHCA patients enrolled in this study fell into one of the categories in which termination of resuscitation is recommended. Therefore, the data may indicate that there is no point in improving OHCA response after patients arrive at the hospital, as was done with the introduction of the CB. However, we believe that introduction of the CB may improve the chance, although rare, that some patients will be able to return to society. Achieving ROSC also gives the patient's family time to accept the patient's condition. Unfortunately, the vast majority of OHCA patients die, but providing adequate medical care promptly at the end of life may alleviate the family's regret. Furthermore, it is important to note that the hospital staff improved their ability to respond to sudden changes in the condition of patients. The consequences of improving a CB and striving for ROSC need to be comprehensively evaluated across the entire medical system.

Conclusions

There is surprisingly little literature on the preparation of hospitals to accept OHCA cases. Most OHCA patients are transported to emergency medical centers that have ample staff, so even if medium-sized hospitals have implemented various measures, these may not be reported in the literature. Although not statistically significant, the introduction of the CB increased the ROSC rate and resulted in some patients surviving to hospital discharge. The introduction of the CB was expected to improve the quality of medical care by convening medical staff more quickly and allowing multiple professions to perform their predefined tasks within the scope of their expertise. We plan to continue to work on improving the CB at our hospital and to provide high-quality emergency medical care to the local community.

Study limitations

This study has some limitations. It was a retrospective study and performed at a single center. Furthermore, the number of enrolled cases was small, so that study may have been underpowered. Initially, although we felt that the introduction of CB had significantly improved the ROSC rate, the ROSC rate had not changed significantly when we actually performed statistical analysis. Therefore, the expected sample size was calculated to be small. Also, the prescribed study period could not be extended. Since our CB system was defined as being activated in OHCA patients including those with ROSC after cardiac arrest and those with post-resuscitation shock, we suggested that including cases who had already achieved ROSC in this study would be biased.

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Conflict of Interest

The authors have no conflict of interest directly relevant to the content of this article.

Informed Consent

Because the study retrospectively collected information from medical records, informed consent was not required.

Author Contributions

Youichi Inoue: study design, data collection, data interpretation, manuscript preparation, and literature search. Keisuke Okamura: study design, data collection, statistical analysis, data interpretation, manuscript preparation, and literature search. Hideaki Shimada, Osamu Imakyure: study design. Shinobu Watakabe, Shiori Hirayama, Machiko Hirata, Ayaka Kusuda, Arisa Matsumoto, Miki Inoue, Emi Matsuishi, Mizuki Yamada: study design, data collection, and data interpretation. Sachiko Iwanaga, Shogo Narumi, Shiki Nakayama, Hideto

Sako, Akihiro Udo, Kenichiro Taniguchi, Shogo Morisaki, Souichiro Ide, Yasuyuki Nomoto, Shin-ichiro Miura, Ichiro Imamura: data interpretation.

Data Availability

Any inquiries regarding supporting data availability of this study should be directed to the corresponding author.

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