Rapid Response System in a University Hospital: A Five-Year Trend

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Abstract

Background: The rapid response system (RRS) aims to prevent unexpected cardiac arrest by responding to the deteriorating condition of hospitalized patients at an early stage. In this study, we evaluated the status of the RRS 5 years after its introduction in St. Marianna University School of Medicine Hospital.

Methods: We retrospectively analyzed the medical emergency team (MET) request data of our hospital for the period of June 2010–May 2015. We compared the status of the RRS before and after the introduction of the critical care outreach team (CCOT) in August 2014.

Results: There were 197 MET requests over the five-year period, with an increasing trend in the number of requests. Acute altered mental status was the most common reason for MET activation, followed by oxygen desaturation (measured by a pulse oximeter) < 90%, hypotension (blood pressure <90 mmHg), and cardiopulmonary arrest (CPA). The general ward requested the MET most frequently (62.9%). Overall, 47.7% of MET-activated patients were transferred to intensive care unit, and 21.3% were “non-transfer” cases. MET activation by general wards (55.6% vs. 78.1%, P=0.0017) and MET activation by CPA significantly increased (9.0% vs. 29.7%, P=0.0003) after the introduction of the CCOT, while the one-month survival/survival-to-hospital discharge rate significantly decreased (75.2% vs. 57.8%, P=0.0143).

Discussion and Conclusion: Over the 5 years, the number of MET requests increased, especially after the introduction of the CCOT. When RRS was required due to cardiopulmonary arrest, the patient’s condition had already deteriorated, and this was considered to have reduced the survival rate of RRS-activated patients. Comparing the data before and after the introduction of CCOT showed results different from the expected effect of RRS, probably because the RRS is usually triggered after a patient’s condition clearly deteriorates. In the case of a cardiopulmonary arrest, when the patient’s condition had already deteriorated and the number of CPA-related requests increased, a decrease in the survival rate was considered. Therefore, efforts must be made to request MET at an earlier stage and to use the Code Blue System to enable an earlier response for cases of cardiopulmonary arrest.

Keywords
Rapid response system, medical emergency team, critical care outreach team, cardiopulmonary arrest, 1-month survival/survival to discharge rate

Introduction

Several reports have shown that signs that indicate risk to life often appear within six to eight hours prior to the onset of cardiopulmonary arrest (CPA) during hospitalization¹.². Notably, 9.2% of hospitalized patients are reported to experience adverse events during hospitalization, of which 43.5% can be

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The rapid response system (RRS), in which physicians and nurses in the intensive care unit (ICU) go to general wards for early emergency response, is considered effective for combating these early signs of deterioration to prevent unexpected CPA. This system has been introduced in many hospitals in the United States and Australia, and is recommended by the American Heart Association. In Japan, the RRS is also recommended by the Japanese Coalition for Patient Safety, which started in 2008. The use of the RRS has been spreading across Japanese hospitals. However, in order to use RRS as part of a hospital system, it is necessary to solve certain problems, such as how nurses in general wards can recognize the deterioration of a patient’s condition, how to activate the RRS and call the medical emergency team (MET) without hesitation, and how quickly the MET can reach the patient’s bedside. It is not quite easy for nurses to accept the instructions of the MET, therefore, it is essential to obtain cooperation of medical staff in the entire hospital to implement the RRS, particularly right after the system is introduced.

The RRS was introduced in St. Marianna University Hospital in 2010. For the purpose of clarifying the changes after the establishment of RRS in the hospital, we retrospectively examined the afferent and efferent components, and the status of the RRS in our hospital for the initial 5 years after the introduction of the system, particularly the operation of the MET.

### Methods

#### Study site

St. Marianna University Hospital is a teaching hospital with 1,208 beds (at the time of 2010), located in northern Kawasaki City. The population of the target medical area is about 840,000 and the total number of hospitalized patients per year is about 320,000. In 2015, there were 30 departments and wards in the hospital, including the general ward; the attached emergency and critical care center included 10 beds in the ICU, six beds in the coronary care unit (CCU), four beds in the stroke care unit (SCU), and 32 beds in the high care unit (HCU).

#### Introduction of RRS

The RRS usually consists of four components: the afferent limb, efferent, process improvement, and administrative components. The RRS of St. Marianna University Hospital is based on the single-parameter criterion (Table 1) as the launch criterion of the component; it also handles responses to in-hospital CPA. The efferent limb of the RRS is the MET, which consists of emergency physicians and nurses that work in the emergency and critical care center. Based on the consensus on RRS at the International Conference on Medical Teams in 2005, the MET is initially contacted through a dedicated Personal Handyphone System (PHS) in the hospital to reach patients within 15 minutes anywhere in the hospital. Upon request, the MET examines the patient at the request site and takes necessary action, and after the patient has been stabilized, the patient is transferred to the ICU.

Depending on the condition of the patient, the site of request, and the judgment of the MET physician, the sites of follow-up observation are decided if needed. The RRS meeting is held once a month to discuss problems in the MET dispatch; the Medical Safety Management Office in the hospital is responsible for the administrative component of the RRS.

The RRS was established in St. Marianna University Hospital in June 2010 for 10 out of 30 departments and wards in the hospital, including the general ward; however, it was expanded to all 30 departments and wards in April 2012. In August 2014, the critical care outreach team (CCOT) began its activities. The CCOT was led by nurses trained in intensive care who regularly visited hospitalized pa-

### Table 1. Indications for RRS Activation Calls

| General condition | Signs |
|-------------------|-------|
| Respiratory       | Respiratory rate, ≤8 breaths/min or ≥28 breaths/min Oxygen saturation, <90% |
| Circulation       | Systolic blood pressure, <90 mmHg Heart rate, ≤40 beats/min or ≥130 beats/min |
| Urinary           | New onset of urine output decrease, ≤50 ml/4 h |
| Neurology         | Sudden altered mental status |

RRS, rapid response system.
tients that left the ICU or patients who had some concerns. The activities of the CCOT were aimed at early detection of patients who met the activation criteria.

Data Collection
RRS data for the period from June 1, 2010 to May 31, 2015 were retrospectively collected using the RRS activation records and the electronic medical records of the hospital. The following information were collected: age, sex, RRS activation number, reason for RRS activation, department and ward that activated the RRS, duration from the time of activation to the arrival of the MET, transfer destinations, number (rate) of one-month survival/survival to hospital discharges of the MET request patients. The one-month survival/survival-to-hospital discharge rate is the survival rate for the first month calculated from the date of admission or survival and the discharge rate if already discharged. This study was approved by the Ethics Committee of St. Marianna University School of Medicine (Approval No. 2498).

Statistical Analysis
JMP®14 was used for statistical analysis; the chi-square test was used to analyze categorical variables, and Fisher’s exact test was used for values within categories of less than 10. Continuous variables were expressed as mean ± standard deviation (SD) for age and time, and median [quartile range] for the rest; they were analyzed using the Wilcoxon’s rank sum test. P < 0.05 was considered statistically significant.

Results

There were 197 RRS activations during the five-year period; the details are shown in Table 2. The mean age of the patients was 64.0 ± 18.8 years, with men accounting for 49% of the 197 patients. The most common reason for activation was acute altered mental status, followed by oxygen desaturation measured by a pulse oximeter (SpO₂ < 90%), hypotension (blood pressure < 90 mmHg), and CPA (27.4%, 23.4%, 16.8%, and 15.7%, respectively). Regarding the RRS activation sites, 124 cases (62.9%) were activated in the general ward, 40 cases (20.3%) in the radiology department, and 16 cases (8.1%) in the outpatient department. The mean duration from time of dispatch to arrival of the MET was 4.4 ± 3.9 minutes. The transfer destination was the ICU/CCU/SCU in 94 cases (47.7%), whereas in 42 cases (21.3%), the patients remained at the original sites of activation.

The one-month survival/survival-to-hospital discharge rate for patients who required the intervention of the MET was 69.5% (137 cases).

The changes in the reason for RRS activation over 5 years is shown in Figure 1. Specifically, there was no case of CPA during the first 3 years after the establishment of the RRS, whereas 7 cases were recorded in the fourth year (June 2013 to May 2014) and 24 cases in the fifth year (June 2014 to May 2015). The number of MET requests from the departments and wards is shown in Figure 2. MET requests from general wards were the most common, regardless of the year. Figure 3 shows the overview of the condition of the patients after the intervention of the MET. Cases of transfer to the ICU/CCU/SCU were the most common, regardless of the year.

A summary of the comparison of the status of the RRS before and after the CCOT began its activities is shown in Table 3. The number of MET requests due to CPA significantly increased after the CCOT commenced their activities (9.0% vs. 29.7%, P=0.0003), whereas requests due to acute altered mental status significantly reduced (33.1% vs. 15.6%, P=0.0078). There was a significant increase in the number of MET requests by the general wards (55.6% vs. 78.1%, P=0.0017); and, there was no significant change in the duration from the time of dispatch to the arrival of the MET (4.8 ± 4.4 min vs. 3.6 ± 3.0 min, P=1.0000). Regarding patient disposition after MET intervention, there was a significant reduction in the number of transfers to emergency department (26.3% vs. 9.4%, P=0.0080) and in the one-month survival/survival to hospital discharge rate (75.2% vs. 57.8%, P=0.0143).

Discussion
This study involved the retrospective investigation of the state of the RRS in St. Marianna University Hospital during the first 5 years after its introduction. In those 5 years, the number of MET requests increased, especially after the introduction of the CCOT. After the introduction of CCOT, the number of MET requests due to acute change of mental status reduced, the number of CPA-related requests increased, and there was a tendency to shift from the emergency department to the ICU/CCU/SCU as a transfer destination, and there was a significant decrease in the one-month survival/survival to discharge rate.

Out of the four components of the RRS, the afferent and efferent components, both of which di-
Table 2. Status of the RRS

| Reason for MET request                  | N (%)     |
|-----------------------------------------|-----------|
| Acute change in mental status           | 54 (27.4) |
| SpO₂<90                                 | 46 (23.4) |
| Hypotension (blood pressure< 90 mmHg)  | 33 (16.8) |
| CPA                                     | 31 (15.7) |
| Provider worried                        | 16 (8.1)  |
| Respiratory rate ≥28 or ≤8/min          | 9 (4.6)   |
| Heart rate ≥130 or ≤40/min              | 8 (4.1)   |

| Department requested MET               | N (%)     |
|-----------------------------------------|-----------|
| General ward                            | 124 (62.9)|
| Radiology department                   | 40 (20.3) |
| Outpatient department                   | 16 (8.1)  |
| Others                                  | 17 (8.6)  |

| Disposition by MET                     | N (%)     |
|-----------------------------------------|-----------|
| Transfer to ICU/CCU/SCU                 | 94 (47.7) |
| No transfer                             | 42 (21.3) |
| Transfer to ED                          | 41 (20.8) |
| Transfer to HCU                         | 14 (7.1)  |
| Transfer to Others                      | 6 (3.1)   |

| Duration from time of MET request to arrival (min) | 4.4±3.9 |
| Survival to discharge or one-month survival N (%) | 137 (69.5) |

- SpO₂, oxygen saturation; min, minutes; RRS, rapid response system; MET, medical emergency team; CPA, cardiopulmonary arrest; ICU, intensive care unit; CCU, coronary care unit; SCU, stroke care unit; HCU, high care unit; ED, emergency Department

rectly involve the patient, are considered to be particularly important. The afferent component consists of RRS activation by a healthcare provider, especially a nurse, who directly observes and monitors the patient. The RRS activation will be initiated when certain criteria are met; this is determined by evaluating the clinical situation, particularly the patient’s vital signs. It is the mainstream practice in Japan to use the single parameter criteria, and in our hospital, the single parameter criteria has been used since the introduction of the RRS (Table 1). However, whether or not to actually request a MET based on this standard largely depends on the situational awareness of the nurses⁹; it is thought that the number of requests is likely to be lower due to hesitation or reluctance to request an MET¹⁰. This seemed to frequently be the case in the early stages after the introduction of the RRS. Moreover, in this early stage, it is reasonable to
A Provider worried
B Heart rate, ≥130 or ≤40/min
C Respiratory rate, ≥28 or ≤8/min
D Hypotension (blood pressure, <90 mmHg)
E Acute change of mental status
F Oxygen saturation measured by a pulse oximeter, <90%
G Cardiac arrest

Figure 1. Changes in the reasons for activation of the rapid response system (RRS) over 5 years
Vertical axis: number of RRS activation events, horizontal axis: time (every year)

Figure 2. Changes in the activation of the rapid response system (RRS) in the divisions and wards
Vertical axis: number of RRS activation events, horizontal axis: time (every year)
consider that a MET request is easier to initiate without hesitation in “cases in which the deterioration of the clinical condition is obvious,” like in CPA cases for example, than in “cases in which the deterioration of the clinical condition is anticipated due to the deterioration of the vital sign.” Although the number of MET requests increased gradually, RRS activation for CPA was not reported at all for 3 years after the introduction of the system. MET requests by the general ward nurse increased during the 2 years after this period, especially RRS activation for CPA. In addition, this tendency was more remarkable before and after the introduction of CCOT, and it seems to be related to the method of the dissemination of education on RRS in the general ward, but it is possible that it has not led to the prediction of CPA. This is considered to be the limitation of RRS, and it is important to activate Code Blue System which enables earlier response to cases of CPA and separate Code Blue System from RRS.

Regarding the efferent component of the RRS, the duration from the time of RRS activation to the arrival of the MET team did not change significantly. Two hospitals with more than 100,000 hospitalizations per year reported that it took an average of 2.4 ± 0.1 minutes for the MET to arrive at the activation site\(^{11}\). However, this is a recent report from a hospital with considerable experience in the use of the RRS; therefore, it is difficult to compare our findings with theirs because our hospital commenced the use of RRS relatively recently. Devita et al. set a target of 15 minutes or less from the time of RRS activation to the arrival of the MET\(^{8}\), whereas Fujitani et al. listed what should be done by the activator within 5 minutes from the time of activation to the arrival of the MET\(^{9}\). Findings of this study indicate that the response times in our hospital were relatively good, with an average of 4.5 ± 4.1 minutes for the entire five-year period and 3.5 ± 2.9 minutes for the last year. In addition, patients transferred as a result of MET interventions were less frequently transferred to the emergency department and more frequently transferred to the ICU/CCU/SCU; this finding was statistically significant for the periods before and after the introduction of the CCOT. This seems to be related to the increase in the number of MET requests by the general ward. In general, there seemed to be a higher possibility that a MET request for a patient who was
### Table 3. Comparison of the Status of the RRS before and after the Introduction of the CCOT

|                  | Before CCOT started | After CCOT started | P   |
|------------------|---------------------|--------------------|-----|
|                  | N=133               | N=64               |     |
| Age              | 62.5±19.1           | 67.0±18.0          | 0.1238 |
| Sex              | Male/Female 66/67   | 30/34              | 0.7176 |
| Reason for MET call |                   |                    |     |
| CPA              | 12 (9.0)            | 19 (29.7)*         | 0.0003 |
| SpO₂<90%         | 28 (21.1%)          | 18 (28.1)*         | 0.2850 |
| Acute change of mental status | 44 (33.1) | 10 (15.6)* | 0.0078 |
| Hypotension (blood pressure < 90 mmHg) | 24 (18.1) | 9 (14.1)* | 0.4778 |
| Provider worried | 11 (8.3)            | 5 (7.8)*           | 1.0000 |
| Respiratory rate ≥28 or ≤8/min | 7 (5.3)  | 2 (3.1)*        | 0.7208 |
| Heart rate ≥130 or ≤40/min | 7 (5.3)  | 1 (1.6)*        | 0.4414 |
| Department that requested the MET |                  |                    |     |
| General ward     | 74 (55.6)           | 50 (78.1)*         | 0.0017 |
| Radiology department | 32 (24.1) | 8 (12.5)*     | 0.0509 |
| Outpatient department | 14 (10.5) | 2 (3.1)*      | 0.0962 |
| Others           | 13 (9.8)            | 4 (6.3)            | 0.5892 |
| Disposition after the MET intervention |                  |                    |     |
| Transfer to ICU/CCU/SCU | 60 (45.1) | 34 (53.1)*       | 0.2917 |
| No transfer      | 29 (21.8)           | 13 (20.3)*         | 0.8102 |
| Transfer to HCU  | 7 (5.3)             | 7 (10.9)*          | 0.1591 |
| Transfer to ED   | 35 (26.3)           | 6 (9.4)*           | 0.0080 |
| Transfer to others | 2 (1.5)           | 4 (6.3)*          | 0.0818 |
| Duration from time of MET request to arrival |                  |                    | 1.0000 |
| Survival to discharge or one-month survival |                  |                    | 0.0143 |

SpO₂, oxygen saturation; min, minutes; RRS, rapid response system; CCOT, Critical care outreach team; MET, medical emergency team; CPA: cardiopulmonary arrest; ICU, intensive care unit; CCU, coronary care unit; SCU, stroke care unit; HCU, high care unit; ED, emergency department

already hospitalized was more serious than that for a patient in the outpatient department. We believe that this was as a result of the increased awareness of the staff working in the general wards and increased MET requests from there. Furthermore, since there is a tendency to be transferred to the ICU/CCU/SCU instead of the ER, it is probable that patients who needed continuous management in the critical ward were targeted for activation rather than temporary treatment in the ER. That is, it has become possible to pick up critically ill patients in the general ward.

The one-month survival/survival to discharge rate for the patients who required the RRS declined throughout the study period, even though the RRS should prevent unexpected deaths and worsening conditions during hospitalization. However, regarding the initial period after the introduction of RRS, which was the subject of this study, we considered that it is difficult to show the prognosis-improving effect of the RRS because the users were not familiar with the operation of the RRS. In addition, in-hospital deaths that were considered a natural prognosis and were not reported has been reported as unexpected deaths after RRS introduction. As a result, that may influence the
survival rate which appears to be decreased. For patients who required the RRS, early intervention, including transfer to the ICU, is expected to improve the prognosis; however, presently, the effect of RRS on prognosis is unclear. Additionally, in the general ward, the extraction and transfer of severely ill patients is expected to improve the overall prognosis. However, a retrospective study of in-hospital cardiac arrest after the start of RRS and the intervention of the MET indicated that the patient’s condition had already deteriorated when the RRS was activated. It is possible to identify critically ill patients in our hospital. However, this led to an increase in CPA-related requests. Therefore, it was important to activate RRS at an earlier stage before any deterioration to CPA which was the original purpose of RRS; which should be separated from Code Blue.

Overall, during the first 5 years of utilizing RRS in our hospital, the number of MET requests in general wards has increased, reflecting the widespread understanding of RRS. Even if the patient showed signs of deterioration, MET tended to be requested after the deterioration became apparent due to reluctance or hesitation, and there was a tendency for it to be requested after the deterioration became apparent. Thus, the proportion required by CPA has increased, leading to a decrease in survival rate. It is important to understand the appropriate use of RRS, which responds rapidly to the signs of deterioration and the Code Blue System, which responds rapidly to cases of CPA.

There were some limitations in this study. First, this was a retrospective observational study. Thus, the presence of an association between RRS and patient prognosis does not indicate a causal relationship. Second, this study evaluated the results of the initial utilization of RRS in a single institution. Since the use of the system is in the relatively early stage, the RRS may not be fully utilized yet. For example, even in cases where the RRS activation criteria were met, it may not have been activated in some cases. Particularly, the significant differences between the frequency of activation and the percentage of activation by the departments before and after the introduction of the CCOT, even when the activation criteria were the same, indicate that there may be subjective differences in the MET requests by general ward nurses.

**Conclusion**

During the first 5 years of utilizing RRS in our hospital, it became possible to identify critically ill patients, and the number of MET requests in the general wards increased; however, there has also been an increase in CPA-related requests. It is important to understand the appropriate activation of RRS at an earlier stage and the use of the Code Blue system for CPA cases.

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**Conflicts of Interest**

The authors have nothing to disclose.

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