Original Article

Reduction of unexpected serious adverse events after introducing medical emergency team

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Aim: To assess the clinical benefits of introducing a medical emergency team system for early medical intervention in hospital care.

Methods: This prospective analysis included all cases of medical emergency team activation during the first year after the introduction of the medical emergency team system at Chiba University Hospital (Chiba, Japan) in February 2011. The rates of in-hospital mortality and unexpected events before and after introduction of the medical emergency team system were compared.

Results: The total number of medical emergency team activation calls was 83 (4.9 per 1,000 admissions). The activation of the medical emergency team system was requested most frequently from the general ward (56.6%) and by a physician (57.8%), with the most important reasons for activation being cardiac arrest (37.3%), breathing abnormality (33.7%), and impaired consciousness (32.5%). The most frequent medical interventions by the medical emergency team were intubation (43.3%) and oxygen inhalation (41.0%). Approximately one-half of the patients requiring activation of the medical emergency team system were critically ill and needed subsequent intensive care unit admission. Although no significant difference was observed between the pre- and post- medical emergency team in-hospital mortalities (2.1% versus 2.0%, respectively), the incidence rate of serious events significantly decreased (12.4% versus 6.8%, respectively; $P = 0.015$).

Conclusion: Most patients requiring activation of the medical emergency team system were critically ill and needed emergency treatment at the location of the medical emergency team activation, with subsequent critical care. Although the introduction of the medical emergency team system did not affect the in-hospital mortality rate, it reduced the incidence of unexpected serious adverse events, suggesting that it may be clinically useful.

Key words: Medical emergency team, other, rapid response system

INTRODUCTION

IN CONTRAST TO the recent marked improvement in prognosis after out-of-hospital cardiac arrest, improvement in prognosis after in-hospital cardiac arrest remains minimal.[1,2] Abnormal changes in vital signs are commonly observed several hours preceding a cardiac arrest.[3,4] In recent years, rapid response systems (RRS) have been introduced in hospital care, to prevent unexpected sudden changes in the patient's condition and unexpected in-hospital cardiac arrest.[5] Although the clinical benefits associated with the introduction of RRS has been evaluated using various parameters such as in-hospital mortality, Code Blue (used to alert the whole hospital staff that a sudden cardiac arrest has occurred and resuscitation is needed) rates, and unexpected events, they remain to be established.[6–13]

The term RRS is used to describe a whole system dedicated to provide patient safety for those in a deteriorating condition. RRS are based on four components: afferent (event detection and response triggering) component, efferent (crisis response) component, patient safety/process improvement component and governance/administrative component. An RRS team consists of either a medical emergency team (MET), mostly led by a physician being able to initiate critical care at the bedside, or rapid response team, mostly led by a nurse.[14]

In February 2011, we introduced the MET system, consisting mainly of physicians and nurses belonging to the department of Emergency and Critical Care Medicine. In

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this study, all cases of MET activation that occurred in the first year after the introduction of MET were analyzed for the patients' background, condition at the time of MET activation, and details of the medical interventions carried out. Additionally, the in-hospital mortality rates and unexpected events before and after the introduction of the MET system were compared to assess the clinical benefits of MET.

METHODS

Medical emergency team

IN FEBRUARY 2011, Chiba University Hospital (Chiba, Japan) introduced the MET system—in addition to the Code Blue emergency call system—to address sudden in-hospital changes in the clinical condition of patients, and simultaneously initiated the collection of prospective data. The MET system at Chiba University Hospital consists of physicians belonging to the department of Emergency and Critical Care Medicine and ICU nurses. Any hospital staff, regardless of their occupation, is allowed to activate the MET system according to pre-defined MET activation criteria. The MET system can be activated for inpatients and outpatients, as well as any individuals within the hospital compound, including visitors, hospital staff, and vendors. The MET activation criteria are as follows: airway obstruction in need of emergent airway management (e.g., asphyxia), respiratory insufficiency, shock, drastically depressed level of consciousness, trauma, unexpected cardiac arrest, a risk of these conditions, and any other deteriorating condition that the discoverer considered in need of MET activation (Table 1). These criteria were made to identify patients who are in a deteriorating condition or are at risk of a deteriorating condition. The MET system is activated by calling a dedicated extension number directly connected to the in-hospital personal handyphone system device carried by the attending physician of the department of Emergency and Critical Care Medicine. The MET activation call is simultaneously broadcasted to the ICU, emergency room, and physician's lounge through pre-installed loudspeakers, to inform all MET members of the place where the unexpected in-hospital clinical instability was identified, the patient's conditions, and any other related information. Medical emergency team members bring a bag containing pre-specified pharmaceuticals and medical devices that are regularly stocked in the ICU to the place requested by the activation call and initiate medical practice using the nearest emergency cart. The diagnosis and treatment are carried out in parallel with attempts to stabilize the patient's condition, and subsequently determine the patient's disposition. The present study was approved by the Ethical Review Board of the Graduate School of Medicine, Chiba University.

Table 1. Criteria for medical emergency team activation

Airway obstruction
Dyspnea
Hypotension
Altered conscious state
Trauma
Cardiac arrest
Staff concerned that deteriorating conditions are developing

Subjects

At Chiba University Hospital, there are 835 beds in total, including 22 ICU beds (4 cardiac, 18 medical/surgical), with 740 physicians and dentists treating a total of 1,985 outpatients and 761 inpatients daily, on average (as of fiscal year 2012).

Our subjects included all patients for whom MET activation was requested between February 2012 and January 2013. First, the number of MET activation calls per unit number of hospital admissions was calculated for this period. The following parameters were subsequently recorded for each case of MET activation: background of the patient for whom MET activation was requested (MET-activated patients), location of the MET activation, the activator's occupation, reason for the MET activation, the patient's condition and emergency treatment given on MET arrival, the patient's disposition, and survival outcome.

The period before MET introduction (from February 2011 to January 2012) was defined as the pre-MET period; the period after MET introduction (from February 2012 to January 2013) was defined as the post-MET period. Data for pre-MET period were collected retrospectively. The pre-MET and post-MET in-hospital mortality rates were calculated separately for comparison, by dividing the number of in-hospital deaths by the number of hospital admissions. The sum of the number of unexpected life-threatening events (including airway, breathing, hemodynamic, and consciousness abnormality in which resuscitative treatment was urgently carried out) and the number of unexpected cardiac arrests—both occurring for any reason other than deterioration of the underlying disease—was defined as the number of total serious events. The pre-MET and post-MET incidence rates of unexpected life-threatening events, unexpected cardiac arrests, and total serious events among in-hospital deaths were separately calculated for comparison.

Statistical analysis

The in-hospital mortality, as well as the incidence of unexpected life-threatening events, unexpected cardiac arrests, and total serious events before and after introduction of MET were compared using the χ^2-test. A commercial package software, GraphPad Prism 4 (GraphPad Software Inc., San Diego, CA, USA), was used for all statistical analyses. *P*-values <0.05 were considered significant.

RESULTS

THE TOTAL NUMBER of MET activation calls during the first year after the introduction of the MET system (February 2012–January 2013) was 83. Given that the total number of hospital admissions during this period was 16,844, the mean number of calls per 1,000 admissions was calculated to be 4.9.

Table 2 summarizes the background characteristics of patients requiring MET activation (mean age, 57.0 years; male, 44.6%). The most frequent underlying disease was chronic heart failure (28.9%), followed by respiratory disease (15.7%). Medical emergency team activation was requested most frequently from the general ward (56.6%) and by a physician (57.8%) (Table 3).

Table 4 shows the condition of the patients and treatment given on MET arrival. The major abnormalities in the vital signs were a decreased O_2 saturation level and decreased level of consciousness. The most frequently encountered medical problems were cardiac arrest (37.3%), breathing abnormality (33.7%), and impaired consciousness (32.5%). The most frequent medical interventions by the MET were

Table 2. Characteristics of patients requiring medical emergency team activation

Age, years	57.0 (11.3)
Male, *n* (%)	37 (44.6)
Inpatients, *n* (%)	55 (66.3)
Surgical, *n* (%)	34 (41.0)
Pre-existing conditions, *n* (%)	
Chronic heart failure	24 (28.9)
Chronic pulmonary disease	13 (15.7)
Chronic liver disease	7 (8.4)
Chronic renal failure	10 (12.0)
Chronic brain disease	10 (12.0)
Chronic corticosteroid use	13 (15.7)
Pulse steroid therapy	5 (6.0)
Chemotherapy	11 (14.5)
Other immune suppression	5 (6.0)
Diabetes	7 (8.4)
Hematologic disorder	7 (8.4)
Solid malignancy	3 (3.6)

Data are mean (standard deviation) for continuous variables.

Table 3. Location of medical emergency team activation and activator's occupation

Location of activation, *n* (%)	
General wards	47 (56.6)
Outpatients department	18 (21.7)
Computer tomography scan room	4 (4.8)
Angiography suite	3 (3.6)
Hallway	2 (2.4)
Emergency room	1 (1.2)
Operating room	1 (1.2)
Dialysis room	1 (1.2)
Others, inside hospital	3 (3.6)
Others, in the vicinity of the hospital	2 (2.4)
Caller's occupation, *n* (%)	
Physician	48 (57.8)
Nurse	19 (22.9)
Other	16 (19.3)

Table 4. Condition of patients and treatments needed on medical emergency team arrival

Vital signs	
Heart rate	99 (35)
Systolic blood pressure, mmHg	115 (43)
Diastolic blood pressure, mmHg	69 (27)
O_2 saturation, %	88 (12)
Respiratory rate, breaths/min	22 (10)
Glasgow Coma Scale	10 (5)
Medical problems, *n* (%)	
Airway abnormality	14 (16.9)
Breathing abnormality	28 (33.7)
Hemodynamic abnormality	16 (19.3)
Consciousness abnormality	27 (32.5)
Cardiac arrest	31 (37.3)
Treatments, *n* (%)	
Intubation	36 (43.3)
Oxygen inhalation	34 (41.0)
Mechanical ventilation	19 (22.9)
I.v. line insertion	16 (19.3)
Fluid bolus	8 (9.6)
Cardiovascular drug administration	24 (28.9)
Chest compression	31 (37.3)
Adrenaline administration	27 (32.5)
Defibrillation	10 (2.0)

Data are mean (standard deviation) for continuous variables.

Table 5. Outcome of patients requiring medical emergency team (MET) activation

Disposition after MET intervention, *n* (%)	
General wards	25 (30.1)
Intensive care units	41 (49.4)
Home	8 (9.6)
Death	7 (8.4)
Mortality after MET call, *n* (%)	
24-h mortality	10 (12.0)
7-day mortality	18 (21.7)
28-day mortality	27 (32.5)

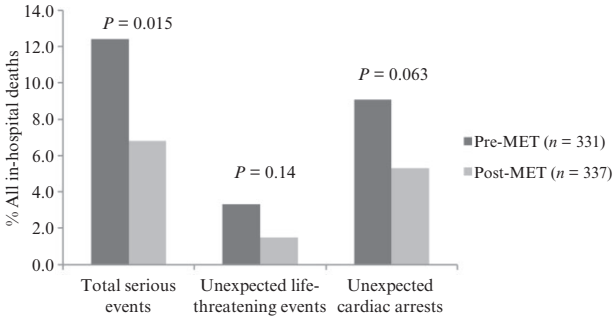

Fig. 1. Unexpected life-threating events and unexpected cardiac arrests among hospital-wide deaths before and 1 year after introduction of a medical emergency team (MET) system. Unexpected life-threatening events (pre-MET 3.3% [11/331] versus post-MET 1.5% [5/337], $P = 0.14$) and unexpected cardiac arrests (pre-MET 9.1% [30/331] versus post-MET 5.3% [18/337], $P = 0.063$) tended to decrease in the post-MET period compared to the pre-MET period. Total serious unexpected events were significantly decreased in the post-MET period compared to the pre-MET period (pre-MET 12.4% [41/331] versus post-MET 6.8% [23/331], $P = 0.015$).

intubation (43.3%) and oxygen inhalation (41.0%). The most frequent disposition of the MET-activated patients was ICU admission (49.4%), followed by general ward admission (30.1%). The 24-h and 28-day mortalities in the MET-activated patients were 12.0% and 32.5%, respectively (Table 5).

No significant difference was observed between the number of pre-MET and post-MET in-hospital mortalities (calculated by dividing the number of in-hospital deaths by the number of total hospital admissions) (pre-MET 2.1% [331/15,514] versus post-MET 2.0% [337/16,844], $P = 0.38$). Among the in-hospital deaths, there was a non-significant trend in the decreased incidence rate of unexpected life-threatening events (pre-MET 3.3% [11/331] versus post-MET 1.5% [5/337], $P = 0.14$) and unexpected cardiac arrests (pre-MET 9.1% [30/331] versus post-MET 5.3% [18/337], $P = 0.063$) after the introduction of the MET system, whereas the incidence rate of total serious events (calculated as the sum of the two) was significantly decreased by the introduction of the MET system (pre-MET 12.4% [41/331] versus post-MET 6.8% [23/337], $P = 0.015$) (Fig. 1).

DISCUSSION

THE TOTAL NUMBER of MET activation calls during the first year after the introduction of the MET system was 83 (4.9 per 1,000 admissions). Most patients requiring MET activation were critically ill and needed emergency treatment at the location of the MET activation with subsequent ICU care, including many with cardiac arrest on arrival of the MET.

The number of MET activation calls in this study (4.9 per 1,000 admissions) is smaller than the values previously reported in the USA and Europe.[6–13] This difference may be attributed to differences in the medical practices and MET activation criteria used, as well as differences between the MET and rapid response team. The present study showed that the patient's condition on MET arrival was highly urgent and serious in most cases (e.g., cardiac arrest, respiratory insufficiency, shock), with almost half being critically ill patients requiring urgent ICU/cardiac care unit admission after MET intervention.

Although the objective of the RRS is to improve the prognosis of inpatients by intervention prior to the occurrence of serious events, 33.7% of the MET activation calls were due to cardiac arrest. Sudden cardiac arrest preceded by no abnormality in vital signs does sometimes occur, such as in patients with acute coronary artery disease. Further investigation is needed to clarify whether the MET activation call could be made prior to the occurrence of the cardiac arrest, in any of the cases in which the MET system was activated due to cardiac arrest.

MET activation was most frequently requested by physicians at our hospital, in contrast to a report from a UK hospital showing that 83% of their MET activation calls were made by nurses.[15] This difference may indicate that, in our hospital, the first person to identify sudden changes in the clinical condition of an inpatient (most probably a nurse) calls the physician in charge of the patient, instead of activating the MET system immediately. As a result, a delayed MET activation call may be made by the physician only after he/she arrives and finds it difficult to address the changes in the condition of the patient. We have held in-hospital study sessions on the introduction of the MET system, followed by

annual education seminars on addressing sudden in-hospital clinical changes, held in every ward. The data presented in this article were obtained in the first year of the MET implementation. The continued efforts to improve education and communication are expected to change the composition of the MET activators in the future.

The MET activation criteria at our hospital are based on the signs indicating that a patient is in a serious condition. Conversely, based on previous reports that abnormalities in vital signs precede serious adverse events,[3,4] many medical institutions adopt abnormalities in vital signs as the MET activation criteria.[16,17] However, given that abnormal vital signs reportedly show a high sensitivity and a low specificity in the prediction of cardiac arrest and unexpected death,[4] there is no general agreement regarding the appropriate MET activation criteria. Multiple scoring systems proposed for vital signs, such as the Modified Early Warning System[18] and National Early Warning System,[19] can be used as MET activation criteria to predict acute deterioration in critically ill patients. Although such vital sign scores are reported to show high specificity,[20] they have not been supported by sufficient evidence at present.[21,22] Considering that the present study evaluates the data obtained during the first year of the MET implementation, further verification and assessment will be necessary regarding MET activation criteria.

The effects of the introduction of the RRS system have previously been evaluated using different outcome measures such as the total in-hospital mortality rate, unplanned ICU admissions, Code Blue rates, and incidence of adverse events.[7–13] Most of the previous reports of decreased in-hospital mortality rate, adverse events, and out-of-ICU cardiac arrests were single-center studies.[23–25] A multicenter randomized study, the MERIT study, failed to show a decrease in the number of cardiac arrests, unplanned admissions to the ICU, or unexpected deaths after the introduction of a MET system.[6] A meta-analysis revealed that the incidence of out-of-ICU cardiac arrests decreased after the introduction of a RRS; however, no change in the in-hospital mortality rate was observed.[8] In another meta-analysis, an increasing number of more recent reports showed a decrease in the mortality rate after the introduction of a MET system; however, the overall results indicated a decrease in the incidence rate of the out-of-ICU cardiac arrests and no change in the in-hospital mortality rate.[13]

Similarly, in our hospital, no difference was observed between the pre-MET and post-MET in-hospital mortality rate. One possible reason may be a relatively small number of MET activation calls, namely 4.9 per 1,000 hospital admissions. The cardiac arrests reportedly decreased with an increase in the MET activation calls.[26–28] A low pre-MET in-hospital mortality of 2.1% (331/15,514), in combination with the small number of MET activation calls, may explain the observed lack of significant effect of the MET system introduction on the number of in-hospital mortalities. Furthermore, as the in-hospital mortality cases included cases whose resuscitation code was modified to "do not attempt resuscitation" after MET treatment, due to deteriorating condition caused by an underlying disease, a significant reduction in the in-hospital mortality rate may be difficult to achieve by the introduction of the MET system alone. Another reason could be the fact that most MET activations were made by physicians in our hospital. This suggests that some of the activations might have been delayed, as discussed above, resulting in no significant change in mortality. A decrease in the ratio of the number of total unexpected events to the number of patients discharged following death was also observed in the present study, which may indicate that MET activations due to unexpected acute clinical deterioration—as opposed to deterioration of an underlying disease—was beneficial to patients.

CONCLUSION

THE CLINICAL DATA obtained during the first year after the introduction of the MET system in February 2012 were examined. The results suggested that the introduction of the MET system could reduce the incidence of unexpected serious adverse events. The majority of the patients requiring activation of the MET system were critically ill and needed emergency treatment at the location of the MET activation, with subsequent ICU admission. Considering that many of these patients had cardiac arrest on arrival of the MET, further assessment is necessary to optimize the activation criteria and operational protocols of the MET system in our hospital.

CONFLICT OF INTEREST

NONE.

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