

ORIGINAL ARTICLE

Use of medical emergency team responses to reduce hospital cardiopulmonary arrests

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Background: Medical emergency team (MET) responses have been implemented to reduce inpatient mortality, but data on their efficacy are sparse and there have been no reports to date from US hospitals. **Objectives:** To determine how the incidence and outcomes of cardiac arrests have changed following increased use of MET.

Methods: Objective criteria for MET activation were created and disseminated as part of a crisis management program, after which there was a rapid and sustained increase in the use of MET. A retrospective analysis of clinical outcomes was performed to compare the incidence and mortality of cardiopulmonary arrest before and after the increased use of MET.

Results: A retrospective analysis of 3269 MET responses and 1220 cardiopulmonary arrests over 6.8 years showed an increase in MET responses from 13.7 to 25.8 per 1000 admissions ($p < 0.0001$) after instituting objective activation criteria. There was a coincident 17% decrease in the incidence of cardiopulmonary arrests from 6.5 to 5.4 per 1000 admissions ($p = 0.016$). The proportion of fatal arrests was similar before and after the increase in use of MET.

Conclusions: Increased use of MET may be associated with fewer cardiopulmonary arrests.

Medical emergency teams (METs)—groups of health-care professionals that can be assembled in response to grave clinical deterioration^{1–9}—may enable hospitals to respond more effectively to inpatient crises. METs are distinct from “code” teams because they aim to respond to acute patient deterioration *before* a cardiopulmonary arrest occurs with the intention of preventing the arrest from ever occurring. Their rationale is based on retrospective studies from hospitals in numerous healthcare settings and countries which have shown that more than half of all cardiopulmonary arrests are preceded by dramatic aberrations in vital signs or other clinical indices during a 6–8 hour period before the arrest.^{10–14} The fundamental assumption behind their implementation is that the physiological processes underlying cardiopulmonary arrests are often treatable, and that those treatments will have greater efficacy if they are initiated earlier.

Although the rationale for MET responses is compelling, clinical data describing their efficacy are extremely sparse and are limited to two observational studies from Australia.^{3,4} Furthermore, the results of these two studies are contrasting, with one suggesting a significant reduction in the incidence and inpatient mortality of cardiopulmonary arrest while the other found no benefit. To add to the published literature describing the impact of MET responses on clinical outcomes, we report changes in the frequency and mortality of cardiopulmonary arrest that occurred following a sharp increase in the use of METs at our urban tertiary care hospital.

METHODS

The MET at our tertiary care university hospital complex consists of eight members (table 1) including physicians, nurses, and a respiratory therapist. It can be activated by any hospital staff member who witnesses a grave clinical deterioration including non-medical personnel. The operator obtains the telephone number of the person calling in the emergency and the location of the emergency. He then activates the emergency pager system and makes two

announcements on the overhead speaker system. Our institution comprises 622 licensed beds in three contiguous hospitals, outpatient clinics, a medical school, a rehabilitation facility, and a skilled nursing facility, all connected by bridges and tunnels. The same MET system is used for the entire complex but, because of the size of the facility, different personnel comprise teams in a number of separate geographical responder zones.

An MET was established at our institution in 1989, but initially it was intended for use only on patients being transferred to the ICU from medical and surgical units. In 1996 (the beginning of the present study) its use was expanded to all hospitalized patients with the exception of specialized units where sufficient equipment and personnel were already on site (ICU, emergency department, post anesthesia care unit). Although it was instituted before other published reports of METs,^{1–3} its organization and objectives are similar to those systems.

Trends in clinical outcomes

After the MET response system was adopted for use throughout our facility, anecdotal evidence suggested that many cultural barriers impeded its implementation and it therefore was not being used in a standardized or effective manner. For this reason, in December 2000 a protocol was established delineating objective criteria for when the emergency team should be activated (box 1) and a peer review mechanism was used to encourage physicians and nurses to follow the protocol. Adherence with these guidelines was monitored and lack of adherence was followed by personal communication with attending physicians, trainee physicians, and nurses responsible for the care of patients and/or administration of the hospital wards where these events occurred.

*See end of article for list of members of Medical Emergency Response Improvement Team.

Table 1 Personnel staffing medical emergency team (MET) responses

Personnel	Role	Objective
ICU physician	Team leader	Direct ACLS team efforts, medical decision making
ICU nurse	Run medication/equipment cart	Prepare medications, equipment, defibrillator for delivery to patient
ICU nurse	Recorder	Coordinate data flow: record events, labs sent, obtain results, other data as required
Floor nurse	Bedside nursing	Deliver medications, obtain vital signs, verify IV function
Anesthesia or critical care	Airway manager	Assure oxygenation and ventilation
Respiratory care	Airway assistant	Oxygen supply, suction, respiratory equipment
Physician	Chest compressions	Assess circulation, deliver chest compressions
Physician	Procedure physician	Perform required procedures: obtain arterial blood for analysis, thoracostomy, central venous access

ACLS = Advanced Cardiac Life Support; ICU = intensive care unit.

Because the use of MET increased significantly over a short time period, it was possible to compare the incidence of cardiopulmonary arrests during the periods before and after this increase in usage to determine if it was associated with improved medical outcomes. The period before the increased use of MET was defined as extending from January 1996 through December 2000, which was the month when objective criteria were instituted and after which the MET response rate began its rapid increase. The period after the increase in use of MET was defined as starting in January 2001 and ending at the last month for which data were complete at the time of writing (September 2002). The incidence of *cardiopulmonary arrest* was determined by hospital

records of “code” team activation and is reported per 1000 admissions.

Although the frequency of MET responses and cardiopulmonary arrests has long been recorded in our institution, only in February 1999 did the Quality Improvement Committee begin to keep a database of unique identifiers for the particular patients who received MET responses. For this reason, the time period during which we analyzed deaths (starting February 1999) is substantially shorter than the time period during which we analyzed the frequency of cardiopulmonary arrest (starting January 1996). Deaths were determined by searching a computerized hospital database of all patient admissions and discharge dispositions. The computerized database established day of death with excellent agreement ($\kappa = 0.91$) compared with the manual chart review performed on a convenience sample of patients. A minority of discharge dispositions could not be identified using the computerized search. For these patients, outcomes were imputed based on contemporaneous MET responses for which outcome data were available. This imputation was made because there was no significant difference in deaths among patients with identifiable outcomes in the database and those without identifiable outcomes based on manual chart review (48% v 40%, $p = 0.518$).

Fatal cardiopulmonary arrests were defined as death during the calendar day of the arrest, and cardiopulmonary arrests without survival to discharge were defined as deaths occurring within the same hospital admission as the cardiopulmonary arrest, regardless of elapsed time. We also compared the proportion of cardiopulmonary arrests with fatal outcomes before and after increased use of MET.

Statistical analyses

The incidences of MET responses, cardiopulmonary arrests, and crises with fatal outcomes were compared before and after increased use of MET using the two sample inference test for incidence rate data. The incidence of MET responses was also compared using a generalized linear model to consider possible confounding due to secular trends. Proportions of events with fatal outcomes were compared before and after increased use of MET using the χ^2 test for binomial proportion. All analyses were two tailed and used a type 1 error of 0.05 as the criterion for statistical significance.

RESULTS

There were 199 024 hospital admissions and 3269 MET responses over the 6.8 year period of analysis; 143 776 admissions (1973 responses) during the 5 year period before MET usage increased and 55 248 admissions (1296 responses) during the 1.8 year period after usage increased. Medical crisis response team usage rose from 13.7 per 1000 admissions to 25.8 per 1000 admissions ($p < 0.001$); this rise

Box 1 Clinical criteria for activating a medical emergency team (MET) response

Respiratory:

- rate < 8 or > 36 ;
- new onset difficulty breathing;
- new pulse oximeter reading less than 85% for more than 5 minutes (unless patient known to have chronic hypoxemia).

Heart rate:

- < 40 or > 140 with symptoms or any rate > 160 .

Blood pressure:

- < 80 or > 200 systolic or 110 diastolic with symptoms.

Acute neurological change:

- acute loss of consciousness;
- new onset lethargy or narcosis without immediate response;
- seizure (outside of seizure monitoring unit);
- sudden loss of movement (or weakness) of face, arm or leg.

Other:

- chest pain unresponsive to nitroglycerine or doctor unavailable;
- color change (of patient or extremity): pale, dusky, gray or blue;
- unexplained agitation more than 10 minutes;
- suicide attempt;
- uncontrolled bleeding;

was rapid and sustained (fig 1) and followed the intervention to increase its use. The mean age of patients requiring MET responses was 61 years and 48% were women. The frequency of MET responses did not differ greatly between hospital work shifts with proportions of 28%, 37%, and 35% occurring during 07.00–15.00 hours, 15.00–23.00 hours, and 23.00–07.00 hours, respectively. Over the period of analysis there was a modest and statistically insignificant increase in case mix severity among patients admitted to the hospital.

Clinical outcomes

There were 930 cardiopulmonary arrests over 5 years before the increase in MET use and 290 arrests over 1.8 years after the increased MET usage. The mean monthly incidence of cardiopulmonary arrests decreased by 17% from 6.5 per 1000 admissions before increased MET use to 5.4 per 1000 admissions ($p = 0.016$) after the increase.

We performed several analyses to investigate whether secular effects such as yearly fluctuations in care quality or illness severity may have influenced the decrease in the incidence of cardiopulmonary arrest. When each month of the year was included in the analysis as a separate covariate, the decrease in the incidence of cardiac arrest was of similar magnitude and remained statistically significant (1.2 fewer arrests per 1000 admissions, $p = 0.014$). When analyses were performed in which severity of illness was included as a separate covariate, the decrease in the incidence of cardiopulmonary arrest also remained similar and statistically significant (1.2 fewer arrests per 1000 admissions, $p = 0.014$). Lastly, there were no significant trends in the monthly incidence of cardiopulmonary arrests when the periods before and after the increase in MET responses occurred were considered independently ($p = 0.175$ and $p = 0.595$, respectively).

There was no suggestion of any change in the proportion of cardiopulmonary arrests that were fatal before and after the increase in MET use. Before the increase 33.3% of patients died on the calendar day of the arrest compared with an identical 33.3% after the increase. Similarly, 55.2% of patients with cardiopulmonary arrest did not survive the hospital admission before the increase compared with 58.9% after the increase. The incidence of fatal cardiopulmonary arrests declined proportionately to the decline in the overall incidence of cardiopulmonary arrests, but this decline did not reach statistical significance.

DISCUSSION

To our knowledge, this is the first published report documenting MET implementation in a US hospital, as well as the first published report from outside the UK that describes changes in clinical outcomes associated with MET use. We found that increased use of MET was followed by a

significant decrease in the incidence of cardiopulmonary arrests.

There are only two other published reports of changes in clinical outcomes following MET implementation. In an observational study at a 300 bed tertiary care teaching hospital in Australia, MET implementation was followed by a 50% decrease in the incidence of unexpected cardiac arrests after case mix adjustment was used to control for secular trends.³ In a cross sectional study comparing three public hospitals in Australia and adjusting for case mix, one with MET implementation and two without, the MET hospital did not have decreased numbers of cardiac arrests but did have decreased numbers of unanticipated ICU admissions.⁴ Our results suggest a decrease in cardiopulmonary arrests with MET implementation that is intermediate between these two results (17%). Our current review is underpowered to detect a decrease in hospital mortality proportional to the observed 17% decrease in the incidence in cardiopulmonary arrests. However, since the proportion of fatal cardiopulmonary arrests did not change after our intervention, it is likely that a proportional decrease in mortality occurred. At our institution this change would result in 21 lives saved annually.

Ensuring appropriate use of the MET was difficult at our hospital because of cultural barriers similar to those reported by other institutions that have implemented METs.^{5–15} Buist *et al* found that initially the number of calls was low because junior medical staff were reluctant to breach the “traditional” system of management and nursing staff were reluctant to respond against doctors’ orders.⁵ Daffurn *et al* noted two potential reasons for failure to initiate a crisis response.¹⁵ Firstly, nurses often felt that the crisis was not severe enough to warrant the MET response and instead called a medical trainee to respond. In fact, when presented with hypothetical patient scenarios, the nurses would call an MET only 2.8% of the time it was indicated. Secondly, the nurses were concerned that they might be reprimanded if they bypassed the resident if the severity of illness did not warrant an MET response. These two barriers existed even though nurses had a favorable attitude towards the MET concept. We were able to breach these barriers by formulating and disseminating objective criteria for when an MET should be activated, and by making this activity compulsory. This reduced the likelihood that the individuals activating the system would be reproached by their supervisors or by senior physicians. Indeed, great effort was made to enlist the support of physicians, nurses, and administrators in leadership roles. Another sign that we have changed the culture of crisis response is the fact that even the ICU staff now activate the crisis response team if a critical care physician is not in the unit when a crisis emerges.

Limitations of the study

Our report has numerous limitations. It is observational so it is difficult to exclude the possibility that confounding factors may have influenced our results. In particular, changes in patient care contemporaneous to increased MET use may have contributed to the observed decrease in the incidence of cardiopulmonary arrest. However, the decrease in cardiopulmonary arrests took place over a relatively brief period of time coincident with the increase in MET responses, and variations in patient severity, hospital census, and time of the calendar or academic year did not affect the magnitude or statistical significance of the decrease. The retrospective nature of these data makes it difficult to exclude hidden biases. For example, it is possible that our MET responses could have resulted in more cardiopulmonary arrests occurring in ICU settings where their occurrence was less likely to be recorded.

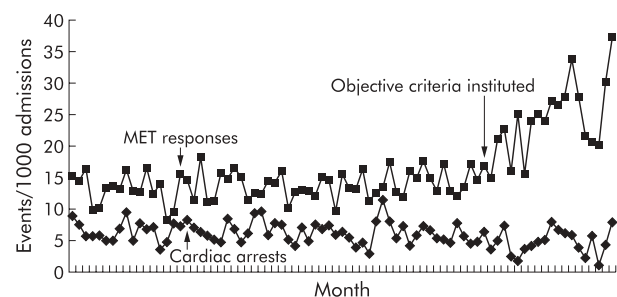


Figure 1 Number of medical emergency team (MET) responses and cardiopulmonary arrests per month before and after objective criteria for MET activation were instituted. Note the rise in emergency events and the decline in cardiac arrests after implementation of criteria.

Key messages

- There are many more medical crisis events than cardiac arrests within a hospital; many may be under-recognised and undertreated.
- Implementing a medical emergency response system may prevent cardiac arrests within hospitals by providing rapid access to critical care professionals and equipment.
- The medical emergency response system should include objective criteria for identifying a crisis.

Another potential criticism is that the MET response is labor intensive and some hospitals may feel they do not have the manpower to staff it. The number of events to which an emergency team must respond can be expected to at least double. Thus, one may believe that an MET system may not be generalizable to other institutions. However, any crisis situation requires large expenditure of resources, irrespective of whether these resources are allocated in advance. For example, in the absence of an MET response, nearby staff must often assist with the crisis for substantial periods of time (in our reviews some require hours of care), which may increase resource use indirectly by increasing the required staffing level. Indeed, our staff report that, following implementation of the MET, the duration of a crisis shortened from hours to minutes, and it has become rare for nurses to spend large amounts of unanticipated time with deteriorating patients. MET events usually require less than 30 minutes to resolve the situation. MET systems can be successfully implemented at tertiary and community hospitals.^{5-7,8} Indeed, staff at a community teaching hospital within our hospital system (UPMC McKeesport Hospital, McKeesport, Pennsylvania) have implemented an MET system. They also found an increase in crisis event frequency and a decrease in the rate of cardiac arrest. We may conclude that both tertiary referral centers and community hospitals can benefit from such a program.

CONCLUSION

MET is a new process of care that is a means of responding more rapidly and effectively to inpatient crises. Our data and data from other centers suggest the possibility that MET utilization may decrease the incidence of cardiopulmonary arrests, but these results are based on observational data and should be interpreted with great caution. Even though prospective evaluation of the benefit of METs is warranted, we believe the weight of the data supports implementing an MET system accompanied by data collection to determine site specific benefit.

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