ORIGINAL ARTICLE

Use of medical emergency team (MET) responses to detect medical errors

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Background: No previous studies have investigated whether medical emergency team (MET) responses can be used to detect medical errors.
Objectives: To determine whether review of MET responses can be used as a surveillance method for detecting medical errors.
Methods : Charts of all patients receiving MET responses during an 8 month period were reviewed by a hospital based Quality Improvement Committee to establish if the clinical deterioration that prompted the MET response was associated with a medical error (defined as an adverse event that was preventable with the current state of medical knowledge). Medical errors were categorized as diagnostic, treatment, or preventive errors using a descriptive typology based on previous published reports.
Results: Three hundred and sixty four consecutive MET responses underwent chart review and 114 (31.3%) were associated with medical errors: 77 (67.5%) were categorized as diagnostic errors, 68 (59.6%) as treatment errors, and 30 (26.3%) as prevention errors. Eighteen separate hospital care processes were identified and modified as a result of this review, 10 of which involved standardization.
Conclusions: MET review may be used for surveillance to detect medical errors and to identify and modify processes of care that underlie those errors.

Recent reports have estimated that between 44 000 and 98 000 preventable deaths occur annually in the US because of medical errors.[1–11] There is a consensus among safety researchers that most medical errors are not the sole result of individual caregivers but, rather, are induced by latent failures in organizational structures or processes.[12–17] For this reason, many have proposed that analyzing the root causes of medical errors is of paramount importance for reducing their future incidence.[12–17] However, in order to analyze medical errors it is first necessary to identify them, and little is known about the most effective surveillance methods for their detection.

Medical errors that are particularly harmful may lead to life threatening clinical deterioration or death. At our institution episodes of life threatening clinical deterioration or sudden death trigger a response by a medical emergency team (MET), a recently developed process of care in which groups of healthcare professionals are assembled to respond more effectively to inpatient crises.[18–26] For this reason, we hypothesized that reviewing the episodes of care surrounding MET responses may be a fruitful case finding technique for detecting those medical errors that are particularly harmful. We therefore introduced a quality improvement initiative that mandated a chart review after every MET response. Our aim was to detect medical errors that were particularly harmful and that would not have been detected by other means. In this report we describe how surveillance of MET responses may be used to detect harmful medical errors, and how root cause analysis of the care processes underlying these errors may be used to improve patient safety.

METHODS

The University of Pittsburgh Medical Center (UPMC) Presbyterian Hospital uses an MET to respond to any medical crisis. It can be activated by any hospital staff member who witnesses grave clinical deterioration. It is described in more detail in our accompanying paper[27] and is outlined in table 1.

Our institution comprises 567 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 three separate geographical zones.

Chart review

Charts of all patients for which the emergency response team was activated during an 8 month period (May–December 2000) were reviewed by a hospital based Quality Improvement Committee within 1 month of the response to establish if the clinical deterioration that prompted the MET response was associated with a medical error. These reviews were usually retrospective and occurred after patients had left the hospital. However, if committee members were notified through informal channels that a medical error may have led to an MET response or if the patient had a particularly long stay in hospital, the review may have occurred while the patient was still in the hospital. During the 8 month period that is the subject of the present report, the committee operated with the imperative of reviewing every MET response regardless of time requirements and successfully reviewed all cases.

Information from the medical records of patients requiring an MET response was abstracted by a team of surgical residents using our institution's electronic medical record system. Each case was assigned to a particular resident and each abstraction took approximately half an hour. During abstraction emphasis was placed on recording a minute by minute sequence of events prior to the MET response including clinical signs and symptoms, tests ordered, personnel

* 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.

directly involved in the care, and personnel consulted. In addition to this timeline, they also abstracted a vignette of the patient's initial presentation to the hospital and a description of the patient's outcome following the MET response. An example is shown in box 1. Because this effort was a quality improvement initiative, review by our Institutional Review Board was not required.

Quality Improvement Committee

The abstracted information was reviewed by members of the Quality Improvement Committee and each review took approximately 10 minutes.

Membership

Membership of the committee included attending physicians in the surgery, critical care, and general internal medicine departments, trainees in the surgical residency program, and nurse administrators. Attendees varied somewhat from session to session, but almost always included at least one surgeon and one critical care physician, surgical trainees, and a senior nurse administrator. The chair of the committee was also the medical director of our institution. The committee made all decisions by consensus during working meetings which were held three times per week. A protocol was used to guide the identification and categorization of medical errors. In reviewing the chart, the committee determined whether there was an associated adverse event and, if so, whether that adverse event was preventable and the result of a medical error.

Definitions

A *medical error* was defined as ''an adverse event that was preventable with the current state of medical knowledge.''[1–3] An *adverse event* was defined as ''an injury caused by medical management rather than by the underlying disease or condition of the patient'' (e.g. sepsis).[1–3] The committee operated in accordance with two main premises: (1) a substantial proportion of preventable adverse events do not result from *active errors* performed by particular individuals, but rather from *latent errors* attributable to the underlying process of care or other system characteristics (for example, respiratory arrest during patient controlled analgesia occurred not because of any particular error but because a number of pharmacy, nursing and educational processes enabled errors to occur); and (2) even when active errors are important in the etiology of adverse events, they are often induced or permitted by latent errors (for example, the wrong medication was given to a patient and this occurred in part because similarly appearing medication canisters were stocked on the same supply shelf).

Errors were categorized by a descriptive and non-mutually descriptive typology based on previous published reports.[1–3] *Diagnostic errors* included incorrect or delayed diagnoses, failure to employ indicated tests, or failure to act on results of monitoring or testing. *Treatment errors* included errors in the performance of an operation, treatment, or test; errors in the administration of a treatment; errors in the dose or method of using a drug; and inappropriate (not indicated) care. *Preventive errors* included failure to provide prophylactic treatment and inadequate monitoring or follow up of treatment. Medication errors and errors due to procedures were considered subgroups of treatment errors.

Assessment

With the intent of characterizing latent errors and reducing their risk of reoccurrence, the committee deliberated on whether there were identifiable root causes and whether particular processes of care may have contributed. If the committee determined that (1) processes of care contributed to the adverse event, (2) these processes could be modified, and (3) their modification could reduce the likelihood of similar adverse events in the future, then a hospital task force was created and delegated to the appropriate hospital department to review and improve the process. This committee had the authority to convene task forces within any hospital department with the aim of improving quality of care.

RESULTS

Three hundred and sixty four MET responses (18.4 per 1000 hospital admissions) occurred during the 8 month period of review for medical errors, and all cases were reviewed by the Quality Improvement Committee. The MET responses generally occurred in response to acute and serious deteriorations in clinical status; 30% of patients were in cardiopulmonary arrest and 25% died on the day of the event.

Medical errors

A review of the episodes of care preceding MET responses showed that 114 (31.4%) of the deteriorations were attributable to one or more medical errors. Seventy seven (67.5%) were categorized as diagnostic errors (errors that resulted from improper or delayed diagnosis, failure to employ indicated tests, or failure to act on the results of monitoring or testing), 68 (59.6%) were categorized as treatment errors (errors involving an operation, procedure, test, or drug; 57 of these involved medications), and 30 (26.3%) were categorized as prevention errors (errors resulting from a failure to provide prophylactic treatment such as not using DVT prophylaxis for immobile patients, or inadequate surveillance for at risk events such as not keeping a patient with rapid

Box 1 Example of chart review

The following information was abstracted and presented to the Quality Improvement Committee. In this particular case, the committee determined that there were associated adverse events (intubation, iatrogenic peritonitis, prolonged hospitalization). In addition, there were the following associated medical errors: delay in transfer to the intensive care unit (a preventive error), delay in performing thoracotomy (a diagnostic error), and iatrogenic peritonitis due to percutaneous endoscopic gastrostomy tube placement (a treatment error).

Vignette

A 78 year old female admitted from outside hospital with diagnosis of community acquired pneumonia, failing to improve on vancomycin and piperacillin/tazobactam. Past medical history was unremarkable.

Timeline

4/17 AM: Arrived on general medicine floor. History and physical examination revealed patient to be ''acutely ill and tachypnic, and with cold extremities''. Vital signs included a respiratory rate of 24 and were otherwise unremarkable. Arterial oxygen saturation was 91% on 6 liters/minute oxygen by nasal cannula. Other diagnostic data were notable for chest radiography showing right lung ''white out'' and a peripheral white blood cell count of 22 000.

4/17 10.53: Arterial blood gas obtained on 6 liters/minute oxygen showed pH 7.27, oxygen pressure 64 mm Hg, and carbon dioxide pressure 50 mm Hg. Patient was started on bi-level positive airway pressure (BIPAP).

4/17 15.30: Patient ''restless but responsive to vocal commands''. Blood pressure decreased to 90/60. Oxygen saturation decreased to 82%, after which oxygen flow rate was increased from 6 liters/minute to 15 liters/minute.

4/17 16.16: Repeat arterial blood gas revealed pH 7.27, oxygen pressure 80 mm Hg, and carbon dioxide pressure 50 mm Hg (now on 15 liters/minute oxygen).

4/17 20.00: Respiratory rate increased to 34; blood pressure and arterial oxygen saturation stable.

4/17 20.30: Repeat arterial blood gas showed pH 7.21, oxygen pressure 90 mm Hg, carbon dioxide pressure 62 mm Hg.

4/17 21.42: Decreased mental status noted. **MET response called**.

Outcome of MET response

STAT transfer to medical intensive care unit and urgent intubation. Thoracoscopy was performed on 4/19 (2 days after arrival) which showed an empyema. Patient survived acute episode and then had protracted hospital stay lasting 62 days. Contributing co-morbidities included development of peritonitis after a percutaneous endoscopic gastrostomy tube became dislodged and discharged contents into peritoneum.

diuresis on telemetric monitoring to detect hypokalemia-related arrhythmias). Of the diagnostic errors, approximately half (n = 39) originated from delays in diagnoses (for example, postponement of computer assisted tomography to rule in pulmonary embolism with consequent delay in anticoagulation treatment), and half (n = 38) resulted from incorrect diagnoses (for example, assuming chest pain was from costochondritis rather than pulmonary embolism with consequent failure to give anticoagulation treatment).

Processes of care

Root cause analysis was an effective means of identifying many processes of care that contributed to these medical errors, and ultimately led to institutional interventions that modified these processes in order to reduce the likelihood of similar errors occurring in the future. Eighteen separate processes of care were identified and separate institutional task forces were convened to improve each process (table 2). The majority of task forces chose to improve care processes by ensuring greater standardization. Ten of the 18 task forces standardized caregiver actions by creating protocols (for example, for administration of IV potassium), five limited the performance of a particular process of care to a specialized and highly trained subgroup (for example, a dedicated team to insert small bore feeding tubes), and two standardized the equipment involved in care processes (for example, ensuring crash carts are uniform throughout the facility). Improvement strategies were not entirely limited to standardization, however. Five task forces implemented a risk stratification protocol to ensure that high risk patients received appropriate surveillance (for example, delineating schedule for tracheostomy surveillance by respiratory therapists). In three cases the task forces created a mechanism for more rapid access to a particular element of care such as the development of a mechanism for obtaining large volumes of unmatched blood. Lastly, in one case, a task force modified an element in the physical plant of the hospital that was unexpectedly found to cause iatrogenic morbidity (falls among the elderly while using automatic doors at the entrance to the hospital).

DISCUSSION

This is the first published report describing the use of MET responses as a surveillance method for detecting medical errors. We found that approximately one third of the episodes of acute clinical deterioration that prompted MET responses were associated with one or more medical errors. We systematically conducted root cause analyses of these errors and were able to identify and improve numerous processes of care that otherwise would have gone undetected.

Most of the care processes that contributed to medical errors carried the risk of great harm yet were not highly standardized. Lack of standardization of complex and potentially dangerous tasks has been reported as one of the most common human factors contributing to error in both medical and non-medical safety literature.[12–18] Depending on the particular process, standardization was achieved either by establishing protocols or guidelines for caregiver actions, limiting personnel authorized to perform an action to a select group of highly qualified specialists, or by establishing uniformity among the required equipment.

If the true rate of medical error in our hospital is similar to previous national reports (29–37 per 1000 admissions),[1] the frequency of MET responses (18.4 per 1000 admissions) and the proportion associated with medical errors (31%) suggest that MET reviews alone may have detected approximately one fifth of all medical errors in our institution. This method may therefore be more sensitive than other methods that rely on voluntary or mandatory reporting, which may have sensitivities as low as 3.7%.[28] Furthermore, the errors identified by MET review were generally serious and life threatening, in contrast with the preponderance of non-life threatening errors that are identified through mandatory surveillance mechanisms such as pharmacy errors. This method may therefore have high specificity for detecting those errors that have the greatest impact on patient morbidity and mortality. Furthermore, we conjecture that errors that are linked to life threatening crises motivate staff to improve the underlying care processes with far more

Table 2 Root cause analysis of medical errors detected from review of medical emergency team (MET) responses

Error	Root cause	Care process improvement
Treatment errors:		
Cardiac arrest from hyperkalemia	Difficult to distinguish potassium solutions of different strength	Protocol for administration of IV potassium. High concentrations limited to pharmacy.
Respiratory depression from excessive narcotic dosing during conscious sedation	Inadequate supervision of medical trainees	Guidelines for the use of conscious sedation on general care units developed; identification of patients as high risk (i.e. sleep apnea)
Aspiration pneumonia or pneumothorax after feeding tube insertion	Inadequate supervision of medical trainees	Dedicated team to insert small bore feeding tubes.
Respiratory depression from excessive narcotic dosing with PCA	PCA pumps may be used by non-intended personnel (family)	Protocol for PCA education laminated on cards and placed on equipment
Respiratory distress from hypoxia during transport	Oxygen tanks not checked before potentially long transport excursions	Oxygen tank exchange protocol
Pneumothorax and other injuries from placing central venous catheter	Inadequate supervision of medical trainees, particularly during offshifts	Certification program for bedside procedures. Supervision available 24/7
Diagnostic errors		
Cardiopulmonary arrest, various etiologies from delays in treatment	Ambiguous physician in charge	Objective criteria for MET activation
Cardiopulmonary arrest, various etiologies from delays in treatment	Difficult to obtain ICU bed when hospital census is high	New MD position established (Resource Intensivist) responsible for triage within and among ICUs
Delay in first shock during cardiopulmonary arrest	Crash carts stocked in inconsistent or incomplete manner	Standardized crash carts throughout the facility.
Exsanguination from delay in blood availability	Blood products difficult to access quickly outside emergency department	Developed mechanism for obtaining large volumes of unmatched blood
Bradycardia/asystole from delay in pacemaker placement	Permanent pacemaker placement considered a low priority consult	Initiated dialogue with cardiology that resulted in more accurate triaging
Prevention errors		
Inadequate surveillance for mucus plugging and other complications in tracheostomy patients	Non-surgical floors may be staffed by personnel with little familiarity with tracheostomy care	Protocol delineating schedule for tracheostomy surveillance by respiratory therapists
Inadequate surveillance for rebound hypoglycemia following treatment of glucose or potassium abnormalities	Danger of hypoglycemia after IV insulin is underappreciated by hospital staff	Protocol describing frequency of monitoring after insulin boluses are administered
Inadequate surveillance for medical deterioration in patients receiving radiology tests	Patients in radiology department not supervised by medical personnel	Pulse oximetry monitoring during radiology tests/ procedures with MET activation if alarm
Inadequate surveillance for medical deterioration in patients in transport	Patients in transport not supervised by medical personnel	Pulse oximetry monitoring during transport with MET activation if alarm
Deaths and colectomies from iatrogenic *C difficile* exposure	Excessive broad spectrum antibiotic use; inadequate infection control	*C difficile* task force and antibiotic management team
Fractures, subdural hematomas from falls in demented elderly	Restraints, no supervision, unpadded environment	Falls task force
Fractures from falls in elderly using automatic doors	Doors not clearly marked and operate too fast for elderly patients	Automated messages of door use, reduced speed of automatic doors

PCA, patient controlled anesthesia.

enthusiasm than errors that are associated with minimal morbidity.

Most error detection methodologies aim to find incident cases of a specific type of error that has already been recognized, such as wrong side surgery. However, we are in the infancy of medical error detection as a field of scientific investigation, and many of the latent errors that contribute to morbidity and mortality may not yet have been identified. Another advantage of using MET response review as a means of error detection is that the investigation is not limited to any specific care process or error type, and hitherto unrecognized errors with high morbidity and mortality impact can be identified. For example, our reviews have uncovered a high incidence of preventable and serious errors stemming from insufficient monitoring of patients with tracheostomies for mucus plugging and other tracheostomy related complications. In addition, our reviews have uncovered a high incidence of dangerous and easily preventable hypoglycemia after hyperkalemic patients have received intravenous insulin. Even though both these types of errors are serious and eminently preventable, they would not have been detected by conventional error finding strategies.

Limitations

Our report has numerous limitations. Data were recorded over a period of less than 1 year and analyses were based on a relatively small number of MET responses and medical errors. The typology used to categorize the medical errors was rudimentary and was based on categories that were not mutually exclusive. The unblinded nature of the reviews may have resulted in hidden biases—for example, it is possible that our MET responses could have resulted in closer scrutiny of events leading up to a medical crisis and result in a higher likelihood that the reviewers would consider an action (or inaction) to be an error. Despite these limitations, we feel that our results have important implications and may guide quality improvement initiatives at other institutions where MET implementation is being considered.

CONCLUSION

MET is a recently developed process of care that is designed to ensure effective responses to inpatient crises. We report a new use for this process as a surveillance mechanism for detecting medical errors. Our data suggest that peer review of the care preceding MET responses is an efficient way of detecting errors with a particularly high impact on patient morbidity and mortality, as well as types of errors that have not yet been recognized. We were also able to use this approach to identify and improve many processes of care that contributed to medical errors at our institution. Evaluating the benefit of MET review for identifying and targeting medical errors in other healthcare settings is warranted.

Key messages

- Although medical emergency teams (METs) were designed to respond more effectively to inpatient crises, they may also be used to identify medical errors that cause harm.
- Root cause analysis of medical errors may be used to identify the processes of care that are latent factors underlying those errors.
- Hospital processes of care may be modified to reduce the likelihood that similar medical errors will occur in the future.

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