

The Role of a Medical Emergency Team in a Teaching Hospital

Submitted for degree of Doctor of Medicine

January 2009

Department of Surgery, Austin Health

Faculty of Medicine, Dentistry and Health Sciences

The University of Melbourne

Doctor Daryl Jones

BSc(Hons), MB, BS, FRACP, FJFICM

Abstract

Modern hospitals treat patients with increasing co-morbidity and complexity. Multiple studies have shown that up to 17% of patient admissions are complicated by a serious adverse event. Such events are often not related to the patients underlying medical condition and may result in morbidity, permanent disability, and in up to 10% of cases, death.

Serious adverse events are often foretold by the development of new complaints that manifest in derangements of commonly measured vital signs. The Medical Emergency Team is a team of intensive care doctors and nurses with skills in reviewing and treating patients who have become acutely unwell on the hospital wards. The team is summoned when a patient fulfil one ore more predefined criteria for activation.

The chapters in this thesis present original research related to the role of the Medical Emergency Team in identifying, reviewing and treating acutely unwell ward patients, primarily at the Austin Hospital in Melbourne, Australia.

The literature relating to the incidence and antecedents to serious adverse events is reviewed. The rationale behind the Medical Emergency Team and the history of its evolution in Australia and The Austin Hospital is then discussed.

In the subsequent chapters, the effect of introduction of the Medical Emergency Team on the outcome of a number of patient cohorts is review including 1). the long term mortality following major surgery; 2) the incidence of cardiac arrests in patients admitted for more than 24 hours; and 3) the in-hospital mortality of medical and surgical patients admitted for more than 24 hours.

In addition, a survey of nurse's attitudes to the Medical Emergency Team and potential barriers to its activation is presented. The change in Medical Emergency Team utilization with time at the Austin and Alfred Hospitals is described.

Finally, the causes for Medical Emergency Team activation are examined, as is the role of the team in end of life care planning.

Declaration

This is to certify that

- i. the thesis comprises only my original work towards the Doctor of Medicine /Doctor of Medical Science.
- ii. due acknowledgement has been made in the text to all other material used and instances where other investigators have made substantial contributions.
- iii. the thesis is less than 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.
- iv. Unless indicated, in all chapters, the study design, data collection and entry, data analysis, and manuscript drafting and revision was conducted primarily by me.

Signature:

Acknowledgement

I wish to acknowledge the supervision of Professor Rinaldo Bellomo and Associate Professor David Story in all phases of the thesis.

Substantial contributions in selected chapters are tabulated below.

Chapter	Co-investigator	Substantial contribution
3	Mortoki Egi	Conducted multi-variate logistic regression analysis
5	Biswadev Mitra	Assistance with entry of calls from Alfred Hospital switchboard log
6	Samantha Bates Mortoki Egi	Assistance with entry of calls from switchboard log Co-assessment and classification of code blue calls Conducted multi-variate logistic regression analysis
7	Helen Opdam	Suggestions during redrafting of original manuscript draft
10	Tammy McIntyre	Blinded assessment of data using standardised case report form
12	Ian Baldwin Tammy McIntyre Inga Mercer	Liaison with senior ward nurses to facilitate conduct of questionnaire Conducting interviews with ward nursing staff

Table Of Contents

Section 1: Background to the Medical Emergency Team

Chapter 1: Background to and History of the Medical Emergency Team	6
Chapter 2: The Medical Emergency Team at the Austin Hospital	18

Section 2: The effect of a MET on long-term postoperative mortality

Chapter 3: Effect of the MET on Long-term Mortality Following Major Surgery	26
---	----

Section 3: Assessment of MET use at two teaching hospitals

Chapter 4: Effect of an Education Program on the Utilization of a Medical Emergency Team in the Austin hospital	41
Chapter 5: Increasing the Use of an Existing Medical Emergency Team in the Alfred Hospital	52

Section 4: The long term effect of the MET at the Austin hospital

Chapter 6: Long Term Effect of a Medical Emergency Team on Cardiac Arrests in the Austin Hospital	62
Chapter 7: Long-Term Effect of a Medical Emergency Team on Mortality in the Austin Hospital	75

Section 5: Timing and characteristics of MET calls at the Austin hospital

Chapter 8: Circadian pattern of Activation of the Medical Emergency Team in the Austin hospital	87
Chapter 9: Patient monitoring and the Timing of Cardiac Arrests and Medical Emergency Team Calls in the Austin hospital	96
Chapter 10: The MET and End of Life Care: a Pilot Study	104
Chapter 11: MET syndromes and an Approach to Their Management	118

Section 6: Nurses attitudes to the MET service at the Austin hospital

Chapter 12: A Survey of Nurses Attitudes to the MET at the Austin Hospital	130
--	-----

References	144
-------------------	-----

Chapter 1

Background to and History of the Medical Emergency Team

Summary

Hospital systems of developed countries service a patient population of increasing complexity and acuity. Up to one in five patients admitted to hospital suffer a serious adverse event including cardiac arrest. Multiple studies reveal that serious adverse events and cardiac arrests in hospitalised patients are not sudden or unexpected. In up to 80% of cases they are heralded by derangements in commonly measured vital signs and laboratory tests. Furthermore, several studies have suggested that the management of ward patients in the hours leading up to the adverse event may be suboptimal and that the event may have been avoidable.

Hospital systems world wide must develop strategies to prevent these events. One such strategy involves the Medical Emergency Team (MET), which comprises staff possessing expertise in the management of acuity unwell ward patients. MET services have been introduced into hospitals to identify, review and treat at-risk patients during the early phases of clinical deterioration. Unlike a cardiac arrest team, a MET can be summoned before arrest occurs, typically when a patient fulfils pre-defined physiological criteria. The hypothesis underlying this approach is that early intervention in the course of deterioration improves clinical outcome. A MET service was introduced into the Austin Hospital in September 2000 after a one year period of education and preparation. Introduction of the MET service was associated with a 65% relative risk reduction (RRR) of cardiac arrest in all hospital patients. In addition, introduction of the MET service was associated with a 36.6% RRR of post-operative mortality, a 44.4% RRR of intensive care admission, and a 59.5% RRR of serious adverse events in patients undergoing major surgery.

Chapter 1 reviews the background to, and history of the MET in Australia. In Chapter 2, the details of the MET at the Austin Hospital is outlined, and proposed areas of knowledge deficit regarding the role of the MET in hospital care are highlighted. Finally, an overview of the thesis and the related peer-review publications arising from it is presented.

Why are Medical Emergency Team Services Needed?

Modern hospitals in developed countries care for patients of increasing age, acuity and complexity [1]. Studies conducted in North America, Australia, New Zealand, and the United Kingdom suggest that such patients suffer adverse events in up to 20% of cases depending on the definition used and population assessed (Table 1.1).

In 1964 Schimmel [2] reported on the incidence of adverse events in a cohort of 1014 patients admitted over an eight month period to a university teaching hospital in the United States. Participating house officers reported “every noxious response to medical care occurring among their patients”. The study found that 20% suffered iatrogenic injury, 6.7% of which were fatal. Subsequently, two large studies, one in New York [3, 4], the other in Utah and Colorado [5] estimated a much lower incidence of adverse events of 2.9-3.7%. However, both of these studies defined adverse events from a medico-legal perspective in an attempt to estimate the incidence of medical negligence. In a different study assessing a broader definition of medical error, Andrews and co-workers [6] found a 17.7% incidence of adverse events.

Four subsequent studies [7-11] defined adverse events as “unintended injury or complication resulting from medical management rather than the underlying disease process”. These studies were conducted in multiple countries world wide including Australia [7], New Zealand [8, 9], England [10] and Canada [11] and enrolled more than 25,500 hospitalised patients (Table 1.1). These studies reported an incidence of adverse events ranging from 7.5% [11] to 16.6% [7] and suggested that between 36.9% [11] to 51% [7] were preventable.

Most relevant to the present thesis, Bellomo and co-workers [12] conducted a four month study of serious adverse events in 1125 patients undergoing major surgery (defined as surgery requiring admission for more than 48 hours) at the Austin hospital. A dedicated research coordinator assessed patient records for the presence of 11 pre-defined serious adverse events (SAEs): acute myocardial infarction, pulmonary embolism, acute pulmonary oedema, unscheduled tracheostomy, respiratory failure, cardiac

arrest, cerebrovascular accident, severe sepsis, acute renal failure, emergency intensive care unit (ICU) admission, and death. The study reported that 16.9% of patients suffered post-operative serious adverse events, and that 7.1% of patients died. Further, in those older than 75 years who underwent unscheduled surgery, the mortality was 20% [12].

Serious adverse events are preceded by signs of instability.

A number of studies have assessed the clinical course and management of patients in the hours leading up to SAEs and cardiac arrests (Table 1.2). Some of these studies [13, 14] have used an expert panel to determine whether the cardiac arrest or iatrogenic arrest was avoidable and whether it was associated with medical error. Such studies suggest that approximately 60% of cardiac arrests were avoidable. Similarly, an assessment of 100 consecutive emergency ICU admissions suggested that 54% of patients received suboptimal care, and that suboptimal care was associated with increased mortality [15].

The major limitation of these studies is their retrospective design and lack of objective criteria for assigning preventability. Consistent with this notion, Hayward and Hofer [16] reported an analysis of 111 deaths in 7 Veteran hospitals in the USA which suggested that previous studies had overestimated the estimations of death due to medical error. In addition, the authors demonstrated considerable inter-observer variability in estimation of preventability, suggesting that “preventability was in the eye of the reviewer” [16].

Other investigators have retrospectively assessed patient’s case histories for objective signs of physiological or biochemical instability in the hours leading up to the cardiac arrest or unplanned ICU admission. At least five studies [17-21] have demonstrated that patients develop new complaints or deterioration in commonly measured vital signs or laboratory investigators in up to 84% of cases in the 24 hours prior to the event (Table 1.2). Such perturbations are not only objective, but they are routinely measured and assessed by treating medical and nursing staff. However, the limitation of these studies is that they fail to demonstrate whether intervention during the course of deterioration would have altered the patient outcome. In addition, they neglect

to assess a control group to document the frequency of such perturbations in patients not suffering cardiac arrest and unplanned ICU admission.

Three studies have attempted to assess the utility, sensitivity and prevalence of deranged vital signs in prospective cohort studies. Thus, Goldhill and McNarry [22] conducted a study in which the vital signs of 433 patients were prospectively recorded on a single day. They reported that increased number of abnormal vital signs was associated with increased risk of death. Bell and co-workers [23] recently reported on a prospective study in which the vital signs of 1097 patients was assessed between 9am and 2pm over two separate days. They reported that 4.5% of the patients in this study had deranged vital signs that satisfied criteria commonly used to trigger review by a Medical Emergency Team (See below). In these patients the 30 day mortality was 25% compared to 3.5% in patients who did not satisfy these criteria. Finally, Buist and co-workers [24] reported that 8.9% of the 6303 patients admitted over a 7-month period fulfilled MET criteria, and that this was associated with a 6.8 fold increase in adjusted mortality.

The rationale behind the Medical Emergency Team (MET)

Although serious adverse events including cardiac arrest are common in hospitalised patients, as many as four out of five patients admitted to hospital will not experience such an event. Every hospital system needs to develop a system to identify at-risk patients, and strategies to prevent and/or treat clinical deterioration to avoid serious adverse events including cardiac arrest. Possible strategies include the provision of 1:1 nursing care or continuous electronic monitoring. However, these approaches are prohibitively expensive, and create unnecessary anxiety and discomfort for patients who will never suffer an adverse event.

The Medical Emergency Team (MET) is part of a system that provides identification, rapid review, and treatment of patients who have clinically deteriorated in hospital wards. The MET is similar in principle to a cardiac arrest team. However, unlike a cardiac arrest team, the MET is summoned to review acutely unwell patients when they develop one or more pre-defined criteria and before the onset of cardio-respiratory arrest. The MET is typically

composed of senior doctors and nurses skilled in advanced resuscitation techniques including, but not limited to, advanced cardiac life support. There are a number of principles underlying the rationale of the role of the MET in acute care hospitals (Table 1.3).

The first principle underlying the MET concept (as outlined above) is that serious adverse events are frequently heralded by signs of physiological instability that manifest as derangements of commonly measured vital signs. Furthermore, these changes occur over several hours, so that there is potentially time to intervene in the course of deterioration. Importantly, the warning signs are detectable by measurement of routine vital signs with no additional costs or risks to the patient. Most importantly, there is increasing evidence that these derangements predict increase risk of in-hospital death [22-24].

An important principle underlying the MET concept is that earlier intervention in the course of deterioration is likely to improve clinical outcome. This observation has been made in patients suffering trauma [25], myocardial infarction [26], and in the resuscitation of patients presenting to the Emergency Department with severe sepsis [27].

Further principles underlying the MET concept are that therapies are available to treat the conditions that commonly precipitate MET calls [28] and that staff with expertise are available in the hospital, typically in the Intensive Care Unit (Table 1.3). In addition, any member of the hospital staff can activate the MET based on pre-defined criteria of deranged vital signs or acute change in clinical status (Table 1.4). Many hospital MET criteria also contain a "Staff member worried" category to allow staff to summon the MET for any possible emergency.

The MET is one example of a rapid response team (RRT). Recently, the findings of the first consensus conference on METs was published [29]. This publication emphasised that a MET should be part of a broader Rapid Response System (RRS) which consists of four elements including 1) An afferent, "crisis detection" and "response triggering" mechanism; 2) an efferent, predetermined rapid response team; 3) a governance / administrative structure

to supply and organize resources; and 4) a mechanism to evaluate crisis antecedents and promote hospital process improvement to prevent future events (quality improvement arm).

The history of the Medical Emergency Team (MET) in Australia.

A thorough review of all forms of RRT is presented elsewhere [29, 30] and is beyond the scope and aims of the present thesis. The discussion below outlines the history of the Physician-led MET in Australia and New Zealand.

The first account of the MET was reported by Lee and co-workers and described the use of the MET and the outcome of patients requiring a MET intervention over the 12 month period between March 1992 and February 1993 [31]. In this 375-bed teaching hospital the MET superseded the pre-existing cardiac arrest team, and the same MET members reviewed both cardiac arrests and other forms of medical emergency. The MET criteria in the original description were extensive and included abnormalities of physiology and biochemistry, as well as specific clinical conditions (cardiovascular, respiratory, shock, metabolic, poisoning, trauma, obstetric, neurological and surgical). The MET provided 522 reviews over the 12 months, and cardiopulmonary resuscitation occurred in 28% of calls. The survival rate was 29% for arrests and 76% for other medical emergencies [31].

The initial report of the MET by Lee and co-workers was largely descriptive, and did not assess the effect of the MET on the incidence or outcome of serious adverse events. In 1998 Daly and co-workers similarly reported the use of a MET in a district general hospital [32]. This model also used a single team to review the 68 hospital emergencies over a 12-month period, most of which were due to chest pain (19.1%), cardiopulmonary arrest (14.7%), seizures (14.7%), or respiratory distress (13.2%).

Bristow and co-workers [33] evaluated the effectiveness of a MET in reducing the rates of serious adverse events in a teaching hospital, compared with two other hospitals that had conventional cardiac arrest teams. The MET

hospital had fewer unanticipated critical care admissions but no difference in cardiac arrest rate or total death rate [33].

In 2002 Buist and co-workers reported the first study of the effect of a MET on the incidence of cardiac arrests in two 12-month periods before (1996) and after (1999) the introduction of a MET into a 300-bed general metropolitan teaching hospital in Dandenong Victoria [34]. After adjustment for case-mix, the introduction of a MET was associated with a 50% reduction in the incidence of unexpected cardiac arrests.

Subsequently, Bellomo and co-workers conducted a before-and-after study to assess the effects of introducing a MET service into the 400-bed acute care campus of Austin Health (See Chapter 2). They reported that introduction of the MET service was associated with a 65% relative risk reduction in cardiac arrests in both medical and surgical patients [35]. In addition, there was a 57.8% relative risk reduction in the incidence of adverse events in patients undergoing major surgery compared with the period before introduction of the MET service.

Finally, in June 2005, the MERIT study investigators reported on the effects of introduction of the MET system in a 23 hospital cluster-randomised trial [36]. Hospitals were randomised to continue functioning as usual (n=11) or to introduce a MET system (n=12). The MET was called to review 30% of those that fulfilled criteria and who were subsequently admitted to ICU. The MET system increased the incidence of calling for an emergency team, but did not affect the incidence of cardiac arrests, unplanned ICU admissions, or unexpected deaths.

Several explanations have been proposed to account for the findings of the MERIT study. First, unexpected deaths fell by more than 30% between the baseline and study periods in both the control and study hospitals [36, 37]. Secondly, the MET was summoned to review only 30% of all patients fulfilling MET criteria [36, 38] and analysis was conducted on intention-to-treat, and the overall call rate was lower than reported in other studies [37]. Thirdly, recording on vital signs was erratic, and missing in 62% of patients in the 15 minutes before the primary event [37]. Finally, the study was not sufficiently powered to

detect a difference in the primary outcome and there was significant heterogeneity between hospitals [36-38]. The findings of the studies presented within the present thesis are discussed in context of the MERIT study where appropriate.

Table 1.1: Studies reporting adverse events in hospitalised patients [£]

Reference(s) and year of inception	Study Population	Definition of adverse events	Major findings
Schimmel [2] 1960-1961	1014 patients admitted over 8 month period to a university affiliated hospital	Every noxious response to medical care occurring among patients....resulting from acceptable diagnostic and therapeutic measures deliberately instituted at the hospital.	20% suffered iatrogenic injury 6.7% of adverse events resulted in death LOS in those with noxious events was 28.7 days compared with 11.4 days in other patients
Brennan et al [3] Leape et al [4] 1984	30 195 patients in 51 hospitals in New York	Unintended injury that was caused by medical management that resulted in measurable disability	3.7% incidence of adverse events 47.7% associated with operation. Drug error, wound infection and technical complication responsible for 45.9% of events
Thomas et al [5] 1992	14 700 patients in 28 hospitals in Utah and Colorado	Injury caused by medical management rather than by the disease process and resulted in prolonged LOS or disability at discharge	2.9% incidence of adverse events 6.6% of adverse events resulted in death 44.9% were due to operative events
Andrews et al [6] 1989-1990	1047 patients from 3 units of a university teaching hospital in the United States	Situations in which an inappropriate decision was made when, at the time, an appropriate alternative could have been chosen	17.7% suffered at least one adverse event Increased events in those with long stays 37.8% due to an individual 9.8% due to administrative decisions
Wilson et al [7] 1992	14 179 patients in 28 hospitals in New South Wales and South Australia	Unintended injury or complication that resulted in disability, death or prolonged hospital stay and was caused by the health care management rather than by the underlying disease process	16.6 % incidence of adverse events 51% had high preventability 13.7% resulted in permanent disability 4.9% resulted in death Resulted in 7.1 day increased LOS
Davis et al [8, 9] 1998	6579 patients in 13 New Zealand hospitals with more than 100 beds	Same as the study by Wilson et al	12.9% incidence of adverse events 37% preventable to a significant degree 15% associated with permanent disability or death Resulted in 9 day increased LOS 57.5% associated with surgery
Vincent et al [10] 1999-2000	1014 patients in 2 London hospitals	Unintended injury that was caused by medical management rather than the disease process	10.8 % incidence of adverse events 48% preventable
Baker et al [11] 2000	3745 patients in 20 Canadian hospitals	Same as the study by Wilson et al	7.5 % incidence of adverse events 36.9% preventable
Bellomo et al [12] 1998-199	1125 patients undergoing major surgery in a university teaching hospital	Specific criteria for 11 pre-defined adverse events	16.9% incidence of serious adverse events 20% mortality in patients over 75 undergoing unscheduled surgery

£ Adapted from Baker et al [11] , LOS = length of stay

Table 1.2: Summary of studies reporting antecedents to serious adverse events and in-hospital cardio-pulmonary arrests

Reference & year of inception	Study Population and setting	Method of assessment	Major findings
Bedell et al [13] 1981	203 cardiac arrests (Most arrests were in medical patients) Boston Beth Israel Hospital	Iatrogenic arrest defined as an arrest that resulted from a therapy or procedure or from a clearly identified error of omission Review by 3 independent internists	14% followed an iatrogenic complication Iatrogenic arrests less likely to have cardiogenic shock or myocardial infarction before arrest 64% of iatrogenic arrests associated with inadequate clinical assessment, medication errors and suboptimal response to symptoms (dyspnea & tachypnea).
Schein et al [17] Jul- Oct 1987	64 consecutive cardiopulmonary arrests (age 51 ± 2 years) Jackson Memorial hospital (1,200 bed university teaching hospital)	Only included arrests in ward patients. Assessment of charts for vital signs, medical and nursing notes during the eight hours before the arrest The patients underlying condition was classified as rapidly fatal, ultimately fatal, or non fatal.	Arrest occurred 161 ± 26 hr post admission 84% had documented deterioration or new complaint within eight hours of the arrest Frequency of alteration were respiratory > multiple > cardiac > neurologic Prognosis of underlying disease non fatal in 36%.
McQuillan et al [15] Winter 1992	100 consecutive emergency admissions to adult ICU in England (Portsmouth and Southampton)	Opinions of two external assessors on quality of care before admission → especially recognition, investigation, monitoring and management of abnormalities of airway, breathing and circulation.	Assessors agreed that 20% received optimal care and 54% suboptimal care. ICU mortality of these patients was 25% and 48%, respectively. Suboptimal care resulted from lack of organisation and knowledge, failure to appreciate urgency, failure to seek advice
Buist et al [19] Jan to Dec 1997	43 cardiac arrests and 79 unplanned ICU admissions in 112 patients Dandenong Hospital Victoria	Retrospective assessment of medical records for abnormalities in vital signs and blood tests	76% of patients had instability for > one hour. Median duration of instability was 6.5 hours Haemodynamic > respiratory > abnormal laboratory results > reduced conscious state Overall mortality = 62% Accounted for 15% all ICU admissions, one third ICU deaths, 18% hospital deaths.
Hodgetts et al [14] 1999	118 consecutive arrests over one year period in all hospital areas except day units and the emergency department 700 bed acute district general hospital in south-east England	Review by expert panel to determine if arrests were potentially avoidable Inadequate treatment included errors in diagnosis, inadequate interpretation of investigations, incomplete treatment, inexperienced doctors, management in inappropriate clinical areas.	Panel unanimously agreed that 61.9% of arrests were potentially avoidable. Cardiac arrests more likely on the weekend OR for potentially avoidable arrest on general ward versus critical care area was 5.1 100% of potentially avoidable arrests deemed to receive inadequate treatment

Table 1.2 (contin.): Summary of studies reporting antecedents to serious adverse events and in-hospital cardio-pulmonary arrests

Reference & year of inception	Study Population and setting	Method of assessment	Major findings
Hodgetts et al [18] 1999	118 cardiac arrests as above Compared with 132 controls who did not suffer cardiac arrest	Compared incidence of abnormal clinical criteria Assessed for risk factors for cardiac arrest using clinical criteria	Risk factors for arrest included abnormalities in respiratory rate, breathing, pulse rate, systolic blood pressure, or temperature, as well as chest pain, hypoxia, or concern by the doctor or nurse.
Buist et al [24] May to Dec 1999	6303 patients admitted over 7 months to 320 bed hospital in Dandenong Australia	Prospective assessment of patients identified by pre-defined abnormal observations	8.9% of admissions fulfilled criteria, Oxygen desaturation and hypotension comprised 68% of all events. The presence of any abnormality was associated with a 6.8-fold increased risk of mortality.
Goldhill et al [21] 13 month period from May 1995	79 unplanned ICU admission in 76 patients	Physiological values and interventions in 24 hr prior to ICU admission	34% underwent cardiopulmonary resuscitation Many had respiratory deterioration: 75% received oxygen, 37% received arterial blood gas analysis, 61% had oxygen saturation measured (63% of these had SpO ₂ < 90%). Overall mortality 58%.
Goldhill and McNarry [22] Dec 2002	Recorded vital signs on 433 patients on a single day	Measured vital signs within 8 hours of patient review	6% died within 30 days. Increased number of abnormal vital signs was associated with increased risk of death. Patients often died many days after admission suggesting there was time to intervene
Nurmi et al [20] Dec 2001 to May 2003	110 cardiac arrests in four Finnish hospitals	Chart review of vital signs, symptoms and interventions in the 8 hr prior to cardiac arrest	54% of cardiac arrests on the ward had MET criteria in the 8 hr before the arrest, documented on average 3.8 hr before the arrest. Most common abnormalities were “respiratory distress” and hypoxia, but respiratory rate was documented in only one of the 110 patients.
Bell et al [23] Two separate days 10/12/2003 and 24/3/ 2004.	1097 patients Karolinska University Hospital Solna	50 nursing students recorded vital signs of 1097 patients between 9am and 2pm on two separate days	4.5% of the cohort fulfilled commonly measured criteria used to trigger Medical Emergency Team (MET) review These patients had a 30 day mortality of 25% compared with 3.5% for patients not fulfilling criteria.

AMI = acute myocardial infarction, OR = odds ratio, ICU = intensive care unit

Table 1.3: Physiological rationale why the MET is a logical approach for preventing serious adverse events in hospitalized patients.

- **Principle one: *There is time for intervention***
 - The evolution of clinical and physiological deterioration is relatively slow.
- **Principle two: *There are warning signs.***
 - Clinical deterioration is preceded by physiological deterioration in commonly measured **vital signs**
 - These observations are easy to measure, are inexpensive, and are non-invasive (measuring them does not hurt the patient).
- **Principle three: *There are effective treatments*** if dangerous conditions are recognized.
 - Examples include beta-blockers for myocardial ischemia, fluid therapy for hypovolemia, non-invasive ventilation and oxygen for respiratory failure, and anticoagulation for thrombo-embolic disease.
 - The majority of interventions of the MET are inexpensive, relatively simple and non-invasive
- **Principle four: *Early intervention improves outcome.***
 - The assumption that early intervention saves lives has been shown for the treatment of trauma as well as septic shock
 - The hospital survival for cardiac arrest is at best 14%
 - It is intuitive that sick people are easier to fix than dead people.
- **Principle five: *Any member of staff can activate the MET .***
- **Principle six: *Ward staff have insufficient skills to manage medical crisis***
 - Junior ward staff do not have the required skill set to identify and manage acutely deteriorating patients on the ward.
- **Principle six: *The expertise exists and can be deployed.***
 - Intensive care doctors and nurses are experts in the delivery of advanced resuscitation.

Table 1.4: MET calling criteria *

“If one is present call 7777 and ask for the MET”

- Staff member is worried about the patient
- Acute change in heart rate <40 or >130 bpm
- Acute change in systolic BP <90 mmHg
- Acute change in RR <8 or >30 bpm
- Acute change in saturation <90% despite oxygen
- Noisy breathing
- Problems with airway or tracheostomy
- Acute change in conscious state
- Acute change in UO to <50 ml in 4 hours.

* Listed are the criteria for the Austin hospital

Chapter 2

The Medical Emergency Team at the Austin Hospital

In the previous chapter the background, rationale for, and history of the MET systems in Australia was discussed. The purpose of the present Chapter is to describe in detail the characteristics of the Austin hospital, the services it provides, and the history and detail of its Rapid Response System (RRS).

Details of Hospital campuses

Austin Health is a teaching hospital of the University of Melbourne. It has three hospital campuses in the northeast of Melbourne, a city with a population of approximately 4 million. The Austin Hospital (400 beds) receives all acute admissions. It is also the principle referral centre for spinal cord injury and liver transplantation for the state of Victoria.

The Heidelberg Repatriation Hospital and The Royal Talbot Rehabilitation Centre are used for limited elective surgery as well as for rehabilitation and aged care medicine. The acute care campus admits approximately 60,000 patients per year and is the campus where the MET system operates. The intensive care unit (ICU) of the acute campus has 21 beds, receives approximately 1,800 admissions per year, and operates according to a “closed” ICU model where only ICU physicians can prescribe treatment.

Assessment of post-operative serious adverse events

In 2002, Bellomo and co-workers reported on the incidence and nature of postoperative serious adverse events (SAEs) amongst patients undergoing major surgery (surgery requiring admission for greater than 24 hours) at the Austin

Hospital [12]. A dedicated research coordinator was employed to assess patient records for the presence of 11 pre-defined SAEs (e.g. myocardial infarction, pulmonary embolism, respiratory failure).

There were 414 SEAs in 190 of the 1125 patients (16.9%) and 80 (7.1%) patients died. The mean duration of hospital stay in patients without SAEs was 18.4 days compared with 38.5 days for those with SAEs ($p < 0.0001$). In patients aged 75 who underwent unscheduled surgery, the mortality was 20%.

Details of the Medical Emergency Team service

In response to the publication of Lee and co-workers [31] and increasing reports of the high incidence of physiological antecedents that precede serious adverse events [17-20], a MET service was introduced into the Austin Hospital in November 2000.

The Traditional Cardiac Arrest Team

Prior to the introduction of the MET the only Rapid Response Team (RRT) in the hospital was a traditional cardiac arrest or “Code Blue” team. This RRT was activated by ward nursing or medical staff in response to detection of a patient who had suffered a cardiac or respiratory arrest. The “Code Blue” team consists of an ICU registrar and nurse, a coronary care registrar and nurse, and the receiving medical registrar of the day.

Members of the team are activated by pagers and the overhead public announcement system. All wards are equipped with semi-automatic defibrillators and resuscitation equipment.

Rapid Response Teams after Introduction of the MET Service

Since November 2000, the Austin Hospital has operated two separate levels of RRT (Figure 2.1) [35, 39]. The first is the traditional cardiac arrest team (as outlined above) designed to review patients who are thought to have suffered a cardio-respiratory arrest. The second RRT is a MET, designed to review all medical emergencies other than cardio-respiratory arrests. This two-tier system is a major difference to the earlier models of RRS described by Lee et al [31] and Daly et al [32] which used a single system to review all in-hospital medical emergencies.

The second major difference of the MET service at the Austin Hospital was the use of a simplified version of calling criteria (or MET activation criteria). These are based on derangement of commonly measured vital signs such as blood pressure, heart rate, respiratory rate, and urinary output (Table 1.4, Figure 2.1). In addition, there is a “staff member worried” criterion to allow ward staff to summon senior assistance for any medical emergency.

The MET service is available 24 hours per day and comprises the ICU registrar and nurse, and the receiving medical registrar of the day. The parent unit of the patient frequently attend the MET call. In cases where they are unable to attend (e.g. doctors in clinic or operating room), they are notified of the MET call and the subsequent management plan by members of the MET service.

Details of the phases of MET service introduction

The details of MET service introduction have been outlined elsewhere [35, 39]. To study the effect of the MET service on patient outcome, Bellomo and co-workers conducted a prospective before-and-after study in which patient outcomes

in a 4-month period after the introduction of the MET service were compared with those in a 4-month period before its introduction (Figure 2.2).

During the 4-month before period (1 May 1999 – 31 August 1999) patient outcomes were measured under the normal operating conditions of the hospital. A preparation and education period was conducted for a 12-month period (1 September 1999 – 31 August 2000) to inform the hospital staff of the hospital of the nature of the MET service and the criteria for activation (Figure 2.2). The details of the education process are outlined in Chapter 4. Since 1 November 2000, the MET service at the Austin hospital has been fully operational. The effect of the MET service on patient outcome was studied in the 4-month after period (1 November 2000 – 28 February 2001).

Effect of MET Service on Cardiac Arrests at the Austin Hospital

In September 2003, Bellomo and co-workers reported that introduction of the MET service into the Austin Hospital was associated with reduction in the incidence and risk of death from cardiac arrest [35]. Thus, they reported that there were 63 cardiac arrests in the “before” period and 22 in the “after” period (RRR 65%, $p < 0.0001$). In addition, survivors of cardiac arrest required fewer ICU (RRR 80%, $p < 0.0001$) and hospital (RRR 88%, $P < 0.0001$) bed days in the period “after” introduction of the MET compared with the period “before” introduction of the MET [35]. Chapter 6 describes the effect of ongoing use of the MET service on the incidence and outcomes of cardia-respiratory arrests between 1 January 1999 and 31 October 2004.

Effect of MET Service on Post-operative SAEs at the Austin Hospital

Bellomo and co-workers subsequently reported that the introduction of the MET service was associated with a 57.8% RRR in SAEs in patients undergoing major surgery, defined as a surgical admission requiring more than 48 hours hospital admission [39]. Identical definitions for SAEs were used in this study as for the previous observational study reported in 2002. Statistically significant reductions were seen the incidence of respiratory failure, stroke, severe sepsis, and acute renal failure requiring renal replacement therapy. In addition, introduction of the MET service was associated with a reduction in post-operative length of stay and mortality. The study in Chapter 3 assesses whether the observed reduction in post-operative death is sustained in the period after hospital discharge.

Thesis Overview and Summary of Related Publications

As outlined above, Bellomo and co-workers reported that introduction of a MET service into the Austin Hospital was associated with a reduction in the incidence of cardiac arrest, and a reduction in SAEs in patients undergoing major surgery. Although they are landmark studies in the literature of the MET system, they have a number of limitations. Firstly, the proposed benefits of the MET on post-operative surgical mortality are assessed only to the point of hospital discharged and do not consider other factors that might effect patient outcome. In Chapter 3, the mortality of patients admitted in the MET period is assessed to 1500 days, and compared with that of the control “before-MET” period.

A number of studies have reported that use of a MET service by hospital staff may be limited because of a reluctance to breach the traditional model of

contacting the most junior member of staff first [34, 40, 41]. In chapter 4 the uptake and use of the MET service at the Austin hospital between August 2000 and June 2004 is assessed. The uptake at the Austin Hospital (Chapter 4) is compared and contrasted with that at the Alfred Hospital (Chapter 5).

A further limitation of the initial studies of Bellomo et al is the use of short (4-month) study intervals in the before-and-after periods. They do not assess whether the benefit of the MET service can be sustained for a longer period. In Chapter 6 the effect of the MET on the incidence and outcome of cardiac arrests between 1 January 1999 and 31 October 2004 is assessed. In Chapter 7 the relationship between in-hospital mortality for medical and surgical patients is assessed in relation to the frequency of MET-call reviews.

In Chapters 8 to 11 the timing and characteristics of MET reviews and cardiac arrests at the Austin Hospital is reviewed. Finally, in Chapter 12 the findings of a survey of 351 nurses attitudes to the MET service at the Austin Hospital is presented. A summary of the aims and citations of the related peer publications arising from the Chapters in this thesis are presented in Table 2.1 and in the table of contents (page 2).

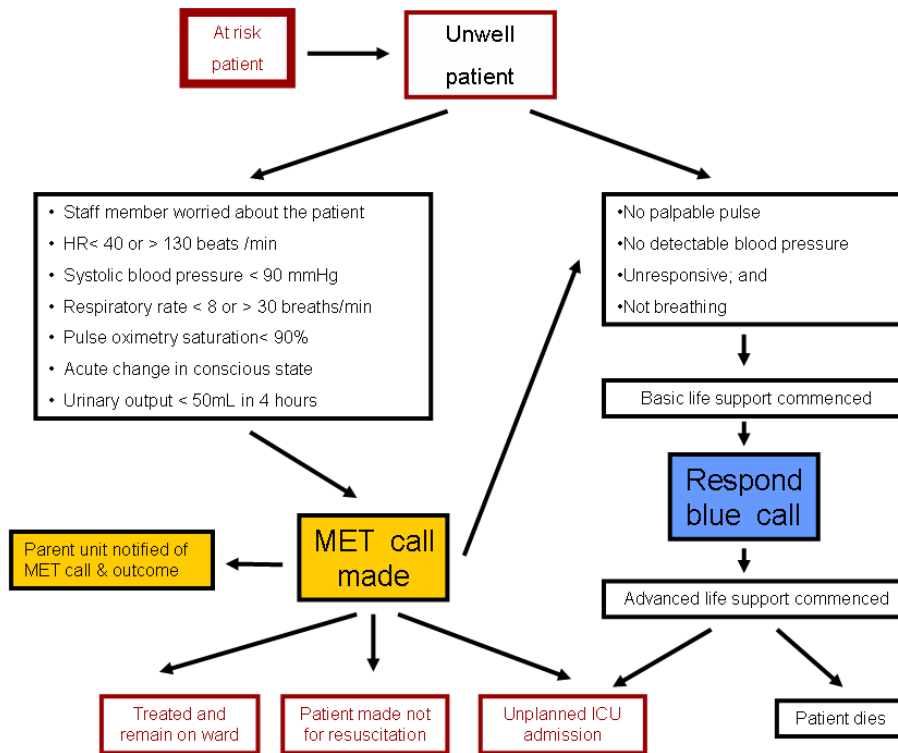


Figure 2.1: Overview of Rapid Response Systems (RRS) at Austin hospital since November 2000.

MET, medical emergency team; HR, heart rate; ICU, Intensive Care Unit.

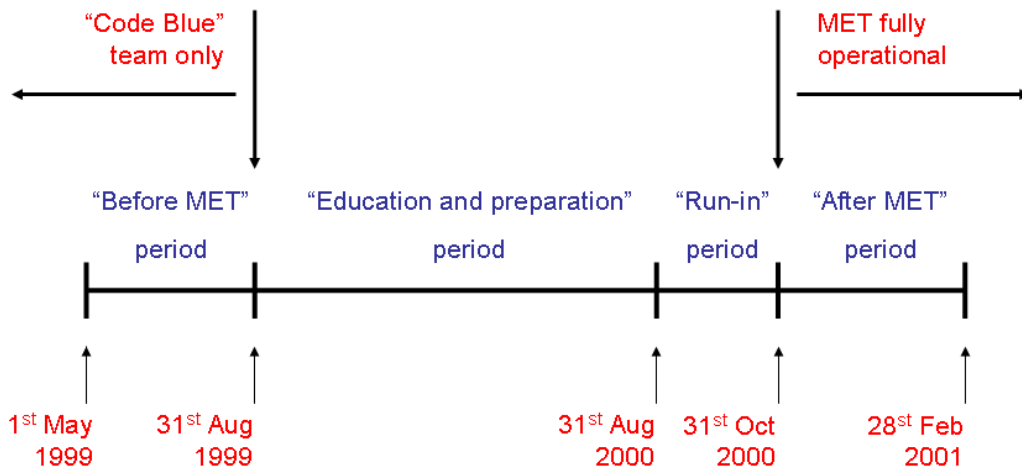


Figure 2.2: Line diagram showing timeline for study periods and introduction of MET service and at Austin hospital.

Table 2.1: Summary of study aims for Chapters in this theses and citation of the related peer-review publication.

Chapter	Summary of Chapter aims	Citation of peer review publication
3	To assess the effect of introduction of the MET service on the mortality of the original cohort of patients studied by Bellomo et al	Jones D, Opdam H, Egi M, Goldsmith D, Bates S, Gutteridge G, Kattula A, Bellomo R. Effect of the Medical Emergency Team on Long-term Mortality Following Major Surgery. <i>Critical Care</i> 2007; 11:R12
4	To assess whether the one year education and preparation period was associated with sustained or increased use of the MET service at the Austin Hospital	Jones D, Bates S, Warrillow S, Goldsmith D, et al. Effect of an Education Program on the Utilization of a Medical Emergency Team in a Teaching Hospital. <i>Internal Medicine Journal</i> 2006; 36: 231-236.
5	To assess the effect of changes in the RRS structure, calling criteria, and method of activation on the use of the MET service at the Alfred Hospital	Jones D, Mitra B, Barbetti J, Choate K, Leong T, Bellomo R. Increasing the Use of an Existing Medical Emergency Team in a Teaching Hospital. <i>Anaesth. Intensive Care</i> 2006; 34: 731-735.
6	To assess whether the reduction in incidence of cardiac arrests observed in the 4-months after the introduction of the MET service is sustained over a protracted period.	Jones D, Bates S, Warrillow S, Goldsmith D, et al. Long Term Effect of a Medical Emergency Team on Cardiac Arrests in a Teaching Hospital. <i>Critical Care</i> 2005; 9: R808-R815.
7	To assess the effect of sustained use of the MET on the in-hospital mortality of both medical and surgical patients in the period September 1998 to December 2004.	Jones D, Opdam H, Egi M, Goldsmith D, Bates S, Gutteridge G, Kattula A, Bellomo R. Long-Term Effect of a Medical Emergency Team on Mortality in a Teaching Hospital. <i>Resuscitation</i> . 2007; 74:235-241.
8	To assess the circadian pattern of activation of the MET service at the Austin hospital	Jones D, Bates S, Warrillow S, Opdam H, et al Circadian Pattern of Activation of the Medical Emergency Team in a Teaching Hospital. <i>Critical Care</i> 2005; 9: R303-R306
9	To assess the circadian pattern of cardiac arrest detection and its relationship with routine nursing observations and episodes of MET service activation	Jones D, Bates S, Warrillow S, Goldsmith D, et al. Patient Monitoring and the Timing of Cardiac Arrests and Medical Emergency Team Calls in a Teaching Hospital. <i>Intensive Care Medicine</i> . 2006 Jul 7; 32(9):1352-6
10	To describe the frequency of unexpected deaths and the role of the MET service in end-of-life care at the Austin Hospital.	Jones D, McIntyre T, Baldwin I, Mercer I, Kattula A, Bellomo R. The Medical Emergency Team and End of Life Care: A Pilot Study. <i>Crit Care Resusc.</i> 2007; 9:151-156
11	To describe which MET criteria and clinical conditions associated with most MET calls. To describe an approach to managing episodes of MET review	Jones D, Duke G, Green J, Briedis J, Bellomo R, et al. Medical Emergency Team syndromes and an approach to their management. <i>Critical Care</i> 2005; 10: R30.
12	To assess nurses attitudes to the MET service at the Austin Hospital	Jones D, Baldwin I, McIntyre T, Story D, Mercer I, Miglic A, Goldsmith D, Bellomo R. Nurses' Attitudes to a Medical Emergency Team Service in a Teaching Hospital. <i>Qual Saf Health Care</i> 2006; 15: 427-432

Chapter 3

Effect of the Medical Emergency Team on Long-term Mortality Following Major Surgery

Abstract

Introduction: Introducing an ICU-based Medical Emergency Team (MET) into the Austin hospital was associated with decreased post-operative in-hospital mortality after major surgery. The purpose of the present study was to assess the effect of the MET and other variables on long-term mortality in this patient population.

Methods: We conducted a prospective controlled before-and-after trial in a University-affiliated hospital. Participants included consecutive patients admitted for major surgery (surgery requiring more than 48 hours hospital stay) during a 4-month control phase and a 4-month MET phase. The intervention involved the introduction of a hospital-wide ICU-based MET service to evaluate and treat ward patients with acutely deranged vital signs. Information on long-term mortality was obtained from the Australian death registry. The main outcome measure was patient mortality at 1500 days. Data on patient demographics, surgery undertaken and whether the surgery was scheduled or unscheduled was obtained from the hospital electronic database. Multi-variable analysis was conducted to determine independent predictors of 1500 day mortality.

Results: There were 1369 major operations in 1116 patients during the control period and 1313 operations in 1067 patients during the MET (intervention) period. Overall survival at 1500 days was 65.8% in the control period and 71.6% during the MET period ($p=0.001$). Patients in the control phase were statistically less likely to be admitted under orthopedic surgery, urology and facio-maxillary surgery units, but more likely to be admitted under cardiac surgery or neurosurgery units. Patients in the MET period were less likely to undergo unscheduled surgery. Multi-variable analysis revealed that age, unscheduled surgery and admission under thoracic surgery, neurosurgery, oncology and general medicine were independent predictors of increased 1500 day mortality. Admission during the MET period was also an independent predictor of decreased 1500 day mortality (OR 0.74; $p=0.005$).

Conclusion: Introduction of a MET service into the Austin hospital was associated with increased long-term survival even after adjusting for other factors contributing to long-term surgical mortality.

Introduction

As outlined in Chapter 1, serious adverse events (SAEs) are common among patients admitted to hospital [42]. A review of more than 30,000 medical records in New York State showed that SAEs affected nearly 4% of all admissions, of which 13.6% led to death [43]. Similar findings have been reported in Australia [7], Canada [11], and Britain [10] demonstrating that this is a world-wide problem. In a study of patients undergoing major surgery in the Austin hospital, 16.9% suffered SAEs and 7.1% died [12] (See Chapter 2).

Cardiac arrests and SAEs in hospital patients are typically not sudden or unexpected. Several studies have demonstrated that these events are heralded by derangements of commonly measured vital signs in the preceding 24 hours [17-19, 21, 44, 45]. Medical Emergency Teams (METs), an example of a Rapid Response Team (RRT), have been introduced into hospitals to identify, review and treat at-risk patients during the early phase of deterioration.

In a previous study [39] Bellomo and co-workers reported that introducing a MET service into the Austin was associated with decreased post-operative SAEs, post-operative mortality, and mean duration of hospital stay (Chapter 2). However, this study only reported on post-operative mortality to the point of hospital discharge. Further, it did not account for possible confounders that may have contributed to the observed outcome differences.

The aim of the present study was to assess the effect of introducing a MET service on the long-term survival (to 1500 days, or 4.1 years) of a cohort of patients undergoing major surgery at the Austin. In addition, we assessed patient-, procedural- and system- related variables that might have also influenced long-term post-operative survival.

Methods

Ethics considerations

We obtained Hospital Human Research Ethics Committee (HREC) approval for the implementation of the Medical Emergency Team (MET) and for the collection of data related to the study. The need for informed consent was waived by the HREC.

A separate ethics approval was obtained from the Australian Registry of Deaths for permission to follow-up and cross-reference outcomes of our cohort of patients with the Australian Registry of Deaths, which records the death of all Australian citizens.

The Hospital and Rapid Response Systems

The details of the Austin Hospital, the services it provides, and its RRS have been outlined in Chapter 2.

Study Design

The study design was that of a prospective controlled before-and-after intervention trial. All patients admitted to hospital who had major surgery were considered as participants. Major surgery was defined as any operation associated with a hospital stay greater than 48 hours. In the present study we assessed the long-term mortality of the cohorts of patients reported in the original publication [39]. The follow-up time of 1500 days (4.1 years) represented the longest follow-up period for the MET (intervention) study cohort at the time of data acquisition from the Australian Registry of Deaths. To maintain consistency between the MET and control periods, outcome data were censored at this time.

Study Periods

The "before" period was a 4-month period (control period) encompassing 1 May 1999 – 31 August 1999 (winter) during which outcome measures were studied under normal operating conditions of the hospital. This period was followed by a preparation and education period (1 September 1999 – 31 August 2000) to allow the introduction of the MET [35, 39] (Chapter 4). During this period the concept of the MET was presented in the form of lectures and tutorials to hospital administration, nursing staff and paramedical personnel (physiotherapists and speech therapists). Extensive and repeated presentations and discussions were held with all members of medical staff. Objections were raised and addressed at

these meetings (See also Chapters 2 and 4). The MET was then implemented and a run-in period of 2 months was allowed. This was done to ensure that there were no logistic or political problems with its implementation and that all members of hospital staff would become familiar with its use.

The "after" period was the following 4-month period (intervention period) encompassing 1 November 2000 – 28 February 2001 (spring and summer) during which the outcome measures were studied under the new (availability of MET) operating conditions of the hospital (See Figure 2.2)

Subjects

Analysis included all subjects who had in-patient surgery during the study period and who remained in hospital for 48 hours or more after surgery. The 48-hour limit was used to exclude patients having day surgery or minor procedures who were not expected to be at risk of serious adverse events.

Data collection

We collected baseline demographic data (patient age and gender, procedure undergone), as well as hospital systems data (surgical specialty of admission, scheduled or unscheduled status of surgery). Information on long-term outcome was obtained from the Australian Registry of Deaths.

The number of procedures in each of 83 operative categories for both the control period and the intervention phase was collated to allow comparison between the MET and control periods. For the purposes of multi-variable analysis, these 83 operative categories were then grouped into 37 operation clusters (labelled 1 → 37; Appendix 3.A). All collation and grouping was performed by a single investigator who was blinded to the patient's outcome. Similarly, the investigator performing outcome analysis was blinded to the classification of the operation clusters (which were labelled 1 through 37) and the admitting unit.

Outcome measures

The primary outcome measure for the study was the time to death (in days) from the date of admission. When performing multivariate logistic regression analysis, vital status at 1500 days was used as the dependent variable.

Statistical analysis

Computerized statistical packages were used for data analysis and descriptive statistics (Statview, Abacus Inc., Berkeley, CA.SPSS 12.0, SPSS Inc, Chicago, Illinois). Descriptive data are presented as mean \pm standard deviation. Comparisons of nominal data for differences in proportions between the two study periods were performed using χ^2 or Fisher's exact test.

Cumulative mortality was determined using the Kaplan-Meier product limit method of survival estimation and comparison of survival of patients in the MET and control periods was performed using the Log-rank test, censoring survival at 1500 days.

We also performed multivariate logistic regression analysis using age (in 10 year intervals), gender, un-scheduled surgery, unit of admission, operation cluster (1→37) and MET period as independent variables, and vital status at 1500 days as the dependent variable. A forward stepwise elimination process was then used to remove co-variables whose multivariate P value was > 0.10 . The final model contained all predictors of mortality with a multivariate $P < 0.10$. In all multivariate logistic regression analyses, we sought to assess 1) the discrimination of the model with the percentages of appropriately classed patients in the final model; 2) the calibration of the model with Hosmer-Lemeshow test; and 3) the role of multi-collinearity with the Variance Inflation Factor (VIF). Every VIF was less than 5, indicating absence of severe multi-collinearity.

For all statistical analysis, a $p < 0.05$ was considered statistically significant.

Results

Baseline characteristics of the patient cohorts

During the control period, there were 1369 procedures in 1116 patients, and during the MET period there were 1313 procedures in 1067 patients (Table 3.1). The average age and proportion of female patients in the two periods was similar. Patients in the control period were statistically more likely to be admitted under units for cardiac or neurosurgery, and less likely to be admitted under units for orthopedic surgery, urology, and ear nose and throat / facio-maxillary surgery (Table 3.1).

Differences in the surgical procedures performed in the control and MET periods

Patients admitted during the MET period were less likely to have unscheduled surgery when compared with the control period (Table 3.2). In addition, patients admitted in the MET period were less likely to undergo valvular cardiac and aortic arch surgery, hepato-biliary, pancreatic, or splenic resection, vascular bypass and fistula surgery, and certain forms of neurosurgery (Table 3.2). In contrast, patients admitted during the MET period were more likely to undergo certain forms of orthopedic and urological surgery (Table 3.2).

Differences in long-term mortality of patients admitted during the control and MET periods

Patients admitted during the MET period had improved 1500 day (4.1 year) survival compared to those admitted during the control period (Figure 3.1, Table 3.3). At 1500 days there were 381 deaths in the control period and 303 deaths in the MET period. Thus, the 1500 days survival for patients admitted during the MET and control periods was 71.6% and 65.8%, respectively (Log-rank test $p=0.001$). The odds ratio of death at 1500 days in the MET period was 0.77 (95% CI 0.64-0.92; $p=0.004$) when compared with the control period. This survival benefit was seen for each yearly interval (Table 3.3).

Analysis of factors contributing to death

Multi-variable analysis of data for patients in both the MET and HDU period revealed a number of independent predictors of death (Table 3.4). Increasing age, non-scheduled surgery and admission under units for thoracic surgery, neurosurgery, oncology, and general medicine were all independent risk factors for death at 1500 days. Similarly, the operation clusters of bronchoscopy, cerebral resection and cystoscopy (\pm bladder resection of tumour) were independently associated with an increased risk of death at 1500 days.

Female gender and admission under units for cardiac surgery, vascular surgery, and the liver transplant unit were independently associated with a decreased risk of death at 1500 days, as were the operation clusters of breast surgery and spinal fusion. After adjusting for other confounding factors, admission during the MET period was an independent predictor of survival at 1500 days (Multi-variate OR 0.74, 95% CI 0.60-0.92; $p=0.005$).

Discussion

We conducted a follow-up study to assess the long-term survival of the original cohort of patients undergoing major surgery at the Austin Hospital [39]. In addition, we assessed the effect of the introduction of a Medical Emergency Team (MET) service on the outcome of such patients in comparison with a cohort treated before its introduction. Finally, we assessed for possible confounders that might explain the observed differences (mortality, hospital length of stay and SAEs) of our original publication dealing with short-term outcomes [39]. We found that at 1500 days there was a significant 5.8% absolute decrease in long-term mortality among patients treated during the MET period, and that admission during the MET period was an independent predictor of 1500 day survival.

A previous study [12] of 1125 patients undergoing major surgery (defined as surgery requiring admission for > 48hrs) in the Austin revealed that 16.9% suffered serious adverse events and 7.1% died. In addition, age > 75 years and unscheduled surgery were predictors of increased risk of in-hospital death [12]. In the present study we confirm that these variables also adversely affect survival to 1500 days.

Subsequently [39], it was demonstrated that the introduction of a MET service was associated with a relative risk reduction (RRR) of post-operative hospital mortality of 36.6%, as well as reductions in ICU admissions (RRR 44.4%), and serious adverse event (RRR 59.5%) (See also Chapter 2). However, this study did not assess for possible confounders that may have influenced the observed differences in outcome and its findings were, accordingly, the subject of criticism. In the present study, we have shown that a difference in patient mortality was sustained out to a period of 1500 days and, that on day 1500, the OR of death for admission during the MET period was 0.77 compared with the control period.

Our study revealed that there were a number of differences in the patient cohorts in the MET and control periods. We also identified a number of factors that were independent predictors of increased risk of long term death including increasing patient age, male gender, unscheduled surgery, and admission under thoracic surgery, neurosurgery, oncology, or general medicine. After adjustment for all assessable confounders, we found that admission during the MET period was associated with a statistically reduced chance of long-term death when

compared with admission during the control period. If this effect could be reproduced elsewhere, the public health consequences would be important. Indeed, in response to preliminary findings that the MET approach may benefit hospital patients, the Institute for Health Improvement has launched a nation-wide initiative to introduce such teams in many American hospitals [46]. Thus, knowing whether the putative in hospital benefits achieved with such teams translate into long-term advantages might be crucial to justifying and sustaining the impetus of such a campaign.

The reduction in mortality between the two study cohorts is perhaps greater than would be expected from the absolute number of MET reviews. We believe that education of hospital staff and the cultural change accompanying the MET is likely to be a substantial contributor to the observed differences in patient outcome associated with the introduction of the MET service.

Our study has several strengths including a prospective design; verifiable, independent and robust outcome; evidence of a clear effect both before and after adjustment for confounding variables and a suitable rate of intervention by MET. However, it also has important limitations. First, it was neither double-blinded, placebo-controlled, nor randomized. However, it is not possible to double-blind intervention by the MET in a single centre study. Furthermore, introducing "sham" intervention as placebo was considered ethically untenable.

The second limitation is that our analysis revealed differences in characteristics of the patient cohorts admitted during the control and MET periods. However, the beneficial effect of the introduction of the MET service on the long-term outcome of the patients persisted even after adjustment for multiple factors. Nonetheless, we can not account for other factors that were not assessed but may have also affected patient outcome. Such factors, rather than the introduction of the MET, might explain our findings.

Our multi-variate analysis also identified a number of conditions and surgical procedures that were independent predictors of long term mortality. It is likely that these differences are due to the prognosis of the underlying condition (e.g. admission under oncology, general medicine or neurosurgery). We are unable to comment as to whether the introduction of the MET service has associated with

improved outcome from these conditions. Further work is required to determine whether these conditions or procedures are associated with increased incidence of MET criteria and conditions for which the MET could intervene. We are also unable to comment on the effect of seasonal variation on the differences in observed patient mortality between the two study periods. However, our analysis did identify differences in baseline characteristics of the surgical conditions performed, and yet the benefits of the MET persisted even after adjustment for these differences.

The third limitation of our study is that it demonstrates the findings in a single institution only in a particular country. Its findings might not apply to other hospitals or health care systems. However, our institution has all the organizational, structural, logistic and clinical performance features of a typical tertiary referral hospital in a developed country. Nonetheless, it is important to note that the MERIT study, a cluster multicentre randomized controlled trial of the introduction of the MET in 23 hospitals in Australia, did not show a significant benefit of METs on several important outcomes [36]. A number of differences exist between the MERIT study and our study that may explain these findings. First, the MERIT study did not focus on mortality among patients having major surgery. Second, because of the large hospital-to-hospital variability and the limited number of centers, the study was statistically underpowered. Third, the “dose” of MET calls in our study ($52/1067 = 48.7$ METs/1000 patients) was 5.6 times that of the MERIT study (8.7 emergency calls / 1000 admissions). This difference in MET use may be explained by the longer education and preparation period for our study (12 months) compared with the MERIT study (four months).

Finally, our study demonstrates reduction in long-term mortality for surgical patients only. The effect on medical patients was not assessed. During the study period there were more than 8,000 medical admissions, making analysis of differences in baseline characteristics and admission diagnosis exceedingly complex. In addition, it is our clinical observation that medical patients have many more chronic co-morbidities and fewer acute physiological derangements amenable to intervention and correction by the MET. Nonetheless, we have previously demonstrated that introduction of the MET service was associated with a reduction in the incidence of cardiac arrests in medical patients [35].

Conclusions

Introduction of an ICU-based Medical Emergency Team was associated with an improvement in the long-term outcome of patients undergoing major surgery in a tertiary referral hospital. Similar studies of long-term outcome for surgical patients from other institutions or health care systems considering the introduction of Rapid Response Systems are now needed to confirm or refute our observations.

Table 3.1: Comparison of the demographics and allocation units for patients admitted during the control and MET periods

	Control period	MET period	p-value
Number of patients	1116	1067	-
Age average (SD)	60.8 (19.7)	60.1 (19.5)	0.46
Percentage female	41.52	42.61	0.49
Number of procedures	1369	1313	
Procedures per Parent Unit			
Cardiac surgery *	188	141	0.04
Thoracic surgery	141	117	0.22
General surgery / colorectal	288	313	0.08
Orthopedic surgery *	253	289	0.02
Vascular surgery	160	132	0.17
Haematology	5	1	0.22
Neurosurgery *	147	112	0.05
Plastic surgery	77	84	0.40
Spinal injury unit	3	5	0.50
Liver transplant unit	28	15	0.06
Nephrology	8	2	0.11
Cardiology	4	4	>0.99
Oncology	6	2	0.29
Urology *	23	48	0.001
Gynaecology	7	12	0.21
Paediatric surgery	11	8	0.55
General medicine	10	3	0.09
ENT/Facio-maxillary surgery *	9	24	0.005

* indicates statistically significant differences in the proportion of admissions

Table 3.2: Differences in the nature of operation clusters for patients admitted in the control and MET periods ¶

	Control period	MET period	p-value OR (95% CI)
Non-scheduled surgery	674	563	< 0.0001 0.66 (0.57-0.77)
Cardiac / Thoracic aortic surgery (not CABGS)	73	41	0.001 0.52 (0.35-0.77)
Hepato-biliary, pancreatic, splenic surgery	96	74	0.04 0.72 (0.52-0.99)
Orthopedic “other”	26	57	0.001 2.15 (1.34-3.44)
Vascular bypass / fistula surgery	95	58	0.0008 0.57 (0.41-0.79)
Intracranial haemorrhage / abscess drainage	29	9	0.0007 0.29 (0.14-0.62)
Neurosurgery “other”	42	27	0.04 0.61 (0.37-0.99)
Anaesthesia related	12	26	0.03 2.1 (1.05-4.20)
Urology “other”	4	23	0.0004 5.60 (1.92 – 16.2)

¶ The characteristics of the operation clusters are outlined in Appendix 3.A.

Table 3.3. Analysis of survival difference between MET and control period for patients undergoing major surgery.

	Hospital discharge ^β	One year	Two years	Three years	4.1 years
Deaths control period	73	195	271	337	382
Deaths MET period	45	133	189	239	303
OR for death	0.57	0.68	0.70	0.71	0.77
95% CI	0.39-0.84	0.55-0.85	0.58-0.84	0.60-0.84	0.64-0.91
p-value	0.004	0.001	<0.001	<0.001	0.003

^β As per original publication [39]

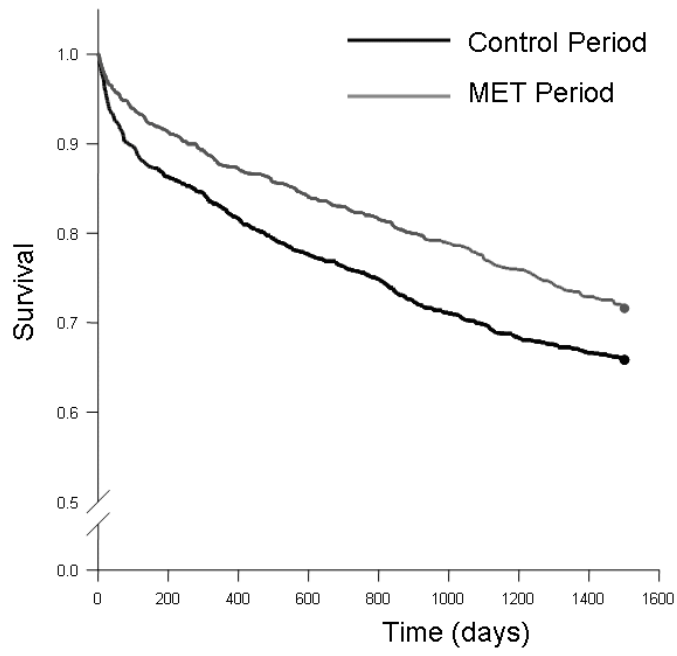


Figure 3.1: Kaplan- Meier survival curves for patients admitted during control and MET periods out to 1500 days.

Table 3.4: Multivariate logistic regression analysis for death within 1500 days after surgery for patients admitted in both the control and MET periods¶.

	Odds ratio	95% CI of odds ratio	P-value	VIF
Age (per 10 years)	1.73	1.61 - 1.86	<0.001	1.09
MET period ^β	0.74	0.60 - 0.92	0.005	1.02
Female gender	0.72	0.58 - 0.89	0.002	1.05
Non-scheduled surgery	1.51	1.21 - 1.89	<0.001	1.18
Admitting Unit				
Cardiac surgery	0.33	0.22 - 0.48	<0.001	1.28
Thoracic surgery	2.76	1.89 - 4.03	<0.001	1.36
Orthopedic surgery	0.50	0.37 - 0.69	<0.001	1.43
Vascular surgery	0.66	0.46 - 0.94	0.023	1.20
Neurosurgery	1.60	1.03 - 2.48	0.036	1.63
Liver transplant unit	0.30	0.09 - 1.03	0.056	1.05
Oncology	10.48	1.2 - 91.65	0.034	1.01
General medicine	3.00	1.13 - 7.95	0.027	1.02
Procedure				
Bronchoscopy	3.13	1.24 - 7.88	0.015	1.16
Breast surgery	0.20	0.04 - 0.95	0.043	1.04
Spinal fusion	0.34	0.17 - 0.68	0.002	1.21
Cerebral resection	3.30	1.6 - 6.77	0.001	1.33
Cystoscopy ± bladder tumour resection	2.90	1.04 - 8.08	0.042	1.02

¶ The characteristics of the operation clusters are outlined in Appendix 3.A.
CI; confidence interval, VIF; Variance Inflation Factor.

For this model, the Hosmer-Lemeshow goodness-of-fit statistic was 13.1 ($P=0.11$).
The percentage of appropriately classified patients in the final model is 75.3%.

β. The OR and 95% CI for introduction of the MET pertains to that derived from the multi-variate model

Appendix 3.A: Characteristics of operation clusters 1 to 37

Operation cluster	Operations contained within the cluster
1. Open heart / thoracic aortic surgery	Aortic valve surgery ± CABGs Aortic and mitral valve surgery Mitral valve surgery ± CABGs Thoracic aortic repair/replacement CABGS and Ventricular surgery CABGS and CEA
2. CABGS	CABGS
3. Resective thoracic surgery	Re-operation post cardiac surgery Sternal wound repair / closure Pericardial surgery Lobectomy or wedge resection Insertion of Denver Shunt Lung Biopsy Mediastinal surgery Thoracic surgery other
4. Pleural surgery	Pleurodesis Pleural decortication Drainage of empyema
5. Bronchoscopy	Brochoscopy (including laser & stent)
6. Upper gastrointestinal surgery	Esophageal surgery Gastric resection / binding
7. Intestinal endoscopy / insertion of feeding tube	Esophagoscopy (including laser/stent) Endoscopy Insertion of feeding tube
8. Appendicectomy	Appendicectomy
9. Hepatobiliary or pancreatic surgery	Gall bladder / biliary surgery ERCP / bile duct manipulation Pancreatic / spleen resection Liver resection / Portocaval shunt
10 Breast surgery	Breast surgery
11. Bowel surgery / hernia repair	Bowel resection / stoma formation or reversal Hernia repair
12. head and neck, facial surgery	Thyroid / parathyroid surgery Head and neck resection Nasal surgery Facial surgery Tracheostomy surgery
13. Wound debridement /mass biopsy	Wound debridement /mass biopsy
14. Haemorroid / perianal surgery	Haemorroid / perianal surgery
15. Laparotomy other	Tenkoff catheter insertion Laparotomy other
16. Hip fracture	Hip replacement / dynamic hip screw
17. Joint aspiration / lavage	Joint aspiration / lavage / scope

18. Spinal fusion / laminectomy	Spinal fusion / laminectomy
19. Amputation	Amputation
20. Limb fracture	Repair fracture upper limb Repair fracture lower limb
21. Orthopedic other	Joint reconstruction / relocation Removal of prosthesis Tendon repair
22. Vascular bypass or endarterectomy / fistula surgery	Lower limb vascular bypass Upper limb vascular procedure Carotid endarterectomy Formation / exploration of fistula
23. Abdominal aortic aneurysm	Abdominal aortic aneurysm repair
24. Other vascular surgery	Renal transplant Varicose veins surgery
25. Cerebral aneurysm clipping	Aneurysm clipping
26. Draining ICH / abscess	Removal of intracranial haemorrhage or AVM Drainage of intra-cranial abscess
27. Cerebral lobectomy / tumor resection	Removal of brain tumor Temporal lobectomy
28. Neurosurgery other	Insertion of spinal catheter Insertion / removal of Ventriculo-peritoneal shunt Neurosurgical other
29. Plastic surgical procedure	Hand surgery Removal of skin cancer and split skin graft Wound debridement and split skin graft Flap formation / reconstruction
30. Liver transplant	Liver transplant
31. Anesthetic procedure	Elective direct current reversion Insertion of Invasive Lines Magnetic resonance imaging other
32. Cystoscopy	Cystoscopy ± Trans-urethral resection of bladder tumor
33. Transurethral resection of prostate	Transurethral resection of prostate
34. Open prostatectomy	Open prostatectomy
35. Nephrectomy	Nephrectomy
36. Urology other	Cystectomy and ileal conduit formation Urolithiasis surgery
37. Gynecological procedure	TAH and/or BSO D + C Gynecology other

AVM = arterial venous malformation; CABGs = coronary artery bypass graft surgery; CEA = carotid end-arterectomy; TAH = total abdominal hysterectomy, D + C = dilatation and curettage, ERCP = endoscopic retrograde cholangio-pancreatography

Chapter 4.

Effect of an Education Program on the Utilization of a Medical Emergency Team in the Austin Hospital

Abstract

Background: Medical Emergency Teams (METs) have been developed to identify, review and manage acutely unwell ward patients. Previous studies have suggested that there may be obstacles to the utilization and activation of the MET.

Aims: To determine the effect of a detailed education program on the rate of utilization of the Medical Emergency Team (MET) system 3.5 years after its introduction in a University teaching hospital.

Methods: Prospective interventional study involving a detailed program of education, feedback and decision support for nursing and medical staff administered before, during and after implementation of a MET system. We measured the number of MET calls per month for both medical and surgical patients for 109,250 consecutive admissions to the acute care campus of Austin Health from August 2000 to June 2004.

Outcome Measures and Results: Overall activation of the MET increased from 25 calls per month to a peak of 79 calls per month over the study period (average increase of one MET call/month). After standardization for monthly admissions, the increase in MET utilization for surgical patients (increase by 1.13 METs/1000 admissions/month) was 4.9 fold greater than for medical patients (increase by 0.23 METs/1000 admissions/month) ($p < 0.0001$). At the peak level of activity (April 2004), the MET was called to review 8.4% of surgical and 2.7% of medical admissions ($p < 0.0001$).

Conclusions: There was a progressive increase in the utilization of the MET service in the 3.5 years following implementation, with the rate of uptake 4.9 times greater for surgical than for medical patients. Sustained uptake of the MET system is possible, but increased utilization may take several years to develop. Short-term studies testing the efficacy of the MET system are likely to significantly

underestimate its impact on reducing adverse events. Intensive care unit resource adjustments will become necessary to meet increased demand.

Introduction

As outlined in Chapter 1, serious adverse events are common in acute care hospitals [2-11] and are often preceded by signs of physiological instability [17-20]. These observations have led to the introduction of early warning systems variably named Medical Emergency Teams (METs), Outreach Teams, or Condition C Teams in several centers in Australia, the UK, and the USA [34, 40, 47, 48]. Early warning systems aim to identify, review and treat patients in the early phase of deterioration, in the assumption that early intervention improves outcome [46].

Previous studies suggest that utilization and activation of a MET service may be impeded by cultural barriers in the hospital [34, 40, 41]. To overcome these barriers, a process of formal education may be required [34, 40, 41]. Also, the effectiveness of a MET service might decrease over time due to the employment of new medical and nursing staff who are unfamiliar with the MET concept and reluctant to breach the “traditional” hierarchical system of patient management that usually involves notification of the most junior member of medical staff first [34, 40, 41]. Thus, it may take some time for these emergency teams to become accepted [48]. Alternatively, they may even fail to become embedded in the overall system of care. Sustained and increased uptake is a crucial aspect of such system change. To our knowledge, only a single study has formally reported on the change in rate and pattern of utilization of such teams over the long term [40].

We hypothesized that a sustained program of staff education and feedback would be associated with sustainability and increased uptake of our MET service over time. To test this hypothesis, we examined the rate and pattern of utilization of the MET over a 3.5-year period after its introduction.

Methods

We obtained Institutional Review Board Ethics Committee approval for the implementation of the MET and for the collection of data related to it. The need for informed consent was waived by the Institutional Review Board.

The Hospital

The details of the Austin Hospital and its services are outlined in Chapter 2.

Austin Hospital Rapid Response Systems (RRS).

The details of the Austin hospital's RRS are outlined in Chapter 2. The key elements are summarized here to contextualize the present chapter and to allow contrast to the MET utilization observed at the Alfred Hospital (Chapter 5).

The acute care campus has 2 levels of medical emergency responses and teams (Figure 2.1). The first is a traditional cardiac arrest ("Code Blue") team, which consists of a cardiology registrar and coronary care nurse, an intensive care registrar and nurse, and the receiving medical unit registrar. All wards are equipped with resuscitation trolleys containing resuscitation drugs and defibrillators. Data regarding cardiac arrests are kept independently on standardized forms by the ICU and Coronary Care Unit.

In September 2000 a MET system was introduced into the acute campus following an extensive preparation and education process [35, 39]. The team consists of an intensive care registrar and nurse, as well as the receiving medical unit registrar. It can be activated by any member of the hospital staff according to preset criteria of physiological instability that are based primarily on derangements of vital signs (Table 1.4, Figure 2.1). The outcome of the MET review depends on the nature of the problem encountered (Figure 2.1). All code blue and MET calls are communicated by the switchboard operators through the hospital loudspeakers and paging system, and a detailed log of all calls is maintained.

Study design

The implementation of the MET service was preceded by an extensive *preparation period* in the form of lectures and tutorials to all nursing staff. Formal presentations were also made to the Divisions of Medicine and Surgery during their respective grand rounds. Emphasis was placed on the theory behind the MET and its role as an "acute second opinion".

During the *implementation phase*, MET activation was reinforced and feedback and debriefing was given to the staff activating the MET system. All doctors in the hospital received written notification of the theory and purpose of the MET service, and were informed that the activation of the MET for unwell ward patients was hospital policy. Accordingly, it was made clear that no member of staff should be criticized for activating the MET system. In addition, large wall posters indicating calling criteria were displayed in every ward to improve awareness of the criteria for MET activation.

After implementation of the MET, education and information sessions were provided for new nursing and medical staff to familiarize them with the function of the MET (Table 4.1). In a collaborative effort between the clinical governance unit and the intensive care unit, measures were also instituted to improve communication and clinical handover between the members of the MET and the parent unit of the patient. Finally, through a nursing initiative, MET-criteria were included and colour coded on a novel observation chart to make it easier to identify MET-call criteria.

Outcome measures

Information on all MET calls is maintained in a hospital switchboard log book that contains the date and time of the call, as well as the ward where the MET review occurred. The number of calls for each month was collated overall and separately for surgical and medical patients. Designation of patients as medical or surgical was based on the ward from which the call originated. The details of 2,270 MET calls were manually entered into an MS Excel™ spread sheet by two investigators who worked together and cross-checked entries to minimize entry error.

Information on medical and surgical hospital admissions was obtained from the hospital electronic data system. A patient admission was defined as any admission involving at least an overnight stay.

Statistical analysis

Uptake of the MET was assessed by analyzing the change in the proportion of admissions that were subject to a MET call each month. Data were analyzed

using MS Windows Stat-View (Abacus Concepts, Berkeley, CA). Comparisons were made using the chi square test. A $p < 0.05$ was considered statistically significant.

Results

Overall use of the MET

The MET service was summoned to review 2,270 medical and surgical patients over the study period. Utilization of the MET service increased progressively from 25 calls per month in August 2000 to a peak of 79 calls per month in April 2004 (Figure 4.1). This corresponded to an average increase in the use of the MET by one call per month over the study period. When adjusted for the number of admissions, MET utilization rose from 12.3 MET calls/1000 admissions in August 2000 to a peak of 40.6 MET calls/1000 admissions in April 2004 ($p < 0.0001$).

Differences in MET usage for surgical and medical patients

Before standardization for monthly admissions, overall use of the MET was similar for both medical and surgical patients over the study period (Figure 4.2). After adjusting for monthly patient admissions, utilization of the MET for surgical patients was greater than that for medical patients for all but 2 months in late 2000 (Figure 4.3). In addition, the rate of increase in MET utilization was 4.9 times greater for surgical patients than for medical patients. Thus, use of the MET service for surgical patients rose by 1.13 METs/1000 admissions/month, compared to an increase of 0.23 METs/1000 admissions/month for medical patients, $p < 0.0001$ (Figure 4.3).

At the peak level of activity (April 2004), the MET was called to review 8.4% of surgical and 2.7% of medical admissions ($p < 0.0001$).

Discussion

We conducted a study to assess the effect of a detailed nursing and medical education program on the long-term rate and pattern of activation of the MET service in a teaching hospital. We found a progressive increase in the utilization of the MET service in our institution. We also found that this increased uptake occurred mostly in surgical units such that, at peak activity, the MET was

summoned to review almost 1 out of 12 surgical patients. Further, 3.5 years after the introduction of the MET service, uptake is still increasing. These observations indicate that, with appropriate education and feedback, the MET system can be sustained over the long term. They also suggest that evaluating a MET system soon after implementation is likely to significantly underestimate its ability to impact on adverse events. Finally, our findings suggest that ICU resources and personnel adjustments may be required with time.

Previous attempts to implement a MET system into a hospital have been impeded by cultural barriers and a reluctance of nurses and junior doctors to breach the “traditional” hierarchical system of patient management [34, 40, 41]. Formal education and audit processes have been required to increase the use of the MET service [34, 40, 41]. For this reason we initiated a detailed education program to prepare the hospital community for the MET system prior to its implementation. During the implementation phase, we provided feedback and debriefing for staff making MET calls on ward patients. We have subsequently introduced an ongoing education program for new doctors and nurses commencing employment at our institution. We have also provided regular reports and formal presentations on MET calls to the Department of Surgery and Medicine. This approach appears to have been successful in leading to a progressive increase in the use of the MET.

We are only aware of three other studies reporting rates of uptake of a MET system in a hospital beyond its initial few months after introduction. Kenward and co-workers in Birmingham, UK evaluated the use of a MET one year after introduction in a 700 bed district general hospital with 53,500 admissions per year [48]. During the first 12 months of use, there were 136 MET activations (2.5 MET calls / 1000 admissions). No further long-term data were reported. In the first 12 months following implementation of a MET service in the Austin (400 beds and 60,000 day and overnight admissions / year), there were 368 activations of the MET (5.6 MET calls / 1000 admissions). In the most recent 12 months, this increased to 809 MET reviews, in the context of a 13% increase in admissions (10.9 MET calls / 1000 admissions). A possible explanation for the difference in the rate of MET activation between the two hospitals may be dissimilarity in the patient acuity. The commitment to education and culture change in the Austin may also account for the observed difference.

DeVita and co-workers (Pittsburgh, USA) recently reported a retrospective analysis of 3,269 MET (Condition C) responses in a 622 bed university medical centre. Over 6.8 years, use of the MET service rose from 13.7 MET calls/1000 admissions to 25.8 MET calls/1000 admissions [40]. This increase occurred only after a comprehensive program of formal education to medical staff. The MET at this institution has eight members, each with designated responsibilities. In our 400 bed institution, using a MET comprised of three staff members, utilization increased from 12.3 MET calls/1000 admissions to a peak of 40.6 MET calls/1000 admissions over a 3.5 year period, demonstrating a much greater increase in utilization over a shorter period of time.

Finally, Lee and co-workers [31] (Sydney, Australia) documented 522 episodes of activation over a 12-month period following the implementation of a MET service. However, the MET service at this institution was also used to treat cardiac arrests (28% of all calls) and information on total patient admissions was not provided to permit comparison with our data. In addition, 62% of all calls involved reviewing patients in the emergency department, an area not currently serviced by the MET at our institution.

A large cluster randomized controlled trial of the introduction of the MET system in Australian Hospitals was recently published [36] (See also Chapter 1). It compared outcomes in 12 hospitals randomized to receive MET implementation to outcomes in 11 hospitals randomized to continue the existing form of cardiac arrest team based emergency care. Due to limited resources, this study assessed the impact of the introduction of MET reviews over 6 months only. The average call rate was reported as only 8.3 emergency calls/1000 admissions. This call rate is one fifth of our current call rate, and only two thirds of the call rate experienced during the first month in the Austin. As it also included cardiac arrest team calls, it probably represents an overestimate of actual MET calls. These observations emphasize the difficulties associated with assessing the potential impact of a MET system on patient outcomes when the duration of observation is short.

Our study is the first to assess levels of activation for medical and surgical patients. After adjusting for monthly patient admissions, the rate of increase in MET service utilization was 4.9 times greater for surgical patients than medical patients. This differential uptake may relate to a desire for ward based staff to

obtain assistance in managing medical problems in surgical patients. Alternatively, the MET service may have been activated more frequently by surgical ward nurses because the doctors of the parent unit were in the operating room, and therefore not immediately available. We are planning a detailed analysis of these surgical MET calls to better understand their epidemiology. At the peak level of activity, the MET was called to review 8.4% of surgical and 2.7% of medical admissions for the corresponding month. There was no difference in the education of staff caring for surgical as opposed to medical patients that would explain the difference in MET utilization.

Another implication of our findings is that ICU resource and personnel adjustments will inevitably become necessary over time to deal with increasing demand. If the MET is to achieve reductions in cardiac arrests, timely review of unwell ward patients is required. This will require increased ICU personal to allow staff to be available to perform the MET review.

Our study has several limitations. First, information on the triggering of MET calls was derived from the hospital PA system log book. However, this was verified using MET report forms completed by the team itself and appeared accurate. Classification of MET calls as being for medical or surgical patients was based on the type of ward that made the call. This is an imperfect methodology. It is possible that a small number of patients were incorrectly allocated using this method because of the presence of surgical patients on medical wards, or the reverse. However, we do not believe that such small numbers would materially alter the findings of this study.

Our study does not exclude other factors that might have contributed to the observed increase in MET calls (e.g. word of mouth among staff members). In addition, the study reports on the experience of a single center and does not demonstrate that a MET service can be sustained, let alone have its uptake increased in other institutions. However, our institution has all the organizational, structural and logistic features of a typical tertiary referral teaching hospital in a developed country. In our opinion, there is no reason to believe that our findings would not apply to similar institutions in our own or other developed countries.

Finally, the effect of the increased utilization of the MET service on reducing cardiac arrests is unknown. We are currently undertaking a detailed study to answer this question.

In summary, we have implemented a detailed program of continuing education and feedback in conjunction with measures to enhance decision support for MET service activation. This implementation was associated with a significant and progressive increase in utilization of the MET service over a 3.5-year period after its introduction. Following adjustments for number of admissions, the rate of uptake and use of the MET was 4.9 times greater for surgical than for medical patients. The study demonstrates that cultural and sociological change within a hospital may take some time. It suggests that short-term studies of a MET system are likely to underestimate its effectiveness, and that Critical Care resource and personnel adjustments will become necessary over time to meet increased demand.

Table 4.1: Details of education program delivered to hospital medical and nursing staff

- Lectures to all new interns.
- Regular presentations to new nursing staff.
- Regular tutorials to resident staff.
- Interactive focus-group sessions with interns.
- Presentations at Surgical and Medical grand rounds.
- Presentations at Medical and Surgical Audits.
- Formal regular documentation and identification of MET calls for Department of Medicine.
- Measures to improve communication and follow-up of surgical patients receiving a MET for a medical reason.

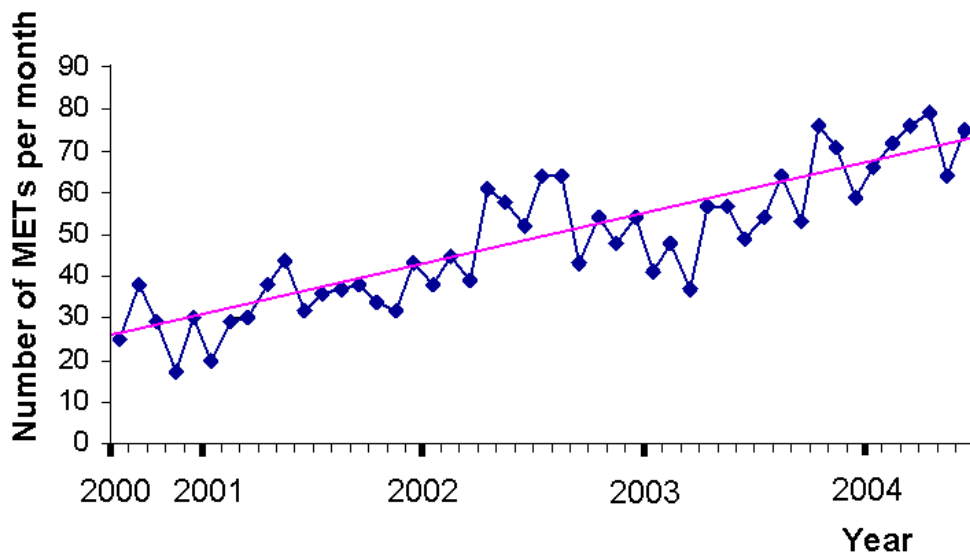


Figure 4.1. Graph demonstrating progressive uptake of MET between August 2000 and June 2004

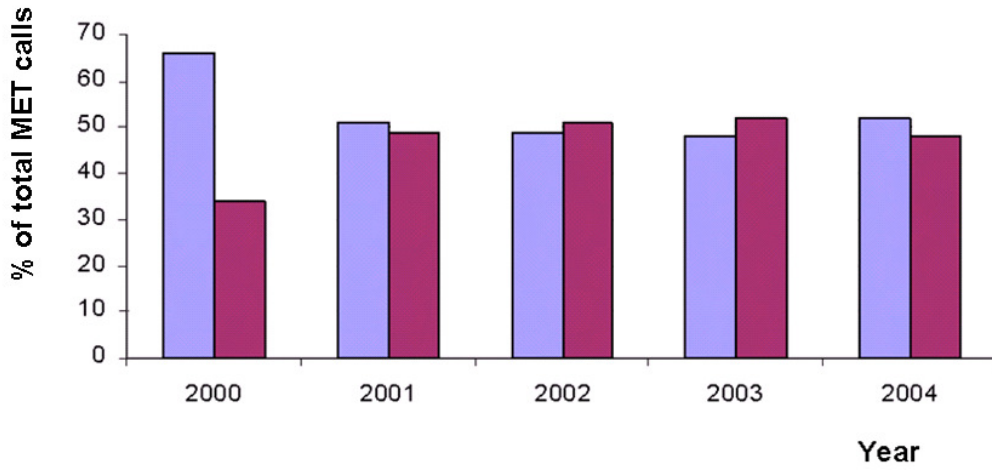


Figure 4.2. Comparison of use of MET for medical (■) and surgical (■) patients over study period prior to adjustment for number of admissions

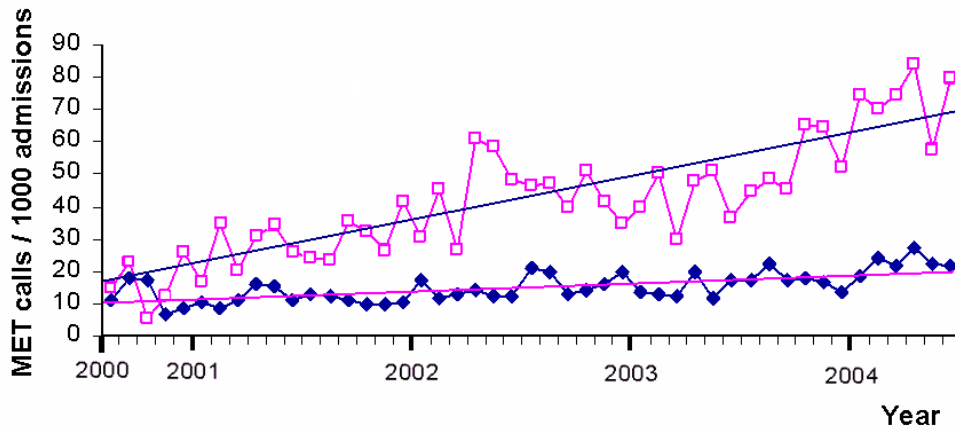


Figure 4.3. Comparison of rate of utilization of MET for medical (◆) and surgical (□) patients after adjusting for number of admissions

Chapter 5

Increasing the Use of an Existing Medical Emergency Team in the Alfred Hospital.

Abstract

Background: Cultural barriers in hospital ward staff may limit the use of a Medical Emergency Team (MET) service. In December 2000 the role of the existing Code Blue team in the Alfred hospital was expanded to incorporate review of patients fulfilling commonly employed MET criteria. Between January 2001 and June 2003, the average call rate was only 9.8 calls / 1000 admissions.

Methods and Interventions: Anecdotal feedback and a group-administered questionnaire conducted in July 2003 revealed a number of obstacles to initiating calls, and the system was modified in October 2004. Specifically, the single Rapid Response Team was separated into Code Blue calls (for cardio-respiratory arrests) and MET calls (with physiological and worried criteria). Further, loud overhead chimes as well as anaesthetist and cardiologist attendance were used only in the case of Code Blue calls (suspected arrests). Finally, the heart rate and respiratory rate criteria for MET service activation were modified.

Results: In the 12-months before the intervention (Oct 2003 - Sep 2004), there were 817 emergency response calls and 51,963 admissions (15.7 calls / 1000 admissions). In the 12 months after the intervention there were 1349 emergency response calls (Code Blue plus MET calls) and 54,593 admissions (24.7 calls / 1000 admissions [OR 1.59; 95% CI = 1.45-1.73; p <0.0001]).

Conclusions: These findings suggest that increasing the use of an existing service to review patients fulfilling MET criteria requires repeated education and a periodic assessment of site-specific obstacles to utilization.

Introduction

The previous Chapter reported that a detailed 12-month education and preparation period resulted in the progressive uptake and use of the MET service at The Austin Hospital. As discussed, at least three studies have suggested that the use of a MET service by hospital staff may be impeded by cultural barriers and allegiance to traditional models of care [34, 40, 41]. Between January 2001 and June 2003, use of the emergency response call system at the Alfred hospital was consistently less than 40% of the rate published elsewhere [40]. In response to anecdotal feedback and the results of a group-administered questionnaire conducted in July 2003 we modified the composition, triggers, and method of activation of the emergency response calls in the Alfred hospital, and conducted a comprehensive education program for hospital staff. We hypothesized that this would lead to an increase in the use of the system to review patients fulfilling MET criteria. To test this hypothesis, we analyzed the frequency of emergency call activation before and after the intervention.

Methods

Ethics approval

Approval was obtained from the Institution Human Research Ethics Committee for implementation of the MET and collection of the data related to it.

The Hospital

The Alfred Hospital is a 350 bed tertiary-referral center affiliated with Monash University in Melbourne, Victoria. The hospital provides a wide variety of medical and surgical services including cardiothoracic and neurosurgery. Moreover, it contains the primary trauma and burns units for the state of Victoria, as well as units for bone marrow, lung, and heart transplantation. The ICU contains on average 30 beds and operates according to a closed model, where only intensive care staff can prescribe therapy.

Overview of Hospital Rapid Response Teams

Formal data collection on medical emergency response calls commenced in January 1999. At that time a single form of Rapid Response Team (RRT) called a "Code Blue" team operated to review patients suffering suspected cardiac arrest. Members of the team were notified via the hospital switchboard using a series of

individual pages. In December 2000, the role of the existing “Code Blue” team was expanded to include review of unwell ward patients that had not suffered cardiac arrest, but who fulfilled pre-defined MET criteria. This approach is similar to that described by Lee and co-workers [31], and used a single RRT to review all emergency response calls. The RRT was notified by a paging system as well as an announcement and loud “chimes” over the hospital PA system. The criteria for MET activation were similar to those described at the Austin hospital [35] and were based on perturbations of heart rate ($HR > 130$ beats/min), respiratory rate ($8 < RR < 30$ breaths/min), pulse oximetry ($SaO_2 < 90\%$ despite oxygen therapy), and acute alterations in conscious state. In addition, there existed a “staff member worried” criterion to permit activation of the service for any other reason.

Between January 2001 and September 2004 a single type of emergency response call (termed “Code Blue” call) continued to operate for both cardiac arrests and patients fulfilling MET criteria, and the RRT comprised an ICU, anaesthetic, cardiology and medical registrar, an ICU nurse, and the parent unit doctors.

As part of a detailed intervention, from October 2004 two types of RRT operated, and calls were separated into Code Blue calls (for cardio-respiratory arrests) and MET calls (with physiological and “worried” criteria).

Study design

The study is a prospective before-and-after interventional trial. All patients admitted to the hospital were considered as participants to the study. A group-administered questionnaire was executed in July 2003. During August and September 2004 an intensive program of nursing and medical staff education was performed by a key group of nurses and an intensivist to reinforce the principles of the MET, and to explain the changes to the emergency response calling system.

To assess the change in utilization of the MET, the proportion of hospital admissions subject to an emergency response call (Code Blue plus MET call) after the intervention was compared with the period before the intervention. Specifically, we analyzed rates of MET use in the period Jan 2001 to July 2003 (commencement of the questionnaire). In addition, we assessed use of the MET in the 12 months after the intervention (Oct 2004) and compared this to use in the

prior 12 months (Oct 2003 to Sep 2004), as well as the period that included and preceded administration of the questionnaire (Jan 2001 to Sep 2003).

Details of the questionnaire

In July 2003 we distributed a questionnaire containing 13 questions to 1900 staff to assess attitudes to the MET service, and potential barriers to its use. In particular, we asked whether the staff member had been involved in a MET call, whether they knew and accepted the MET call criteria, and the reasons for not initiating a MET call in the presence of MET criteria. The response rate to the survey was only 29%. The major reasons for not initiating a MET call in the presence of MET criteria included reluctance to go against senior medical and nursing staff, confidence in the staff members own ability to manage the patient, and lack of acceptance of the limits for the MET calling criteria. An additional barrier appeared to be the use of the overhead chimes and the large size of the team that arrived to manage MET calls.

Details of the education and intervention

The intervention consisted of modifications in four key areas (Table 5.1). First, the single Code Blue calling system was separated into a two-tier calling system. Code Blue calls were reserved for patients that were thought to have suffered a cardio-respiratory arrest. A separate MET call was introduced to cater for patients fulfilling objective criteria of physiological instability but not suffering a cardiac arrest.

The second modification involved using the overhead chimes only for Code Blue calls. The chimes are loud and were thought to be acting as a disincentive to staff calling the MET, particularly overnight. After the intervention, activation of the MET service involved an announcement and paging notification of the ward where the MET activation had occurred. The third modification entailed modifying the heart rate and respiratory necessary to achieve MET criteria, in concordance with those published previously (Table 5.1) [33].

Finally, the composition of the two teams was modified. The Code Blue team retained input from both the anaesthetic and cardiology departments, whereas, the MET service comprised only the ICU registrar and nurse, and the

receiving medical registrar of the day. The parent unit doctors were notified for all medical emergency response calls (Table 5.1).

During August and September 2004 a detailed program of education was delivered by an intensivist and a key group of nurses to all hospital nursing and medical staff. The presentations highlighted the theory and evidence behind the MET, reinforced the MET as a hospital policy, and outlined the pending changes to the composition, triggers and methods of activation of the MET and Code-blue teams. In the period following October 2004, ongoing informal education was provided to nursing staff by the ICU liaison nurses and information sessions were provided for all new hospital staff during hospital orientation.

Data on admissions and emergency response calls

Data on the number of monthly hospital admissions was obtained from the hospital computer system. Data on all emergency response calls is maintained in a detailed logbook by the hospital switchboard operators. The log contains details of the date and time of call and the parent unit of the patient subject to the call. From November 2004, the nature of the call (MET or Code Blue) has also been documented. Data on 3,722 calls between January 2001 and September 2005 were manually entered into a MS Windows Excel™ spreadsheet by two operators who worked concurrently and cross-checked entries to minimize errors.

Outcome measures and statistical analysis

The number of emergency response calls was quantified and compared with the number of admissions for the same period. Data on the proportion of admissions receiving emergency calls before and after the intervention were compared using the chi-squared test and analyzed using MS Windows Stat-view (Abacus Concepts, Berkeley, CA). A p-value of < 0.05 was considered statistically significant. After the intervention, the frequency of Code Blue and MET calls were assessed independently.

Results

Pattern of emergency response calling before intervention

The emergency response call rate was essentially unchanged at an average of 9.8 calls / 1000 admissions until administration of the survey in July 2003 (Figure 5.1). Between January 2001 and September 2003 there were 2,373 emergency calls for 204,326 admissions (11.6 calls / 1000 admissions). In the subsequent 12 month period (Oct 2003 – Sep 2004) there were 817 emergency calls and 51,963 admissions (15.7 calls / 1000 admissions), giving an odds ratio (OR) for risk of emergency medical call of 1.36 (95% CI = 1.25-1.47, $p < 0.0001$) when compared with the period preceding and including the survey (Figure 5.2).

Change in emergency response calling after the intervention

The modifications to the composition, triggers, and method of activation of emergency response calls in the Alfred hospital (Table 5.1) were associated with a marked increase in the frequency of calls (multiple χ^2 $p < 0.0001$) (Figure 5.2). Thus, there were 1,349 calls for 54,593 admissions (24.7 calls / 1000 admissions) in the period October 2004 to September 2005, giving an OR for risk of emergency call after the intervention of 2.16 (95% CI = 2.02-2.31, $p < 0.0001$) when compared with the period January 2001 to September 2003. Further, the OR for risk of emergency called was 1.59 (95% CI = 1.45-1.73, $p < 0.0001$) when compared with the 12-month period before the intervention (October 2003 – September 2004).

Composition of calls after the intervention

Analysis of the nature of the call (MET call or Code Blue call) was possible from November 2004. The majority of calls after this period were MET calls, and there was a trend for reduction in the use of Code Blue calls. Thus, there were 24 Code Blue calls from a total of 120 calls in November 2004, and 17 Code Blue calls from a total of 127 calls in September 2005 (OR for Code Blue call = 0.62; 95% CI = 0.31-1.22; $p = 0.16$).

Discussion

We conducted a study to assess the effect of a detailed intervention on the frequency and pattern of use of medical emergency response calling for acutely unwell ward patients in the Alfred hospital. We found that modification of the staff composition, triggers, and method of activation of emergency response calls in the

hospital was associated with a marked increase in use for patients fulfilling MET criteria.

Previous studies have shown that the uptake of a MET service in a hospital may take time [48]. Similar observations have been made for trauma systems [49, 50]. At least three studies have shown that use of a MET service by hospital staff may be impeded by cultural barriers in the hospital [34, 40, 41]. Specifically, it has been suggested that medical and nursing staff are reluctant to breach the “traditional” hierarchical system of patient management that usually involves notification of the most junior member of medical staff first [34, 40, 41]. In these studies a detailed education program was required to increase use of the existing MET service.

In the Alfred hospital, the major barrier to initiating review of unwell ward patients appeared to be reluctance to use the traditional “Code Blue” team to review patients fulfilling MET criteria who had not suffered a cardio-respiratory arrest. The two major concerns related to the size of the attending team and the use of the loud overhead chimes to initiate the call. The introduction of a two-tier calling system and provision of a MET service with a more discrete activation mechanism was associated with a marked increase in the use of the system. Additional barriers to calling the MET may have included a lack of acceptance of the limits of the existing MET criteria, as some patients had baseline vital signs that were always approximating MET criteria. Furthermore, some ward staff indicated that they felt comfortable in managing the patient themselves. Finally, on some occasions ward staff indicated a reluctance to call the MET either because they felt disempowered, or because they feared criticism from the MET regarding their management.

The present study has several strengths and limitations. It is the second to formally report that a detailed intervention can produce increased use of a MET. DeVita and co-workers presented a retrospective analysis of 3,269 MET calls (Condition C responses) in a 622 bed university hospital [40]. Over 6.8 years, the use of the MET at this hospital rose from 13.7 MET calls/ 1000 admissions to 25.8 calls / 1000 admissions. In the current study we were able to increase the call rate in the Alfred hospital from 15.7 to 24.7 calls / 1000 admissions in just one year following the intervention.

Importantly, the current call rate is three times that of the call rate seen in the first six months of the recently completed MERIT study (8.3 calls / 1000 admissions) [36]. This observation emphasizes the fact that time may be required for a system change such as the MET service to become established in a hospital. Similar observations have been made for trauma services [50].

Despite these strengths, the present study reveals the experience of only a single centre. In addition, it does not exclude an increase in the use of the service due to other factors such as the passage of time, and word of mouth following the administration of the survey. However, use of the MET service was markedly higher than the period before the intervention, and was also higher than the 12 month period that followed the survey.

Finally, the present study does not assess the effect of the increased MET use on changes in outcomes such as unexpected ICU admission and cardiac arrest. These questions will require subsequent studies.

In summary, we have demonstrated that it is possible to increase the use of an existing system to review unwell ward patients fulfilling MET criteria. Although the specific barriers identified in the present study may not apply to other hospitals, the generalities of the approach do. Achieving behaviour change requires **1)** a period of “information and diagnosis analysis” (e.g. assessment of barriers using a questionnaire or focus groups), **2)** development of strategies to address these barriers, **3)** implementation of these strategies (e.g. education and focus groups), and **4)** maintenance of behaviour change through constant reminding and positive feedback [51]

Table 5.1: Details of intervention aimed at improving the use of the MET service.

Variable	Before intervention	After intervention
Nature of calls and Rapid Response Teams	“Code Blue” call and single RRT for all medical emergency response calls	Emergency response calls separated into Code Blue calls (for suspected cardio-respiratory arrests) and MET calls (with physiological and worried criteria).
Method of calling emergency response team	Loud overhead chimes and announcement for all calls	Overhead chimes used for Code Blue calls only
Criteria for activation of calls other than cardiac arrest	HR > 130 bpm BP < 90 mmHg systolic RR < 8 or > 30 breaths / min SaO ₂ < 90% despite oxygen therapy Alterations in conscious state	Upper limit of HR increased to > 140 bpm Lower limit of HR < 40 bpm added Upper limit of respiratory rate > 36 breaths per minute
Composition of team attending call	Anaesthetic registrar and/or consultant ICU registrar and nurse Coronary care Registrar General medical registrar Parent Unit Doctors	For Code Blue Call Anaesthetic registrar / consultant ICU registrar and nurse Coronary care Registrar and nurse General medical registrar Parent Unit doctors For MET call ICU registrar and nurse General medical registrar Parent Unit doctors

MET, Medical Emergency Team; SaO₂, pulse oximetry oxygen saturations; bpm, beats per minute; ICU, Intensive care unit.

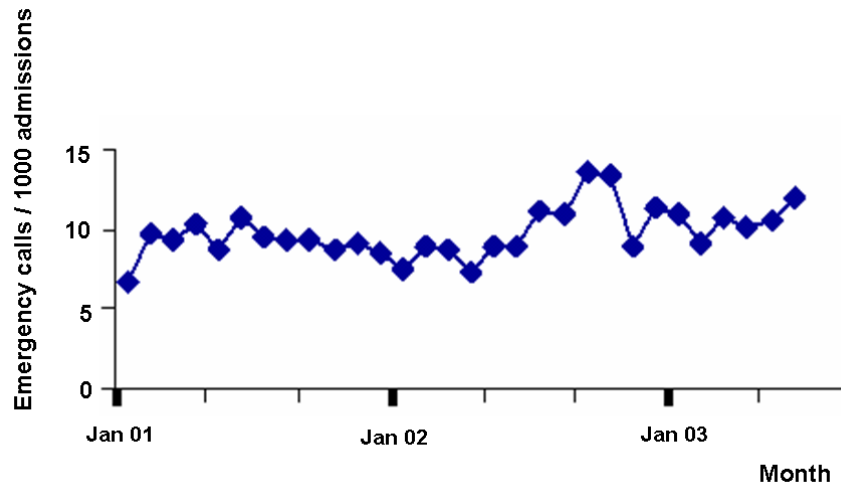


Figure 5.1: Line diagram showing number of emergency calls per thousand admissions before the administration of the group administered questionnaire. The average call rate over between January 2001 and July 2003 was 9.8 calls / 1000 admissions.

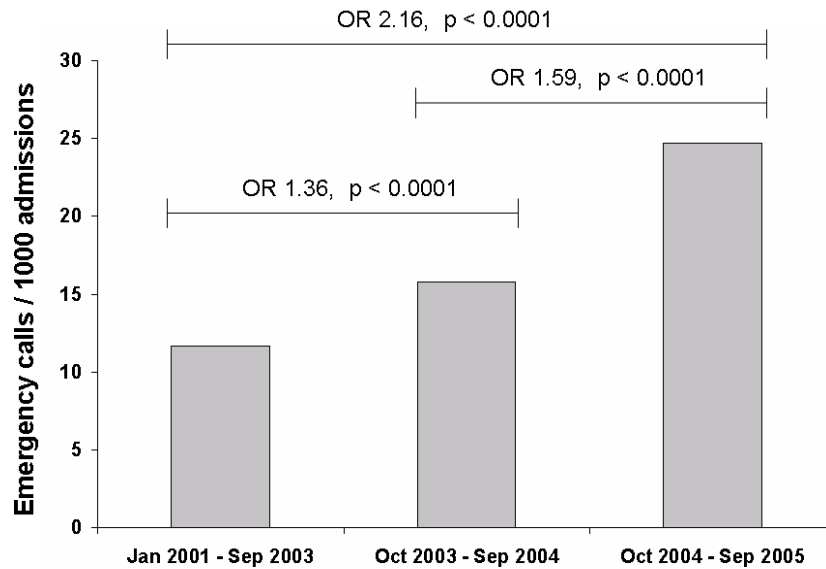


Figure 5.2: Histogram showing the frequency of emergency admission calls for three time intervals. The questionnaire was conducted in July 2003 and the detailed intervention to increase use of the MET commenced in October 2004. Shown is the frequency of emergency calls for the year before and after the detailed intervention, as well as the period January 2001 to September 2003. Odds ratios (OR) for “risk” of emergency call between different time intervals are also shown.

Chapter 6

Long Term Effect of a Medical Emergency Team on Cardiac Arrests in the Austin Hospital

Abstract

Introduction: It is unknown whether the reported short-term reduction in cardiac arrests associated with the introduction of the medical emergency team (MET) system into the Austin Hospital can be sustained.

Methods: We conducted a prospective, controlled before-and after examination of the effect of a MET system on the long-term incidence of cardiac arrests. We included consecutive patients admitted during three study periods: before the introduction of the MET; during the education period preceding the implementation of the MET; and a period of four years from the implementation of the MET system. Cardiac arrests were identified from a log book of cardiac arrest calls and cross referenced with case report forms and the intensive care unit admissions database. We measured the number of hospital admissions and MET reviews during each period, performed multivariate logistic regression analysis to identify predictors of mortality following cardiac arrest and studied the correlation between the rate of MET calls with the rate of cardiac arrests.

Results. Before the introduction of the MET there were 66 cardiac arrests and 16,246 admissions (4.06 cardiac arrest / 1000 admissions). During the education period the incidence of cardiac arrests decreased to 2.45 / 1000 admissions (odds ratio (OR) for cardiac arrest 0.60; 95% CI 0.43-0.86; p = 0.004). After the implementation of the MET, the incidence of cardiac arrests further decreased to 1.90 / 1000 admissions (OR for cardiac arrest 0.47; 95% CI 0.35-0.62; p <0.0001). There was an inverse correlation between the number of MET calls in each calendar year and the number of cardiac arrest for the same year ($r^2 = 0.84$; p = 0.01), with 17 MET calls being associated with one less cardiac arrest. Male gender (OR 2.88; 95%CI 1.34-6.19) and an initial rhythm of either asystole (OR 7.58; 95%CI 3.15-18.25; p<0.0001) or pulseless electrical activity (OR 4.09; 95% CI 1.59-10.51;p=0.003) were predictors of increased risk of death following cardiac arrest.

Conclusions: Introduction of a MET into the Austin hospital was associated with a sustained and progressive reduction in cardiac arrests over a four year period. Our findings suggest that for each 17 additional MET calls a cardiac arrest might be prevented.

Introduction

Despite advances in medical technology and the introduction of cardiac arrest teams, the mortality following in-hospital cardiac arrests remains high at approximately 85% [52]. As discussed in Chapter 1, up to 80% of patients suffering cardiac arrests have signs of physiological instability (alterations in the commonly measured vitals signs) in the 24 hour period prior to the event. [17-19, 21, 44, 45]. In response to this observation, hospitals are increasingly implementing specialized teams (variably named medical emergency teams, rapid response teams, or outreach teams) to identify, review and treat unstable ward patients in the early phase of deterioration, with a goal of preventing cardiac arrests.

Medical emergency teams (METs) are characterized by the presence of a doctor, and have been shown to reduce the incidence of cardiac arrests in hospitalized patients in short-term before-and-after studies [34, 35, 48]. DeVita and co-workers have recently reported a 17% reduction in cardiac arrests in the 1.8 years following increased utilization of the MET service in a teaching hospital [40]. The effectiveness of METs in achieving or sustaining this outcome for periods greater than this has not been shown to date.

Sustained system change requires a strong organizational commitment to safety [53] as well as continued education and awareness-raising activities. Institutionalization of system change may fail because of turnover of key employees [54] such as doctors and nurses. This may result in the introduction of new staff who are unfamiliar with the MET concept [34, 40, 41].

Since the introduction of the MET service in the Austin we have conducted an educational campaign to improve awareness of the service. In association with this educational program there has been a progressive increase in the utilization of the MET at the Austin [55] (Chapter 4). We hypothesized that this increased use of

the MET service would be associated with a sustained reduction in cardiac arrests. To test this hypothesis, we analyzed the incidence of cardiac arrests in the four years following the introduction of the MET service.

Materials and Methods

Ethics approval

Approval was obtained from the Institutions Ethics Committee for implementation of the MET and collection of the data related to it. The need for informed patient consent was waived by the committee.

The hospital and RRS

The details of the Austin hospital, the services it provides, and its RRS have been described elsewhere (Chapter 1 and Chapter 4).

Study design

The study is a prospective before-and-after interventional trial as previously described [35] (Chapter 2; Figure 2.2). All patients admitted to the hospital for at least one night were considered as participants. The period 1 Jan 1999 to 31 Aug 1999 was the control or “before” period. In the educational phase preceding the MET (1 Sep 1999 – 31 Aug 2000), detailed education and information sessions were held over with all members of hospital staff. The period “after” the implementation of the MET included the interval spanning 1 Sep 2000 to 31 Oct 2004.

Data on admissions, cardiac arrests and MET calls

A log book of all emergency calls is maintained by the switchboard operators and contains details of the date and time of the call as well as the ward from which the call originated. Standardized case report forms on Code Blue calls are maintained independently by both the coronary care and ICU. Details of MET calls are kept on similar forms by the ICU. Details of the time, date and ward of call of the Code Blue calls from the switchboard log were cross referenced with the case report forms and the ICU admission data base. Calls were designated as “documented cardiac arrest”, “not cardiac arrest” or “insufficient data”. Information was confirmed by two investigators by analysis of the case report form and/or analysis of the patients file.

A cardiac arrest was defined as the sudden onset of all of the following: 1. no palpable pulse; 2. no measurable blood pressure; 3. no responsiveness; and 4. the commencement of basic life support. Calls from the coronary care unit, operating room and emergency room (acute care areas) were not considered for analysis, as were calls in which the patient had a documented “not for resuscitation” order prior to the call. Calls designated “insufficient data” were still considered as being “true cardiac arrests” in the educational phase and in the period after the introduction of the MET. Calls designated as “not cardiac arrest” were then classified into one of nine sub-groups (faint, seizure, haematemesis and melena, surgical bleeding, respiratory distress, altered conscious state, hypotension, arrhythmia, chest pain).

Outcome measures

The number of cardiac arrests in each of the study periods (“before MET”, “educational phase preceding MET” and “after MET implementation”) was quantified and related to the number of admissions for the same period. Information on the age, gender and initial documented rhythm were obtained from the case report forms. Data on patient outcome and destination of discharge were obtained from the hospital electronic data base.

Statistical analysis

Data on the incidence of cardiac arrests during the 3 periods of the study were compared using the χ^2 test and analyzed using MS Windows Stat-view (Abacus Concepts, Berkeley, CA). Correlation between levels of MET service activation and the incidence of cardiac arrests was analyzed using the Spearman-rank test.

We performed multivariate logistic regression analysis using death as the dependent variable and patient gender, age, parent unit, primary rhythm and time of cardiac arrest as independent variables. Data were analyzed using SPSS (version 12, SPSS Inc, Chicago, IL) and results are presented as odds ratio (OR) with 95% confidence intervals. A p-value of < 0.05 was considered statistically significant.

The number of MET reviews associated with a decrease of one cardiac arrest was estimated by calculating the reciprocal of the line of regression of the association between the level of MET service activation and the incidence of cardiac arrests.

Results

Characteristics of Code Blue calls

Compared to the period before the MET, there was an initial reduction in the number of Code Blue calls during the education phase (OR for Code Blue call 0.75; 95% CI 0.57-0.98; $p = 0.033$). After the implementation of the MET, however, there was a further significant reduction in Code Blue Calls (OR for Code Blue call = 0.51; 95% CI 0.41-0.64; $p < 0.0001$) (Table 6.1). At least 30% of Code Blue Calls were made for indications other than cardiac arrest. Specifically, the major reason for such Code Blue calls were respiratory distress, hypotension, altered GCS, seizure, and a simple collapse or faint (Table 6.1).

In addition, there was no significant difference in the proportion of patients in whom a Code Blue call was made despite a prior documented “not for resuscitation order” (OR 1.40; 95% CI 0.46-4.23; $p = 0.57$).

Impact of MET implementation on the incidence of cardiac arrests

When the Code Blue calls classified as “insufficient data” were included as true cardiac arrests for the education and post-MET implementation period, the number of cardiac arrests before the MET, during the educational phase preceding the MET, and after the implementation of the MET was 66, 62 and 198, respectively (Table 6.1). The overall process of introduction of the MET was associated with a statistically significant reduction in cardiac arrests when compared with the period before the MET (multiple χ^2 $p < 0.0001$). During the educational phase preceding the MET the OR for risk of cardiac arrest was 0.60 (95% CI 0.43-0.86; $p = 0.004$) when compared with the period before the MET.

After the introduction of the MET the OR of cardiac arrest was 0.47 (95% CI 0.35-0.62; $p < 0.0001$) when compared to the period before MET implementation and 0.77 (95% CI 0.58-1.03; $p = 0.078$) when compared to the educational phase. In the year 2004, there was a further reduction to a rate of 1.3 arrests per thousand

admissions such that the OR for cardiac arrest was 0.31 (95% CI 0.20-0.48; $p < 0.0001$) when compared with the period before the MET and 0.51 (95% CI 0.32-0.80; $p = 0.003$) compared with the educational phase preceding the MET.

Characteristics and outcome of documented cardiac arrests

There were 279 documented cardiac arrests during the study period (table 6.2). The majority of these patients were male, and their average age was 71.3 years. Patients from five of the 20 units (general medicine, respiratory medicine, cardiology, renal medicine and haematology/oncology) comprised 62% of all calls. The majority (170/228 = 74.6%) of patients who died following a cardiac arrest did so at the time of the cardiac arrest. The most common rhythms present on arrival of the cardiac arrest team were asystole (122/279 = 43.7%) and pulseless electrical activity (70/279 = 25.1%). The survival rate following a cardiac arrest was not affected by the introduction of the MET (OR for survival = 0.60; 95% CI = 0.30-1.21; $p = 0.15$).

Several independent variables were shown to have an impact on outcome following cardiac arrest (Table 6.3). Male gender and an initial rhythm of asystole or pulseless electrical activity (PEA) were associated with an increased risk of death following cardiac arrests. In addition, none of the 23 patients admitted under haematology/oncology survived a documented cardiac arrest in the study period. Predictors of a decreased risk of death following cardiac arrest included admission under cardiothoracic surgery, spinal cord injuries unit, cardiology unit, or an arrest between the hours of 08:00-10:00.

There was an inverse correlation ($r^2 = 0.84$, $p = 0.01$) between the number of MET calls per 1000 admissions in each calendar year and the number of cardiac arrests per 1000 admissions over the corresponding period (Figure 6.1). The gradient of the line of regression for this correlation was -0.061 , suggesting that for every 17 MET calls ($1/0.061$) there was an associated decrease of one cardiac arrest.

Discussion

We conducted a study to test whether the ongoing use of the MET system at the Austin Hospital could be associated with a sustained reduction in the incidence of cardiac arrests over the four years since its introduction. We found that education alone decreased the incidence of cardiac arrests. However, the risk of cardiac arrest further decreased after the introduction of the MET and remained lower over time. We also found an inverse association between levels of MET use and the risk of occurrence of cardiac arrests, suggesting a “dose effect” of the MET on cardiac arrests.

Implementation of MET systems have previously been shown to reduce the incidence of cardiac arrests in hospital patients in a number of short term before-and-after studies [34, 35, 48] (See Chapter 1). DeVita and co-workers however, reported that increasing the utilization of an existing MET was associated with a 17% reduction in the incidence of cardiac arrests in the subsequent 1.8 years to rate of 5.4 per thousand admissions [40]. In the present study, the incidence of cardiac arrests was 4.06 per thousand admissions before the introduction of the MET. After the introduction of the MET, the incidence of cardiac arrests was 1.90 per thousand admissions (53% reduction) and this decreased to 1.3 per thousand admissions (69% reduction) in 2004. These results suggest a greater reduction in the incidence of cardiac arrests than previously reported following the introduction of a MET service.

Sustained system change requires strong organizational commitment to safety [53]. System change may fail to be institutionalized because of a turnover of key employees [54] resulting in new doctors and nurses unfamiliar with the MET system concept [34, 40, 41]. Prior to the implementation of the MET service at the Austin a 12 month period of preparation and education was undertaken (educational phase). Since the introduction of the MET service we have provided ongoing education to all existing and new staff members (See Chapter 4). This approach appears to have been successful in producing a sustained and progressive reduction in the incidence of cardiac arrests at the Austin.

In addition to the reduction in incidence of cardiac arrests demonstrated after the introduction of the MET service, we have found an inverse association between levels of MET activation and the incidence of cardiac arrest. This

suggests an association between increasing utilization of the MET and a reduction in cardiac arrests. From this association, we estimate that for every 17 MET calls a single cardiac arrest may be prevented.

Multivariate logistic regression analysis revealed male gender and a primary rhythm of asystole or pulseless electrical activity as predictors of increased risk of death following cardiac arrest. Predictors of improved outcome following cardiac arrest included admission under cardiothoracic surgery, the spinal cord injury unit, or cardiology. This improved outcome may be secondary to increased levels of monitoring leading to earlier detection of cardiac arrests in these patients, or may suggest greater reversibility of the underlying process leading to the arrest (eg myocardial ischemia in cardiac patients, or altered autonomic tone with spinal cord injury). Improved outcome for cardiac arrests occurring between 08:00 and 10:00 may relate to increased levels of staffing and earlier detection of events.

Our study has a number of strengths and limitations. It is a prospective before-and-after study that demonstrates a progressive and dose-dependent reduction in the annual incidence of cardiac arrests in a large teaching hospital in a study period including over 145,000 admissions. However, it is not randomized, blinded or placebo controlled, and only represents the findings of a single center.

A large cluster-randomized multi-centre study of the effect of the MET on cardiac arrests in 23 Australian hospitals has been recently published [36]. The incidence of cardiac arrests in the 12 hospitals randomized to receive MET implementation was not statistically different to that in the 11 hospitals randomized to continue the existing form of cardiac arrest teams. However, this study involved an education and preparation period of only 4 months, and assessed the impact of the introduction of MET reviews over 6 months only. In addition, the average call rate (cardiac arrests and MET calls) was reported as only 8.3 calls/1000 admissions. This call rate is one fifth of our current call rate. These observations suggest that time may be required before a MET system can show its full effectiveness in reducing the incidence of cardiac arrests. The benefits from other system changes such as trauma services [50] have also been shown to take some time to mature. Our results also suggest that the “dose” of MET reviews (calls/1000 patients) may impact on patient outcome.

The second limitation of our study relates to the inclusion of episodes of insufficient data. However, in analyzing the effectiveness of the education process and MET service, we have assumed that these events represented a true cardiac arrest. In doing this we would have actually underestimated the effectiveness of the MET system as such calls likely inflated the true cardiac arrest call value.

Our study does not reveal the mechanism for the reduction of the cardiac arrests. It is possible that the observed reduction in the incidence of cardiac arrest may be due to the education of staff alone, as the incidence of cardiac arrests in the educational phase decreased by 40% compared with the period before the introduction of the MET. However, the incidence of cardiac arrests after the introduction of the MET was 23% lower than during the education and preparation period, and has continued to fall with increasing utilization of the MET. This suggests education and awareness together with a system to promptly review unwell ward patients work together in reducing the incidence of cardiac arrests.

It is possible that our favourable findings were due to a high incidence of cardiac arrests in the control period or an abnormally low seasonal incidence in the intervention period. Australian data [33] show an incidence ranging from 3.6 to 5.1 per 1,000 admissions. Recent data from the MERIT study, which included several smaller hospitals with patients of limited acuity and counted all day visits (no overnight stay) as admissions, showed a pre-intervention cardiac arrest rate of 2.08 cases per 1,000 admissions [36]. Our incidence of cardiac arrests was 3.2 per 1,000 overnight hospital admissions during the control period.

We studied the MET within a single institution. Its findings might not apply to other hospitals. Institution specific heuristics and unique administrative features may have lent themselves to making the impact of the MET approach greater in our institution than in others. However, our institution has all the organizational, structural and logistic features of a typical tertiary referral hospital. The way our MET was configured might differ from the way other institutions implement such a service [33, 36]. Whether organizing the MET service in different ways has an impact on its efficacy remains unknown. We believe that our approach is simple and low cost. It is also possible that the decrease in cardiac arrests was secondary to some other improvements in patient care during the period that separated the control from the intervention period. There were no changes in the structure,

referral pattern or activity of the Austin, however, as supported by the total number of admissions during the two study periods, which remained unchanged.

Furthermore, there were no changes in 'not for cardio-pulmonary resuscitation' policy, hospital admission policy, discharge practices or surgical case mix during the study. We are not aware of any improvements or advances in medical or surgical treatment that could explain a greater than 60% reduction in cardiac arrests and a 25% reduction in overall mortality.

Conclusion

The introduction of an ICU-based MET service, in conjunction with a detailed education program aimed at increasing its use, was associated with a sustained and progressive reduction in the incidence of cardiac arrests in the four years following its implementation. There was an inverse correlation between the level of activation of the MET service and the incidence of cardiac arrests, suggesting either a “dose effect” or a “maturation effect”.

Table 6.1: Characteristics of Code Blue calls over the study period ^a

	Pre – MET	Education Phase	Post MET
Code Blue calls	100	116	327
Documented cardiac arrests	66	51	162
Missing data	1	11	36
Patient NFR (arrests in NFR patient)	4 (2)	7 (5)	18 (17)
not cardiac arrests	31	49	112
Faint	4	4	11
Seizure	7	2	11
Haematemesis & malena	1	3	5
Surgical bleeding	2	0	10
Respiratory distress	13	19	38
Change GCS	1	8	13
Hypotension	2	10	17
Arrhythmia	1	2	7
Chest pain	0	1	0
Admissions	16,246	25,216	104,001
Cardiac arrests ^b			
Number	66	62	198
Number/1000 admissions	4.06	2.45	1.90
Odds ratio for risk of cardiac arrest	X	0.60 (95%CI 0.43-0.86) p = 0.004	0.47 (95%CI 0.35-0.62) p <0.0001

^a The three study periods cover the dates: pre-MET, 1 January 1999 to 31 August 1999; education phase, 1 September 1999 to 31 August 2000; post-MET implementation, 1 September 2000 to 31 October 2004.

GCS, Glasgow coma score; NFR, not for resuscitation.

^b Cardiac arrests represent the combined number of “documented cardiac arrests” and “insufficient data” for “during” and “after” MET implementation phases. Odds ratios are for comparisons with “before” MET data

Table 6.2: Characteristics of documented cardiac arrests ^a.

	Pre – MET	Education Phase	Post MET
Arrests	66	51	162
Male gender	41	44	104
Mean Age (Years)	73.4	70.5	70.8
Parent Unit			
General Medicine	19(4)	11(1)	45(3)
Respiratory Med	6(1)	5(1)	13(3)
Cardiology	1(0)	5(2)	19(8)
Nephrology	8(3)	3(0)	16(2)
Gastroenterology	3(0)	1(0)	2(0)
Neurology	0	4(0)	7(1)
Haematology / oncology	2(0)	7(0)	14(0)
General Surgery	5 (0)	7(2)	9(1)
Vascular Surgery	8(2)	1(0)	2(0)
Neurosurgery	3(0)	1(0)	7(3)
Thoracic Surgery	2(2)	1(1)	4(0)
Cardiac Surgery	5(3)	3(2)	9(3)
Orthopedic Surgery	2(1)	1(0)	8(0)
Spinal Surgery	1(0)	0	2(2)
Liver Transplantation	1(0)	0	3(0)
Other	0	1(0)	2(0)
Survivors (% total)	16 (24.2)	9 (17.6)	26(16.0)
Home	10	5	20
Rehabilitation	5	3	6
Nursing Home	1	1	0
Died	50	42	136
Died Arrest	33	27	110
Died < 24 h	10	5	9
Died > 24 h	7	10	17
Primary Rhythm			
VF	8(3)	10(1)	20(9)
VT	4(2)	6(3)	15(6)
Asystole	30(1)	8(2)	74(6)
PEA	15(4)	13(2)	42 (3)
SVT	2(2)	0	3 (1)
other	7(4)	4(1)	8 (1)

VT = Ventricular tachycardia, VF = ventricular fibrillation, PEA = pulseless electrical activity, SVT = supra-ventricular tachycardia.

^a The three study periods cover the dates: pre-MET, 1 January 1999 to 31 August 1999; education phase, 1 September 1999 to 31 August 2000; post-MET implementation, 1 September 2000 to 31 October 2004.

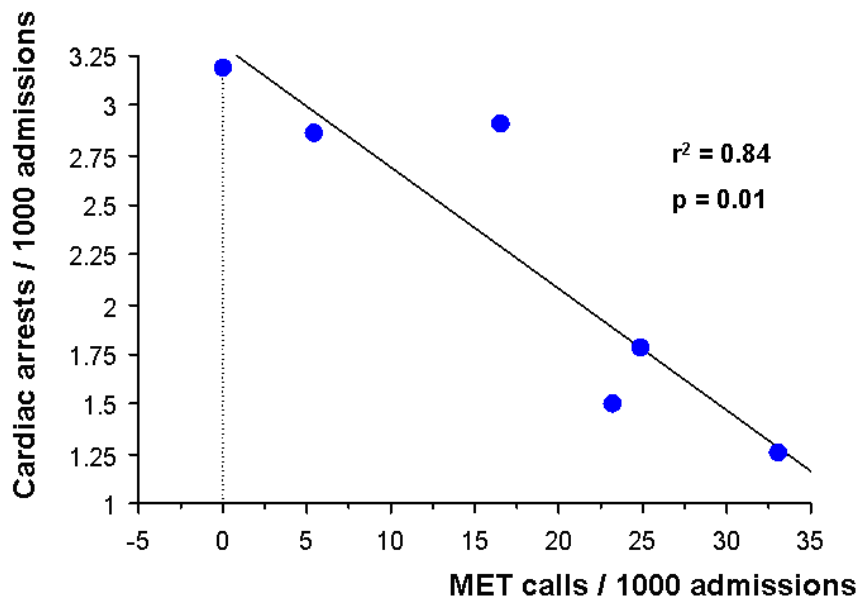


Figure 6.1: Correlation between the number of MET calls and incidence of cardiac arrests between 1999 and 2004.

Table 6.3: Predictors of death following cardiac arrest using step-wise multivariant logistic regression analysis.

Variable	Odds ratio	95% confidence interval	p value
Male gender	2.88	1.34-6.19	0.007
Asystole	7.58	3.15-18.26	<0.0001
PEA	4.09	1.59-10.51	0.004
Cardiothoracic patient	0.15	0.05-0.49	0.002
Spinal injury patient	0.03	0.01-0.57	0.02
Cardiology patient	0.27	0.09-0.65	0.01
Arrest between 08:00 and 10:00 am	0.25	0.09-0.65	0.005

Chapter 7

Long-Term Effect of a Medical Emergency Team on Mortality in the Austin Hospital.

Abstract

Aim: To assess the effect of a Medical Emergency Team (MET) service on patient mortality in the four years since its introduction into the Austin hospital.

Methods: Using the hospital electronic database we obtained the number of admissions and in-hospital deaths “before-” (Sep 1998-Aug 1999), “during education -” (Sep 1999- Aug 2000), the “run-in period-” (Sep 2000-Oct 2000), and “after-” (Nov 2000-Dec 2004) the introduction of a MET service, intended to review and treat acutely unwell ward patients.

Results: There were 42,230 surgical and 112,321 medical admissions over the study period. During the education period for the MET the odds ratio (OR) of death for surgical patients was 0.82 compared to the “before” MET period (95% CI 0.67-1.00; $p = 0.055$). During the 2 month “run in” period it remained statistically unchanged at 1.01 (95% CI 0.67-1.51; $p=0.33$). In the four years “after” introduction of the MET, the OR of death for surgical patients remained lower than the “before” MET period (multiple χ^2 -test $p=0.0174$). There were 1252 surgical MET calls, and in Dec 2004 the ratio of surgical MET calls to surgical deaths was 1.76: 1. In contrast, in-hospital deaths for medical patients increased during the “education period”, the “run in” period and into the first year “after” the introduction of the MET (multiple χ^2 -test $p < 0.0001$). There were 1278 medical MET calls, and in Dec 2004 the ratio of medical MET calls to medical deaths was 1: 2.47 (0.41:1). For each 12-month period, the relative risk of death for medical patients as opposed to surgical patients ranged between 1.32 and 2.40.

Conclusions: Introduction of an Intensive Care-based MET into the Austin hospital was associated with a fluctuating reduction in post-operative surgical mortality which was already apparent during the education phase, but a sustained increase in the mortality of medical patients which was similarly already apparent during the education phase. The differential effects on mortality may relate to

differences in the degree of disease complexity and reversibility between medical and surgical patients.

Introduction

Despite advances in medical care and the introduction of cardiac arrest teams, SAEs (Including unexpected deaths and cardiac arrests) continue to affect 4-19% of admissions in the United States of America [42] and Australia [7]. Unexpected deaths and cardiac arrests are frequently preceded by a period of physiological instability [17-19, 21, 44, 45] indicating that they are neither sudden nor unpredictable [34]. This observation has led to the conception of Medical Emergency Teams (MET) comprised of doctors and nurses skilled in advanced resuscitation of the acutely unwell patient. The MET is an example of a Rapid Response Team (RRT) and can be activated by any member of hospital staff according to preset criteria of physiological instability (Chapter 1). The aim of the MET service is to rapidly mobilize appropriately trained staff to deliver prompt and definitive treatment in the early phase of clinical deterioration and, hence, reduce cardiac arrests and mortality [47].

In a recent short term before-and-after intervention study into the Austin hospital, the introduction of an Intensive Care-based MET service was associated with a reduced incidence of post-operative adverse outcomes, post-operative mortality, and mean duration of hospital stay in patients undergoing major surgery [39] (See Chapter 2).

Little information exists on the sustainability and continued effectiveness of the MET over an extended period. Indeed, the effectiveness of the MET in a hospital system may be diminished over time due to employment of new junior medical staff and nurses who are unfamiliar with the MET concept or reluctant to breach “traditional” hierarchical system of patient management [34, 40, 41].

There has been a progressive increase in the use of the MET system at our institution [55] (Chapter 4). In addition, the rate of increase of MET activation for surgical patients was 4.9 fold greater than that for medical patients [55]. We hypothesized that this sustained MET utilization might result in a continued reduction in hospital mortality. We tested this hypothesis by conducting a study of

the effect of sustained MET utilization on the hospital mortality of patients for the four year period after its introduction.

Methods

We obtained Institutional Review Board approval for the introduction of the MET and for the collection of data related to it. The need for informed patient consent was waived by the Institutional Review Board.

The Hospital and Hospital Rapid Response Teams.

The acute care campus of Austin Health operates two levels of Rapid Response Teams (RRTs) (See Chapter 2). The first is a traditional cardiac arrest (“Code Blue”) team that is composed of a cardiology fellow and coronary care nurse, an intensive care fellow and nurse, and the receiving medical unit fellow. The MET service was introduced into the acute care hospital in September 2000, following an extensive preparation and education process [35, 39, 55] (Chapter 4).

After a two-month run-in period (Sep-Oct 2000) the service became fully operational (from November 2000). The MET consists of an intensive care fellow and nurse, and the receiving medical unit fellow. The MET service can be activated by any member of hospital staff according to preset criteria of physiological instability. A detailed log of all Code Blue and MET calls is maintained by the switchboard operators.

Study design

The study is a prospective before-and-after study. Information about admissions and deaths for medical and surgical patients was obtained from the hospital electronic database. The study assessed all cases of in-hospital mortality (Both DNAR and non-DNAR related deaths). An admission was defined as any hospital stay lasting more than one night. Data on admissions “before” the introduction of the MET (Sep 1998 - Aug 1999) were used as a historic control. The period during the “preparation” for the MET was the interval spanning the “education” and run-in phases before the actual introduction of the MET service. The education phase comprised the period Sep 1999 – Aug 2000 and this was followed by a two month “run-in” phase where the MET was partially active (Sep – Oct 2000). The “after” introduction period (when the MET service was fully operative) was Nov 2000 - Dec 2004.

Episodes of MET review were identified from the switchboard log, and were classified as medical or surgical according to the type of ward where the review occurred.

Statistical analysis

Statistical significance for differences in proportions (deaths/admissions) was determined using the χ^2 test and data was analyzed using MS Windows Stat-view (Abacus Concepts, Berkeley, CA). Risk of death in medical and surgical patients is presented as an odds ratio when using historic controls. In comparing death rates for medical and surgical patients in the same time period a relative risk ratio was employed. Data are quoted as a risk ratio with 95% confidence intervals. A p value of < 0.05 was considered significant.

Results

Effect of the introduction of the MET service on mortality of surgical patients.

“Before” the introduction of the MET system there were 7441 surgical admissions and 209 deaths (28.09 deaths/thousand admissions) (Table 7.1). There was a near significant reduction in the number of surgical deaths / 1000 patient admissions during the “education phase” (but not during the “run in” period) and “after” the introduction of the MET (Figure 7.1, Table 7.1). Thus, the odds ratio (OR) of death for surgical patients during the phase of “education” for the MET was 0.82 (95% CI = 0.67-1.00; p = 0.055) but 1.01 (95% CI 0.67-1.51; p = 0.33) during the “run in” period. “After” the introduction of the MET, the OR of death for surgical patients remained lower than the “before” MET period (multiple χ^2 -test p=0.0174) but was unchanged compared to the education period. The OR of death for surgical patients in the first (OR = 0.75; 95% CI 0.60-0.93; p = 0.008) and third (OR = 0.67; 95% CI 0.54-0.84; p=0.0005) years after the introduction of the MET the risk of death was lower than before the introduction of the MET. There was also a trend for reduction in the risk of surgical death in the second (OR = 0.85; 95% CI 0.69-1.04; p=0.126) and fourth (OR = 0.85; 95% CI 0.69-1.05; p=0.14) years “after” the introduction of the MET compared with the period “before” the MET.

Effect of the introduction of the MET service on the mortality of medical patients.

“Before” the introduction of the MET system there were 17893 medical admissions and 664 deaths (37.11 deaths / thousand admissions) (Table 7.1).

When compared with the period “before” MET introduction, the death rate for medical patients increased during the “education phase” (OR 1.20; 95% CI 1.08 – 1.33; $p=0.008$) and during the “run in period (OR 1.45; 95% CI 1.21-1.74; $p<0.0001$), into the first year “after” MET introduction (OR 1.33; 95% CI 1.20 – 1.47; $p < 0.0001$), and subsequently remained higher than in the period before the MET (multiple $\chi^2 = < 0.0001$) (Figure 7.2).

Comparison of death rates and MET utilization for medical and surgical patients

Since the introduction of the MET service there has been a progressive increase in MET call rate for both medical and surgical patients, although the extent of use was greater in the surgical population (Figures 7.3 and 7.4). For surgical patients there were 1252 episodes of MET review over the study period. The number of surgical MET calls per 1000 admissions has been greater than the number of surgical deaths per 1000 admissions since Feb 2002 (Figure 7.3). In Dec 2004, the ratio of MET calls:deaths in surgical patients was 1.76:1.

In the cohort of medical patients there were 1278 MET reviews over the study period. The number of medical MET calls per 1000 admissions has remained less than the number of medical deaths per 1000 admissions since the introduction of the MET (Figure 7.4). In Dec 2004, the ratio of MET calls:deaths in medical patients was 1:2.47 (0.41:1).

Comparison of death rates for medical and surgical patients

In each 12-month period of the study there was a statistically increased risk of death in patients admitted for a medical reason when compared to patients admitted for a surgical condition (Table 7.1). Thus, the relative risk for death in patients admitted for a medical reason ranged from 1.32 (95% CI = 1.22-1.43; $p = 0.0003$) “before” the introduction of the MET, to 2.40 (95% CI = 2.23-2.57; $p < 0.0001$) in the third year “after” the introduction of the MET (Table 7.1).

Discussion

We conducted a long-term assessment of the effect of the MET service on in-hospital mortality and found a statistically significant reduction in the number of deaths in surgical patients over an extended period. In contrast, the number of

deaths amongst medical patients increased “during” and “after” the introduction of the MET system, and has remained higher than the “before” MET period.

A detailed program of staff education and feedback has been associated with progressive uptake and utilization of the MET at our institution [55]. At the peak of activity (April 2004), the MET was summoned to review 8.4% of surgical and 2.7% of medical admissions [55] (Chapter 4).

A previous study at our institution conducted between December 1998 and March 1999 revealed a 16.9% incidence of serious adverse events and a 7.1% mortality rate in a cohort of patients undergoing major surgery (defined as surgery associated with a hospital length of stay > 48hrs) [39]. In the current study, we have shown that since Feb 2002 the monthly number of surgical MET calls has exceeded the number of surgical deaths. Together, these observations might suggest an association between MET utilization for surgical patients and the observed reduction in surgical deaths associated with introduction of the MET service. However, much of the decrease in surgical mortality appeared to occur during the “education period” preceding the implementation of the MET. This suggests that, in fact, awareness of the risks associated with physiological instability and understanding of the need for prompt intervention was perhaps equally or even more important in achieving surgical patient safety.

Prior to the present study, the effect of the MET on all-cause in-hospital mortality of medical patients admitted to the Austin had not been assessed. There are several possible explanations for the differential effect on medical and surgical mortality seen following the education phase and then the introduction phase of the MET system. First, it is possible that the MET system has had no impact on mortality in either of the patient populations and the observed changes simply represent changes in the natural history of the respective outcomes with time.

Second, it is possible that the introduction and use of the MET service has contributed to the increased mortality observed in medical patients. However, we have recently documented that increased use of the MET at the Austin was associated with a progressive reduction in the incidence of cardiac arrests in both medical and surgical patients [35, 56] (Chapters 2 and 6). In addition, the “call rate” for surgical patients was greater than medical patients and yet a mortality

reduction was seen in the former but not the latter. A further possible reason for the increase in mortality seen in medical patients after the introduction of the MET service may relate to a change in the patient case mix. Finally, differences in patient outcome from year-to-year may be influenced by differences in the composition and skill mix of the members of the MET. In an attempt to minimize such differences, all ICU registrars and nurses involved in the MET receive education on how to manage MET calls.

A further possible explanation for the differential mortality in medical and surgical patients may relate to the greater degree of acuity and a lesser degree of reversibility of the conditions leading to medical admission as compared to surgical admission. Consistent with this, we have demonstrated that admission for a medical reason, as opposed to a surgical reason, was associated with an RR of death ranging between 1.32 and 2.40.

At least some of the observed differences in mortality may be due to the difference in utilization of the MET service for medical and surgical patients. By the completion of the current study, the number of MET reviews for surgical patients out-numbered the number of deaths in this patient population by a factor of 1.76. In contrast, for medical patients the reverse was the case, with the number of medical deaths out-numbering MET calls in medical patients by a factor of 2.47. In summary, our findings suggest that patients admitted for a surgical condition are less likely to die and more likely to be reviewed by the MET service.

Future analyses of the effectiveness of a MET on hospital mortality of medical patients may require assessment of the epidemiology of "unexpected deaths". A possible explanation for the observed difference in MET use for surgical and medical patients may relate to the perceived ability of the respective doctors to manage physiological derangements. Of further interest, while the education period was associated with a decrease in surgical mortality, it was simultaneously associated with an increase in medical patient mortality compared to the baseline period. As it is difficult to conceive that education would be responsible for simultaneously increasing and decreasing mortality in two different cohorts of patients, we further consider that changes in patient mix might have been responsible for these findings. We note that medical patients typically have

underlying co-morbidities which are not amenable to acute treatment and powerfully determine hospital outcome.

We are aware of two prior studies that report on the use of a MET for a period of at least one year. Kenward and co-workers [48] evaluated the impact of a MET one year after its introduction in a 700-bed district general hospital. There were 130 episodes of MET review but this was not associated with a significant reduction in number of deaths and cardiac arrests.

Devita and co-workers [40] assessed the effect of a MET on cardiac arrests over a 6.8 year period and demonstrated a 17% reduction in cardiac arrests. No data were presented in this study on the impact of the MET service on all-cause hospital mortality. Neither study assessed the differential effects of the MET service on medical and surgical patients.

Our study has a number of limitations. First, a reduction in hospital mortality was only demonstrated for surgical patients and this was not statistically significant in all years. Second, the reduction in post-operative deaths is only shown in a single center and may not apply to other centers. However, our institution has similar features and levels staffing to other teaching hospitals, and the system could be implemented in a similar manner elsewhere.

The study design is a before-and-after-interventional study, and is not randomized or double blinded. However, we believe that it would be unethical to randomize patients with evidence of acute physiological instability to observation only.

The current study does not reveal the reasons for reduction in post-operative surgical deaths. In particular, it does not demonstrate the extent of reduction of cardiac arrests, as opposed to deaths from other causes. However, our findings suggest that education is important in ensuring surgical patient safety. We have also previously reported that increased use of the MET reduced both medical and surgical cardiac arrests in the Austin [35, 56].

The study does not demonstrate whether the observed changes in mortality in surgical and medical patients is attributable to alterations in the acuity or severity

of illness of the respective populations with time. Furthermore, in the assessment of deaths, we were unable to determine differential effects of the MET on DNAR and non-DNAR deaths.

Finally, the nature of the MET call (surgical or medical) was defined according to the type of ward and was derived from the hospital switchboard log book. This approach is imperfect, in that it does not recognize medical patients that may have been on a surgical ward, or surgical patients who were on a medical ward, during the study period. However, data on the number of medical and surgical admissions and deaths were derived from the hospital electronic database and are entered prospectively according to parent unit. Accordingly, these data reflect information on medical and surgical patients very reliably.

Conclusions

Introduction of an Intensive Care-based Medical Emergency Team (MET), in conjunction with a detailed program of continuing staff education and feedback was associated with a reduction in post-operative surgical deaths at the Austin hospital. This benefit was rapidly seen during the pre-MET education phase of our intervention. In contrast, the number of deaths in medical patients rose during the education phase for the MET, and has remained higher than the before-MET period. The differential effects of staff education and the MET service on the in-hospital mortality of medical and surgical patients may be due to differences in the effect of education on safety awareness, MET utilization, and/or differences in the acuity and degree of reversibility of the diseases in the respective patient populations.

Table 7.1: Death rates for medical and surgical patients before, during and after implementation of a MET service in a University teaching hospital

	Before MET	During MET implementation	First year of MET	Second year of MET	Third year of MET	Fourth year of MET
Surgical Deaths	209	198	141	161	130	149
Admissions	7441	8353	6657	6743	6822	6214
Deaths/1000 admissions	28.09	23.70	21.18	23.88	19.06	23.18
OR of surgical death §	-	0.84 (0.69-1.02) p = 0.08	0.75 (0.60-0.93) p = 0.008	0.85 (0.69 – 1.04) p = 0.126	0.67 (0.54-0.84) p = 0.0005	0.85 (0.69-1.05) p = 0.14
Medical deaths	664	934	820	902	848	919
Admissions	17893	20621	16856	18474	18580	19897
Deaths/1000 admissions	37.11	45.29	48.65	48.83	45.64	46.19
OR of medical death ¶	-	-	-	1.00 (0.91-1.11) p = 0.93	0.94 (0.85-1.03) p = 0.18	0.95 (0.86-1.04) p = 0.26
RR of medical versus surgical death ¥	1.32 (1.22-1.43) p = 0.0003	1.91 (1.79- 2.04) p <0.0001	2.30 (2.14-2.47) p <0.0001	2.04 (1.91-2.19) p <0.0001	2.40 (2.23-2.57) p <0.0001	1.93 (1.80-2.06) p <0.0001

§ Odds ratio of surgical death shown for comparison with “before” MET period

¶ Odds ratio of medical death shown for comparison with first year following MET implementation

¥ Relative risk ratio of risk of medical death shown for comparison with risk of surgical death for same time period.

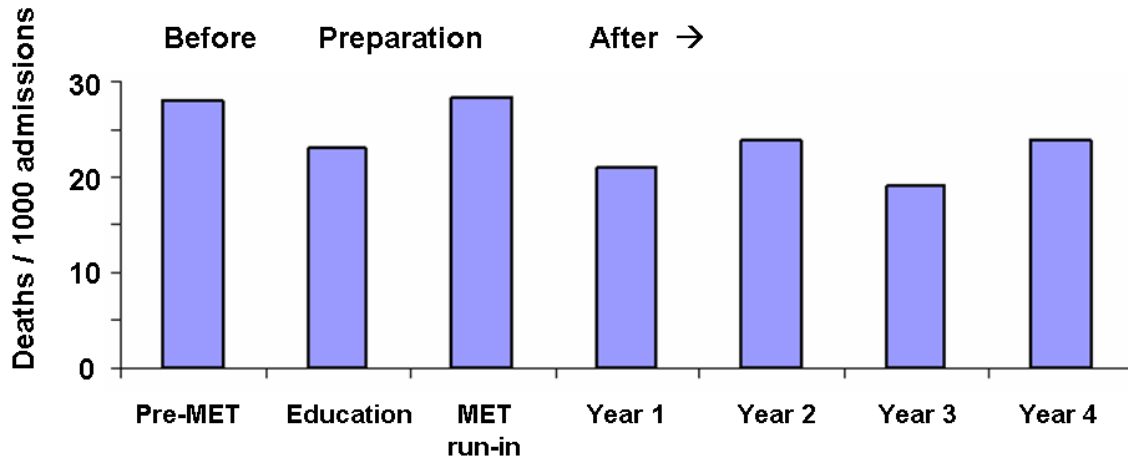


Figure 7.1: In hospital mortality for surgical patients before, during the education and run-in periods, and after introduction of an Intensive Care- based MET service into the Austin hospital.

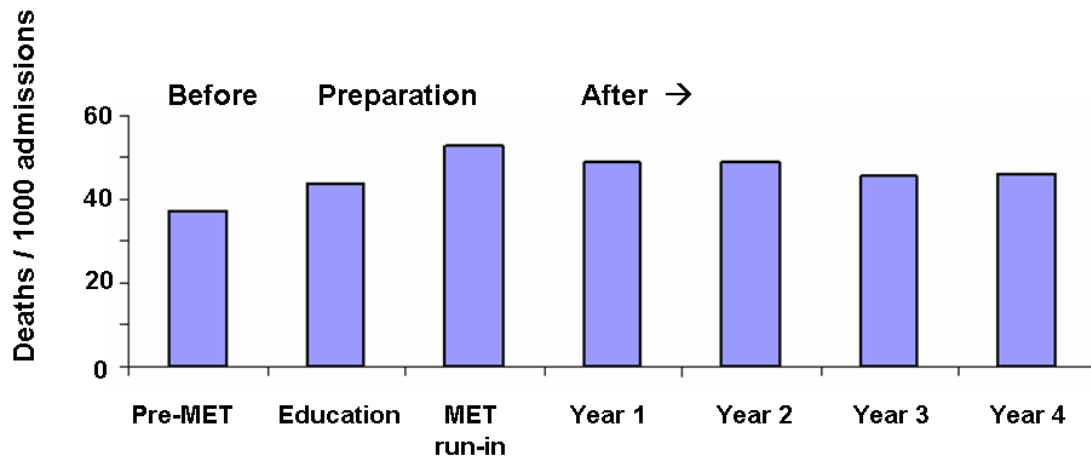


Figure 7.2: In hospital mortality for medical patients before, during the education and run-in periods, and after introduction of an Intensive Care- based MET service into the Austin hospital.

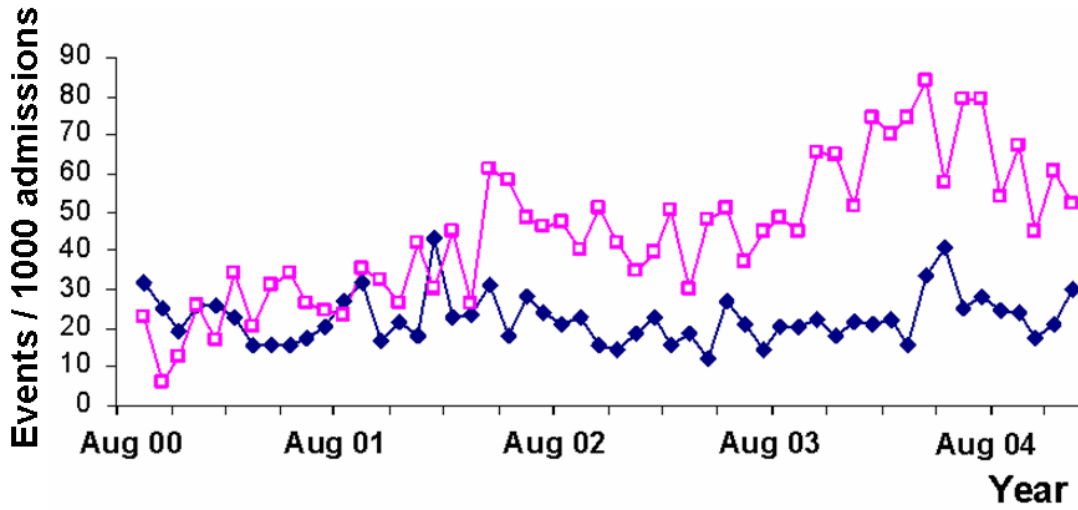


Figure 7.3: Figure demonstrating the number of MET calls / 1000 admissions (□) in relation to number of deaths/ 1000 admissions (◆) for surgical patients between August 2000 and Dec 2004

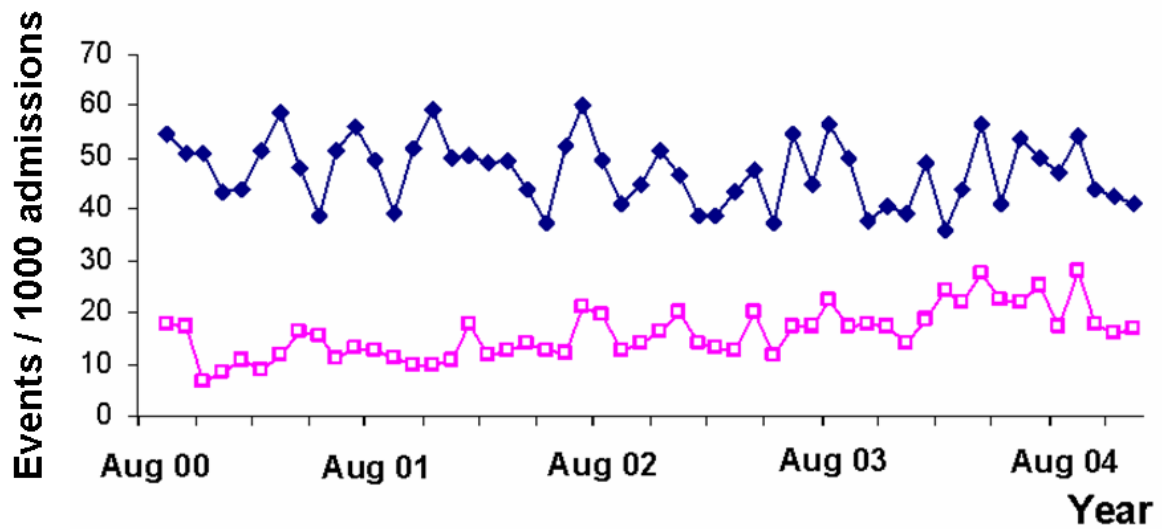


Figure 7.4: Figure demonstrating the number of MET calls / 1000 admissions (□) in relation to number of deaths/ 1000 admissions (◆) for medical patients between August 2000 and Dec 2004.

Chapter 8

Circadian Pattern of Activation of the Medical Emergency Team in the Austin Hospital.

Abstract

Introduction: Hospital Medical emergency teams (METs) have been implemented to reduce cardiac arrests and hospital mortality. The timing and system factors associated with their activation are poorly understood. We sought to determine whether the frequency of activation of a MET service at the Austin Hospital varies according to the time of day, and relate fluctuations in activation to aspects of nursing and medical routine.

Methods: We conducted a retrospective observational study in a University-affiliated hospital in Melbourne, Australia. The time of activation for 2,568 episodes of MET attendance was analysed. Each episode of MET attendance was allocated to one of 48 half-hour intervals over the 24-hour daily cycle. Activation were related to aspects of nursing and medical routine.

Results: During the study period (August 2000 to September 2004) there were 120,000 consecutive overnight medical and surgical admissions. Although the hourly rate of MET calls was greater during the day (47 % of calls in the 10 hours between 08:00-18:00), 53% of the 2,568 calls occurred in the 14 hour period not covered by the parent unit doctors (18:00-08:00). Use of the MET service was increased in the half-hour after routine nursing observation, and in the half-hour before each nursing handover. When compared with the average hourly use over the 24-hour period, MET service utilization was 1.25 times more likely in the three one-hour periods spanning routine nursing handover ($p=0.001$; 95% CI 1.11-1.52). The highest level of half-hourly utilization was seen between 20:00-20:30 (OR 1.76; $p=0.001$; 95% CI 1.25-2.48) prior to the evening nursing handover. Additional peaks were seen following routine nursing observations between 14:00-14:30 (OR 1.53; 95% CI 1.07-2.17; $p=0.022$), and following the commencement of the daily medical shift (9:00-9:30 am; OR 1.43; 95% CI 1.00-2.04; $p=0.049$).

Conclusions: Peak levels of MET service activation occur around the time of routine observations and nursing handover in keeping with the nature of criteria for

activation at the Austin Hospital. These findings raise questions about the appropriate frequency and methods of observation in at-risk hospital patients, reinforce the need for adequately trained medical staff to be available 24 hours per day, and provide useful information for allocation of resources and personnel for a MET service.

Introduction

The medical emergency team (MET) concept is an evolving hospital system change that aims to reduce morbidity and mortality in acutely ill ward patients [29, 30, 47]. The MET is most often comprised of Intensive care-based staff who are mobilized by ward-based doctors and nurses to review critically ill patients on the ward. The success of the MET system relies on the assumption that early intervention in the course of clinical deterioration improves patient outcome [35]. It would be important to gain insight into the possible processes that lead to MET calls and to understand their circadian variation in order to plan appropriate staff allocation.

Implementation of a MET system in the Austin hospital resulted in a 65% relative risk reduction of in-hospital cardiac arrests over a 4-month period [35] (Chapter 2) which was sustained in the subsequent 3.5 years [56] (Chapter 6). Analysis of the pattern of activation for the MET service in the original study at the Austin hospital [35] revealed a trend for increased activation during the evening ($p=0.12$). Lee and co-workers [31] reported that 36% of 522 MET calls registered over a one-year period occurred between the hours of 20:00 and 08:00. No information, however, exists on the possible relationship between routine nursing or medical activity and MET calls.

Available evidence suggests that between 69 and 82% of MET calls are initiated by a nurse [31, 35, 39]. The criteria for MET activation at the Austin Hospital are based on derangements of vital signs that are typically measured or assessed at times of routine nursing observations and handover (Table 1.4, Figure 2.1). Thus, we hypothesized that activation of the MET service at the Austin hospital would cluster around these times. To test this hypothesis we analysed the frequency of MET activation at half hourly intervals over a 24-hour period and related this to aspects of nursing and medical daily routine.

Methods

Austin Hospital Rapid Response System.

The characteristics, services provided and RRS structure of the Austin hospital are described elsewhere (Chapter 1 and 4). The calling criteria for the MET service are based on acute changes in heart rate (<40 or >130 beats/min), systolic blood pressure (<90 mmHg), respiratory rate (<8 or >30 breaths/min), conscious state, urine output (<50 mL over 4 hours) and oxygen saturation derived from pulse oximetry (<90%, despite oxygen administration). In addition, the calling criteria contain a “staff member is worried” category to allow staff to summon senior assistance to manage any possible emergency situation (Table 1.4, Figure 2.1).

Outcome measures

Information on the activation of all MET calls is maintained on a hospital switchboard logbook that includes the date and time of the call, as well as the ward where the MET review occurred. The details of 2,568 MET calls were manually entered into an MS Excel™ spread sheet by two investigators that worked together and cross-checked the entries to minimize errors.

Each call was allocated to one of 48 half-hourly intervals over a 24-hour period (24:00-00:30, 00:31-01:00, 01:01-01:30, 01:31-02:00, etc.) A graph was then constructed from the 2,568 episodes of MET service review to illustrate the frequency of activation at various times over the 24-hour period.

Episodes of activation were related to the periods of routine nursing handover (07:00, 13:00, 21:00), routine nursing observations (02:00, 06:00, 10:00, 14:00, 18:00, 22:00), and commencement and completion of the daily medical shift (08:00-18:00).

Statistical analysis

The frequency of MET service activation during peak periods of was compared to the average activation over the 24-hour period. In the case of nursing handover, the one-hour period spanning handover (half hour before and after, repeated 3 times per day for a total of 3 hours) was compared to the average activation over the 24-hour period. Statistical significance was determined by analysis with Fisher's exact test using MS Windows Stat-view (Abacus Concepts, Berkeley, CA). A p-value of < 0.05 was considered statistically significant.

Results

During the study period (August 2000 to September 2004) there were 120,000 consecutive overnight medical and surgical admissions to the Austin Hospital and 2,568 activations of the MET service. Activation of the MET service was not uniform over the 24-hour period (Figure 8.1).

Over the study period, 53% of the 2,568 calls occurred in the 14 hours between 18:00 and 08:00 hours (58% of the day). On an hourly basis, MET call utilization was more common during the hours covered by the parent unit doctors (47% of MET calls during 42% of the day). In the five years that the MET system has operated, there has been a trend for an increasing proportion of calls to occur after hours (18:00-08:00) (Figure 8.2). Thus in 2004, 374 of 669 (55.9%) MET calls occurred after hours, compared with 69 of 139 (49.6%) during the year 2000 (OR 1.13, $p=0.19$, 95%CI 0.82-1.54).

On average there were 106 calls for each hour period (2,568/24), or 53 calls per half-hour period (2,568/48). Increased activity of the MET service was typically seen in the half hour following routine observations, and in the half hour prior to routine nursing handover (Figure 8.1). A total of 401 calls were made in the 3 one-hour periods spanning nursing handover. During these periods, activation of the MET service was 1.25 times more likely when compared to the average activation over the 24-hour period ($p=0.001$; 95% CI 1.11-1.52).

The highest level of MET service activation for any given half hour period was seen between 20:00-20:30, when use of the MET service was 1.8 times greater than average half-hourly utilization ($p=0.001$; 95% CI 1.25-2.48). Additional peaks of activity were seen between 14:00-14:30 (OR 1.53; $p=0.022$; 95% CI 1.07-2.17) and between 9:00-9:30 (OR 1.43; $p=0.049$; 95% CI 1.00-2.04). All other peaks of activity failed to reach statistical significance.

Discussion

We report, for the first time a detailed analysis of the level of utilization of a MET service over a 24-hour period and found a significant increase in the number of MET calls around periods of nursing handover and routine nursing observations. In addition, although MET calls occur more frequently during the hours of 08:00-18:00 (47% of calls in 42% of day), a substantial proportion of MET calls occur after normal working hours (53% of calls during 58% of the day), with the peak time of activity occurring between 20:00 and 20:30 hours. These findings have important implications for the frequency and method of patient monitoring, as well as for allocation of critical care resources and MET personnel and require detailed discussion.

In a previous study at our institution there was a trend for more frequent activation of the MET service in the evening [35]. In a study of 522 MET calls over a one-year period, Lee and co-workers [31] demonstrated that 36% of MET calls were registered during night-shift (20:00-8:00). Although the rate of MET calls did not vary during periods of reduced staffing, the investigators emphasized the importance of providing appropriately trained medical staff on a 24-hour basis. In the current study, 53% of all calls occurred “out of hours” (18:00-08:00) when wards are not staffed by parent unit doctors. In addition, there was a trend for increased frequency of activation of the MET service during these hours in the five years following the introduction of the MET system. When directly compared to the study by Lee and co-workers [31], 46.2% of the 2,568 MET calls registered in the current study occurred between 20:00 and 08:00 hours. Our findings suggest a greater utilization of our MET service in the hours not covered by the parent unit medical staff than has been previously reported.

The frequent use of the MET service after 18:00 hours has important implications for allocation of resources to the MET service out of hours, and further reinforces previous opinion [31] that appropriately trained medical staff should be available on a 24-hour basis to assess and treat acutely ill hospital patients.

Utilization of a MET system has been associated with a reduction in the incidence of cardiac arrests in our institution [35, 56] (Chapter 2 and 6). Thus, our observation that MET service activation clusters around times of nursing handover and routine nursing observations raises questions about the appropriate frequency

and methods of observations in “at-risk” hospital patients. A more frequent or automated (e.g. telemetry) observation system for such at risk patients may result in a further reduction of mortality and morbidity. It is unlikely that patients would develop acute illness more frequently at specific times that happen to coincide with nursing observations or handover. It is more likely that the patient was discovered to be unwell only during a “scheduled visit” by his/her caregivers. In the case of medical staff this would correspond to the morning medical ward round. In the case of nursing staff, we have clearly demonstrated increased levels of MET activity during periods where nurses are more likely to be tending to the patient.

It is likely therefore, that a substantial proportion of these patients would have been ill for some time before the call was made, and only identified during routine observations or at the time of nursing handover. It is also possible that the diurnal variation of identifying “patients in crisis” observed in our current study would not be seen in an environment with more automated and/or continuous monitoring.

The present study has a number of limitations. First, it is an observational study and does not demonstrate the effect of MET service utilization on patient outcome. We do know, however, from previous studies [35, 39, 56] that the introduction of the MET service was associated with significant beneficial effects on morbidity and mortality. Second, the pattern of fluctuation of the MET service at our institution is likely to be based on the calling criteria we have implemented. Our study may not apply to other hospitals where alternative calling criteria are employed. However, we have deliberately employed simple calling criteria to increase the ease of utilisation of the MET system at our institution. Furthermore, the timing and frequency of patient observations reported in our study would be typical of most hospitals.

Finally, information on episodes of MET review was obtained from the hospital switchboard log and did not provide information on the member of staff that activated the system. It would be interesting to know whether there was variation in the nature of the member (doctor versus nurse) and seniority of staff at various times of the day. We are currently collecting information on this aspect of MET operation.

Conclusions

In the Austin hospital, peak levels of MET service utilization occur around the time of routine nursing observations and nursing handover and the majority of calls occur after hours. Our results raise questions about the appropriate frequency and technology of observations in hospital ward patients. They also provide useful information to guide appropriate resource allocation for the provision of the MET service.

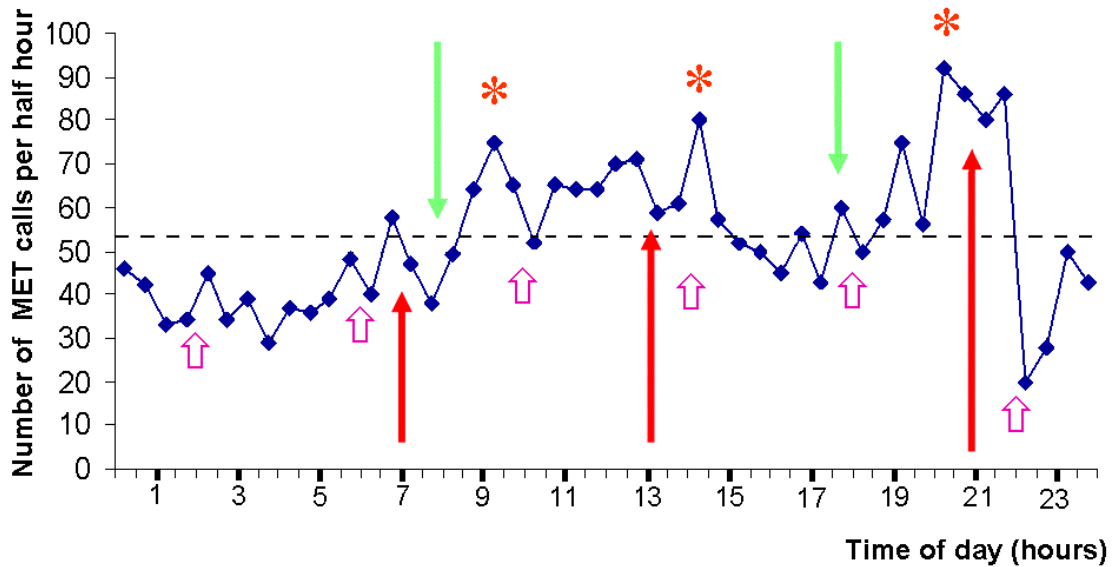


Figure 8.1: Graph illustrating number of MET calls made per half hour over a 24-hour period for 2,568 episodes of MET review in relation to aspects of daily nursing and medical routine. Arrows demonstrate periods of nursing handover (↑), beginning and end of daily medical shift (↓), as well as periods of routine nursing observations (↑). The dotted line represents the average number of MET calls made per half hourly interval. Statistically significant ($p < 0.05$) levels of increased activity are also indicated (*).

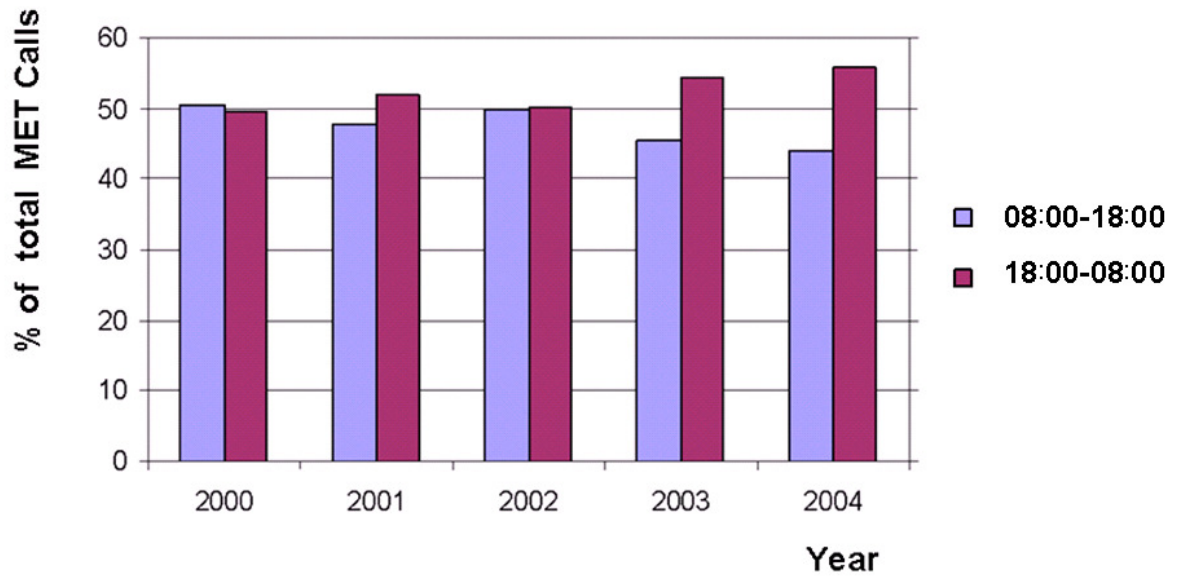


Figure 8.2: Comparison of the percentage of MET calls made between the hours of 08:00-18:00 and 18:00-08:00 for the years 2000 to 2004.

Chapter 9

Patient Monitoring and the Timing of Cardiac Arrests and Medical Emergency Team Calls in the Austin Hospital.

Abstract

Objective: To describe the timing of cardiac arrest detection in relation to episodes of Medical Emergency Team (MET) review and routine nursing observations.

Design and setting: Retrospective observational study in the Austin hospital.

Patients: 279 confirmed cardiac arrests involving ward patients

Measurements and results: Each of the 279 cardiac arrests was allocated to one of 24 one-hourly intervals (24:00-00:59, 1:00-1:59, etc). The actual hourly rate of cardiac arrests was related to the expected average hourly rate. Peak levels of cardiac arrest detection occurred during times of routine overnight nursing clinical observations between 2:00 and 3:00 (OR 3.06; $p=0.0011$), and 6:00-7:00 (OR 1.95; $p = 0.077$). The lowest level of cardiac arrest detection occurred between 20:00 and 21:00 (OR 0.42; $p =0.085$).

After introduction of the MET, there were 162 cardiac arrests, 28% of which occurred shortly after an initial MET call. The odds ratio for risk of cardiac arrest during periods of lowest MET activation (24:00 – 08:00) when compared with periods of highest MET activation (16:00 – 24:00) was 2.26 ($p = 0.0006$).

Conclusions:

Cardiac arrest detection in the Austin hospital is episodic with peak levels corresponding to periods of overnight routine nursing observations following a period when patient review is likely to be low. After the introduction of the MET, there was an inverse link between detection of cardiac arrests and levels of MET activation over the 24 hour period. Increased overnight utilization and earlier MET activation may further reduce the incidence of cardiac arrests in the Austin hospital.

Introduction

As outlined in Chapter 1, up to 80% of in-hospital cardiac arrests are associated with a period of prolonged physiological and clinical instability [14, 17, 19]. Medical Emergency Teams (MET) systems have been introduced into hospitals to identify, review and treat acutely unwell ward patients during this period. However, MET services have been shown to reduce the incidence of in-hospital cardiac arrests by only 2% to 65% in single centre short term before-and-after studies [34, 35, 40, 48]. The reason why they have not been shown to prevent a greater proportion of in-hospital cardiac arrests is not understood.

The introduction of a MET into the Austin hospital was associated with a 65% reduction in the incidence of cardiac arrests [35] (Chapter 2). As described in Chapter 8, activation of the MET service at the Austin Hospital is not uniform over a 24 hour period, and that peak levels of activation corresponded to periods of routine nursing observations and handover [57].

At least two studies have demonstrated a circadian variation of sudden cardiac death [58] and witnessed out of hospital cardiac arrest [59], with peak levels occurring between 06:00 and 12:00. A circadian variation of in-hospital cardiopulmonary arrests has been demonstrated for patients on a general medical ward, with peak intervals occurring between 4 to 7:59 am, with a secondary peak occurring during 8 to 11:59 pm [60].

This Chapter assesses the circadian pattern of detection of cardiac arrests at the Austin hospital in relation to aspects of routine medical and nursing care. In addition, correlation is made between rates of detection of cardiac arrests with levels of MET review at various times of the day. Finally, the chapter describes the phenomenon of cardiac arrests that occurred shortly after an initial MET service activation.

Materials and Methods

Ethics approval

Approval was obtained from the Institutional Ethics Committee for implementation of the MET and collection of the data related to it. The need for informed consent was waived by the committee.

The Hospital and Rapid Response Systems

The characteristics of the Austin Hospital, the services provided and the RRS have been described elsewhere (Chapter 2 and 4).

Data on admissions, cardiac arrests and MET calls

A log book of all emergency calls is maintained by the switchboard operators and contains details of the date and time of the call as well as the ward from which it originated. Cardiac arrests were analyzed for all hospital wards other than the critical care areas of the hospital (ICU, coronary care unit, Operating rooms). Data was entered into a MS Excel™ spreadsheet by 2 operators concurrently. Standardized case report forms (CRFs) on Code Blue calls are maintained independently by both the coronary care unit and ICU. Details of MET calls are kept on similar CRFs by the ICU. Episodes of cardiac arrest were identified from analysis of the Code Blue CRFs, the ICU admission data base, and patient files and were cross referenced with the switch board log (See Chapter 6).

Cardiac arrest was defined as the sudden onset of all of the following: 1. no palpable pulse; 2. no measurable blood pressure; 3. no responsiveness; and 4. commencement of basic life support.

Information on outcome of cardiac arrests was obtained from the hospital electronic data base. The data was assessed for two separate study periods. The first involved 279 cardiac arrests for the entire study period (January 1999 to October 2004). The second involved 162 cardiac arrests for the specific period within it following the introduction of the MET (September 2000 to October 2004).

Outcome measures

Each cardiac arrest was allocated to one of 24 one-hourly intervals (24:00-0:59, 1:00-1:59, 2:00- 2:59, etc) based on the documented time of call in the switchboard log. A similar process has previously been performed for MET calls [57] (Chapter 8). A graph was then constructed for the 279 episodes of cardiac arrest detection to illustrate the frequency of activation at various times over the 24-hour period.

Episodes of activation were related to the periods of routine nursing handover (07:00, 13:00, 21:00), routine nursing clinical observations (02:00, 06:00, 10:00, 14:00, 18:00, 22:00), and commencement and completion of the daily medical shift (08:00-18:00).

For the 162 documented cardiac arrests that occurred after the introduction of the MET, the number of cardiac arrests in the eight hours of lowest MET activity was compared to the number of cardiac arrests in the eight hours of highest MET activity.

Statistical analysis

The frequency of cardiac arrest detection during peak periods was compared to the average hourly level of activation over the 24-hour period. Statistical significance was determined by analysis with χ^2 analysis using MS Windows Stat-view (Abacus Concepts, Berkeley, CA). A p-value of < 0.05 was considered statistically significant.

Results

Circadian pattern of Cardiac Arrest detection

There were 279 documented cardiac arrests between January 1 1999 and October 31 2004. The detection of cardiac arrests was not uniform over the 24 hour period (Figure 9.1). On average, there were 11.6 cardiac arrests for each one hour period (279/24). Peak levels of cardiac arrest detection were seen between 02:00 and 03:00 (OR 3.06; 95% CI 1.54-6.10; p =0.0011) and between 6:00 and 7:00 (OR 1.95; 95% CI 0.94 - 4.05; p =0.077). These time periods correspond to the timing of routine nursing observations (02:00 and 06:00), as well as morning nursing handover (07:00).

The lowest level of cardiac arrest detection was seen between 20:00-21:00 when the odds ratio for cardiac arrest detection was 0.42 (95% CI 0.14 - 1.2; p = 0.085). This period precedes the timing of the evening nursing handover (21:00).

Frequency of cardiac arrests during periods of high and low levels of MET activation

Detection of the 162 cardiac arrests and activation of 2568 MET interventions following introduction of the MET service (September 2000 to October

2004) were also not distributed evenly over the 24 hour period (Figure 9.2). The highest levels of activation of the MET were seen during periods when the frequency of detection of cardiac arrests was lowest. Sixty nine of the 162 cardiac arrests occurred during periods of low MET activity (24:00 – 08:00) versus forty during periods of high MET activity (16:00 – 24:00). Thus, the OR for detection of cardiac arrest during periods of low MET activity versus periods of high MET activity was 2.26 (95% CI 1.41-3.62; $p = 0.0006$)

Cardiac arrests following an initial MET call

Of the 162 cardiac arrests documented following the introduction of the MET service, 45 (28%) occurred following an initial MET call activation. Activation of the cardiac arrest team (Code Blue) occurred between 0 – 5 minutes in 38 of the 45 calls, between 5-10 minutes for four calls, and greater than 10 minutes for three calls. The survival to hospital discharge for a cardiac arrest following an initial MET call was 13.3% (6/45) versus 17.1% (20/117) for those not following a MET call (OR for survival = 0.75; 95% CI 0.28-2.00; $p = 0.56$)

Discussion

We analysed the circadian variation of detection of cardiac arrests and found that the peak levels of detection occurred overnight at times of routine nursing observations when patients are deemed to be asleep. In addition, after the introduction of the MET service the highest rates of cardiac arrest detection occurred during the periods where levels of MET activation are lowest. Finally, we demonstrated that 28% of the cardiac arrests occurring after the implementation of the MET did so very shortly after the initial activation of the MET service. These observations have important clinical implications and require detailed discussion.

The circadian variation of out of hospital cardiac arrests has been shown to exhibit a marked circadian variation with peak levels occurring between 06:00 and 12:00 and a minimum between midnight and 06:00 [58]. In contrast, our analysis of the 279 episodes of in hospital cardiac arrest shows that peak levels of detection occur between midnight and 07:00. In hospital cardiac arrests differ from sudden out of hospital cardiac arrests in that they are preceded by variable periods of abnormality in commonly measured vital signs in up to 80% of cases [14, 17, 19] (Chapter 1). The introduction of a MET service to review acutely unwell ward

patients was shown to reduce the incidence of in-hospital cardiac arrests by 65% in a before-and-after study in the Austin hospital [35, 56] (Chapters 2 and 6).

The circadian variation of episodes of MET review in the Austin hospital occurs around the time of routine observations and nursing handover [57] with the lowest levels of activation occurring between midnight and 08:00 (Chapter 8). Thus, the peak level of cardiac arrest detection occurs during periods where utilization of the MET is the lowest. Consistent with this, we have demonstrated that the risk for cardiac arrest during periods of low MET activity was statistically higher than during periods of high MET activity. This finding may suggest that the current level of monitoring overnight is insufficient to adequately detect unwell patients.

Peak levels of cardiac arrest detection also correspond to episodes of overnight routine nursing observations. This is in keeping with suggestions that the more care givers visit a patient, the more likely they are to detect patient deteriorations [61]. Improved utilization of the MET service overnight might further reduce the incidence of cardiac arrests at the Austin hospital. This may be achieved via a focused education program for permanent night staff, or by assessing potential obstacles for its use during this period.

Previous studies have shown that up to 80% of in-hospital cardiac arrests are preceded by a period of prolonged instability [14, 17, 19]. In the present study we demonstrated that 45 of the 162 cardiac arrests occurring following the introduction of the MET service occurred very shortly after an initial MET call (often before the MET team had reached the bedside) and that the mortality following these cardiac arrests was similar to the events where a prior MET call had not occurred. These findings suggest that a proportion of cardiac arrests in the Austin hospital might occur in the context of an excessively delayed MET call. They may also suggest that the MET may have been inappropriately activated instead of the Code Blue team or that the MET failed to act appropriately to prevent cardiac arrests. The latter option seems unlikely given the previous report from the Austin hospital that the introduction of the MET reduced cardiac arrests by 65% [35, 56]. We are uncertain about the total number of these cardiac arrests that were preceded by signs of physiological instability.

Buff and co-workers have previously demonstrated a circadian variation of in-hospital cardiopulmonary arrests on the general medical ward [60]. The peaks of cardiac arrest detection in this study were seen between 4 to 8 am with a secondary peak occurring between 8pm and midnight and the majority of these were deemed to be unexpected. They concluded that patients in unmonitored beds are at significantly higher risk of having a cardiac arrest at night which is unwitnessed. However, this study did not include surgical patients, and did not report on the frequency or nature of patient monitoring.

Other studies [62, 63] did not demonstrate a circadian variation in cardiac arrests, but demonstrated a lower survival rate in patients suffering an arrests non-business hours. We are unable to state whether these findings apply to our patient cohort.

The present study has a number of strengths and limitations. It is the first to demonstrate the circadian variation of cardiac arrest detection in a teaching hospital following the introduction of a MET service. However, the study design is retrospective and observational, with all the inherent limitations of such studies. It also demonstrates the findings only in a single centre. It does not provide information on whether the patients suffering cardiac arrests had antecedent vital signs that fulfilled MET criteria. However, we have shown that 28% of cardiac arrests occurred very shortly after a MET call suggesting that this may be the case in a substantial proportion of cardiac arrests. Finally, all of the cardiac arrests in our study occurred on hospital wards other than the critical care areas. Thus, it is likely that the majority of the patients did not receive continuous ECG or pulse oximetry monitoring. We are unable to state whether there is a circadian variation of cardiac arrest detection in more intensely monitored areas of the Austin hospital.

Conclusions:

The detection of cardiac arrests in ward patients in the Austin hospital is episodic, with peak levels occurring overnight when patients are considered asleep and review by care givers is least frequent. Cardiac arrests are identified only at pre-determined times of routine nursing observation and during periods when use of the MET service is lowest. A substantial proportion of cardiac arrests may occur in the context of an excessively delayed MET call. Improved overnight utilization

and earlier activation of the MET service may further reduce the incidence of in-hospital cardiac arrests.

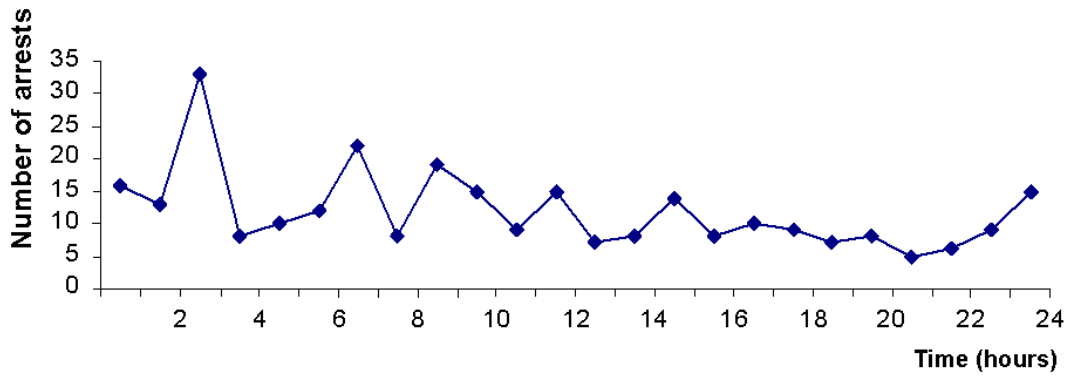


Figure 9.1: Circadian variation of 279 cardiac arrests occurring between January 1999 and October 2004.

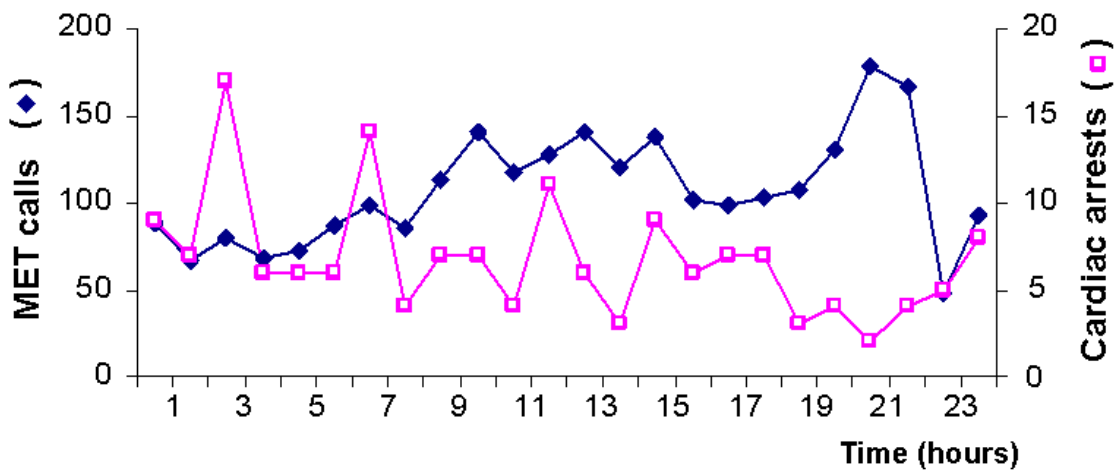


Figure 9.2: Circadian variation of 162 cardiac arrests (□) and 2568 episodes of MET review (◆) since the introduction of the MET service (September 2000 to October 2004).

Chapter 10

The Medical Emergency Team and End of Life Care: A Pilot Study

Abstract

Objectives: To assess the characteristics of patients dying in the Austin hospital and the role of the Medical Emergency Team (MET) in their end of life care.

Methods: Retrospective analysis of 105 deaths over one month by a blinded investigator to document patient age, parent unit, co-morbidities, presence and timing of not for resuscitation (NFR) designation, and presence and timing of first MET review. Analysis of differences between medical versus surgical patients, NFR versus non-NFR patients, and MET-reviewed versus non-MET reviewed patients.

Results: Of the 105 deaths, 80 were medical and 25 were surgical. Only five patients were not NFR at the time of death, and only three of these had antecedent MET criteria in the 24 hours before death. Of the 100 patients that were NFR at the time of death, 35 received a MET call during their admission. Of the 35 MET calls, 10 occurred on the same day as the patient's death, and 12 occurred on the same day as the NFR designation. Documentation of NFR status in patients who received a MET call during their admission occurred later than in those who did not receive a MET call (13.3 ± 16.1 versus 5.3 ± 10.8 days after admission; $p = 0.0025$). Hypotension, hypoxia, and tachypnoea were the commonest MET triggers and pulmonary oedema, pneumonia and acute coronary syndromes were the most common reasons for the deterioration. Following the MET review, patients were admitted to ICU and newly classified as NFR in 15 and 9 of the 35 MET calls, respectively.

Conclusions: Most patients dying in the Austin hospital are NFR at the time of death. One third of such patients were seen by the MET prior to death. In approximately 10% of cases, the MET participated in the decision to make the patient NFR

Introduction

Patients admitted to hospital wards are increasingly complex and have a growing number of co-morbidities [64]. Medical Emergency Teams (MET) have been introduced into hospitals to identify, review, and treat acutely unwell ward patients in an attempt to reduce cardiac arrests, serious adverse events and unplanned ICU admissions [33-35, 39, 40, 64-69] (Chapter 1).

The introduction of a MET service into the Austin hospital has been associated with a reduction in cardiac arrests over a sustained period [56] (Chapter 6). Assessment of the epidemiology of patients dying in the Austin hospital might reveal information necessary to develop strategies that further prevent in-hospital deaths.

An additional role of the MET service involves decisions and discussions about end of life care and “not for resuscitation” (NFR) status [36]. The role of the MET service in end of life care planning at the Austin hospital is not known.

We undertook a retrospective study to assess the epidemiology of 105 patient deaths over a one-month period in the Austin hospital. In addition, we described the frequency and timing of NFR status documentation, as an objective marker of end of life care. Finally, we determined the frequency and timing of MET calls in patients dying with an NFR-status, and then analysed differences in timing of NFR documentation between the patients who did- versus did-not receive a MET call.

Methods

Details of the Austin hospital and Rapid Response Teams

The hospital characteristics and features of the rapid response teams (RRTs) at the Austin hospital have been described in detail previously [35, 39, 55] (Chapter 2 and Chapter 4).

Criteria for activation

The calling criteria for the Austin Hospital MET service are based on acute changes in commonly measured vital signs (Table 1.4, Figure 2.1). Additional criteria include the presence of noisy or difficulty with breathing and problems with a tracheostomy tube. Finally, the calling criteria contain a “staff member is worried”

category to allow staff to summon senior assistance to manage any possible emergency situation. The MET service is an integral aspect of hospital policy. During education of new staff it is emphasized that no staff member should be criticized for activating the MET, including for patients that are designated NFR. At present there is no formal written NFR policy in the hospital, and NFR designation is performed by the treating clinicians in conjunction with the patient and/or their next of kin.

Study design, patient cohort, and methods of data collection

Patients were identified from the hospital's electronic database as dying during May 2005. Analysis of the patient files was conducted by an ICU nurse blinded to the study objectives, using a prospectively developed case report form. Information on dates of admission and death were derived from the hospital's electronic database. Information on the number of MET calls for the study period was obtained by the hospital switchboard log as previously described [55, 57] (Chapter 4 and 8).

Details of data collected

We collected information on patient age and parent unit (medical versus surgical) as well as the prevalence of 16 pre-defined co-morbidities, based on clinical diagnoses in the medical and nursing clinical notes. In addition, we recorded the dates of patient admission, patient death, and the date of completion of a NFR form. Finally, we documented the date of the first recorded MET call as an indicator of the time when the ward medical and nursing staff first became concerned about the patient's clinical status. Information on the characteristics and management of the MET calls was obtained from case report forms completed by MET members at the conclusion of each call. Specifically, we recorded the physiological trigger and presumed clinical cause for the MET, treatment instituted by the MET, and whether the patient was admitted to the ICU following the MET review. Finally, we recorded whether the MET members made recommendations for limitation of medical treatment including whether in the opinion of the MET the patient should be NFR, not be for subsequent MET calls, or should be for palliation.

Data analysis and comparisons

We assessed the number of co-morbidities in the cohort overall, for surgical versus medical patients, and for patients with a NFR status who did- versus did-not have a MET call during their admission.

In patients who did have an NFR form completed, the timing of NFR status was compared to the date of admission and date of death. Comparison of the timing of NFR documentation was then performed separately for patients who did-versus did-not have a MET call during their admission.

Furthermore, in patients who did receive a MET call, we assessed the timing of the first MET call in relation to the date of death. Histograms were constructed to describe the timing of the first MET call in relation to patient death, and the timing of the first MET call in relation to the documentation of NFR status.

In patients who did not have an NFR form completed (presumed unexpected death), further patient file analysis was undertaken by two investigators to assess the following prospectively defined questions: 1) Was there was evidence of palliation or care de-escalation despite the absence of an NFR form ?; 2) Did the patient have MET criteria in the 24 hrs before death?; 3) Who was the most senior doctor to review the patient in the 24 hours before death?; 4) what was the patient's admission diagnosis and/or presumed cause of death?

Statistical analysis

Descriptive data are presented as raw numbers and percentages of overall cases. Distributed data are presented as mean \pm standard deviation (SD). Differences in numerical data were compared using the Mann-Whitney test and, for proportions, using the χ^2 or Fishers-exact test as appropriate. In cases where comparators were $>$ zero, analyses of comparisons are also presented as odds ratios (OR) and 95% confidence intervals (CI). A $P < 0.05$ was taken to indicate statistical significance.

Results

The results of the study are summarized in Figure 10.1.

Prevalence of pre-existing co-morbidities

Of the 105 patients, 80 were admitted under a medical unit, and 25 under a surgical unit. The average (\pm SD) age of the cohort overall was 75.5 ± 13.9 years (Table 10.1). On average there were 2.4 co-morbidities/patient, and medical patients had a similar number of co-morbidities to surgical patients on average (2.5 versus 2.3,

respectively; $p = 0.87$). Ten patients (9.5%) had five or more co-morbidities (Table 10.1).

Rhythm disturbance, ischemic heart disease, diabetes mellitus and solid organ malignancy were the most common pre-existing co-morbidities, each present in approximately one-third of patients. Dementia and heart failure were each documented in approximately one-quarter of patients (Table 10.1). Medical patients showed trends toward more rhythm disturbances (OR 3.33, 95% CI 1.04-10.62, $p = 0.05$) and multiple (≥ 5) co-morbidities ($p = 0.11$) compared to surgical patients (Table 10.1).

Characteristics of patients without NFR form at the time of death

Five of the 105 patients did not have a completed NFR form at the time of death (Figure 10.1). Of these patients, three had a code blue call and two received a MET call during their admission. The maximum interval between the emergency call and death was 3 days (2 same day, 2 day prior, one 3 days prior). There was no statistically significant difference in number of co-morbidities between patients who did versus did not have and NFR order at the time of death (average co-morbidities 1.8 vs 2.5, respectively; $p = 0.127$).

Four of the five patients without completed NFR forms were admitted to the general ward. Of these four patients, two had moderate dementia, one had carcinoma of the lung, and the other had severe right heart failure and pulmonary hypertension secondary to recurrent pulmonary emboli. Three of these four patients were admitted with infections, and the fourth was admitted with severe dehydration in the context of gastroenteritis. The fifth patient died in the coronary care unit from refractory cardiogenic shock following a large anterior myocardial infarct.

Two of the five patients had no MET criteria at any stage during their admission. The remaining three had MET criteria for greater than 24 hours prior to death, but only one received a MET call in the 24 hrs before death. In no patient was there evidence of de-escalation of care on the ward or documentation of discussions regarding NFR status. In two of the five patients there was documented consultant review in the 24 hours before death. In the remaining three, a registrar was the most senior person to see the patient in the prior 24 hours. All patients suffered a cardiac arrest (three asystolic, two EMD) and

received attempts at advanced cardiac life support. One patient was successfully resuscitated, but therapy was withdrawn the following day in the ICU.

Details of timing of first MET call in patients NFR at the time of death

Thirty five of the 100 patients with a completed NFR form at the time of death received a MET call during their admission (Figure 10.1). As there were 93 MET calls in May 2005, 37.6% (35/93) of MET calls involved a patient that subsequently died with an NFR status. The average time between admission and the first MET call was 10.7 ± 9.8 days, and the average time between MET and death was 8.8 ± 13.1 days (Figure 10.1). In 10 patients, the first MET call was made on the same day as the patient's death (Figure 10.2). Thus, in 10% of deaths in NFR patients (10/100) and in 28.6% (10/35) of MET calls for patients dying with an NFR form, the first MET call was made on the same day as the patient's death.

Similarly, the first MET call was most frequently made on the same day as the NFR documentation (Figure 10.3). Thus in 12% (12/100) of patients with a completed NFR form and 12/35 (35%) MET calls in NFR patients the first MET call was made on the same day as completion of the NFR form. In 15 of the 35 MET calls, the first MET call preceded the day of NFR documentation, and in eight of the 35 the first MET call occurred in a patient who had already been documented as being NFR (Figure 10.3). Thus, at least 8.6% of the 93 MET reviews occurring in May 2005 occurred in patients with a pre-existing NFR order.

Differences between patients receiving and not receiving a MET call during admission

Within the 100 patient with NFR documentation at the time of death, the timing of the NFR documentation differed according to whether the patient received a MET call or not (Figure 10.1, Table 10.2). Thus, in the 35 patients who received a MET call, NFR documentation was completed 13.3 ± 16.1 days after admission, compared with 5.3 ± 10.8 days after admission for the 65 patients who did not receive a MET call ($p = 0.0025$). The interval between NFR documentation and death was similar in both groups (6.3 ± 9.9 vs. 5.9 ± 8.3 days). The average length of hospital stay for the patients that received a MET call was

correspondingly longer than for those who did not (19.5 ± 18.4 vs 11.2 ± 15.0 days; $p = 0.0024$).

Characteristics, management and outcome of 35 MET calls

Case report forms completed at the time of the original MET review were available in 31 of the 35 MET reviews. The most common physiological triggers for the MET call were hypotension, hypoxia, and tachypnoea (Table 10.3). Pulmonary oedema, pneumonia and acute coronary syndromes were the most common diagnosis as the cause of the deterioration. The most common therapies instituted included increasing or commencing oxygen therapy, administering a fluid bolus, and administering frusemide (Table 10.3). Following the MET review 15 of the 35 patients were admitted to the ICU. Nine patients with no prior NFR order were newly documented as being NFR.

Discussion

We conducted a retrospective analysis of 105 deaths occurring over a one month period in the Austin hospital to assess the epidemiology of in-hospital deaths and the role of the MET in end of life care planning in such deaths. We found that patients who died in the Austin hospital (especially medical) were elderly, had multiple pre-existing co-morbidities, and were mostly NFR at the time of death. We also found evidence that the MET participated in NFR documentation in approximately 10% of deaths, typically when advanced care planning was delayed.

Only five of the 105 deaths were not associated with formal NFR documentation suggesting that the vast majority of deaths in the Austin hospital are anticipated or expected. Furthermore, of these five patients, two had advanced dementia, one solid organ cancer, and the other advanced right heart failure. Finally, only three of the five patients designated “for resuscitation” at the time of death had antecedent MET criteria prior to death. Combined, these findings suggest that the MET may have a limited capacity to further reduce unexpected in-hospital deaths in the Austin hospital.

More than one-third of the 100 patients dying with an NFR order received a MET call during their stay. In these patients the MET was most likely to be called

on the day of the patient's death as well as the day when NFR documentation occurred. In addition, the time interval between admission and NFR documentation in patients that did receive a MET call was longer than for those who did not receive a MET call. Combined, these findings may suggest that the MET was called to assist NFR decision making in patients where advanced care planning was delayed or suboptimal. Alternatively, our findings may suggest documentation of NFR status occurred after a period of attempted active treatment, which was later considered to have failed. If this were true, at least 10% of NFR orders might be made in patients who were initially for active treatment. Consistent with this hypothesis, we found that in 9 of the 35 MET calls, the MET newly classified the patient as NFR following the MET review. However, 15 of the 35 patients were admitted to ICU and the majority received treatment during the MET review. This suggests that the MET was not merely adjudicating NFR status in the patients reviewed.

A number of previous studies have attempted to assess the role of the MET in end of life care. In the original description of the MET system, Lee and co-workers [31] reported that 36 of the 522 calls occurring between Feb 1992 and March 1993 were "inappropriate", in part because the patient was terminally ill and/or NFR. In a subsequent 12-month study in 1998, members of the MET felt that an NFR order would have been appropriate in 130 of the 713 cases (23%) [70].

In a study performed in 1999, Buist and co-workers reported that 13 of the 152 MET calls (8.6%) led to the allocation of NFR orders during the visit [34]. Finally, 8.3% of the calls in hospitals randomised to the MET in the recently completed MERIT study [36] resulted in an NFR order. All of these studies differ from ours as they assess the proportion of MET calls that were associated with documentation of NFR status, rather than assessing the proportion of patients dying with an NFR status who received a MET call during their admission. In our current study, we found that 35% of patient who died with an NFR status had a MET call during their admission

The present study has a number of strengths and limitations. To our knowledge it is the first to assess in detail the role of the MET in patients dying

within a hospital. This assessment has provided important information regarding the potential capacity for the MET to further reduce unexpected in-hospital deaths.

Despite this, our study has a number of limitations. It assesses the deaths of only 105 patients in a single centre, and is retrospective in design. However, the case report form was designed to assess prospectively defined objectives and questions, and were completed by an investigator blinded to the study objectives. Confirmation of our findings will require a larger study, possibly multi-centre in nature. A further limitation of our study is that it does not assess the frequency of NFR documentation in patients who did not subsequently die.

Conclusions

Our pilot study suggests that the majority of patients dying in the Austin hospital do so with a documented NFR order, and that a minority of deaths are unexpected or unanticipated. These findings suggest that the capacity of the MET service to further reduce unexpected deaths at the Austin hospital is limited. The MET appears to participate in NFR discussions in approximately 10% of hospital deaths, often where advanced care planning is delayed or where active management might have failed.

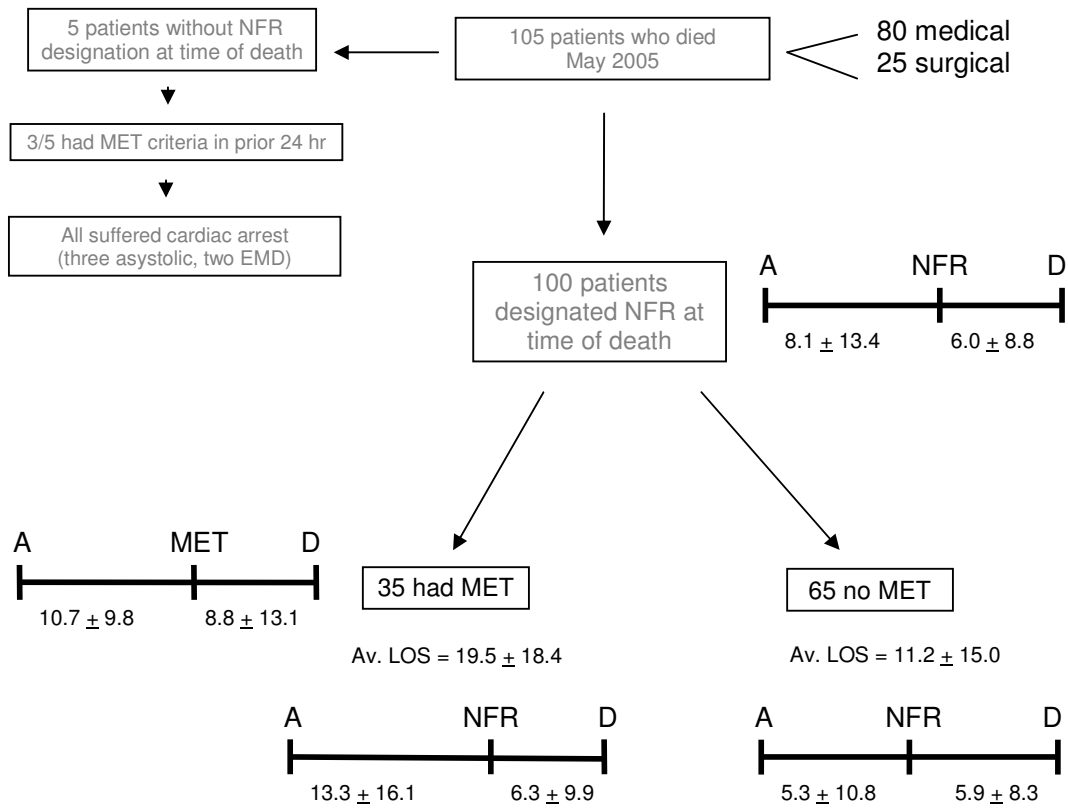


Figure 10.1: Flow diagram showing characteristics of 105 patients dying over a one month period. Line diagrams show time lines in days (average \pm SD) for not for resuscitation (NFR) documentation and medical emergency team (MET) review in relation to hospital admission (A) and patient death (D).
hr = hours; EMD = electromechanical dissociation; Av. LOS = average length of stay.

Table 10.1. Number and nature of co-morbidities in 105 patients dying over a one month period.

	Overall cohort	Medical	Surgical
Number	105	80	25
Average age	75.5 ± 13.9	75.7 ± 14.1	74.8 ± 13.6
Number of co-morbidities (number of patients) [£]			
0	3	3	0
1	31	25	6
2	25	17	8
3	26	18	8
4	10	7	3
≥ 5	10	10	0 [¶]
Average number of co-morbidities	2.4	2.5	2.3 ^β
Nature of co-morbidities (%) [£]			
Rhythm disturbance	34.3	38.8 [§]	20.0
Ischemic heart disease	29.5	26.3	40.0
Solid organ cancer	28.6	28.8	28.0
Diabetes	28.6	28.8	28.0
Dementia	23.8	25.0	20.0
Heart failure	23.8	26.3	16.0
Renal failure	18.1	20.0	12.0
COAD	15.2	13.8	20.0
Peripheral vascular disease	10.5	8.8	16.0
Valvular heart disease	6.7	7.5	4.0
Asthma	6.7	7.5	4.0
Current smoker	5.7	2.5	16.0
Chronic liver disease	5.7	5.0	8.0
Hematological cancer	4.8	6.3	0
Dialysis dependent	1.9	2.5	0
Intellectual disability	1.0	1.3	0

[¶] p = 0.11, [§] OR 3.33, 95% CI 1.04-10.62; p = 0.05, ^β p = 0.87, [£] p-value > 0.18 for all other comparisons.

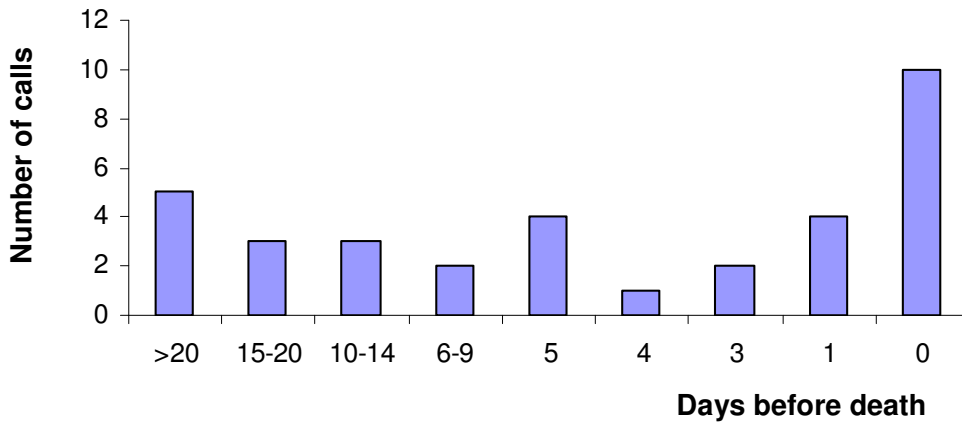


Figure 10.2. Histogram showing frequency of the first MET call occurrence in relation to death in 35 patients receiving a MET call who were NFR at the time of death. In 10/35 patients the MET call was made on the same day as the patient's death.

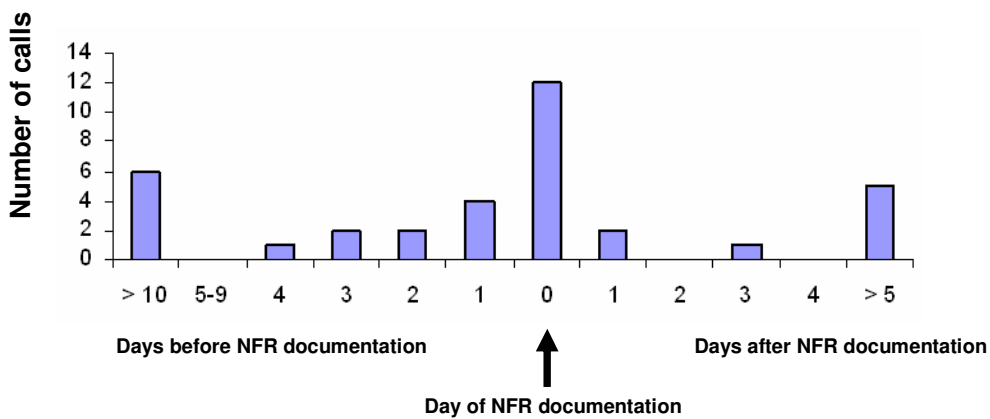


Figure 10.3. Histogram showing frequency of first MET call occurrence in relation to NFR documentation in 35 patients receiving a MET call who were NFR at the time of death. In 12/35 patients the MET call was made on the same day as the documentation of NFR status.

Table 10.2. Differences in characteristics of NFR timing and co-morbidities according to MET call review.

	Had MET during admission	No MET during admission
number	35	65
Average age	74.8 ± 12.4	75.8 ± 15.2
Average LOS	19.5 ± 18.4	11.2 ± 15.0
Timing of NFR in admission		
Days between NFR and admission	13.3 ± 16.1	5.3 ± 10.8
Days NFR before death	6.3 ± 9.9	5.9 ± 8.3
Number of co-morbidities ¶		
0	0	3
1	5 §	22
2	10	15
3	12	14
4	3	7
≥ 5	5	4
Average No. co-morbidities	2.9	2.2

§ OR 0.33, 95% CI 0.11-0.96; p = 0.06; Fishers exact test

¶ p > 0.23 for all other comparisons

§ OR 0.33, 95% CI 0.11-0.96; p = 0.06

Comparisons of proportions conducted using Fisher's exact test

Table 10.3. Aetiology and management of patients receiving MET review

MET criteria triggering call ¶

Hypotension (13), Low SaO₂ (10), High respiratory rate (7), altered GCS (6), arrhythmia (4), abnormal breathing (3), low UO (1), worried criteria only (1)

Presumed cause of deterioration ¶

Pulmonary oedema / cardiogenic shock (14), pneumonia (6), acute coronary syndrome (4), hypovolemia / bleeding (4), primary arrhythmia (4), sepsis not pneumonia (3), exacerbation COAD (2), Respiratory arrest (1), intracranial haemorrhage (1), narcosis (1)

Investigations performed ¶

ECG (11), radiological test (10), Arterial blood gas (8), blood tests (5),

Treatments performed ¶

Increased oxygen therapy (10), Fluid bolus (8), frusemide (7), IV insertion (4), Arterial line (3), IDC (3), NIV (3), Bag-mask ventilation (3), GTN (3), electrolyte replacement (2), vasoactive agent (2), CVC (2), antibiotics (2), amiodarone (1), hydrocortisone (1), Endotracheal intubation (1), acute coronary angioplasty (1).

Outcome from MET ¶

Admitted to ICU (15), classified NFR (9), recommendation for palliation (6), classified "Not for further MET calls" (5).

¶ Patient may satisfy more than one category.

GCS, Glasgow coma score; UO, urine output; ECG, electrocardiogram; IV, intra-venous; CVC, central venous catheter; ICU, intensive care unit; NFR, not for resuscitation.

Chapter 11

MET Syndromes and an Approach to Their Management

Abstract

Introduction: The majority of literature on the Medical emergency team (MET) relates to its effects on patient outcome. Less information exists on the most common causes of MET syndromes or an approach to their management.

Methods: We reviewed the calling criteria and clinical causes of 400 MET calls in the Austin hospital. We propose a set of minimum standards for managing a MET review and developed an approach for managing common problems encountered during MET calls.

Results: The underlying reasons for triggering MET calls were hypoxia (41%), hypotension (28%), altered conscious state (23%), tachycardia (19%), increased respiratory rate (14%) and oliguria (8%). Infections, pulmonary oedema, and arrhythmias featured as prominent causes of all triggers for MET calls. The proposed minimum requirements for managing a MET review included determining the cause of the deterioration, documenting the events surrounding the MET, establishing a medical plan and ongoing medical follow-up, and discussing the case with the intensivist if certain criteria are fulfilled.

A systematic approach to managing episodes of MET review was developed based on the acronym “**A to G**”: **A**sk and **a**ssess; **B**egin **b**asic investigations and resuscitation, **C**all for help if needed, **D**iscuss, **d**ecide, and **d**ocument, **E**xplain aetiology and management, **F**ollow-up, and **G**raciously thank staff. This approach was then adapted to provide a management plan for episodes of tachycardia, hypotension, hypoxia and dyspnoea, reduced urinary output, and altered conscious state.

Conclusion: The approach permits audit and standardization of the management of MET calls and provides an educational framework for the management of acutely unwell ward patients. Further evaluation and validation of the approach is required.

Introduction

Medical Emergency Team systems (METs) have been introduced into hospitals to identify, review, and treat acutely unwell ward patients (Chapter 1). The majority of the literature related to METs has concentrated on their effects in reducing cardiac arrests and serious adverse events [61], primarily in single centre studies. However, a recent Australian multi-center cluster -randomized trial failed to confirm that the introduction of METs into hospitals was able to improve these outcomes [36]. Despite this negative result, substantial interest in the utility of METs has developed both in the United States and the United Kingdom.

Limited information exists regarding the causes and outcomes for episodes of MET reviews. Even less information exists regarding the process of assessment and management undertaken by the MET during an episode of MET review. To our knowledge, no information exists on a systematic approach to managing MET calls. It is likely that a limited number of conditions precipitate MET calls [71] and that a MET syndrome or several MET syndromes exist [61].

In this Chapter, the MET call triggers and clinical cause of 400 MET reviews is presented. In addition, a systematic approach and guidelines for the assessment and management of problems commonly encountered during an episode of MET review is presented.

Methods

The Hospitals

The Northern and Austin Hospitals are both situated in the north of Melbourne and are affiliated with The University of Melbourne. The Northern Hospital provides acute and elective medical services, except cardiac surgery, neurosurgery and organ transplantation. The Austin Hospital provides all acute and elective medical services and is the referral center for liver transplantation and spinal cord injuries for the state of Victoria. The Northern Hospital has a 10 bed ICU that is staffed by an Intensive Care Registrar during the day, and a senior hospital medical officer and anaesthetic registrar over night. The Austin Hospital has a 21 bed ICU that is staffed by Intensive care registrars at all times. In both hospitals the medical staff may have a background in anaesthesia, internal medicine, or emergency medicine.

Ethics approval

Approval for the introduction of the MET and collection of data related to it was obtained from the Hospital Research and Ethics Committee of both hospitals.

Rapid Response Teams

Both hospitals have two levels of RRT. The traditional “Code Blue” call is intended for resuscitation of cardiac arrests and other acute life-threatening emergencies. It consists of an anesthetic registrar, a coronary care registrar and nurse, an ICU registrar and nurse, as well as the Medical registrar of the receiving unit of the day. The medical emergency team is intended to review all medical emergencies other than cardiac arrests, and has been described in detail previously [35, 39, 55] (Chapters 2 and 4). It can be activated by any member of hospital staff according to pre-determined criteria that are based primarily on abnormalities of vital signs and clinical status (Table 11.1).

At the Austin hospital the MET consists of an ICU registrar and nurse, as well as the Medical registrar of the receiving unit of the day. Previously, activation of the MET at the Northern Hospital resulted in notification of only the patient’s parent unit doctors. As part of an ongoing program to improve utilization of the MET at the Northern Hospital, activation of the MET now results in notification of the Medical Registrar and Intensive care registrar or HMO.

Details of MET calls

At both hospitals, a detailed log book is maintained by the hospital switchboard operators that records all medical emergency calls. At the Austin Hospital, case report forms are completed by the ICU Registrar at the end of each call. These forms document the parent unit of the patient as well as the indications for the MET call. Since March 2002, the registrar has also recorded a provisional diagnosis as to what medical condition is thought to have caused the MET call. Details of 400 calls that occurred between April and October 2004 were manually entered into an Excel Spread sheet to provide details on the trigger and presumed aetiology of the call. Data are presented as percentages or absolute number of calls. No assumptions are made in cases where data on presumed diagnosis were missing.

Proposed minimum standards for managing a MET call

The proposed minimum standards were developed following a series of meetings and electronic communications between all authors of the manuscript associated with this chapter [28]. The “**A to G**” approach to managing a MET call was subsequently developed to achieve these minimal standards. Finally, the “**A to G**” approach was adapted to provide a plan for the management of the five most common “MET syndromes”: 1) tachycardia; 2) hypotension; 3) dyspnoea and hypoxia; 4) altered conscious state; 5) oliguria.

Results

Characteristics of 400 MET calls

Of the 400 MET calls, 23 had only “staff worried” criteria. Of the remainder, 248 had one listed physiological MET criteria, 105 had two, 23 had three and one patient had four criteria. The average number of listed MET criteria for the 400 MET calls was 1.3 (531 criteria for 400 calls).

The proportions of MET criteria triggering a call were hypoxia (41%), hypotension (28%), altered conscious state (23%), tachycardia (19%), increased respiratory rate (14%) and oliguria (8%). Of the 531 calling criteria for the 400 MET calls, 61 had no documented provisional diagnosis. A number of common causes for these triggers were identified (Table 11.2). Infections (especially pneumonia; 125/531 criteria), cardiogenic shock or pulmonary oedema (104/531 criteria), and arrhythmias (51/531 criteria) were thought to be responsible for 53% (280/531) of all triggers for MET calls (Table 11.2).

Proposed minimum standards for managing a MET call.

The proposed minimum requirements for managing an episode of a MET review were determining the cause of the deterioration, documenting the events surrounding the MET, establishing a medical plan and ongoing medical follow-up, and discussing the case with the intensivist if pre-defined criteria are fulfilled (Table 11.3). Requirements specific for the Austin Hospital include automatic medical referral for surgical patient subject to a MET call for a medical reason who remains on the ward, and compulsory review of the patient by an Intensivist for a patient requiring two MET reviews in a seven day period.

Approach for the Management of a MET call

An approach to the management of a MET call was developed using the acronym “**A to G**” (Table 11.4). The members of the MET are encouraged to **ask** the nurses the reason for the MET call (i.e. what calling criteria initiated the MET call) and **assess** the patient for the **a**etiology of the deterioration before **b**eginning **b**asic resuscitation. They are also encouraged to **call** for help if needed. After initial resuscitation and assessment the staff are instructed to **d**iscuss the case with appropriate medical staff, **d**ecide where the patient should be managed, and **d**ocument the events surrounding the MET. Issues surrounding the resuscitation status of the patient should also be **d**iscussed if appropriate. Once a management plan is established the members of the MET are encouraged to **e**xplain the cause of the call and subsequent management and **f**ollow-up plan to the medical and nursing staff, the patient and/or their next of kin. The subsequent frequency of monitoring of vital signs is also discussed, as are the criteria for doctor re-notification. Finally, the members of the MET are encouraged to **g**raciously thank staff for their help with the MET call.

In addition to these guidelines, emphasis is placed on three important principles regarding MET call management. **1)** Always be helpful, **2)** Never criticize the staff for making the call, or for the management of the patient; and **3)** Always remain calm and concentrate on the management of the patient.

Management of the “hypoxic / tachypnoeic MET call”

Using the framework of the acronym “**A to G**”, a plan was developed for the management of an episode of MET review initiated for a patient who is hypoxic or tachypnoeic (Table 11.5). Similar plans were developed for the management of the “hypotensive MET call”, the “tachycardic MET call”, the “oliguric MET call”, and finally, the “altered conscious state MET call”.

The aetiology and features of the common causes of the call are listed, as well as an approach to the management of each cause. In addition, criteria for seeking assistance or for notifying the Intensivist are listed.

Discussion

We conducted a study to determine the most common reasons for triggering of 400 MET calls in a teaching hospital. In addition, we proposed minimum standards for the management of a MET call and developed a systematic framework for the assessment, management and referral of the various “MET syndromes” that resulted in these calls.

The majority of the literature related to METs has concentrated on their effects in reducing cardiac arrests and serious adverse events [61], primarily in single centre studies.

Limited information exists on the cause of MET calls and even less information exists on the process of assessment and management undertaken by the MET during an episode of MET review. To our knowledge, no information exists on a systematic approach to the management of such episodes.

Our limited analysis of 400 recent MET calls at the Austin Hospital revealed initial evidence supporting previous opinion that MET calls are likely to be called for a limited number of conditions [71] and that a MET syndrome or several MET syndromes exist [61].

Infections, pulmonary oedema, and arrhythmias featured as prominent causes of the 400 MET calls analyzed. These syndromes have defined aetiologies and treatments.

At least two other studies have assessed the abnormalities leading to the activation of a MET service. In the original description of the MET, Lee and co-workers analyzed the cause of 522 MET calls, 148 of which were cardiac arrests, and 62% of which occurred in the Emergency Department [31]. The most common causes of MET calls in this study were acute respiratory failure, status epilepticus, coma, and severe drug overdose. Kenward and co-workers analysed 136 MET calls over a 12 month period and found that altered conscious state, hypoxia, tachypnea, hypotension and tachycardia were the commonest precipitants [48]. An audit of 80 MET calls at The Northern Hospital in 2001 revealed that alteration in conscious state, hypotension, and noisy breathing were the commonest

precipitants (unpublished data). These findings highlight the need to assess regional variations in the epidemiology of MET calls.

At least two other courses exist that teach junior medical staff to manage acutely unwell hospital patients. The ALERT™ course was developed by staff affiliated with the University of Portsmouth [72]. The course provides an overall plan of assessment as well as approaches to the “blue and breathless patient”, “the patient with a disordered conscious level”, and “the oliguric patient”. The “**A to G**” approach outline in this article provides information regarding the aetiology, management, and guidelines for referral and follow up of patients with these and other syndromes.

The CCrISP course was developed by The Royal College of Surgeons (England) and is a 2 day course aimed at surgical house officers [73]. The “**A to G**” approach outlined in this article is aimed primarily at medical and intensive care registrars and incorporates acute deteriorations of both medical and surgical patients. It emphasizes the need to establish a diagnosis of the aetiology of the call and to establish a management and follow-up plan for the patient. In addition, we have included strategies to facilitate communication between members of the MET and the parent unit of the patient. Finally, we have emphasized the importance of not criticizing ward staff for initiating the call. Fear of criticism has been shown to be an obstacle for activation of MET services [34, 40].

Our study has a number of strengths and limitations. Our approach lends itself to education of the members of the MET and auditing of the MET review process. It is tailored for the team approach of the MET that involves an initial assessment and coordination of ongoing care. The other major strength of the approach is the ability to adapt it to the requirements of different hospitals. First, the “MET syndromes” can be adapted according to the case mix and demographics of the patients at the hospital to reflect the most common criteria and causes for the initiation of a MET call. Second, the details of the management plans can be altered according to local medical opinion and to reflect the level of experience of members of the MET. Third, it is possible to apply more objective and specific criteria for notification of senior members of medical staff (e.g. call intensivist if patient remains hypotensive despite 3 litres of fluid).

The major limitation of the approach is that it has not been validated. We are currently implementing a detailed education program at The Northern Hospital based on these recommendations that aims to improve the documentation and outcome of patients who receive a MET review.

Table 11.1: Calling Criteria for Medical Emergency Teams

- Staff member is worried about the patient
- Airway
 - Noisy breathing / stridor
- Breathing
 - Acute change in respiratory rate to < 8 or > 30 breaths / min
 - Acute change in pulse oximetry saturation to < 90% despite oxygen administration
- Circulation
 - Acute change in heart rate to < 40 or > 130 beats / min
 - Ischemic chest pain ¶
 - Acute change in systolic blood pressure to < 90 mmHg
 - Acute change in urinary output to < 50 mL in 4 hrs.
- Conscious state
 - Acute change in conscious state
 - Multiple seizures ¶

¶ Indicates criteria specific for The Northern Hospital

Table 11.2: Common reasons for MET calls at The Austin Hospital

Cause of the MET call	Number of calls
Hypoxia / Increased respiratory rate	218
Pulmonary oedema / fluid overload	66
Pneumonia / aspiration	52
Exacerbation chronic obstructive airways disease	16
Sepsis	11
Pulmonary embolism	11
Arrhythmia	12
Sputum plug, narcotized, acidemia, pleural effusion, tracheostomy blocked, atelectasis, intracranial event	30
No cause documented	20
Hypotension	112
Sepsis	30
Bleeding / hypovolemia	28
Acute pulmonary oedema / myocardial ischemia	15
Arrhythmia	10
Cardiac arrest	4
Epidural related, Pulmonary embolism, anaphylaxis, vasovagal, Narcosis	13
No cause documented	15
Altered conscious state	93
Sepsis	13
Stroke / Transient ischemic attack or Intracranial bleed	13
Seizure	11
Hypovolemia	8
Cardiogenic shock / acute coronary syndrome	6
Drug related	5
CO ₂ narcosis	5
Vasovagal, arrhythmia, cardiac arrest, encephalopathy, uremia, meningitis	21
No cause documented	12
Tachycardia	77
Arrhythmia	29
Sepsis	13
Acute pulmonary oedema / myocardial ischemia	10
Drug related	4
Hypovolemia	3
Respiratory distress	3
Pulmonary embolism, Epidural related, stroke	3
No cause documented	11
Oliguria	31
Sepsis	7
Cardiogenic shock	7
Hypovolemia	4
Urinary tract obstruction	2
Drug related, hepatorenal syndrome, stroke	5
No cause documented	3

Table 11.3: Proposed minimum criteria for managing a MET call

- Determine the etiology of the deterioration
- Document the events surrounding the MET call
(A pre-formatted fluorescent yellow sticker is used at The Austin Hospital)
- Organize a management plan and appropriate medical follow-up
- Automatic medical referral for surgical patient subject to a MET call for a medical reason in cases where the patient remains on the ward[¶]
- Communicating with the parent unit (or their cover) that the MET has occurred
- Compulsory review of the patient by an Intensivist for a patient requiring two MET reviews in a seven day period[¶]
- Communicating with the intensivist if the following criteria are fulfilled:
 - The patient remains unstable following initial resuscitation
 - The patient requires ICU or HDU admission
 - The patient may require ICU or HDU admission in the future
 - The patient has been admitted to ICU or HDU during this hospital admission
 - The members of the MET are unsure how to manage the patient (i.e. the members of the MET are worried about the patient).

¶ Criteria specific for Austin Hospital.

MET, Medical Emergency Team; ICU, Intensive Care Unit; HDU, High Dependency Unit.

Table 11.4: An approach to managing a MET call

Ask and Assess

- Ask** the staff how you can help them
- Ask** about the reason for the MET call
- Assess** for the etiology of the deterioration

Begin **b**asic investigations and resuscitation therapy

Call for help / **c**all consultant if needed

Discuss, Decide, and Document

- D**iscuss MET with parent unit / consultant
- D**iscuss advanced care planning if appropriated
- D**ecide where the patient needs to be managed
- D**ocument the MET and subsequent frequency of observations

Explain: the cause of the MET, the investigations required and subsequent management plan

Follow-up: which doctor to follow-up the patient? What are the criteria for doctor re-notification?

Graciously thank the staff at the MET

Table 11.5: Management of the “Hypoxic – tachypneic MET call”

Assess for aetiology

- Pulmonary oedema / Cardiac failure (Past history of heart disease. Current evidence of myocardial ischemia, raised JVP, oedema, bilateral crepitations, cardiomegaly)
- Dependent atelectasis/collapse (Patient immobile, basal chest signs, recent surgery)
- Asthma / COAD (Wheeze, prolonged expiration, hyper-inflated chest)
- Sepsis anywhere. eg lung, kidney, wound, intra-abdominal.
- Pulmonary embolism – immobile, recent surgery, history of thrombo-embolism, tachycardia, ECG changes of right ventricular strain

Begin basic investigations and resuscitation

- Administer oxygen and obtain portable CXR
- ECG, Cardiac enzymes, electrolytes
- Sepsis screen: FBE, CRP, blood, urine, sputum, wound.
- Consider ABG +/- lactate
- Pulmonary edema – Loop diuretic, **morphine**, **nitrates**, **oxygen**, **posture**, consider CPAP
- Dependent atelectasis/collapse – chest physiotherapy, humidified oxygen
- Asthma / COAD – bronchodilators, steroids, antibiotics ?BiPAP.
- Pulmonary embolism – V/Q scan or CTPA. Consider anti-coagulation.

Call for help

- $SaO_2 < 90\%$ despite 10L inspired oxygen
- $RR > 40$, elevated $PaCO_2$, altered conscious state

Discuss & Decide

- Is the patient stable or unstable?
- What is the management plan?
- Does the patient need ICU/HDU/surgery?
- Communicate with patient/Next of kin/parent unit/Intensivist
- What is the subsequent follow up plan?

Explain

- Cause of the hypoxia and subsequent management plan.
- Subsequent observations required.

Follow-up

- Who will follow-up the patient?

JVP = jugular venous pressure, COAD = chronic obstructive airways disease, WCC = white cell count, ECG = electrocardiogram, CXR = chest X-ray, ABG = arterial blood gas, FBE = full blood examination, CRP = C-reactive protein, V/Q = ventilation perfusion, CTPA = CT pulmonary angiogram, SaO_2 = saturation oxygen, RR = respiratory rate, $PaCO_2$ = partial pressure of carbon dioxide, ICU = Intensive Care Unit, HDU = High dependency Unit.

Chapter 12

Nurses' Attitudes to a Medical Emergency Team Service in the Austin Hospital

Abstract

Background: Cultural barriers including allegiance to traditional models of ward care and fear of criticism may restrict use of a Medical Emergency Team (MET) service, particularly by nursing staff. A one year preparation and education program was undertaken prior to implementing the MET at the Austin hospital. During the four years after introduction of the MET, education has continued to inform staff of the benefits of MET and to overcome barriers restricting its use.

Objectives: To assess whether nurses value the MET service and to determine if barriers to calling the MET exist in a 400 bed teaching hospital.

Methods: Immediately before ward nursing handover, we conducted a modified personal interview, using a 17- item Likert agreement scale questionnaire.

Results: We created a sample of 351 ward nurses and obtained a 100% response rate. This represents 50.9% of the 689 ward nurses employed at the hospital. Most nurses (91%) felt that the MET prevented arrests and helped manage unwell patients (97%). Few nurses suggested that they restricted MET calls because they feared criticism of their patient care (2%) or criticism that the patient was not sufficiently unwell to need a MET call (10%). Nineteen percent of respondents indicated that MET calls are required because medical management by the doctors has been inadequate; many ascribed this to junior physicians and a lack of knowledge and experience. Despite hospital MET protocol, 72% of nurses suggested they would call the covering doctor before the MET for a sick ward patient. However, 81% indicated they would activate the MET if they were unable to contact the covering doctor. In line with hospital MET protocol, 56% suggested they would make a MET call for a patient they were worried about even if the patient's vital signs were normal. Further, 62% indicated they would call the MET for a patient who fulfilled MET physiological criteria but did not look unwell.

Conclusions: Nurses in the Austin hospital value the MET service and appreciate its potential benefits. The major barrier to calling the MET appears to be allegiance to the traditional approach of initially calling parent medical unit doctors, rather than fear of criticism for calling the MET service. A further barrier seems to be underestimation of the clinical significance of the physiological perturbations associated with the presence of MET call criteria.

Introduction

Medical emergency team (MET) systems have been introduced into hospitals to identify, review and treat acutely unwell ward patients, to potentially reduce serious adverse events and cardiac arrests. Most studies of the MET system focus on its role in reducing cardiac arrests or detecting medical error [61]. A recent cluster randomized prospective controlled trial of the MET system in 23 Australian hospitals failed to demonstrate improved outcome with use of the MET system [36]. However, half of the patients suffering cardiac arrests in this study had prior documented MET criteria, but for unknown reasons, the MET service was not called [36].

At the Austin hospital the majority of MET calls are initiated by nurses [35, 39]. Informal surveys of nursing staff during the introduction of the MET suggested that fear of criticism was an important barrier to calling the MET (unpublished results). Other studies have shown that calling of the MET by nursing and junior medical staff may be hindered by traditional hospital social and cultural barriers [34, 40, 41].

A one-year education and preparation program was undertaken prior to introducing our MET system, and ongoing education continues for all new and existing hospital staff (Chapter 4). To date, the attitudes of staff activating the system are not known. We prospectively proposed that education processes would lead to nurses understanding the key concepts and potential benefits of the MET service. We also proposed that barriers to activation of the MET system may still exist, particularly fear of being criticised for making a MET call, adherence to previous models of care for unwell patients, and allegiance to the traditional medical hierarchy. To test these hypotheses, we conducted a questionnaire of ward nursing staff in the Austin.

Methods

Ethics approval

Prospective approval was obtained from the hospital Human Research Ethics Committee for the survey to be conducted.

The hospital and RRS

The details of the Austin hospital, the services it provides, and its Rapid Response System have been described elsewhere [35, 39, 55](Chapters 2 and 4).

Education process (See also Chapter 4)

A one-year program of preparation and education was provided to all hospital staff prior to implementing the MET service. After obtaining support from medical and nursing administration, we conducted a series of presentations at medical and surgical grand rounds, as well as smaller group presentations for ward nursing and medical staff. In the four years following the introduction of the MET, all new and existing employees of the hospital have received regular education regarding the theory behind the MET system, the criteria for making a MET call, and changes to MET protocol. As part of this education, we emphasize that it is hospital policy that no member of staff should be criticised for initiating a MET call.

Details of survey process

We used an anonymous Likert-type agreement questionnaire to survey the nursing staff. The principles behind the designs and execution of the survey are those of a group administered survey as outlined elsewhere [74-76].

Survey objectives and prospectively defined research questions

The survey was undertaken to assess whether the nurses understand the theory behind the MET and to assess obstacles to its use. Specifically, we wished to assess: **1.** If nurses understand the potential benefits of the MET system. **2.** If nurses find the MET service useful in managing unwell ward patients. **3.** Whether obstacles exist that restrict nurses from using the MET service. **4.** What patient and system factors nurses think result in patients needing MET calls. **5.** Under what conditions nurses make / do not make a MET call **6.** If nurses believe that the MET reduces their ability to manage acutely unwell patients.

Target population

We obtained a list of nurses' names for the general and specialty medical and surgical wards where the MET service operates from nursing administration. This was converted into a MS Excel™ spreadsheet and itemised according to ward. Respondents' names were checked-off to prevent multiple questionnaire completion by the same respondent.

Developing the questionnaire

The initial questionnaire contained 15 items with a closed format response that utilized a Likert-type agreement scale. The questions were designed to be uni-dimensional (only ask one question at a time) and to address the six study questions outlined above. The items were revised on three occasions prior to pre-testing. Space was left to permit additional comments (text open-ended format) and to record the level of experience of the nurse (closed multiple-choice format).

Pre-testing of the survey

The survey was piloted to predict the emotional responses, comprehension and interpretation of items by the target population [74] using a focus group with different levels of nursing experience that was nominated by nurse unit managers on target wards. Moderation and feedback were conducted by the principal investigators and all members of the focus group participated. Following pre-testing, poorly worded items were modified and two items added. The focus group also suggested that the best time to administer the survey was at the start of nursing handover.

Sample frame construction, recruitment and survey administration

The target population for the survey was every ward nurse employed during the period of the administration of the survey. From this population a sample frame was constructed by visiting wards and approaching nurses working on morning, evening, and night duty. The nurse unit manager on each ward was notified of the planned times for survey administration. Nurses were approached to complete the survey during the first 10 minutes of nursing handover. Three interviewers used a pre-rehearsed verbal introduction to limit interviewer bias. The sample frame surveyed thus comprised the nurses that were available on the chosen shift. Each nurse completed the questionnaire (Table 12.1) in the presence of the interviewer but without communication with the interviewer or other nurses of their ward. We documented the characteristics of the sample frame by recording the proportion of nurses on each ward that were approached

to complete the survey. In addition, we documented the response rate by recording the proportion of nurses approached who completed the survey. The survey was conducted in May and June 2005.

Data management and analysis

The completed questionnaires were entered manually into a MS Excel™ spreadsheet and double-checked by a second investigator. No assumptions were made about missing fields, which were omitted from analysis. Responses are presented as a percentage of the overall responses for each field.

Analysis of additional comments

Additional comments were assessed before grouping them into several themes. Each theme was summarised by paraphrasing one or more of the respondents' comments. The number of comments in each category was subsequently collated.

Results

Details of Pre-testing

The focus group of 12 nursing staff included three associated nurse unit managers, four clinical nurse specialists, four division one nurses of less than four years experience, and one division two nurse. Spacing between items was increased and the wording of 10 of the 15 items was altered. Two items (16 and 17) were added (Table 12.1) in response to feedback from the focus group.

Characteristics of the sample frame

At the time of survey administration there were 689 ward nurses employed at the hospital. A total of 351 nurses completed questionnaires from day, evening and night shifts. Thus, we were able to survey approximately 50% of the overall accessible target population. The proportion of nurses approached to complete the questionnaire varied between wards from 35% to 65% (Table 11.2). Every nurse approached to undertake the survey completed the questionnaire (response rate 100%).

Ninety seven percent of the completed questionnaires contained the nurse's level of experience. Of these, 20% were graduate nurses, 40% were division one nurses of 2-9 years experience, 11% were clinical nurse specialists, 13% were associated nurse unit managers, 2% were nurse unit managers, and 14% were division two nurses.

Characteristics of questionnaire item responses

There were only 33 missing responses in the 5967 (351 surveys each with 17 items) responses. More than 96% of respondents agreed or strongly agreed that patients in the Austin Hospital have complex medical problems (Table 12.1, item 1).

Potential benefits of the MET

For questions about nurses' understanding of potential benefits of the MET, more than 91% of respondents agreed or strongly agreed that the MET prevents unwell patients from having an arrest (Table 12.1, item 2), and almost 93% agreed or strongly agreed that the MET can be used to prevent a minor problem becoming a major problem (Table 12.1, item 15).

Usefulness of the MET for nursing staff

For questions about whether nurses find the MET service helpful in managing unwell ward patients, more than 97% of respondents agreed or strongly agreed that the MET allowed them to seek help in managing a patient they are worried about (Table 12.1, item 3). Eighty eight percent disagreed or strongly disagreed when asked if they thought that the MET is not helpful in managing sick patients on the ward (Table 12.1, item 4). More than 86% disagreed or strongly disagreed when asked if they thought that the MET was over used in the management of hospital patients (Table 12.1, item 11).

Obstacles to the nurse using the MET service

When asked if they were reluctant to call a MET call on a patient for fear of criticism if they were not that unwell, more than 81% of respondents disagreed or strongly disagreed, while 10% agreed or strongly agreed (Table 12.1, item 7). More than 95% of respondents disagreed or strongly disagreed when questioned if they do not like calling MET calls because they will be criticised for not looking after their patient well enough (Table 1, item 12). More than 84% disagreed or strongly disagreed that using the MET system increases their workload when caring for sick patients (Table 12.1, item 14).

Why do the nurses think MET calls are required for ward patients?

Few (7%) agreed or strongly agreed that MET calls were required because the management of the patient by the nurse had been inadequate (Table 12.1, item 9). In contrast, when asked whether MET calls were required because the management of the patient by the doctor had been inadequate, 64% disagreed or strongly disagreed, with 19.1% agreeing or strongly agreeing with this statement (Table 12.1, item 8).

Under what conditions do nurses make / not make a MET call?

Seventy two percent of respondents agreed or strongly agreed that they would call the covering doctor before the MET when one of their patients was sick (Table 12.1, item 5). More than 81% agreed or strongly agreed that they would call the MET if they could not contact the covering doctor about a sick patient (Table 12.1, item 6). Only 55.9% of respondents agreed or strongly agreed that they would call a MET call on a patient they were worried about even if their vital signs were normal (Table 12.1, item 10). When asked if they would not make a MET call on a patient that fulfilled MET criteria but did not look unwell 61.6% of respondents disagreed or strongly disagreed, 22.6% stated they were uncertain, and 15.8% agreed or strongly agreed (Table 1, item 16).

Impact of the MET on nurses' ability to manage unwell patients

Almost 95% of respondents disagreed or strongly disagreed when asked whether they thought the MET reduced their skill in managing sick patients (Table 12.1, item 13). In fact, almost 71% agreed or strongly agreed that the MET teaches them how to better manage sick patient in their ward (Table 12.1, item 17).

Additional comments

Additional comments were made on 143 of the 351 (40.7%) of completed questionnaires. A total of 255 comments were made regarding various aspects of the MET service. These were grouped into several themes (Table 12.3). Fifty-two respondents stated that the MET service provided backup and support for doctors and nurses in the management of sick ward patients. Twenty- three respondents made reference to item 9 of the questionnaire. All stated that MET calls are "sometimes" required because the management by the doctors has been inadequate. All such comments provided further qualifications such as "especially new interns" or "due to lack knowledge and experience".

Ninety-five of the 255 additional comments (37.3%) suggested that the decision to initiate a MET call in response to the scenarios presented in four of the items (item 5, 6, 10, 16) would depend on how sick the patient was.

Four comments suggested that item 5 was poorly worded, with two suggesting that the word "sick" was either "not specific" or should have been replaced by the term "acutely unwell".

Discussion

We conducted a survey on the nurses' attitudes to the MET system four years after its introduction to the Austin hospital. We found that the majority of nurses surveyed understood the potential benefits of the MET, valued its presence and did not believe that using the MET increased their workload or reduced their skills in managing sick patients. However, despite hospital protocol, we found evidence to suggest that nurses use clinical judgement and discretion and not just the pre-defined MET criteria, when choosing whether to activate the MET service.

A one-year education phase was undertaken prior to implementing the MET system in the Austin hospital. In addition, education sessions are provided for all new and existing staff employed by the hospital [55] (Chapter 4). This approach appears to have been successful in instilling knowledge of the theoretical benefits of the MET service into our nursing staff.

We found that the majority of respondents indicated that they value the MET service, that the MET was useful in the management of ward patients, and that they believed the MET was not overused in the management of hospital patients. Despite this, almost three-quarters of nurses suggested that they would call the covering doctor before calling the MET when a patient in their ward was sick. However, a similar proportion suggested they would call the MET if they were unable to contact the covering doctor. These findings are consistent with at least two other studies suggesting that use of a MET service may be impeded by cultural barriers in the staff of the hospital [34, 40, 41].

Specifically, it has been suggested that some medical and nursing staff are reluctant to breach the "traditional" hierarchical system of patient management that usually involves notification of the most junior member of medical staff first [34, 40, 41]. The observation that our nurses call the covering doctors prior to the MET service may also have implications for the findings of the MERIT study [36]. In particular, it was observed that 50% of the patients suffering cardiac arrests in the MET-hospitals had antecedent MET criteria but did not receive a MET review [36].

The inclination of nurses to call covering doctors before the MET would not appear to result from fear of criticism. The majority of nurses surveyed suggested they did not limit initiating MET calls because of fear of criticism regarding their management of the patient, and only 10% agreed or strongly agreed that they feared criticism for initiating a

MET call on a patient that was not very unwell. Thus our study suggests that there is a disparity between nurses' belief of the benefits of the MET, and their expressed intent to call the MET service in the presence of MET call criteria.

Our findings suggest that nurses at the Austin use clinical judgement and discretion in addition to, or instead of, the objective pre-defined criteria for MET activation. In a previous study at the Austin [35, 39] the "staff member worried" criterion was the most common indication for initiating a MET call. Despite this, only half of respondents agreed or strongly agreed that they would initiate a MET call on a patient they were worried about even if their vital signs were normal. Further, only three out of five disagreed or strongly disagreed when asked if they would not make a MET call on a patient that fulfilled MET criteria but did not look unwell.

Further evidence that our nurses use discretion when deciding to make a MET call comes from the additional comments. More than one third of the 255 additional comments suggested that the decision to initiate a MET call in response to the scenarios presented in four of the items (items 5, 6, 10, 16) would depend on how sick the nurse thought the patient was.

Any future strategy to overcome to apparent reluctance of ward nurses to call the MET will need to strike a balance between three important issues. First the MET should ideally be used to review patients in cases where the patient is very unwell, and in instances where the covering physicians are unavailable. Second, the ICU must be seen to be collegial and cooperative, and not to take over the management of ward patients from the attending doctors. Finally, increases in the use of the MET must take into account resource limitations of the ICU.

Our study has several strengths and limitations. It is the first to formally assess the attitudes of nursing staff to the MET system. The questionnaire was developed to address prospectively defined questions and was pre-tested and revised prior to implementation. The survey was administered to a large sample frame that is likely to be representative of the accessible target population. Using a personal interview approach at a time when it was convenient for the respondents to participate (at the start of nursing handover), we obtained a response rate of 100% thereby eliminating contamination of results by non-responder bias. The interviewers introduced the survey in a prescribed manner to limit interviewer bias.

The two possible sources of bias that could have affected the validity and generalizability of our survey findings to the target population are population sample bias and bias resulting from poorly worded items. The target population was derived from a list supplied by nursing administration. However, the dynamic nature of the nursing workforce (staff changing wards, staff joining nurse bank, staff on leave) meant we were unable to guarantee the exact number of nurses working on each ward at the time of the study. Sampling from the target population was done on the basis of respondent presence on the day of interviewing. The use of a random number generator may have improved randomisation of the sample. We are unable to comment on difference between those nurses that were approached to complete the questionnaire, and those who were not. Despite these limitations, we have shown that the sample frame contained representatives from all target wards and that the participants had variable levels of nursing experience. In addition, we were able to sample approximately 50% of the accessible target population and obtain a response rate of 100%. Accordingly, we believe that the responses obtained to our questionnaire are likely to be representative of those of the wider population of nurses in the Austin hospital.

Despite pre-testing, we found evidence that at least 4 respondents had difficulty with interpreting the word “sick” in item 5. Alternate wording of this item may have altered responses. However, the remaining 46 comments regarding this item suggested that their response was conditional upon how sick the patient was and did not make reference to the wording of the item *per se*.

A further limitation is that the survey represents the opinions of nurses at only a single centre. It would be of interest to learn the attitudes of nurses at other institutions that possess a MET service. At least two studies [34, 41] have reported that uptake of the MET service was hindered because of a reluctance of nurses to call the MET.

Conclusions

In the Austin, a detailed information and education program was associated with an understanding of the potential benefits of the MET service by our nursing staff. In addition, nurses appeared to value the service and did not believe that it reduced their skills or increased their workload when managing acutely unwell ward patients. Despite these positive impressions, there appears to be a persistent commitment to the traditional model of calling a junior covering doctor before the MET service. Our findings also suggest that underestimation of the significance of physiological perturbations is likely to be a greater barrier than fear of criticism for making a MET call in the Austin.

Table 12.1: Responses to "Survey of nurses attitudes to the MET"[¶]

	Strongly Disagree	Disagree	Uncertain	Agree	Strongly agree
1. Patients in the hospital have complex medical problems (n=347)	0.3	2.0	1.4	34.9	61.4
2. The MET prevents unwell patients from having an arrests (n=350)	0.6	4.6	3.7	38.0	53.1
3. The MET allows me to seek help for my patients when I am worried about them (n=349)	0	0.9	1.7	28.7	68.8
4. The MET is not helpful in managing sick patients on the ward (n=350)	49.1	38.9	4.6	4.6	2.9
5. When one of my patients is sick I call the covering doctor before calling a MET (n=343)	1.7	9.0	17.2	58.0	14.0
6. If I can not contact the covering doctor about my sick patient I call a MET call (n=345)	1.7	6.4	10.7	47.8	33.3
7. I am reluctant to call a MET call on my patients because I will be criticized if they are not that unwell (n=350)	35.4	46.3	8.3	8.0	2.0
8. MET calls are required because the management of the patient by the doctors has been inadequate (n=350)	16.6	48.0	16.3	15.4	3.7
9. MET calls are required because the management of the patient by the nurses has been inadequate (n=351)	38.2	48.7	6.6	4.8	1.7
10. I would call a MET call on a patient I am worried about even if their vitals signs are normal (n=351)	1.1	19.4	23.6	41.9	14.0
11. I think that the MET is over used in the management of hospital patients (n=350)	43.4	42.9	9.7	2.9	1.1
12. I don't like calling MET calls because I will be criticized for not looking after my patient well enough (n=350)	51.4	44.0	3.1	0.9	0.6
13. MET calls reduce my skills in managing sick patients (n=351)	51.0	43.6	3.4	0.9	1.1
14. Using the MET system increases my work load when caring for a sick patient (n=351)	39.9	44.4	6.6	8.3	0.9
15. The MET can be used to prevent a minor problem becoming a major problem (n=347)	1.4	2.6	3.2	37.5	55.3
16. If my patient fulfills listed MET criteria but does not look unwell I would not make a MET call (n=349)	22.1	39.5	22.6	13.8	2.0
17. MET calls teach me how to better manage sick patients in my ward (n=350)	2.9	12.0	14.3	53.7	17.1

¶ Numbers within columns indicate the % of overall responses for each option in the Likert agreement scale. (n) indicates the number of 351 respondents that completed each question.

Table 12.2: Proportion of nurses approached to complete survey according to ward or unit

Ward / Unit	Surveyed	Not surveyed	% surveyed
Long term respiratory medicine	18	10	64.3
Spinal cord medicine	26	21	55.3
General Medicine	79	44	64.2
Nephrology	19	15	55.9
Oncology	26	35	42.6
Neurosurgery	29	20	59.2
Neurology	26	23	53.1
General surgery and urology	39	72	35.1
Orthopedic surgery	20	17	54.1
Respiratory medicine	19	21	47.5
Cardiothoracic medicine	32	23	58.2
Nursing pool / bank	18	37	32.7
total	351	338	50.9

Table 12.3: Categorization of additional comments

Category	Number of comments
It is reassuring to have the MET as backup when managing sick patients	52
The MET improves outcome or prevents deterioration	28
MET calls are required because of doctor inexperience or poor management	23
I have been criticized or fear criticism for making a MET call	14
The MET teaches me how to manage sick patients	10
MET calls are required because of poor nursing management	8
I have not been involved in a MET call	7
The MET staff are friendly, patient, and approachable	7
The MET helps establish a management plan for unwell patients	6
I would consult others (Registrar other nurse) before making a MET call	5
Decision to make a MET call depends on how sick the patient is	
Item 5	46
Item 6	25
Item 10	6
Item 16	14
Item 5 poorly worded	4

References:

1. Zajac, J.D., *The public hospital of the future*. Med J Aust, 2003. **179**(5): p. 250-2.
2. Schimmel, E., *The hazards of hospitalization*. Annals of Internal Medicine 1964. **60**: p. 100-110.
3. Brennan, T.A., et al., *Identification of adverse events occurring during hospitalization. A cross-sectional study of litigation, quality assurance, and medical records at two teaching hospitals*. Ann Intern Med, 1990. **112**(3): p. 221-6.
4. Leape, L.L., et al., *The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II*. N Engl J Med, 1991. **324**(6): p. 377-84.
5. Thomas, E.J., et al., *Incidence and types of adverse events and negligent care in Utah and Colorado*. Med Care, 2000. **38**(3): p. 261-71.
6. Andrews, L.B., et al., *An alternative strategy for studying adverse events in medical care*. Lancet, 1997. **349**(9048): p. 309-13.
7. Wilson, R.M., et al., *The Quality in Australian Health Care Study*. Med J Aust, 1995. **163**(9): p. 458-71.
8. Davis, P., et al., *Adverse events in New Zealand public hospitals I: occurrence and impact*. N Z Med J, 2002. **115**(1167): p. U271.
9. Davis, P., et al., *Adverse events in New Zealand public hospitals II: preventability and clinical context*. N Z Med J, 2003. **116**(1183): p. U624.
10. Vincent, C., G. Neale, and M. Woloshynowych, *Adverse events in British hospitals: preliminary retrospective record review*. Bmj, 2001. **322**(7285): p. 517-9.
11. Baker, G.R., et al., *The Canadian Adverse Events Study: the incidence of adverse events among hospital patients in Canada*. Cmaj, 2004. **170**(11): p. 1678-86.
12. Bellomo, R., et al., *Postoperative serious adverse events in a teaching hospital: a prospective study*. Med J Aust, 2002. **176**(5): p. 216-8.
13. Bedell, S.E., et al., *Incidence and characteristics of preventable iatrogenic cardiac arrests*. Jama, 1991. **265**(21): p. 2815-20.
14. Hodgetts, T.J., et al., *Incidence, location and reasons for avoidable in-hospital cardiac arrest in a district general hospital*. Resuscitation, 2002. **54**(2): p. 115-23.
15. McQuillan, P., et al., *Confidential inquiry into quality of care before admission to intensive care*. Bmj, 1998. **316**(7148): p. 1853-8.
16. Hayward, R.A. and T.P. Hofer, *Estimating hospital deaths due to medical errors: preventability is in the eye of the reviewer*. Jama, 2001. **286**(4): p. 415-20.
17. Schein, R.M., et al., *Clinical antecedents to in-hospital cardiopulmonary arrest*. Chest, 1990. **98**(6): p. 1388-92.
18. Hodgetts, T.J., et al., *The identification of risk factors for cardiac arrest and formulation of activation criteria to alert a medical emergency team*. Resuscitation, 2002. **54**(2): p. 125-31.
19. Buist, M.D., et al., *Recognising clinical instability in hospital patients before cardiac arrest or unplanned admission to intensive care. A pilot study in a tertiary-care hospital*. Med J Aust, 1999. **171**(1): p. 22-5.
20. Nurmi, J., et al., *Observations and warning signs prior to cardiac arrest. Should a medical emergency team intervene earlier?* Acta Anaesthesiol Scand, 2005. **49**(5): p. 702-6.
21. Goldhill, D.R., S.A. White, and A. Sumner, *Physiological values and procedures in the 24 h before ICU admission from the ward*. Anaesthesia, 1999. **54**(6): p. 529-34.
22. Goldhill, D.R. and A.F. McNarry, *Physiological abnormalities in early warning scores are related to mortality in adult inpatients*. Br J Anaesth, 2004. **92**(6): p. 882-4.
23. Bell, M.B., et al., *Prevalence and sensitivity of MET-criteria in a Scandinavian University Hospital*. Resuscitation, 2006. **70**(1): p. 66-73.

24. Buist, M., et al., *Association between clinically abnormal observations and subsequent in-hospital mortality: a prospective study*. Resuscitation, 2004. **62**(2): p. 137-41.
25. Nardi, G., et al., *[Impact of an integrated treatment approach of the severely injured patients (ISS => 16) on hospital mortality and quality of care]*. Minerva Anesthesiol, 2002. **68**(1-2): p. 25-35.
26. Fresco, C., et al., *Very early assessment of risk for in-hospital death among 11,483 patients with acute myocardial infarction*. GISSI investigators. Am Heart J, 1999. **138**(6 Pt 1): p. 1058-64.
27. Rivers, E., et al., *Early goal-directed therapy in the treatment of severe sepsis and septic shock*. N Engl J Med, 2001. **345**(19): p. 1368-77.
28. Jones, D., et al., *Medical emergency team syndromes and an approach to their management*. Crit Care, 2006. **10**(1): p. R30.
29. Devita, M.A., et al., *Findings of the first consensus conference on medical emergency teams*. Crit Care Med, 2006. **34**(9): p. 2463-78.
30. Aneman, A. and M. Parr, *Medical emergency teams: a role for expanding intensive care?* Acta Anaesthesiol Scand, 2006. **50**(10): p. 1255-65.
31. Lee, A., et al., *The Medical Emergency Team*. Anaesth Intensive Care, 1995. **23**(2): p. 183-6.
32. Daly, F.F., K.L. Sidney, and D.M. Fatovich, *The Medical Emergency Team (MET): a model for the district general hospital*. Aust N Z J Med, 1998. **28**(6): p. 795-8.
33. Bristow, P.J., et al., *Rates of in-hospital arrests, deaths and intensive care admissions: the effect of a medical emergency team*. Med J Aust, 2000. **173**(5): p. 236-40.
34. Buist, M.D., et al., *Effects of a medical emergency team on reduction of incidence of and mortality from unexpected cardiac arrests in hospital: preliminary study*. Bmj, 2002. **324**(7334): p. 387-90.
35. Bellomo, R., et al., *A prospective before-and-after trial of a medical emergency team*. Med J Aust, 2003. **179**(6): p. 283-7.
36. Hillman, K., et al., *Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial*. Lancet, 2005. **365**(9477): p. 2091-7.
37. *The "MERIT" Trial of Medical Emergency Teams in Australia: An Analysis of Findings and Implications for the 100,000 Lives Campaign*. [cited 2007 28th January].
38. Piquette, D. and R.A. Fowler, *Do medical emergency teams improve the outcomes of in-hospital patients?* Cmaj, 2005. **173**(6): p. 599-600.
39. Bellomo, R., et al., *Prospective controlled trial of effect of medical emergency team on postoperative morbidity and mortality rates*. Crit Care Med, 2004. **32**(4): p. 916-21.
40. DeVita, M.A., et al., *Use of medical emergency team responses to reduce hospital cardiopulmonary arrests*. Qual Saf Health Care, 2004. **13**(4): p. 251-4.
41. Foraida, M.I., et al., *Improving the utilization of medical crisis teams (Condition C) at an urban tertiary care hospital*. J Crit Care, 2003. **18**(2): p. 87-94.
42. McGlynn, E.A., et al., *The quality of health care delivered to adults in the United States*. N Engl J Med, 2003. **348**(26): p. 2635-45.
43. Brennan, T.A. and L.L. Leape, *Adverse events, negligence in hospitalized patients: results from the Harvard Medical Practice Study*. Perspect Healthc Risk Manage, 1991. **11**(2): p. 2-8.
44. Kause, J., et al., *A comparison of antecedents to cardiac arrests, deaths and emergency intensive care admissions in Australia and New Zealand, and the United Kingdom--the ACADEMIA study*. Resuscitation, 2004. **62**(3): p. 275-82.
45. Franklin, C. and J. Mathew, *Developing strategies to prevent inhospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event*. Crit Care Med, 1994. **22**(2): p. 244-7.

46. *Protecting 5 Million Lives from harm: Establish a Rapid Response Team.* [cited 2007 16th January]; Available from: <http://www.ihl.org/IHI/Topics/CriticalCare/IntensiveCare/Changes/EstablishaRapidResponseTeam.htm>.
47. Hillman, K., et al., *Redefining in-hospital resuscitation: the concept of the medical emergency team.* Resuscitation, 2001. **48**(2): p. 105-10.
48. Kenward, G., et al., *Evaluation of a medical emergency team one year after implementation.* Resuscitation, 2004. **61**(3): p. 257-63.
49. Nardi, G., et al., *Impact of an integrated treatment approach of the severely injured patients on hospital mortality and quality of care.* Minerva Anesthesiol, 2002. **68**(1-2): p. 25-35.
50. Jurkovich, G.J., *Strengthening of the case for organised trauma-care systems.* Lancet, 2000. **355**(9217): p. 1740-1.
51. Grol, R. and M. Wensing, *What drives change? Barriers to and incentives for achieving evidence-based practice.* Med J Aust, 2004. **180**(6 Suppl): p. S57-60.
52. McGrath, R.B., *In-house cardiopulmonary resuscitation--after a quarter of a century.* Ann Emerg Med, 1987. **16**(12): p. 1365-8.
53. Firth-Cozens, J., *Evaluating the culture of safety.* Qual Saf Health Care, 2003. **12**(6): p. 401.
54. *Advances in Patient Safety: From Research to Implementation.* . 2006 [cited 2007 28th January].
55. Jones, D., et al., *Effect of an education programme on the utilization of a medical emergency team in a teaching hospital.* Intern Med J, 2006. **36**(4): p. 231-6.
56. Jones, D., et al., *Long term effect of a medical emergency team on cardiac arrests in a teaching hospital.* Crit Care, 2005. **9**(6): p. R808-15.
57. Jones, D., et al., *Circadian pattern of activation of the medical emergency team in a teaching hospital.* Crit Care, 2005. **9**(4): p. R303-6.
58. Arntz, H.R., et al., *Diurnal, weekly and seasonal variation of sudden death. Population-based analysis of 24,061 consecutive cases.* Eur Heart J, 2000. **21**(4): p. 315-20.
59. Soo, L.H., et al., *Circadian variation in witnessed out of hospital cardiac arrest.* Heart, 2000. **84**(4): p. 370-6.
60. Buff, D.D., et al., *Circadian distribution of in-hospital cardiopulmonary arrests on the general medical ward.* Arch Intern Med, 1992. **152**(6): p. 1282-8.
61. DeVita, M., *Medical emergency teams: deciphering clues to crises in hospitals.* Crit Care, 2005. **9**(4): p. 325-6.
62. Dumot, J.A., et al., *Outcome of adult cardiopulmonary resuscitations at a tertiary referral center including results of "limited" resuscitations.* Arch Intern Med, 2001. **161**(14): p. 1751-8.
63. Herlitz, J., et al., *Characteristics and outcome among patients having out of hospital cardiac arrest at home compared with elsewhere.* Heart, 2002. **88**(6): p. 579-82.
64. Hillman, K., *The changing role of acute-care hospitals.* Med J Aust, 1999. **170**(7): p. 325-8.
65. Ball, C., M. Kirkby, and S. Williams, *Effect of the critical care outreach team on patient survival to discharge from hospital and readmission to critical care: non-randomised population based study.* Bmj, 2003. **327**(7422): p. 1014.
66. Garcea, G., et al., *Impact of a critical care outreach team on critical care readmissions and mortality.* Acta Anaesthesiol Scand, 2004. **48**(9): p. 1096-100.
67. Goldhill, D.R., et al., *The patient-at-risk team: identifying and managing seriously ill ward patients.* Anaesthesia, 1999. **54**(9): p. 853-60.
68. Pittard, A.J., *Out of our reach? Assessing the impact of introducing a critical care outreach service.* Anaesthesia, 2003. **58**(9): p. 882-5.

69. Priestley, G., et al., *Introducing Critical Care Outreach: a ward-randomised trial of phased introduction in a general hospital*. Intensive Care Med, 2004. **30**(7): p. 1398-404.
70. Parr, M.J., et al., *The Medical Emergency Team: 12 month analysis of reasons for activation, immediate outcome and not-for-resuscitation orders*. Resuscitation, 2001. **50**(1): p. 39-44.
71. Runciman, W.B., et al., *A classification for incidents and accidents in the health-care system*. J Qual Clin Pract, 1998. **18**(3): p. 199-211.
72. Smith, G.B., V.M. Osgood, and S. Crane, *ALERT--a multiprofessional training course in the care of the acutely ill adult patient*. Resuscitation, 2002. **52**(3): p. 281-6.
73. Subbe, C.P., et al., *Does earlier detection of critically ill patients on surgical wards lead to better outcomes?* Ann R Coll Surg Engl, 2005. **87**(4): p. 226-32.
74. Boynton, P.M., *Administering, analysing, and reporting your questionnaire*. Bmj, 2004. **328**(7452): p. 1372-5.
75. Boynton, P.M. and T. Greenhalgh, *Selecting, designing, and developing your questionnaire*. Bmj, 2004. **328**(7451): p. 1312-5.
76. Jones, D., et al., *An introductory guide to survey research in anaesthesia*. Anaesth Intensive Care, 2006. **34**(2): p. 245-53.



Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:

JONES, DARYL

Title:

The role of a Medical Emergency Team in a teaching hospital

Date:

2009

Citation:

Jones, D. (2009). The role of a Medical Emergency Team in a teaching hospital. Doctorate, Faculty of Medicine, Dentistry & Health Sciences, Surgery - Austin Health and Northern Health, The University of Melbourne.

Publication Status:

Unpublished

Persistent Link:

<http://hdl.handle.net/11343/35176>

Terms and Conditions:

Terms and Conditions: Copyright in works deposited in Minerva Access is retained by the copyright owner. The work may not be altered without permission from the copyright owner. Readers may only download, print and save electronic copies of whole works for their own personal non-commercial use. Any use that exceeds these limits requires permission from the copyright owner. Attribution is essential when quoting or paraphrasing from these works.