

Physiological antecedents and ward clinician responses before medical emergency team activation

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Studies conducted between 1990 and 2002 have suggested that serious in-hospital adverse events, such as cardiopulmonary arrest, unplanned intensive care unit admission and sudden death, are commonly preceded by physiological abnormalities.¹⁻⁷ A substantial proportion of these events may therefore be predictable and potentially preventable.⁸ Medical emergency teams (METs) were introduced to prevent adverse events by facilitating the early recognition and management of ward patients whose condition was deteriorating.⁸ However, multicentre research now shows that patients who receive an MET review have an in-hospital mortality as high as 34%,⁹⁻¹² at least three times that of critically ill patients in ICUs.^{12,13} These data suggest that METs may be identifying patients at a late, potentially irremediable stage of deterioration and, therefore, earlier recognition and management is required to improve patient survival.⁴

Patients who have abnormal vital signs, even signs that are not considered deranged enough to breach MET activation criteria, are at a high risk of death.^{6,14-18} The Australian Commission on Safety and Quality in Health Care (ACSQHC) has promoted a system that identifies clinical deterioration in the period before MET activation.¹⁹ At our hospital, the pre-MET escalation system is termed urgent clinical review (UCR). Although the prevalence of patients fulfilling pre-MET escalation system criteria²⁰ and the effectiveness of one pre-MET escalation system²¹ have been reported, there is little understanding of the relationship between the trajectory of early clinical deterioration and subsequent MET activation.

We undertook a retrospective audit of 200 randomly selected MET activations to examine for prior evidence of clinical instability, and collected data for the proportion of MET activations preceded by UCR criteria and how long such criteria had been present. We also assessed the frequency and characteristics of UCR criteria breaches. Finally, we examined the escalation-of-care responses by ward clinicians (ward nurses and doctors), including the frequency of documented UCR system activation and medical review.

Methods

Design and setting

We used a retrospective, descriptive, exploratory design. Ethics approval was granted by the Human Research Ethics Committees at the study site (LNR/15/Austin/67) and Deakin University (2015-065).

ABSTRACT

Objectives: To investigate the frequency, characteristics and timing of objectively measured clinical instability in adult ward patients in the 24 hours preceding activation of the medical emergency team (MET). We also examined ward clinician responses to documented clinical instability.

Design, setting and participants: A descriptive, exploratory design with a retrospective medical record audit. We descriptively analysed data from 200 ward patients reviewed by the MET at a tertiary teaching hospital in Melbourne, Australia, during 2014.

Main outcome measures: Frequency and characteristics of urgent clinical review (UCR) criteria breaches in the 24 hours preceding MET activation, and in-hospital mortality.

Results: Overall, 78.5% of patients breached UCR criteria at least once in the 24 hours preceding MET activation, with 80.9% having multiple breaches. The most common causes of UCR criteria breaches were hypoxaemia without supplemental oxygen (27.4%, $n = 43$) and hypoxaemia with supplemental oxygen (21.7%, $n = 34$) for first UCR criteria breaches, and tachycardia (33.1%, $n = 42$) for last UCR criteria breaches during the 24 hours we examined. The median time before MET activation for first and last breaches was 17.1 hours and 1.2 hours, respectively. Examination of the clinician documentation suggested a high incidence of pre-MET activation afferent limb failure. In-hospital mortality was 12%.

Conclusions: Patients commonly and repeatedly breached objectively measured UCR criteria in the 24 hours preceding MET activation, providing numerous opportunities for clinicians to recognise and respond to early clinical deterioration. The high incidence of pre-MET afferent limb failure requires further exploration.

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We conducted our study at a 560-bed acute care, tertiary teaching hospital in Melbourne, Australia. The study site had a three-tier rapid response system (RRS), comprising the cardiac arrest team (Respond Blue), the MET and the UCR system. The MET was first implemented in 2000 and details of its design and implementation are published elsewhere.²² MET activation criteria are shown in Table 1.

Table 1. Medical emergency team and urgent clinical review criteria^{23,24}

Category of concern	Criteria for medical emergency team	Criteria for urgent clinical review
Airway, breathing	Obstructed airway Noisy breathing or stridor Problem with a tracheostomy tube Any difficulty breathing Respiratory rate > 25 breaths/min or < 8 breaths/min SpO ₂ ≤ 90% despite 10 L/min supplemental oxygen*	Unrelenting shortness of breath Respiratory rate > 24 breaths/min or < 10 breaths/min SpO ₂ ≤ 94%*
Circulation	Systolic blood pressure < 90 mmHg Heart rate > 120 beats/min or < 40 beats/min Severe bleeding > 100 mL/h Urine output < 50 mL over 4 h	Systolic blood pressure > 180 mmHg or < 100 mmHg Patient with spinal condition: systolic blood pressure > 150 mmHg or < 80 mmHg Heart rate > 100 beats/min or < 50 beats/min Increased or unexpected fluid or blood loss New presence of oliguria
Temperature	–	≥ 38°C ≤ 35.5°C
Conscious state	Sudden change in conscious state Patient cannot be roused Prolonged or uncontrolled seizures	Responds to pain only Any change in consciousness or mental state
Other	Severe or uncontrolled pain Nurse concern about inpatient for any other reason	Nurse concern about patient who does not fit criteria

* SpO₂ was measured using peripheral pulse oximetry.

When a patient breaches UCR activation criteria (Table 1), hospital policy requires ward nurses to activate a medical review by the patient's parent unit. Responding interns or residents are required to review the patient at their bedside, and responding registrars (specialists in-training), fellows (junior physicians) and consultants (attending physicians) can provide advice over the phone if appropriate. Bedside medical reviews must occur within 30 minutes of the UCR escalation of care. Escalation to more senior doctors is required for every 10 minutes that passes without a medical review. The occurrence of a UCR and the associated outcomes and plan are to be documented by ward clinicians on the designated UCR record and in the progress notes at the clinicians' discretion.

Sample

The study population was patients who received one of the 2584 MET activations at our hospital during 2014. Two hundred adult patients (aged at least 18 years) who had been hospitalised for at least 24 hours were randomly selected using a random number generator based on the first MET activation, thus negating the risk of duplicate patients.

Data collection

We collected the following data from the MET database and patient records: patient characteristics, documented vital signs, records of care and limitations of medical treatment orders for the 24 hours before MET activation. We also examined the following patient outcomes: immediate MET outcome, transfer to the ICU, hospital admission outcome and in-hospital mortality. Importantly, we focused only on the UCR criteria that fulfilled the ACSQHC criteria for physiological instability (respiratory rate, oxygen saturation, heart rate, blood pressure, temperature and conscious state).²⁵ We analysed documents to determine if patients breached UCR criteria in the 24 hours preceding MET activation, the frequency, timing and characteristics of these UCR criteria breaches and the ward clinician escalation-of-care responses to the breaches. We consulted the UCR records, progress notes and comments section on observation and response charts to determine the occurrence of a documented UCR.

When patients had only one UCR criteria breach in the 24 hours preceding MET activation, this was classified as the first and only breach. When patients had more than one UCR criteria breach, we examined only the first and last

breaches in the 24 hours preceding MET activation, with the last breach being the breach closest to MET activation. A UCR criteria breach was defined as when one or more parameters of the vital signs breached UCR criteria (Table 1) at a single time point. A documented UCR was considered to have occurred if there was evidence of a medical review on the UCR record or in the progress notes within 90 minutes of the UCR criteria breach.

Data analysis

We analysed the data using SPSS Statistics, version 22.0 (IBM), and used descriptive statistics to summarise the data. Medians and interquartile ranges (IQRs) are presented, as the data were not normally distributed.

Results

Patient characteristics

Of the 200 randomly selected adults reviewed by the MET during 2014, 52.0% ($n = 104$) were men and the median age was 70 years (IQR, 57–82 years). Before MET activation, 67.0% of patients ($n = 134$) were designated for full resuscitative measures and 33.0% ($n = 66$) had a limitation of treatment order in place. The sample comprised 103 patients (51.5%) admitted under surgical units, and 97 (48.5%) admitted under medical units. The three most common diagnoses were gastrointestinal (29.5%, $n = 59$), musculoskeletal (15.0%, $n = 30$) and neurological conditions (11.5%, $n = 23$). The primary reasons for MET activation are shown in Table 2. The three most common reasons for MET activation were tachycardia (29.0%, $n = 58$), hypotension (21.0%, $n = 42$) and hypoxaemia (13.0%, $n = 26$). There were no MET activations for bradypnoea or severe bleeding.

Frequency of UCR criteria breaches

A breach of the UCR criteria in the 24 hours preceding MET activation occurred at least once in 78.5% of patients ($n = 157$). These 157 patients breached UCR criteria a total of 671 times (Table 3), with 80.9% of patients ($n = 127$) breaching UCR criteria multiple times. The median number of times that patients breached UCR criteria was three (IQR, 1–5 times).

Characteristics and timing of UCR criteria breaches

We conducted a more detailed analysis for the first and last UCR criteria breaches (Table 4). The most common first UCR criteria breaches were hypoxaemia without supplemental oxygen (27.4%, $n = 43$), hypoxaemia with supplemental oxygen (21.7%, $n = 34$), hypotension (14.0%, $n = 22$) and hypertension (6.4%, $n = 10$). The median time between first UCR criteria breach and MET activation was 17.1 hours (IQR, 8.8–21.0 hours).

Table 2. Primary reason for activation of medical emergency team (MET) ($n = 200$)

Reason for MET activation	Patients, n	Proportion (%)
Tachycardia (HR > 120 beats/min)	58	29.0%
Hypotension (SBP < 90 mmHg)	42	21.0%
Hypoxaemia (SpO ₂ ≤ 90% despite 10 L/min supplemental oxygen)	26	13.0%
Change in conscious state or not rousable	21	10.5%
Tachypnoea (RR > 25 breaths/min)	18	9.0%
Nurse concern	13	6.5%
Obstructed airway, noisy breathing or breathing difficulty	9	4.5%
Seizures (prolonged or uncontrolled)	5	2.5%
Bradycardia (HR < 40 beats/min)	4	2.0%
Low urine output (< 50 mL over 4 h)	3	1.5%
Severe or uncontrolled pain	1	0.5%

HR = heart rate. SBP = systolic blood pressure. RR = respiratory rate.

Table 3. Frequency of urgent clinical review (UCR) criteria breaches in the 24 hours preceding medical emergency team activation ($n = 200$)

Criteria and breaches	Patients, n	Proportion (%)
UCR criteria present	157	78.5%
Number of breaches		
1–5	111	70.7%
6–10	37	23.6%
11–15	8	5.1%
16–20	1	0.6%

For the 127 patients who breached UCR criteria multiple times, we also examined the last UCR criteria breach (the breach occurring closest to MET activation). Tachycardia (33.1%, $n = 42$), hypoxaemia with or without supplemental oxygen (both 20.5%, $n = 26$) and hypotension (18.1%, $n = 23$) were the most common reasons for last UCR criteria breaches (Table 4). The median time between last UCR criteria breach and MET activation was 1.2 hours (IQR, 0.3–4.4 hours).

Escalation-of-care responses of ward clinicians to UCR criteria breaches

The most common documented response to first UCR criteria breaches was no action (58.0%, $n = 91$). In 29.3% of instances ($n = 46$), nurses documented that care was escalated by informing doctors that UCR criteria had been breached. Only 13.4% of first UCR criteria breaches ($n = 21$) and 7.9% of last UCR criteria breaches ($n = 10$) resulted in a documented UCR.

Table 4. Characteristics of first (*n* = 157) and last (*n* = 127) urgent clinical review (UCR) criteria breaches

Criterion	First breach, <i>n</i> (%)	Last breach, <i>n</i> (%)
Tachypnoea	4 (2.5%)	3 (2.4%)
Hypoxaemia		
Without supplemental oxygen	43 (27.4%)	26 (20.5%)
With supplemental oxygen	34 (21.7%)	26 (20.5%)
Hypertension	10 (6.4%)	6 (4.7%)
Hypotension	22 (14.0%)	23 (18.1%)
Tachycardia	8 (5.1%)	42 (33.1%)
Bradycardia	4 (2.5%)	4 (3.1%)
High temperature	8 (5.1%)	9 (7.1%)
Low temperature	2 (1.3%)	2 (1.6%)
Altered conscious state (responds to pain only)	2 (1.3%)	2 (1.6%)
No. of UCR criteria breached		
1	140 (89.2%)	111 (87.4%)
2	15 (9.6%)	16 (12.6%)
3	2 (1.3%)	0

Table 5. Documented escalation-of-care responses by ward clinicians to first (*n* = 157) and last (*n* = 127) UCR criteria breaches

Documentation and response	First breach, <i>n</i> (%)	Last breach, <i>n</i> (%)
No documented UCR	136 (86.6%)	117 (92.1%)
Documented UCR*	21 (13.4%)	10 (7.9%)
Documented nursing actions		
None	91 (58.0%)	45 (35.4%)
Not reported to anyone but evidence of self-management	12 (7.6%)	3 (2.4%)
Informed nurse in charge	1 (0.6%)	0
Informed unspecified doctor	22 (14.0%)	15 (11.8%)
Informed nurse in charge and unspecified doctor	1 (0.6%)	0
Informed intern	5 (3.2%)	2 (1.6%)
Informed HMO, RMO or resident	17 (10.8%)	12 (9.4%)
Informed registrar	1 (0.6%)	0
Informed consultant	0	0
Escalated to MET activation	7 (4.5%)	50 (39.4%)

UCR = urgent clinical review. HMO = hospital medical officer. RMO = resident medical officer. MET = medical emergency team. * Medical documentation of a review in progress notes or in UCR record within 90 minutes of criteria being breached.

For the last UCR criteria breaches, the most common documented nursing response was escalation to an MET activation within 60 minutes of the UCR criteria being breached (39.4%, *n* = 50). Nurses documented that they informed doctors of UCR criteria breaches in 22.8% of cases (*n* = 29). Table 5 shows the escalation-of-care responses by ward clinicians to the first and last UCR criteria breaches.

When medical documentation of the breach was present within the progress notes, it typically contained a description of the problem (eg, tachycardia), the patient's history and reason for presentation to hospital, the assessments performed and evaluated, the overall impression and the recommendations and plan. Typical nursing phrases used in the progress notes or in the comments section were "UCR activated", "UCR attended", or "Dr [name and designation] notified" (in relation to an abnormal vital sign).

Patient outcomes

Immediately after MET activation, most patients (90.0%, *n* = 180) remained on their current ward. Nineteen patients (9.5%) required transfer to another clinical area and, of these, 12 patients were admitted to the ICU. One patient (0.5%) with a limitation of medical treatment (for ward management only) died during the MET activation from a respiratory arrest. During the period immediately after the MET activation, 63.5% of patients (*n* = 127) remained designated for full resuscitative measures, and 36.5% (*n* = 73) had a limitation of treatment order in place. Among the 200 patients studied, 56% (*n* = 112) were discharged home and 21% (*n* = 42) were discharged to sub-acute campuses of the health service, including rehabilitation and palliative care facilities. The in-hospital mortality was 12.0% (*n* = 24/200) for the acute campus, 14.3% (*n* = 6/42) for the sub-acute campuses and 15% (*n* = 30/200) for the total stay in the health service.

Discussion

Summary of findings

We conducted a retrospective observational study of 200 MET activations and found that nearly 80% of patients breached UCR criteria in the 24 hours preceding MET activation, and that eight in 10 of these patients did so multiple times. UCR criteria breaches occurred as early as 17–24 hours before MET activation in half the patients. Documented UCRs were infrequent, although documented UCR activation by nurses exceeded documented UCRs by doctors. Apparent delayed responses to UCR criteria breaches often resulted in escalation to the MET.

Comparison with previous studies

Our findings differ from a previous study,²⁰ which reported that 19% of patients fulfilled pre-MET activation criteria

and that only 18% fulfilled these criteria multiple times. Importantly, their sample involved all ward-based patients, not just those reviewed by the MET, as in our study. Study sites were similar in terms of patient acuity and maturity of MET systems. Thresholds for activation of clinical review were similar but not identical to those of UCR in this study.

The frequency of pre-MET clinical deterioration (78.5%) in our study was similar to the incidence of pre-arrest clinical deterioration (84%) reported in early studies.⁶ The most common reasons for pre-MET clinical deterioration were hypoxaemia and tachycardia. This is in keeping with previous research findings that respiratory dysfunction (hypoxaemia, tachypnoea, bradypnoea and dyspnoea) is a common phenomenon preceding adverse events such as cardiac arrest, unplanned ICU admission^{6,26,27} and unexpected in-hospital death.²⁸

Tachypnoea was relatively uncommon in our study, possibly due to the narrow gap between thresholds in the MET and UCR activation criteria in our hospital. A UCR is required for a respiratory rate above 24 breaths/min but below 26 breaths/min, which is the MET activation criterion (Table 1). Thus, for a UCR activation, the respiratory rate had to be exactly 25 breaths/min.

In our study, 17.6% of the first and last UCR criteria breaches involved tachycardia. For patients who had multiple UCR criteria breaches, tachycardia was the most common reason (33.1%) for the final UCR criteria breach, which, for all final UCR criteria breaches, occurred at a median time of 1.2 hours before their MET activation. Several previous studies showed that tachycardia is associated with adverse events.^{2,3,17,28,29} One study showed that tachycardia was the third most common and significant premonitory sign of an adverse event.² Another found specifically that tachycardia (heart rate, 100–119 beats/min) occurred in 22.3% of patients who were reviewed by an ICU outreach service.¹⁷

We found that documented medical review in response to UCR criteria breaches occurred in only one-tenth of patients. Other studies report that MET and pre-MET afferent limb failure occurs in 23%–47% of patients.^{20,30} Another study also reported that doctors did not respond to 16% of nursing escalations to a clinical review.²⁰

Based on available documentation, we found that almost half of all nurses did not respond to the first and last UCR criteria breaches. Similarly, previous work found that 54% of nurses did not activate the MET when patients breached MET criteria.³¹ Further, in that study, there was no documentation indicating changes in vital sign assessment frequency or any other therapeutic intervention afterwards. Their study also examined patients who breached MET criteria but not UCR criteria. Therefore, those findings may be reflective of a different degree of deterioration, when compared with our study, which nurses may perceive to warrant a different response.³¹

The in-hospital mortality of patients requiring MET activation in our study was 12%, but the overall mortality within the health service was 15%. This is less than the in-hospital mortality of 25%–40% reported in previous studies.^{12,32–34} This difference in mortality may be because previous studies evaluated outcomes in the context of delayed MET activations as opposed to timely MET activations; such findings may or may not be comparable with our study cohort. The lower mortality in our study may also be due to the maturity of the RRSs at the study site and routine follow-up by the ICU liaison nurses.

Our study found a high frequency of delayed escalation to ward-based doctors, infrequent medical reviews despite activation and sub-optimal documentation of the medical review. There is a need to explore the barriers to escalation of care for ward-based clinicians and to develop strategies to improve documented medical reviews.

The UCR criterion for hypoxaemia ($\text{SpO}_2 \leq 94\%$), particularly in the absence of supplemental oxygen, may be excessive, and this may have contributed to the high rate of UCR criteria breaches. The British Thoracic Society (BTS) *Guideline for emergency oxygen use in adult patients*³⁵ suggests that an oxygen saturation of 94%–98% is normal in unwell patients and that supplemental oxygen should be only be applied when the oxygen saturation is $< 94\%$. The BTS guideline stipulates that an oxygen saturation of $\leq 93\%$ warrants intervention.³⁵ Clinical practice guidelines by the Thoracic Society of Australia and New Zealand state that oxygen should be administered to target lower saturations of 92%–96%.³⁶ Given that the threshold for UCR activation is an oxygen saturation $\leq 94\%$ with no apparent requirement for supplemental oxygen, some UCR activations may have been overzealous.

Study limitations

Our study had several limitations. First, it was conducted at a single hospital, and the findings may not be representative of the trajectory of early clinical deterioration in other patient populations at other hospitals. However, patients were randomly selected to reduce the risk of bias. Second, this study defined potential pre-MET clinical deterioration as the presence of vital signs meeting objective UCR criteria in the 24 hours preceding MET activation. We acknowledge that there may be other potential characteristics of this phenomenon, including subjective changes and/or changes arising more than 24 hours preceding MET activation, that are not captured by this study. Third, this study was a retrospective medical record audit that was reliant on rigorous measurement and recording of vital signs and escalation-of-care responses by clinicians. Verification of the data obtained was not possible although, legally, documentation is used as a proxy for actual care. It was not within the scope of our study to report on exactly what

clinicians documented when UCR criteria were breached. The frequency of pre-MET clinical deterioration depended on how often nurses measured vital signs, and it was beyond the scope of the study to examine the frequency of assessment in detail.

Conclusion

In our hospital, patients commonly and repeatedly breach UCR vital sign criteria in the 24 hours preceding MET activation. There may be numerous opportunities to respond to early clinical deterioration before the need for activation of the MET. Barriers to recognition and response to pre-MET clinical deterioration require further explanation.

Competing interests

None declared.

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