

# Antecedents to cardiac arrests in a hospital equipped with a medical emergency team

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Inhospital cardiac arrests occur at a rate between 0.6 and 11.2/1000 hospital admissions.<sup>1,2</sup> Historical studies revealed that inhospital cardiac arrests are preceded by signs of deterioration in up to 84% of cases.<sup>3-5</sup> In response to this and other observations, many hospitals have implemented a medical emergency team (MET) service to review patients in the early phases of deterioration, in an attempt to prevent adverse events, including cardiac arrests.

We previously reported that the introduction of a MET service in our hospital resulted in a sustained, progressive reduction in cardiac arrests.<sup>6,7</sup> Despite this, some cardiac arrests still occur in our hospital, particularly overnight.<sup>8</sup> Additionally, in about 28% of cases, the cardiac arrest was preceded by a MET call.<sup>8</sup>

Although antecedents to cardiac arrests have been assessed in the era before MET implementation,<sup>3-5</sup> there is limited information on this in the environment of a mature MET service. We conducted a prospective audit of cardiac arrests to determine what proportion were preceded by derangements in vital signs that fulfilled MET criteria.

In addition, we assessed the proportion of patients in whom there were pre-existing comorbidities that may have warranted a not-for-resuscitation (NFR) order. Finally, we documented the inhospital mortality of the patients who had cardiac arrests, particularly in relation to the initial cardiac rhythm.

## Methods

### Ethics considerations

Ethics approval for this study was obtained from the hospital research and ethics committee (approval no. H2008/03390). Being an observational study, the need for individual informed consent was waived.

### Study design and setting

This study was conducted at the Austin Hospital, Melbourne, Australia, between 1 April 2010 and 30 September 2010. We conducted a prospective audit using a standardised case-report form. Our hospital is a 400-bed university teaching hospital and tertiary referral centre that admits about 31 000 patients each year (excluding admissions shorter than 24 hours). The intensive care unit contains 18 beds and admits 2100 patients per year.

## ABSTRACT

**Background:** Studies conducted before the conception of medical emergency teams (METs) revealed that cardiac arrests were often preceded by deranged vital signs. METs have been implemented in hospitals to review ward patients whose conditions are deteriorating in order to prevent adverse events, including cardiac arrest. Antecedents to cardiac arrests in a MET-equipped hospital have not been assessed.

**Objectives:** To determine what proportion of patients who had cardiac arrests had documented MET criteria before the arrest, and what proportion had a pre-morbid status suggesting they were unsuitable resuscitation candidates.

**Design and setting:** Prospective observational study of cardiac arrests at the Austin Hospital, Melbourne, Australia, 1 April – 30 September 2010. Data were obtained from the patients' records and electronic "respond blue" database.

**Main outcome measures:** Patients' pre-morbid medical condition and functional status; prior "not-for-resuscitation" (NFR) order; presence or absence of a MET call before cardiac arrest; time and rhythm of cardiac arrest; and inhospital mortality.

**Results:** 27 patients had a cardiac arrest during the study period, 22 of whom had no prior documented NFR order. Among these 22 patients, 18 (82%) had an initial rhythm of asystole or pulseless electrical activity, and 16 (73%) died in hospital. Fifty per cent of arrests were detected between midnight and 08:00. All six patients classified as unsuitable resuscitation candidates died in hospital, and there were trends for increased age and poorer functional status when compared with suitable candidates. A further six patients had documented MET criteria in the 6 hours before the arrest, but did not receive MET review.

**Conclusions:** In this 6-month audit, about half the patients with cardiac arrest may have been unsuitable for resuscitation, or had objective warning signs that were not acted on. Further improvements in advanced care planning and optimisation of MET activation may further reduce cardiac arrest calls at our hospital.

### The emergency response team

The hospital has two forms of medical emergency response teams and calls. The “respond blue” call is made for acute medical emergencies requiring very urgent attention. It includes cardiac and respiratory arrests, but may also include syncopal episodes, seizures, sudden falls in coma score, or profound respiratory distress.<sup>7</sup> The respond blue team includes an ICU registrar, an ICU nurse, a coronary care nurse, an anaesthetic registrar and an internal medicine registrar.

The MET reviews all other medical emergencies. It is activated when patients fulfil predefined physiological criteria, which also includes a “staff worried” criterion.<sup>6</sup> The team is composed of an ICU nurse and registrar.

### Resuscitation policy and advanced care planning

The hospital has a detailed policy for the provision of life-prolonging treatment, as well as paper-based and electronic mechanisms for documenting these discussions and decisions. This policy emphasises the need to complete a resuscitation plan for patients aged over 75 years. Several wards also have implemented the Respecting Patient Choices program for assisting the process and documentation of advanced care planning.<sup>9</sup>

### Inclusion criteria and data capture

Cardiac arrests that occurred in inpatient areas, with the exception of the emergency department, operating theatre and ICU, were eligible for inclusion. A cardiac arrest was defined as any event where there was cessation of circulatory function, as defined by the absence of responsiveness and a palpable pulse, and the commencement of cardiopulmonary resuscitation. Respiratory arrests without loss of circulatory function were excluded from analysis, as were cardiac arrests occurring in patients with a pre-existing and documented NFR order.

To ensure documentation of all cardiac arrests during the study period, an ICU pager was kept on at all times. The ICU medical staff were then asked about the details of any recorded respond blue episodes. To identify MET calls that escalated to cardiac arrests but did not trigger a respond blue call, the registrar covering MET and respond blue calls was contacted about any cardiac arrests at the conclusion of each shift.

To cross-reference potentially missed cases, data from the ICU’s database of MET calls and respond blue episodes were scrutinised. The database is constructed from a handwritten logbook, kept on the MET call trolley, and is completed by nursing staff after each MET or respond blue call. This logbook was then further crosschecked with the hospital switchboard’s record of respond blue and MET calls.

We used standardised case report forms to collect data from the hospital electronic respond blue database and the patients’ files. For each cardiac arrest, data in three major categories were collected. We collected demographic data about each patient, including the presence of documented advanced care planning and comorbidities. In addition, we assessed the vital sign chart in the 6 hours before the cardiac arrest to assess whether the patient fulfilled the hospital’s criteria for MET activation. We also documented data about each cardiac arrest, including the initial rhythm of the arrest, whether it was witnessed, and the short- and long-term outcomes.

We also collected detailed information on the presence of chronic comorbidity and functional status before admission.

### Suitability for resuscitation

For every cardiac arrest, two senior intensivists were briefed about the case in a standardised manner with an oral summary, including patient age, functional state and comorbidities, but were blinded to the patient’s outcome. The intensivists were then asked to provide opinions on each patient’s suitability for full resuscitation. If both clinicians agreed that resuscitation was not suitable, the patient was classified as an “unsuitable resuscitation candidate”.

### Statistical analysis

Descriptive statistics are reported as numbers and percentages. Continuous variables were found to be skewed (non-Gaussian) and are thus reported as median (interquartile range [IQR]). Comparison of continuous data was conducted using the Mann–Whitney *U* test, and comparison of categorical data and proportions was conducted using the  $\chi^2$  test or the Fisher exact test, as appropriate.  $P < 0.05$  was considered significant.

### Results

In the 6-month study period, there were 72 respond blue events, 937 MET calls, and 16 142 hospital admissions lasting over 24 hours (MET dose = 58.0 calls/1000 admissions). A total of 27 events fulfilled our definition of cardiac arrest, five of which involved patients who had a pre-existing NFR order in place. Thus, there were 22 cardiac arrests in patients without documented treatment limitations (cardiac arrest rate, 1.36/10 000 admissions). Among these 22 patients, the median age was 74.0 years (IQR, 49–79 years), and 16/22 patients were men (73%). Four of the cardiac arrests occurred in monitored areas (two in the cardiac catheterisation laboratory, one each in the coronary care unit and surgical recovery); thus, 18 cardiac arrests occurred among patients in the wards (1.12/1000 admissions).

**Table 1. Details and outcomes of cardiac arrests by initial rhythm**

	PEA	Asystole	VF	Total
Number	13	5	4	22
Witnessed arrest	9	2	4	15
Monitored area	1	0	3	4
Survived arrest	5	1	2	8
Number of arrests between 08:00 and 17:00 hours	6	0	1	7
MET call criteria within 6 hours before arrest, but no MET called	5	1	0	6
Admitted to intensive care	4	1	1	6
Discharged from intensive care	2	1	1	4
Discharged home (% survival)	3 (23%)	1 (20%)	2 (50%)	6 (27%)

PEA = pulseless electrical activity, VF = ventricular fibrillation.  
MET = medical emergency team.

**Table 2. Differences in baseline characteristics and outcomes of patients deemed to be unsuitable and suitable resuscitation candidates**

	Unsuitable resuscitation candidates (n = 6)	Suitable resuscitation candidates (n = 16)	P
Median age in years (IQR)	78.0 (75–80)	67.5 (45–78)	0.065
No. > 75 years	5	6	0.074
Initial rhythm			
Asystole	3	2	0.116
PEA	3	10	
VF	0	4	
Functional status			
Fully active	1	12	0.044
Dependent in ADLs	4	2	
Bedbound	1	1	
Missing data	0	1	
Survived to hospital discharge	0	6	0.133

IQR = interquartile range. PEA = pulseless electrical activity. VF = ventricular fibrillation.  
ADLs = activities of daily living.

### Initial rhythm and arrest outcome

In 18 of the 22 cardiac arrests (82%) the initial rhythm was either asystole or pulseless electrical activity (PEA) (Table 1). Eight patients (36%) survived the initial cardiac arrest, but two subsequently died in the ICU. Thus, the overall mortality was 73% (16/22). Admission to the ICU was not necessary after two cardiac arrests, and in both of these cases the patient survived and was discharged home.

Among the four patients whose cardiac arrests occurred in a monitored area, three had ventricular fibrillation (VF) and one had PEA. Three of the four patients survived to hospital discharge.

### Arrest timing

The detection of cardiac arrests occurred evenly over the 7 days of the week (data not shown). Most cardiac arrests were detected out of business hours — 7/22 of arrests (32%) occurred between 08:00 and 17:00 hours, four arrests between 17:01 and 23:59 hours (18%), and 11 arrests between midnight and 07:59 (50%).

Ten arrests occurred within 48 hours of admission (45%), eight between days 3 and 6 after admission (36%), and four more than 8 days after admission (18%).

### Chronic comorbidity and adjudication of unsuitable resuscitation candidates

Of the 22 cardiac arrest patients, six were classified by two intensivists to have occurred in unsuitable resuscitation candidates. There was disagreement regarding a seventh patient (Table 2).

Three of the six patients had advanced cardiorespiratory disease, one had known metastatic malignancy, and one had end-stage renal disease and had been NFR in previous admissions. Another patient was bedbound and fed by percutaneous endoscopic gastrostomy 3 months after complex surgery.

When compared with patients who were classified as being suitable for resuscitation, those classified as being unsuitable resuscitation candidates tended to be older, were less likely to have a shockable initial rhythm, more likely to have a worse pre-morbid functional state, and were less likely to survive to hospital discharge (Table 2).

### Antecedent medical emergency team call criteria

For six of the 22 cardiac arrest patients, vital signs that fulfilled MET call criteria were documented in the 6 hours before cardiac arrest. None of these patients had a MET call activated in this period. Of the six MET activation criteria fulfilled, three were for hypotension (systolic blood pressure <90 mmHg), two for increased respiratory rate (>25 breaths/min), and one for tachycardia (heart rate >130 beats/min). Five of these six patients also fulfilled MET criteria at least once in the 2 hours before the cardiac arrest. Only one of the 22 patients received a MET review in the 14 hours before the arrest.

There were no patients with MET antecedents who were also classified as unsuitable resuscitation candidates.

## Discussion

We conducted a 6-month audit in our hospital and found 22 cardiac arrests without NFR orders. We noted six patients with MET antecedents but no MET call, and six patients who were deemed unsuitable for resuscitation. Importantly, most patients in our study were found to have an initial rhythm of either asystole or PEA. This suggests that 55% of cardiac arrest calls may have been avoidable.

The cardiac arrest rate and MET dose in our hospital during the study period were 1.36 and 58.0 per 1000 admissions, respectively. When only the 18 cardiac arrests in ward areas are included, the cardiac arrest rate was 1.12 per 1000 admissions. This compares with the cardiac arrest rate and MET dose of 1.26 and 33.1 per 1000 admissions in our hospital during 2004.<sup>7</sup> Thus, the rate of cardiac arrests in ward patients has not changed significantly since the last audit of cardiac arrests in our hospital, despite a marked increase in MET call rates.

To our knowledge, only one other study has assessed antecedents to cardiac arrests in a MET-equipped hospital. Trinkle and Flabouris assessed the incidence of afferent limb failure in a MET-equipped hospital, and found that 3/35 (9%) had antecedent MET criteria without receiving a MET call.<sup>10</sup>

Most patients in our study had either asystole or PEA as their initial rhythm. This accords with a previous study from our hospital<sup>7</sup> and with a study of over 86 000 cardiac arrests from the United States.<sup>11</sup> Our overall survival rate of 27% is higher than the 16% previously reported in our hospital<sup>7</sup> and in the US study.<sup>11</sup>

Only 27% of cardiac arrests in our study had MET antecedents. This is lower than seen in studies conducted before the development of MET services.<sup>3-5</sup> The lower rate of cardiac arrests with antecedent warning signs may be due to the reduction in cardiac arrests associated with increased MET call rates.<sup>7</sup> Thus, the remaining cardiac arrests in the present study may reflect a lower rate of potentially avoidable cardiac arrests in a mature MET service.

Six of the patients fulfilled MET criteria in the 6 hours before their arrest, yet a MET response was not activated. This finding suggests the MET system in our hospital may not have reached its full potential in reducing cardiac arrests. However, we believe it is important to highlight that during the 6-month period there were 937 MET calls, and only six cardiac arrests where the MET was not activated. Additional strategies for earlier identification of patient deterioration also need to be developed to prevent cardiac arrests.

We also found that a significant proportion of the cardiac arrests occurred among patients who may not have been

suitable resuscitation candidates. This suggests that advanced care planning may need improvement in some areas of our hospital. In keeping with this, we found that five of six patients deemed unsuitable for resuscitation were aged over 75 years, but did not have a completed resuscitation plan, as is our hospital policy.

We estimate that with further improvements in advanced care planning and use of the MET, there could have been as few as 10 cardiac arrest calls in 6 months.

The strengths of our study include its prospective nature, complete capture of cardiac arrest episodes, and use of a standardised case-report form. Limitations include its single-centre design, observational nature, and small sample size. In addition, we relied on data charted by ward staff. It is possible that more missed MET opportunities existed, but the abnormal observations to support this were not documented. Finally, because of the small sample size, our study cannot provide information on multivariate predictors of patient outcome after cardiac arrest in a MET-equipped hospital.

Further research is required to understand ward clinicians' decision-making processes around NFR designation and end-of-life care planning. Additional studies are needed to ascertain whether the findings of our study are generalisable to other institutions.

## Conclusion

The rate of cardiac arrests in our hospital is similar to the rate reported during 2004.<sup>7</sup> Most cardiac arrests have an initial rhythm of asystole or PEA. About a quarter of these patients display antecedent MET criteria, and another quarter have comorbidities suggesting they may have been unsuitable for resuscitation. Further interventions to optimise MET activation and improve end-of-life care planning may further reduce cardiac arrests at our hospital.

## Competing interests

None declared.

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