

# Physiological status during emergency department care: relationship with inhospital death after clinical deterioration

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The intent of rapid response teams (RRTs) is to facilitate early recognition of, and response to, clinical deterioration.<sup>1-3</sup> RRT activation occurs when patients fulfil predefined criteria (staff concern or specific vital sign abnormalities). Personnel with expertise in the assessment and treatment of critical illness assemble at the point of care.<sup>4,5</sup> Even though RRT activation has been shown to decrease cardiac arrests and unplanned intensive care unit admissions,<sup>1-3</sup> the inhospital mortality of patients needing RRT activation is as high as 34%.<sup>1,6-8</sup> This high mortality has driven further initiatives to recognise and manage clinical deterioration before the patient meets RRT activation criteria.<sup>9</sup>

Annually in Australia, there are almost 7 million attendances to emergency departments (EDs), with an admission rate of 27%, resulting in 1.8 million hospital admissions via the ED.<sup>10</sup> Unplanned ICU admission in patients admitted to the wards from the ED occurs in 1.2% of patients, and they are more likely to be older, male, allocated to higher acuity triage categories on ED arrival, and to suffer comorbidities.<sup>11</sup> Mortality after unplanned ICU admission from the wards in ED patients was 10 times greater than in patients admitted via the ED and who remained on the ward (37% v 3%,  $P < 0.001$ ).<sup>11</sup> The relationship between physiological abnormalities in ward patients and serious events such as cardiac arrest and unplanned ICU admission is well documented.<sup>12,13</sup> There are also well established relationships between altered conscious state,<sup>14</sup> tachypnoea<sup>14</sup> and hypotension<sup>14-16</sup> during ED care, and inhospital death.

Between 1.5% and 15% of ED patients fulfil ED-specific or hospital-wide RRT activation criteria at some stage during emergency care.<sup>17-19</sup> One in 10 patients who needed RRT activation in the ED later required RRT activation on the ward. The median time between ward admission from the ED and RRT activation was 36 hours, and one-third of RRT activations occurred within 24 hours of leaving the ED.<sup>17</sup> Patients who needed RRT or cardiac arrest team (CAT) activation within 24 hours of ED admission (compared with beyond 24 hours) were more likely to be triaged as Australasian triage scale (ATS) category 1 (5.4% v 1.2%,  $P = 0.005$ ); were less likely to need ICU admission (7.6% v 13.9%,  $P = 0.039$ ) or to have recurrent RRT or CAT activation during their hospital stay (9.7% v 34%,  $P < 0.001$ ); and had a shorter median hospital length of stay (LOS) by 4 days

## ABSTRACT

**Objective:** To examine the relationship between patient physiological status in the emergency department (ED) and inhospital mortality after rapid response team (RRT) or cardiac arrest team (CAT) activations within 72 hours of emergency admission to medical or surgical wards.

**Design, setting and participants:** A multisite, retrospective, cohort study of 660 randomly selected (220 patients per site) adult medical or surgical patients who were admitted from the ED during 2012 and who had had an RRT or CAT activation within 72 hours of admission, at three hospitals in Melbourne, Australia.

**Main outcome measure:** Inhospital mortality.

**Results:** There were 825 RRT activations (for 634 patients) and 42 CAT activations (for 35 patients). The median time to the first RRT or CAT activation was 18.8 hours and was significantly shorter in patients who died in hospital (14.6 v 20.6 hours,  $P = 0.036$ ). Compared with survivors, patients who died were more likely to have at least one observation meeting RRT criteria during their ED stay (45.9% v 34.8%;  $P = 0.029$ ): tachypnoea (21.1% v 13.4%,  $P = 0.039$ ), hypotension (20.2% v 11.8%,  $P = 0.018$ ), hypoxaemia (8.3% v 3.1%,  $P = 0.001$ ) and altered conscious state (6.2% v 1.3%,  $P = 0.001$ ) were more common in patients who died. The risk-adjusted odds ratio (OR) for inhospital death was highest for patients with an altered conscious state during their ED stay (OR, 4.633; 95% CI, 1.365–15.728;  $P = 0.014$ ).

**Conclusions:** In patients who needed an RRT or CAT activation within the first 72 hours of emergency admission to medical or surgical wards, there was a strong association between physiological derangement during ED care and inhospital death.

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( $P < 0.001$ ).<sup>20</sup> The relationship between physiological status during ED care, and adverse events and RRT activation is poorly understood. Our primary aim was therefore to describe the characteristics and physiological status of

**Table 1. Rapid response team activation criteria, by site**

Criterion	Hospital A	Hospital B	Hospital C
Bradypnoea (RR, breaths/min)	<8	<8	<6
Tachypnoea (RR, breaths/min)	>30	>30	>36
Hypoxaemia, on oxygen (SpO <sub>2</sub> , %)	<90%	<90%	<90%
Bradycardia (HR, beats/min)	<50	<40	<40
Tachycardia (HR, beats/min)	>130	>130	>140
Hypotension (SBP, mmHg)	<90	<90	<90
Altered conscious state	Acute change	Sudden change, unrousable	↓ >2 GCS points or seizure
Staff concern	–	–	–

RR = respiratory rate. HR = heart rate. SBP = systolic blood pressure. GCS = Glasgow coma score.

**Table 2. Sampling procedure, by study site****Hospital A**

- 1480 RRT and CAT activations, hospital wide in 2012
- 819 RRT and CAT activations for patients admitted via the ED (*n* = 18 058)
- 302 patients meeting inclusion criteria
- 220 patients randomly selected

**Hospital B**

- 2597 RRT and CAT activations, hospital wide in 2012
- 1136 RRT and CAT activations for patients admitted via the ED (*n* = 18 437)
- 561 patients meeting inclusion criteria
- 220 patients randomly selected

**Hospital C**

- 2252 RRT and CAT activations, hospital wide in 2012
- 1545 RRT and CAT activations for patients admitted via the ED (*n* = 11 513)
- 271 patients meeting inclusion criteria (July–December 2012)
- 220 patients randomly selected

RRT = rapid response team. CAT = cardiac arrest team. ED = emergency department.

Inclusion criteria = RRT or CAT activation within 72 hours of admission to medical or surgical ward

patients in the ED who subsequently needed RRT or CAT activation within 72 hours of admission to medical or surgical wards. Our secondary aim was to compare, in this cohort, the patient characteristics and physiological status in the ED of patients who died in hospital versus in-hospital survivors.

**Methods****Design**

We conducted our retrospective, multicentre cohort study in three hospitals in metropolitan Melbourne, Australia. The study was approved by the human research and ethics

committees at the three study sites and Deakin University. The number of inpatient admissions via the ED per year were 23 268 at Hospital A, 26 012 at Hospital B and 30 413 at Hospital C. At all hospitals, patients who met predefined criteria for clinical deterioration or who had a cardiorespiratory arrest are immediately attended to by an RRT. The RRTs include an ICU doctor, a specialist critical care registered nurse, medical staff from the parent medical team, a general medical registrar (when available) and, in the case of cardiorespiratory arrest, an anaesthetist. The ICU doctor is typically a registrar (advanced trainee) or, if available, an ICU specialist. The RRT activation criteria for each site are shown in Table 1.

**Participants**

Our cohort included adult patients (aged 18 years or over), admitted via the ED to medical or surgical wards during the 2012 calendar year and who received an RRT or CAT activation within the first 72 hours of admission. For the purposes of our study admission was deemed to have started at the time the patient left the ED for transfer to the ward.

Exclusion criteria included patients aged under 18 years, patients transferred from the ED to a ward with continuous monitoring (eg, the ICU, high dependency unit, coronary care unit, or neurosurgical, cardiac surgical or thoracic surgical wards); and patients admitted to short stay units and mental health and maternity wards. Random sampling was used to select 220 patients per site who met the inclusion criteria (*n* = 660), using SPSS, version 21.0 (IBM Corporation).

We collected study data using a retrospective medical record audit by trained research nurses, who collected the following data for each patient:

- patient characteristics: age, sex, ED triage category, ED LOS, limitation of medical treatment (LOMT) order
- physiological status: frequency and nature of physiological abnormalities during ED care
- patient outcomes: time from ED discharge to first RRT or CAT activation, in-hospital death.

For the purpose of our study, we use “physiological status” to refer to respiratory rate, oxygen saturation, heart rate, systolic blood pressure, conscious state or temperature.

We analysed our data using SPSS, version 22.0, and used descriptive statistics to summarise the study data. As data were not normally distributed (according to the Kolmogorov–Smirnov test), we present data as medians with interquartile ranges (IQRs). We compared patients who died

**Table 3. Factors associated with in-hospital mortality**

Factor	Deaths (N= 109)	Survivors (N= 551)	Odds ratio	95% CI	P
Arrival by ambulance, n (%)	90 (82.6%)	370 (67.2%)	2.518	1.455–4.358	0.001*
Usually lives at home, n (%)	79 (72.5%)	480 (87.1%)	0.390	0.239–0.635	< 0.001*
ATS category, n (%)					
1	0	4 (0.7%)	0.834	0.806–0.863	0.372*
2	39 (35.8%)	129 (23.4%)	1.823	1.176–2.826	0.007*
3	5 (50.5%)	338 (61.3%)	0.642	0.425–0.970	0.034*
4	15 (13.8%)	80 (14.5%)	0.939	0.519–1.702	0.837*
RRT activation criteria recorded during ED care, n (%)					
Tachypnoea	23 (21.1%)	74 (13.4%)	1.724	1.024–2.903	0.039*
Hypotension	22 (20.2%)	65 (11.8%)	1.891	1.108–3.227	0.018*
Staff concern	11 (10.1%)	56 (10.2%)	0.992	0.502–1.962	0.982*
Tachycardia	10 (9.2%)	41 (7.4%)	1.256	0.609–2.592	0.536*
Hypoxaemia	9 (8.3%)	17 (3.1%)	2.827	1.226–6.520	0.011*
Altered conscious state	7 (6.4%)	8 (1.3%)	6.156	2.184–17.352	< 0.001*
Bradycardia	0	13 (2.4%)	na	na	na
Bradypnoea	1 (0.9%)	4 (0.7%)	1.266	0.140–11.439	1.000*
Recordings fulfilling RRT activation criteria during ED care, n (%)					
0	59 (54.1%)	359 (65.2%)	0.631	0.417–0.956	0.029*
1	14 (12.8%)	69 (12.5%)	1.029	0.556–1.904	0.926*
2–10	25 (22.9%)	105 (19.1%)	1.264	0.771–2.073	0.352*
>10	11 (10.1%)	18 (3.3%)	3.324	1.523–7.254	0.001*
Parameters fulfilling RRT activation criteria during ED care, n (%)					
0	59 (54.1%)	359 (65.2%)	0.631	0.417–0.956	0.029*
1	29 (26.6%)	130 (23.6%)	1.174	0.735–1.875	0.502*
2	11 (10.1%)	46 (8.3%)	1.232	0.617–2.463	0.554*
≥3	10 (9.2%)	16 (2.9%)	3.378	1.490–7.658	0.002*
Age, years (median [IQR])	81 (73–89)	76 (60–85)	na	na	< 0.001**
ED length of stay, hours (median [IQR])	7.6 (5.9–11.5)	7.1 (5.4–11.5)	na	na	0.800**
Time, ED discharge to first RRT or CAT activation, hours (median [IQR])	14.6 (6.4–31.6)	20.6 (7.7–38.9)	na	na	0.036**

ATS = Australasian triage scale. RRT = rapid response team. ED = emergency department. na = not applicable. IQR = interquartile range. CAT = cardiac arrest team. \* Using the  $\chi^2$  test. \*\* Using the Mann–Whitney *U* test.

with survivors using the  $\chi^2$  test for categorical data and using the Mann–Whitney *U* test for continuous data. We used binary logistic regression to examine factors associated with in-hospital mortality, and we indicate statistical significance with a two-sided  $P < 0.05$ .

## Results

### Participant characteristics

We included 660 patients in our study, 220 patients from each site. The numbers of patients admitted from the ED to the wards of interest in this study during 2012 were 48 008 (18 058 at Hospital A, 18 437 at Hospital B and 11 513 at

Hospital C). Table 2 details the sampling procedure at each site.

The median age was 77 years (IQR, 62.25–85.75 years) and 48.8% of patients were men ( $n = 322$ ). Two-thirds of patients arrived at the ED by emergency ambulance (69.7%,  $n = 460$ ), 26.8% arrived by private car ( $n = 177$ ), 2.3% arrived by private ambulance ( $n = 15$ ) and 0.2% were brought in by police ( $n = 1$ ). Most patients usually lived at home (84.7%,  $n = 559$ ), and 15.3% of patients lived in supported living (residential aged care or community-based supported housing) ( $n = 101$ ).

The triage category distribution of patients was as follows: 0.6% needed immediate emergency care (ATS 1,  $n = 4$ ), 25.5% needed emergency care within 10 minutes (ATS 2,

**Table 4. Factors associated with in-hospital mortality after RRT or CAT activation in first 72 hours of admission**

Factor	Odds ratio	95% CI	P*
Age	1.023	1.005–1.041	0.013
Emergency ambulance ED arrival	1.451	0.788–2.670	0.232
Usually lives in supported accommodation	1.507	0.865–2.626	0.147
Limitation of medical treatment order in place at ED discharge	2.811	1.734–4.556	<0.001
ATS category			
4 (reference)			
1	na	na	0.999
2	1.088	0.519–2.281	0.824
3	0.704	0.357–1.389	0.312
Parameters fulfilling RRT criteria during ED care			
Hypotension	1.467	0.802–2.683	0.214
Tachypnoea	1.023	0.564–1.857	0.940
Hypoxaemia	1.425	0.532–3.817	0.481
Altered consciousness	4.633	1.365–15.728	0.014
Time from ED discharge to first RRT or CAT activation	0.994	0.982–1.006	0.299

RRT = rapid response team. CAT = cardiac arrest team. ED = emergency department. ATS = Australasian triage scale. na = not applicable. \* Using the  $\chi^2$  test.

$n = 168$ ), 59.5% needed emergency care within 30 minutes (ATS 3,  $n = 393$ ), and 14.4% needed emergency care within 60 minutes (ATS 4,  $n = 95$ ). The median ED LOS was 7.7 hours (IQR, 5.5–11.5 hours) and 10.3% of patients ( $n = 68$ ) had an ED LOS of 4 hours or less. LOMT orders were in place for 29.1% of patients ( $n = 192$ ) when they left the ED.

During the first 72 hours of emergency admission, there were 825 RRT activations for 634 patients and 42 CAT activations for 35 patients. Most patients (73.3%,  $n = 484$ ) had only a single RRT activation. Recurrent RRT activations occurred for 21.7% of patients ( $n = 143$ ) and recurrent CAT activations occurred for 0.4% of patients ( $n = 3$ ). The median time from leaving the ED to the first RRT or CAT activation was 18.8 hours (IQR, 7.3–37.9 hours). The first RRT or CAT activation occurred within 4 hours for 15.2% of patients ( $n = 100$ ), and within 24 hours of admission in 58.6% of patients ( $n = 387$ ).

In-hospital death occurred in 16.5% of the 660 patients ( $n = 109$ ). Among these, 13 deaths (11.9%) were unexpected deaths (defined as an absence of an LOMT order at the time of death). Death immediately after an RRT or CAT activation occurred in 2.3% of patients ( $n = 15$ ). The median hospital LOS for patients who had an RRT or CAT activation within 72 hours of emergency admission was 8 days (IQR, 4–13 days). During their ED care, 29.1% of the 660 patients

( $n = 192$ ) had one or more documented parameters that fulfilled their hospital's RRT activation criteria. The most common RRT activation criterion documented as occurring during ED care was hypotension. The median number of RRT activation criteria documented during ED care per patient was one (IQR, 1–2 criteria).

### Comparison of in-hospital deaths and survivors

Comparison of patients who did and did not die in hospital showed that patients who died were more likely to have one or more observations meeting RRT criteria during their stay in the ED, (45.9% [ $n = 50$ ] v 34.8% [ $n = 192$ ];  $P = 0.029$ ). In particular, they were more likely to have tachypnoea, hypotension, hypoxaemia or an altered conscious state (Table 1). The total number of single vital sign recordings meeting RRT criteria ranged from none to 37 recordings (median, 0 recordings; IQR, 0–1 recordings). The number of parameters (respiratory rate, oxygen saturation, heart rate, systolic blood pressure, conscious state, staff concern) meeting a hospital's RRT criteria that were documented during ED care ranged from none to five criteria (median, 0 criteria; IQR, 0–1 criteria). There were no significant differences in ED LOS for patients who died in hospital versus survivors. The times from ED discharge to first RRT versus first CAT activation were significantly shorter in patients who died in hospital (medians, 14.6 hours v 20.6 hours,  $P = 0.036$ ) (Table 3).

Using in-hospital mortality as the independent variable, a test of the full model with 653 patients against a constant-only model was statistically reliable ( $\chi^2 = 75.969$ ,  $P < 0.001$ ). Application of the Hosmer–Lemeshow statistic confirmed good model fit ( $\chi^2 = 6.465$ ,  $P = 0.595$ ). The model explained 18.6% of the in-hospital mortality variance (Nagelkerke  $R^2$ ) and correctly classified 83.8% of cases. After adjusting for confounding factors, the risk-adjusted odds ratio (OR) of in-hospital death was highest for patients with an altered conscious state meeting RRT criteria during ED care (OR, 4.633; 95% CI, 1.365–15.728;  $P = 0.014$ ) (Table 4).

### Discussion

In our study, in-hospital mortality after RRT or CAT activation within the first 72 hours of emergency admission was 16.5%. Patients who died were more likely to have one or more physiological parameters that met their hospital's RRT activation criteria documented during their ED care than survivors.

The inhospital mortality reflects that of other Australian studies. Inhospital mortality in ED patients who have an RRT activation within 24 hours of admission varies from 16.2% in patients admitted to medical or surgical wards<sup>20</sup> to as high as 21.6% when admissions to all hospital areas are included.<sup>7,21</sup> Fewer than 1% of patients needing RRT activation had an immediate outcome of death. Schneider and colleagues<sup>22</sup> and Herod and colleagues<sup>23</sup> have also shown that the short-term outcome of RRT calls is favourable, with as many as 82% of patients staying on the ward immediately after RRT activation,<sup>23</sup> and 89.1% of patients alive and remaining on the ward at 24 hours after RRT activation.<sup>22</sup>

Patients who died in hospital were older, more likely to arrive by ambulance and had significantly earlier initial RRT or CAT activations than survivors. In our study, the median time to RRT or CAT activation was 14.6 hours for patients who died and 20.6 hours for survivors. It may be that the timing of RRT activations after emergency admission is a surrogate indicator for the severity of a patient's condition, but the effect of RRT timing on patient outcomes is poorly understood and warrants further investigation. An Australian study of RRT and CAT activations in patients admitted to medical or surgical wards via the ED showed no significant difference in the mortality of patients whose RRT or CAT activation occurred within 24 hours compared with patients whose RRT or CAT activation occurred later in their admission (mortality, 16.2% v 21.6%).<sup>20</sup> A study of ward outcomes of patients admitted via the ED who had triggered an ED early warning system for physiological derangement showed that 17% of patients admitted to medical or surgical wards had an RRT activation on the ward, and in seven patients, RRT activation occurred within the first 24 hours of admission.<sup>17</sup> Survival outcomes of these patients were not specifically reported.<sup>17</sup>

When compared with survivors, patients who died were more likely to have had one or more physiological parameters documented during their ED stay that met their hospital's RRT activation criteria. They were more likely, while in the ED, to have had one or more episodes of tachypnoea, hypotension, hypoxaemia or altered conscious state, which are known precursors to inhospital adverse events in ward patients.<sup>12,24-26</sup> Altered conscious state,<sup>14</sup> tachypnoea<sup>14</sup> and hypotension<sup>14-16</sup> in the ED have been associated with inhospital death. In patients who have had an RRT or CAT activation in the first 72 hours of admission, the presence of an abnormal conscious state in the ED was associated with inhospital death (adjusted OR, 4.633). This finding supports that of Burch and colleagues,<sup>14</sup> who reported that an abnormal conscious state in the ED was associated with inhospital death (OR, 5.1). The relationship between physiological derangements in the ED and other

inhospital adverse events, such as ICU admission from the wards or RRT activation, is poorly understood.

Limitations of our study include a retrospective design and limitations inherent in the use of organisational data. However, data abstraction was performed by trained research nurses who used a data dictionary in order to optimise data reliability. We examined RRT and CAT activations and their outcomes; we did not examine which patients had a true cardiac arrest. There were variations in RRT activation criteria between sites that may have affected the study results, but these variations were subtle and related only to respiratory rate, heart rate and conscious state thresholds. Patients were randomly selected from three sites, minimising the possibility of selection bias. Our study design precludes conclusions about predictors of RRT and CAT activation after emergency admission and may not be generalisable to other institutions with markedly different processes for detecting and managing clinical deterioration.

## Conclusions

Physiological derangements meeting hospital RRT activation criteria were present during ED care in one-third of patients needing RRT or CAT activation within 72 hours of emergency admission, and were almost twice as likely to be present in patients who later died in hospital. An ability to identify patients at risk of inhospital death, RRT or CAT activation during the early stages of admission may enable a more proactive approach to care planning, in particular the frequency of assessment and timing of specialist referrals.

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## Competing interests

None declared.

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