Modifications to predefined rapid response team calling criteria: prevalence, characteristics and associated outcomes

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ABSTRACT

Objective: Standardised rapid response team (RRT) calling criteria may not be applicable to all patients, and thus, modifications of these criteria may be reasonable to prevent unnecessary calls. Little data are available regarding the efficacy or safety of modifying RRT calling criteria; therefore, this study aimed to detail the prevalence and characteristics of modifications to RRT call triggers and explore their relationship with patient outcomes.

Design and outcome measures: A pilot retrospective cohort study within a convenience sample of patients attended by a hospital RRT between July and December 2014; rates of repeat RRT calling and in-hospital mortality were compared between patients with and without modifications to standard calling criteria. Secondary analyses examined four different types of modifications, narrowing or widening of existing physiological calling criteria, to observations without defined calling criteria, and others. All analyses were performed using multivariable regression.

Results: During the study period, 673 patients had RRT calls, of whom 620 (91.2%) had data available for analysis. The majority of study patients (393; 63.4%) had modifications documented. Patients with modifications were more likely to have repeat RRT calls (odds ratio [OR], 2.86; 95% CI, 1.69–4.85) and experience in-hospital mortality (OR, 2.16; 95% CI, 1.31–3.57) versus patients without modifications. In the secondary analyses, although all classes of modification had higher rates of repeat calling, none reached statistical significance. Mortality was associated with having modifications that were more conservative than the standard calling criteria (adjusted OR, 2.81; 95% CI, 1.31–6.08).

Conclusion: Modifications to standard calling criteria were frequently made, but did not seem to prevent further RRT calls and were associated with increased mortality. These findings suggest that modifications should be made with caution.

Crit Care Resusc 2019; 21 (1): 32-38

Hospital inpatients may be at risk of unexpected clinical deterioration, which can result in adverse outcomes if uncorrected.[1-3] Previous investigations have indicated that this deterioration might be recognised early, providing the opportunity for a timely clinical response.[4,5]

This risk of adverse outcomes led to the development of a rapid response system, which incorporates an afferent limb that monitors patient physiology and activates an efferent limb, the rapid response team (RRT), if certain triggers are reached.[6] These calling criteria are based on physiological parameter abnormalities that may predict cardiac arrest.[4-10] These have been incorporated into "track and trigger" charts that protocolise recognition of and response to patient deterioration.[1,2,6,11-13]

A drawback of standardised activation criteria is that they may not be applicable for all patients. For example, patients with chronic obstructive pulmonary disease (COPD) often chronically tolerate mild hypoxia.[13] In such cases, the use of standard criteria could result in "false positive" RRT calls. Therefore, the establishment of tailored modifications to the calling criteria on a per-patient basis would seem reasonable.[2]

Careful consideration would seem prudent before deviating from predefined RRT calling triggers. Indiscriminate modification of these triggers may prevent appropriate and necessary calling, undermining the original ethos of the rapid response system: to protect patients from adverse outcomes arising from uncorrected reversible deterioration.[1-3,6] Conversely, narrowing the calling criteria may provide little to no additional protective benefit to patients while incurring the resource burden of avoidable calls.

Thus far, no publication has focused on the safety profile of modifications to RRT calling criteria. Therefore, this pilot study was conducted to detail the prevalence and characteristics of modifications to RRT call triggers and explore their relationship with patient outcomes.

Methodology

Design

We conducted a pilot retrospective cohort study of characteristics and outcomes of RRT-attended patients, with and without modifications to predefined standardised RRT calling criteria.

Setting

The study was conducted at Lyell McEwin Hospital, a tertiary metropolitan hospital located in Adelaide, South Australia.

Rapid response system afferent limb

In early 2014, as part of the South Australian Department of Health's compliance with the National Standard 9,[1] the rapid detection and response (RDR) chart was introduced

Table 1. Rapid response team activation criteria

	Criteria	Trigger values
Physiological parameter-based	Heart rate	≥ 140 beats per min
		< 40 beats per min
	Systolic blood pressure	≥ 200 mmHg
		< 90 mmHg
	Respiratory rate	> 30 breaths per min
		< 8 breaths per min
	Pulse oximetry (percentage saturation)	< 90%
	Conscious level (sedation score)	Only responding to physical or painful stimulus (> 2)
Clinical condition-based	Cardiac arrest	na
	Respiratory arrest	na
	Threatened or obstructed airway	na
	Prolonged seizures	na
	"Worried" or unresolved clinical concern	na

na = not applicable.

at the investigating site. This chart employs a "track and trigger" system to assist identification and escalation of clinical deterioration.

The RDR chart captures observations of respiratory rate, oxygen saturation, blood pressure, heart rate, temperature and conscious state. Each parameter has a range of normal and abnormal values, with a corresponding clinical response requirement. RRT calls are triggered based on breach of criteria (Table 1).

A section of the RDR chart permits documentation of modifications to predefined calling triggers (Figure 1). Any modifications require specifying the physiological parameter, the new calling trigger, the action to be taken if this trigger is reached, the duration of the effect and the rationale for the modification.

Study cohort

Convenience sampling from the hospital's electronic rapid response system database was undertaken of patients subject to at least one RRT call between July 2014 and December 2014. This process aimed to ensure that the relationship between RDR charts modifications and RRT calling rates could be assessed, to provide a reasonably homogenous "at risk" population, and to permit completion of the study within a reasonable timeframe. Patients aged under 18 years or not admitted to the hospital were excluded.

Case records for all eligible subjects were manually checked for RDR adult observation charts. Patients were separated into two groups: those with and those without RRT calling modifications on their RDR charts.

Rapid detection and response chart modifications

When modifications on RDR charts were found, data were collected, including the time, physiological parameter, range, rationale, designation of the clinician making the modification, and whether a consultant was involved in that decision.

Modifications on the RDR chart were divided into four types:

- **Type 1:** using the same as predefined calling criteria, or making them more conservative so that calls would be triggered at lesser degrees of physiological derangement; for example, raising the oxygen saturation call trigger to 92% (or less) rather than the default 90% (or less).
- **Type 2:** relaxing of predefined calling criteria to tolerate greater physiological derangement before calls would be triggered; for example, lowering the oxygen saturation call trigger to 85% (or less).
- **Type 3:** a tolerance of abnormalities in other physiological parameters for which the RDR chart does not specify a defined numerical RRT calling criteria, but might trigger RRT calls for staff concern; for example, pain score or urine output.
- **Type 4:** an illegible or ambiguous instruction, or treatment order, that would normally be documented elsewhere; for example, not for resuscitation.

Outcomes

The primary outcome was repeat RRT calling; that is, more than one call during an inpatient admission. The secondary outcome was in-hospital mortality. For both outcomes, the relationship with having any RDR chart modifications was assessed in an adjusted multivariable model, with inclusion of other factors such as patient demographics (age and gender) and admission characteristics (admitting team, Charlson Comorbidity Index, and length of hospital stay).

Secondary analyses were performed to assess the relationship between outcomes and each of the different types of modifications. To ensure these groups were mutually exclusive, the secondary analyses were constrained to patients with no more than one modification.

Statistical analysis summaries

Categorical data are reported as frequencies with percentages, with numerical data presented as medians with interquartile range (IQR). Comparisons between study groups were performed with the χ^2 or Mann–Whitney U test. The relationship between numerical variables was assessed with Pearson correlation.

Study outcomes were analysed by backward stepwise logistic regression, with inclusion of covariates to fit multivariable (adjusted) models. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). All variables were included in the initial multivariable model and were retained in the final model if their associated *P* value was less than 0.05. Statistical analyses were performed with SPSS for Windows version 24 (IBM, Armonk, NY).

Ethics approval

This study was approved by the Central Adelaide Health Network Human Research Ethics Committee (no. HREC/15/TQEH/95). Waiver of individual patient consent was granted under the remit of a quality assurance project and due to the use of de-identified retrospective data.

Results

Study cohort

During the study period, 673 patients were subject to RRT calls, of whom 620 (92.1%) had RDR charts available from case records. There were 393 patients (63.4%) with at least one RDR chart modification and 227 (36.6%) with no modifications made to their RDR charts.

Patients in the modification group were older than those in the group without modifications (median, 75 years [IQR, 60.5–82.0] *v* 70 years [IQR, 52.0–80.0]; $P < 0.01$), had longer hospital lengths of stay (median, 7.1 days [IQR, 4.0–13.3] *v* 5.5 days [IQR, 2.9–11.5]; $P < 0.01$), and were most likely to be admitted under the internal medicine team ($P < 0.01$). There were no differences between the groups for gender, rates of unplanned admission, or Charlson Comorbidity Index.

Modifications

A total of 1404 modifications to RRT calling triggers were found on the RDR charts reviewed. The majority of patients with modifications had more than one documented (median, 2 modifications; IQR, 1–5); the largest number of modifications made during any individual patient's hospital admission was 24. Full data on modifications by parameter and type are presented in Table 2 and Table 3.

Type 1 modifications

There were 877 Type 1 modifications. Of these, the commonest change was to modify the upper heart rate calling criterion (median, 120 beats per minute; IQR, 110–130). Other modifications in this group included oxygen saturations (median, 92%; IQR, 90–92%) and the upper respiratory rate criterion (median, 30 breaths per minute; IQR, 25–30). Thereafter, most Type 1 modification entries merely replicated existing calling criteria.

Figure 1. Modification section of the rapid detection and response chart

Modifications

If abnormal observations are to be tolerated for the patient's clinical condition, write the acceptable ranges and rationale (where a response will not be triggered) below. Duration of modification must be specified.

	Modification 1	Modification 2	Modification 3	Modification 4
Date	/ /	/ /	/ /	/ /
Time	:	:	:	:
Duration				
Observation(s) and acceptable range				
Brief rationale *(full description in medical record)*				
Doctor's signature				
Doctor's name *(print)*				
Doctor's designation				
Nurse signature				
Nurse name *(print)*				
Nurse designation				

Table 2. Rapid detection and response modifications to predefined physiological parameter triggers

Parameter	RRT calling criteria	Modification type	Count	Median modification (IQR)	Furthest outlier modification
Heart rate (beats per min)	High (≥ 140)	Type 1	212	120 (110–130)	
		Type 2	41	150 (150–160)	240
	Low (< 40)	Type 1	104	45 (40–50)	
		Type 2	6	35 (35–35)	30
	na	Type 4	4		
Systolic blood pressure (mmHg)	High (≥ 200)	Type 1	82	190 (180–200)	
		Type 2	11	220 (220–220)	300
	Low (< 90)	Type 1	160	90 (90–90)	
		Type 2	158	80 (80–85)	60
	na	Type 4	4		
Respiratory rate (breaths per min)	High (> 30)	Type 1	120	30 (25–30)	
		Type 2	61	40 (35–40)	50
	Low (< 8)	Type 1	4	8 (8–8)	
		Type 2	2	7 (6–7)	6
	na	Type 4	1		
Oxygen saturations (%)	Low (< 90)	Type 1	195	92 (90–92)	
		Type 2	164	88 (88–88)	75
	na	Type 4	2		
Sedation score	High (> 2)	Type 1	0		
		Type 2	1	3 (na)	3
	na	Type 4	1		

IQR = interquartile range. na = not applicable. RRT = rapid response team.

Type 2 modifications

There were 444 modifications found which widened standard calling criteria. The most frequently modified criteria were for oxygen saturations (median, 88%; IQR, 87.5–88%) and low blood pressure (median, 80 mmHg; IQR, 80–85 mmHg), of which the lowest modification seemed to accept a systolic level of 60 mmHg. Other outlier calling criteria modifications were 240 beats per minute for high heart rate, 300 mmHg for high blood pressure, and 50 breaths per minute for high respiratory rate.

Type 3 modifications

There were 41 RDR chart annotations for Type 3 modifications. Most annotations related to urine output (median, 10 mL/h; IQR, 10–20 mL/h) or Glasgow Coma Score (median, 12; IQR, 10–12; minimum 6). Other parameters included in Type 3 modifications were mean arterial pressure, pain score and core body temperature.

Type 4 modifications

This type of modifications comprised 19 instances of illegible or unclear annotations to physiological parameters, 12 clinical instructions that were not related to patient observations (eg, "post liver biopsy management"), eight orders precluding further escalation for deterioration and three precluding RRT calls for seizures.

Governance

The majority of modifications (1018; 72.5%) were instituted by trainee medical officers, of which five also had the name of an endorsing consultant documented. In 295 instances (21.0%), neither the name nor the designation could be ascertained. Only 22 of the modifications (1.5%) were documented by a consultant.

A clinical rationale was documented to justify most modifications (72.7%). For 885 modifications (63.0%), a finite time limit was set. For these, the median duration was 18 hours (IQR, 9.4–24 hours). The majority of modifications (60.2%) were made outside normal operating hours (8 am to 6 pm, Monday to Friday).

Outcome measures

Repeat rapid response team calling

Patients in the modification group were more likely to have these repeat RRT calls during their hospital admission than patients without modifications (83 [21.1%] *v* 20 [8.8%] patients, respectively) with an OR of 2.86 (95% CI, 1.69–4.85; $P < 0.01$). There was also a correlation between the number of RDR chart modifications and the number of RRT calls per patient (Pearson's r 0.17; $P < 0.01$).

In the secondary analysis, 12.9% of patients with Type 1 modifications, 18.8% with Type 2 modifications, 15.4% with Type 3 modifications and 28.6% with Type 4 modifications had repeat calls. When adjusted for covariates, although all modification groups had higher point estimates

Table 3. Rapid detection and response modifications to non-defined physiological triggers

Parameter	Modification type	Count	Median modification (IQR)	Furthest outlier modification
Mean arterial pressure (mmHg)	Type 3 (above normal)	1	110 (na)	110
	Type 3 (below normal)	3	60 (60–60)	60
	Type 4	0		
Core temperature (°C)	Type 3 (above normal)	5	40.0 (39.0–40.0)	40.0
	Type 3 (below normal)	10	34.3 (33.6–35.0)	32.0
	Type 4	0		
Glasgow Coma Scale	Type 3	8	12 (10–12)	6
	Type 4	3		
Pain score (out of 10)	Type 3	4	7 (5–8)	8
	Type 4	0		
Urine output (mL/hour)	Type 3	9	10 (10–20)	0
	Type 4	4		

IQR = interquartile range. na = not applicable.

(for likelihood of repeat calls) than the group without modifications, none reached statistical significance (Table 4). No other variables were retained in the final model.

Mortality

Of the whole study cohort, 114 patients (18.4%) died in hospital. In the multivariable regression model, adjusted for patient and admission characteristics, there was a significant relationship between mortality and having any RDR chart modifications (OR, 2.16; 95% CI, 1.31–3.57; $P < 0.01$). There was also a correlation between mortality and the number of modifications per patient (adjusted OR, 1.08; 95% CI; 1.01–1.15; $P = 0.03$).

The secondary analysis showed that patients with only Type 1 modifications had significantly higher mortality, by comparison to patients with no modifications (OR, 2.81; 95% CI, 1.30–6.08; $P < 0.01$). Patients with only Type 2 or only Type 3 modifications had no increase in mortality risk (OR, 1.72 [95% CI, 0.65–4.57]; $P = 0.28$; and OR, 0.77 [95% CI, 0.09–6.94]; $P = 0.82$, respectively). None of the patients with only Type 4 modifications died in hospital. Other factors that retained significance in the final model were male gender, age and hospital length of stay.

Discussion

Almost two-thirds of this study of RRT-attended patients had modifications to calling criteria on their RDR charts. This was contrary to our expectation that modifications would be an exception rather than the norm and used only in selected circumstances.[2]

The RDR chart had only been introduced to the hospital a few months before this study was conducted, so the findings may reflect some unfamiliarity with usage of the modification section of the chart.[14-16] This is supported by study data showing that the majority of modifications were Type 1, whereas the intent by the chart developers was to facilitate Type 2 modifications as a means of reducing unnecessary calling.

For Type 2 modifications — relaxing of predefined calling criteria to tolerate greater physiological derangement before calls would be triggered — a reasonable a priori expectation was that patients with this type of modification may have higher mortality rate than patients without modifications.[4,5,7-10] However, the study findings contradicted this in showing no difference. This result reassures that either widening of standard call triggers only occurred in stable patients or did not result in a failure to rescue clinical deterioration. Therefore, these modifications seem to not present an obvious mortality risk to patients; which may in part be due to the increased calling rates seen in these patients versus other groups, countering the rationale for the Type 2 modifications (ie, to prevent unnecessary or avoidable calling).

In practice, it would seem that modifications caused unease and, rather than calling for criteria breaches, RRT calls occurred due to staff concern instead.[17-19] In such scenarios, the increased attendance by the skilled, experienced RRT may have had a degree of protective effect.[2,20,21]

This study found that patients with Type 1 modifications — the same as predefined calling criteria, or making them more conservative to trigger calls at lesser degrees of physiological derangement — had an almost three-fold mortality risk versus patients without modifications. This seems counter-intuitive, as narrowing the standard calling criteria should either have had no effect on mortality or reduced it due to earlier detection of clinical deterioration.[3-5]

Furthermore, narrowing of calling criteria was expected to result in a significant increase in calling. However, the likelihood of repeat calling for Type 1 modifications was the lowest of all modification groups. Hence, it would seem that some reluctance or uncertainty arose, which may have

Table 4. Secondary analysis (multivariable model) for repeat calling

Patient groups	Number of patients with repeat calls (%)	Adjusted odds ratio (95% CI)	*P*
No modifications	20 (8.8%)	Reference group	
Type 1 modifications	9 (12.9%)	1.58 (0.68–3.67)	0.29
Type 2 modifications	6 (18.8%)	2.32 (0.84–6.39)	0.10
Type 3 modifications	2 (15.4%)	1.86 (0.38–9.00)	0.44
Type 4 modifications	2 (28.6%)	4.29 (0.78–23.62)	0.09

flowed on to indecision around activation of the RRT when appropriate under the standard criteria.[14-19]

Regardless of the rationale, it would seem that a paradoxical risk effect may be in effect, which questions the use of Type 1 modifications.

Governance

This study flagged the importance of oversight and supervision.[1,2,6,20,21] The majority of modifications were documented by trainee medical officers, which does not imply that consultants were uninvolved or unaware of modifications, but this is hard to substantiate in the absence of documentation. A likely explanation is that, since the majority of modifications were made outside normal working hours, consultants were not locally present.[21]

Some modifications seem problematic, especially the outlier values shown in Table 3. These values likely reflect a well intentioned attempt to avoid RRT calls that would serve no benefit to a patient. For example, calls for asymptomatic hypoxia in a stable patient with COPD could be reasonably avoided.[22] But permitting wide deviations from the standard criteria risks setting a precedent and normalising such practice. This risk could be mitigated through senior involvement and the recording of a comprehensive rationale in the patient's case notes[2,21]

Strengths and limitations

To the best of the authors' knowledge, this is the first study describing rates and outcomes of modifications to RRT calling criteria. The use of adjusted multivariable models excludes the effect of potential confounders (such as age) on observed mortality.

Nevertheless, the constraint to a convenience sample of RRT-attended patients limits the applicability to a wider population of hospitalised patients. In particular, no conclusions can be reached regarding whether modifications successfully prevented unnecessary RRT calls in stable patients. The constraint was applied for pragmatism to reduce the labour of hand-searching case notes of all patients admitted during the study period, and to ensure a relatively homogenous study cohort in whom mortality effects could be easily observed.

The small numbers of patients included in the secondary analyses raise the possibility of findings from these analyses being underpowered. While inferences can be drawn, the study does not support making robust conclusions. A large, prospective trial would address this shortcoming.

Finally, for all groups, there was no identification of patients who had treatment limitation orders initiated either before or at their RRT calls. The possible effect of these on repeat calling rates could not be accounted for. However, hospital protocols for end-of-life care stipulated ceasing physiological observations; therefore, any call triggers modifications for dying patients would become void.

Potential areas for further exploration

Calling criteria were developed by analysing patient data and determining the level of physiological deterioration associated with poor outcomes.[3,5] Thus, they provide a degree of implicit safeguard against which to objectively assess patients. In light of this, modifications should not be routine practice, but instead applied on a bespoke basis for the individual subtleties of each patient. Ideally, the decision to invoke them would involve senior clinicians with the experience to gauge appropriateness.[2,20,21]

An important consideration that this study was not able to fully address is the organisational impact of the additional RRT calls associated with modifications in this study. Most RRTs do not have supernumerary staffing, so the diverting of staff to attend potentially avoidable calls may reduce productivity and disrupt workflow and attendance to routine duties.[20] Thus far, that has not shown to incur clinical sequelae to other patients, but there are still risks from disruptions to workflow.[23]

Finally, while this study may be the first publication specifically examining modifications to RRT calling triggers, it only examined the effects in a cohort of RRT-attended patients and, therefore, it cannot draw a conclusion on patient groups without calls, suggesting the need for further comprehensive studies to provide data on safety and effectiveness.

Conclusion

This study found that modifications to predefined RRT calling criteria were common, did not reduce rates of repeat calling and seemed to be associated with in-hospital mortality. The use of modifications should be judged carefully and made on a per-patient basis.

Competing interests

None declared.

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