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Review article

Rapid response system

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Abstract
There is growing evidence that early detection and response to physiological deterioration can improve outcomes for hospitalized infants, children, and adults. A rapid response system (RRS) is a multidisciplinary system to decrease the incidence of in-hospital cardiopulmonary arrests by detecting a crisis event and triggering a response and by dispatching a responding team. For quality improvement of the system, a review mechanism is vital to identify opportunities for preventing future events or improving response after crises occur. The whole system requires an administrative component that oversees the RRS and provides support. The system is designed to locate and respond rapidly to a suddenly critically ill patient who lacks necessary critical care resources. Over the past decade, RRSs have been widely implemented in adult practice in the United States, Canada, Australia, the United Kingdom, and Scandinavian countries.

Key words Rapid response system · Medical emergency team · Cardiopulmonary arrest · Crisis response

Definition of a rapid response system (RRS) and its rationale

A rapid response system (RRS) is a multidisciplinary team strategy to better anticipate and thus prevent in-hospital cardiopulmonary arrests. There is growing evidence that early detection and response to physiological deterioration can improve outcomes for infants, children, and adults. Because up to 80% of cardiopulmonary arrests are preceded by prolonged periods of physiological instability [1–4], early intervention during this period, in the form of a RRS crisis-call, should help in preventing some cardiopulmonary arrests. Also, a single institutional, controlled before-and-after trial showed that the introduction of an intensive care unit-based medical emergency team was associated with a reduced incidence of postoperative adverse outcomes, reduced postoperative mortality rate, and reduced mean duration of hospital stay [5].

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Birth and dissemination of the RRS

In 1999, in *To Err Is Human: Building a Safer Health System*, the Institute of Medicine [6] suggested that a disturbingly high frequency of life-threatening or even lethal medical complications existed in healthcare centers. The Institute of Medicine further recommended establishing multidisciplinary team training programs to reduce such medical complications, incorporating efficient methods such as simulation. These recommendations led to the development of the RRS. The RRS experience in Australia gained support from the Institute for Healthcare Improvement in the United States and from the governmental healthcare administrations in the United Kingdom and Canada. Over the past decade, RRSs have been widely implemented in adult practice in the United States, Canada, Australia, and the United Kingdom, and they have recently been introduced in Scandinavia.

Four crucial components of the RRS

The following four components have been identified as the crucial parts of a RRS: (1) an "afferent" crisis detection component, (2) an "efferent" response team component, (3) an ongoing "evaluative or process improvement" component, and (4) an "administrative" oversight component [7].

The "afferent" component

The first RRS component is "crisis detection." The floor personnel, especially nurses on the wards, often are the

Table 1. Clinical criteria for activating a medical emergency team (MET) response [17,24]

Respiratory
- Rate <8 or >36 breaths per min
- New-onset difficulty in breathing
- New pulse oximeter reading less than 85% for more than 5 min (unless patient is known to have chronic hypoxemia)

Heart rate
- <40 or >140 beats per min (bpm) with symptoms or any rate >160 bpm

Blood pressure
- <80 or >200 mmHg systolic or 110 mmHg diastolic with symptoms

Acute neurological change
- Acute loss of consciousness
- New-onset lethargy or narcan use without immediate response
- Seizure (outside of seizure monitoring unit)
- Sudden loss of movement (or weakness) in face, arm, or leg

Other
- Chest pain unresponsive to nitroglycerine, or doctor unavailable
- Color change (of face or extremity): pale, dusky, gray, or blue
- Unexplained agitation lasting more than 10 min
- Suicide attempt
- Uncontrolled bleeding

first to detect a patient's clinical deterioration. Crisis calls (referred to as "condition C" in the hospital) or cardiopulmonary arrest calls (referred to as "condition A") are activated by alerting call center personnel. The distinction between conditions C and A is important to recognize. "Condition A" stands for "arrest," as in cardiopulmonary arrest, and such patients had been cared for by a traditional "code team." "Condition C," on the other hand, stands for "crisis"; the goal of the RRS in this situation is to prevent the further clinical deterioration of the patient, which can lead to a "condition A" situation. The call center dispatches a crisis response team by a mass paging system and an overhead announcement. Of note, the crisis response team can be activated by *anyone* (staff, patient, or family) and anywhere in the hospital, 24 h a day and 7 days a week [8]. The reliability of crisis detection and team triggering is increased if objective vital sign thresholds are disseminated among healthcare professionals and all are encouraged to call for help (Table 1). Early warning scores are better predictors of risk than objective vital sign thresholds [9,10], but are more difficult for staff to use.

The "efferent" component

This second component of the RRS is "the crisis response." Terms used for responder teams include "medical emergency team (MET)" for a physician-led team, "rapid response team (RRT)" for a team without a physician responder, and "critical care outreach team (CCOT)," for a team which, in addition to responding to crises, will make routine visits to patients at highest risk of clinical deterioration, such as those recently transferred out of an intensive care unit (ICU) setting. These teams may replace or coexist with traditional cardiac arrest teams, which typically respond to patients already in cardiac arrest. In this article, the term "MET" will be used to represent this efferent component.

The MET should possess the skills and equipment required to provide immediate onsite stabilization and management of patients with physiological deterioration (or cardiopulmonary arrest), and to initiate discussions of appropriate indications (or limitations) to medical interventions. The team is typically led by a critical care medicine (CCM) or hospital physician, and the rest of the team may be composed of CCM fellows, ICU nurses, and respiratory therapists [11]. A bed flow coordinator often accompanies the team for smooth transferring of the patient to the ICU, if indicated. Furthermore, secondary specialist teams can be summoned by the CCM faculty. These specialist teams include a difficult airway team (anesthesiologists/ear-nose-throat [ENT] surgeons), a chest pain team (cardiologists), or a stroke team (neurologists/neurosurgeons). The anesthesiology team and the ENT surgical team can be good resources for rare, very challenging difficult airway cases.

The "evaluative or process improvement" component

Each time a "condition C" (or "A") call is made, the call center personnel record the following event variables: date, time, location, call type, and patient identifiers. This information is then entered into an electronic "Code" database. The Hospital Code Review Commit-

tee (comprised of the medical director, a senior CCM faculty member, a CCM fellow, a patient safety fellow, and a nursing unit director) reviews all cardiopulmonary arrest events bi-weekly and holds a monthly multidisciplinary review conference to discuss the call cases and their outcomes. Attendance at the conference includes, but is not limited to, CCM faculty members and fellows, nurses, pharmacists, respiratory therapists, and case managers. Education/training for MET members is also provided by a monthly test-call of a condition and a performance evaluation of the call, as well as various lectures and training sessions at a simulation center [12].

The "administrative" component

This final component of the RRS is comprised of the healthcare administration in the hospital. The administrators' understanding and support is mandatory for the success of the RRS, and they are expected to provide the necessary resources to fulfill the requirements of the RRS. The resources needed to promote the system can be large, and include equipment, medications, personnel, and even motivation/psychological support.

Guidelines for data recording

The need for standardized reporting of RRS data was prompted by the International Liaison Committee on Resuscitation in 2007. They developed a reporting template with consensus-derived data elements and standardized definitions for monitoring and reporting of data related to these systems [13]. In this consensus statement, a list of core and supplemental data elements was developed in the Utstein style for monitoring the incidence and outcome of such in-hospital events [14]. It is hoped that this system will enable a detailed analysis, which will lead to evidence-based recommendations for best clinical practice and improve outcomes in hospitalized patients.

How effective is the RRS in preventing cardiopulmonary arrests?

The theoretical basis behind the RRS is that identifying patients with sudden critical care needs and intervening early, in the form of a RRS during prolonged periods of physiological and clinical instability, should help in preventing some cardiopulmonary arrests. There is evidence both for and against this hypothesis. Several non-randomized studies in adult hospitals have shown a benefit from introducing a RRS [15–17]; however, the largest study of the RRS [the Medical Emergency Response Improvement Team (MERIT) study], a cluster randomized controlled trial, failed to show an effect of the RRS on rates of cardiac arrest, unexpected death, or unplanned admission to the ICU [18]. Recently, another study, from a single institution that looked at the benefits of the RSS before and after implementation, showed negative findings [19].

Can we conclude the RRS is a well-intentioned system, but an ineffective one in improving patients' outcomes in a hospital setting? There are significant drawbacks in the two studies showing negative results for the RSS [18,19]; therefore, readers should be cautious in assessing their conclusions. The MERIT study [18] showed no RSS benefit most likely because it was analyzed on an intention-to-treat basis. Some of the hospitals in the "No MET" arm of the study actually had a MET and some in the "MET" arm had very few MET activations. So in essence, there was neither a control nor an intervention group: they were the same. Those investigators who noticed the problem have recently re-analyzed their data using an "as-treated" basis instead of an "intention-to-treat" basis [20]. Instead of comparing the control and intervention arms as they did in their first analysis, they compared the number of response team (MET) activations and the cardiac arrest rate. They found that as the number of MET activations increased, there were decreases of the in-hospital cardiac arrest rate and mortality [20]. Chan and colleagues' study [19] (before-after implementation of a RRS in a single institution) is not a MET study but rather a RRT study; RRT is nursing-led while a MET is physician-led. As one might predict, they found that introducing a nursing-led crisis team (RRT) into a hospital with physicians in house did not improve outcome [19].

There seem to be differences in the beneficial effects of RRSs based on the patient population. Jones and colleagues from the Australian and New Zealand Intensive Care Research Centre (ANZIC-RC) [21] reported that the introduction of a MET system in a university hospital showed a sustained (4-year) but fluctuating reduction of in-hospital deaths of "surgical" patients; the odds ratios of death during MET periods compared with that during pre-MET periods ranged from 0.67 to 1.01. In the "medical" patients, however, they failed to find a reduction of in-house mortality; odds ratios of death during MET periods compared with that during pre-MET periods ranged from 1.20 to 1.45. They postulated that the differential mortality in medical and surgical patients may have been related, at least in part, to (1) the greater degree of acuity and lesser degree of reversibility of the conditions leading to medical admission as compared to the conditions leading to surgical admission, and (2) the potential difference in use of the MET service for medical and surgical patients, where the ratio of MET calls per deaths in medical patients

was 0.41:1, while in surgical patients it was 1.76:1 [21].

Effect of the RRS (MET) on patients' long-term outcomes

The long term beneficial effect of a RRS with an ICU-based MET has been reported by Jones and colleagues from ANZIC-RC, who conducted a prospective, controlled, before-after trial in a University hospital [22]. In patients who were admitted for major surgery requiring a hospital stay of more than 2 days, they compared patient mortality at 1500 days after admission between a 4-month control phase and a 4-month MET phase. Overall survival at 1500 days was significantly better in the MET group (71.6% vs 65.8%; $P = 0.001$). Multivariate logistic regression analysis identified that admission during the MET period was one of the independent predictors of decreased 1500-day mortality (odds ratio, 0.74; $P = 0.005$). This study counters a concern that the MET may only delay the timing of death due to the intervention.

Current issues in the RRS debate and their implications

Debate on RRS effectiveness

A core question in the RRS debate is what level of evidence we need to introduce a new system of care in our current practice. The notion of the early detection and treatment of critically ill patients intuitively makes sense, yet no level 1 evidence exists to support the notion. Should we seek evidence from randomized-controlled trials to embrace the idea of the RRS? Is it even possible to do such a trial? Such a trial might not be realistic for at least two reasons. First, the unit of randomization for such a study would have to be the whole hospital, which of course is constantly changing and therefore is nearly impossible to control for contamination and for guaranteeing that the intervention is carried out perfectly [23]. The large numbers participating and the long study periods that would be required make these problems even more difficult. Second, because the unit of randomization is a hospital, and the fact that the intervention is behavioral, it is probably impossible to conduct such a trial in a blinded fashion.

On the other hand, none of the adult studies (even the trials with negative results) thus far has indicated any detrimental effects of implementing a RRS. There have been concerns raised regarding the potential for an increased volume of unplanned ICU days due to the use of a RRS, but, to our knowledge, there are no data to support this claim. Data are needed to identify both the positive and negative impacts of the RRS. Of course, an increased number of admissions to the ICU might not necessarily mean an increased number of days in the ICU; theoretically, earlier detection of critically ill patients might reduce the number of days each patient needs to be in the ICU. It has been argued that providing critical care to critically ill patients early on is a "commonsense intervention" that should not be withheld due to lack of level 1 evidence. As in the case of cardiac arrest and trauma teams that have become integral parts of the medical system, adaptation of the RRS may be observed in a slow and progressive fashion, even in the absence of level 1 evidence. The accumulation of evidence from different settings and situations, though methodologically imperfect, may increase the rationale for and logic of the RRS.

Underutilization of the RRS

Underutilization of the RRS can be found due to cultural barriers in the workplace and lack of standardization, and these problems should be expected in the early phase of implementation of such a system. DeVita and colleagues (DeVita et al. [17] and Foraida et al.[24]) reported that several strategies were attempted to increase the utilization of the RRS, with significant effect: (1) immediate reviews of all sequential emergency pages, (2) feedback to caregivers responsible for delays in condition C activation, (3) creation of objective criteria for initiating a crisis response, and (4) dissemination of objective criteria among healthcare professionals through posting in units, e-mail, and in-service oral presentations.

Concern for potential deskilling of the ward staff

Because an RSS involves an expert team that dispatches quickly to solve any emergency situation, concerns have been expressed about the deskilling of ward staff to take care of patients whose condition is deteriorating critically. These concerns seem to be only theoretical at this time. Many RRSs are implemented in parallel with education programs. A basic principle of the RRS is to assess the patient whose clinical condition is deteriorating, together with ward physicians and nurses. Therefore, the RRS can provide a good opportunity for the bedside education of the ward staff; over time, this experience can assist ward staff in their decision-making and treatment of critically ill patients. Additionally, the increased familiarity between the ICU staff and the general ward staff will be valuable in other situations as well. The opportunity to interact with other departments can offer the ICU staff a stimulating alternative to the often very demanding daily tasks in an ICU.

Future directions

Education using simulator training

Simulation training has become a common teaching method in medicine during the past decade. Grenvik and colleagues [25] have stressed that members of a RRS can be taught using this method, based on several advantages of simulation training over traditional medical education methods: (1) provision of a safe environment for both patient and student during training in risky procedures; (2) unlimited chance of exposure to rare but important clinical events; (3) ability to plan and shape training opportunities rather than waiting for a suitable situation to arise clinically; (4) ability to provide immediate feedback; (5) opportunity for a repeat performance; (6) opportunity for team training; and (7) lower costs, both direct and indirect.

Use of an RRS to find medical errors

The review of RRS response records may be used for surveillance to detect medical errors, or to detect adverse events that can be preventable with the current state of medical knowledge. Braithwaite and colleagues [11] performed a retrospective chart review of 364 consecutive RRS responses for 8 months. They found that 114 responses (31.3%) were associated with medical errors; 77 (67.5%) of these were categorized as diagnostic errors, 68 (59.6%) as treatment errors, and 30 (26.3%) as prevention errors (errors resulting from a failure to provide prophylactic treatment). Eighteen separate hospital care processes were identified and modified as a result of this review, 10 of which involved standardization. This finding suggests that a RRS can be used to identify and support improvement in the processes of care that underlie these errors.

Computerized RRS data entry system

To improve data collection and compliance with the data entry by a MET during a crisis response, an innovative computer system may be needed. This system might include a computer display in each ward room where MET resuscitation occurs, and a wireless computer system could recognize the name cards of key personnel entering the room. A paperless charting system during cardiopulmonary resuscitation might also be an integral part of the computer system.

Conclusion

The RRS holds promise to decrease in-hospital cardiopulmonary arrests through early detection and MET intervention in patients with physiological deterioration preceding cardiopulmonary arrest. Although further studies will be necessary to prove its effectiveness, the RRS has become the "de-facto" standard in the current healthcare system in many countries and has been widely supported by various patient safety organizations worldwide.

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