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Chapter 2

Managing the Prevention of In-Hospital Resuscitation by Early Detection and Treatment of High-Risk Patients

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Abstract

In hospitalized patients, cardiorespiratory collapse mostly occurs after a distinct period of deterioration. This deterioration can be discovered by a systematic quantification of a set of clinical parameters. The combination of such a detection system—to identify patients at risk in an early stage —and a rapid response team—which can intervene immediately—can be implemented to prevent life-threatening situations and reduce the incidence of in-hospital cardiac arrests outside the intensive care setting. The effectiveness of both of these systems is influenced by the used trigger criteria, the number of rapid response team (RRT) activations, the in- or exclusion of patients with a DNR code >3, proactive rounding, the team composition, and its response time. Each of those elements should be optimized for maximal efficacy, and both systems need to work in tandem with little delay between patient deterioration, accurate detection, and swift intervention. Dependable diagnostics and scoring protocols must be implemented, as well as the organization of a 24/7 vigilant and functional experienced RRT. This implies a significant financial investment to provide an only sporadically required fast intervention and sustained alertness of the people involved.

Keywords: early warning score, rapid response team, in-hospital cardiac arrest, proactive rounding

1. Introduction

While the organization and optimization of resuscitation of in-hospital cardiorespiratory collapse already receives due attention, there is a growing consciousness that a more

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proactive strategy by improved detection of deteriorating patients and adequate intervention may prevent many inpatient deaths. This awareness is reflected in the 5 Million Lives campaign [1].

In the UK, the incidence of in-hospital cardiac arrest is 1.6/1000 hospital admissions [2]. Still, between 25 and 67% of the successfully in-hospital resuscitated patients die during the first 24 h after the return of spontaneous circulation (ROSC) [3]. In comparison, the survival to discharge after in-hospital cardiopulmonary resuscitation for cardiac arrest in nonelderly (18–64 years) in the US (2007–2012) was reported as only 30.4% and for patients >18 years as 27.4% [4, 5].

Particularly, in-hospital cardiorespiratory collapse is more frequently caused by preventable or correctable factors like respiratory problems or sepsis, compared to prehospital cardiorespiratory collapse, which is more frequently preceded by sudden, unexpected causes like cardiac rhythm disturbances or trauma [6].

In general, patients admitted to the intensive care unit (ICU) from hospital wards have a higher mortality risk compared to patients from theaters, postoperative recovery, or the emergency department. As such, there should be a focus on hospital wards to recognize patients who are critically ill prior to cardiopulmonary collapse [7].

Several studies have identified physiological abnormalities as a marker for clinical deterioration. Kause et al. [8] identified threatened airway, respiratory rate < 5, respiratory rate > 36, pulse rate < 40, pulse rate > 140, systolic blood pressure < 90 mmHg, fall of GCS by two points or more, and prolonged seizure activity. Goldhill et al. [9] defined the level of consciousness, heart rate, age, systolic pressure, and respiratory rate as predictive markers.

Based on a combination of those parameters, multiple scoring systems to identify patients at risk have been conceived, but they often lack validation [10].

Experience teaches that an exclusive implementation of a cardiac arrest team is both ineffective and expensive [7]. Keeping such a team continuously operational requires a significant financial investment [11], and the outcome remains poor [12]. Likewise, even advanced detection strategies, based on scoring systems to identify deteriorating patients, produced disappointing results [13]. This might be owing to a lack of validation of the scoring system [14]. In the MERIT study, a medical emergency team was implemented in 12 hospitals, and the outcome was compared with 11 other hospitals without such a team. The implementation of the team "greatly increased emergency team calling, but did not substantially affect the incidence of cardiac arrest, unplanned ICU admissions, or unexpected death". In this study, a rapid response team was implemented but still with disappointing results, which may be due to the lack of a reliable early warning system [12].

Above all, both afferent and efferent components are needed to be effective: a track-and-trigger system must be organized to firstly detect deteriorating patients early with suitable sensitivity and specificity, followed by a fast intervention by a professional team to optimize the treatment or bring the patient to an intensive care unit.

The managerial task for enabling such an effective program is, therefore, the implementation of reliable early identification of patient deterioration, followed by a fast and appropriate response without significantly increasing nurse workload and without turning ward areas into ICUs [15]. It consists of two separate systems working in tandem: an early warning system and a rapid response team.

Repetitive nursing staff education must provide fast and reliable patient scoring with high sensitivity and acceptable specificity. Secondly, to permit swift intervention when necessary, a dedicated hospital informatics system is required enabling the RRT to view all the patients in the hospital. Thirdly, detection of a deteriorating patient must prompt swift intervention.

2. The EWS scoring system

The British National Institute for Health and Clinical Excellence documented in the National Institute of Health and Clinical Excellence (NICE) 2007 guidelines [16] that physiological track and trigger systems should be used to monitor all adult patients and facilitate the recognition of patient deterioration. According to the scoring (low, medium, or high score group), a graded response strategy should be followed (**Figure 1**). A score is given to different

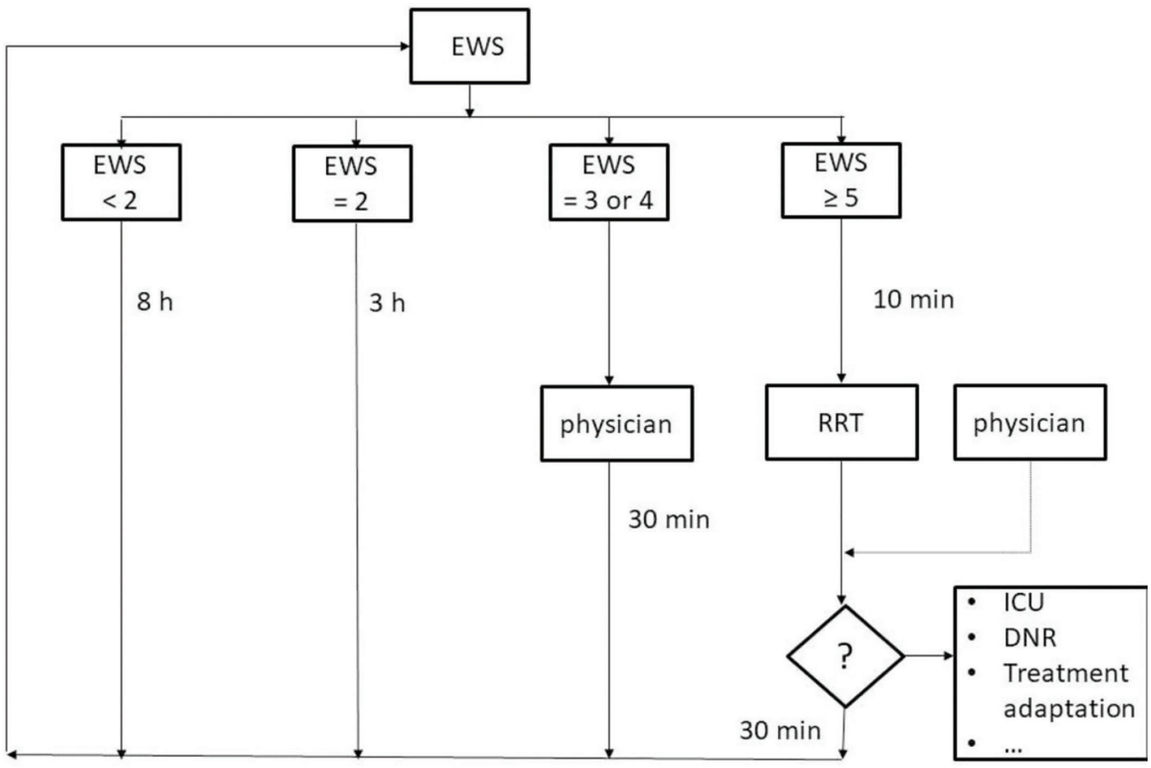

Figure 1. Example of a formalized decision process with graded response.

physiological measurements, which are often already routinely measured and recorded in hospitals. The magnitude of the score reflects how extreme the parameter deviates from the norm. The different scores are aggregated and uplifted for people requiring oxygen [17]. Depending on each calculated score, the algorithm provides a recommendation. At moderate scores, the frequency of subsequent clinical monitoring is increased to enable accelerated detection of deterioration. At higher scores, an increasingly urgent clinical assessment up to emergency intervention is triggered [17].

In the past, several scoring systems were proposed, where the weight allocated to each parameter defines the sensitivity of the final score to trigger a response. An expert working group reviewed the weightings used in a number of early warning score (EWS) systems such as the VitalPAC early warning score (ViEWS) [18] and made small adjustments based on the clinical opinion from the working group [17]. Different approaches can be proposed with divergent consideration and often conflicting priorities. In clinical practice, a scoring system needs to be integrated into daily practice and should, therefore, be user friendly and not too complex. Failure to meet this requirement will result in noncompliance and unreliable scoring. As such, the features of a system aiming for 100% sensitivity and specificity will differ from a convenient screening tool. The group also recommended a color-coded clinical chart to aid identification of abnormal clinical parameters.

2.1. Different parameters

Known statistically significant risk factors for cardiac arrest are as follows: abnormal respiratory rate, abnormal breathing, abnormal pulse, reduced systolic blood pressure, abnormal temperature, reduced pulse oximetry, chest pain, and nurse or doctor concern [19].

In addition, several clinical observations are significant predictors of mortality: decrease in Glasgow Coma score by two points, onset of coma, hypotension <90 mmHg, respiratory rate < 6/min, oxygen saturation < 90%, and bradycardia >30/min [20].

The National Institute for Health and Clinical Excellence (NICE) [16] and the National Early Warning Score (NEWS) Development and Implementation Group [17] recommended:

- Pulse rate

Tachycardia can reflect pyrexia, pain, general distress, cardiac arrhythmia, or circulatory compromise such as in sepsis, volume depletion, or cardiac failure. Bradycardia can be induced by medication, hypothermia, central nervous system (CNS) depression, heart block, and hypothyroidism.

- Respiratory rate

The respiratory rate is frequently the first parameter to change in the advent of clinical deterioration. Tachypnea can be induced by pain, distress, sepsis, CNS disturbance, and metabolic disturbance. Bradypnea can be due to CNS depression or narcosis [21]. Respiratory deterioration is one of the most common reasons for ICU admission. Early identification and treatment of these patients may, therefore, reduce ICU admission. Increased risk factors are chronic respiratory disease, sedation outside the operating room, and administration of patients who

receive opioids [15]. The respiratory rate is elevated significantly above normal in a majority of patients with cardiac arrest [22] and is predictive of cardiac arrest [23].

- Systolic blood pressure

Hypertension can be a manifestation of cardiovascular disease or be a consequence of pain. Hypotension can be due to rhythm disturbance, CNS depression or naturally low blood pressure, or can reflect circulatory compromise such as sepsis, volume depletion, or cardiac failure. Hypotension is more indicative of acute illness than hypertension. Importantly, a change of systolic blood pressure was identified as an independent predictor of cardiac arrest [19], although earlier reports had concluded the opposite [23].

- Level of consciousness

This is quantified by alert-reaction to voice-reaction to pain-unresponsive (AVPU). This score is assessed in sequence and records only one outcome. Agitation also counts as an independent scoring point. Confusion is not part of the AVPU assessment, but recently developed confusion or worsening of confusion is a major concern and must trigger urgent clinical evaluation. Consciousness just failed statistical significance to predict cardiac arrest but was considered clinically significant, and therefore it was incorporated into the activation criteria [19]. Moreover, prior research had shown that 42% of the patients with cardiac arrest had alterations in mental function [22].

- Oxygen saturation

This is not always incorporated in the scores owing to the necessity for additional hardware. Pulse oximetry, however, is noninvasive and permits a rapid indication of oxygen levels but may be misleading due to false positive alarms. Pattern recognition of the waveform may improve the accuracy of these measurements [15]. Pulse oximetry cannot replace measurement of the respiratory rate [19], for which capnography is sometimes put forward as an alternative.

- Temperature, as a measure of pyrexia or hypothermia
- The requirement of supplemental oxygen for patients, which includes routine oxygen delivery by mask or nasal cannula. If present, a weighting score of two should be added, because patients are at greater clinical risk.

In a model reported in 2005, aiming to predict the need for intervention, all physiological components except temperature contributed significantly. Additionally, in the model predicting hospital outcome, all components except temperature and heart rate contributed [24]. Moreover, a higher number of events experienced by a patient were correlated with a higher risk of mortality [20].

In addition to the components included in the National Early Warning Score of the UK (NEWS), several variables are known risk factors for patient deterioration. The mortality increases significantly with age, although including age in the model offers little practical benefit in this context [18, 23, 25]. The urine output is essential for some patients, but it is not

available at first assessment and is not routinely performed. It is recommended that it should only be assessed when clinically appropriate [16, 17]. Pain scores are included in the chart in NEWS but are not part of the aggregated scoring system.

Gender, ethnicity, and obesity alter several values, but this is not considered in most scoring systems. Likewise, during pregnancy, most parameters are modified. Conventional EWS triggers are therefore inapplicable in patients who are pregnant [17]. Several variables and comorbidities are for now not included in the EWS but may improve the model upon improved modeling. Abdominal pain, for instance, is not considered statistically significant in general but may be relevant in specific subpopulations [19]. Likewise, immunosuppression or other conditions may require disease-specific scoring systems. In addition, the inclusion of routine laboratory tests does not add sufficient consistency to be included in current EWS models [22], but advances in hospital informatics may change this in the future.

2.2. Scoring algorithms

The modified early warning score [26] prescribes a minimum frequency of monitoring of 12 h unless a decision has been made at a senior level to increase or decrease this frequency for an adult patient [17, 27]. If abnormal values are detected, the frequency of monitoring should increase [16]. The threshold should regularly be reviewed to optimize sensitivity and specificity [16]. Several strategies were explored to trigger the response [16]:

- Single-parameter system:

  This consists of periodic observations of selected vital signs that are compared with a simple set of criteria with predefined thresholds, with a response algorithm being activated when any of the criteria are met [20, 28]. Advantages of such a system are its ease of use and reproducibility. A significant disadvantage is that it permits only limited grade response strategy, and has low sensitivity, resulting in a lot of false negatives.

- Multiparameter system

  This response algorithm requires more than one criterion to be met, or the response differs according to the number of criteria met [9, 24]. This strategy allows monitoring and graded response strategy and has a higher sensitivity [29] but is expensive—owing to increased clinical contact time and additional equipment—and has low specificity when only one abnormal observation is present.

- Aggregate scoring system

  Weighted scores are assigned to physiological values and compared with predefined trigger thresholds [19, 26, 30]. Since this permits simple monitoring and a graded response strategy, it is widely used. It is however also expensive and is prone to human errors. The specificity and sensitivity depend on the used cut-off value.

- Combination system:

  This strategy is defined as multiple parameter systems used in combination with aggregate weighted scoring systems.

While more time-consuming, an aggregate weighted scoring system is more sensitive than single parameter systems and therefore promoted in most guidelines [29].

2.3. Specific EWS systems

Clusters of hospitals often use the same scoring system. For instance, the patient-at-risk score (PARS) [24] is used in all hospitals of the Worcestershire Mental Help Partnership Trust. It facilitates patient and staff transfer between hospitals within the Trust. A particular purpose of nation-wide standardized systems, such as NEWS in the UK, is to avoid a lack of familiarity with local systems.

Importantly, NEWS cannot be used in children, pregnant women, or patients with chronically disturbed physiology, for example, chronic obstructive pulmonary disease (COPD), for which alternative systems are needed [17]. Such specific scoring systems are proposed for patients with chronic respiratory disease (e.g., CREWS – S-NEWS [31], sequential sepsis-related organ failure assessment [qSOFA]), and systemic inflammatory response syndrome [SIRS]) or in patients with suspected sepsis [32]. Implementation of a proposed pediatric scoring system (Bedside PEWS) however did not result in reduced mortality [33]. A specific neonatal trigger score (Neonati), however, showed better than PEWS [34].

2.4. Hospital informatics

To optimize the effectiveness of the RRT, particularly in case of automated recordings, the informatics system of the hospital should provide an electronic dashboard showing all hospital patients in a single view, ranked by EWS score and updated in real time. This permits immediate notification of deviant scores and swift intervention. Such a display also allows the RRT to take a proactive approach to see patients, monitor patients and review patients at risk, rather than relying exclusively on bedside nurses to activate the RRT. Until further research, the clinical benefit of an electronic dashboard remains unproven [35]. Nevertheless, it has a very promising advantage that it permits an active search for the patients who are the most at risk in the hospital. This allows the RRT to visit and eventually treat the patients in the ward proactively. In addition, the electronic dashboard can also be considered an approach to reduce alert fatigue in the RRT.

2.5. EWS scoring as standard-of-care

Of particular importance for optimal performance is the managerial endorsement that the EWS assessments and consequential RRT interventions are a hospital-wide standard-of-care protocol. As such, all measurements are standardized nursing measures for which no permission or instruction of the physician is required. Only individualized opting-out is possible, but this must be prescribed for each individual patient as a written medical order if deemed suitable.

2.6. DNR registration

In patients with a do not resuscitate (DNR) code higher than 3, the RRT will not be mobilized. Still, also when the RRT is mobilized, they will consider the DNR code in further patient

management. The awareness of the importance of the DNR code on the RRT interventions will often also result in its more correct and timely registration. The subsequently improved decision-making regarding patient suitability for DNR orders can be one of the explanations of reduced incidence of resuscitations in several reports [29].

3. The rapid response team

3.1. Organization of the response

After reliable identification of patients at risk, the efferent component of the system must be initiated as fast as possible. The first report about the institution of RRTs is dated from 1995 [36]. Initially, in-hospital interventions were also assigned to the regular medical emergency team, but soon specific teams were "tailored to the specific population it serves" [29].

Likewise, the decision to mobilize the RRT was initially left to the personal assessment of the nurse, but in subsequent improvements, the decision-making process was increasingly formalized. An example of such a formalized decision process is shown in **Figure 1**.

3.2. Composition of the team

The composition of the current teams varies between different countries and care systems [8, 29]. Of utmost importance, effective inter-professional communication between and among nurses and doctors is essential for an adequate response [37]. There is still discussion about whether a physician should be part of the RRT, and a meta-analysis did not identify the presence of a physician to be significantly associated with mortality reduction [38]. In addition, the effect of the presence of a physician might be different in university hospitals versus community hospitals, and the response to deterioration might be most effective when a clinician leads it [29]. A recent comprehensive review concluded that there is evidence that RRTs are effective in reducing readmission to ICU (2+) and in reducing hospital mortality (2+) [29].

Hospitalist physicians have been integrated on the general wards in US hospitals since 1996 [39] and might be useful members of the rapid response team. These hospitalists are mostly specialized in general internal medicine and have a coordinating function with a focus on the general medical care of hospitalized patients [40]. Not only are they an important information pool for patients, family members, nurses, and consultants, they also can assign additional diagnostic and therapeutic activities in case of urgent situations [40]. A positive effect of the introduction of hospitalists on the patients' average length of hospital stay and total hospital costs has already been demonstrated [39] but seems to be dependent on the hospitalist workload [41]. Including a hospital physician in the rapid response team can immediately increase the knowledge of a specific patient and decrease the code call rate. However, it does not seem to affect the general hospital mortality rate [42].

Recently, it is believed that there is a need for an acute care physician or so-called resuscitationist who cooperates with specialized trauma surgeons [43]. Currently, there is no data

present which evaluate the effect of the resuscitationist on the outcome of the patient population [44]. Since these physicians are specialized in resuscitation, trauma, and critically ill and emergency patients [44] they might have essential skills to participate in the RRT.

Similar to other physicians, both the acute care physician and hospitalist can bring valuable knowledge to the RRT but are often not able to prioritize RRT calls due to additional tasks and a usually high workload. In practice, a specialized nurse-driven team is therefore often necessary to guarantee an immediate RRT response, while close communication and cooperation with specialized physicians are expected to improve the decision-making process.

3.3. Organization of 24/7 availability

Because of the significant financial cost of a 24/7 operational RRT, while the team is not performing interventions most of the time, they are often attributed other responsibilities within the hospital. It is however imperative that absolute priority is given to the necessary monitoring and interventions to preserve its full effect. When the RRT is not operational 100% of the time, there exists a significant risk that during the absence of the trained RRT, its responsibilities are passed back on the most inexperienced members of the clinical team [29]. Following the NEWS guidelines, the RRT should be free of other clinical responsibilities and available 24/7 [17].

3.4. Educational component

In addition to the implementation of the EWS and RRT, a strong and sustained educational component is of vital importance toward both reducing cardiac arrests and improving decision-making [29]. Recent studies have shown that for an RRT to be successful, it must be implemented with a continuing medical education program [45]. A nurse-driven approach often lowers the threshold for effective communication, improving the educational effect on the nursing staff, ultimately leading to more accurate detection of patient deterioration.

4. Impact of EWS-RRT implementation

The impact of EWS-RRT implementation has been extensively described and resumed in a comprehensive review [29]. Beneficial effects have been shown for specific outcomes, but a comparison is difficult owing to heterogeneities, including but not limited to study design, team composition, duration, RRT area, and nomenclature [38]. As such, standardized reporting is needed to enable comparative analysis [46]. Decreases have been reported in the incidence of cardiac arrest [47–50] and in cardiac arrest mortality [49, 51]. A reported decrease in in-hospital mortality of 1580 lives in the study population would extrapolate to over 100,000 lives saved in Western Europe [50, 52].

The economic implications of an implementation are difficult to measure [11], as the cost of the monitoring outreach team and additional costs at ward level, the use of equipment, and clinical contact time must be compared to the reduction in ICU admissions/readmissions [16].

An unexpected additional advantage may be a more accurate registration of the DNR code [50]. As the RRT improves the quality of care via early identification/reversal of physiological decompensation, this may lead to a more timely activation of palliative therapies and as such enhanced end-of-life care [53].

5. Pitfalls during the implementation

The response of the RRT may suffer from excessive false alerts, making the team desensitized, leading to alarm fatigue [15, 38, 54]. This underlines the necessity of a scoring system with sufficient specificity, such as an aggregate score like EWS.

Manual registration of some variables, such as the respiratory rate, might incite the recording of inaccurate values to limit subsequent burden. Moreover, it is generally recommended that the respiratory rate be counted over a whole minute or two 30 s intervals, and this procedure can represent a significant investment in nursing time in the ward setting, such that accurate rates may only be recorded as little as 37% of the time [15]. The respiratory rate is therefore often particularly poorly recorded, although it may be the most important early manifestation of critical illness [7, 21]. The long-term effectiveness of the program may also decrease in the absence of periodic training and therefore requires continued educational investment [51].

6. Conclusions

The prevention of in-hospital resuscitations requires a "whole system" approach, consisting of a reliable EWS, combined with an effective RRT, sustained feedback, and focused education. In addition to the implementation of the dedicated systems and teams, its effectiveness necessitates a changing culture of the whole organization.

Conflict of interest

No conflicts of interest.

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