

ORIGINAL ARTICLE

The assessment of critically ill patients: Evaluation of the rapid response system in a university medical centre

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Keywords - Hospital Rapid Response Team, general surgery, outcome and process assessment (healthcare), hospital mortality, cardiac arrest, financial analysis, health plan implementation**Thesis committee:**J.G. van der Hoeven¹, L. Schoonhoven^{2,3}, J. Mintjes⁴, B.G. Fikkers¹¹Department of Intensive Care Medicine, Radboud University Nijmegen Medical Centre, Nijmegen, the Netherlands²Scientific Institute for Quality of Healthcare, Radboud University Nijmegen Medical Centre, Nijmegen, the Netherlands³Faculty of Health Sciences, University of Southampton, Southampton, UK⁴Faculty of Health and Social Studies. HAN University of Applied Sciences, Nijmegen, the Netherlands**Abstract**

The aim of the thesis was to gain insight into the effect of a rapid response system (RRS) on cardiac arrests and/or unexpected deaths and on unplanned ICU admissions in surgical patients. In addition, we aimed to gain insight into the effect of a multifaceted implementation strategy on adherence of the ward staff to the afferent RRS procedure. Lastly, we assessed the effects of an RRS on health-related quality of life (HRQOL) and on hospital costs.

Results

We were unable to show a significant positive effect of an RRS on the incidence of cardiac arrest and/or unexpected death, nor on HRQOL. We found that implementation of an RRS increased hospital costs, which were to a large extent caused by the increased number of unplanned ICU admissions after RRS implementation. However, we cannot conclude that introduction of an RRS is ineffective for several reasons. First, the low baseline incidence of cardiac arrest and/or unexpected death made it very difficult to prove a significant reduction in these outcomes in the surgical ward of our hospital. Second, implementation was likely suboptimal since half of the unplanned ICU admissions were not preceded by a medical

emergency team (MET) consultation. Our scenario analysis suggests that costs can be lowered, provided earlier MET calls lead to earlier unplanned admissions to the ICU, resulting in a shorter length of stay in the ICU and lower costs.

Implications for clinical practice and further research

To achieve earlier MET calls further implementation strategies are needed. Continuous evaluation with the use of the outcome parameter 'number of ICU days per 1000 patient-days' may be more helpful to gain insight into the effectiveness of an RRS on a particular ward.

Introduction

Hospital care is becoming increasingly complex and consequently the opportunity for errors also increases. Back in 1991, two large studies in the United States revealed that approximately 3% of hospital patients experienced a serious adverse event (SAE), half of which could have been prevented. Subsequent studies in the United States and other countries were in line with these findings.^[1] A study in the Netherlands showed that 5.7% of hospital patients were confronted with SAEs and 2.3% of these events were possibly due to an error by the hospital staff.^[2] Therefore, a nationwide hospital patient safety program was launched in 2008.^[3] The program consisted of ten main topics, including the implementation of a rapid response system (RRS) for prompt identification and treatment of critically ill hospital patients.^[4] Studies have established that most patients experience unstable vital functions from 1 to 48 hours prior to an SAE.^[5,6] RRSs are based on the concept that if unstable vital functions are timely identified and corrected, SAEs may be prevented and the patient's outcome may improve. Other expected benefits of an RRS are a reduction in unplanned ICU admissions and in hospital length of stay.

An RRS includes an afferent and efferent limb and an evaluation and feedback system. The afferent limb of the RRS stands for the

early detection of critically ill patients and obtaining adequate help. To detect a critically ill patient in a timely matter, a variety of physiological track and trigger systems have been developed. The track and trigger system consists of periodic observations of selected basic vital functions (the 'tracking') with predetermined criteria (the 'trigger') for activating adequate help. The efferent limb includes the assessment of the patient by a specialised team, preferably available 24 hours a day, 7 days a week. These specialised teams should be able to establish a diagnosis, initiate therapy, and rapidly triage the patient to a higher level of care. Thorough documentation and evaluation of response team activation and preventable SAEs for which the response team was not activated is necessary to be able to show improvement of the hospital processes.^[7]

Although the effectiveness of an RRS appears to be self-evident, it is not unequivocally proven by a decline in SAEs.^[8-11] In several studies authors have suggested that the effectiveness of an RRS was underestimated due to underutilisation of the response team. Implementation strategies in these studies included informing or educating the ward staff about the trigger criteria and the procedure of calling in the response team, placement of posters, handing out laminated cards to the ward staff, communication with ward staff members if the calling protocol was not followed and debriefing the ward staff after a response team activation. Continued education and the use of a more sophisticated, broad-based implementation strategy including the use of key leaders, regular feedback etc. are suggested interventions to enhance the effectiveness of the RRS.^[12-14]

Prevention of SAEs is the primary goal of any rapid response system; however, the system may also have an impact on health-related quality of life (HRQOL). Quality of life outcomes reflect a patient's health perspective and contribute to a better understanding of healthcare expenditure and resource utilisation in patient care.^[15]

The aim of this thesis was to gain insight into the effect of an RRS on SAEs in surgical patients. In addition, we aimed to gain insight into the effect of a multifaceted implementation strategy on adherence of the ward staff to the afferent procedure. Furthermore, we assessed the effects of an RRS on HRQOL and on hospital costs. In this article we summarise and discuss the study results.

Effect of the RRS on SAEs in surgical patients

In our hospital the RRS included the use of an early warning score (EWS) system and the introduction of a response team consisting of a physician and a critical care nurse; the medical emergency team (MET), accessible 24/7. The EWS consisted of the following criteria: respiratory rate <8 or >30 per minute, oxygen saturation <90%, systolic blood pressure <90 or >200 mmHg, heart rate <40 or >130 per minute, a decrease of two points in the eye, motor, verbal (EMV) score or if the nurse felt worried about the patient's condition. The protocol included

observation and documentation of the EWS by ward nurses, three times daily. The MET calling protocol was two-tiered. In the first tier, nurses had to call the ward physician immediately if one of the EWS criteria was met. The ward physician had to evaluate the patient at the bedside within 10 minutes. In the second tier, the ward physicians activated the MET immediately if there was a serious situation or if the patient did not stabilise after an initial intervention. If the ward physician was unable to visit the patient in time, nurses were expected to activate the MET directly.

Methods and results

In a before-after study we studied the incidence of cardiac arrest and/or unexpected death and unplanned ICU admissions. Unexpected death was defined as death in the surgical ward or death in the intensive care unit (ICU) after an unplanned ICU admission. An unplanned ICU admission was defined as an unexpected ICU admission from the ward, with or without a preceding emergency reoperation. We included 1376 surgical patients before, and 2410 patients after introduction of the RRS. We showed that the introduction of an RRS on the surgical ward resulted in a 50% reduction of the SAEs cardiac arrest and/or unexpected death, from 0.5% (7/1376) to 0.25% (6/2410). However, this decrease did not reach statistical significance (odds ratio (OR) 0.43; 95% CI 0.11-1.59). In contrast, the number of unplanned intensive care unit (ICU) admissions increased significantly from 2.5% (34/1376) before the implementation of an RRS to 4.2% (100/2400) (OR 1.66; 95% CI 1.07-2.55) after implementation. However, no significant decrease in the median APACHE II score of unplanned ICU admissions (16 vs 16 p=0.68) or in the median unplanned ICU length of stay (3.5 vs 3 days, p=0.94) was found. Finally we showed that MET calls were absent or delayed for one or two days in over 50% of the SAEs although clear warning criteria were present.

Discussion

We were unable to show a positive effect of RRS introduction on the rate of cardiac arrest and/or unexpected death. However, we cannot conclude that introduction of an RRS was ineffective for several reasons. First, the low baseline incidence of cardiac arrest and/or unexpected death makes it very difficult to prove a significant reduction in these outcome parameters in our hospital. Studies that did show a significant reduction in mortality had a high baseline mortality of 10 or more per 1000 admissions.^[13,16-18] Second, we studied the effects of an RRS in surgical patients, because it was expected that those patients would benefit most from the RRS system. However, one study showed that an RRS had a greater impact in medical patients compared with surgical patients.^[18] Third, implementation was likely suboptimal since half of the unplanned ICU admissions were not preceded by a MET consult. Surprisingly, we found a significant increase in unplanned ICU admissions. We question

the hypothesis that an RRS decreases the number of unplanned ICU admissions, as more ward patients may be detected as critically ill and referred to the ICU.

Effect of a multifaceted implementation strategy on adherence of the ward staff to the afferent RRS procedure

Our implementation strategy was multifaceted, including the development of clear objectives; participation and support from key leaders of the medical and nursing staff; use of a tailored RRS procedure including a two-tiered MET warning protocol, a one-day training program including a before-after knowledge test, mandatory for nurses and voluntary for physicians; use of reminders and feedback. After the training program we showed that nurses' knowledge concerning the basic vital functions and the EWS criteria, was adequate.

Methods and Results

After implementation of the RRS we retrospectively analysed a sample of daily patient charts and medical records of patients with a serious adverse event (SAE) from two days preceding an SAE and the day an SAE occurred.

Complete EWS recordings were present in 90% of the day shifts, 88% of the evening shifts and 80% of the night shifts. In addition, in the medical records of patients with an SAE (in)complete EWS recordings were present at least once in 92 of the 101 records; in 91 of those 92 records the EWS was abnormal at least once. In 87% of those events the nurse called the ward physician once or more. After being called by the nurse, the ward physician called the MET once or more in 75%.

Discussion

Our data show a lower observation frequency at night time compared with day time. This fact has been shown by others.^[19] To minimise sleep disturbances, nurses may be reluctant to observe EWSs during the night. Even though there is no international consensus concerning the frequency at which EWS observations should be made, a time interval of 12 hours may be too long.^[20] Furthermore, less EWS values were copied from the daily patient charts into the medical records and often without an exact time indication was missing. The history of a patient's vital signs should be easily accessible for clinicians.^[20] This information is of importance in order to interpret actual vital scores.

Both nurses and ward physicians were less likely to call for help in 13% and 25%, respectively. This may be partly explained by the fact that some patients were temporarily stabilised after a ward staff intervention. Possible other explanations for our findings are that ward staff underestimated the patient's risk of further deterioration. Most ward physicians are juniors and often lack the knowledge and experience to recognise medical emergency situations.^[21] As only 5% of the ward physicians attended the one-day training program, this may certainly

play a role. In contrast, ward staff may have felt that they were able to handle the situation by themselves.^[22,23] For example, Pantazopoulos found that nurses with a higher level of education or who attended a resuscitation course were less likely to call for help.^[24] Furthermore, ward staff may have felt uncertain to call for help even when the patient met the warning criteria.^[23] Nurses often rely on other nursing team members instead of procedures when making their decisions.^[25,26] Nurses' and ward physicians' uncertainty increases when the attending ward physicians or MET do not expect them to follow procedures too rigorously,^[22,27-29] or when they get mixed messages from their leaders when asking for help.^[30,31]

Effects of an RRS on HRQOL

In addition to medical outcomes, quality of life measures are also becoming increasingly important to healthcare research. Quality of life outcomes reflect a patient health perspective and are relevant to better understand and improve healthcare expenditure and resource utilisation in patient care.^[15]

Method and Results

To test the hypothesis that our RRS system has a positive effect on HRQOL, we conducted a prospective cohort study in surgical patients before and after implementation of an RRS. HRQOL was measured using the EuroQol-5 dimensions (EQ-5D) and the EQ visual analogue scale, preceding surgery and at three and six months after surgery.

We found no effect of RRS implementation on the EQ-5D index and EQ-visual analogue scale, three and six months after surgery. This was also true for the subpopulation of patients with the SAE 'unplanned ICU admission'. In an additional analysis we found that pre-surgery HRQOL and American Society of Anesthesiologists physical status (ASA-PS) scores were strongly associated with HRQOL three and six months after surgery.

Discussion

We question if HRQOL is an adequate measure to assess the influence of an RRS, and whether an RRS influences the quality of life after hospitalisation at all, since other factors probably have far more impact on HRQOL.

Effects of an RRS on hospital costs

Proceedings of the first international consensus conference on Medical Emergency Teams claimed an outcome benefit not only including reduction in SAEs but also in ICU and hospital length of stay and lower costs.^[7]

Methods and Results

We have determined the mean costs of the RRS per patient-day. A patient-day was defined as a day of the patient admitted to the hospital. The analysis was performed from a healthcare perspective where only direct medical costs related to the RRS

were included. Costs included implementation (€0.33 per patient-day), training (€0.90 per patient-day), nursing time for extended vital signs observation (€2.20 per patient-day), MET consults (€129.50 per consult, €0.57 per patient-day) and differences in unplanned ICU days before and after RRS implementation (€22.87 per patient-day). The total RRS costs were €26.87 per patient-day, this was an increase of 4.5% of the total hospital costs per patient-day. Most of the RRS costs, 85%, were explained by the increased unplanned ICU days after RRS implementation. We conclude that RRS costs for extra unplanned ICU days were relatively high (€22.87) and remaining RRS costs were relatively low (€4.00).

Furthermore, we have tested the hypothesis that earlier MET calls would lead to admitting patients to the ICU with lower APACHE II scores, resulting in a lower ICU length of stay and lower ICU costs. For this, we performed a scenario analysis. In the scenario we used the mean APACHE II score of 14 points instead of the empirical 17.6 points in patients admitted to the ICU unplanned. The standard deviation was set at 6.1, based on the SD found in our effect study. The APACHE II score range was set from 0 to 48; this range was derived from the hospital ICU database, period 2004-2011. Subsequently, the ICU length of stay for each of the 10,000 simulated APACHE II scores was added into the database. This provides a mean ICU length of stay with an SD based upon a mean APACHE II score of 14. In addition, we included 33% extra MET consults and 22% extra unplanned ICU admissions. In the scenario analysis mean RRS costs per patient-day decreased to €10.18, mainly caused by the decrease in costs for unplanned ICU days.

Discussion

We found that implementation of an RRS increased hospital costs, which were to a large extent caused by the increased number of ICU days per 1000 patient-days after RRS implementation.

Our scenario analysis showed that an increase of unplanned ICU admissions may result in a decrease of ICU days per 1000 patient-days, provided that patients are admitted to the ICU at an earlier stage in their illness. We were aware that the scenario was built on several assumptions. However, the calculated mean unplanned ICU length of stay for the mean APACHE II score of 14 points in the scenario was based on empirical data. Furthermore, in our view, we made realistic assumptions for the costs of extra MET consults and extra unplanned ICU admissions. In addition, we did not correct for the possible reduction of costs for avoiding unplanned ICU admissions as an effect of timely MET consults. Therefore we consider that our scenario analysis is far from being too optimistic. Nevertheless, intervention studies are needed to estimate the effects of earlier ICU referrals on the outcome ICU days per 1000 patient-days and on costs.

Implications for clinical practice and further research

To measure the effects of earlier ICU admissions, first a more intensive use of the MET and referrals of less sick patients to the ICU should be achieved. Therefore, further implementation strategies aimed at an interdisciplinary team level are necessary. Training programs for the interdisciplinary ward staff concerning protocol knowledge and interdisciplinary communication skills alone will probably not suffice, since shared perceptions regarding patient safety norms and behaviours by the ward staff is a premise for successful patient safety interventions.^[32] This means that the ward staff should understand the principles of 'safe design' including standardisation, use of appropriate checklists and learning from mistakes. Furthermore, the ward staff should understand that teams make better decisions with the input from all of the participating disciplines. Elements of a crew resources management training, may also be useful for ward team training.^[33] In addition, education should be continuous since several studies identified this as a major factor affecting the failure of a RRS.^[28] Another reason to train the entire team is that the literature shows that nurses' uncertainty to call the ward physician increases when they get mixed messages from their leaders, including management, senior medical and nursing personnel, when asking for help.^[28,30] Implementation strategies including the team leaders is therefore essential when improving the safety climate.^[34-36] This approach was shown to be effective in a study for improving hand hygiene.^[34] In addition, training the communication skills of MET personnel should also be considered. The literature shows that the communication skills of the MET members are very important for protocol adherence of the ward staff. The MET members should be supportive and behave like colleagues and should never criticise the ward staff for calling the MET.^[37]

Since the effectiveness of our RRS was difficult to show by the outcomes unexpected death and/or cardiac arrest, continuous evaluation with the use of the outcome parameter 'number of ICU days per 1000 patient-days', may be more helpful to get insight into its effectiveness.

In addition, process evaluation is essential since this will give insight into what specific strategies are needed to improve the outcome. Process evaluation by means of a formal debriefing procedure should be carried out immediately after the MET consult. Furthermore, evaluation of the RRS protocol after cardiac arrests, unexpected deaths and unplanned ICU admissions with high APACHE scores where the MET was not consulted is essential to determine if these events were avoidable and if so, to learn from it.

If the 'number of ICU days per 1000 patient-days' does not decrease despite a policy to refer less sick patients to the ICU, further implementation strategies and regular process evaluations, other solutions for the care of the critically ill patient, rather than maintaining (all elements of) the RRS system on a particular ward, should be considered.

Disclosure

The author declares no conflict of interest. No funding or financial support was received.

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