Rapid response systems. Recognition and management of the deteriorating patient
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Chapter 11

Summary in English
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Implementation of new procedures, systems, or therapeutic modalities without rigorous scientific evidence is challenging and maybe even undesired. However, some interventions are inherently difficult to study either because epidemiologic or methodological reasons. An example of this is the implementation of Rapid Response Systems (RRS).

The situation in the Netherlands offered a unique opportunity to study the large scale implementation of RRSs because implementation of an instrument like RRS was mandated by the Inspectorate of Healthcare. This enabled to implement the system in multiple hospitals and contribute to the body of knowledge regarding RRS effectiveness. However, because of the obligatory nature, a randomized and placebo controlled trial like the MERIT trial was impossible. Working within these limitations, the Cost and Outcome of Medical Emergency Teams (COMET) trial has provided important and valid scientific data within this field. More importantly, this thesis has also focused on the afferent side of the system and the reasons for failure in detection of the deteriorating patients. This approach is new and original and sheds light on the degree of implementation and factors associated with (failed) implementation and recognition of the deteriorating patient.

**Part 1. The deteriorating patient on the general ward**

The following studies were aimed to illustrate the state of care that was provided to patients who experienced a (major) adverse event (AE) prior introduction of a RRS or one of its components. Direct focus is paid to the way vital signs are measured and the quality of care is perceived by the care-providers directly prior the events. As the elderly population is a growing proportion of the admitted patients in the hospital, admission to ICU may become necessary during their clinical course. Knowing the prognosis after ICU admission may be helpful to determine if an admission is beneficial. In a systematic review, we review the literature for validated and clinically useful models for prediction of mortality of the elderly ICU population.

**Chapter 2** deals with a retrospective study in which patients experiencing a major AE in 2007 within the Academic Medical Center (AMC) were included. In total, 204 patients experienced either a cardiopulmonary arrest, unplanned ICU admission, emergency surgery, or unexpected death. For these patients, all vital parameters in the preceding 48 hours of the event were analyzed. Current practice in vital signs measurement was analyzed together with the possible usefulness of the Modified Early Warning Score (MEWS). In 81% of the patients, a MEWS of 3 or more (positive MEWS) was found, indicating that they would be identified in the 48 hours prior the event if the MEWS was used at that moment. Measurement of vital signs was unstructured and mostly incomplete. Respiratory rate, oxygen saturation, and diuresis were only measured...
between 17 and 48% of measurements taken and only increased incrementally in case a positive MEWS was present (likely indicating increasing severity of illness). This study gave important insight that a system like the MEWS may be of great value in the clinic to structure nurse assessment and help in prioritization of care provided in the busy ward environment.

To describe the quality of care from the care-provider viewpoint, semi-structured questionnaires were administered to the physicians and nurses who cared for a patient experiencing a major AE. This cross-sectional prospective study is described in chapter 3, which included 47 events and 198 questionnaires of all care-providers taking care for these patients in the 12 hours prior the event. Care-providers were unanimous that the quality of care provided to these patients was good to excellent in respect to communication, cooperation, and coordination of the care with median score between 7.3 and 8.0. However, nurses and residents attributed the coordination of care largely to themselves in 74 and 76% of cases. To interpret the perception and presence of delay in recognition of the deteriorating state, perception of delay was cross-referenced with an expert panel. Negative predictive values of presence of delay compared with an expert panel were 37% for nurses and 38% for the physicians. These findings may partly explain reluctance of care-providers to implement patient safety initiatives including systems like RRS.

In a systematic review described in chapter 4, prognostic research literature was analyzed for developmental and/or validation studies addressing predictive models of mortality in elderly ICU patients. Seven studies were identified which included 17 models of which six were developed for the general adult ICU population and eleven specifically for the elderly patient. The area under the receiver operating characteristics curve was commonly used to measure performance (range 0.71 - 0.88). The median number of criteria met for clinical credibility was 4.5 out of 7 (range 2.5 - 5.5) and 17 out of 20 for methodological quality (range 15 – 20). This systematic review shows that all models score relatively well on methodological quality, however, none can be considered to be clinically useful for the elderly ICU patient at this moment.

**Part 2. Rapid Response Systems**

In the second part of this thesis, the main focus is on effectiveness of a RRS and the Cost and Outcome analysis of Medical Emergency Teams (COMET) trails is described. Besides the effectiveness of a RRS and maybe even more important, studies identifying factors associated with (degrees of) implementation are also presented. These studies provide a new and more comprehensive insight in the process of identification and management of the deteriorating patient.

The degree and content of RRS implementation in the Netherlands is described in chapter 5 in which questionnaires were sent to all medical directors of all the non-
pediatric ICUs in the Netherlands. The questionnaire contained questions how each hospital completed the concept of RRS as proposed by the Health Care Inspectorate. This also contained questions regarding their perception of possible effectiveness and feasibility of the RRS within their institution. The response rate was 88% and interestingly the vast majority of hospitals implemented the RRS as described in the multicenter COMET trial. The MEWS or a similar system was adopted by 86% of the hospitals. In 68% of the hospitals, the track and trigger (TT) system was accompanied by simultaneous implementation of a communication instrument. The Rapid Response Team (RRT) was primarily physician based in 57% of hospitals and available 24/7 in 89%. The added value of the RRS was perceived high (median 4 on a scale of -5 to 5) although perceived workload to maintain and implement the system was also high (median 3). Although general content of the RRS is similar in the Netherlands, nationwide meta-analysis of data regarding cardiac arrest rates and other outcomes is methodologically impossible due to variations between hospitals in the specific content of the systems for instance the MEWS thresholds.

As a first way in which the degree and also culture change was analyzed after implementation of the MEWS and SBAR (Situation-Background-Assessment-Recommendation) tools, nurses from three surgical and three internal nursing wards were compared in a pseudo-clinical environment. In a prospective quasi-experimental design, chapter 6 analyses the application of these tools and differences in identification between two groups of trained and non-trained nurses. 48 non-trained nurses were 77% of the trained nurses assessed the patient immediately versus 58% of the non-trained nurses. Respiratory rate was measured in 53% (trained) versus in 25% (non-trained) nurses. The MEWS was only measured in 11% of trained nurses, but the physician was notified in 67% of trained versus in 43% of the non-trained nurses. This study provided evidence that trained nurses reacted more appropriately to a deteriorating patient but compliance and more rigorous implementation is required to achieve optimal effectiveness.

These findings let to a randomized controlled trial held from September until November 2011 in which the RRS was implemented in the Academic Medical Center. Chapter 7 describes the analysis of the effect of measurement of the MEWS three times daily compared to ‘on indication’ and its effect on earlier detection of the deteriorating patient. In total, 902 patients were included corresponding to 6598 measurements in the three study weeks. Compliance of the protocolized wards to measuring the complete set of vital signs and MEWS was 43%. The indication wards determined the MEWS in just 4% of instances where this was imperative. Delay in notification of the physician was present in 49% of the protocolized compared to in 50% of the indication patients resulting in a relative risk of experiencing delay in recognition of 0.982 (95% CI 0.356 to 2.711). Interestingly, the absolute reduction in incidence of AEs was 37% on the protocolized versus 29% on the indication wards. As the number of RRT calls increased (primarily
on the protocolized wards) patients on these wards were taken less often to the ICU in November compared to September (31% versus 64%). Although this study was not powered to analyze effectiveness of RRS on clinical outcome, protocolized measurement of vital signs and MEWS does show a trend towards a decrease in AEs and earlier recognition of the deteriorating patient compared to MEWS measurement on indication. The finally study revolves around the effectiveness of RRS and the multicenter COMET trial which has been held in 12 Dutch hospitals. Chapter 8 describes the study protocol of this before-after trial in which Generalized Linear Mixed Modeling (GLMM) was employed to correct for confounding. The COMET study is set up to analyze the consecutive implementation of first the detecting limb (MEWS and SBAR instruments) and after seven months, the implementation of the RRT for an additional 17 months. Five months of prior the MEWS phase is incorporated to prospectively collect data as part of the “before phase” of the study. The last five months of the RRT phase, subsequently named “RRT phase”, are used for the primary comparisons within the study. Four nursing wards (two surgery and two internal medicine wards) per hospital were included. The consecutive implementation enabled the differential analysis of the additive effect of RRT compared to the more structured and systematic assessment (MEWS) as part of the afferent limb. As primary endpoint, the composite endpoint of either cardiac arrest, unplanned ICU admission, or mortality rate on the included nursing wards were analyzed. The results of the COMET study are shown in Chapter 9. A total of 166,569 patients were included, representing 1,031,172 hospital admission days. The primary analyses focused on the comparison between the prospectively gathered measurements of the before phase and the last five months of the RRT phase. The results were corrected for case mix variables but also specific hospital confounders including contribution of each hospital and differences between before and the RRT period. The composite endpoint was significantly reduced, adjusted odds ratio (OR) 0.847 (95% CI 0.725-0.989, p=0.036). The individual components of the composite endpoint were also assessed separately. Cardiopulmonary arrests and in hospital mortality were significantly reduced, OR 0.607 (95 CI 0.393-0.937, p=0.018) and OR 0.802 (95% CI 0.644-1.0, p=0.05) respectively. Unplanned ICU admission showed a declining trend, OR 0.878 (95% CI 0.755-1.021, p=0.092). When specific characteristics of the endpoints are analysed, no differences were found regarding patient demographics or disease (severity) markers such as APACHE scores or outcomes after a cardiopulmonary arrest, unplanned ICU admission or death. Only for death, the mean age in the RRT phase was 75.0 (14) compared to 76.8 (12), p=0.021. The ratio of RRT calls per 1000 admissions in the first 12 months in which the RRT was available reached 6.8/1,000 (95% CI 6.2-7.5) and increased in the RRT phase to 7.3/1,000 (95% CI 6.4-8.3).

Finally, we conclude with the discussion of the strengths and limitations of our work. Future research or direct management should focus on the immediate improvement
of compliance. Accountability of care-providers not following agreed protocols should be discussed. In the foreseeable future, automation of patient data will enable (great) leaps in the real-time insight of the processes involved in recognition and management of deteriorating patients including the RRS. At that moment, focus can also be shifted from not only patients experiencing an unplanned ICU admission, but also to those experiencing clinical deteriorating without a serious AE. In this way, the RRS would truly be effective because initial clinical deterioration is immediately detected and management. Also surveillance (from the side line) is much easier and processes can be adjusted more easily and swiftly.

The topics that have been discussed in this thesis are a clear indication that the quality of care for deteriorating patients has improved since the start of these studies. Less cardiopulmonary arrests, unplanned ICU admissions and hospital mortality has been observed after introduction of RRSs. Awareness and systematic evaluation of patients has increased. However the degree of non-compliance creates a situation in which the imperfect implementation of RRSs may have contributed to underestimation of the clinical benefit of RRSs as observed in the COMET study. Despite the lack of randomisation of the COMET study, there is ample evidence that RRSs are effective in the early detection and management of deteriorating patients and that it has a significant contribution in the avoidance of serious adverse events.