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Research Paper

Correlation of the predictive ability of early warning metrics and mortality for cardiac arrest patients receiving in-hospital Advanced Cardiovascular Life Support

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A B S T R A C T

Background: The Modified Early Warning Score (MEWS) helps identify patients experiencing a decline in physiological parameters that indicate risk for cardiac arrest (CA).
Objectives: To assess the association between MEWS values and patient survival following in-hospital CA.
Methods: Retrospective cohort study of patients who experienced in-hospital CA. The relationship between CA survival and MEWS values as well as other risk factors such as age, gender and type of electrographic cardiac rhythms was analyzed using logistic regression.
Results: Survival rate to hospital discharge was 21%. Strong predictors for survival were MEWS values at hospital admission ($p < .002$), younger age ($p < .005$), ventricular fibrillation ($p < .0001$), and ventricular tachycardia ($p < .0001$). Gender and MEWS 4 hours prior to CA were not significantly associated with survival.
Conclusions: Survival following CA was significantly associated with MEWS at hospital admission but not 4 hours prior to CA. The type of cardiac rhythm and age were also predictive of survival.

Introduction

Cardiac arrest (CA) is a leading cause of death in the United States and internationally, with an overall survival rate ranging from 3% to 15%.[1–3] In the U.S., Girotra and colleagues found that survival rates for in-hospital CA have improved from 13.7% to 22.3% over the last decade (2000–2010).[2,4] This improvement in survival rates has been ascribed to the immediate delivery of high quality Advanced Cardiovascular Life Support (ACLS) by trained personnel that has shown an increase in the survival rate two-to three-fold. Nonetheless, among those who survive to hospital discharge, more than 25% suffer permanent neurological disability, requiring nursing home or long-term care.[2,5,6]

Many in-hospital CAs are preceded by subtle changes in physiological parameters, such as pulse, blood pressure, respiratory rate, and level of consciousness which, if identified early, may enable treatments to avoid deterioration and death.[7–12] Failure to respond to these warnings of deterioration in patient respiratory or cerebral function may lead to cardio-respiratory arrest, intensive care unit (ICU) admission and even death.[7,13–15]

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A prediction tool to identify patients at risk of deterioration is critical for preventing the occurrence of serious adverse events. The development of early warning systems to help hospital staff identify patient physiological deterioration began in the late 1990s, based on five physiological parameters (systolic blood pressure, pulse rate, respiratory rate, temperature, and mental state). Building on this, Stenhouse's group developed a modified version of the early warning system.[16,17] On the general medical floors, an elevated MEWS score identifies patients at risk of deterioration, prompting activation of a rapid response team (RRT).[14,15,18,19]

Many studies have highlighted the usefulness of the clinical response to MEWS in reducing the incidence of CAs, the proportion of ICU patient admissions and patient mortality.[20–24] Churpek and colleagues found that MEWS was a more accurate tool when used to detect CA and mortality in younger patients than in elderly patients.[25] More recently, Johnson and Nileswar found a significant increase in survival at hospital discharge after the implementation of MEWS in a tertiary hospital and suggested that MEWS could be used in the hospital to detect impending CA.[26] In contrast, Subbe and colleagues found that the mortality of patients experiencing CA did not correlate with MEWS.[14] Similarly, other studies showed that MEWS values were not associated with CA survival nor with other outcomes, such as transfer to the ICU or high-dependency unit admissions.[14,20] A systematic review concluded that although several studies showed an improvement in patients' clinical outcomes after the introduction of EWS/MEWS systems, it is difficult to draw a general conclusion due to the lack of standardized scores and the use of different patient populations in the studies analyzed.[19] Therefore, the debate continues over the role of MEWS in identifying patients at risk of deterioration and in need of intensive clinical care. We sought to contribute to this discussion by examining the conditions under which MEWS may accurately predict patient survival among patients hospitalized with cardiovascular conditions who experienced CA while hospitalized. Specifically, we examined the relationship between MEWS values and survival immediately after CA, as represented by ROSC, as well as patient survival to discharge. To clarify the process further, we differentiated between MEWS at admission as well as 4 h preceding the CA. In addition, we controlled for risk factors such as age and gender, as well as types of cardiac rhythms. Although cardiac rhythms have been found to be associated with patient survival, they might have limited predictive value for clinicians since they occur close to the time of CA. In this study, we also explore the relationship between cardiac rhythms and MEWS values at admission and 4 h prior to CA.

Methods

Study design

We conducted a retrospective, single-center chart review study at a large tertiary care hospital operating in the New York metropolitan area, focusing on two units, Cardiac Care and Cadiothoracic Telemetry. We examined hospital medical records of 446 patients with cardiovascular conditions, who experienced in-hospital CA (defined by the documented loss of a pulse and respiration) and delivery of ACLS interventions [i.e., cardiopulmonary resuscitation, defibrillation and resuscitation medications] from January 2007 until December 2013.

Human subjects

The Northwell Health Institutional Review Board (IRB#12–428A) approved the study protocol.

Inclusion/exclusion criteria and rationale for sample size

Cardiac patients, 18 years and older, who experienced in-hospital CA and were treated with ACLS were included in the study. We excluded patients who were under do not resuscitate (DNR) or do not intubate (DNI) orders, admitted to the ICU, or treated in the operating suites or emergency department. If a patient had more than one CA on the floor during the hospitalization, only the first event was included. Patient charts with incomplete data were excluded. The sample size for this study was 417 charts. After reviewing 446 charts, we excluded 29 incomplete or illegible charts. The sample size was based solely on feasibilty and resource availability, rather than on a formal power calculation.

Variables measures and procedures

The MEWS calculation was based on a patient's respiratory rate, heart rate, systolic blood pressure, temperature, and mental status where a clinician allocates points to the measurement of these physiological parameters resulting in summary scores.[15] We define MEWS at admission (MEWS-ad) as the first documented MEWS score calculated for each patient upon hospital admission. The investigators calculated the MEWS score 4 h before CA (MEWS-4h). We classified patients into low-risk (1–4.9) and high-risk (5–11) based on their MEWS values.

The hospital first implemented MEWS in 2003. In the hospital, a patient care assistant takes a patient's vital signs every 4 h and a MEWS score is automatically generated when the vital sign scores are entered into the electronic medical record (Sunrise Clinical Manager). If the total is seven or more, the ward registered nurse is immediately informed and the patient's vital signs are measured every 2 h. A MEWS score of nine or more requires calling a Rapid Response Team whereas a MEWS score of 10 or more requires changes in the level of service (i.e., transfer to the ICU).

In this retrospective chart review, an investigator (AR), trained by the site investigator (GM) to properly abstract medical record data, reviewed 446 charts that met the initial inclusion criteria. Return of Spontaneous Circulation (ROSC) was defined as the presence of 60 mm Hg systolic blood pressure and a palpable pulse in the first 20 minutes after ACLS. Sustained ROSC was defined as the presence of 60 mm Hg systolic blood pressure and a palpable pulse more than 20 minutes after ACLS. Other variables considered were: age, gender, and cardiac arrest rhythms. Cardiac arrest data was retrieved from the patients' electronic medical record (Sunrise). We used the CA information recorded by the code team that performed the ACLS. If needed, we also retrieved data from patients' charts and microfilms.

Statistical methods

Descriptive statistics are presented as mean or median/interquartile range (IQR), and as frequency/percentage wherever appropriate, including ranges of values, as needed. A univariable screen was carried out using the chi-square test. Any factor that was significantly ($p < .05$) associated with survival to hospital discharge was included in a multivariable logistic regression model to assess the effects of those factors and survival to hospital discharge. Backward selection was used to remove factors that did not contribute information to the model. Logistic regression was utilized to model survival as a function of each factor of interest; namely, age, gender, cardiac rhythms, MEWS at hospital admission and 4 h prior to cardiac arrest, and ROSC achieved. All reported p values were 2-sided and a p value of less than 0.05 was considered statistically significant. Statistical analyses were performed using