Original Article

Feasibility of using the predisposition, insult/infection, physiological response, and organ dysfunction concept of sepsis to predict the risk of deterioration and unplanned intensive care unit transfer after emergency department admission

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Abstract

Background: Recognizing patients at risk for deterioration and in need of critical care after emergency department (ED) admission may prevent unplanned intensive care unit (ICU) transfers and decrease the number of deaths in the hospital. The objective of this research was to study if the predisposition, insult, response, and organ dysfunction (PIRO) concept of sepsis can be used to predict the risk of unplanned ICU transfer after ED admission.
Methods: The ICU transfer group included 313 patients with unplanned transfer to the ICU within 48 hours of ED admission, and the control (non-transfer) group included 736 randomly sampled patients who were not transferred to the ICU. Two-thirds of the total 1049 patients in this study were randomly assigned to a derivation group, which was used to develop the PIRO model, and the remaining patients were assigned to a validation group.
Results: Independent predictors of deterioration within 48 hours after ED admission were identified by the PIRO concept. PIRO scores were higher in the ICU transfer group than in the non-transfer group, both in the derivation group [median (mean $\pm$ SD), 5 (5.7 $\pm$ 3.7) vs. 2 (2.5 $\pm$ 2.5); $p < 0.001$], and in the validation group [median (mean $\pm$ SD), 6 (6.0 $\pm$ 3.4) vs. 2 (2.4 $\pm$ 2.6); $p < 0.001$]. The proportion of ICU transfer patients with a PIRO score of 0−3, 4−6, 7−9, and $\geq$10 was 14.1%, 46.5%, 57.3%, and 83.8% in the derivation group ($p < 0.001$) and 12.8%, 37.3%, 68.2%, and 70.0% in the validation group ($p < 0.001$), respectively. The proportion of inpatient mortality in patients with a PIRO score of 0−3, 4−6, 7−9, and $\geq$10 was 2.6%, 10.1%, 23.2%, and 45.9% in the derivation group ($p < 0.001$) and 3.3%, 12.0%, 18.2%, and 20.5% in the validation group ($p < 0.001$), respectively.
Conclusion: The PIRO concept of sepsis may be used in undifferentiated medical ED patients as a prediction system for unplanned ICU transfer after admission.
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Keywords: emergencies; intensive care unit; patient transfer; risk factors; sepsis

1. Introduction

The emergency department (ED) is an important source of hospital inpatients, especially those with critical problems. However, the condition of some patients may deteriorate after admission and require an unplanned transfer to the intensive care unit (ICU). Patients with an unplanned ICU transfer after ED admission have a higher rate of mortality than those who are admitted directly to the ICU from the ED.[1−5] Although admissions from the ED account for the majority of unplanned transfers to the ICU,[6] strategies to decrease unplanned ICU transfers after ED admission are lacking. Some researchers have tried to determine the risk of unplanned ICU transfer after ED admission[7,8]; however, these studies were based primarily on administrative data or focused only on certain age groups. The Modified Early Warning Score (MEWS) and its physiologically based derivatives have been validated as predictors of admission, inpatient mortality, and the need for ICU admission in ED patients.[9−13] However, these systems use only vital sign variables and have a lower sensitivity to predict inpatient mortality.[14] In addition, the MEWS is inferior to the Mortality in Emergency Department Sepsis (MEDS) in risk assessment for death in ED patients with sepsis.[15] The MEDS and other scoring systems have been used to identify predictors of death from multiple dimensions, including demographic data, comorbid illnesses, physiological changes, and laboratory abnormalities.[16−18]

The predisposition, insult, response, and organ dysfunction (PIRO) concept was proposed by experts at the International Sepsis Definition Conference in 2001 to describe the phenotypes of sepsis.[19] The PIRO model, with multi-dimensional predictive variables, has been validated in risk staging for sepsis.[20−23] Sharing some common features of clinical presentations with sepsis, diseases other than infections may have risk factors for clinical deterioration and/or mortality from multiple dimensions, similar to the PIRO model for sepsis. This observational study was performed to determine if the PIRO concept of sepsis can be used as a prediction system for unplanned ICU transfer due to clinical deterioration after undifferentiated medical ED admission.

2. Methods

2.1. Setting

This study was conducted in the ED of a suburban teaching hospital. Staffed by full-time emergency physicians (EPs), this ED has historically served approximately 50,000 patients annually with an admission rate of 25%, which accounts for 45% of inpatients in this facility.

2.2. Study design and patients

Patients with non-traumatic conditions who underwent an unplanned transfer to the ICU within 48 hours of ED admission between January 1, 2007 and December 31, 2010, were included in this study (ICU transfer group). Additionally, we randomly sampled patients who were not transferred to the ICU within 48 hours of admission (non-transfer group) to serve as controls. The ratio of controls to cases was approximately 2:1. Patients were included if they were to be admitted to a general ward, but remained in the ED because of a delay in transfer or blocked access. Patients were excluded if they were younger than 18 years of age, were admitted for injuries/intoxications/suicides or obstetric problems, or had critical conditions but initially refused ICU admission. We excluded patients who had signed "do not resuscitate" (DNR) orders, because it may affect the decision of transferring patients to ICU and medical efforts to resuscitate the patients. We also excluded patients who showed no clinical deterioration after admission but were transferred to the ICU for a second opinion of potential risk. Patients who were transferred to the ICU within 48 hours for close monitoring after a major operation or invasive procedure (expected transfer) were also not enrolled in the study. The development of study patients is illustrated in Fig. 1.

Two research nurses with at least 3 years of experience in emergency medicine and critical care, respectively, reviewed the medical records and abstracted the data on a structured data sheet. Another research assistant was responsible for data entry. Each of the research nurses was responsible for different parts of the data abstraction, and one research nurse rechecked the correctness of data entry. A board-certified EP checked the quality of the data sheets and examined the quality of the data by establishing criteria to confirm that the data were logically valid. The research nurses were trained on the objective of the study, the definition of variables, and the technique of reviewing medical records and abstraction of data. Both electronic and written medical records were reviewed to identify the desired information. The research nurses reviewed the diagnoses of outpatient visits and hospitalizations, medication used, and results of examinations to ensure that certain important comorbid illnesses were present.

2.3. Candidate predictor variables

The candidate predictor variables included those of predisposition (P; demographic data, comorbid conditions, and chronic organ insufficiency), insult (I; diseases and organ system), physiological responses to diseases (R; vital sign changes), and organ dysfunction (O). The comorbid conditions were applied in part from the Charlson comorbidity index,[24] and chronic organ insufficiencies were from Acute Physiology and Chronic Health Evaluation (APACHE) scores.[25] We used physiological responses in systemic inflammatory response syndrome as the R variables in our study, but defined a maximum heart rate (HR) $\geq$ 130/minute and a maximum respiratory rate (RR) $\geq$ 30/minute as the thresholds. These threshold values were the same as the highest scores in the MEWS.[9] The acute O variables were introduced from definitions of severe sepsis.[26]

Regarding the reasons for admission, which was used as "Insult" (diseases and organ system) in the PIRO classification, we categorized all patients presenting with infection from