Journal of Microbiology, Immunology and Infection (2014) 47, 469–477

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ORIGINAL ARTICLE

Derivation of a clinical prediction rule for bloodstream infection mortality of patients visiting the emergency department based on predisposition, infection, response, and organ dysfunction concept

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Received 25 February 2013; received in revised form 1 June 2013; accepted 28 June 2013
Available online 19 August 2013

KEYWORDS
Bacteremia;
Bloodstream infection;
Mortality;
Pitt bacteremia score predictive model

Background/Purpose: Bloodstream infection (BSI) is a serious infection with a high mortality. We aimed to construct a predictive scoring system to stratify the severity of patients with BSI visiting the emergency department (ED).
Methods: We conducted a retrospective cohort study consisting of patients who visited the ED of a tertiary hospital with documented BSI in 2010. The potential predictors of mortality were obtained via chart review. Multivariate logistic regression was utilized to identify predictors of mortality. Penalized maximum likelihood estimation (PMLE) was applied for score development.
Results: There were 1063 patients with bacteremia included, with an overall 28-day mortality rate of 13.2% ($n = 140$). In multiple logistic regression with penalization, the independent predictors of death were "predisposition": malignancy (β-coefficient, 0.65; +2 points); "infection": *Staphylococcus aureus* (*S. aureus*) bacteremia (0.69; +2 points), pneumonia (1.32; +4 points), and bacteremia with an unknown focus (0.70; +2 points); "response": body

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http://dx.doi.org/10.1016/j.jmii.2013.06.012

temperature <36°C (1.17; +3 points), band form >5% (1.00; +3 points), and red blood cell distribution width (RDW) >15% (0.63; +2 points); and "organ dysfunction": pulse oximeter oxygen saturation <90% (0.72; +2 points) and creatinine >2 mg/dL (0.69; +2 points). The area under receiver operating characteristic curve (AUROC) for the model was 0.881 [95% confidence interval (CI), 0.848–0.913], with a better performance than the Pitt bacteremia score (AUROC: 0.750; 95% CI 0.699–0.800, $p < 0.001$). The patients were stratified into four risk groups: (1) low, 0–3 points, mortality rate: 1.5%; (2) moderate, 4–6 points, mortality rate: 10.5%; (3) high, 7–8 points, mortality rate: 28.6%; and (4) very high, ≥9 points, mortality rate: 65.5%.
Conclusion: The new scoring system for bacteremia could facilitate the prediction of the risk of 28-day mortality for patients visiting the ED with BSI.

Introduction

Bloodstream infection (BSI) is a serious infection. The estimated 28-day and 1-year mortality rates are about 15–20%[1] and 25%,[2] respectively. Given the heterogeneous nature of BSI, patients with BSI have a wide spectrum of risk for death.[3] The ability to stratify patients based on their disease severity and risk of mortality, is important, especially in order to allocate the limited medical resources. Accordingly, a scoring system to quantify the risk of death is helpful to stratify high-risk patients for intensive care unit (ICU) admission, predict hospital length of stay, and guide treatment decisions.[4]

Several scoring systems have been developed for use in the ICU to predict the risk of death, including the acute physiology and chronic health evaluation (APACHE)[5] and sequential-related organ failure assessment score.[6] However, these two scoring systems were developed for general critically ill patients, not only for bacteremic patients. The Pitt bacteremia score has been developed to assess the severity of bacteremic patients, but it only categorizes patients into "severely ill" or not.[7,8] The Pitt bacteremia score does not provide finer gradations of the mortality risk that exist clinically.

In the 2001 International Sepsis Definition Conference, several researchers advocated staging patients with sepsis, to predict the risk of adverse outcome and the response to therapy. The predisposition, infection, response and organ dysfunction (PIRO) concept was proposed for staging of patients with sepsis.[9] It was inspired by the Tumor-Nodes-Metastasis (TNM) system of cancer staging to predict the outcome of patients and to guide the therapy. The elements of PIRO include predisposition (demographics, comorbidities, and genetics), infection (source of infection and pathogen), response (systemic inflammatory response), and organ dysfunction.[10–13] The PIRO concept has been used to construct models for severity assessment in patients with sepsis, community-acquired pneumonia, and ventilator-associated pneumonia.[14–16] However, it has not been incorporated into risk scoring systems for BSI.

In this study, we aimed to construct a specific risk scoring system, utilizing the predictors readily available in the primary care setting, based on the PIRO concept to predict the severity of patients visiting the emergency department (ED) with BSI.

Materials and methods

Study design and patients

We conducted a retrospective cohort study consisted of patients who visited the ED at the Chang Gung Memorial Hospital (CGMH) in Taoyuan, Taiwan, between January 2010 and December 2010. The hospital is a 3700 bed university-affiliated hospital and tertiary referral medical center in northern Taiwan. This study was approved by the Institutional Research Board of CGMH. Patients who visited our ED and received two sets of blood culture were eligible. If the patients experienced more than one episode of bacteremia, only the first episode was included. Patients who were: (1) <18 years old; and (2) referred from other hospitals, were excluded.

Data collection and case definition

Structured query language (SQL) was used to retrieve clinical information from electronic medical records. We also double-checked the results of the electronic chart review by different program codes, as well as by manual chart review. Potential predictors were obtained, including basic demographic data, underlying disease, blood culture result, infectious focuses, ICU admission, requirement for mechanical ventilation, and mortality date. Body temperature, heart rate, respiratory rate, blood pressure, and Glasgow coma score (GCS) were recorded at triage in the ED. Laboratory data, including complete blood counts, differential counts, serum creatinine, liver function test, serum sodium, serum potassium, C-reactive protein, and arterial blood gas were recorded.

True bacteremia was defined as two separate sets of blood cultures growing the same microorganism, or a single set of positive blood culture with documented infection. When single blood culture yielded coagulase-negative *Staphylococci*, *Corynebacterium* species, *Propionibacterium* species, *Bacillus* species, *Aerococcus* species, or *Micrococcus* species, the blood cultures were considered as contaminants and theses cases were not included.

Liver cirrhosis was diagnosed according to the results of abdominal ultrasonography or an abdominal computed