American Journal of Emergency Medicine 34 (2016) 185–188

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Original Contribution

Effect of an electronic medical record alert for severe sepsis among ED patients

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ARTICLE INFO

Article history:
Received 3 August 2015
Received in revised form 2 October 2015
Accepted 4 October 2015

ABSTRACT

Background: Severe sepsis and septic shock are a major health concern worldwide. The objective of this study is to determine if Severe Sepsis Best Practice Alert (SS-BPA) implementation was associated with improved processes of care and clinical outcomes among patients with severe sepsis or septic shock presenting to the emergency department (ED).

Methods: This is a single-center, before-and-after observational study. The intervention group (n = 103) consisted of adult patients presenting to the ED with severe sepsis or septic shock during a 7-month period after implementation of the SS-BPA. The control group (n = 111) consisted of patients meeting the same criteria over a prior 7-month period. The SS-BPA primarily acts by automated, real-time, algorithm-based detection of severe sepsis or septic shock via the electronic medical record system. The primary outcome was in-hospital mortality. Secondary outcomes included hospital length of stay (LOS), time to antibiotic administration, and proportion of patients who received antibiotics within the target 60 minutes.

Results: Time to antibiotics was significantly reduced in the SS-BPA cohort (29 vs 61.5 minutes, $P < .001$). In addition, there was a higher proportion of patients who received antibiotics within 60 minutes (76.7 vs 48.6%; $P < .001$). On multivariable analysis, in-hospital mortality was not significantly reduced in the intervention group (odds ratio, 0.64; 95% confidence interval, 0.26-1.57). Multivariable analysis of LOS indicated a significant reduction among patients in the SS-BPA cohort (geometric mean ratio, 0.66; 95% confidence interval, 0.53-0.82).

Conclusion: Implementation of the SS-BPA for severe sepsis or septic shock among ED patients is associated with significantly improved timeliness of antibiotic administration and reduced hospital LOS.

1. Introduction

Sepsis is defined as a systemic host response to an infection, which can lead to further complications including severe sepsis (acute organ dysfunction secondary to sepsis) and septic shock (severe sepsis with hypotension refractory to fluid resuscitation). Severe sepsis accounts for a significant portion of mortality and health care costs around the world. The mortality rate varies throughout the literature but can range from approximately 25% to 50% [1-3].

Hospitals throughout the country have been implementing initiatives to reduce sepsis-related mortality and resultant health care costs. The first step in the process to improve survival is early identification of severe sepsis and using an evidence-based treatment protocol [1]. Numerous studies have demonstrated the beneficial impact of implementing a regimented protocol for severe sepsis screening and time-sensitive treatments. Performance improvement efforts for early severe sepsis recognition and subsequent management have been associated with improved patient outcomes including mortality benefits [4-7]. A key component to reducing mortality from severe sepsis is improving time to administration of intravenous antibiotic therapy following diagnostic recognition. Kumar et al [8] published in 2006 a retrospective cohort study to determine the impact of delays in initiation of effective antimicrobial therapy on mortality in patients with septic shock. The study concluded that effective antimicrobial therapy within the first hour of hypotension improved survival and each hour therapy was delayed was associated with a 7.6% reduction in survival [8]. In 2014, Ferrer et al [9] demonstrated that patients with severe sepsis and septic shock had higher mortality when first antibiotic administration was delayed. Their study also found a linear increase in mortality risk for every hour antibiotic therapy was delayed [9]. Initial empiric antibiotic therapy should target all likely infectious organisms. This requires the use of broad-spectrum antibiotics that have demonstrated activity against a

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http://dx.doi.org/10.1016/j.ajem.2015.10.005
0735-6757/

Table 1
Selection criteria

Inclusion criteria	Exclusion criteria
Adult inpatients (≥18 years of age)	Sepsis due to fungal or viral pathogens
ED patients	Expired before receiving first dose of antibiotics
Severe sepsis/septic shock (*ICD-9* code and clinical definition per Surviving Sepsis Campaign)	Palliative care or expired within 24 h of sepsis episode
	Transferred from outside hospital with sepsis
	Admitted to any pediatric service

wide range of gram-positive and gram-negative organisms [1]. The use of a severe sepsis protocol can potentially help ensure timely administration of appropriate therapy.

A successful protocol targeting early recognition and management of severe sepsis requires a systematic approach to diagnosis and treatment. Following implementation of a protocol that involves a diverse team of health care providers, performance improvement measures should be taken to ensure appropriate therapy. Regular feedback to clinicians and audits on protocol compliance have shown to further improve patient outcomes by decreasing overall hospital mortality [10,11].

At the institution, a Severe Sepsis Best Practice Alert (SS-BPA) in the electronic medical record (EMR) was developed for emergency department (ED) patients as part of a quality improvement initiative focused on sepsis-related outcomes. The SS-BPA provided automated, real-time, electronic surveillance for patients meeting criteria for severe sepsis and septic shock. The objective of this study was to determine if SS-BPA implementation was associated with improved processes of care and clinical outcomes among patients with severe sepsis and septic shock presenting to the hospital ED.

2. Methods

2.1. Study design

This is a single-center, before-and-after observational study assessing the efficacy of the SS-BPA in ED patients at an academic medical center. The intervention group (January 2013 to July 2013) was studied via EMR chart reviews from time of SS-BPA implementation. The historical control (March 2012 to October 2012) was assessed via retrospective chart reviews in the EMR before SS-BPA implementation. The EMR used at the hospital is Epic (Madison, WI). This study was approved by the Committee on Human Research (Institutional Review Board) at the institution.

2.2. Intervention

The SS-BPA primarily acts by automated, real-time, algorithm-based detection of severe sepsis and septic shock via the EMR. This was launched October 29, 2012—immediately after the conclusion of the historical control enrollment period. The SS-BPA alerts health care providers with 2 EMR alerts: one when the patient meets 2 or more systemic inflammatory response syndrome (SIRS) criteria and another if severe sepsis or septic shock criteria are met (ie, ≥2 SIRS criteria and the addition of end-organ dysfunction or fluid nonresponsive hypotension, respectively). The alert appears as a pop-up window when the provider logs into the EMR and selects a patient who has met the SS-BPA criteria. Once initiated, the severe sepsis protocol includes drawing serum lactate, drawing blood cultures before administering antibiotics, giving broad-spectrum antibiotics within 60 minutes of meeting severe sepsis or septic shock criteria, and initiating a fluid bolus to restore perfusion (ie, mean arterial pressure >65). Additional components of the protocol process development included real-time quality improvement feedback to all providers involved in bundle noncompliant cases. There also have been intensive educational efforts with faculty, residents, nurse practitioners and physician assistants, nurses, and pharmacists. Lastly, there are monthly department-wide e-mails detailing the ED bundle compliance.

2.3. Study subjects

The target population for the study was all adult patients with severe sepsis and septic shock in the ED. The accessible population included adult ED patients with severe sepsis and septic shock (use of *International Classification of Diseases, Ninth Revision* [*ICD-9*], diagnostic code) at the institution. Selection criteria for patients in this study are listed in Table 1. In the intervention group (prospective observational cohort), patients meeting the definition of severe sepsis or septic shock were sampled by a consecutive sampling strategy. The historical control group consisted of patients meeting the selection criteria and selected from a period before SS-BPA implementation. Chart reviews of patient medical records were conducted to screen for clinical definition of severe sepsis and septic shock (per Surviving Sepsis Campaign definitions [1]) in a manner identical to the intervention group.

2.4. Measurements

The primary predictor variable was study period: before or after implementation of the SS-BPA. Data were collected on potential confounders, which included age, sex, presence of antibiotic allergies, comorbidities (measured by Charlson comorbidity index [12]), predicted mortality due to disease severity on admission (measured by Sequential Organ Failure Assessment [SOFA] score [13]), infectious pathogen (culture data), physiologic source of infection, presence of septic shock, and initial antibiotic regimen.

2.5. Outcomes

The primary outcome variable was in-hospital mortality. Secondary outcomes included time to antibiotic administration (time 0 defined as time when a patient met: ≥2 SIRS criteria, evidence of end-organ dysfunction, and a suspected or confirmed infection), proportion of patients who received antibiotics within target 60 minutes and hospital length of stay (LOS).

2.6. Statistical analysis

Demographic data were analyzed by descriptive statistics. The χ^2 test was used for comparison of categorical variables; and the Student *t* test, for comparison of continuous variables. For variables with nonparametric distributions, the Mann-Whitney *U* test was used. When highly skewed data were present, data were log transformed before statistical analysis. Logistic regression analysis was performed to evaluate for factors associated with the primary and secondary outcomes, and a multivariable logistic regression model was constructed to adjust for potential confounding effects. Statistical analyses were performed with Stata software version 13.0 (Stata Corp, College Station, TX).

3. Results

The study population of ED patients at the institution is shown in Table 2. Various demographics and potential confounders were assessed including SOFA score, Charlson comorbidity index score, and patients who presented in septic shock vs severe sepsis. There were no statistically significant differences between study cohorts, although