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Original Contribution

Prehospital recognition of severe sepsis: development and validation of a novel EMS screening tool☆

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ABSTRACT

Objective: To derive and validate a predictive model and novel emergency medical services (EMS) screening tool for severe sepsis (SS).
Design: Retrospective cohort study.
Setting: A single EMS system and an urban, public hospital.
Patients: Sequential adult, nontrauma, nonarrest, at-risk, EMS-transported patients between January 1, 2011, and December 31, 2012 were included in the study. At-risk patients were defined as having all 3 of the following criteria present in the EMS setting: (1) heart rate greater than 90 beats/min, (2) respiratory rate greater than 20 beats/min, and (3) systolic blood pressure less than 110 mm Hg.
Interventions: None.
Measurements and Main Results: Among 66,439 EMS encounters, 555 met the criteria for analysis. Fourteen percent (n = 75) of patients had SS, of which 19% (n = 14) were identified by EMS clinical judgment. In-hospital mortality for patients with SS was 31% (n = 23). Six EMS characteristics were found to be predictors of SS: older age, transport from nursing home, Emergency Medical Dispatch (EMD) 9-1-1 chief concern category of "sick person," hot tactile temperature assessment, low systolic blood pressure, and low oxygen saturation. The final predictive model showed good discrimination in derivation and validation subgroups (areas under curves, 0.843 and 0.820, respectively). Sensitivity of the final model was 91% in the derivation group and 78% in the validation group. At a predefined threshold of 2 or more points, prehospital severe sepsis (PRESS) score sensitivity was 86%.
Conclusions: The PRESS score is a novel EMS screening tool for SS that demonstrates a sensitivity of 86% and a specificity of 47%. Additional validation is needed before this tool can be recommended for widespread clinical use.

1. Introduction

Early recognition of severe sepsis is of paramount importance in order to facilitate timely initiation of lifesaving treatment. The goal of early recognition is supported by the most recent Surviving Sepsis Campaign guidelines as a means of maximizing mortality benefit, primarily from early antibiotics and intravenous fluid therapy [1–3]. Despite best care practices, however, severe sepsis mortality remains as high as 18% to 30% [3,4]. Notably, the emergency medical services (EMS) care setting is a critical health care access point for up to 40% to 50% of patients with severe sepsis [5]. However, there are currently no standardized, evidence-based screening tools available to enable EMS providers to accurately recognize severe sepsis in the field. This recognition is a crucial first step to the provision of both supportive and definitive therapy. As the point of first medical contact, EMS recognition has the potential to positively impact patient outcomes by allowing for the development of coordinated care systems that facilitate earlier treatment in the emergency department (ED). Notably, this type of strategy has proven beneficial for other life-threatening, time-sensitive conditions including cardiac arrest, heart attack, stroke, and trauma [6–8].

Small studies suggest that EMS recognition of severe sepsis may be beneficial in reducing time to initiation of antibiotic and intravenous fluid administration [9,10]. However, these reports have used screening tools that demonstrate low sensitivity to rule out sepsis, have not been formally validated, or require point-of-care (POC) diagnostic testing such as POC venous lactate that is not readily available to most EMS providers [10–12]. In addition, the need for a practical, reliable EMS screening tool is highlighted by the finding that EMS clinical judgment is only 17% sensitive for recognizing severe sepsis [12]. This finding

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can likely be explained by a variety of factors, most important of which are the following: the absence of a validated EMS screening tool; protocols derived from them; the complex, dynamic, and heterogeneous nature of the sepsis syndrome; and the low-resource nature of ambulances.

A practical, reliable EMS screening tool would allow for earlier recognition of this life-threatening condition and fuel efforts to develop coordinated EMS-ED care delivery systems improve sepsis outcomes through expediting definitive treatment. The aim of this study was to develop a simple, reliable EMS screening tool to aid first responders in detecting severe sepsis. As such, we herein report the derivation and validation of the prehospital severe sepsis (PRESS) score.

2. Methods

2.1. Study design and patient population

A retrospective cohort study of all adult patients (age, ≥18 years) transported by Grady EMS to Grady Memorial Hospital was conducted between January 1, 2011, and December 31, 2012. All patients met a priori criteria for being at risk for having sepsis. The at-risk group was defined in order to both enrich the study population and to reflect the practical realities of how a severe sepsis screening tool might be used. This approach is recommended when creating a predictive model and is similar to the approach used by EMS providers in screening patients for stroke and heart attack, for example [13]. In these situations, screening is not performed on every EMS patient but rather is triggered by the presence of at-risk features such as unilateral weakness or chest pain, respectively.

Patients were defined as being at-risk if all 3 of the following criteria were present in the EMS setting: (1) heart rate (HR) greater than 90 beats/min, (2) respiratory rate (RR) greater than 20 beats/min, and (3) systolic blood pressure (SBP) less than 110 mm Hg. At-risk criteria were chosen based on modified systemic inflammatory response syndrome criteria and previously published reports of the association between low EMS SBP and acute illness [1,14].

Patients were excluded if any of the following conditions were identified by Emergency Medical Dispatch (EMD) call takers or by EMS initial impression on-scene: trauma injury, cardiac arrest, pregnancy, psychiatric emergency, or toxic ingestion. Exclusion criteria were based on (1) existence of mature care pathways for the condition, (2) a low likelihood of severe sepsis being present, or (3) if the condition is not treated in the main Grady ED. Patients were also excluded if the EMS patient care record could not be linked to a corresponding hospital encounter.

2.2. Study setting

Grady EMS manages the EMD of 9-1-1 medical calls for the portion of the City of Atlanta located in Fulton County, GA (88% of the city's population). Of approximately 74,000 annual ambulance transports by Grady EMS, approximately 30,000 are transported to Grady Memorial Hospital, a 900-bed, urban, public hospital. Emergency Medical Dispatch call takers use an integrated software system, ProQA (version 3.4.3.33; Priority Dispatch Corporation, Salt Lake City, UT), to query callers as well as categorize and prioritize caller information [15]. Emergency Medical Dispatch complaint categories are generated by caller answers to scripted questions supplied by the standardized EMD protocol set. The "sick person" category is a standard classifier in the ProQA cardset and software system which is defined by Priority Dispatch as "a patient with a non-categorizable chief complaint who does not have an identifiable priority symptom" [15]. Please see the Appendix for a list of sick person nonpriority complaints.

Grady EMS ambulances are staffed with basic life support emergency medical technicians and advanced life support paramedics. The level of expertise for a given response is based on the acuity of the complaint, as provided by the caller. Information routinely captured during the on-scene evaluation and treatment phase of EMS care includes a chief concern–based patient history, an initial EMS impression, routine vital signs, physical examination, and a summary clinical impression by EMS providers. The guidelines for arriving at these impressions are protocol-driven. Although temperature is not routinely measured, tactile temperature assessment is performed. Emergency medical services tactile temperature assessment has been shown to correlate with first measured, core temperature in the ED [16].

2.3. Data abstraction

Emergency medical services and hospital electronic medical records were manually linked based on the following criteria: date and time of

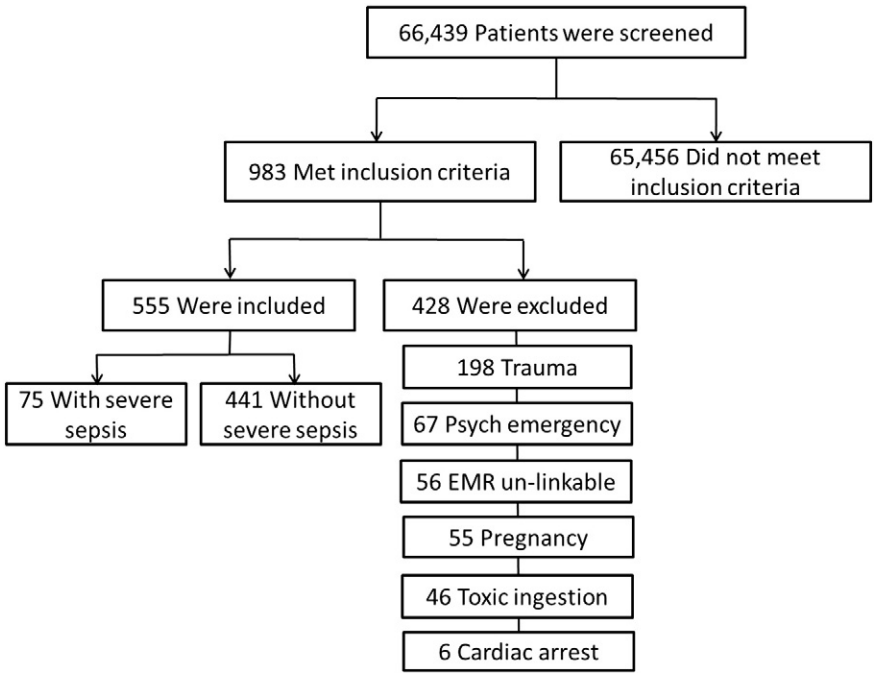

Fig. 1. Patient selection†. Abbreviation: EMR, Emergency Medical Record. †Inclusion criteria: age ≥ 18 y, EMS SBP < 110 mm Hg, EMS HR > 90 beats/min, EMS RR > 20 beats/min.