EARLY DETECTION AND TREATMENT OF PATIENTS WITH SEVERE SEPSIS BY PREHOSPITAL PERSONNEL

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Abstract—Background: Severe sepsis is a condition with a high mortality rate, and the majority of patients are first seen by Emergency Medical Services (EMS) personnel. Objective: This research sought to determine the feasibility of EMS providers recognizing a severe sepsis patient, thereby resulting in better patient outcomes if standard EMS treatments for medical shock were initiated. Methods: We developed the Sepsis Alert Protocol that incorporates a screening tool using point-of-care venous lactate meters. If severe sepsis was identified by EMS personnel, standard medical shock therapy was initiated. A prospective cohort study was conducted for 1 year to determine if those trained EMS providers were able to identify 112 severe sepsis patients before arrival at the Emergency Department. Outcomes of the sample of severe sepsis patients were examined with a retrospective case control study. Results: Trained EMS providers transported 67 severe sepsis patients. They identified 32 of the 67 severe sepsis patients correctly (47.8%). Overall mortality for the sample of 112 severe sepsis patients transported by EMS was 26.7%. Mortality for the sample of severe sepsis patients for whom the Sepsis Alert Protocol was initiated was 13.6% (5 of 37), crude odds ratio for survival until discharge was 3.19 (95% CI 1.14–8.88; \( p = 0.040 \)). Conclusions: This pilot study is the first to utilize EMS providers and venous lactate meters to identify patients in severe sepsis. Further research is needed to validate the Sepsis Alert Protocol and the potential associated decrease in mortality. © 2013 Elsevier Inc.

Keywords—prehospital; Emergency Medical Services; sepsis; venous lactate

INTRODUCTION

Severe sepsis and septic shock combined are the 10th leading cause of death, resulting in 215,000 deaths annually and 50.37 deaths per 100,000 people in the United States (US) (1). There are an estimated 751,000 cases of sepsis every year, and age-related, sepsis-associated mortality continues to rise (2,3). The cost of caring for this group of patients is estimated to be $22,100 per case and $16 billion annually (2). More than one third of Emergency Department (ED) patients with an infection and patients with severe sepsis and septic shock received their initial care from prehospital personnel (4,5). In addition, patients presenting by Emergency Medical Services (EMS) have higher mortality rates, even after adjusting for demographics and comorbidities (5). Health care providers can decrease patient morbidity and mortality by identifying those with severe sepsis as early as possible and initiating treatment in the most proximal phase of illness (6–8).

Early EMS detection of patients with other severe and critical disorders and advance notification to the receiving
ED has been shown to decrease time to diagnosis and treatment times and potentially improve outcomes. For example, in cases of acute stroke, EMS providers have been trained to identify patients and relay this information to the receiving hospital. These patients have shorter door-to-computed tomography scan times and a modest increase in the use of tissue plasminogen activator (9). Similarly, decreased door-to-balloon times have been demonstrated in ST segment elevation myocardial infarction patients by using prehospital electrocardiograms (10,11). A need for increased awareness and more aggressive treatment in the out-of-hospital setting has been recommended previously, and a prehospital severe sepsis screening tool based on consensus definitions has been developed, but not tested (5,12).

We created this pilot study to investigate the feasibility of a prehospital sepsis screening tool. To that end, we developed a methodology comparable with the cardiac and stroke alert prenotification process to the ED. The Sepsis Alert Protocol (Table 1) contained many familiar components of our longstanding EMS cardiac and stroke alert programs, such as early notification and standardized EMS treatment (13). Our study included two components, identification and treatment. The identification component was executed solely by EMS. The treatment component was initiated by EMS and was to be continued by the ED staff after arrival in the ED. It is important to note that the treatments initiated before hospital arrival were standard EMS interventions for medical shock and contained no new treatment modalities except prompt initiation of treatment. For the ED, treatment was defined as reception of the patient by appropriate staff with the resources necessary for the care of a patient in severe sepsis. Continuation of EMS-initiated treatments was at the discretion of the receiving ED physician.

The primary objective of this study was to determine if EMS providers could identify patients with severe sepsis after having received training in identification of severe sepsis using an evidence-based screening instrument. The secondary objective was to examine differences in mortality between EMS patients in severe sepsis for whom the Sepsis Alert Protocol was initiated or not initiated. We also attempted to evaluate any factors or interventions identified a priori from past studies that might have affected patient survivability: patient comorbidities, time to antibiotics, amount of intravenous fluid infused, central line placement, and intubation. In addition, we have established a platform for future research studies on prehospital identification and treatment for severe sepsis.

**METHODS**

**Setting**

The three participating hospitals are tertiary care centers and collectively care for > 80,000 ED patients annually. Approximately 57% of the 911 EMS transports into the three hospitals are from EMS agencies that function under the medical control of the researching entity. Four board-certified Emergency Physicians provide medical direction for the various agencies, with additional staff responsible for supervision, training, and education for > 950 Emergency Medical Technicians (EMTs) and paramedics. All 911 calls are received and screened by dispatchers and responding units are Advanced Life Support—staffed with two paramedics or one paramedic and an Emergency Medical Technician. The three hospital EDs participating in the study were staffed by physicians from one group who agreed to fully cooperate with the study. This cooperation enabled uniform reception of all study patients across the three hospital EDs.

**Study Design and Data Collection**

This study used a multi-method, quantitative design in order to evaluate first the feasibility of EMS early identification of severe sepsis before hospital arrival and, second, if there would be any improvement in outcomes for those patients treated early for severe sepsis. The first analysis extended for 1 year and used a prospective cohort study to evaluate if EMS providers trained in sepsis recognition could successfully identify patients in severe sepsis using the Sepsis Alert Protocol screening tool. The independent variable, or exposure, in the cohort study is application of the screening tool by trained EMS providers, and the outcome variable is percent of severe sepsis patients correctly identified. Data were collected prospectively during the study time frame on this cohort of EMS providers and the success of their recognition and identification in the prehospital setting of severe sepsis patients. Patient data were collected retrospectively on the number of EMS patients that arrived at the ED in severe sepsis that EMS providers, previously instructed in the Sepsis Alert Protocol, failed to recognize. Identification

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**Table 1. Prehospital Sepsis Alert Protocol Criteria as Stated on Laminated Cards**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 years and older and not pregnant</td>
<td>18 years and older and not pregnant</td>
</tr>
</tbody>
</table>
| At least two systemic inflammatory response syndrome criteria | Temperature > 38 °C (100.4 °F) or < 36 °C (96.8 °F)  
Pulse > 90 beats/min  
Respiratory rate > 20 breaths/min or mechanically ventilated  
Suspected or documented infection  
Hypoperfusion as manifested by one of the following:  
Systolic blood pressure < 90 mm Hg  
Mean arterial pressure < 65 mm Hg  
Lactate level ≥ 4 mmol/L |

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Table 2. Level 2 Screening: Patient Charts Were Reviewed for All Three of the Following Criteria During Their Emergency Department Stay

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>&gt; 38°C (100.4°F) or &lt; 36°C (96.8°F)</td>
</tr>
<tr>
<td>Pulse</td>
<td>&gt; 90 beats/min</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>&gt; 20 breaths/min or mechanically ventilated</td>
</tr>
<tr>
<td>White blood cell count</td>
<td>&gt; 12,000, or &lt; 4,000, or &gt; 10% bandemia</td>
</tr>
<tr>
<td>Suspected or documented infection as noted in the medical record</td>
<td></td>
</tr>
<tr>
<td>Hypoperfusion as manifested by one of the following:</td>
<td></td>
</tr>
<tr>
<td>Systolic BP</td>
<td>&lt; 90 mm Hg</td>
</tr>
<tr>
<td>MAP (calculated)</td>
<td>&lt; 65 mm Hg</td>
</tr>
<tr>
<td>Lactate level</td>
<td>≤ 4 mmol/L</td>
</tr>
</tbody>
</table>

BP = blood pressure; MAP = mean arterial pressure. Emergency Department vital signs and laboratory values are on patient arrival.

consisted of a three-level process: Level 1 review examined the medical records of all ED patients arriving by EMS at the three participating hospitals during the study period to identify patients with one or more of the International Classification of Diseases, Ninth Revision diagnosis codes associated with an infection (2). Level 2 screening consisted of a review of the medical charts from patients identified in the level 1 screening. Severe sepsis patients were identified through examination of initial ED vital signs, initial white blood cell count (WBC), initial venous lactate levels, and primary diagnosis (Table 2). Lastly, EMS patient care reports of unidentified patients were also examined for vital signs, mean arterial pressure values, and venous lactate levels to determine if they would have met criteria for severe sepsis using the Sepsis Alert Protocol. Inclusion criteria for the cohort study were only those EMS providers that transported patients into the three participating hospitals and were trained in identification of severe sepsis using the Sepsis Alert Protocol.

The second analysis used a retrospective case-control study to examine mortality for EMS severe sepsis patients. The independent variable was identification and initiation of treatment using the Sepsis Alert Protocol, and the outcome variable was survival until discharge. Cases were the group of EMS severe sepsis patients that were prospectively identified and treated by EMS using the Sepsis Alert Protocol. Controls were those severe sepsis patients unrecognized by EMS that arrived at the ED in severe sepsis, identified retrospectively by structured chart review. Inclusion criteria consisted of all severe sepsis patients transported to the ED by both trained EMS providers and untrained EMS providers during the study time frame and were admitted to the hospital. Exclusion criteria for both studies were any patients under 18 years old, pregnant patients, and hospital-scheduled transfers. Any patient for whom an EMS provider initiated the Sepsis Alert Protocol before hospital arrival was tracked. These included providers that did not participate in the instruction on recognition and treatment; they, however, were excluded from the cohort study examination identification. One of the principal study investigators, an EMS educator specializing in quality assurance and research, performed structured chart reviews on the prehospital reports and ED and hospital admission records to obtain demographic and clinical information.

A total of 15,338 EMS patients presented to the three participating EDs during the study time frame and, of those patients, 1,069 were identified as having infections. Application of the level 1 and 2 screening tools identified a total of 112 EMS patients transported to the three EDs in severe sepsis. They formed the sample of patients under study.

**Human Subject Committee Review**

This study was approved by the participating hospitals’ Joint Institutional Review Board and met criteria for waiver of informed consent for research in Emergency settings.

**Operational Definitions of Variables and Protocol**

- **Trained EMS providers**: defined in this study as EMTs and paramedics who were trained by the research team in the identification of severe sepsis and the Sepsis Alert Protocol before the start of the study.
- **Severe sepsis**: defined as an infection and is indicated by the presence of two or more systemic inflammatory response syndrome (SIRS) criteria with associated hypoperfusion (14).
- **Severe sepsis patient**: EMS patient with a primary diagnosis of severe sepsis upon arrival to the ED.
- **Cryptic sepsis**: severe sepsis with venous lactate ≥ 4 mmol/L, systolic blood pressure > 90 mm Hg, and mean arterial pressure > 65 mm Hg (15,16).
- **Sepsis Alert Protocol screening tool**: designed by the principal investigators by modifying the well-accepted SIRS criteria: respiratory rate > 20 breaths/min or mechanically ventilated, temperature > 38°C (100.4°F) or < 36°C (96.8°F), and heart rate > 90 beats/min (14,17,18). Identification criteria were fulfilled by verifying two of the three SIRS criteria: a suspected or known infection and by demonstrating hypoperfusion, defined as systolic blood pressure < 90 mm Hg, mean arterial pressure < 65 mm Hg, or venous lactate ≥ 4 mmol/L. The screening tool does not use the WBC measure as a SIRS criterion because this
Emergency Physician, an ED registered nurse, a critical care technician, the nursing supervisor for the hospital, a phlebotomist, a medical imaging technician, and a respiratory therapist. The portable ED ultrasound and equipment for central-line insertion was placed in the room. Further treatment was determined by the attending Emergency Physician, according to established ED protocols for treatment of severe sepsis.

- **Sepsis Alert Protocol patient**: EMS patient identified by prehospital providers using the Sepsis Alert Protocol screening criteria described previously.

- **Description of EMS education and training**: Two months before beginning the study, 686 EMTs and 265 paramedics were given a mandatory 2-h class on the pathophysiology of severe sepsis, which included how to identify patients with severe sepsis using the Sepsis Alert Protocol criteria and venous lactate meters. Agency medical directors and staff educators carried out the instruction during November 2008, consisting of formal instruction with a single PowerPoint presentation created by the study primary investigator. Due to regulation from the state of Colorado at the time of the study, only paramedics could measure venous lactates. All trained EMS providers were given quick reference cards (Table 1) that delineated the Sepsis Alert Protocol criteria and included a table to determine mean arterial pressure. In May of 2009, all participating EMS agencies received venous lactate meters for use in the study.

- **Time frame**: Training began November 1, 2008; prospective data collection of identified patients began January 1, 2009, and was completed December 31, 2009. The case-control study examining mortality was not begun until after the cohort study completion December 31, 2009.

### Analytical Methods

Percentages were used to summarize positive identification of the severe sepsis patient for the cohort study. Mortality was examined by case-control study using an odds ratio to evaluate the effect of the Sepsis Alert Protocol on mortality: Fisher’s exact test with Yates continuity correction, and 95% confidence intervals for the odds ratio was calculated to determine if there were any significant differences. Descriptive statistics were calculated for all severe sepsis patients (n = 112) transported by both trained EMS providers and those providers who did not receive the Sepsis Alert Protocol education. These statistics included demographic information, prehospital vital signs, fluid administration at 6 h, total fluid administration, and time to antibiotic administration, length of

<table>
<thead>
<tr>
<th>Table 3. Emergency Medical Services Treatment Protocol for Medical Shock Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administer high-flow oxygen via non-rebreather mask</td>
</tr>
<tr>
<td>Establish two large-bore intravenous lines and draw blood samples</td>
</tr>
<tr>
<td>Administer 20-cc/kg bolus of crystalloid fluid in 500-cc increments with reassessment of blood pressure and breath sounds after each bolus</td>
</tr>
<tr>
<td>Contact base station if systolic blood pressure remains &lt; 90 mm Hg after the 20-cc/kg bolus</td>
</tr>
<tr>
<td>Reassess patient regularly and record vital signs, breath sounds, cardiac rhythm, pulse oximetry, venous glucose, and capnography (if available)</td>
</tr>
</tbody>
</table>
stay, endotracheal intubation, and central line placement. Results were examined for significant differences between Sepsis Alert Protocol patients and non—Alert protocol patients using Wilcoxon rank-sum for nonparametric data and Student’s t-test for continuous variables. Bivariate analysis using Pearson’s χ² assessed homogeneity in comorbidities between Sepsis Alert Protocol patients and non—Alert protocol patients. Spearman’s ρ was used to calculate correlation coefficients between prehospital venous lactate values and hospital venous lactate values. Data for both the Sepsis Alert Protocol patient and non—Sepsis Alert Protocol groups are presented as mean and standard deviation of the mean. Significance for all statistical tests was set a priori to an α of 0.05. Analysis was performed with SPSS version 17.0 (SPSS Inc., Chicago, IL).

RESULTS

During the study time frame of 2009, trained EMS providers transported 67 of 112 EMS patients in severe sepsis to the EDs of our three hospitals. Trained EMS providers identified 32 (47.8%) of the severe sepsis patients and initiated the Sepsis Alert Protocol. Trained EMS providers did not identify 35 of the 67 patients with documented severe sepsis upon hospital arrival and initial ED evaluation. In five of these unidentified cases, the patient’s systolic blood pressure, mean arterial pressure, and venous lactate did not meet the hypoperfusion criteria to initiate the Sepsis Alert Protocol before hospital arrival; however, the first vital signs upon arrival in the ED confirmed hypoperfusion. In an additional eight patients with cryptic septic shock, the prehospital providers did not yet have access to venous lactate meters, and the patients were identified by the first lactate measurement in the ED. Thirteen patients were identified as having severe sepsis by using the SIRS criteria of WBC and this test was not available to the prehospital providers. The remaining nine severe sepsis patients did not require identification using hospital-specific tests and met Sepsis Alert Protocol criteria for identification, but were not recognized by trained EMS providers (Table 4).

Overall mortality for the sample of 112 patients in severe sepsis was 26.7% (30 of 112). Mortality for the sample of severe sepsis patients for whom the Sepsis Alert Protocol was initiated was 13.6% (5 of 37). Crude odds ratio for survival until discharge was 3.19 (95% CI 1.14–8.88; p = 0.040, Fisher’s exact test) (Table 5). Within the entire sample of 112 severe sepsis patients transported by EMS, 5 patients were correctly identified in severe sepsis and treated by EMS providers who did not receive instruction in severe sepsis recognition and the Sepsis Alert Protocol. Examination of hospital treatments between Sepsis Alert Protocol patients and non—Alert protocol patients (Table 6) revealed that Sepsis Alert Protocol patients were intubated less frequently than non-Alert patients (8% vs. 35%; p = 0.003). While chronic obstructive pulmonary disease was the only significant comorbid difference between the study groups (Table 7), there was no association between having chronic obstructive pulmonary disease and incidence of intubation (χ², p = 0.517). Antibiotic administration was more prompt in the Alert protocol sample than non-Alerts, but the result did not reach statistical significance. There was no significant difference between Alert patients and non-Alert patients receiving central lines. Baseline characteristics (Table 8) of systolic blood pressure, heart rate, and temperature were all significantly higher in the Alert group, while the WBC was higher in the non-Alert group (Table 8). Although not statistically significant, Sepsis Alert Protocol patients received more fluids at 2 h and 6 h than non-Alert patients (Table 9); non-Alert patients received more fluids over their entire length of stay. Hospital length of stay was shorter for Alert patients, although not to a statistically significant degree. Spearman’s ρ correlation was 0.86 for 22 prehospital venous lactates with hospital-recorded venous lactates (p = 0.001). Mean patient arrival to ED venous lactate assessment was 14.9 min and all hospital readings were within 1 h of the prehospital measurement.

DISCUSSION

Sepsis is a leading cause of death, with an estimated annual mortality of 215,000 deaths annually and 50.37 deaths per 100,000 people in the US (1). While the rate of increase in sepsis-related deaths has decreased over the last 20 years, the aging population is contributing to an overall increase in sepsis-related mortality (3). The faster patients with severe sepsis can be identified and treated, the better their outcomes, as demonstrated by the national Survive Sepsis program and Early

Table 4. Patients with Diagnosis of Severe Sepsis: Sepsis Alert Protocol Was Not Initiated by Trained Paramedics Using the Screening Tool

<table>
<thead>
<tr>
<th>Protocol Not Initiated Due To</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prehospital vital signs did not meet criteria</td>
<td>5</td>
</tr>
<tr>
<td>Patients had crypetic shock and EMS lactate was not available</td>
<td>8</td>
</tr>
<tr>
<td>Patients were identified by an elevated WBC SIRS criteria</td>
<td>13</td>
</tr>
<tr>
<td>Severe sepsis not recognized by providers</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>35</strong></td>
</tr>
</tbody>
</table>

EMS = Emergency Medical Services; SIRS = systematic inflammatory response syndrome; WBC = white blood cell count.
Goal-Directed Therapy (6–8,26–28). Our hypothesis was that EMS providers can further decrease morbidity and mortality of patients with severe sepsis by identifying and treating these patients before hospital arrival. Earlier resuscitation of the sepsis patient should intuitively lead to improved outcomes, but this has never been demonstrated in the prehospital setting. Many patients with severe sepsis and septic shock receive their initial treatment in the ED and present via the EMS system (5). This provides an opportunity for prehospital treatment to potentially improve the outcomes of this cohort of patients. Unlike hospital-based Early Goal-Directed Therapy, no complex procedures, such as central-line placement, are required. All procedures initiated are used frequently by EMS providers to treat hypoperfusion and shock. These prehospital measures, nearly universally available in the US, can easily be applied by most EMS agencies.

Despite the large number of patients being treated by out-of-hospital providers, EMS education has been lacking in this area. Results of a Web-based survey of 226 EMS providers demonstrated poor understanding of the diagnosis and management of sepsis (29). An EMS provider’s sepsis knowledge base did not correlate with years of training or experience as an EMS provider. Treatment in the prehospital setting has also been shown to be variable, with up to one third of patients with severe sepsis not receiving an intravenous catheter or intravenous fluid (30,31). A need for increased education and awareness coupled with earlier aggressive resuscitation in the out-of-hospital setting has been recommended previously, and a prehospital severe sepsis screening tool based on consensus definitions has been developed, but not tested (5,12).

A basic concern for the Sepsis Alert Protocol was the potential harm aggressive treatment can cause patients incorrectly identified with severe sepsis (false positives). Because our EMS treatment was unchanged from existing medical shock protocol, we theorized this would not be the case. In our pilot study, 11 false-positive patients were identified. All had serious medical conditions other than severe sepsis requiring emergent treatment (Table 10). All 11 of these patients required hospital admission and none were subsequently found to be harmed by early initiation of medical shock treatment specified in the Denver Metro EMS Medical Directors patient treatment protocols. This finding should be corroborated by a larger study and remains a legitimate concern.

Trained EMS providers failed to identify 35 of 67 severe sepsis patients documented on hospital arrival and initial ED evaluation. Absence of confirmatory vital signs consistent with severe sepsis before hospital arrival and the inability to perform WBC accounted for more than half (18 of 35) of those not identified (Table 4). Universal prehospital utilization of venous lactate monitors might...
have assisted in identifying an additional eight patients for whom presenting ED venous lactate was > 4 mmol/L. If these limitations are addressed, a significant improvement in our prehospital screening tool would likely result.

Severe sepsis is a continuum of disease; in the case of many patients, global hypoperfusion occurs before changes in blood pressure (28,32). Lactate identifies shock in a more proximal phase in sepsis and trauma and, to our knowledge, is the first study using prehospital venous lactate measurements to identify patients with severe sepsis (28,32,33). The prehospital venous lactate values enabled the prehospital providers to accurately use the screening tool in eight cases and,


<table>
<thead>
<tr>
<th>Variable</th>
<th>Alert (n = 37)</th>
<th>Non-Alert (n = 75)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y), mean ± SD</td>
<td>72.4 ± 15.1</td>
<td>72.5 ± 16.6</td>
<td>0.46</td>
</tr>
<tr>
<td>Sex (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>34.0</td>
<td>66.0</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>32.3</td>
<td>67.7</td>
<td></td>
</tr>
<tr>
<td>Systolic BP (mm Hg), mean ± SD</td>
<td>104.6 ± 21.0</td>
<td>96.7 ± 26.1</td>
<td>0.041</td>
</tr>
<tr>
<td>Heart rate (beats/min), mean ± SD</td>
<td>111.6 ± 19.4</td>
<td>109.7 ± 27.3</td>
<td>0.003</td>
</tr>
<tr>
<td>Temperature (°C), mean ± SD</td>
<td>38.6 ± 1.3</td>
<td>37.2 ± 1.8</td>
<td>0.003</td>
</tr>
<tr>
<td>Respiratory rate (breaths/min), mean ± SD</td>
<td>26.0 ± 7.8</td>
<td>23.9 ± 8.0</td>
<td>0.39</td>
</tr>
<tr>
<td>Mean arterial pressure (mm Hg), mean ± SD</td>
<td>72.0 ± 16.5</td>
<td>67.1 ± 19.6</td>
<td>0.069</td>
</tr>
<tr>
<td>Baseline laboratory values, mean ± SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White cell count (per liter)</td>
<td>11.6 ± 7.5</td>
<td>16.9 ± 9.2</td>
<td>0.007</td>
</tr>
<tr>
<td>Lactate (mmol/L)</td>
<td>4.6 ± 6.5</td>
<td>4.7 ± 4.2</td>
<td>0.27</td>
</tr>
</tbody>
</table>

BP = blood pressure; SD = standard deviation.
* Statistically significant where p < 0.05.

### Table 9. Intravenous Fluid Administration: Sepsis Alert Protocol Patients and Non–Sepsis Alert Protocol Patients with Severe Sepsis

<table>
<thead>
<tr>
<th>Intravenous Fluid Administered</th>
<th>Sepsis Alert Patients</th>
<th>Non-Alert Patients</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid at 2 h (n = 77†)</td>
<td>16.88 ± 12.97</td>
<td>14.97 ± 11.87</td>
<td>0.54</td>
</tr>
<tr>
<td>Fluid at 6 h (n = 108†)</td>
<td>42.97 ± 33.23</td>
<td>35.17 ± 26.81</td>
<td>0.30</td>
</tr>
<tr>
<td>Total fluid (n = 108†)</td>
<td>208.4 ± 258.9</td>
<td>263.4 ± 228.2</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Values presented as cc/kg. Includes fluids given by prehospital providers. Values presented as mean ± standard deviation.
* Wilcoxon rank sum.
† Missing values in patient records; 35 missing values at 2 h and 4 missing values at 6 h and total time.

if available, might have contributed to the identification of eight additional patients with cryptic septic shock. Of all 112 patients with severe sepsis in our study, 30% were found to have cryptic septic shock. This is not dramatically different from a recently published prevalence of prehospital cryptic shock in septic patients of 20% (15). Either figure represents a significant proportion of severe sepsis patients and highlights the importance of EMS venous lactate monitor utilization to properly identify and treat these patients. Furthermore, lack of evidence of hypoperfusion before hospital arrival and the inability of EMS to measure WBC count or venous lactates would account for 26 of the 35 severe sepsis patients not identified by EMS. All of these conditions were not within the control of the treating EMS provider and lend credence to the potential for a significant improvement in the reported accuracy of our identification tool if these limitations are addressed.

The outcomes of mortality and measures of hospital interventions and intravenous fluids received were evaluated for all Sepsis Alert Protocol and non-Alert patients. The overall mortality for our study patients was 26.7%, similar to other recent reports (3,8,27,31,34,35). Patients identified before hospital arrival as Sepsis Alert Protocol patients had significantly decreased mortality and rates of intubation. In addition, this set of patients trended toward receiving greater volumes of intravenous fluids, having shorter times to ED administration of antibiotics and shorter lengths of hospital stay, although none of these observations reached statistical significance (Table 6).

The improved mortality and decreased intubation rates observed in this pilot study are evidence that early recognition and treatment of patients in the prehospital setting can potentially improve outcomes in severe sepsis. The accuracy of the Sepsis Alert Protocol screening tool can be improved with increased initial education coupled with prompt follow-up on individual performance, universal use of point-of-care venous lactate meters, and obtaining core body temperatures. The authors of this study
also believe greater, more focused education for all EMS personnel, pertaining solely to proper utilization of the screening tool, will enhance the tool’s precision. The assessment tool will always have some limitation because the diagnosis of severe sepsis relies on the SIRS criteria, including abnormal WBC, a test not currently available to EMS health care providers. Caution must be applied in adopting this new sepsis protocol in additional EMS systems until it is validated in other trials.

This pilot study is the first to utilize EMS providers to identify patients in severe sepsis (15). It was designed to explore the feasibility of sepsis identification by prehospital personnel. The true value of this research might lie in the clinical importance of early EMS identification of severe sepsis driving accelerated treatment modalities in both the prehospital setting and EDs.

**Strengths and Limitations**

Our study had several limitations that require discussion. The primary limitation was the small sample size of EMS patients transported with severe sepsis, evident in the wide confidence intervals for the odds ratio. This small sample size prevented us from achieving greater precision in determination of the effect size, however, statistical significance was achieved. Selection bias in retrospective designs cannot be overlooked, although controls were representative of those individuals who would have been selected as cases had they been recognized as severe sepsis patients. These patients were selected independent of any risk factors for severe sepsis except documented infection. The introduction of venous lactate meters did not occur until May 2009 and did further confound our analysis of identification, as eight patients were transported early in the study by providers who did not yet have access to point-of-care monitors. These patients did not meet physiologic criteria for severe sepsis except documented infection. The introduction of venous lactate meters did not occur until May 2009 and did further confound our analysis of identification, as eight patients were transported early in the study by providers who did not yet have access to point-of-care monitors. These patients did not meet physiologic criteria for severe sepsis except documented infection.

This pilot study is the first to utilize EMS providers and venous lactate meters to identify patients in severe sepsis. It was designed to explore the feasibility of sepsis identification by prehospital personnel. The true value of this research might lie in the clinical importance of early EMS identification of severe sepsis driving accelerated treatment modalities in both the prehospital setting and EDs.

**CONCLUSIONS**

This pilot study is the first to utilize EMS providers and venous lactate meters to identify patients in severe sepsis. It was designed to explore the feasibility of sepsis identification by prehospital personnel. Accuracy of identification of severe sepsis before hospital arrival utilizing the Sepsis Alert Protocol was 47.8%. Mortality from severe sepsis for all EMS patients was 26.7%; mortality for severe sepsis patients identified and treated under the Sepsis Alert Protocol was 47.8%. Mortality from severe sepsis for all EMS patients was 26.7%; mortality for severe sepsis patients identified and treated under the Sepsis Alert Protocol was 13.6%, reaching statistical significance ($p = 0.040$). Significantly decreased intubations were also observed in Sepsis Alert Protocol patients. Further research is needed to validate the Sepsis Alert Protocol and the potential decrease in mortality.

**REFERENCES**


ARTICLE SUMMARY

1. Why is this topic important?
   Severe sepsis is a common medical problem presenting to the Emergency Department and the majority of these patients are first seen by Emergency Medical Services. The mortality of severe sepsis patients remains high despite well-established treatment protocols.

2. What does this study attempt to show?
   Can Emergency Medical Services providers identify patients with severe sepsis in the prehospital setting? Once identified does mortality change if the receiving Emergency Department is notified before arrival and prehospital treatment is begun before arriving to the Emergency Department?

3. What are the key findings?
   Using a sepsis alert tool including subjective information, physiologic data, and prehospital lactate measurements Emergency Medical Services providers were able to identify patients with severe sepsis with an accuracy of 48%. Severe sepsis patients correctly identified by Emergency Medical Services had a mortality of 13.6% compared with 26.7% ($p = 0.026$) for all prehospital severe sepsis patients.

4. How is patient care impacted?
   The mortality of severe sepsis patients can be significantly decreased if these patients can be accurately identified by Emergency Medical Services personnel, the receiving hospital is notified before their arrival, and treatment is begun in the most proximal phase of their illness.