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Opportunities for Emergency Medical Services care of sepsis☆

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Abstract

Objective—Emergency Medical Services (EMS) systems play key roles in the rapid identification and treatment of critical illness such as trauma, myocardial infarction and stroke. EMS often provides care for sepsis, a life-threatening sequelae of infection. In this study of Emergency Department patients admitted to the hospital with an infection, we characterized the patients receiving initial care by EMS.

Methods—We prospectively studied patients with suspected infection presenting to a 50,000 visit urban, academic ED from September 16, 2005–September 30, 2006. We included patients who had abnormal ED vital signs or required hospital admission. We identified patients that received EMS care. Between EMS and non-EMS patients, we compared patient age, sex, nursing home residency, vital signs, comorbidities, source of infection, organ dysfunction, sepsis severity and mortality. We analyzed the data using univariate odds ratios, the Wilcoxon rank-sum test and multivariate logistic regression.

Results—Of 4613 ED patients presenting with serious infections, 1576 (34.2%) received initial EMS care. The mortality rate among those transported by EMS was 126/1576 (8.0%) compared to 67/3037 (2.2%) in those who were not. Adjusted mortality was higher for EMS (OR 1.8, 95% CI: 1.3–2.6). Of patients who qualified for protocolized sepsis care in the ED, 99/162 (61.1%) were transported via EMS. EMS patients were more likely to present with severe sepsis (OR 3.9; 3.4–4.5) or septic shock (OR 3.6; 2.6–5.0). EMS patients had higher sepsis acuity (mortality in ED sepsis score 6 vs. 3, $p < 0.001$).

Conclusions—EMS provides initial care for over one-third of ED infection patients, including the majority of patients with severe sepsis, septic shock, and those who ultimately die. EMS systems may offer important opportunities for advancing sepsis diagnosis and care.

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Conflict of interest statement
The authors declare no financial or other conflicts of interest.

Keywords

Infection; Sepsis; Emergency Medical Services

1. Introduction

Sepsis is the syndrome of microbial infection complicated by systemic inflammation. Sepsis may result in organ dysfunction, shock and death. Sepsis poses a major public health problem, afflicting over 750,000 hospitalized patients, resulting in almost 570,000 Emergency Department visits and causing over 215,000 deaths annually in the United States.[1,2] The successful treatment of sepsis requires timely diagnosis and early, aggressive resuscitation. Recent studies highlight that early, aggressive, structured resuscitative approach strategies can improve sepsis survival.[3,4]

Emergency Medical Services (EMS) systems play key roles in the rapid identification and treatment of critical illnesses such as trauma, myocardial infarction and stroke.[5–8] In these organized community systems, EMS personnel provide early case recognition, initial resuscitative therapies and rapid transport to appropriate receiving medical facilities.

EMS often provides similar initial care to critically ill victims of infection and sepsis, performing essential interventions such as intravenous fluid therapy, ventilatory support and airway management. However, there are few organized descriptions of EMS sepsis care. In this study we describe the characteristics EMS of patients presenting to the ED with a serious infection.

2. Methods

2.1. Study design and setting

The Institutional Review Boards of the University of Alabama at Birmingham, University of Pittsburgh and Beth Israel Deaconess Medical Center approved this study. We studied a cohort of patients presenting to an urban academic Emergency Department (ED) and receiving admission to the hospital for treatment of an infection.

2.2. Study population

This study included patients ≥18 years of age presenting to the ED of the Beth Israel Deaconess Medical Center, Boston, Massachusetts, an urban, academic teaching hospital providing care to 50,000 patients annually. This analysis used data from an ongoing prospective observational cohort study of ED patients admitted to the hospital with a suspected infection. The parent study included ED patients during the period September 16, 2005 through September 30, 2006.

2.3. Methods of measurement

The methodological details of the parent study have been described previously.[9,10] We identified eligible cases through review of hospital admitting diagnoses. Trained research assistants performed structured chart reviews on Emergency Department and hospital admission records to determine pertinent demographic and clinical information. We

previously reported strong inter-rater agreement ($\kappa = 0.9$) for identification and classification of infection-related admissions. We obtained laboratory values by linkage with hospital computer records.

2.4. Clinical covariates and outcomes

The primary exposure of interest was transportation to the ED by Emergency Medical Services (EMS). Research assistants determined EMS transport cases by reviewing ED records. Because the chart review process did not include linkage with EMS records, we did not have access to additional information regarding the type of EMS unit or the course of EMS care.

Other abstracted data included patient demographics, preexisting medical conditions, initial vital signs, history of immunosuppression, organ dysfunction, source of infection and outcomes. Demographic data included age, sex, and nursing home or rehabilitation center residence. Pre-existing medical conditions included alcoholism, coronary artery disease, myocardial infarction, stroke, congestive heart failure, connective tissue disorder, chronic obstructive pulmonary disease, diabetes, hemiplegia, peptic ulcer disease, intravenous drug abuse, liver disease, peripheral vascular disease, prosthetic heart valve, renal insufficiency, use of dialysis, and the presence of a vascular or urinary catheter. History of immunosuppression included human immunodeficiency virus, chronic steroid use, splenectomy, leukemia, chemotherapy, lymphoma, history of organ transplant and cancer. We calculated the Charlson Comorbidity Index for each patient.[11]

We determined the source of infection from admission diagnoses or physician notes. Sources of infection included neutropenia, pneumonia, urinary tract infection or pyelonephritis, intra-abdominal infection, meningitis, skin or soft tissue infection, venous catheter infection, endocarditis, biliary condition, perforated viscus, surgical wound infection and unknown source of infection. We determined organ dysfunction from laboratory values or Emergency Department records. Organ dysfunction included altered mental status (Glasgow Coma Scale <15), respiratory failure (SaO_2 <90%, respiratory rate >24 or mechanically ventilated), liver failure (acute ALT/AST >80), renal failure (creatinine >2 mg/dl without a prior history of renal dysfunction), cardiovascular failure (systolic blood pressure <90 after 20–30 ml/kg of intravenous fluids or vasopressor use), hematopoietic failure (platelets <100,000 cells/mm^3) or protime/prothrombin time >50% of normal.

We defined sepsis as a suspicion of infection with at least two Systemic Inflammatory Response Syndrome (SIRS) criteria.[12] We defined severe sepsis as sepsis with at least one organ dysfunction. We defined septic shock as sepsis with systolic blood pressure ≤90 mm Hg and refractory to an initial fluid bolus. We calculated the Mortality in Emergency Department Sepsis (MEDS) score, a previously validated measure of sepsis severity upon initial Emergency Department presentation.[13] We also determined patient status (alive or dead) on hospital discharge.

2.5. Data analysis

We analyzed the data using descriptive statistics, identifying differences between those that did and did not receive initial EMS care. We evaluated the associations between initial EMS care and each patient characteristic using univariable odds ratios with 95% confidence intervals and the Wilcoxon rank-sum test for non-parametric measures. To determine adjusted mortality, we fit a multivariable logistic regression model with discharge status (dead vs. alive) as the dependent variable and EMS transport as the key independent variable, adjusting for age, sex, infection source, number of comorbidities and MEDS score. We analyzed the data using Stata Version 10.1 (Stata Incorporated, College Station, Texas).

3. Results

Of 4613 ED patients admitted to the hospital for an infection, 1576 (34.2%) received initial EMS care. The overall mortality rate for the population was 4.2%.

EMS patients were more likely to be elderly, female or nursing home residents (Table 1). EMS patients were more likely to have tachypnea, hypoxia, and initial hypotension. Serum lactate levels were slightly higher for EMS patients. EMS patients had higher numbers of comorbid conditions (2 vs. 1, Wilcoxon rank-sum $p < 0.01$) (Table 2). EMS patients had higher Charlson Comorbidity Index Scores (2 vs. 1, Wilcoxon rank-sum $p < 0.01$) (Table 2). EMS patients were more likely to have pneumonia, urinary tract infection or pyelonephritis (Table 3). EMS patients were less likely to present with intra-abdominal or skin/soft tissue infections.

EMS patients were more likely to present with organ dysfunction. EMS patients were nearly four times more likely to present with severe sepsis or septic shock (Table 3).

Of the 162 patients qualifying for protocolized sepsis care (Early Goal-Directed Therapy), 99 (61.1%) were transported via EMS. The mortality rate among those transported by EMS was 126/1576 (8.0%) compared to 67/3037 (2.2%) in those who were not; two-thirds of sepsis deaths were transported by EMS. Mortality remained higher for EMS patients, even after adjusting for age, sex, infection source, number of comorbidities and MEDS score (adjusted OR 1.8, 95% CI: 1.3–2.6). The multivariable model demonstrated good fit (Hosmer-Lemeshow $p = 0.58$).

4. Discussion

Patients with infection and sepsis often present with acute organ failure and hemodynamic instability.[14] While prior studies have described the hospital course of sepsis patients, few efforts have characterized the subset receiving initial care from EMS. In this series, EMS provided initial care for over one-third of patients hospitalized for infection. EMS cared for the highest acuity patients, including the majority with hemodynamic instability, severe sepsis and septic shock. EMS cared for the majority of patients requiring protocolized resuscitation. EMS also cared for a higher proportion of elderly and nursing home patients, as well as those with higher numbers of comorbidities. Few studies have identified the involvement of EMS in infection and sepsis care. Since timely initiation of resuscitation may improve sepsis survival, EMS may play a key role in the care of these patients.

Simple innovations could improve the ability of EMS personnel to identify sepsis. For example, EMS personnel do not commonly measure oral, tympanic or other body temperature. EMS personnel could use the dyad of fever + hypotension to identify septic shock. Practitioners in the ED often use elevated serum lactate as a marker of occult shock (i.e., shock in the absence of hypotension).[3,9,15] If validated for EMS use, inexpensive point-of-care lactate detectors could provide another tool for identifying septic shock.[10,16–18] EMS performs many of the salient elements of sepsis resuscitation such as the use of intravenous fluids, vasopressors and ventilatory management.[3,4,14,19–21] With simple guidelines or protocols, EMS personnel could potentially identify and initiate treatment for sepsis.

An important conceptual question is whether EMS could – or should – integrate with hospital sepsis resuscitation protocols. A prominent example of protocolized sepsis therapy is Early Goal-Directed Therapy, which provides structured guidelines for the administration of intravenous fluids, vasopressors, vasodilators, inotropes, oxygen and blood products.[3] In the Untied States, EMS integration with such protocols would require significant skill and resource expansion. For example, most US EMS personnel do not administer antibiotics, corticosteroids or blood products. Most US EMS personnel are not able to insert central venous or arterial blood pressure catheters. The effectiveness of hospital sepsis resuscitation protocols (both advanced and simplified forms) also remains unclear. Given these limitations, US EMS practitioners should approach sepsis recognition and resuscitation using current conventional prehospital techniques.

Limitations of this study include the use of Emergency Department-based data, without the availability of prehospital data. However, our study provides important perspectives of sepsis patients receiving EMS care, elements that would have been missed in an EMS-based study. Key unanswered questions include the transport times of EMS sepsis patients, their population settings, the clinical presentation on EMS arrival, and the executed prehospital interventions.

We did not have information on the EMS agencies that transported patients to this particular hospital and therefore could not comment on EMS agency characteristics nor approaches to assessment and care. While EMS units handling interfacility transports often possess specialty critical care capabilities, in this series none of the EMS cases were transferred from other Emergency Departments or hospitals. Important future directions include linkage of hospital with prehospital records.

Our analysis originates from a single urban tertiary care center and merits validation on a multi-center basis across EMS systems and hospitals. While our analysis alludes to conceptual approaches to expanding EMS sepsis care, this paper does not define the viability or effectiveness of this approach. While we observed increased mortality among EMS patients, we believe that this reflects differing severity of illness rather than the results of EMS care. The effectiveness of EMS sepsis identification and treatment would be best tested using prospective methods.

5. Conclusion

EMS provides initial care for over one-third of ED infection patients, including the majority of patients with severe sepsis and septic shock. EMS systems may offer important opportunities for advancing sepsis diagnosis and care.

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HEW and NIS conceived and designed the study. HEW and MDW obtained the data and performed the analysis. HEW drafted the manuscript, and all authors contributed substantially to its revision. HEW had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Table 1

Characteristics of Emergency Department patients admitted to the hospital with an infection. Odds ratios and *p*-values reflect differences between EMS vs. non-EMS patients. EMS: Emergency Medical Services.

Patient characteristic	EMS (*n*= 1576) *n* (%)	Non-EMS (*n* = 3037) *n* (%)	Total (*n* = 4613) *n* (%)	Odds ratio (95% CI) or *p*-value
Age–mean (95% CI)	69.4 (68.6–70.3)	55.1 (54.4–55.8)	60.0 (59.4–60.6)	*t*-Test $p < 0.001$
Sex				
Male	703 (44.6%)	1533 (50.5%)	2236 (48.5%)	0.8 (0.7–0.9)
Female	873 (55.4%)	1504 (49.5%)	2377 (51.5%)	Referent
Ethnic category				
White	1129 (71.6%)	2239 (73.7%)	3368 (73.0%)	0.9 (0.8–1.0)
Black or African American	236 (15.0%)	317 (10.4%)	553 (12.0%)	1.5 (1.3–1.8)
Asian	39 (2.5%)	87 (2.9%)	126 (2.7%)	0.9 (0.6–1.3)
Hispanic or Latino	63 (4.0%)	156 (5.1%)	219 (4.8%)	0.7 (0.6–1.0)
American Indian or Alaskan	0 (0.0%)	2 (0.06%)	2 (0.04%)	0.0 (0.0–3.7)
Other	30 (1.9%)	66 (2.2%)	96 (2.1%)	0.9 (0.5–1.4)
Unknown	79 (5.0%)	170 (5.6%)	249 (5.4%)	0.9 (0.7–1.2)
Nursing home or rehabilitation facility patient	376 (23.9%)	67 (2.2%)	443 (9.6%)	13.9 (10.6–18.4)
Emergency Department Triage Hemodynamic Instability				
Tachycardia (heart rate ≥90 beats/min)	827 (52.5%)	1637 (53.9%)	2464 (53.4%)	0.9 (0.8–1.1)
Tachypnea (respiratory rate ≥20 breaths/min)	779 (49.4%)	872 (28.7%)	1651 (35.8%)	2.4 (2.1–2.8)
Hypoxia (SaO_2 ≤90%)	160 (10.2%)	109 (3.6%)	269 (5.8%)	3.0 (2.4–3.9)
Hypotension (systolic blood pressure ≤90 mm Hg)	129 (8.2%)	118 (3.9%)	247 (5.4%)	2.2 (1.7–2.9)
Serum lactate level–mean (95% CI)	2.37 (2.3–2.5)	1.87 (1.8–1.9)	2.05 (2.0–2.1)	*t*-Test $p < 0.001$

Table 2

Pre-existing conditions of Emergency Department patients admitted to the hospital with an infection. Odds ratios and *p*-values reflect differences between EMS vs. non-EMS patients.

Pre-existing condition	EMS (*n* =1576) *n* (%)	Non-EMS (*n* = 3037) *n* (%)	Total (*n* = 4613) *n* (%)	Odds ratio (95% CI) or *p*-value
Alcoholism	41 (2.6%)	43 (1.4%)	84 (1.8%)	1.9 (1.2–2.9)
Coronary artery disease	339 (21.5%)	407 (13.4%)	746 (16.2%)	1.8 (1.5–2.1)
Myocardial infarction	105 (6.7%)	120 (4.0%)	225 (4.9%)	1.7 (1.3–2.3)
Stroke	176 (11.2%)	147 (4.8%)	323 (7.0%)	2.5 (2.0–3.1)
Congestive heart failure	262 (16.6%)	184 (6.1%)	446 (9.7%)	3.1 (2.5–3.8)
Connective tissue disease	66 (4.2%)	76 (2.5%)	142 (3.1%)	1.7 (1.2–2.4)
Chronic obstructive pulmonary disease	220 (14.0%)	137 (4.5%)	357 (7.7%)	3.4 (2.7–4.3)
Dementia	125 (7.9%)	43 (1.4%)	168 (3.6%)	6.0 (4.2–8.7)
Diabetes	414 (26.3%)	626 (20.6%)	1040 (22.5%)	1.4 (1.2–1.6)
Hemiplegia	23 (1.5%)	20 (0.7%)	43 (0.9%)	2.2 (1.2–4.3)
Hypertension	802 (50.9%)	1115 (36.7%)	1917 (41.6%)	1.8 (1.6–2.0)
Peptic ulcer disease	12 (0.8%)	23 (0.8%)	35 (0.8%)	1.0 (0.5–2.1)
Intravenous drug abuse	23 (1.5%)	49 (1.6%)	72 (1.6%)	0.9 (0.5–1.5)
Liver disease	92 (5.8%)	194 (6.4%)	286 (6.2%)	0.9 (0.7–1.2)
Peripheral vascular disease	99 (6.3%)	118 (3.9%)	217 (4.7%)	1.7 (1.2–2.2)
Prosthetic heart valve	10 (0.6%)	24 (0.8%)	34 (0.7%)	0.8 (0.3–1.7)
Renal insufficiency	127 (8.1%)	99 (3.3%)	226 (4.9%)	2.6 (2.0–3.4)
End-stage renal disease (dialysis)	87 (5.5%)	101 (3.3%)	188 (4.1%)	1.7 (1.3–2.3)
Vascular catheter	73 (4.6%)	127 (4.2%)	200 (4.3%)	1.1 (0.8–1.5)
Urinary catheter	29 (1.8%)	26 (0.9%)	55 (1.2%)	2.2 (1.2–3.9)
Human immunodeficiency virus	64 (4.1%)	178 (5.9%)	242 (5.3%)	0.7 (0.5–0.9)
Chronic steroid use	129 (8.2%)	220 (7.2%)	349 (7.6%)	1.1 (0.9–1.4)
Splenectomy	4 (0.3%)	10 (0.3%)	14 (0.3%)	0.8 (0.2–2.7)
Transplant recipient	35 (2.2%)	132 (4.4%)	167 (3.6%)	0.5 (0.3–0.7)
Cancer	288 (18.3%)	554 (18.2%)	842 (18.3%)	1.0 (0.9–1.2)
Number of comorbidities–median (IQR)	2 (1–4)	1 (0–2)	2 (1–3)	Rank-sum p <0.01
Charlson comorbidity inde–median (IQR)	2 (0–3)	1 (0–2)	1 (0–3)	Rank-sum p <0.01

EMS: Emergency Medical Services.

Table 3

Source of infection, organ dysfunction and outcomes of Emergency Department patients admitted to the hospital with an infection. Odds ratios and *p*-values reflect differences between EMS vs. non-EMS patients.

Characteristic	EMS (*n* = 1576) *n* (%)	Non-EMS (*n* = 3037) *n* (%)	Total (*n* = 4613) *n* (%)	Odds ratio (95% CI) or *p*-value
Source of infection				
Pneumonia	414 (26.3%)	405 (13.3%)	819 (17.8%)	2.4 (2.1–2.8)
Urinary tract infection/pyelonephritis	287 (18.2%)	315 (10.4%)	602 (13.1%)	1.9 (1.6–2.3)
Intra-abdominal	66 (4.2%)	247 (8.1%)	313 (6.8%)	0.5 (0.4–0.7)
Skin, soft tissue	179 (11.4%)	799 (26.3%)	978 (21.2%)	0.4 (0.3–0.4)
Unknown or other	630 (40.0%)	1271 (41.9%)	1901 (41.2%)	0.9 (0.8–1.0)
Organ dysfunction				
Altered mental status	287 (18.2%)	132 (4.4%)	419 (9.1%)	4.9 (3.9–6.1)
Respiratory failure	320 (20.3%)	247 (8.1%)	567 (12.3%)	2.9 (2.4–3.5)
Mechanical ventilation	36 (2.3%)	23 (0.8%)	59 (1.3%)	3.1 (1.8–5.4)
Liver failure	8 (0.5%)	18 (0.6%)	26 (0.6%)	0.9 (0.3–2.1)
Renal failure	62 (3.9%)	55 (1.8%)	117 (2.5%)	2.2 (1.5–3.3)
Cardiovascular failure	42 (2.7%)	16 (0.5%)	58 (1.3%)	5.2 (2.8–9.9)
Septicemia	11 (0.7%)	9 (0.3%)	20 (0.4%)	2.4 (0.9–6.5)
Hematopoetic failure	3 (0.2%)	13 (0.4%)	16 (0.4%)	0.4 (0.1–1.6)
Vasopressor use	95 (6.0%)	59 (1.9%)	154 (3.3%)	3.2 (2.3–4.6)
Sepsis severity				
Sepsis	1075 (68.2%)	1820 (59.9%)	2895 (62.8%)	1.4 (1.3–1.6)
Severe Sepsis	604 (38.3%)	419 (13.8%)	1023 (22.2%)	3.9 (3.4–4.5)
Septic Shock	111 (7.0%)	63 (2.1%)	174 (3.8%)	3.6 (2.6–5.0)
Mortality in emergency department sepsis score—median (IQR)	6 (3–10)	3 (0–6)	5 (3–8)	Rank-sum $p < .01$
Outcomes				
Alive	1450 (92.0%)	2970 (98.8%)	4420 (95.8%)	Referent
Dead	126 (8.0%)	67 (2.2%)	193 (4.2%)	3.9 (2.8–5.3)[a]

[a]Unadjusted odds ratio. Odds of death adjusted for age, sex, infection source, number of comorbidities and Mortality in Emergency Department Sepsis Score (MEDS) = 1.8 (95% CI: 1.3–2.6). EMS: Emergency Medical Services.