Severe sepsis in prehospital emergency care: analysis of incidence, care, and outcome

Christopher W. Seymour, MD MSc
Thomas D. Rea, MD MPH
Jeremy M. Kahn, MD MSc
Allan J. Walkkey, MD MSc
Donald M. Yealy, MD
and Derek C. Angus, MD MPH

Online Data Supplement
Study definitions

We defined hospitalization for severe sepsis using a clinically validated, administrative definition for severe sepsis based on International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes for a bacterial or fungal infectious process and the presence of acute organ dysfunction. ICD-9-CM coding for severe sepsis changed after 2002, and we included codes 995.91 (systemic inflammatory response syndrome due to infectious process without acute organ dysfunction), 995.92 (severe sepsis), and 785.52 (shock without mention of trauma; septic shock) in our definition algorithm. Explicit diagnoses of severe sepsis (ICD-9-CM 995.92 or 785.52) were considered a case, while ICD-9-CM 995.91 required a concomitant organ dysfunction code to be present.

Angus et al. validated the original definition by comparing severe sepsis cases identified with their ICD-9-CM definition with a contemporary, prospectively enrolled sample at eight hospitals. They concluded that the definition adequately captured clinical severe sepsis patients, and it has been used as the gold standard for identifying administrative cases of severe sepsis since 2001. A second external validation was recently published by Iwashyna et al. (E1) The authors report that in a random sample of 111 patients, the Angus implementation for severe sepsis had a PPV of over 70%, NPV of over 90%, and specificity of 96%. Two alternative ICD-9-CM definitions of severe sepsis had high PPVs but sensitivities that were below 20%.

To identify hospitalizations for acute myocardial infarction, we used ICD-9-CM codes 410.xx, excluding 410.x2 (episode of care for myocardial infarction that has already received initial treatment). (E2) In the Atherosclerosis Risk in Communities (ARIC) cohort, this code has stable operating characteristics over time, and greater than 75% of patients discharged with this code were validated as definite or probable AMI. (E3) Others report
sensitivity as high as 94% for definite or probable AMI. (E4) We restricted our definition to AMI cases rather than those with angina or suspected chest pain, as current EMS guidelines integrate care specifically for patients with ST-elevation on pre-hospital 12-lead ECGs. (E5)

We defined hospitalization for stroke using a previously validated algorithm in the CHARS database. (E6) This definition includes codes for ischemic stroke (433.x1, 434 excluding 434.x0, or 436), intracerebral hemorrhage (431), subarachnoid hemorrhage (430), and transient ischemic attack (435). This approach has a sensitivity of 86% for ischemic stroke, 82% for intracerebral hemorrhage, and 98% for subarachnoid hemorrhage. Overall stroke classification had a kappa statistic of 0.79 compared to a gold standard medical record review. (E6)

We defined mortality using hospital discharge disposition fields in CHARS. Previous validation of CHARS disposition fields revealed a 100% sensitivity, 99% specificity, and 97% positive predictive value for in-hospital deaths confirmed by manual review. (E6)

Validation of “present on admission” indicator codes for severe sepsis

We manually validated the present on admission indicators for the Angus implementation of severe sepsis using data from a recently published study of community severe sepsis in JAMA. (E7) This validation study was approved by the Boston University Medical Campus Institutional Review Board. Among 163 patients with ICD-9-CM 995.92 (either “present on admission” or “not present on admission”) from 2008-2009, we identified 152 patients meeting the Angus et al. ICD-9-CM definition. (E8) We defined patients as having “present on admission” severe sepsis if present on admission indicators were coded in the administrative record for both infection and organ dysfunction, or the explicit diagnosis of severe sepsis (ICD-9-CM 995.92). Among these charts, we performed blinded chart review in order to determine if severe sepsis was present on the day of admission. A diagnosis of severe sepsis was designated as “present on admission” during chart review if a
provider assessment a diagnosis of any of the following on the day of admission: 1) “severe sepsis”, 2) “sepsis” + an acute organ dysfunction, or 3) a suspected infection in the presence of 2 of 4 systemic inflammatory response syndrome criteria and a new organ dysfunction.

We observed that POA codes among Angus severe sepsis cases agreed with manual review in the large majority of charts.

<table>
<thead>
<tr>
<th>Severe sepsis definition</th>
<th>N</th>
<th>ICD-9-CM codes reviewed for POA flag</th>
<th>POA indicator present (%)</th>
<th>Kappa statistic</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICD-9-CM 995.92</td>
<td>163</td>
<td>995.92</td>
<td>116 (71)</td>
<td>0.77 (0.66, 0.88)</td>
<td>0.91 (0.84, 0.95)</td>
<td>0.89 (0.77, 0.97)</td>
</tr>
<tr>
<td>Angus implementation</td>
<td>152</td>
<td>Infection + OD</td>
<td>114 (75)</td>
<td>0.78 (0.67, 0.88)</td>
<td>0.89 (0.81, 0.94)</td>
<td>0.97 (0.86, 0.99)</td>
</tr>
</tbody>
</table>

Statistics provided with 95% confidence interval

*Abbreviations: NPV - negative predictive value; OD - organ dysfunction; POA - present on admission; PPV - positive predictive value*

**Details of prehospital data**

We gathered incident and transport characteristics on EMS encounters from the King County EMS database, including demographics, initial vital signs, incident location (e.g. nursing home, home), level of prehospital care (advanced life support vs. basic life support only), call urgency per EMS personnel (e.g. non-urgent, urgent, life-threatening) and prehospital time intervals (min). To describe the illness severity of EMS patients over time, we calculated the risk of hospitalization for critical illness for each EMS encounter. This previously reported integer score ranges from 0 – 8 and includes demographic and initial vital sign abnormalities available to EMS personnel during prehospital care.[E9] We defined hospitalization outcomes using the CHARS database, from which we abstracted the etiology of severe sepsis, presence of organ failures,[E8] admission to the intensive care unit using UB-92 revenue codes,[E10] Charlson co-morbidity index,[E11] length of stay, and discharge disposition.
2006 Sensitivity Analysis of Severe Sepsis hospitalizations by Admission Source and EMS transport

We conducted a sensitivity analysis to determine the proportion of all severe sepsis hospitalizations in King County that were or were not transported by EMS in 2006. Our primary study database only includes King County EMS encounters and their associated hospitalizations, and did not include Seattle MedicOne records (the only other EMS agency in King County). Our sensitivity analysis, thus, required two additional steps of inking to create a complete dataset of all hospitalizations linked to all EMS encounters for the calendar year: 1) linking Seattle MedicOne records to hospital data, and 2) merging all hospital records not linked to an EMS encounter.

In a study approved by Seattle MedicOne and the Washington State IRB, we linked Seattle MedicOne records from 2006 to hospital data using our hierarchical deterministic match. Of 36,974 adult, non-trauma, non-cardiac arrest encounters, we matched 7,615 records to hospitalizations. Second, all remaining non-EMS, adult hospitalizations in CHARs for 2006 (N=161,177) were merged to the master database for 2006.

We then identified severe sepsis cases using the Angus implementation (N=8,124) among all hospitalizations, and defined admission source according to CHARs (e.g. interfacility, emergency department, MD referral, clinic referral, other). As King County EMS and Seattle MedicOne are the only EMS agencies in the County, we could define whether any severe sepsis hospitalization during the entire year activated 9-1-1 and was transported by EMS. We observed that 2,311 of all 8,124 severe sepsis hospitalizations (28%) used EMS, more than 38% for severe sepsis admissions who arrived in the ED (2,311 of 6,010). We also compared the etiology of sepsis, organ failures, and outcomes for EMS vs. non-EMS severe sepsis hospitalizations (eTable 2).
References