“Inflammatory Statements”

Using $\text{ETCO}_2$ Analysis in Sepsis Syndromes

George A. Ralls M.D.
Orange County EMS System
Sepsis

- Over 750,000 cases annually
  - Expected growth of 1.5% per year
- Over 215,000 deaths
- 10th leading cause of death in US
  - Equals deaths from AMI
Sepsis

• Infection that triggers a systemic inflammatory response

• Systemic Inflammatory Response Syndrome (SIRS)
  • 36-38°C
  • Heart rate >90 beats/min
  • Respiratory rate of >20 or a PCO2<32 mm Hg
  • White blood cell count <4000 or >12000
SIRS
- 36-38°C
- HR >90
- RR >20
- WBC

Known or Suspected Infection

Sepsis

Mortality rate of 30-40%
- Up to 60 % if hypotensive
- Once activated, acute organ dysfunction may occur even if infection controlled
Sepsis

- Tissue hypoxia begins early in the sepsis continuum
  - May be “occult”
  - May precede any significant changes in vital signs

- Tissue hypoxia results in elevated serum lactate levels
  - Oxygen demand exceeds supply
  - Eventually lactic acidosis ensues

Elevated lactate levels signify a “High Risk” patient
Early Goal Directed Therapy

Protocolized management that starts in the ED reduces mortality from sepsis:

- Early recognition and treatment of sepsis
- Reversal of global tissue hypoxia in the first few hours of treatment
- Presence of SIRS criteria in addition to elevated lactate levels or hypotension

Time Matters!
2 SIRS Criteria
- 36-38°C
- HR > 90
- RR > 20 or PCO2 < 32 mm Hg
- WBC count < 4000 or > 12000

Global Tissue Hypoxia
- Hypotension (SBP < 90)
- Lactate level > 4 mmol/L

EGDT

34% reduction in in-hospital mortality
32% reduction in mortality at 28 days
2 SIRS Criteria
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- Early Goal Directed Therapy
- Resuscitation Centers
CO₂

HCO₃⁻

PCO₂

Lactic Acid

Lactate

H⁺
Impact of EMS on ED Care on Severe Sepsis
Jonathan Studnek, et al.

- EMS provided care for half of patients with severe sepsis requiring EGDT
- EMS patients had shorter time to antibiotics and shorter time to initiation of EGDT

"if a patient is recognized as having sepsis early by EMS an important trajectory is started..."
Opportunities for EMS Care of Sepsis
Henry E. Wang, et al.

• 4613 ED patients presenting with serious infections
  • 34% received initial EMS care

• Mortality rate:
  • 8.0% for EMS transported patients
  • 2.2% for those who were not

• EMS transported 61% of patients who qualified for protocolized sepsis care in the ED

• EMS patients more likely to present with severe sepsis (OR 3.9) or septic shock (OR 3.6)

• EMS patients had higher sepsis acuity (mortality in ED sepsis score 6 vs. 3, p < 0.001)

• **EMS provides care for the majority of patients with severe sepsis**
• **May offer important opportunities for advancing sepsis diagnosis**...
Less than half of patients with severe sepsis transported by ALS received out-of-hospital fluid.
End-Tidal Carbon Dioxide Levels Are Associated with Mortality In Emergency Department Patients with Suspected Sepsis

Hunter CL, et al. Orlando Regional Medical Center, Orlando, FL

- There was a significant association between levels of ETO2 and in-hospital mortality in emergency department patients with suspected sepsis

- ETCO2 levels were significantly and inversely correlated with lactate levels in these patients
<table>
<thead>
<tr>
<th></th>
<th>Total Patients N=201</th>
<th>Survivors N=172</th>
<th>Non-Survivors N=29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (%female)</td>
<td>47 [40-54]</td>
<td>49 [42-57]</td>
<td>34 [16-53]</td>
</tr>
<tr>
<td>LOS</td>
<td>8.6 [7.4-9.8]</td>
<td>9.2 [7.9-10.5]</td>
<td>5.0 [2.1-7.9]</td>
</tr>
<tr>
<td>ICU Admit (%)</td>
<td>36 [29-42]</td>
<td>27 [20-34]</td>
<td>86 [73-100]</td>
</tr>
<tr>
<td>Lactate (mMol/L)</td>
<td>3.1 [2.6-3.5]</td>
<td>2.6 [2.2-3.0]</td>
<td>6.1 [4.3-8]</td>
</tr>
<tr>
<td>ETCO2 (mmHg)</td>
<td>32 [30-33]</td>
<td>33 [31-34]</td>
<td>26 [21-30]</td>
</tr>
</tbody>
</table>
Venous

Correlation coefficient = -0.526
P < 0.001

Arterial

Correlation coefficient = -0.493
P < 0.001
Correlation coefficient = -0.507 (P<0.001)

Mean EtCO2 versus Lactate

LACTATE (mMol/L)

Mean EtCO2 (mmHg)
Initial Study
- ETCO2 & Lactate (relationship)
- Suspected sepsis population

Derivation Study
- ETCO2 & Pre-hospital vitals (relationship)
- All comers

Prospective Validation
- Pre-hospital protocol implementation
- Prospective validation
- Re-adjust protocol
Correlation coefficient = -0.507 (P<0.001)

Mean EtCO2 versus Lactate

Possible Future Application
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