Active Deresuscitation: Does It Have a Role?

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Critical Care Canada Forum
Toronto Canada
November 14, 2011
J.G.  57 year old man
Necrotizing pancreatitis:  ICU Day 6

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td>108</td>
</tr>
<tr>
<td>BP</td>
<td>102/50</td>
</tr>
<tr>
<td>T</td>
<td>37.8°C</td>
</tr>
<tr>
<td>CVP</td>
<td>14</td>
</tr>
<tr>
<td>ScVO₂</td>
<td>71%</td>
</tr>
<tr>
<td>FIO₂</td>
<td>0.6</td>
</tr>
<tr>
<td>Norepinephrine, dobutamine</td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td>187</td>
</tr>
<tr>
<td>Hb</td>
<td>82</td>
</tr>
<tr>
<td>Lactate</td>
<td>3.2</td>
</tr>
<tr>
<td>Fluid</td>
<td>+ 17.8 liters</td>
</tr>
<tr>
<td>U/O</td>
<td>20 – 30 ml/hr</td>
</tr>
</tbody>
</table>
Would you ...

• Administer fluid challenge?
Would you …

• Administer fluid challenge?
• Increase vasoactive drugs?
Would you …

• Administer fluid challenge?
• Increase vasoactive drugs?
• Transfuse?
Would you ...

- Administer fluid challenge?
- Increase vasoactive drugs?
- Transfuse?
- Diurese?
Would you ...

- Administer fluid challenge?
- Increase vasoactive drugs?
- Transfuse?
- Diurese?
- Do nothing further?
Shock

“... the rude unhinging of the machinery of life ...”

Samuel D. Gross 1862
Shock

Reduced intravascular fluid volume

Alfred Blalock
Oxidative Metabolism

Glucose + O₂ → H₂O + CO₂ + 38 ATP
O₂ Delivery

= Cardiac output X Hb X % Saturation
Oxygen Delivery in the Microcirculation

- Gradient
- Distance
- Rate of flow
- Avidity of Hb
Oxygen Delivery in Hypovolemic Shock

- Reduced flow
- Reduced volume
- Reduced interstitial fluid
Mean Arterial Pressure

CVP

<8

Fluids

<65

Pressors

≥ 8

≥ 65

ScvO_2

< 65

Transfusion, Inotropes

≥ 70

Goals achieved

Goals achieved
# Early Goal-directed Therapy for Septic Shock

<table>
<thead>
<tr>
<th></th>
<th>Standard (N=133)</th>
<th>Goal-Directed (N=130)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVO$_2$</td>
<td>65.3±11.4</td>
<td>70.4±10.7*</td>
</tr>
<tr>
<td>APACHE II</td>
<td>15.9±6.4</td>
<td>13.0±6.3*</td>
</tr>
<tr>
<td>Mortality</td>
<td>46.5%</td>
<td>30.5%*</td>
</tr>
</tbody>
</table>

* p<0.02

# Goal-Oriented Hemodynamic Therapy in Critically Ill Patients

<table>
<thead>
<tr>
<th></th>
<th>% Success</th>
<th>% Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controls</strong></td>
<td>94.3</td>
<td>48.4</td>
</tr>
<tr>
<td><strong>Cardiac Index</strong></td>
<td>44.9</td>
<td>48.6</td>
</tr>
<tr>
<td><strong>SVO$_2$</strong></td>
<td>66.7</td>
<td>52.1</td>
</tr>
</tbody>
</table>

• What are the limits of resuscitation?

• Should we actively deresuscitate?
## Delayed Resuscitation for Penetrating Torso Trauma

<table>
<thead>
<tr>
<th></th>
<th>Mortality</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate</td>
<td>116/309</td>
<td>38</td>
</tr>
<tr>
<td>Delayed</td>
<td>86/289</td>
<td>30*</td>
</tr>
</tbody>
</table>

* * p=0.04

### Mortality after Fluid Bolus in African Children with Severe Infection

Mortality

<table>
<thead>
<tr>
<th></th>
<th>48 Hr</th>
<th>28 Day</th>
<th>p.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin</td>
<td>10.6%</td>
<td>12.2%</td>
<td></td>
</tr>
<tr>
<td>Saline</td>
<td>10.5%</td>
<td>12.0%</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>7.3%</td>
<td>8.7%</td>
<td>0.004</td>
</tr>
</tbody>
</table>
• What are the limits of resuscitation?

• Should we actively deresuscitate?
Sequelae of Resuscitation

- Increased total body sodium
- Increased capillary permeability
- Increased extravascular fluid
- Increased interstitial pressure
- Increased $O_2$ diffusive distance

Does this resolve spontaneously?
The Microcirculation in Distributive Shock

- Reduced resistance
- Increased permeability
- Tissue edema
- Increased diffusion distance
Edema is not necessarily benign ...
Adverse sequelae of edema

- Cerebral edema
  - Impaired cognition
  - Delirium

- Myocardial edema
  - Conduction disturbance
  - Impaired contractility
  - Diastolic dysfunction

- Pulmonary edema
  - Impaired gas exchange
  - Reduced compliance
  - Increased work of breathing

- Hepatic congestion
  - Impaired synthetic function
  - Cholestasis

- Renal interstitial edema
  - Reduced RBF
  - Increased interstitial pressure
  - Reduced GFR
  - Uremia
  - Salt & water retention

- Gut edema
  - Malabsorption
  - Ileus

- Tissue edema
  - Impaired lymphatic drainage
  - Microcirculatory derangements
    - Poor wound healing
    - Wound infection
    - Pressure ulceration

- Increased renal venous pressure

- Prowle Nat Rev Nephrol 6:107, 2010
Net fluid balance increases over first 4 days ... and is associated with increased mortality

- Boyd, Crit Care Med 39:259 2011
## Risk Factors for the Development of ARDS

(2583 Patients Ventilated > 48 Hours)

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak pressure</td>
<td>1.31</td>
<td>(1.08 – 1.59)</td>
</tr>
<tr>
<td>Net fluid balance</td>
<td>1.30</td>
<td>(1.09 – 1.56)</td>
</tr>
<tr>
<td>Plasma transfusion</td>
<td>1.26</td>
<td>(1.07 – 1.49)</td>
</tr>
<tr>
<td>Sepsis</td>
<td>1.57</td>
<td>(1.00 – 2.45)</td>
</tr>
<tr>
<td>Vt</td>
<td>1.29</td>
<td>(1.02 – 1.52)</td>
</tr>
</tbody>
</table>

Positive Fluid Balance is Associated with ALI/ARDS

<table>
<thead>
<tr>
<th>Variable</th>
<th>ALI/ARDS</th>
<th>No ALI/ARDS</th>
<th>p.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N=393)</td>
<td>(N=2754)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 0 balance</td>
<td>1.2±2.6</td>
<td>0.6±1.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>48 hour balance</td>
<td>2.2±4.3</td>
<td>0.8±3.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>72 hour balance</td>
<td>2.5±5.8</td>
<td>0.8±3.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>96 hour balance</td>
<td>2.4±7.1</td>
<td>0.7±4.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Daily balance</td>
<td>0.2±1.6</td>
<td>0.1±1.2</td>
<td>0.81</td>
</tr>
</tbody>
</table>

-Sakr, *Chest* 128:3098, 2005
## Impact of Fluid Strategy in ARDS

<table>
<thead>
<tr>
<th></th>
<th>Conservative (N=503)</th>
<th>Liberal (N=497)</th>
<th>p.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>60 day mortality</strong></td>
<td>25.5%</td>
<td>28.4%</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>Ventilator-free days</strong></td>
<td>14.6±0.5</td>
<td>12.1±0.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>ICU-free days</strong></td>
<td>13.4±0.4</td>
<td>11.2±0.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>CNS failure FD</strong></td>
<td>18.8±0.5</td>
<td>17.2±0.5</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Albumin/furosemide Treatment Improves Oxygenation and Increases Shock-free Days in Acute Lung Injury

- Martin, Crit Care Med 33:1681, 2005
J.G. 57 year old man
Necrotizing pancreatitis: ICU Day 6

HR 108; BP 98/50; T 37.8; CVP 14;
ScVO2 71%

FIO2 0.6

Norepinephrine, dobutamine

Cr 254    Hb 82    Lactate 3.2

+ 17.8 liters; U/O 20 – 30 ml/hr
Algorithm for Deresuscitation

Furosemide challenge

Urine output > 300 ml/Hr?

Furosemide

Re-evaluate

Infusion
Conclusions

Hemodynamic resuscitation is a core element of the management of shock, BUT …

It has adverse consequences and should be undertaken early and judiciously …
Conclusions

... and active de-resuscitation following successful resuscitation may expedite recovery.
Thank You!!