Improving MET-based patient care using treatment algorithms

Michael R. Pinsky, MD - June 29, 2006

Disclaimer

- Michael R. Pinsky, MD is the inventor of a University of Pittsburgh-held patent “Functional Hemodynamic Monitoring”
- Michael R. Pinsky, MD is a consultant regarding hemodynamic monitoring systems for:
  - LiDCO
  - Edwards Life Sciences

Different Environments Demand Different Rules

- Emergency Department
  - Rapid, minimally invasive, high sensitivity
  - Triage, trends, protocols
- Operating Room
  - Accurate, invasive, high specificity
  - Close titration, zero tolerance for complications
- ICU
  - Somewhere in between ER and OR
- Non-ICU
  - God only knows

Hemodynamic Monitoring


MET-based Non-ICU care

- Problem: Now what?
- How to deal with complex and often uncommon presentations of acute complications and natural disease progression in an environment with limited diagnostic resources?
- Solution:
  - Hierarchy of care: life threatening issues first
  - Protocolized management
    - Pitway algorithms
    - Standard operating procedures

Protocolized Support of Active Medical Care

- Protocol for managing hypertension (n=29, 166, 2231)
- Feedback comparing care with diabetes protocol (n=226)
- Reminder of prior tests when ordering new ones (n=9496)
  - reduction in test ordering
- Alerts for in-patients taking digoxin (n=396)
  - action taken
    » White et al. J Am Coll Cardiol 4:571-6, 1984
- Recommendations for management of 79 acute medical problems (n=155)
  - # of errors in ordering tests
    » Young. Medical Informatics 6:13-7, 1981
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**Protocolized Care: Theory**
- Protocolized minimizes practice variance
- Allows individualization of care only as exception
- Improves process in the real world
  - Where error are a major course of impairment
- Decreases process in the ideal world
  - Where excellence 24/7 is the standard of care

**Reduced Variance in Practice as a Source of Improved Outcome from Critical Illness**
- Assuming that more good is not beneficial but a little bad is terrible
- Eliminating the few transgressions in care (prolonged FIO2, high Paw) will minimize complications
- Decreased noise will also allow for discrimination among treatments

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**ARDSNet NHLBI Study Group**

**Protocolized Care Reduces Outcome Variance**

- **PaO2 Distribution**
  - **Control Group**
    - Minimum: 45
    - Maximum: 7060
    - Mean: 868
    - Median: 3130
    - Variance: 1100
  - **Protocol Group**
    - Minimum: 1477
    - Maximum: 11483
    - Mean: 569
    - Median: 2378
    - Variance: 1520

**Tidal Volume Distribution**

- **Control Group**
  - Minimum: 100
  - Maximum: 1300
  - Mean: 693
  - Median: 609
  - Variance: 1310
- **Protocol Group**
  - Minimum: 100
  - Maximum: 1417
  - Mean: 693
  - Median: 609
  - Variance: 1310

**Problems with Protocolized Care**
- Requires defined input and feedback
  - SpO2 and FiO2
  - MAP and vasoactive drugs
  - Blood glucose and insulin
- Limited protocols available
- Major clinical issues not addressed
  - Circulatory shock
  - Acute respiratory failure

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East TD, et al.
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Monitoring Truth

No monitoring device, no matter how accurate or insightful its data will improve outcome, Unless coupled to a treatment, which itself improves outcome

- Pinsky & Payen. Functional Hemodynamic Monitoring, Springer Verlag, 2004

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Why Not Give Volume to All Hemodynamically Unstable Patients?

- Signs of cardiovascular insufficiency are impressive but not specific
- Hypotension must decrease blood flow to the heart and brain
- Most forms of circulatory shock have a pathological component of decreased effective circulatory blood volume

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Predicting Fluid Responsiveness in ICU Patients

<table>
<thead>
<tr>
<th>Responders / Non-Responders</th>
<th>% Responders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calvin (Surgery 81)</td>
<td>20 / 8</td>
</tr>
<tr>
<td>Schneider (Am Heart J 88)</td>
<td>13 / 5</td>
</tr>
<tr>
<td>Reuse (Surg 91)</td>
<td>26 / 15</td>
</tr>
<tr>
<td>Magder (J Crit Care 92)</td>
<td>17 / 16</td>
</tr>
<tr>
<td>Diebel (Arch Surgery 92)</td>
<td>13 / 9</td>
</tr>
<tr>
<td>Diebel (J Trauma 92)</td>
<td>26 / 39</td>
</tr>
<tr>
<td>Wagner (Surg 94)</td>
<td>20 / 16</td>
</tr>
<tr>
<td>Tavernier (Am J Cardiol 99)</td>
<td>21 / 14</td>
</tr>
<tr>
<td>Magder (J Crit Care 99)</td>
<td>13 / 16</td>
</tr>
<tr>
<td>Tousignant (Am J Cardiol 99)</td>
<td>16 / 24</td>
</tr>
<tr>
<td>Michard (AJRCCM 99)</td>
<td>16 / 24</td>
</tr>
<tr>
<td>Feissel (Chest 99)</td>
<td>10 / 9</td>
</tr>
</tbody>
</table>

Mean 211 / 195 52 %


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Neither ΔCVP or ΔPpao Mirror ΔSV


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Neither CVP or Ppao reflect Ventricular Volumes or Tract Preload-Responsiveness

Dr. Pinsky’s Hemodynamic Truths

- Tachycardia is never a good thing
- Hypotension is always pathological
- There is no normal cardiac output
- CVP is only elevated in disease
- Peripheral edema is of cosmetic concern

Kumar et al. Crit Care Med 32:691-9, 2004

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www.metconference.com
**Functional Hemodynamic Questions**

- Will cardiac output increase with fluid resuscitation, and if so, by how much?
- Is arterial tone increased, normal or decreased?
- Is the heart able to maintain an adequate output under pressure without high filling pressures?

**Predicting Preload Responsiveness from CVP waveform analysis**

<table>
<thead>
<tr>
<th>Inspiratory fall in CVP</th>
<th>No inspiratory fall in CVP</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

**Respiratory variations in CVP predict response to fluid challenge**

![Graph](image3.png)

**Initial Central Venous Pressure**

![Graph](image4.png)

**Predicting Preload-Responsiveness Passive Leg Raising Protocol**

![Graph](image5.png)

**Change in Mean Aortic Flow during PLR**

![Graph](image6.png)
Mean aortic blood flow is better than PP in predicting preload-responsiveness during PLR during spontaneous breathing and with arrhythmias.

Rule: CVP and Flow Variation
- ΔCVP with spontaneous breathing & Δflow with passive leg raising accurately identify subjects whose cardiac output will increase during a fluid challenge and by how much.
- If either ΔXVP or Δflow are not present, then fluid loading will not increase cardiac output.

Arterial Tone Assessed by Ventriculo-Arterial Coupling
Stroke Volume Defines Arterial Pressure

Ventriculo-Arterial Coupling

Continuous Monitoring of Preload Responsiveness
- CVP
- Arterial Pressure
  - Non-invasive
  - Pulse oximetry pulse density contour
- Invasive
  - Arterial catheterization
- Arterial flow
  - USCOM®
  - Esophageal Pulsed Doppler
  - Arterial Hemoflow®
- Invasive
  - Deltex CardiaQ®
  - Echocardiograms
- Combined Pressure and Flow
  - Pulse Contour Technology
  - PIICO®, LiDCO®

Hemodynamic Monitoring Protocol
Thank You