Goal-directed vs “Flow-guided-responsive” therapy

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Flow-directed vs goal directed strategy for management of hemodynamics
**SHOCK:** oxygen consumption is inadequate flow for metabolic needs

\[ \dot{V}O_2 = \dot{Q} \times (C_aO_2 - C_vO_2) \]

- **HR and SV**
- **Hb**
- **PO_2**
- Requires mitochondrial function

= oxygen delivery
What can increase $O_2$ delivery?

$$\dot{DO}_2 = \dot{Q} \times Hb \times k \times Sat_a$$

- Volume (preload)
- Blood
- PO$_2$ Usually not much gain

↑ Contractility
↑ HR
↓ Afterload
A Randomized Clinical Trial of the Effect of Deliberate Perioperative Increase of Oxygen Delivery on Mortality in High-Risk Surgical Patients

Owen Boyd, MRCP; R. Michael Grounds, MD, FFARCS; E. David Bennett, FRCP

Objective.—To assess the effect of deliberate perioperative increase in oxygen delivery on mortality and morbidity in patients who are at high risk of both following surgery.

Design.—Prospective, randomized clinical trial.

Patients did better
What was the difference between the –ve and +ve trials?

• Haye’s and Gattinoni (-ve trials) were in septic (inflamed) patients

• Boyd’s study was on perioperative high risk surgical pts.

Need to treat septic and perioperative studies differently

• In sepsis therapy is directed at returning values towards normal

• In perioperative management therapy is directed at avoiding “downward” drift and loss of normal organ function from volume loss and vascular depression from anesthesia
Goal-directed era

ProCESS American 2014

A Randomized Trial of Protocol-Based Care for Early Septic Shock

ProMISe British 2015

Trial of Early, Goal-Directed Resuscitation for Septic Shock

ARISE ANZICS 2014

Trial of Early, Goal-Directed Resuscitation for Patients with Early Septic Shock
## Mortality

<table>
<thead>
<tr>
<th></th>
<th>Time(d)</th>
<th>Control</th>
<th>EGDT</th>
<th>Year</th>
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<tbody>
<tr>
<td>Rivers</td>
<td>60</td>
<td>49.2</td>
<td>33.5</td>
<td>2001</td>
</tr>
<tr>
<td>ProCESS</td>
<td>60</td>
<td>18.5</td>
<td>21</td>
<td>2014</td>
</tr>
<tr>
<td>ARISE</td>
<td>90</td>
<td>18.8</td>
<td>18.6</td>
<td>2014</td>
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</tbody>
</table>

**Message**

- We are doing better based on good clinical judgement
- Rather than being “Goal-directed” monitoring protocols should be used to indicate whether the therapy corrected a problem that the clinician identified
- ie “responsive approach”
High risk surgical pt also improved dramatically (Control pt in GDT Sx studies)
There is no evidence to defend these “goals”

**Goals in Rivers:**
- CVP 8-12 mmHg
- Mean BP 65-90
- CvO\(_2\) sat ≥ 70%
- Hct ≥ 30

**Goals in Surgical studies**

- **Boyd**
  - mBP 80-110
  - \(P_{pao}\) 12-14
  - Hb > 120
  - \(\text{DO}_2\) – 600 (vol and dopexamine)

- **Pearce**
  - Colloid for maximum SV (LiDCo) (Treated – 1500 ml vs Control 2600 ml)
  - Dopexamine at a fixed dose
  - Hb ≥ 80 g/L
  - mBP 60-100 mmHg
  - Sat ≥ 90%
Goal-directed protocols push patients to the plateau of the cardiac function curve

In the plateau range the normal “Starling” mechanism is not operative and only HR, contractility and afterload can change cardiac output
We function normally with a relatively constant volume (except for adjustments in stressed and unstressed volume)

Flow involves redistributing the volume and creating pressure differences across vascular beds
Since volume does not change much, preload is not a major mechanism for increasing cardiac output in normal physiology.

- Preload functions to **fine tune** the heart and matches cardiac output to changes in venous return.
- CVP/Pra is determined by interaction of cardiac function and return function.
- Little change in Pra during exercise.
Pra vs Cardiac Output during incremental exercise

Cardiac output (L/min)

Right Atrial Pressure (mmHg)

Little change in CVP

No volume needs to be added to reach the high cardiac output at peak exercise!

Notarius et al Am Heart J 1998
CVP at “Plateau” (ie non-responsive) is variable

One size does not fit all!
ScvO$_2$

- Volume could potentially decrease the value by lowering Hb
- Does it really need to be $> 70\%$?
  - Can fall with increased wakefulness/agitation
  - Restoration of O$_2$ debt
  - Only tells you upper body and not lower
Reactive Flow-Directed Approach
An abnormality ("trigger") develops that you believe indicates a decrease in $O_2$ delivery

- Change in sensorium
- Decrease in urine output
- Hypotension
- Increase in lactate
- Fall in central venous saturation

You hypothesize that volume may help.

A reactive approach tests the hypothesis.
Where did the volume go?

**Septic patient**
1. Capillary leak
2. Increase in capacitance
3. Lack of regulation of resistances re-distributes flow to areas of low need
4. Lack of intake because of altered sensorium

**Surgical patient in OR**
1. Bleeding
2. Evaporative losses in long open case
3. Excessive urinary loss
4. Increase in capacitance from anesthetic
What does volume do for DO$_2$?

- It increases **cardiac output** by increasing cardiac filling
- If the problem was not fixed you need to know if **cardiac output** increased
- If **yes**: give more volume
- If **no**: 1. Was enough volume given? OR 2. Is the patient not volume responsive and something else must be done
1. Assess the value of Pra (NOT the wedge).

2. Give sufficient fluid to raise Pra by ~2mmHg and observe Q.

Type of fluid is not of importance if given fast enough.

Increase in CVP tells me that I tested Starlings law.
Change in CVP of even 1 mmHg should be sufficient to test the Starling response.

\[ Q \text{ (l/min)} \]

\[ \text{Pra (mmHg)} \]

\[ \text{Slope} = 500 \text{ ml/mmHg/min} \]

Plateau
Assessment of cardiac output is the key element in a responsive approach

- **Indirect**: improvement of: – BP, urine output, sensorium, skin perfusion, lactate, ScvO$_2$ (ie the “trigger”)

- **Direct measurement**
  – many non-invasive products available today but they vary in their accuracy of measurement
This should make it possible to now have flow-based protocols for fluid management and to avoid over-use of fluids.
## Accuracy vs Precision

<table>
<thead>
<tr>
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<th>Accurate</th>
<th>Inaccurate (systematic error)</th>
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<tbody>
<tr>
<td>Precise</td>
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<td><img src="image2.png" alt="Precise Inaccurate" /></td>
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<tr>
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<td><img src="image4.png" alt="Imprecise Inaccurate" /></td>
</tr>
</tbody>
</table>
Precision vs Accuracy

• Accuracy indicates similarity of measured value to gold-standard
  – Important when value is used as a “trigger”

• Precision indicates that the value is reproducible
  – Important when value is used for trending
  – Accuracy is then not as important
729 Fluid Challenges

 Potter et al J Crit Care 2012
The less invasive the device the less the precision

- High precision and accuracy: Pulmonary artery catheter, PiCO (thermodilution), LidCo plus (calibrated with lithium)
- Medium to high: esophageal Doppler – velocity and not flow and affected by diameter and angles – only descending aorta – need to be intubated
- Medium to low: arterial waveform, plethysmographic
- Low finger pulsation devices

The less ill the patient the less need for accuracy - the trend is key

Non-cardiac Sx pt do not need high accuracy – flow is used to indicate the fluid response
Accuracy of 4 devices compared to PA catheter
Devices tested tracked changes very well (good precision)

- Pts post cardiac surgery
- PA catheter and low invasive devices
- 18 to 24 hr post surgery
- Received multiple interventions – fluid boluses, NE, Epi, Dobutamine, Nitroprusside
Fluids after cardiac surgery: A pilot study of the use of colloids versus crystalloids*

Sheldon Magder, MD; Brian J. Potter, MD; Benoit De Varennes, MD; Steve Doucette, Msc; Dean Fergusson, PhD; for the Canadian Critical Care Trials Group

Crit Care Med 2010 Vol. 38, No. 11

62% reduction in need for catecholamines the morning after surgery with use of colloid and no increase in renal injury or blood requirement
CI < 2.2
or
MAP < Target
or
SBP < Target
or
CVP < 3

No

CI < 4 and CVP < 12?

Yes

Patient on Catecholamines?

Weaning Protocol

Observe

No

Catecholamine Protocol

R/O Low SVR or RV limitation

Fluid Protocol
This meant that a pt who had an increase in CVP from 2-4 mmHg and $\Delta$CI < 0.3 L/min/m² would not get further volume boluses.
Conclusion

• Goal-directed therapy uses targets which have not been validated
  – Can lead to excess treatment
  – Currently no advantage over standard therapy
• A flow-directed responsive approach allows the clinician to follow the response to his/her clinical hypothesis
• Since the major role of volume therapy is to increase cardiac output it is important to know what happened to CO with the therapy
BP = Cardiac Output \times SVR

Measured variable

First Question to ask:

*Is the cardiac output decreased*

Cardiac output is the problem

*Is the cardiac output normal or increased*

SVR is the problem
1 Assess the value of Pra (NOT the wedge).

2 Give sufficient fluid to raise Pra by ~2mmHg and observe Q.

*Type of fluid is not of importance if given fast enough*