Pitfalls of using Minimally Invasive Cardiac Output Monitoring in the Operating Room

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Minimally Invasive Cardiac Output Monitoring

Pulse Contour
FloTrac, LiDCO, PiCCO

BioImpedance
NICOM Cheetah, PhysioFlow

Doppler (Ext. & Oesoph.)
USCOM, CardioQ
Ideal MICOM does not exist

Convenient
Reliable
Easy to use
Low cost
Probably need a selection of MICOMs: And choose the best one(s) for each case

PhysioFlow / USCOM / CardioQ
Focus on USCOM:

- Because MICOM I use most
- Set up in < 5min
  - Used at point of care
- Easy to use:
  - Probe application simple
  - Scanning – time to learn
- Minimal cost:
  - Permanent probe
  - Do need acoustic gel
- Readings trustworthy?
Hand held USCOM probe with acoustic gel applied to the head.
When should I use the USCOM?

**Planned use**
- Colorectal & GDFT
- ASA3 - CV disease
- Research cases

**Unexpected problem**
- Unexplained ↓BP
- Excessive blood loss
Planned Use of USCOM: How is it used?

1. Turn On
   - Battery or Mains supply

2. Boot Up system
   - Create new patient file
   - Calibrate – patient data

3. Ready to scan

4. Focus probe beam
Aortic Valve

Pulmonary Valve

Ventilation Inspiration Beam occluded by lungs
Beam direction and route: Aortic Valve
Scanning the Aortic Valve: For optimum signal

SHOW VIDEO OF USCOM BEING USED
How reliable is my scan data?

*Two important issues*

**Correct flow profile**
Where is the signal origin?

**Quality of the signal**
Which signal is correct?
CAN I OBJECTIVELY ASSESS THE USCOM SIGNAL?

<table>
<thead>
<tr>
<th>Quality</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>very reliable</td>
</tr>
<tr>
<td>Good</td>
<td>reliable</td>
</tr>
<tr>
<td>Fair</td>
<td>acceptable</td>
</tr>
<tr>
<td>Poor</td>
<td>reject</td>
</tr>
</tbody>
</table>
Objective assessment of signal quality?

12-point assessment score (>5/12)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>2 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstroke</td>
<td>Well-defined on all 3 peaks</td>
</tr>
<tr>
<td>Downstroke</td>
<td>Well-defined on all 3 peaks</td>
</tr>
<tr>
<td>Apex</td>
<td>Well-defined on all 3 peaks</td>
</tr>
<tr>
<td>Area</td>
<td>Entire area is shaded blue</td>
</tr>
<tr>
<td>A valve opening</td>
<td>-</td>
</tr>
<tr>
<td>A valve closing</td>
<td>-</td>
</tr>
<tr>
<td>E or A wave</td>
<td>-</td>
</tr>
<tr>
<td>Baseline</td>
<td>-</td>
</tr>
</tbody>
</table>

Study to determine the repeatability of supra-sternal Doppler (ultrasound cardiac output monitor) during general anaesthesia: effects of scan quality, flow volume, and increasing age

Coefficient of variation (CV) of 6 (six) serial USCOM scan readings used.

The lower the CV % the better the repeatability of the readings, where <5-10% is clinically acceptable.

N = 180 patients
What factors effect my ability to find and insonate the aortic valve flow?

- Ability to insert probe into sternal notch
  - Prominent trachea
- Aging
  - Unfolding and calcification of the aorta
- Low cardiac output
  - Doppler signal is weak
Effect of Age on signal quality

![Graph showing the effect of age on ability to use the USCOM. The x-axis represents patient's age (years) ranging from 0 to 100, and the y-axis represents Cattermole score ranging from 0 to 12. The graph includes a dashed line indicating USCOM unreliable below this line (Cattermole) and another dashed line indicating USCOM readings still accepted.]

- USCOM unreliable below this line (Cattermole)
- USCOM readings still accepted
Correlation between supra-sternal Doppler cardiac output (USCOM) measurements and chest radiological features

L. Huang,¹ L. A. H. Critchley,² R. L. K. Lok³ and Y. Liu⁴
Age related changes in the aorta: bigger, longer & more tortuous → Calibration
COMPARED TO OTHER METHODS USCOM REQUIRES TRAINING & USER SKILL

DISINCENTIVE TO ACCEPT TECHNOLOGY
How do I use USCOM to assess trends and perform goal directed fluid therapy?

- Compare numerical readings
- Compare scans before and after IV fluid bolus
- Time plots of SV and CO
Before volume expansion

After volume expansion - volvulyte 250 ml
USCOM trend plots
Can I trust the changes in CO? Are they reliable?

**DOPPLER**
- Direct flow measurement
- Quality of scan critical
- Angle of insonation:
  - USCOM (in line of flow)
  - CardioQ (45 degrees)

**PULSE CONTOUR ANALYSIS**
- Indirect measurement
  - Pressure converted to Flow
  - Effected by other factors i.e. peripheral resistance!
Can I trust the changes in CO? Are they reliable?

- **BIOIMPEDANCE**
  - Direct or Indirect measurement?

- Still not determined what is being measured
  - i.e. the underlying bio-electric principle behind impedance signal

- Probably:
  - Mass movement of blood within an electric field
    - The flux of alternating current passing across the heart and great blood vessels.
  - Therefore is a **direct** measurement of blood flow!
How does CardioQ compare to USCOM?

- **Continuous readings:**
  - Used as monitor intra-op.

- **Still have to:**
  - Save profiles (limited!)
  - Focus probe

- **Reading vary with:**
  - Probe depth
The effect of aorta unfolding and remodelling on oesophageal Doppler readings as probe depth is varied

J. Zhang¹, L. A. H. Critchley²,* and L. Huang²
How can I verify my USCOM data?

- Compare to other methods:
  - USCOM pulmonary valve
  - CardioQ
Dual Doppler reference method:  

**Using USCOM and CardioQ together**

- USCOM plus CardioQ  
  - Alternative to PAC – TD

- Time plots showed good tracking ability across a wide range of CO in most patients.

- Correlation between the two devices was excellent in 14 patients (R² >0.85), good in another four (R² >0.64) and poor in two (N=20).

- Used Dual Doppler to assess the NICOM Cheetah.

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Unplanned use to diagnose the haemodynamic status: i.e. Low BP

\[ \text{BP} = \text{CO} \times \text{SVR} \]

\[ \text{CO} = \text{SV} \times \text{HR} \]
Ectopic pregnancy: Low BP with Tachycardia?

- USCOM CO = 10 L/min
- Haemoglobin = 4 g/dl
- Viscosity / SVR problem NOT hypovolaemia
- Rather than more IV fluids gave red blood cells
Does USCOM harm the patient?

The USCOM Kiss
Main points about PhysioFlow

• **BiolImpedance technology**
  – Safe, simple & cost effective
  – Continuous data
  – Susceptible diathermy but not movement

• **Electrodes and their positioning critical**
  – Posterior lower chest leads
  – Low impedance

• **Provides visual waveforms assessment**
  – Waveform morphology
F/56, ASA 1, Open resection bowel tumour: Comparison of PhysioFlow to Doppler
Electrode positioning for PhysioFlow: Anteriolateral vs. Posterior

**Learning points:**
- Changed to posterior back leads
- Value of a reference trend-line
- Importance of looking beyond just the numerical readings
F/35, ASA I, Lap. Re-implant Ureter

Cardiac output comparisons over time

In some cases the PhysioFlow readings drift downwards (become lower) making the readings unreliable. Currently investigating the cause.