Cardiac Output Monitoring: Expense justified by outcome?

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Contents of this talk

• Cardiac output in intensive care settings
  – by PA catheter and other means
• Is there any benefit to such measures?
  – Opinion, non-randomised studies
  – Randomised Controlled Trials
  – Systematic Reviews
  – Health Technology Assessments
• If there is any benefit – is it worth the cost?
CO monitoring methods and devices

- Thermodilution
  - PA catheter
- Lithium dilution
- Pulse contour analysis
  - Pulsion PiCCO
  - Edwards Flotrac/Vigileo
- Doppler (oesophageal or suprasternal)
  - Aortic cross section area and flow-time analysis
- Thoracic bioimpedence
US market ($USDm) for devices 2006-2009 and forecast 2010-2012

Insight Market Report #A346, June 2008
Pulmonary artery catheterisation

- **History**
  - Self-catherisation (Forssmann) 1929
  - Diagnosis in cardiac labs (Cournand and Richards) 1945
  - Balloon-tipped catheter (Swan and Ganz) 1969
  - Thermistor for CO measurement (Ganz) 1972

- **Risks**
  - PA rupture, PA thrombosis, pulmonary infarction, bleeding, valve damage, endocarditis, dysrhythmias, catheter ‘knotting’, some early deaths reported …
  - No attributable deaths in 2642 patients in 6 recent RCTs

- **Benefits**
  - Not measured as they were thought to be ‘obvious’ …
Controversy over benefit began a long time ago..

- ‘The use of pulmonary artery flow-directed catheters has assumed epidemic proportions without clinical trials establishing improved outcome as a result of their use.

A clinical trial is urgently needed to assess the balance between risks and benefits.’

Because monitors don’t treat patients …

- For monitoring to benefit patients
  - Data from a monitor must reliably reflect the physiologic state (better than a clinical exam)
  - An intervention must be available to change the physiologic state
  - Changing the physiologic state must improve patient outcome
Does maximising oxygen delivery improve outcome?

- Meta-analysis of seven RCTs
  - Relative mortality risk 0.86 [0.62-1.20, NS]
  - ‘Interventions designed to achieve supra-physiologic goals of cardiac index, DO$_2$, and VO$_2$ did not significantly reduce mortality rates in all critically ill patients’
  - ‘..no evidence to support .. a strategy to maximize DO$_2$ in a group of unselected patients. Nonetheless, this management approach is bound to continue to fuel controversy as clinicians often interpret evidence differently, and hold different beliefs about the value of a given approach, regardless of the quality of the evidence’

Further doubts were cast by epidemiologic association data …

- 5735 ICU patients, 2184 with PAC
  - Case-matched by disease and propensity score
  - OR 1.24 [1.03-1.49] for 30-day mortality in PAC patients
  - ‘These findings justify reconsideration of a randomized controlled trial of right heart catheterization and may guide patient selection for such a study’

“Is it time to pull the PA catheter?”

- ‘Does pulmonary artery catheter-guided management improve outcomes in patients with sepsis or septic shock?’

‘Uncertain.’

‘Various management strategies for sepsis and septic shock (intravenous fluids, vasoactive medications, inotropic medications, etc.) should be evaluated in prospective, randomized, controlled trials’

Clash of the Titans...

- ‘.. misuse of the PA catheter is common .. a moratorium is not necessary .. clinical trials in heterogeneous ICU populations are not warranted’


- ‘.. a provocative, opinion-based overview of PA catheter use... a point of view that has led to the current problems we face. We are using technology introduced on the rationale of physiologic measurement without hard data about potential benefits, costs and harms’

RCTs began (at last) … #1

• 1994 ASA III or IV patients
  – Booked for major surgery and elective 24 hr minimum ICU admission
  – Pre-op PA catheter plus goal-directed therapy vs. standard care

• No difference in
  – Hospital mortality (PAC 7.8% vs. No-PAC 7.7%)
  – Hospital length of stay (both groups median 10, IQR 7 – 15 days)
  – Survival at 6 (PAC 87% vs. No-PAC 88%) or 12 months (83% vs. 84%)

• Pulmonary embolism
  – More with PAC (8/997 vs. 0/997, p = 0.04)

RCT #2

- 433 patients with severe heart failure
  - Randomized to PA catheter vs. clinical assessment
- No difference in
  - Days alive out of hospital in the first six months
  - Exercise, QOL, biochemical and ECHO changes
- More adverse events
  - PAC 21.9% vs. no-PAC 11.5%, p = 0.04

RCT #3

- 201 general ICU patients in a single centre
  - Median APACHE-II 21, sepsis 50%, acute renal failure 12%
  - Randomized to PA catheter vs. no PA catheter
  - Treatment at clinician discretion

- No difference in
  - 28-day mortality (PAC 47.9% vs. No-PAC 47.6%)
  - ICU or hospital length of stay for all patients
  - ICU or hospital length of stay for survivors

Rhodes A et al. A randomised, controlled trial of the pulmonary artery catheter in critically ill patients. Intens Care Med 2002; 8: 256-264
RCT #4

- 676 patients with shock and/or ARDS
  - Septic shock 67%, acute renal failure 44%
  - Randomized to PA catheter vs. no PA catheter
  - Treatment at clinician discretion

- No difference in
  - Mortality at 14 days  28 days  90 days
    50% vs. 51%  59% vs. 61%  71% vs. 72%
  - Organ failure-free days, ICU or hospital stay

Richard C et al. Early use of the pulmonary artery catheter in patients with shock and the acute respiratory distress syndrome. JAMA 2003; 290:2713-20
RCT #5

- 1041 patients in 65 British ICUs
  - Sepsis 57%, APACHE-II score median 22
  - PAC vs. no PAC, clinician treatment

- No difference in
  - ICU mortality, 28-day mortality, hospital mortality
    60% vs. 57%, 62% vs. 60%, 68% vs. 66%
  - Organ-support days in ICU, ICU stay or hospital stay
  - In the ‘no-PAC arm’ mortality was identical (66%)
    in both the 400 patients with and the 107 without
    alternative means of cardiac output measurement

RCT #6

- 1000 patients with ALI in 20 US/Canadian ICUs
  - APACHE-III score median 22, Murray score median 2.7
  - PAC (CO and PAOP, no SVO₂) vs. CVC (CVP only)
  - Early treatment of shock by clinician discretion, subsequently fluid/inotrope/diuretic by protocol

- No difference in
  - 60 day mortality (27% PAC vs. 26% CVC)
  - Ventilator-free days in first 28 days (13.2±0.5 vs. 13.5±0.5)
  - ICU-free days in first 28 days (12.5±0.5 vs. 12.0±0.4)

After RCTs ... come systematic reviews ... #1

• 11 studies of length of hospital stay
  – 4433 patients; 2246 with PAC, 2187 without PAC
  – Mean 0.11 days [-0.51 to +0.74, NS] longer with PAC

• 13 studies of mortality
  – 5026 patients, 2536 with PAC, 2490 without PAC
  – OR for mortality 1.04 [0.90 – 1.20, NS] with PAC

12 studies identified
- General ICU patients 4 studies, 1923 patients
- High-risk surgery patients 8 studies, 2763 patients
- No effect of PAC on mortality, length of ICU or hospital stay
- Higher charges (4 US studies) with PA catheter

After systematic reviews come Health Technology Assessments ...

- Eleven RCTs
  - 3 in general ICU patients with PAC after admission
  - 8 in high-risk surgical patients
  - 5 with ‘pre-operative optimisation’ and 3 without

- ‘Overall, regardless of the patient population studied or inclusion of additional interventions, there was no improvement in patient outcomes as a result of management with a PAC.’

Two systematic reviews of cardiac output monitoring by oesophaggeal doppler … #1

- Nine RCTs, 40–170 [median 100] patients – total 945
  - All in surgical patients intraoperatively
  - ‘No effect on mortality (but already <2% overall)
  - ‘Shorter hospital stay 2.3 days [95% CI 1.8–2.9; p<0.00001]’
  - ‘More IV colloid 736 mL [680–792; p<0.00001]’
  - ‘Fewer complications OR 0.37 [0.27 to 0.50; p<0.00001]’
  - ‘ODM is potentially cost-effective because it reduces length of stay and postoperative complications’

Two systematic reviews of cardiac output monitoring by oesophageal doppler ... #2

- Eleven RCTs
  - 9 intra-operative in surgical patients (same as review #1)
  - 2 in ICU patients (trauma, post-cardiac surgery)
  - ‘Effects on mortality some papers, but no effect overall’
  - ‘Shorter hospital stay and fewer complications in some’
  - ‘ODM strategies are likely to be cost-effective’
  - ‘Further research should include economic evaluation.’

Two HTAs of cardiac output monitoring by doppler … #1

- USCOM device (external probe)

Suprasternal notch  Supraclavicular
Two HTAs of cardiac output monitoring by doppler … #1

- USCOM device only (Compared to PAC)
- Six useable studies, 22–50 [median 30] patients – total 190
  - ‘Likely safer than PAC’
  - ‘Lack of agreement with thermodilution cardiac output’
  - ‘Evidence did not demonstrate how information would change management or improve health outcomes’
  - ‘Cost-effectiveness cannot be determined’

Medical Services Advisory Committee. Real-time measurement of cardiac output and other cardiac flow parameters (without concurrent cardiac imaging) using continuous wave Doppler techniques. Dept. of Health and Ageing, Commonwealth of Australia, June 2009
Online ISBN 1-74186-858-0
Two HTAs of cardiac output monitoring by doppler … #2

- CardioQ oesophageal doppler device only
- Eight RCTs, 40–174 [median 95] patients – total 764
  - ‘No high quality evidence of reduced mortality and no high quality studies in medical patients in critical care’
  - ‘Trials favour CardioQ-ODM … reduced hospital stay, fewer complications and quicker recovery from surgery’
  - ‘Reduction in hospital stay almost completely responsible for reduction in cost with CardioQ-ODM’
  - ‘Uncertain base LOS and treatment effects of comparators’

NICE External Assessment Centre Report. CardioQ-ODM (oesophageal Doppler monitor) to guide intravenous fluid management in patients undergoing surgery or in critical care. October 2010
One more very recent RCT …

- 388 haemodynamically unstable ICU patients
  - Randomized to minimally invasive CO monitoring (MICO) by pulse contour analysis (Flow-Trac® Ver 1.07, Edwards) or control
  - PAC allowed in both arms (38/201 vs. 49/187 in controls, p=0.11)
  - Similar patient characteristics at baseline
  - No difference in:
    - Haemodynamic stability at six hours
    - ICU length of stay or mortality
    - Hospital length of stay or mortality
  - MICO should be tested in combination with treatment protocols

NICE guidance released in March 2011

‘The CardioQ-ODM should be considered for use in patients undergoing major or high-risk surgery or other surgical patients in whom a clinician would consider using invasive cardiovascular monitoring.’

‘The cost saving per patient, when the CardioQ-ODM is used instead of a central venous catheter in the peri-operative period, is about £1100 based on a 7.5-day hospital stay.’
NICE guidance opens a £65 million opportunity for Deltex; shares rocket

Today the all-powerful National Institute for Clinical Excellence put its weight behind the heart monitoring device used in patients undergoing major or high-risk surgery.

NICE’s recommendations are keenly followed by the physicians and more importantly hospital bean-counters who hold the purse strings.

Its guidance was wider ranging than anticipated, meaning that CardioQ-ODM could be considered for use in up to 1 million patients a year. So powerful was the NICE endorsement that the shares shot up … by 48%

Source: http://www.proactiveinvestors.co.uk/ 30th March 2011
Summary

• CO monitoring by ODM combined with treatment designed to increase stroke volume may be cost-effective
  – in some peri-operative settings
  – depending mainly on any resultant changes in length of stay
  – But patient selection criteria are not well defined

• Studies with other technologies (PAC etc.) and in other settings (e.g. general ICU patients)
  – Do not support CO monitoring in reducing mortality or morbidity
  – Or as cost-saving

• Existing (especially economic) data are inadequate but clinical practice will likely be driven by marketing now …