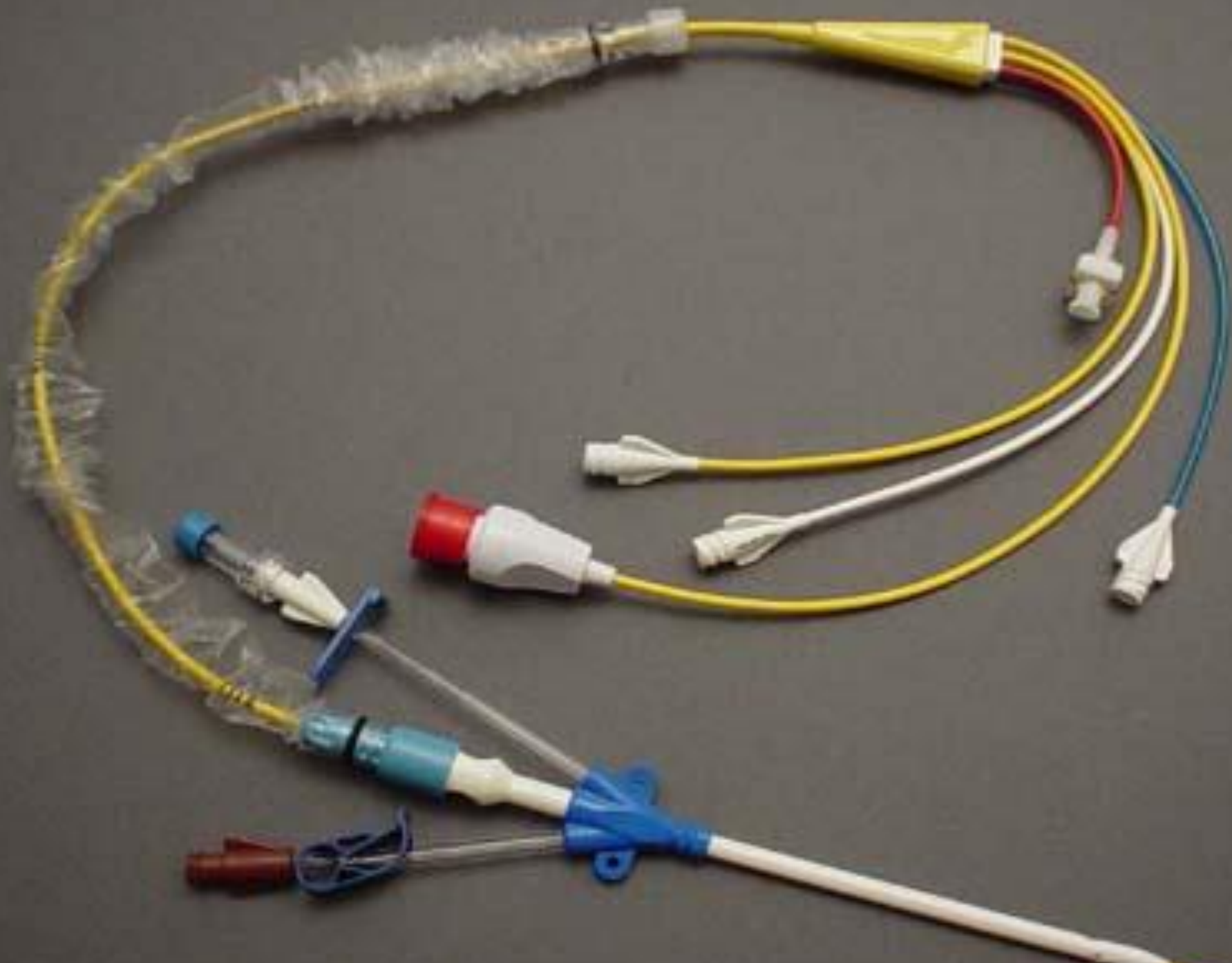


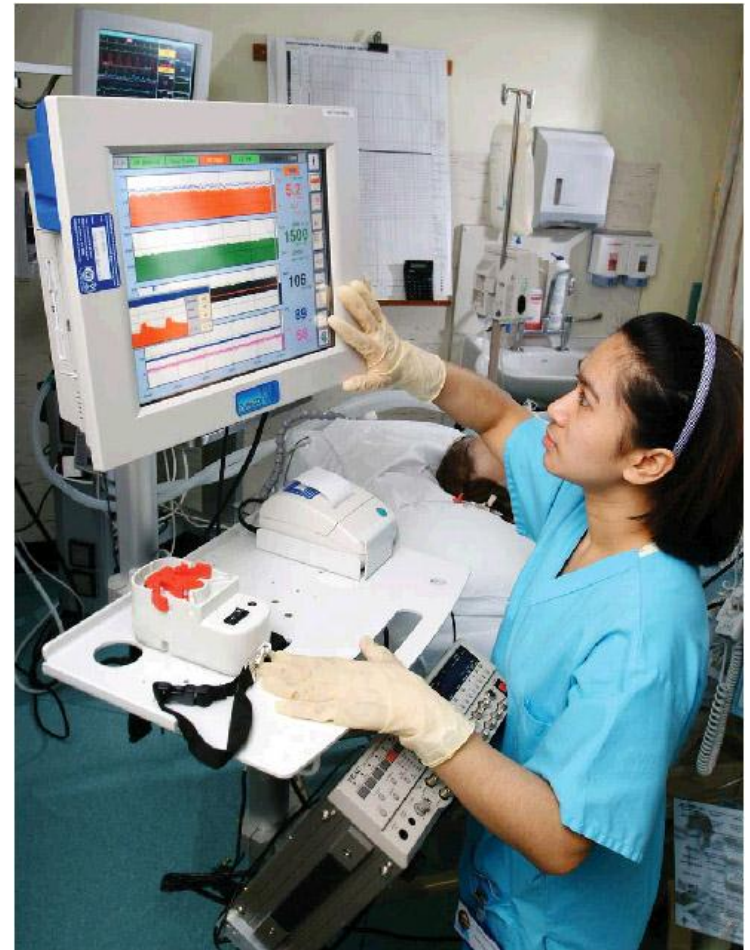
Modern haemodynamic monitoring during caesarean delivery: LiDCO to NICOM - sifting through the evidence

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Cardiac monitoring in obstetrics

- HR and BP used as surrogate markers of CO
- Required for hypertensive disease/critical illness
- Invasive monitoring undesirable
- Minimally invasive indices may predict fluid responsiveness
 - SBPV, PPV and SVV

Non- and minimally-invasive monitoring

1. Ultrasound based

- Transthoracic/transoesophageal echocardiography
- Transoesophageal Doppler
- Suprasternal aortic Doppler velocimetry

2. Bioimpedence / bioreactance

3. Modelflow

4. Analysis of arterial waveform

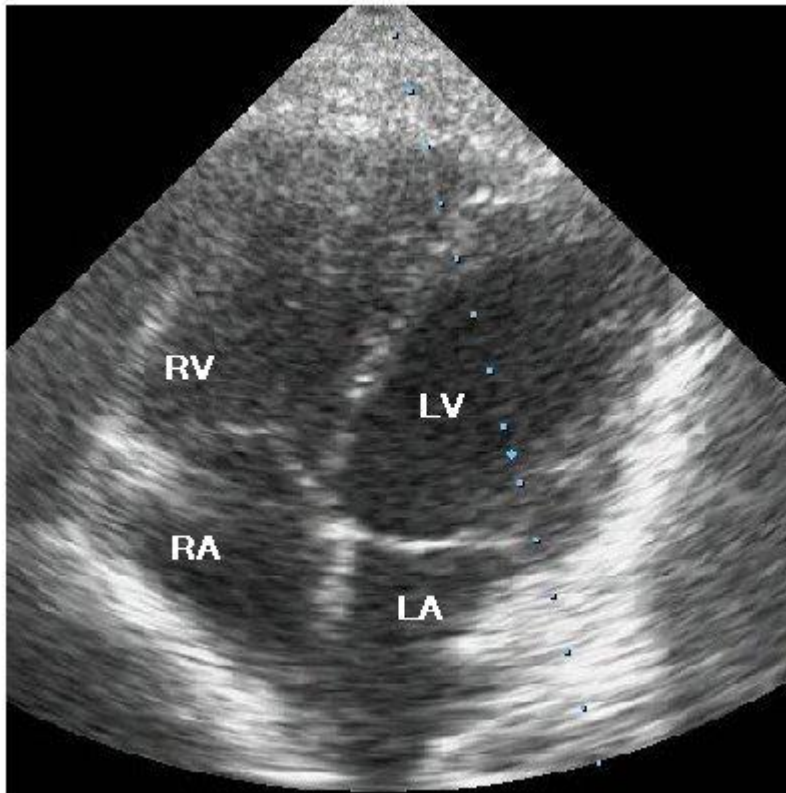
- LiDCO
- PiCCO
- FloTrac-Vigileo

5. Pulsed dye densitometry

Ideal monitor

- Accurate
- Reproducible
- Limits of agreement comparable to PAC
- Reliable
- Measure cardiac output continuously
- Quantify effect of therapeutic interventions

Transthoracic and transoesophageal echocardiography (TTE/TOE)



- Allows assessment of:
 - Filling status
 - Contractility
 - Structure
- Descending aorta not used
- Excellent correlation between echocardiography and thermodilution

Transthoracic echocardiography in obstetric anaesthesia and obstetric critical illness

Dennis IJOA 2011

- Truly non-invasive
- Appropriate and applicable
- Useful as adjunct to other haemodynamic monitoring
- Critically ill parturients:
 - Improves diagnostic accuracy
 - Continuous intervention and monitoring

TOE over TTE?

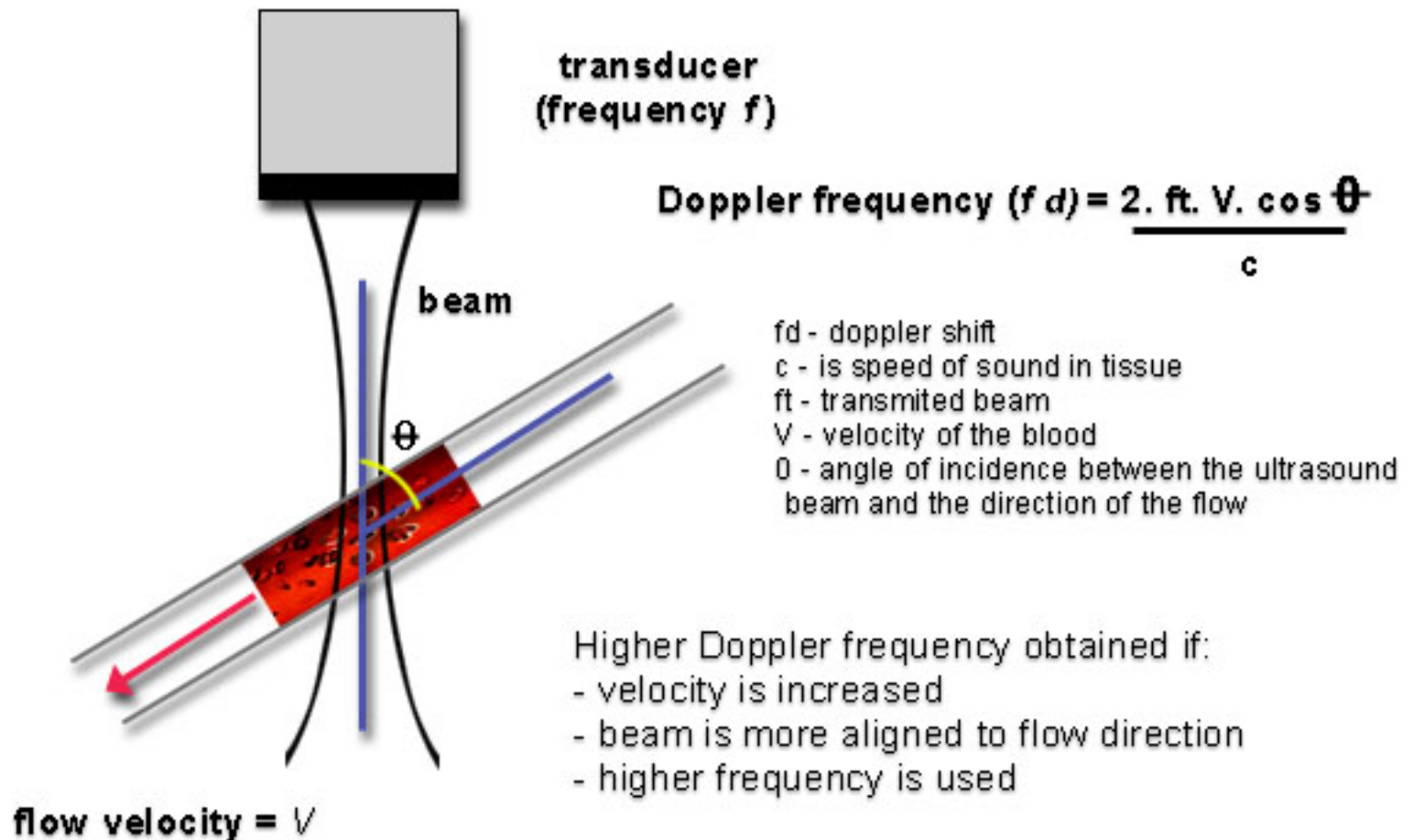
- Clearer images
- Improved views of atria/atrial septum
- Requires sedation / GA
- Routinely used in:
 - High risk cardiac conditions
 - Fulminant cardiomyopathy
 - Pulmonary/amniotic fluid emboli

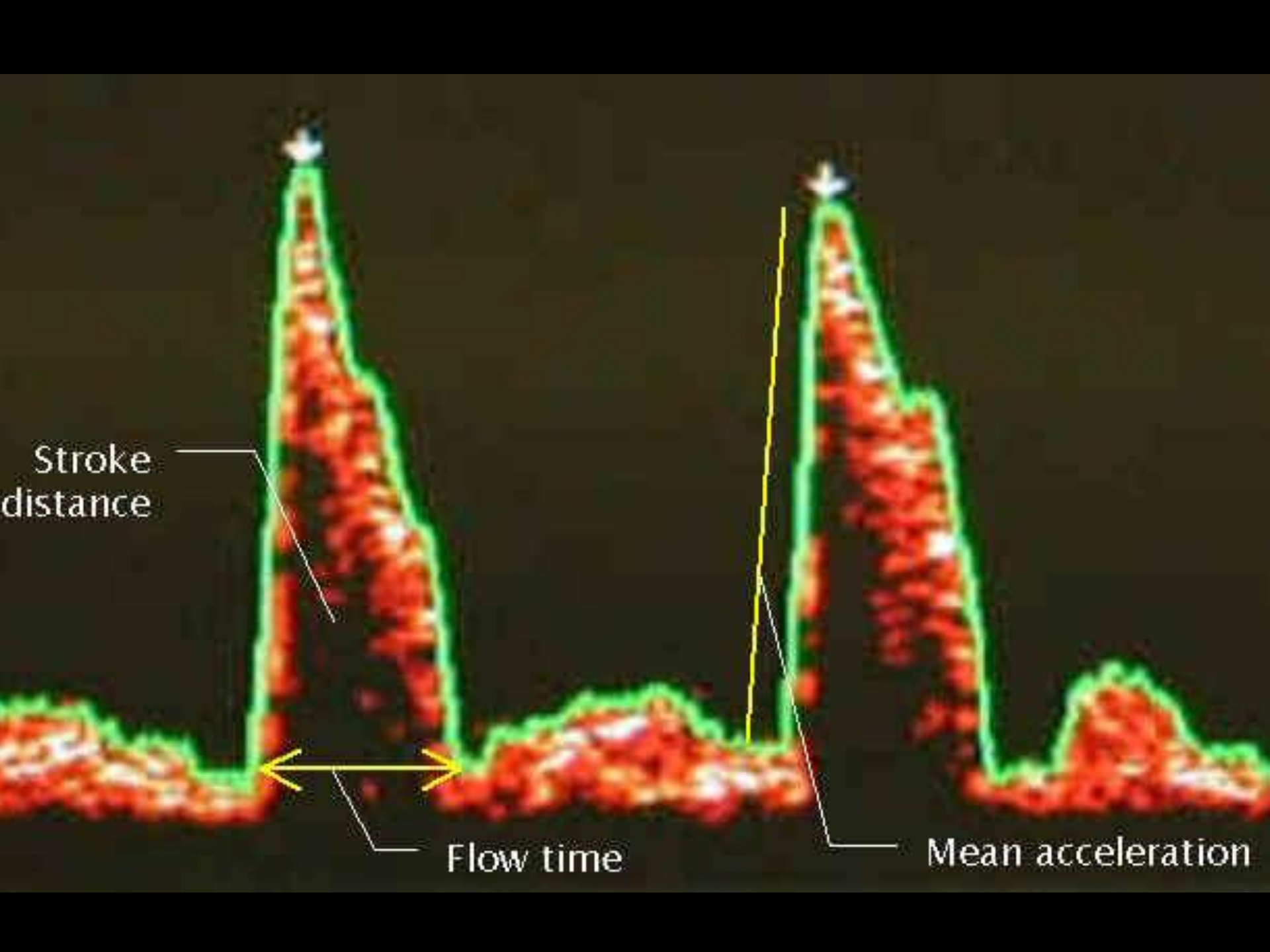
Other considerations

- Rarely acquired skill
- Unsuitable for the occasional user
- Interpretation complex
- Ongoing education and quality assurance required
- Key impact and outcome measures



Doppler velocimetry using ultrasound





Stroke distance

Flow time

Mean acceleration

Oesophageal Doppler

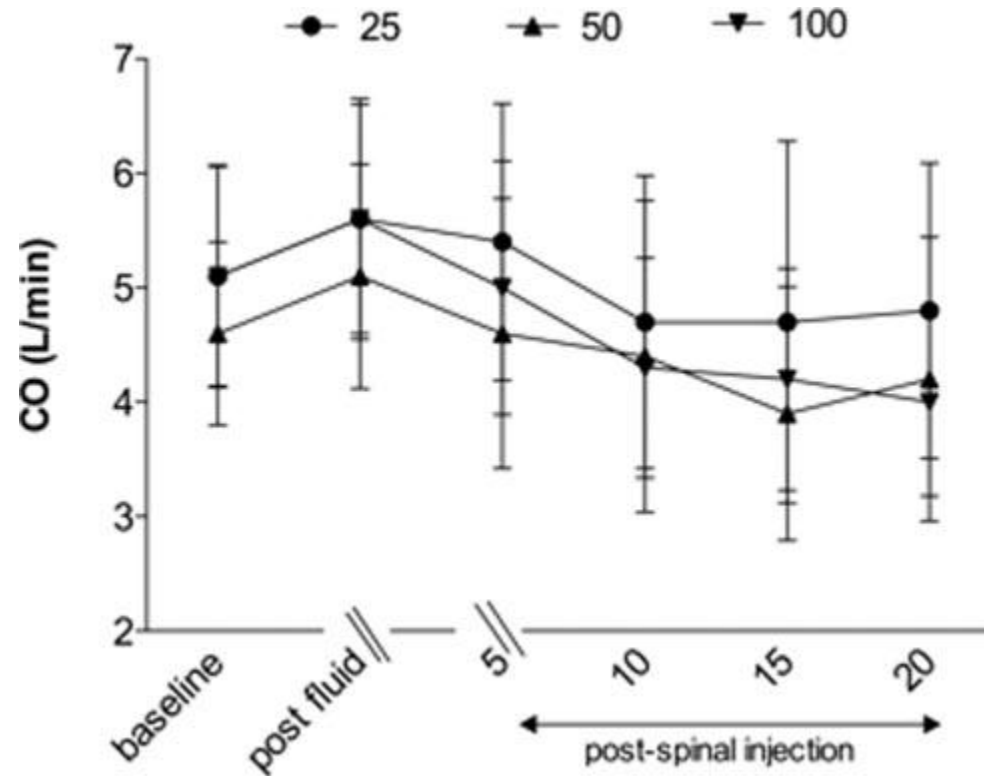
- NICE guidelines 2011 recommend use in high-risk major surgery
- Advantages
 - Easy to use after initial training
 - Comparable to PAC
 - Accurately reflects trends
- May aid management of haemodynamically unstable parturient under GA

Suprasternal aortic Doppler velocimetry



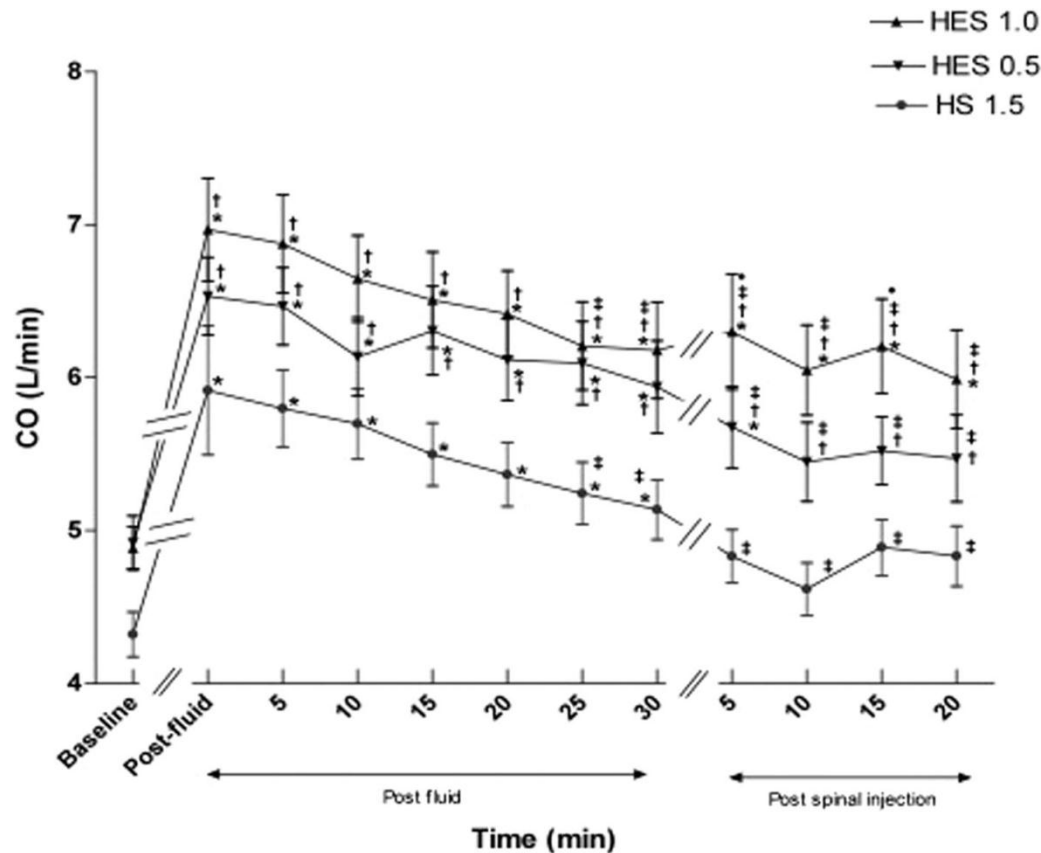
The Dose-Dependent Effects of Phenylephrine for Elective Cesarean Delivery Under Spinal Anesthesia

Stewart et al A&A 2010



The Effects of Crystalloid and Colloid Preload on Cardiac Output in the Parturient Undergoing Planned Cesarean Delivery Under Spinal Anesthesia: A Randomized Trial

Tamilselvan et al A&A 2009



Advantages/disadvantages

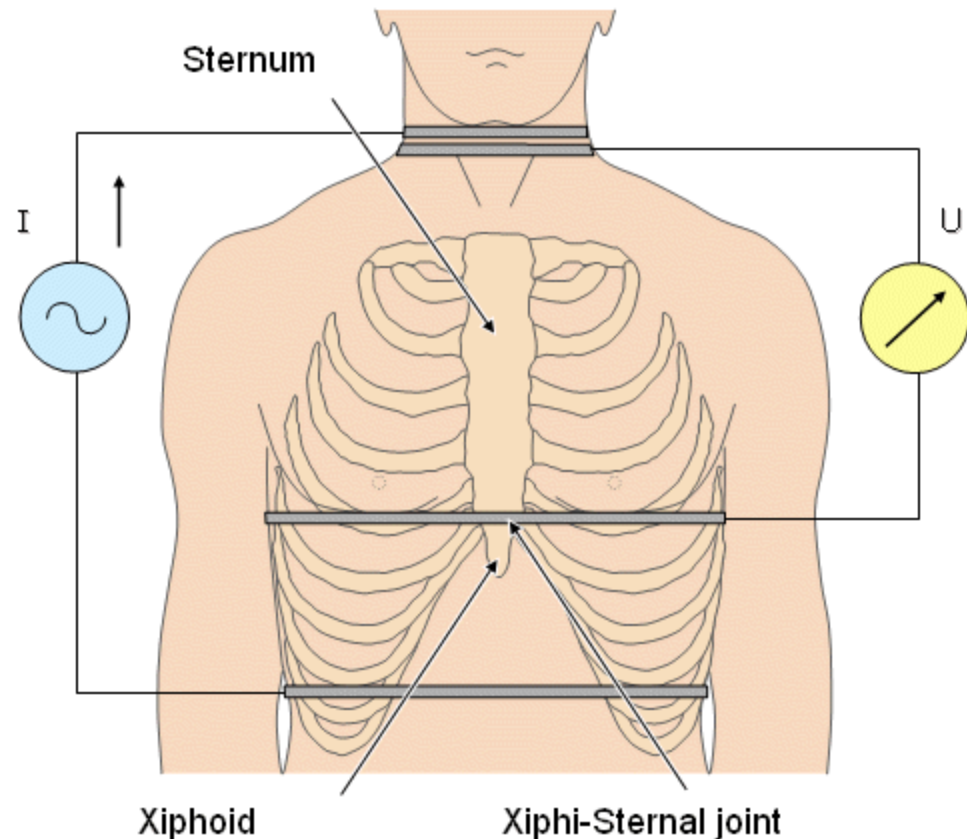
- Completely non-invasive
- Long learning curve
- Concerns regarding inter-observer variability



Transthoracic and whole body impedance

- Detect electrical resistance changes across the thorax / whole body induced by vascular flow
- Simple
- Non-invasive
- Low cost
- Ease of application

100 kHz
4 mA



Thoracic electrical bioimpedance measurement of cardiac output—Not ready for prime time

Clarke Crit Care Med. 1993

- Not reliable or accurate in the clinical setting
- Poor validation in studies in critically ill/septic patients
- Studies in pregnant women have had varying success

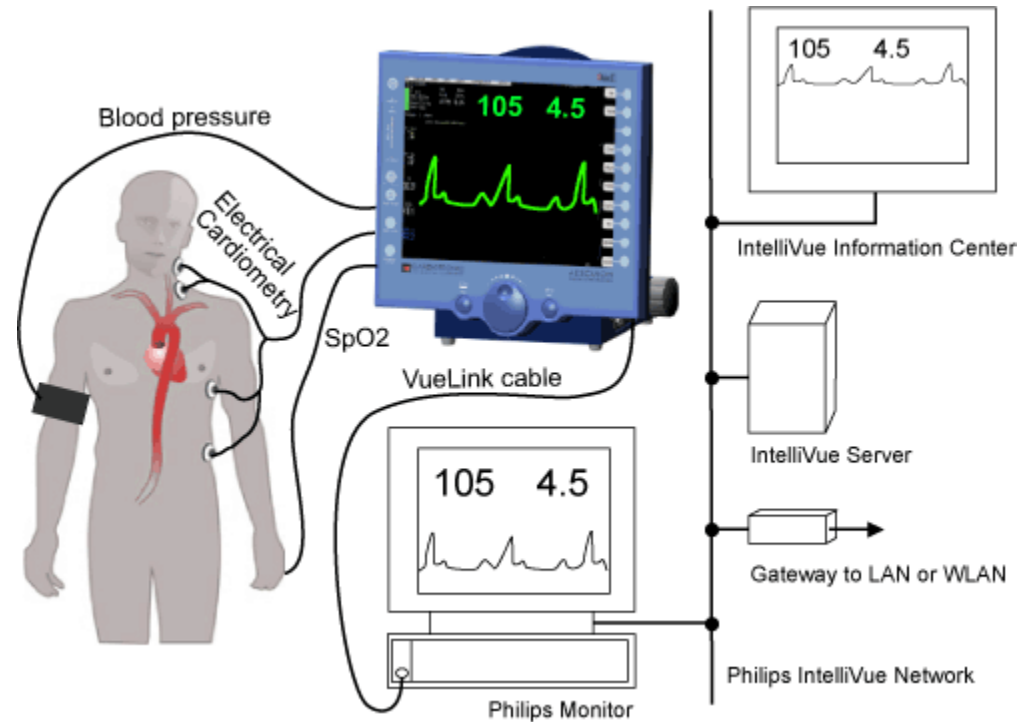
Why so unreliable in obstetrics?

- Pulmonary oedema / changes in PVR affect measurements
- Affected by whole patient positioning therefore not appropriate in labour
- Intraoperative factors:
 - Diathermy
 - Surgical manipulation
 - Mechanical ventilation

Bioreactance

- Analysis of relative phase shifts of an oscillating current traversing the thoracic cavity
- Thought to improve signal:noise
- Sensor position flexibility
- Less affected by:
 - Pulmonary oedema
 - Morbid obesity

NICOM and AESCULON



Non-Invasive Hemodynamic Assessment of Non-pregnant, Healthy Pregnant and Preeclamptic Women using Bio-Reactance

Ohashi et al Rev Bras Anesthesiol 2010

“The NICOM device is simple to use, operator independent, and provides clear and consistent monitoring signals.

The output identified distinct hemodynamic profiles that are consistent with the findings of more invasive existing methods.”

Non-Invasive Monitoring Based on Bioreactance Reveals Significant Hemodynamic Instability during Elective Cesarean Delivery under Spinal Anesthesia

Doherty et al Rev Bras Anesthesiol 2011

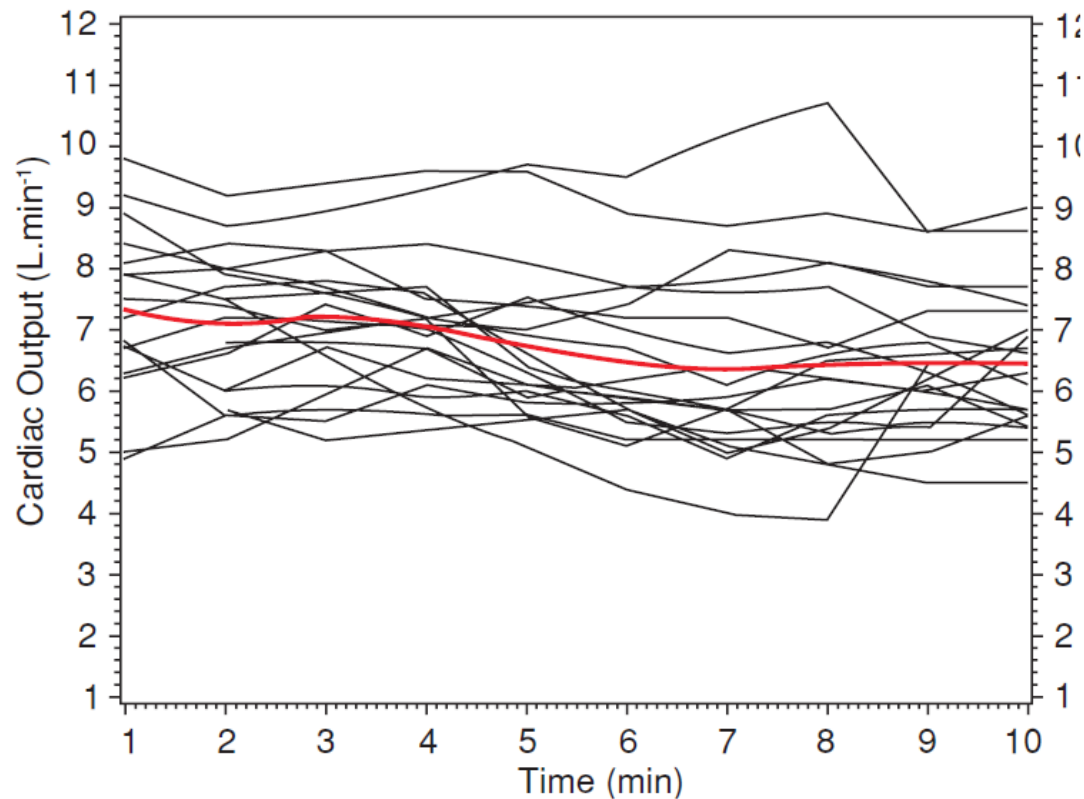


Figure 1 - Cardiac Output over Time during the Postspinal Period.

Modelflow

- Uses finger arterial pressure to calculate aortic waveform
- Convenient
- Continuous estimation of BP



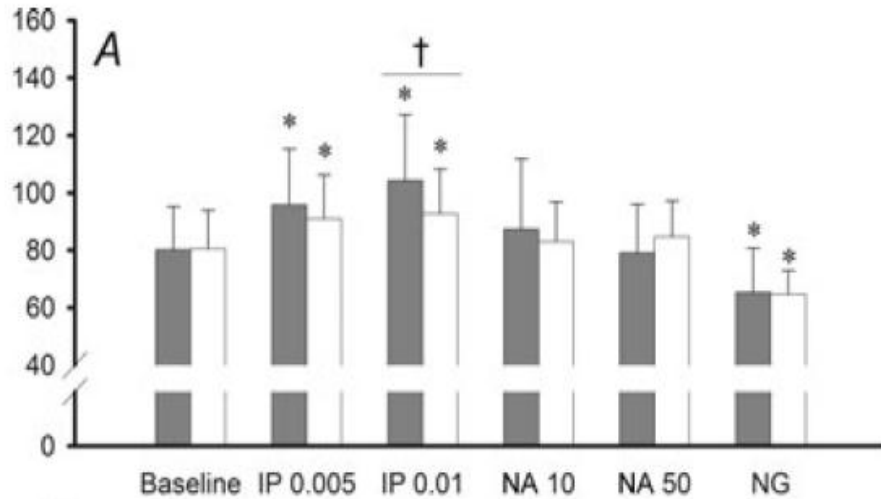
Physiological changes of pregnancy and monitoring

Carlin et al. Best Pract Res Clin Obstet Gynae 2008

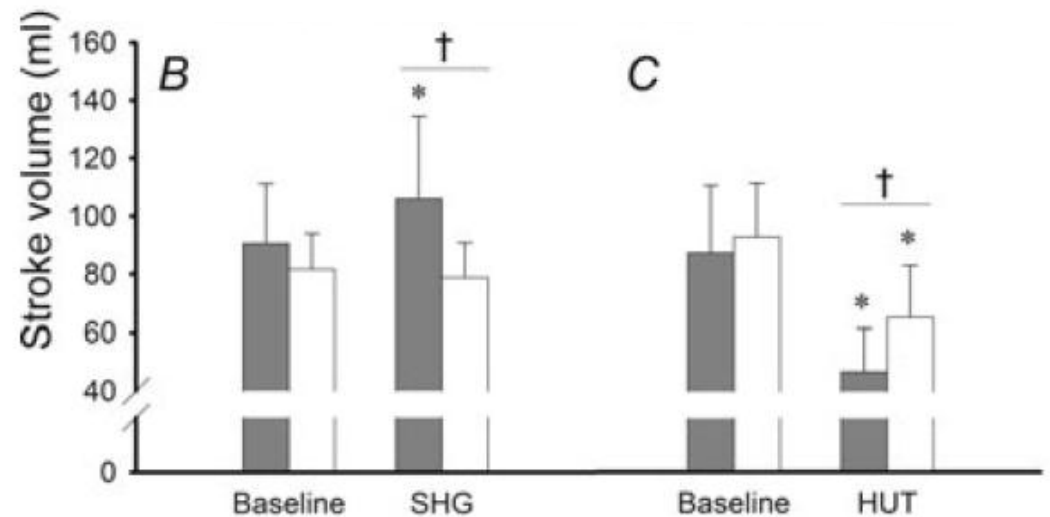
- Provides limited haemodynamic data
- Underestimates SV in pregnancy
- Inaccurate - 3-element model estimated from in-vitro aortas:
 - NIBP waveform not identical to aortic waveform
 - Movement artefact

Modelflow estimates of cardiac output compared with Doppler ultrasound during acute changes in vascular resistance in women

Dyson et al. Exp Physiology 2010

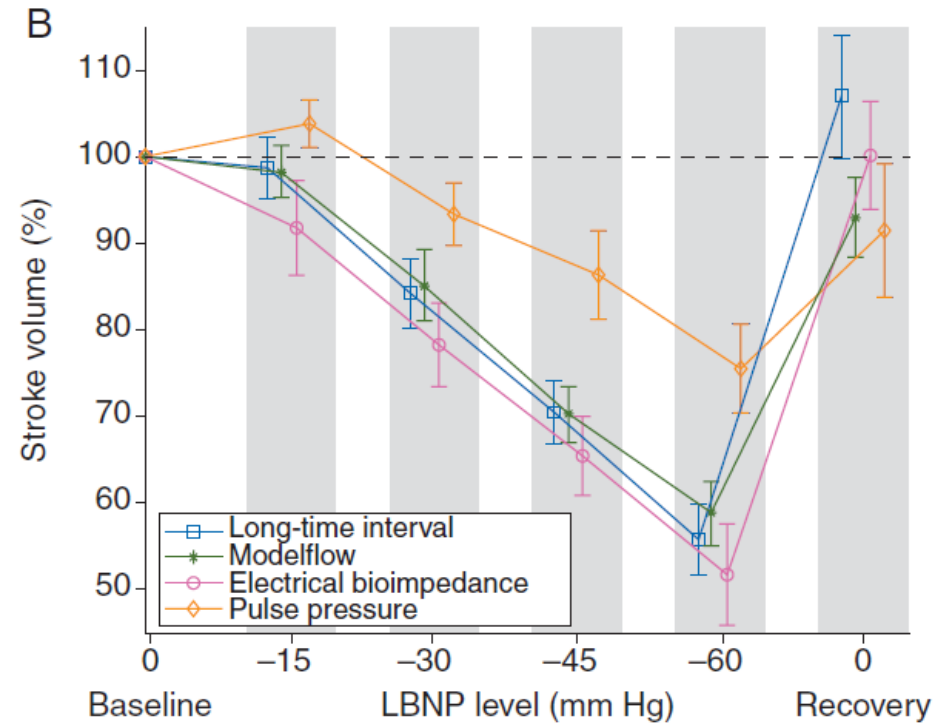
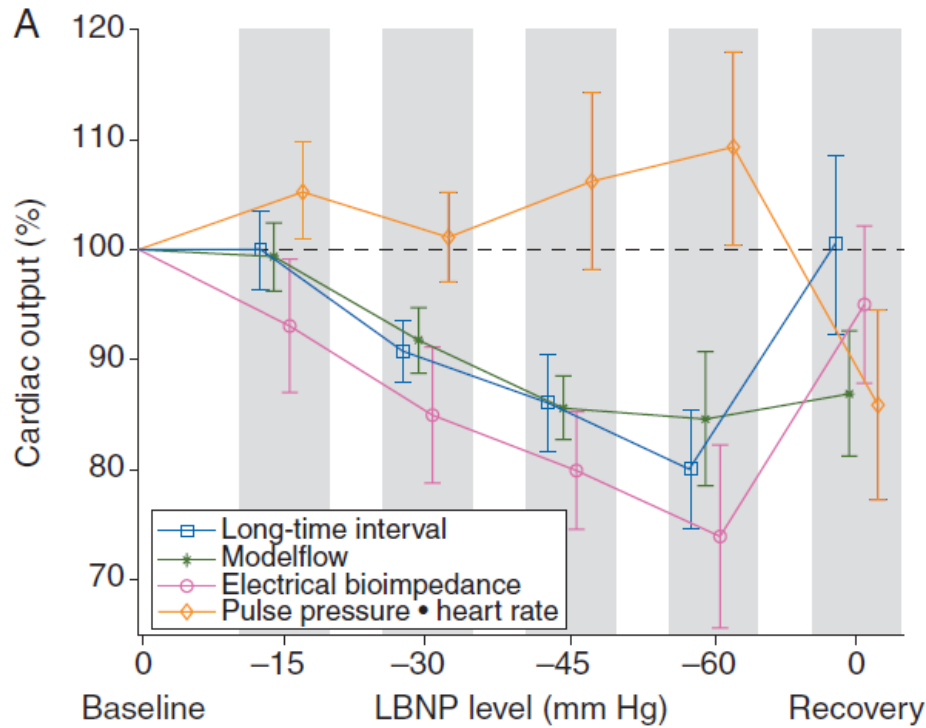


Stroke volume as measured by Doppler US (grey bars) and Modelflow (open bars) during vasopressor infusion (left) and static hand-grip/head up tilt (below)



Monitoring non-invasive cardiac output and stroke volume during experimental human hypovolaemia and resuscitation

Reisner et al. BJA 2011



Pulse contour waveform analysis

- Uses the arterial waveform to predict vascular flow
- Calibrated devices:
 - LiDCO (lithium dilution)
 - PiCCO (transpulmonary thermodilution)
- Non-calibrated devices
 - Flotrac -Vigileo

Advantages to the obstetric anaesthetist

- Minimally invasive (if arterial line in situ)
- Easy to set up
- Beat-to-beat continuous real-time data
- Arterial cannula allows sampling
- Precise/reliable to follow changes in CO
- Allows prediction ventricular preload responses
- Well-studied and validated (bias 0.03-0.3L/min)

Affected by:

- Arterial waveform changes
- Irregular pulse rate
- Extrinsic factors (PEEP, TV)

Cross-comparison of cardiac output trending accuracy of LiDCO, PiCCO, FloTrac and pulmonary artery catheters

Hadian et al Crit Care 2010

- Different devices displayed similar mean CO
- Trended differently in response to therapy
- Showed different inter-device agreement

LiDCO, LiDCOplus and PulseCo

- PulseCo
 - Pulse power analysis monitor
 - Algorithm based on patient height, weight, gender and age to estimate arterial compliance function
 - Used to follow trends
- LiDCOplus
 - Lithium dilution calibration of SV

1) A bolus of Lithium is flushed through a central or venous line



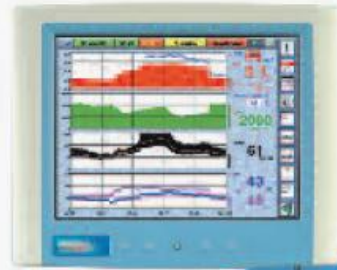
2) A Lithium sensitive sensor, attached to a peripheral arterial line, detects the concentration of Lithium ions in the arterial blood



3) The Lithium indicator dilution 'wash-out' curve on the LiDCOplus provides an accurate absolute cardiac output value

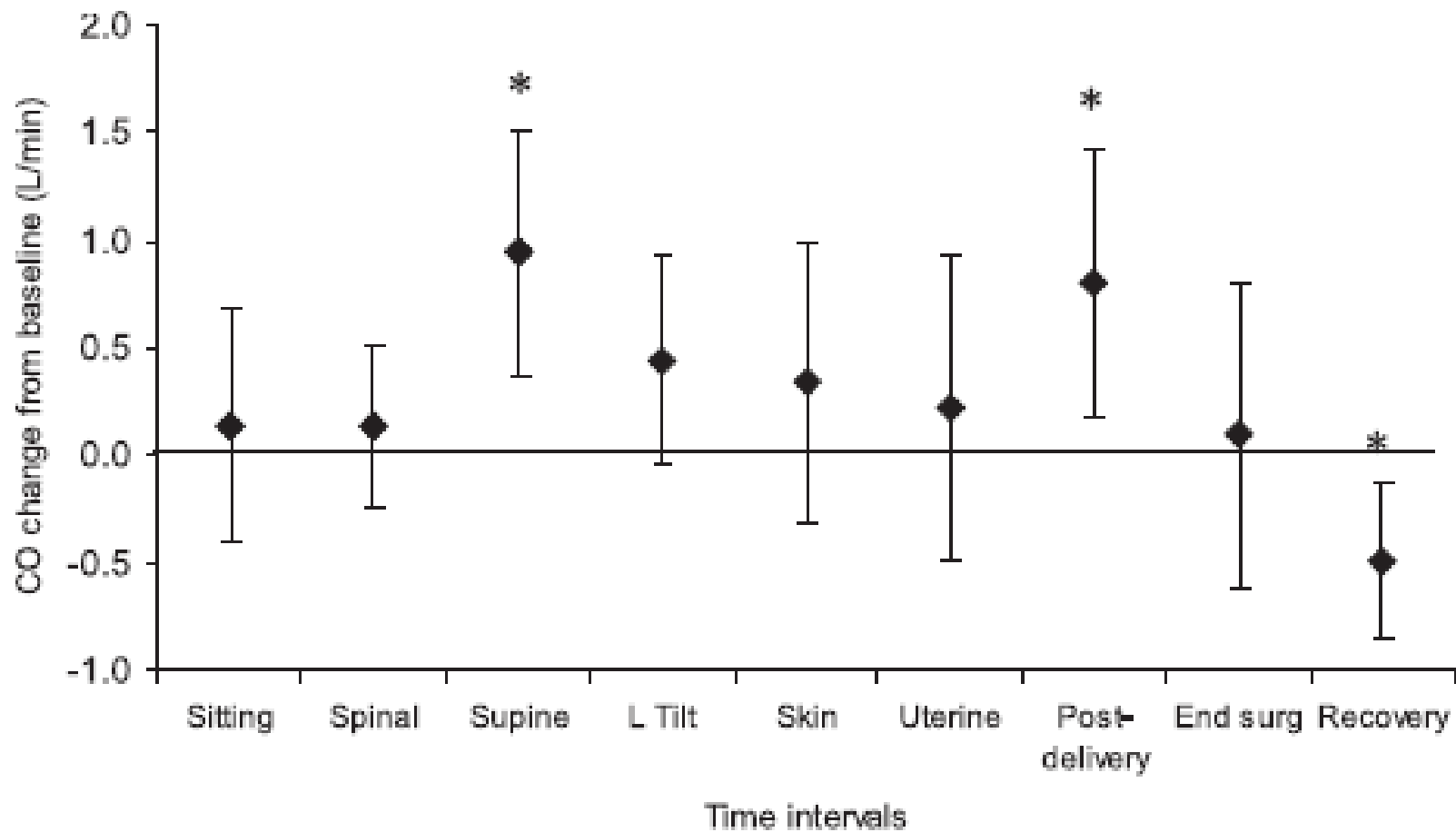


4) This value is then used to calibrate the LiDCOplus to give continuous cardiac output and derived variables from arterial waveform analysis.



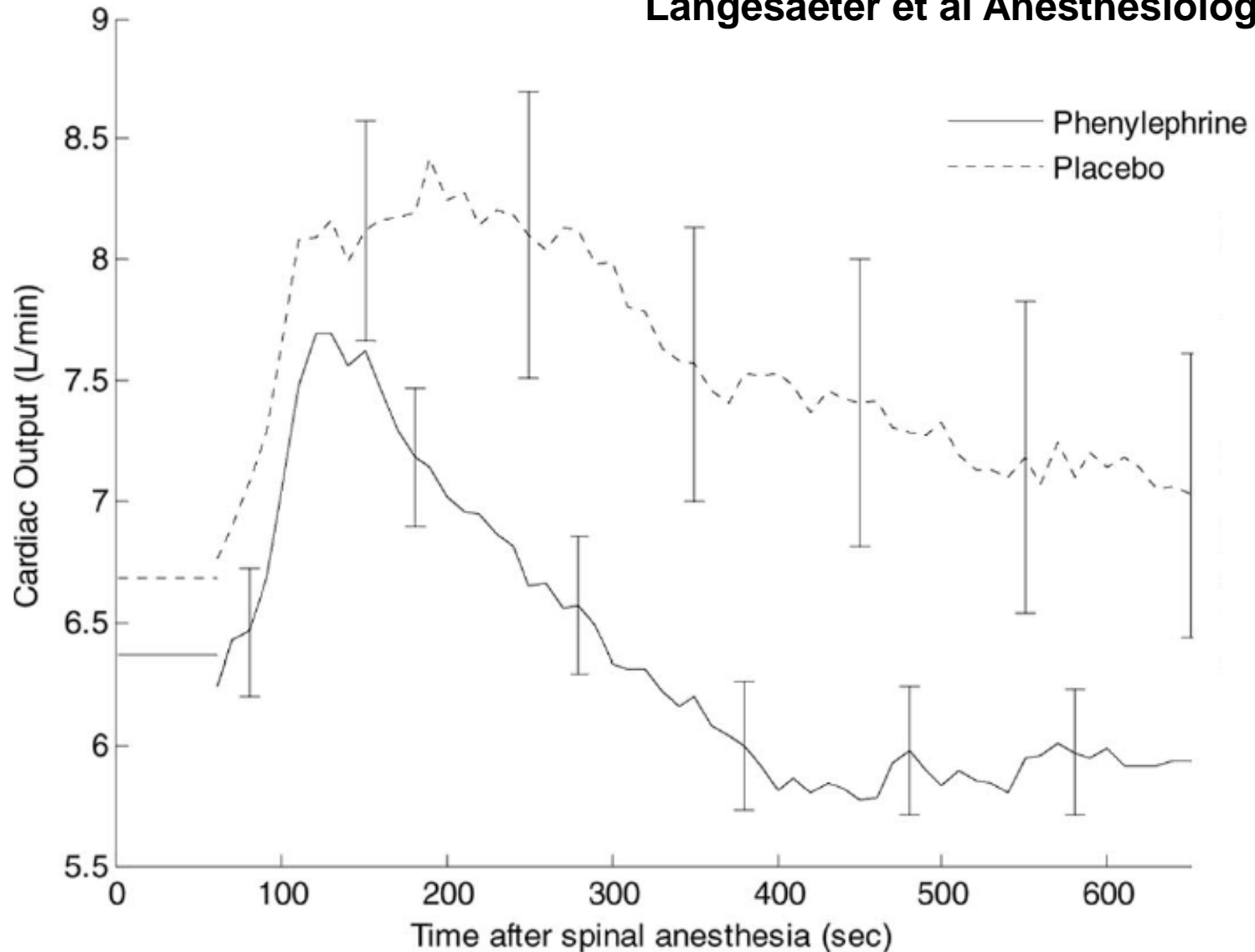
Hemodynamic Changes Associated with Spinal Anesthesia for Cesarean Delivery in Severe Preeclampsia

Dyer et al Anesthesiology 2008



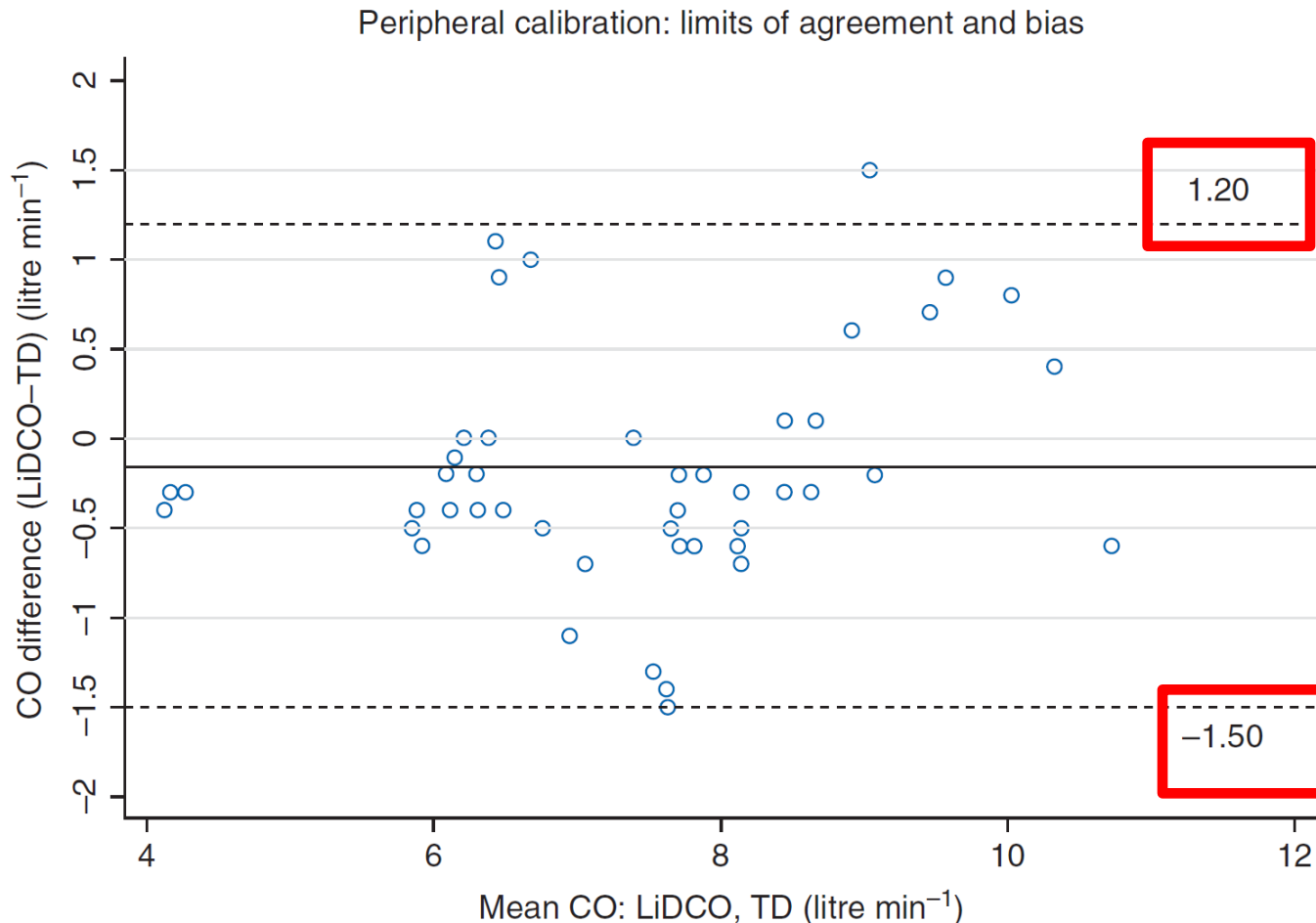
Continuous Invasive Blood Pressure and Cardiac Output Monitoring during Cesarean Delivery

Langesaeter et al Anesthesiology 2008



Comparison between pulse waveform analysis and thermodilution cardiac output determination in patients with severe pre-eclampsia

Dyer et al BJA 2011





Continuous cardiac output monitoring via arterial pressure waveform analysis following severe hemorrhagic shock in dogs*

Cooper et al CCM 2007

- PulseCO system may grossly overestimate CO
- Manufacturers state:
 - First trimester is a contraindication
 - Greater knowledge gained as to its safety in later pregnancy
- Affected by neuromuscular blocking agents
- More research required into monitoring major haemodynamic changes

PiCCO



- Transpulmonary thermodilution method to measure absolute CO
- Pulse contour analysis used to generate continuous beat-to-beat CO
- CVP and arterial line required
- NO published studies in obstetrics
- Acceptable levels of agreement in validation studies
- Some studies suggest hourly recalibration!

FloTrac-Vigileo



- >20 validation studies
- Statistical analysis of 20s windows of radial artery pressure waveforms
- Self-calibrating software installed
- Does not perform continuous real-time data

Comparison of two versions of the Vigileo-FloTrac™ system (1.03 and 1.07) for stroke volume estimation: a multicentre, blinded comparison with oesophageal Doppler measurements

Chatti et al BJA 2009

- Found percentage error in SV measurement was 58% (clinically acceptable = 30%)
- 3/15 published validation studies <30%
- Studies in cardiac patients:
 - Variable levels of correlation with PAC
- Studies in hepatic patients
 - Question the ability of Flo-Trac to track trends



“There was no umbilical cord - these days babies are connected by Bluetooth”

Summary

- Basic surrogate markers of CO continue to be essential in caesarean section
- Minimally and non-invasive haemodynamic monitoring may become integral to the management of the high-risk and critically ill parturient

- Transthoracic echocardiography is the only technique to have been validated and proven useful in pregnancy
 - Mainstream education of obstetric anaesthetists
- Pulse contour devices promising but formal validation in pregnancy is required



THANK YOU