

Basic haemodynamic monitoring

Continuing development of BASIC is supported by an unrestricted educational grant from



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Definition

Basic Hemodynamic Monitoring

- Continuous documentation of heart rate, blood pressure and indirect markers of tissue perfusion such as skin perfusion, urine output, arterial and ventral venous oxygenation and lactate

Aim of hemodynamic monitoring

- Early identification and correction of cardiovascular instability by the continuous assessment of heart rate, filling status, blood flow and pressure.



Case presentation

- 45 years-old male is admitted to the emergency department after complaining about abdominal pain for 24 hours and confusion since a few hours.
- On admission BP was 110/50 mmHg, HR 123 b/min, RR 32 b/min and SpO₂ 95%.
- Clinical examination revealed cold extremities and a painful abdomen with signs of cholecystitis



Clinical assessment

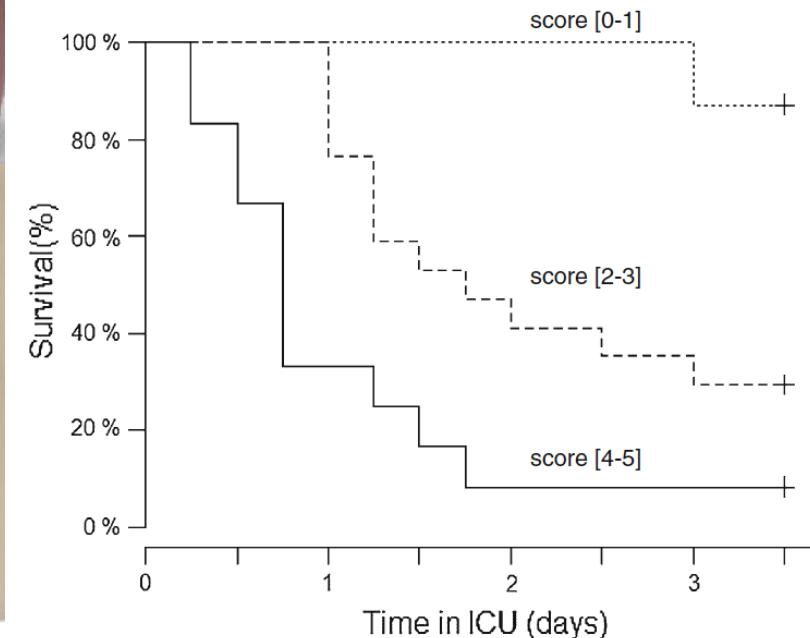
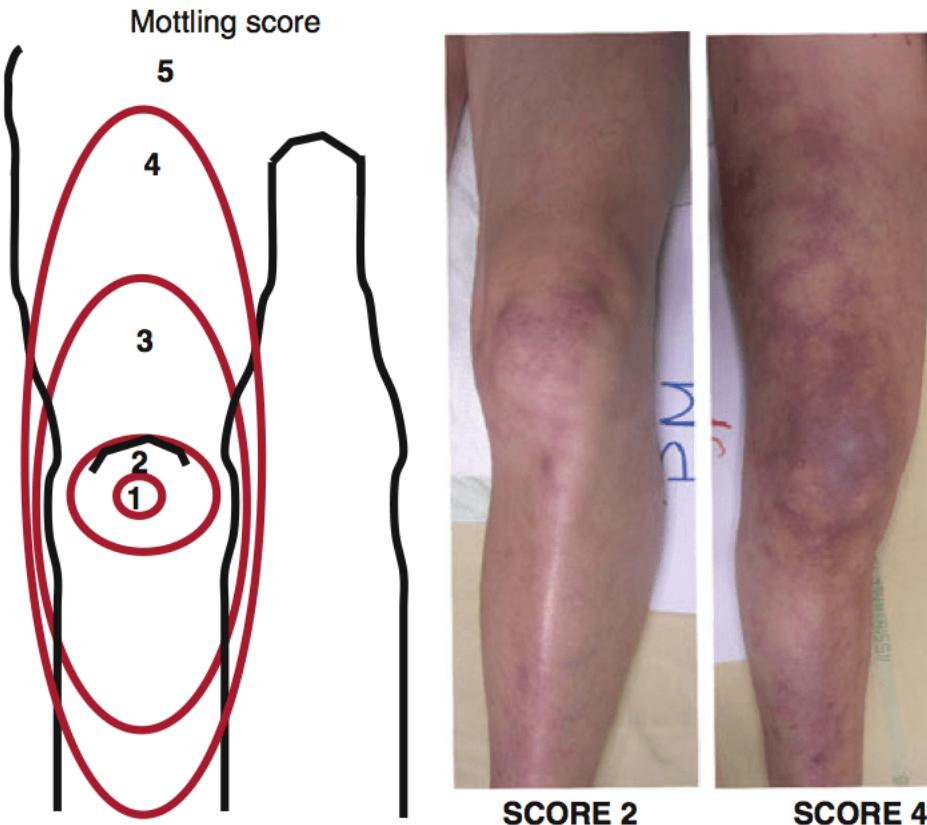
- Systemic circulation
 - BP 110/50 mmHg, HR 123 b/min
 - Compensatory sympathetic stimulation
 - Tachycardia
 - Sweating
 - Vasoconstriction
- End-organ function
 - Mental state (GCS 12)
 - Tachypnoe (RR 32 b/min)
 - Lactate 3.2 mmol/L





Clinical examination

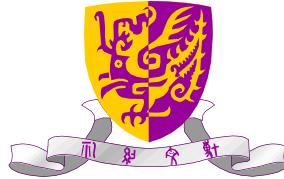
– Mottling score



Ait-Oufella H. et al ICM 2011 37:801



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Clinical examination

– Capillary refill time

- Assess peripherally and centrally
- Press for 10-15 sec. and then release
- Normal values
 - ✓ Finger: < 2 sec.
 - ✓ Patella: < 5 sec.



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Case presentation

- Arterial blood sampling was performed:
 - CRP 40 mg/l, PCT 24 µg/l, Creatinine 143 µg/l, Urea 10.4 mmol/l. GOT 89 U/L, GPT 58 U/L, Alk Phos 230 U/L, P-amylasise 45 U/L.
 - Hb 155 g/l, Hk 47%, Lc 1.2 G/L Tc 86 G/L, Quick 45%
 - Venous blood gas shows pH 7.39, HCO^{3-} 16 mmol/L, BE -5.2, lactate 3.2 mmol/L



Open questions

- What's the problem?
- Does my patient need an ICU?
 - If yes why?



Does my patient needs an ICU?

- **YES** → Sepsis, risk of death > 40% → transfer as soon as possible to your ICU

CAVE before transfer! Blood culture → AB treatment is started → Fluids

- Does my patient need a monitoring?
 - If yes, what a kind of monitoring does he need?
 - BP non-invasive vs. invasive?
 - Central venous line?
 - Urine catheter?
 - Advanced hemodynamic monitoring?



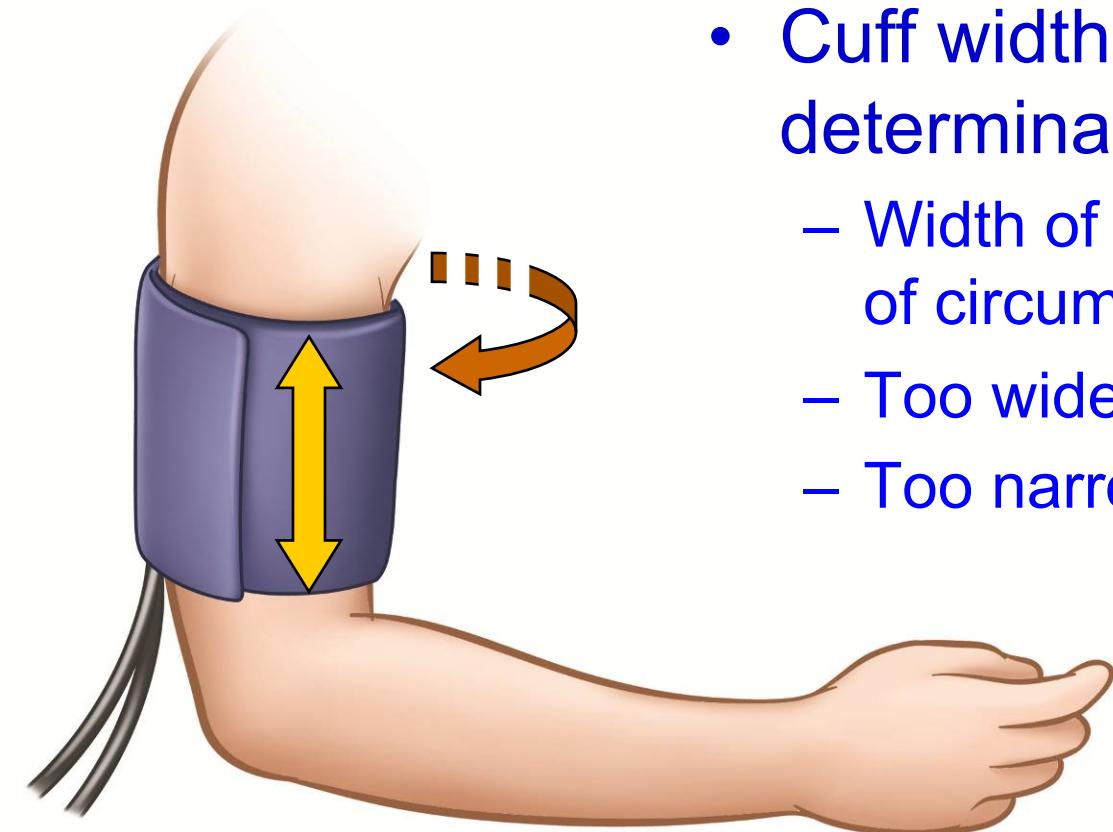
Measuring blood pressure

- Non-invasive automated devices
- Invasive measurements



Non-invasive BP

- Cuff width most important determinant of accuracy
 - Width of cuff should be ~40% of circumference of arm
 - Too wide ⇒ underestimate
 - Too narrow ⇒ overestimate



Non-invasive BP

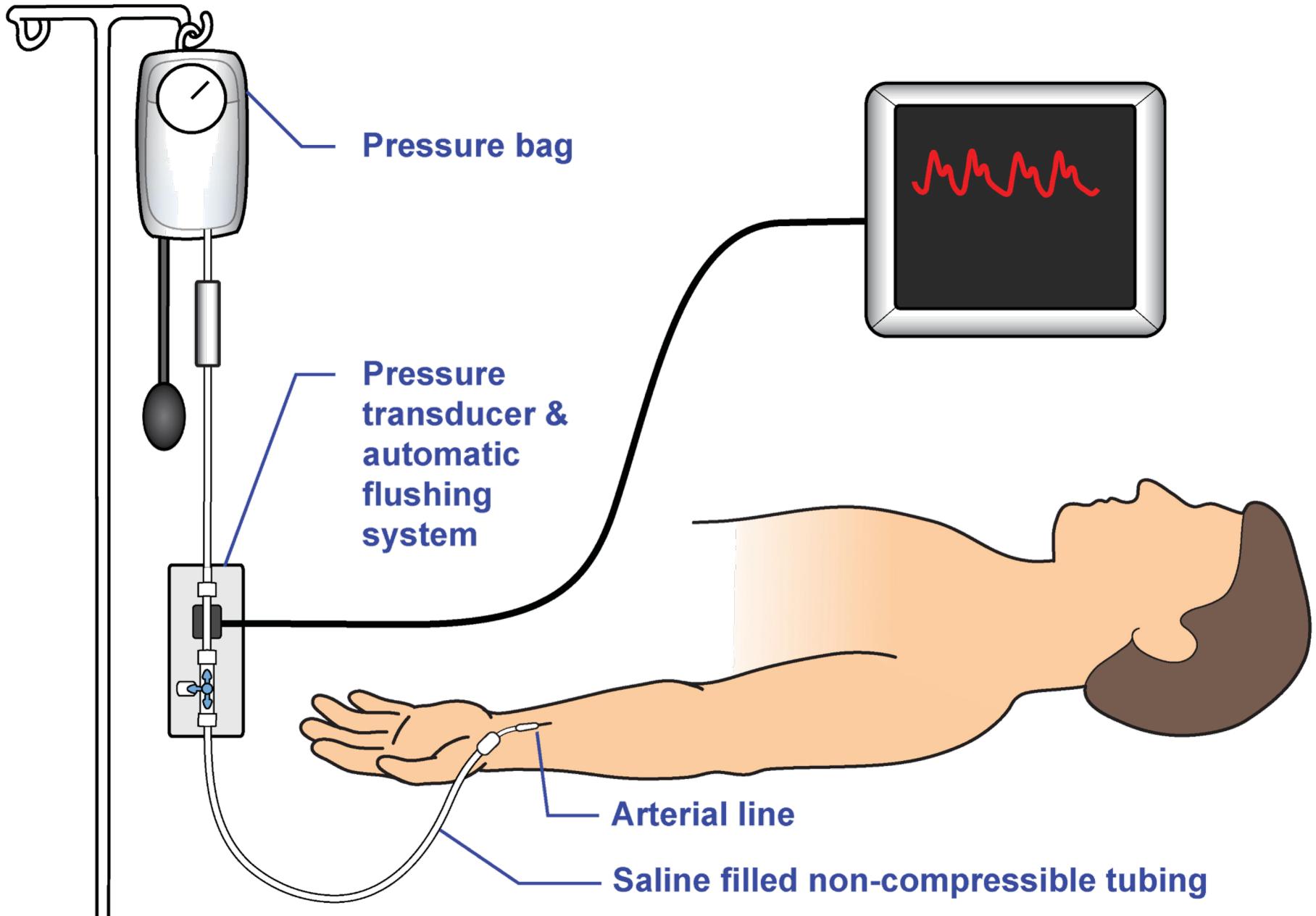
- Under-read at high pressures
- Over-read at low pressures
- Less accurate during arrhythmias



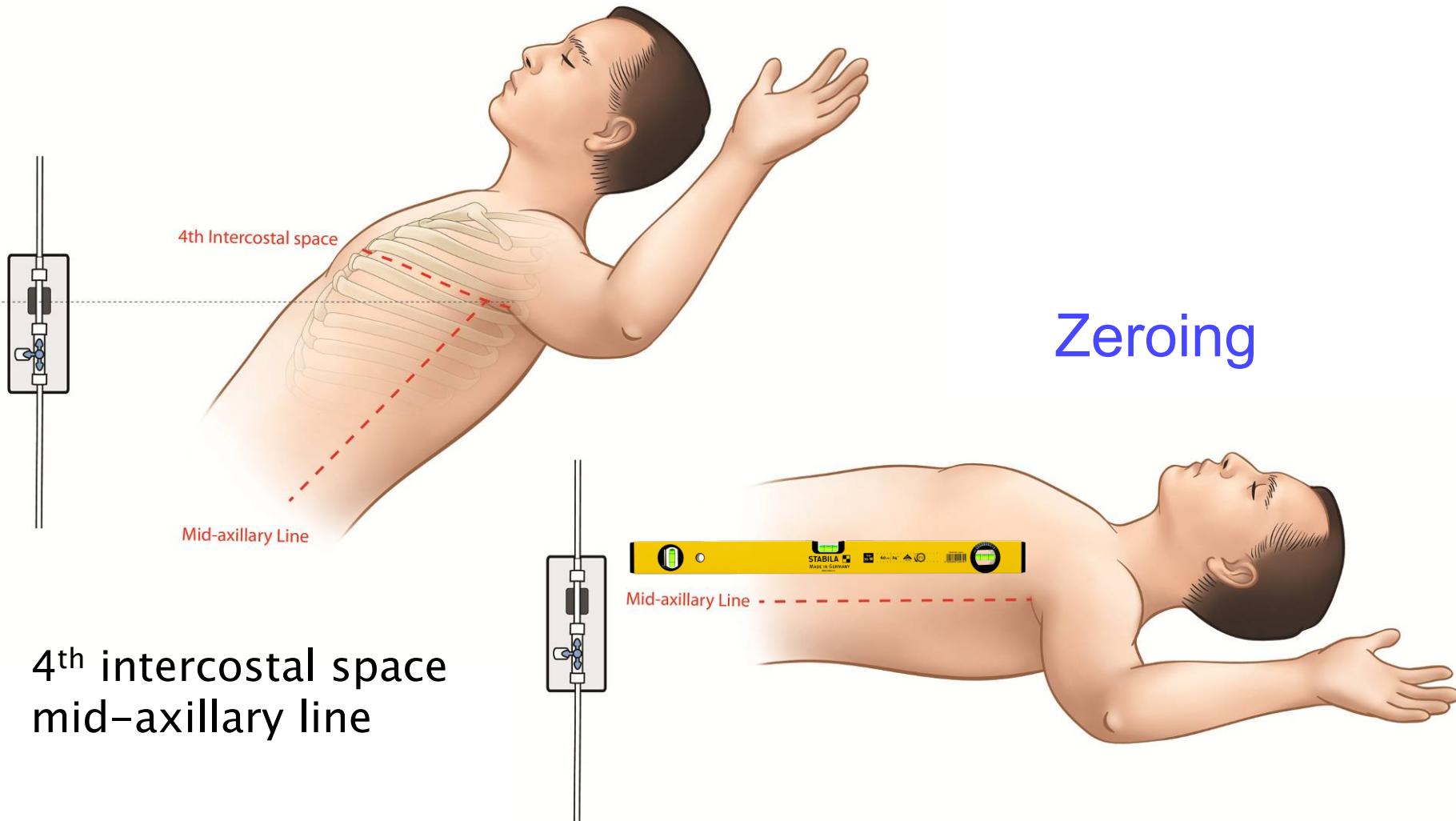
Arterial line

- Advantages
 - Continuous monitoring
 - Allows blood sampling
 - More accurate





Transducer position



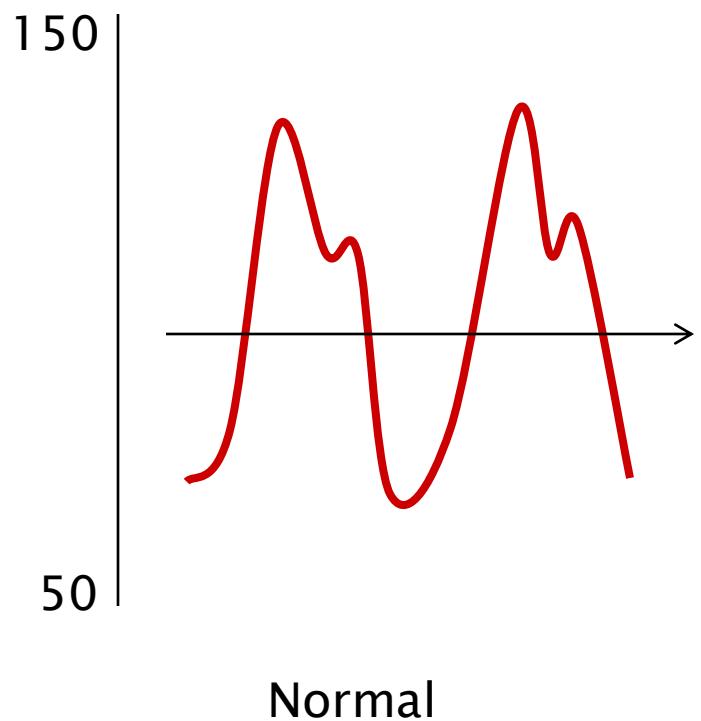
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Sources of error

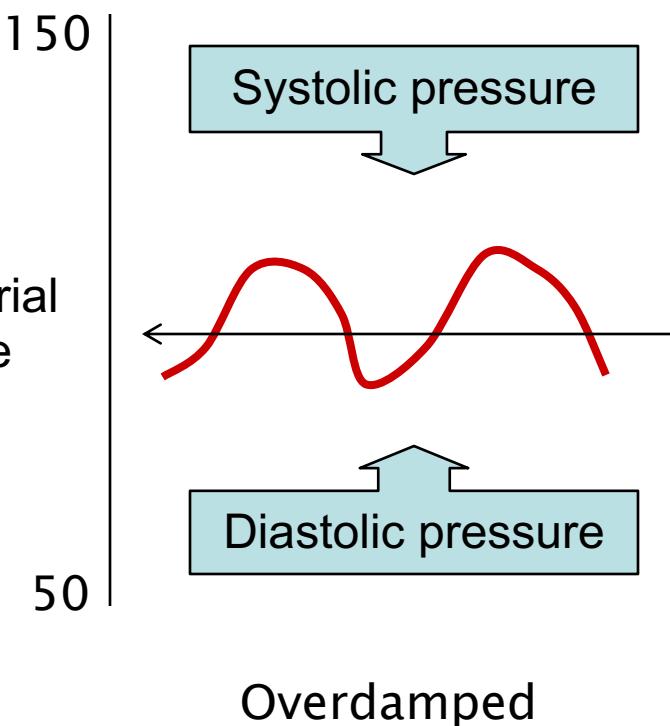
- Transducer position
- Zeroing
- Damping
 - Over-damping
 - Underdamping



Overdamping

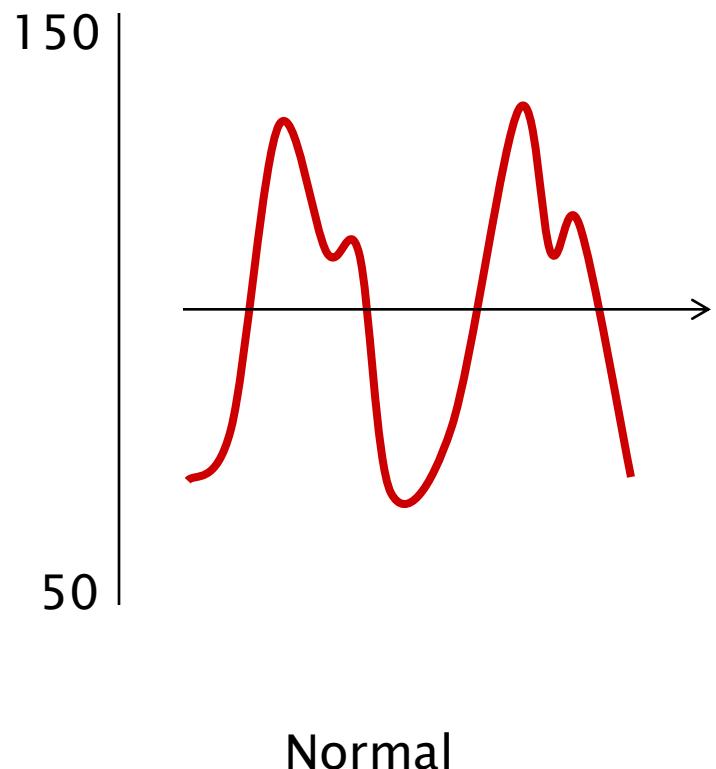


Mean arterial
pressure

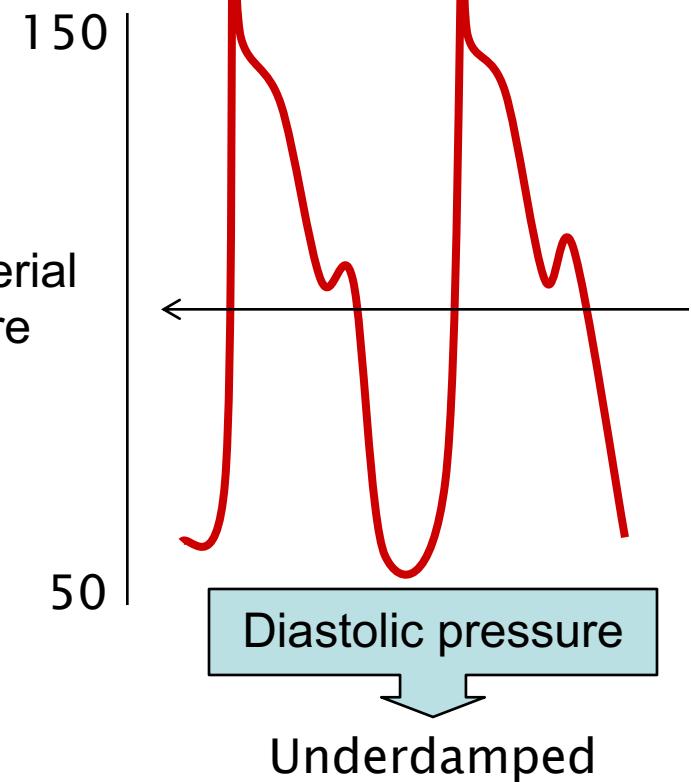


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Underdamped



Mean arterial
pressure



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Arterial line

- Complications
 - Ischaemia
 - Thrombosis
 - Embolism
 - Infection
 - Haemorrhage
 - Accidental drug injection
 - Damage to artery



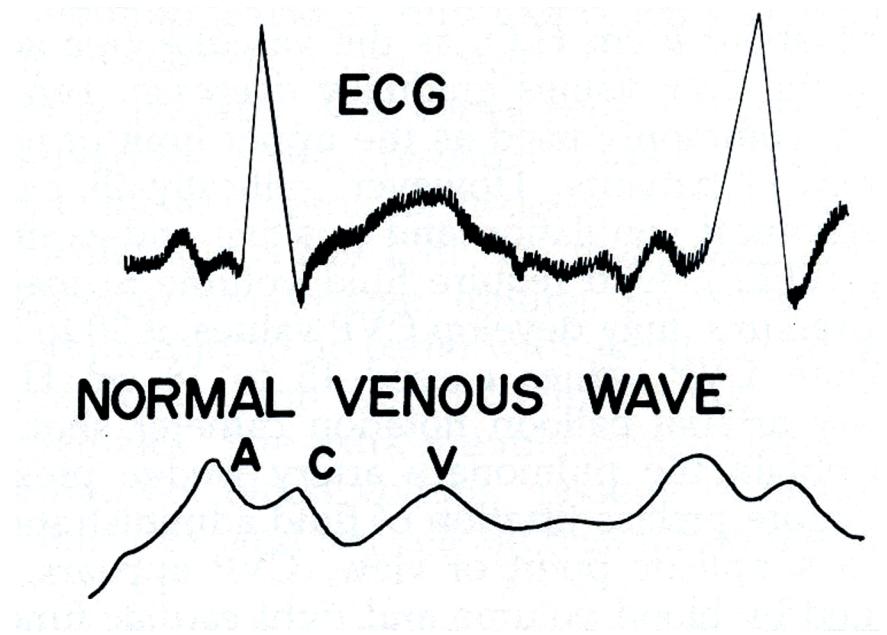
Which pressure?

- Systolic pressure
 - Bleeding risk, arterial wall stress
- Diastolic pressure
 - Peripheral vascular tone
 - Perfusion of left ventricle
- Mean pressure
 - Perfusion of most other organs



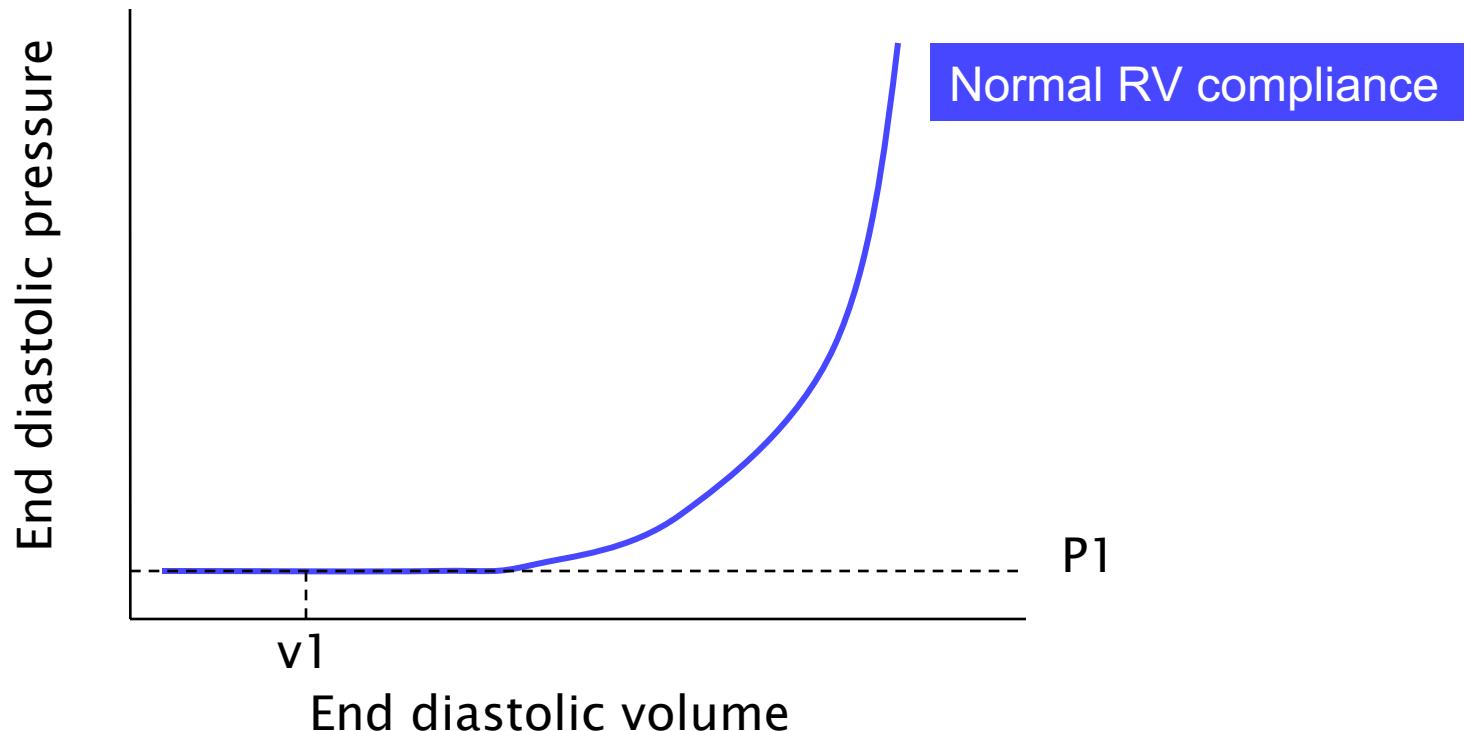
Central venous pressure

- Central venous pressure is determined by
 - right ventricular end-diastolic compliance
 - Right ventricular filling



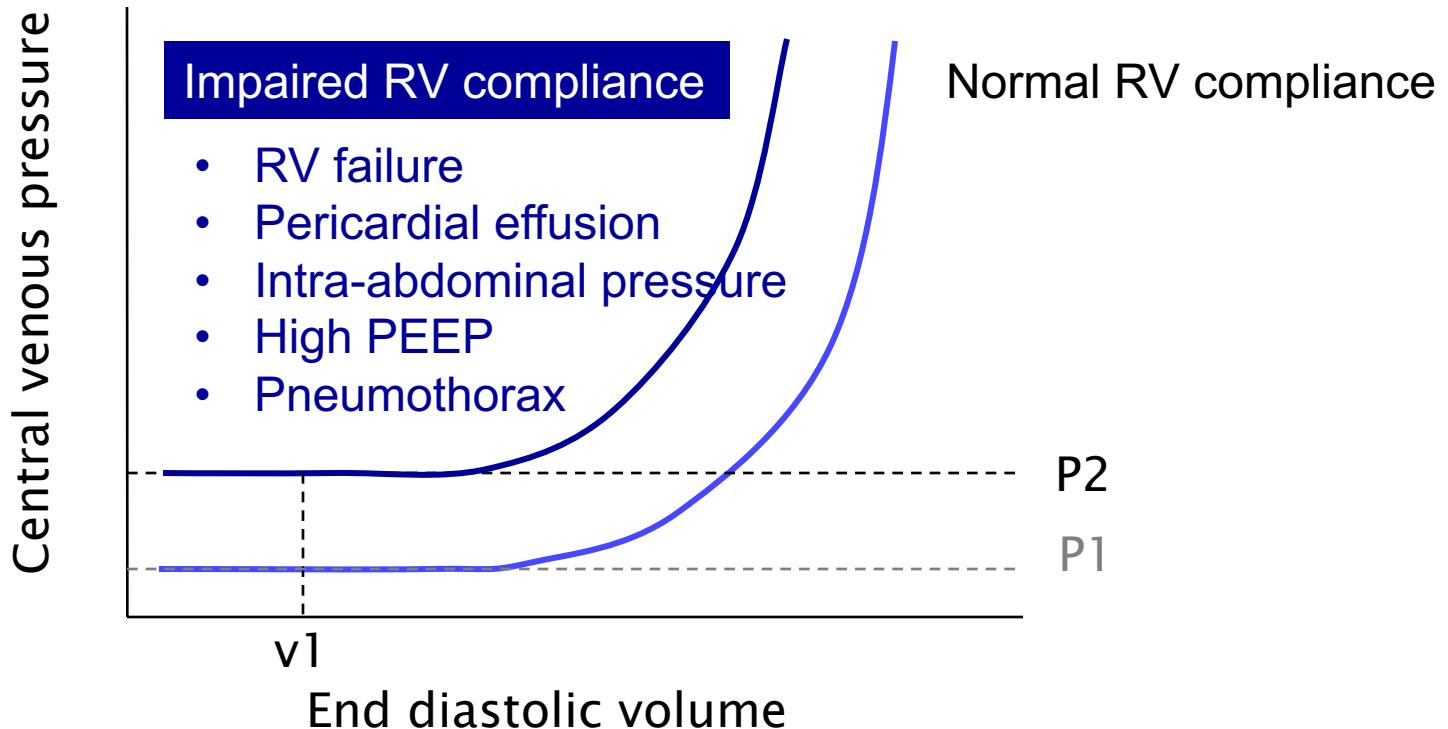
CVP interpretation

Ventricular pressure / volume curve



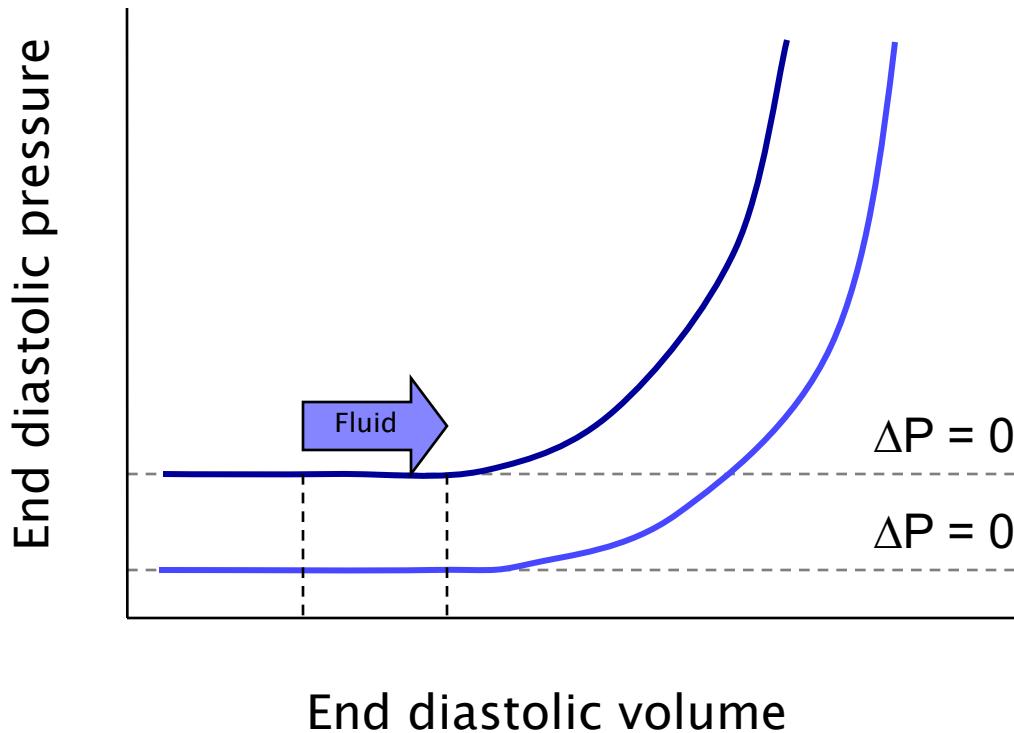
CVP interpretation

Ventricular pressure / volume curve



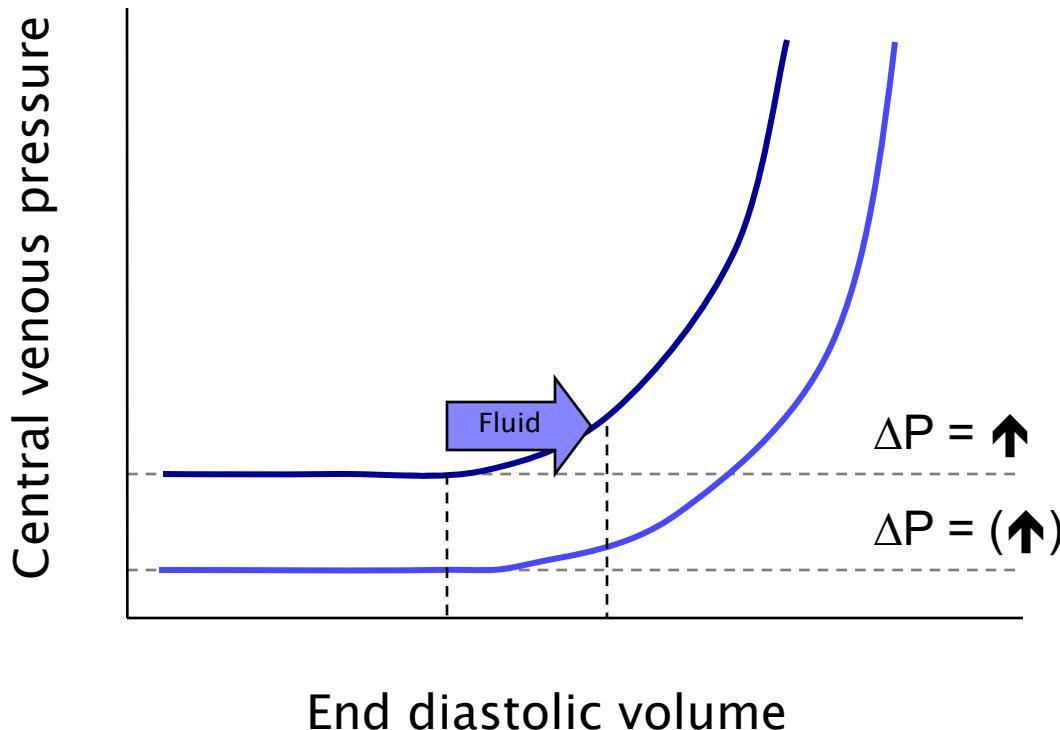
CVP interpretation

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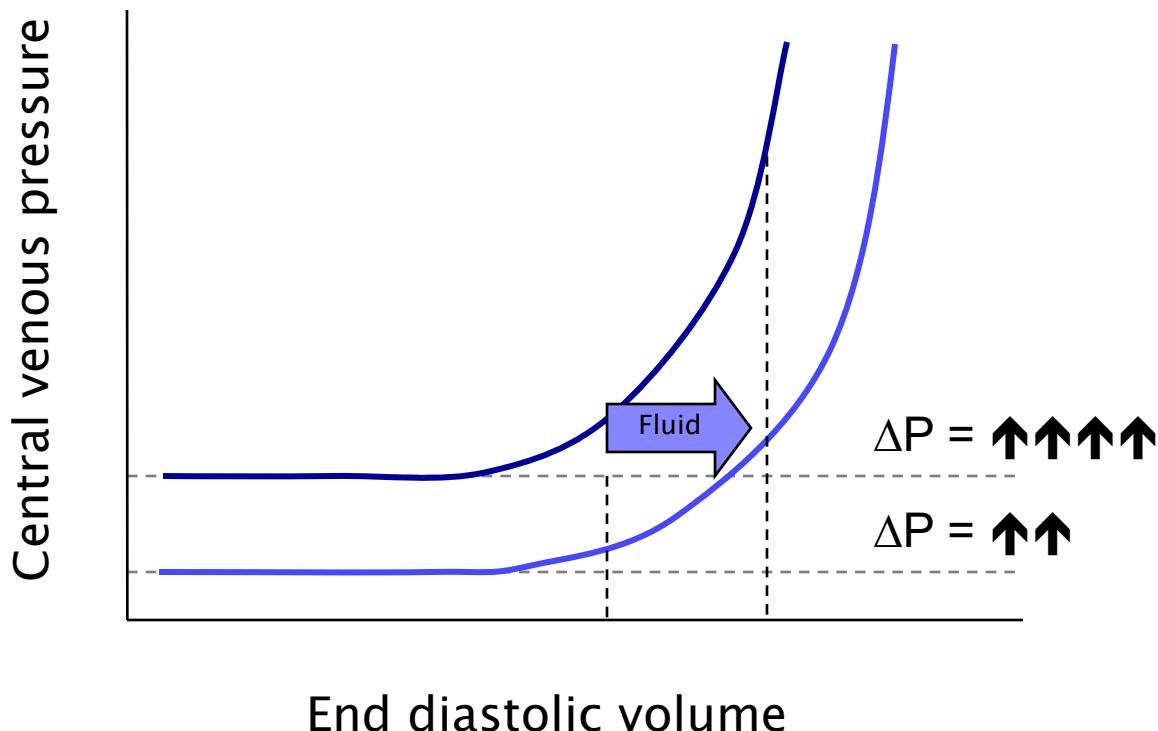
CVP interpretation

Ventricular pressure / volume curve



CVP interpretation

Ventricular pressure / volume curve

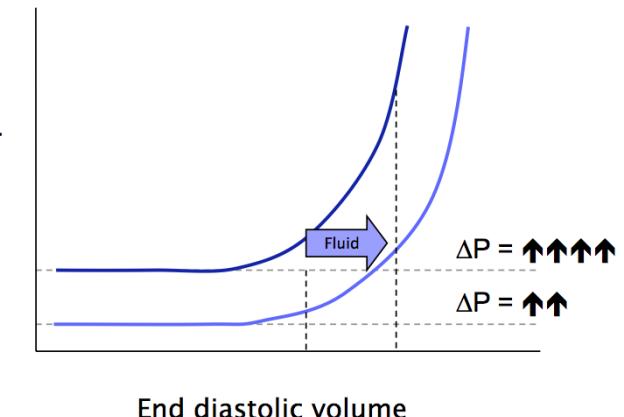


Rule of thumb

- Change in CVP measured before and 5 mins after bolus of fluid
 - 0-3 mmHg: underfilled
 - 3-5 mmHg: adequately filled
 - 5-7 mmHg: overfilled

CAVE
Poor marker of preload!

Ventricular pressure / volume curve



Advanced hemodynamic monitoring

PiCCO₂

Get the complete picture ...



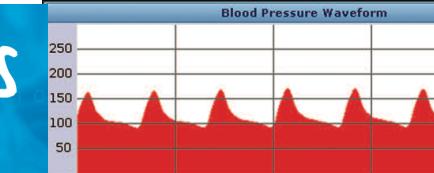
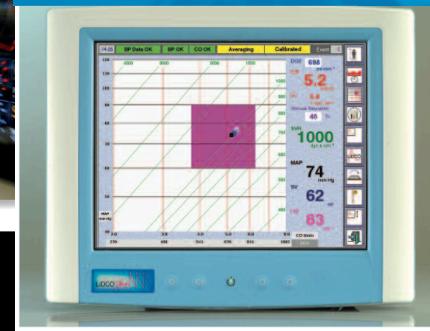
Unique:

- The pulsating blue LED indicates signal quality (e.g. weak signal)
 - The orange LED shows ProAQT-Sensor status (e.g. zeroing required)

ProAQT
Perioperative Haemodynamic
Management



EV1000
Clinical Platform



LIDCO Rapid



Heart size reflects patient volumetric status



Vasculature can depict vasoconstriction or vasodilation



5 levels of lung water shown in lungs



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Switch to other presentation



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PPV Limitations

- Irregular cardiac rhythm (i.e. Atrial fibrillation)
 - Variable stroke volume
 - Variable pulse pressure
- Spontaneous breathing
 - Intrathoracic pressure changes difficult to predict
 - All breaths must be control breaths



PPV Limitations

- Low V_T
 - Smaller change in intrathoracic pressure \Rightarrow smaller variation in pulse pressure
 - If PPV <10% and $V_T \leq 6 \text{ ml/kg PBW}$
 - Increase V_T to 8 ml/kg temporarily to assess PPV
- Low lung compliance
 - Stiff lung as it is the case in severe ARDS (compliance < 30 cmH₂O)



Summary

- Clinical monitoring by nurse and doctor are the most important
- Is there and what is the problem?
 - Define your working diagnosis
 - Define your treatment goals
- Which monitoring do I need?
 - Clinical monitoring
 - Basic monitoring: ECG, arterial pressure, (CV-line for the measurement of: CVP, ScvO₂)
 - Advanced hemodynamic monitoring: continuous pulse analysis for PPV, transpulmonary thermodilution for CO

