Hemodynamic Monitoring in the Critically Ill Patient

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Overview

- goals of hemodynamic monitoring
- examine some of the different ways we can monitor a patient's hemodynamic status
  - Basic global tissue perfusion measurements
  - Organ specific tissue perfusion measurements
  - Advanced global tissue perfusion measurements
  - New techniques

What is Hemodynamic Monitoring?

- The goal of hemodynamic monitoring is the early diagnosis and intervention for the provision of tissue perfusion and tissue oxygenation
- Why do we monitor these parameters?
  - early detection
  - therapeutic guidance
  - prognostic outcomes

Basic Techniques

Skin Colour

- normal colour, central cyanosis, pallor

Skin warmth

- are the toes warm?
  - Schey 2009 showed that skin temperature was strongly correlated with cardiac output and lactate levels
  - can document the difference in skin temperature along a limb pre and post resuscitation
- Pulse
  - strong or weak

Basic Techniques

- Blood pressure
  - Manual
    - more accurate than NIBP as compared with arterial line especially in shock states
  - NIBP
    - more convenient that manual BP readings
    - not as accurate in low flow states

Basic Techniques

- Pulse Pressure
  - systolic - diastolic pressure = pulse pressure
    - e.g. 120-80=40
  - normal is 40 mm Hg
  - narrow pulse pressure
    - may indicate hemorrhagic or cardiogenic shock or aortic stenosis
  - wide pulse pressure
    - may indicate aortic regurgitation, increased intercranial pressure or septic shock

Organ Specific Monitoring

Cerebral Monitoring

- Level of consciousness
- Glasgow Coma Scale
- Cerebral perfusion pressure
  - MAP-ICP=CPP
- ICP
- Angiography
- CT Scan
- Jugular venous oximetry
- Transcranial Doppler Ultrasound

Respiratory Function

- Arterial blood gasses
- Chest x-ray
- CT scan
- Mechanical ventilation waveforms
- Pulmonary function studies

Renal Function

Kidneys

- Urine output
  - sensitive marker for renal perfusion
- Creatinine, BUN

Cardiac Monitoring

- Cardiac enzymes
  - Troponin, CK-Mb, BNP
- 12 lead ECG
- Echocardiogram
  - Wall motion abnormalities
  - fluid status
- CVP monitoring
- PA line monitoring

Abdominal Compartment Syndrome

- Abdominal compartment syndrome is a clinical syndrome characterized by progressive intra-abdominal organ dysfunction resulting from elevated intra-abdominal pressure
- Symptoms include:
  - tense distended abdomen
  - decreased renal function
  - elevated airway pressures
  - hypoxia, inadequate ventilation

Abdominal Compartment Syndrome

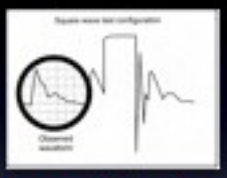
- most often monitored via a urinary catheter and a standard pressure tubing
- abdominal compartment syndrome is classified as sustained IAP >20 with new organ dysfunction
- Treatment of ACS can include: reducing IV fluids, diuresis, surgically opening the abdomen, escharotomies in burn patients

Global Measurements

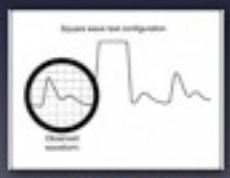
Arterial Line

- most accurate readings are recorded when the line is properly calibrated and return to flow waveform test satisfactory
- inaccurate measurements occur when waveform is under or overdamped
- there is a potential increase risk of infection when the catheter is placed in the femoral artery

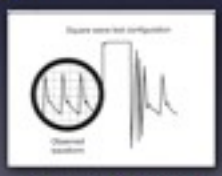
Square Wave Test



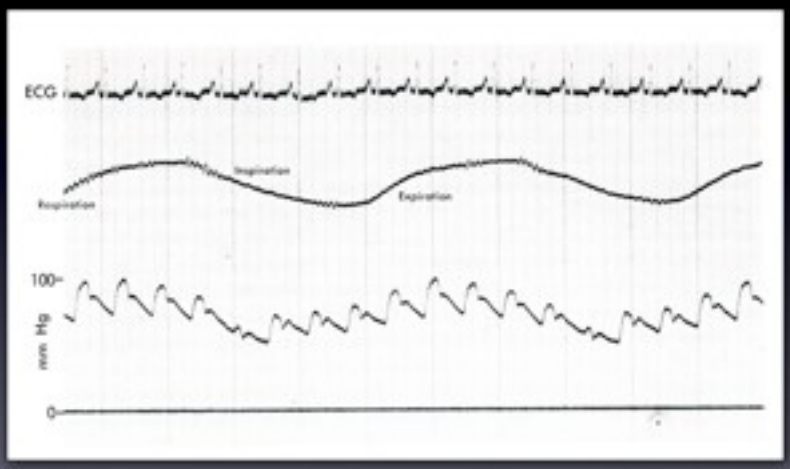
Normal Waveform



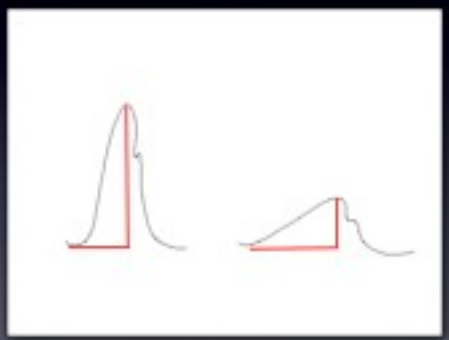
Underdamped



Overdamped



Timing of the Systolic Peak Pressure



Global Measurements

- Metabolic markers
  - Arterial lactate
    - patients inability to clear lactate is associated with an increase in mortality
    - the key for improving survival is early resusitation
  - ScVO2 verses SVO2
    - ScVO2 taken from a CVP line
    - SVO2 taken from a PA line
    - values are not the same for individual measurements
    - they do correlate for physiological trends

Central Venous Pressure

- has not be shown to be predictive of fluid responsiveness
- many situations may cause inaccurate measurements
  - high PEEP/pulmonary hypertension
  - diastolic dysfunction
  - pericardial effusion/tamponade
  - tricuspid regurgitation
  - intra-abdominal hypertension
  - measurement error

Pressure does not equal Volume

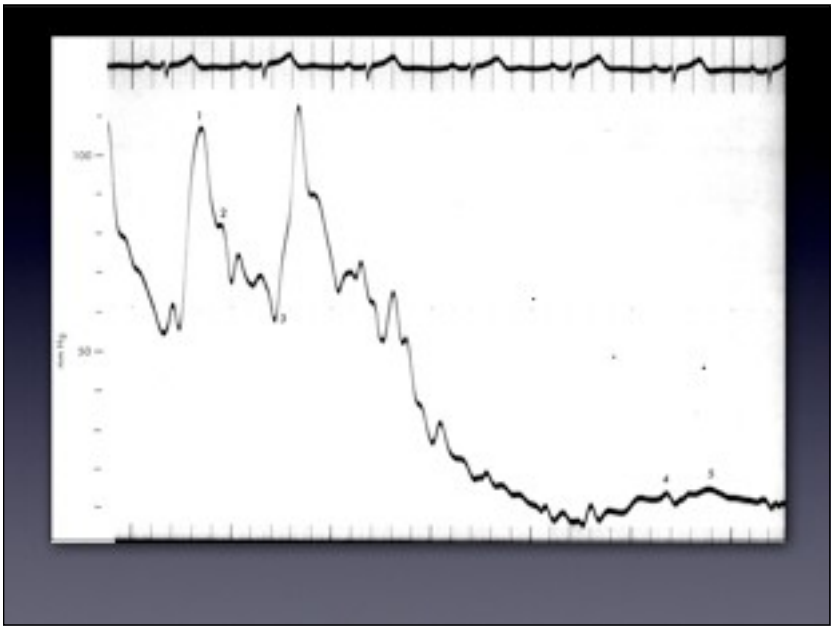
Pulmonary Artery Catheter

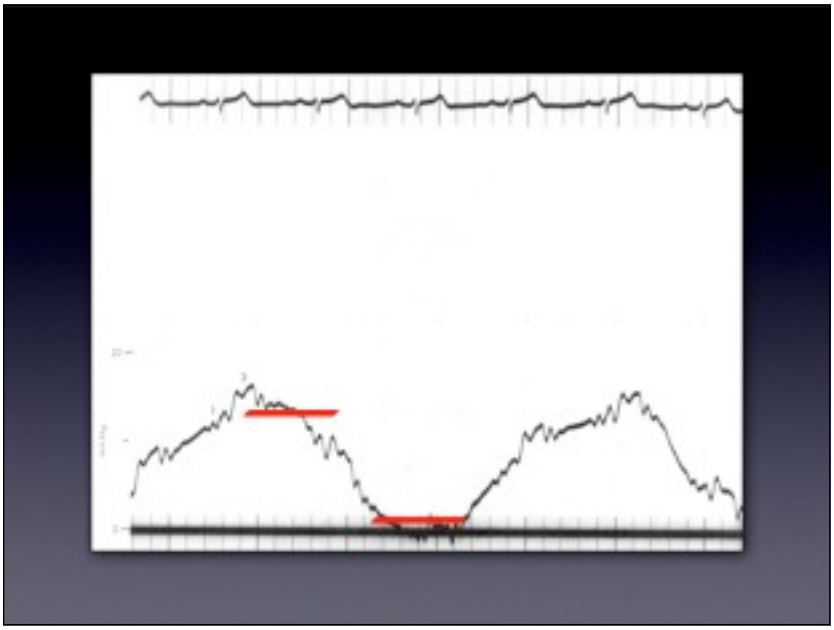
PA Lines

- not as commonly used as in previous years
- earlier study (Conner, 1996) demonstrated a correlation between PA lines and increased mortality in critically ill patients
- no further study has replicated these results
- Friese et al in 2006 showed that PA lines reduced mortality in the critically ill trauma patients
- PA lines may be of benefit in some critically ill patient populations

PA Lines

- It is important that health care providers
  1. ensure that the measurements collected are accurate
  2. understand the data that is being collected
  3. use the data to help guide therapy





New Technology

FlowTrac

- uses a special arterial line and a computer monitor to measure cardiac output

PiCCO

- uses an arterial line and a central line to calculate cardiac output
- both systems are not as accurate with patients with arrhythmias valvular incompetence

SpHb Monitoring

- Continuously monitors Hb levels with a finger probe
- Can be useful in identifying occult bleeding and tailoring transfusion requirements
- monitors Hb, carboxyhemoglobin, methemoglobin, SpO2 and pulse

StO2 Monitoring

- StO2 Monitoring
  - continuous monitoring of tissue oxygen saturation
  - studied in trauma population

Are we on the Right Track?

- Is ensuring adequate O2 delivery to the tissues enough?
- Is oxygen the only thing cells need?