LEC.4

Patient Monitoring in ICU

Monitoring definition

Interpreting available clinical data to help recognize present or future mishaps or unfavorable system conditions.

Monitoring goals

- Enhances (but not replaces) the vigilance of the intensivist.
- Provides means to assess physiological function.
- Provides information that improves the safety of patient.

Monitoring guidelines

- Qualified personnel should be present in the ICU
- Physical examination, Assessment & Diagnosis

Remain the most important tools available to the intensivist

Basic Monitoring

1) Oxygenation
2) Ventilation
3) Circulation
4) Temperature

Should be continually evaluated.

1) Oxygenation

Objective: To ensure adequate oxygen concentration in the delivered gas and in the blood.

Methods

1) Clinical: color, respiratory pattern (rate, rhythm, depth, etc.), equal air entry, wheezing, crackles.
2) Delivered gas: the concentration of oxygen in the patient breathing system shall be measured by an oxygen analyzer.
3) Blood oxygenation: a quantitative method of assessing oxygenation such as pulse oximetry shall be employed and ABGs show PaO_2.

2) Ventilation

A. Every patient should have the adequacy of ventilation continually evaluated.

1) Clinical signs such as chest movement and auscultation of breath sounds are useful.

2)

- ABGs show PaCO2
- Continual end-tidal carbon dioxide analysis
- Monitoring of the volume of expired gas is strongly encouraged in mechanically ventilated patients.

B. When ventilation is controlled by a mechanical ventilator, there shall be in continuous use a device that is capable of detecting disconnection of components of the breathing system. The device must give an audible signal.

3) Circulation

- Every patient shall have the ECG continuously.
- Every patient shall have BP and HR determined and evaluated at close intervals.
- Other clinical evaluation methods like Palpation of a pulse, Auscultation of heart sounds & Oximetry

4) Other used monitors:

- Temperature [pharyngeal, axillary, esophageal]
- Urine output
- Central venous line: measuring CVP
- Arterial line:
  - Continuous BP monitoring
  - Easy access allowing for frequent ABGs

5) Less frequently used monitors:

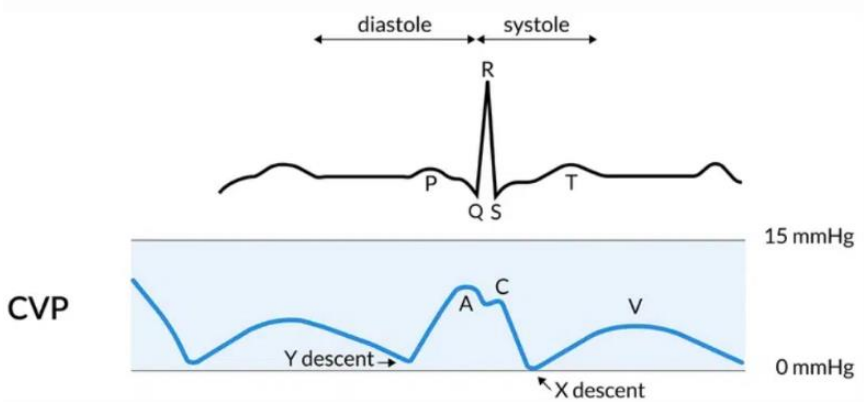
- Swan-Ganz catheter, PCWP: pulmonary artery pressures, cardiac output
- ICP monitoring
- EEG
- Transesophageal echocardiography (TEE)

Central venous pressure (CVP)

- is the pressure recorded from the right atrium or superior vena cava and is representative of the filling pressure of the right side of the heart?
- CVP monitoring in the critically ill is established practice but the traditional belief that CVP reflects ventricular preload and predicts fluid responsiveness has been challenged by a large body of evidence
- CVP represents the driving force for filling the right atrium and ventricle
- Normal value is 0-6mmHg in a spontaneously breathing non-ventilated patient

• Measurement
  - Recorded at the end of expiration
  - measured by transducing the waveform of a central venous line
  - electronic transducer placed & zeroed at the level of the RA (the “hemostatic axis” – usually the 4th intercostal space in the mid-axillary line is used)

• CVP WAVEFORM
  - a = atrial contraction
  - c = closing and bulging of the tricuspid valve
  - x = atrial relaxation, with downward movement of the tricuspid valve during ventricular contraction
  - v = passive filling of atrium (tricuspid valve still closed)
  - y = ventricular filling with opening of the tricuspid valve



- USE
  - Value and waveform assist with diagnosis of:

1) Right ventricular infarction
2) Right heart failure and corpulmonale
3) Tamponade
4) Tricuspid regurgitation or stenosis
5) Complete heart block
6) Constrictive pericarditis

  - Determining:

1) mechanical atrial capture with AV pacing
2) presence of P waves in cases of SVT
3) differential diagnosis of shock state
4) correct central line placement

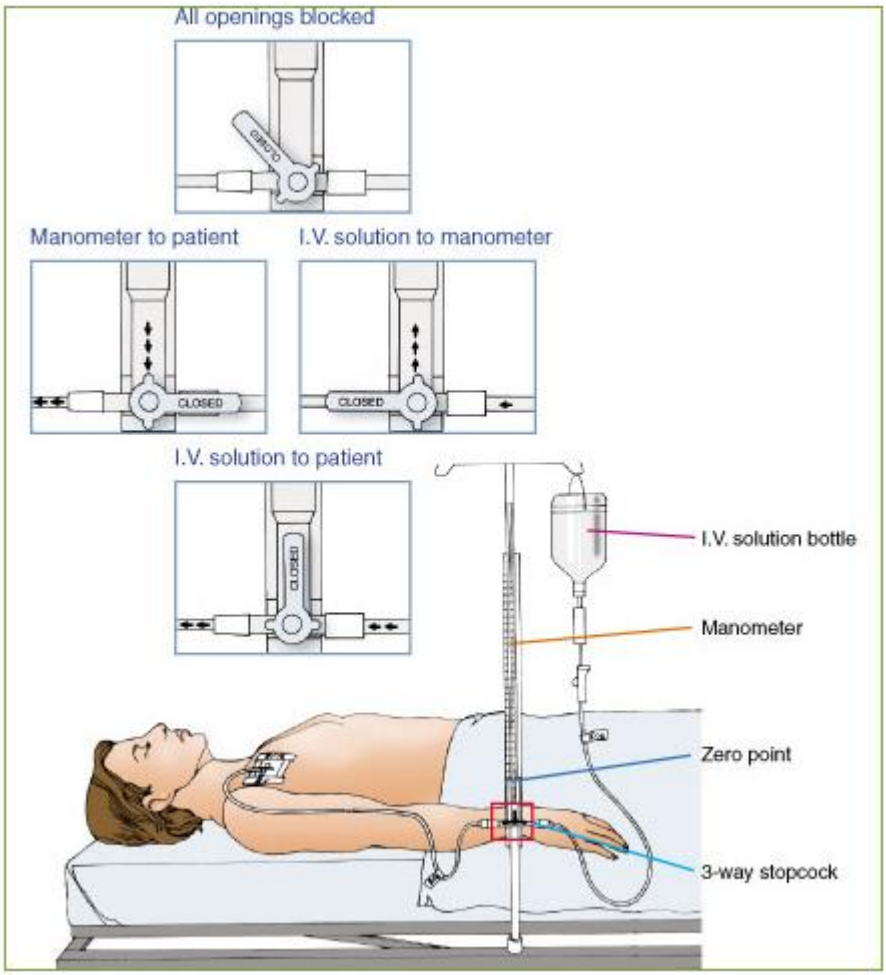


Fig 1: A water manometer setup.

CAUSES OF RAISED CVP

1) Right ventricular failure
2) Tricuspid stenosis or regurgitation
3) Pericardial effusion or constrictive pericarditis
4) Superior vena caval obstruction
5) Fluid overload
6) Hyperdynamic circulation
7) High PEEP settings

Low Central Venous Pressure

Some factors that can decrease central venous pressure are hypovolemia or vasodilation. Either of these would decrease venous return and thus decrease the central venous pressure. A decrease in central venous pressure is noted when there is more than 10% of blood loss or shift of blood volume. A decrease in intrathoracic pressure caused by forced inspiration causes the vena cava to collapse which decreases the venous return and, in turn, decreases the central venous pressure.

CVP WAVEFORM ANALYSIS

Waveform abnormalities may indicate specific pathologies:

- Dominant a wave – pulmonary hypertension, tricuspid stenosis, pulmonary stenosis
- Cannon a wave – complete heart block, ventricular tachycardia with atrio-ventricular dissociation
- Dominant v wave – tricuspid regurgitation
- Absent x descent – atrial fibrillation
- Exaggerated x descent – pericardial tamponade, constrictive pericarditis
- Sharp y descent – severe tricuspid regurgitation, constrictive pericarditis
- Slow y descent – tricuspid stenosis, atrial myxoma
- Prominent x and y descent – right ventricular infarction6

Airway / Respiratory Axis

- Oxygenation
- Ventilation
- Correct ETT placement
- ETT cuff pressure (keep between 20-30 cm H2O)
- Airway pressure7

Respiratory Monitoring

Various alarms by the ventilator:

- Low airway pressure: leakage, disconnection.
- High airway pressure: kink, biting of the tube, blocked tube, bronchospasm.
- Low expired tidal volume: leakage.
- Apnea alarm: disconnection.
- O2 sensor failure: (unfortunately common in many of our ventilators).
- Flow sensor failure: (unfortunately common in many of our ventilators).

NEVER ignore an alarm by the ventilator!

PEAK INSPIRATORY PRESSURE (PIP)

- Depends on: Airway resistance (Raw) & lung compliance (Cl).
- During controlled ventilation look for increase airway resistance (e.g., bronchospasm, kinked ETT) or decrease in pulmonary compliance (e.g., pulmonary congestion).

Oxygenation and ventilation

- Pulse oximetry (vital sign for Oxygenation)
  - Measures O2 saturation in blood8
- Capnography (vital sign for ventilation &perfusion)
  - Measures CO2 in the airway
  - Provides a breath-to-breath status of ventilation

Cardiovascular Axis

1. Arterial Blood Pressure
2. Electrocardiography
3. Central Venous Catheterization
4. Pulmonary Artery Catheterization
5. Cardiac Output:
    a. Thermodilution
    b. Dye Dilution
    c. Pulse Contour Devices
    d. Esophageal Doppler
    e. Fick Principle
    f. Echocardiography
    g. Thoracic Bioimpedance

Electrolyte / Metabolic Axis

- Fluid balance
- Sugar
- Electrolytes
- Acid-base balance
- Nutritional status

Visual Monitoring

- Respiratory: patient color, respiratory pattern (accessory muscle use etc.)
- Patient monitor numbers and waveforms
- Bleeding/coagulation
- Diaphoresis / movements
- Line quality (is my IV reliable?)
- Positioning safety review

Clinical Tips

- ALWAYS remember that your clinical sense & judgement is superior to any monitor.
- You are a clinician, not a technician.
- The monitor is present to help you, not to be ignored and not to cancel your brain.
- Never panic Particularly when the patient is going to die and you have no idea why.
- If a monitor gives an abnormal value, such as low oxygen saturation, Check the patient first then the equipment.
- Know where the defibrillator is kept in the unit and how it works
- All 1 ml ampoules look the same (check very carefully)
- Always label all syringes

MCQ TEST

1- Alarms in ICU ventilator (all true except one)
   a. Low airway pressure: leakage,
   b. High airway pressure: disconnection.
   c. Low expired tidal volume: leakage.
   d. Apnea alarm: disconnection.
   e. O2 sensor failure: (unfortunately common in many of our ventilators).

2- PEAK INSPIRATORY PRESSURE (PIP) (all true except one)
   a) Depends on airway resistance (Raw)12
   b) Not affected by lung compliance (Cl).
   c) During controlled ventilation look for increase airway resistance
   d) Increased by bronchospasm
   e) Increased by kinked ETT

3- All the following are for circulation monitoring except one
   a) Urine output
   b) Central venous line: measuring CVP
   c) Arterial line Invasive BP mentoring :
   d) ECG

e) Glasgow coma scale

4- Causes of high CVP
   a) Right ventricular failure
   b) Pericardial effusion
   c) Superior vena caval obstruction
   d) Fluid overload
   e) low PEEP settings

5- Waveform abnormalities of CVP and specific pathologies (all true except one)
   a) Dominant a wave – pulmonary embolism
   b) Cannon a wave – complete heart block
   c) Dominant v wave – tricuspid regurgitation
   d) Absent x descent – atrial fibrillation
   e) Exaggerated x descent – pericardial tamponade