HEMODYNAMIC MONITORING

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OBJECTIVES

At the end of this class the learner will be able to:

- Identify the purpose of hemodynamic monitoring
- Discuss the basic principles of hemodynamic monitoring
- Identify specific patients who would be candidates for hemodynamic monitoring
- Analyze and interpret pressure measurements on the various hemodynamic monitoring devices
- Identify abnormal waveforms to report
- Implement nursing measures for patients with hemodynamic monitoring
- Demonstrate troubleshooting techniques for the various hemodynamic monitoring devices

Types of Hemodynamic Monitoring

- Arterial Pressure
- Central Venous Pressure
- Pulmonary Artery Pressure
- Cardiac Output
- Venous Oxygen Saturation

ARTERIAL PRESSURE MONITORING

Arterial Pressure Monitoring

- PURPOSE: Provide continuous B/P readings through direct intra-arterial line
- PROCEDURE: Use of transducer to convert arterial pressures into electrical impulses
  - Radial artery usually the choice site
  - Brachial, femoral, or other peripheral artery can be used

Indications of use of A-lines

- Any patient that could have rapid changes in arterial blood pressure
  - Shock states
  - Hypoperfusion states
  - Rapid fluid/blood losses or replacement
  - HTN crisis with drug therapy
  - Cardiovascular dysfunction
  - Drug therapy assessment
  - Access site for blood sampling
**Arterial Monitoring Set-up**

Prior to insertion, distal circulation needs to be evaluated if possible.

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**Modified Allen Test**

Prior to insertion, distal circulation needs to be evaluated if possible.

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**Nursing Responsibilities for Insertion of A-lines**

- Assist with Allen test, if radial artery used
- Assemble equipment:
  - 20 or 22 gauge angiocaths, skin prep, tape, 4x4s, pressure bag, IV pole, transducer holder
  - 500cc Heparinized saline (usually 1-2units/cc)
  - Pressure tubing with transducer and flush system
  - Cable to connect transducer to monitor
- Explain procedure to patient
- Assist physician with procedure

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**Nursing Responsibilities for Maintenance of A-lines**

- Check all connections to prevent blood loss
- Evaluate CSM distal to A-line insertion site
- Redress site every 48 hours or according to agency protocol
- Verify accuracy of A-line with B/P cuff
- Keep pressure in system at 300mmHg
- Record B/P and strips per protocol
- Maintain proper transducer alignment
- Zero/Calibrate monitors Q shift and prn

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**Phlebostatic axis/level**

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**Zero/Calibration Referencing Procedure**

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A-line Waveforms

NORMAL READING FOR ARTERIAL LINES

- Systolic: 90-140 mmHg
- Diastolic: 60-90 mmHg
- Mean: 70-105 mmHg

Blood sampling from A-line

Complications of A-lines

- Accidental disconnection
- Embolization
- Infection
- Compromised distal blood flow
- Compromised distal neurological integrity and motor function

HEMODYNAMIC PRINCIPLES

\[ \text{CO} = \text{HR} \times \text{SV} \]

- \( \text{CO} \): CARDIAC OUTPUT
  - Amount of blood pumped out of the heart each minute
  - NORMAL 4 - 8 L per minute
- \( \text{HR} \): HEART RATE
- \( \text{SV} \): STROKE VOLUME
  - Amount of blood ejected from the ventricle with each heart beat
  - NORMAL 60 - 80 mL per beat

The 3 determinants of stroke volume

- PRELOAD
- AFTERLOAD
- CONTRACTILITY
PRELOAD - the volume and pressure generated within the ventricle at the end of diastole.
AFTERLOAD - the force of resistance against which the heart has to pump to eject blood during systole.
CONTRACTILITY - is the force generated by the contracting myocardium.

CENTRAL VENOUS PRESSURE MONITORING

CVP

- Measurement of pressure in the superior vena cava (SVC) or right atrium (RA)
- Reflects the relationship between systemic venous return to the heart and right ventricular output.
- Pressure reading can be obtained through:
  - Water manometer connected to single, double, or triple lumen catheter threaded in SVC or RA
  - Pressurized system: Proximal lumen of pulmonary artery catheter or distal port of TLC

Indications for CVP Lines

- To monitor changes in cardiac function and intravascular volume status
- Route to administer medications, fluids, and obtain blood samples
- Emergency route for temporary pacemaker insertion

CVP Monitoring

NORMAL READINGS FOR CVP MONITORING
0 - 8 mmHg
4 - 12 cm H2O

Reading CVP Water Manometer

- Zero at phlebostatic axis
- Fill manometer with IV fluid
- Take CVP reading when fluid level ceases
CVP Waveform

Pressure System

Nursing Responsibilities for Insertion of CVP lines

- Assist with insertion procedure
- Single or multiple lumen central line tray
- Pressure or water manometer set-up
- Appropriate site preparation
- Explain procedure to patient
- Proper positioning for insertion
- Securing insertion site and cover with sterile dressing
- Confirm placement with CXR prior to infusing fluids

Nursing Responsibilities for Maintenance of CVP lines

- Dressing changes according to hospital protocol
- Obtaining and recording CVP measurement as indicated for patient
- Zero / calibration of system
- Monitoring for balanced I & O, change in vitals, dysrhythmias, and response to medical treatment(s)
- Reporting any abnormalities

Complications of CVP lines

- Hemorrhage
- Arrhythmias
- Infection
- Accidental fluid overload
- Thromboembolic events
- Electrical microshocks
- Air embolism
- Perforation of cardiac chambers
- Pneumothorax

Pulmonary Artery (PA)
Pressure Monitoring

- Use of balloon-tipped, flow-directed thermodilution catheter (Swan-Ganz)
- Allows continuous monitoring of pressures in the right atrium (RA), right ventricle (RV), and pulmonary artery (PA)
- Periodic measurement of pulmonary artery occlusive pressure (PAOP) or "wedge" pressures (PCWP)
- PAOP/PCWP is reflective of estimated left ventricle end diastolic pressure (LVEDP)
**Indications for PA Monitoring**

(Assessing LV function)

- Complicated MI’s
- Shock states (all causes)
- Congestive Heart Failure
- Cardiac structural defects
- Post CABG
- Cardiac tamponade/effusion
- Pericardial constriction
- Respiratory disease (ARDS, COPD, PE)
- Sepsis

**PA Catheter**

**PA Catheter Insertion**

- Subclavian, jugular, or femoral vein approach
- Threaded to junction of vena cava and RA
- Balloon is then inflated
- Venous circulation carries the catheter tip through the RA and RV to a branch of PA
- Balloon will wedge
- Deflated balloon will drift into PA

**Normal PA pressures**

- **RIGHT ATRIUM**
  - MEAN PRESSURE
    - 0-8 mmHg

- **RIGHT VENTRICLE**
  - SYSTOLIC PRESSURE
    - 15-25 mmHg
  - DIASTOLIC PRESSURE
    - 0-8 mmHg

**Normal PA Pressure**

- **PULMONARY ARTERY**
  - SYSTOLIC PRESSURE
    - 15-25 mmHg
  - DIASTOLIC PRESSURE
    - 6-12 mmHg
  - MEAN PRESSURE
    - <15 mmHg

**PA Wedge Pressure**

- **PULMONARY CAPILLARY WEDGE PRESSURE**
  - MEAN PRESSURE
    - 6-12 mmHg
  - Should be < PAP
**Multiple Waveform Monitoring**

![Waveform Graphs]

**PAWP Waveform**

**Nursing Responsibilities for Insertion of PA lines**

- Assemble the appropriate equipment
- Prepare patient
- Assist with insertion procedures
- Secure line and cover with sterile dressing
- Record insertion strips and patient tolerance of procedure

**Nursing Responsibilities for Maintenance of PA lines**

- Ongoing monitoring of all pressures and waveforms
- Maintain system
- Obtain PCWP’s as indicated
- Make sure catheter rests in PA
- Dressing and tubing changes as per protocol

**Troubleshooting PA lines**

- Marked changes in pressure measurement or inappropriate pressures
- Inability to obtain a wedge reading
- Damped pressure tracing
- No waveform
- Over-wedging
Complications of PA lines
- Dysrhythmias
- Balloon Rupture
- Emboli – air, blood
- Knotting of catheter
- Damage to cardiac structures
- Infection
- Pneumothorax
- Pulmonary ischemia or infarction
- Rupture of pulmonary artery

Cardiac Output
- Amount of blood discharged from the left or right ventricle per minute
- Values calculated via proximal (RA) port of PA catheter and computer

Indications
- Important measurement of perfusion status and response to therapy
- Will reflect hypoperfusion problems before B/P drops

CO Procedure
- Rapid/smooth injection of a preset amount of room temperature or iced solution into proximal (RA) port of PA catheter
- This empties and mixes with blood in RA
- Carried through RV to PA where thermodilution sensor is located
- Curve is plotted graphically with injections
- Usually performed in series of 3 and mean calculated by computer
- Computer calculates CO and CI

Cardiac Output
- CO = SV X HR
  - Normal: 4-8 liters/minute

Cardiac Index
- CI = CO ÷ BSA
  - Represents a more precise measure of blood flow relative to a square meter of BSA
  - Normal: 2.5-4.2 liters/minutes/meter²
CO Printout

VENOUS OXYGEN SATURATION

SvO2

- Obtained from fiberoptic sensor on PA catheter
- Measures amount of oxygen remaining in the venous blood after it has passed through the body’s nutritional capillaries
- Normal 60-80%
- On-going assessment oxygen supply/demand
- Reflective of SaO2 / PaO2
- ↓ SvO2 with suctioning, respiratory or cardiac dysfunction, anemia, or ↓ tissue demands
- ↑ SvO2 with ↓ tissue utilization (sepsis, cyanide toxicity) and ↑ hemoglobin to hang on to oxygen