Hemodynamic Monitoring

Measurement of:

1. Pressure
2. Flow
3. Oxygenation

Assesses:

• heart function
• fluid balance
• effects of drugs on CO
Hemodynamic Monitoring
Invasive vs non-Invasive

- Preload-CVP
- Afterload/SVR
- CO
- RA/RV/PAP/PCWP
- PVR
PRELOAD AND AFTERLOAD

Preload
Volume of blood in ventricles at end of diastole (end diastolic pressure)

Increased in:
- Hypervolemia
- Regurgitation of cardiac valves

Afterload
Resistance left ventricle must overcome to circulate blood

Increased in:
- Hypertension
- Vasoconstriction

↑ Afterload
↑ Cardiac workload
Hemodynamic Monitoring
Terminology

• PAWP: reflects left ventricular end-diastolic pressure

• CVP: reflects right ventricular end-diastolic pressure
Hemodynamic Monitoring
Terminology

• Vascular resistance
  • Systemic and pulmonary
  • Reflect afterload

• Contractility
  • Strength of ventricular contraction
  • No direct clinical measure
• A.J., a 78-year-old male, is admitted to the ICU in acute decompensated heart failure.

• Health care provider decides to insert an arterial line and pulmonary artery catheter to facilitate treatment decisions.
Case Study

- How will you prepare the patient for the a-line and PA insertion?
Components of Pressure Monitoring System
Case Study

• Why is it important to zero reference the transducer and perform a dynamic response test during initial setup of the equipment for A.J.?

• Where is the phlebostatic axis located?
Principles of Invasive Pressure Monitoring

- Zeroing: confirms that when pressure within system is zero, monitor reads zero
  - Open reference stopcock to room air
  - Initial setup and PRN
Dynamic Response Test
(Square Wave Test)

Square wave test configuration

When the fast flush of the continuous flush system is activated and quickly released, a sharp upstroke terminates in a flat line at the maximal indicator on the monitor and hard copy. This is then followed by an immediate rapid downstroke extending below baseline with just 1 or 2 oscillations within 0.12 second (minimal ringing) and a quick return to a baseline. The patient’s pressure waveform is also clearly defined with all components of the waveform, such as the dicrotic notch on an arterial waveform, clearly visible.

 Intervention

There is no adjustment in the monitoring system required.

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Types of Invasive Pressure Monitoring

- Arterial pressure monitoring
  - Mean >65 mm Hg post cardiac* (2015 AHA update)
  - 20-gauge, 2-inch nontapered Teflon catheter into peripheral artery
  - Suture in place
  - Immobilize insertion site
Case Study

• When planning care for A.J., what nursing interventions will you perform to prevent complications related to his arterial line?
Pulmonary Artery Pressure Monitoring

- Guides management of complicated cardiopulmonary problems
- PA diastolic (PAD) pressure & PAWP → cardiac function and fluid volume status
- Allows for precise manipulation of preload

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Pulmonary Artery Pressure Monitoring

- PA flow-directed catheter (e.g., Swan-Ganz)
  - Distal lumen port in PA
  - Balloon inflated to measure PAWP
  - Two proximal lumens to measure CVP, inject fluid for CO, draw blood, administer fluids or drugs
  - Thermistor port distally
Pulmonary Artery Pressure Monitoring

ECG

PAP

Balloon inflation

PAWP

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Central Venous Pressure Monitoring

- Measurement of right ventricular preload → reflects fluid volume
- Obtained from:
  - Central venous catheter
  - PA catheter
- Similar to PAWP waveforms
Central Venous Pressure Waveforms

Schematic of waveform and cardiac cycle events

ECG

CVP

Atrium

Valve

Ventricle

a wave

c wave

v wave

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After insertion of the PA line, the health care provider orders CO measurement every 4 hours.

How will you obtain the CO measurements?

What are your nursing responsibilities?
Measuring Cardiac Output

Normal curve

Temperature

Injection

Smooth upstroke to peak, then gradual downslope to baseline. Computer looks for a smooth curve.

Time
Measuring Cardiac Output

- SVR, SVRI, SV, and SVI calculated when CO is measured
- ↑ SVR
  - Indicates vasoconstriction
- ↓ SVR
  - Indicates vasodilation
Venous Oxygen Saturation

- PA and CVP catheters can be used
  - CVP measures central venous oxygen saturation ($\text{Scvo}_2$)
  - PA measures mixed venous oxygen saturation ($\text{Svo}_2$)
- Determines adequacy of tissue oxygenation
Venous Oxygen Saturation

- $\text{SvO}_2/\text{ScvO}_2$
  - balance between oxygenation of arterial blood, tissue perfusion, and tissue oxygen consumption.
- Assess hemodynamic status and response to treatment/activity
  - Normal 60%–80%

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Venous Oxygen Saturation

- ↓ In $SvO_2/ScvO_2$
  - ↓ Arterial oxygenation
  - Low CO
  - Low hemoglobin level
  - ↑ Oxygen consumption or extraction
Venous Oxygen Saturation

• $\uparrow$ In $\text{SvO}_2/\text{ScvO}_2$
  • May indicate clinical improvement (e.g., improved arterial oxygen saturation)
  • Worsening clinical condition (e.g., sepsis)
What nursing interventions will you plan to prevent complications related to A.J.’s pulmonary artery catheter?
Case Study

• A.J.’s PA diastolic and PCWP are elevated.

• What does this mean?
Noninvasive Arterial Oxygenation Monitoring

- Pulse oximetry
  - Continuous arterial oxygenation (SpO$_2$)
  - Normal 95%–100%
  - Site for electrode: finger, forehead or earlobe
  - Evaluate effectiveness of O$_2$ therapy
• Correlate baseline data with data obtained from biotechnology (e.g., ECG; arterial, CVP, PA, and PAWP pressures; SvO$_2$/ScvO$_2$)

• Monitor trends
Circulatory Assist Devices (CADs)

- Decrease cardiac work and improve organ perfusion when drug therapy fails
- Provide interim support when:
  - Recovering from acute injury
  - Stabilizing before surgical repair
  - Awaiting cardiac transplant
Case Study

• Despite aggressive medical care, A.J.’s heart failure does not respond to medical treatment.

• The health care provider decides to insert an intraaortic balloon pump (IABP).

• What is the purpose of the IABP?
• How does it work?
Intraaortic Balloon Pump (IABP)
Intraaortic Balloon Pump (IABP)

- Consists of:
  - Sausage-shaped balloon
  - Pump that inflates and deflates balloon
  - Control panel for synchronizing balloon inflation to cardiac cycle
  - Fail-safe features
Intraaortic Balloon Pump (IABP)

- Balloon inserted into femoral artery and placed in thoracic aorta
- Confirm placement with x-ray
- Inflate balloon with helium in conjunction with ECG
IABP Timing

A

mm Hg
140
120
100
80

Assisted systole
Diastolic augmentation
Assisted systole
Dicrotic notch
Assisted aortic end-diastolic pressure

B

mm Hg
140
120
100
80

Unassisted systole
Diastolic augmentation
Unassisted aortic end-diastolic pressure
Assisted aortic end-diastolic pressure

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When updating the plan of care for A.J., what interventions will you include related to the IABP?
Ventricular Assist Devices (VADs)

- Short- and long-term support
- Allows more mobility than IABP
- Inserted into path of flowing blood to augment or replace action of ventricle
- Internal or external
- Left, right, or biventricular
Ventricular Assist Devices (VADs)

- VADs can
  - Be implanted (e.g., peritoneum) or positioned externally
  - Provide biventricular support
Schematic Diagram of Biventricular Assist Device
Ventricular Assist Devices (VADs)

- Indications for VAD therapy
  - Failure to wean from bypass
  - Failure after MI
  - Bridge while awaiting transplant
- Cannula sites depend on type of device used
Nursing Management
Ventricular Assist Devices

- Frequent assessments and observe for complications
- Increase mobility / require an activity plan
- In-depth teaching if discharged to home
Nursing Management
Circulatory Assist Devices

• Goal
  • Recovery through ventricular improvement
  • Heart transplantation
  • Artificial heart implantation

• Many patients die or choose to terminate device, causing death
• Emotional support for patient and caregiver essential