Arterial Blood Pressure Monitoring

Course ID: 1018    Credit Hours: 2

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Disclosures
none

Audience
Registered Nurse

Accreditation
KLA Education Services LLC is accredited by the State of California Board of Registered Nursing, Provider # CEP16145.

Course Objectives
At the end of this educational offering the participant will be able to identify:
1. The most frequent complication of invasive BP monitoring
2. 3 patient conditions that require continuous blood pressure monitoring
3. Necessary equipment for setting up an arterial line
4. 3 steps to ensure accuracy of waveform evaluation
5. Recommended patient position for zeroing of a transducer
6. Identify 5 distinct components of an arterial waveform
7. Steps for performing a dynamic response test (square wave test)
8. 3 characteristics of an optimally damped system (normal square wave test)
9. 3 characteristics of an overdamped system
10. 3 characteristics of an underdamped system
11. 6 nursing actions to consider while maintaining an A-line.
Overview

- Introduction
- Equipment
- Procedures
  - System set up + steps to ensure accuracy
    - Priming of Tubing
    - Zeroing transducer
    - Dynamic Response Test (Square Wave Test)
  - Blood Draws
  - Removal of non-sutured arterial catheters
- Precautions/Key Points
Overview

• The most frequent complication monitoring is equipment misuse misinterpretation...

• Setting up and maintaining A-line equipment
  – Evaluating waveforms
  – And making clinical decisions regarding changes in BP
Introduction

What is Arterial BP monitoring and how is it done?

Catheter is inserted into an artery and with the use of special equipment a signal is transmitted and gives us information with regards to a patient’s cardiovascular status and tissue perfusion.

-more accurate than non-invasive forms of BP measurement b/c invasive based on SVR + blood flow vs. non-invasive is just based on blood flow
Introduction

• More accurate than non-invasive forms of BP monitoring
  – Non-invasive ➔ blood flow
  – Invasive ➔ blood flow + SVR
• Indicated when highly accurate and/or continuous BP measurements are required
  – Hemodynamically unstable
  – Severe obesity or edema
• Provides direct & continuous blood pressure monitoring
• Allows for arterial blood sampling/blood draws
Equipment

- Pressure Bag
- Disposable Pressure Tubing
- Transducer
- Transducer Holder
- Transducer Cable
Transducer System Setup

- Pressure Bag
- Pressure Bag Gauge
- Dead End Cap on 3 way stopcock
- Transducer
- Transducer Holder
- Calibration Button
- Fast Flush Device
Preparing the Monitor & Tubing System

• Improper systems can cause erroneous measurements of hemodynamic indices which can potentially invalidate a patient’s entire hemodynamic profile.

• To ensure accuracy:
  – Priming of the pressure tubing
  – Leveling and zeroing
  – Dynamic response testing
Preparing the Monitor & Tubing System

• If we don’t set up our system correctly, we won’t get correct readings which can invalidate a pt’s hemodynamic profile.

• The most frequent complication of invasive BP monitoring is equipment misuse and misinterpretation.

• In order to ensure accuracy and minimize incorrect measurements, three procedural steps should be followed to prepare the monitoring tubing system: priming of the pressure tubing, leveling and zeroing, and dynamic response testing.
Priming the Pressure Tubing

- Use 500 mL Normal Saline
- Check all connectors on tubing
- Use aseptic technique to spike bag and prime entire tubing (stopcocks, luer-locks, transducer)
- Insert IV fluid bag into pressure bag and inflate the pressure bag to 300 mmHg
- Insert transducer into the transducer holder
Priming the Pressure Tubing

• Label IV bag with date and time solution is hung + initials
  – How often does solution need to be changed 24 hours

• Make sure that the connectors are secure but don’t over tighten them b/c they can become stripped

• Be sure to eliminate all air bubbles as they can be a main factor in waveform distortion.

• Why insert IV fluid bag into pressure bag and inflate the pressure bag to 300 mmHg
  – Prevents air from going into the solution and catheter from clotting allows 3ml/hr flush solution to be delivered through the catheter
Zeroing the Transducer

When do leveling and zeroing of the transducer need to be done?

Whenever the reference point on the patient changes the air-fluid interface changes.
Zeroing the Transducer Reference Point

1. Place HOB from zero to 45 degrees

2. Position the patient and the transducer at the same level

3. Make sure the transducer is located at the phlebostatic axis
Zeroing the Transducer Reference Point

• Before invasive arterial pressure monitoring can be done, the pressure transducer needs to be placed in the appropriate position relative to the patient.

• Zeroing electronically establishes for the monitor atmospheric pressure as the atmospheric zero reference point.

• It establishes the interface level as the hydrostatic zero reference point.
Zeroing the Transducer Reference Point

• With a carpenter’s level or yard stick move the transducer up or down along the IV pole so that the transducer is located at the phlebostatic axis
  – (right atrium of the heart – 4th intercostal space, midaxillary line).

• This ensures the accuracy of the readings by eliminating hydrostatic forces on the transducer.
  – If transducer is too high will have falsely low BP readings.
  – If the transducer is too low will have falsely elevated BP readings.
Zeroing the Transducer

- Turn the stopcock just above the transducer off to the patient’s arterial catheter ... “off to the patient”

The patients intravascular pressures are referenced against ambient atmospheric pressures.

Air-fluid interface
Zeroing the Transducer

By opening the stopcock to air, the monitoring system uses atmospheric pressure as a reference for zero. Pressing the zero button negates the effects of atmospheric pressure so that the pressure values reflect only those of the patient.

- **Zero Balance & Calibrate the Transducer by:**
  - Open stopcock on transducer to port or “air” by removing the dead end cap
  - Activate flush device
  - Press zero button on bedside monitor (will read 0/0)
  - Hold down 100mmHg calibration button to eliminate drift (will read 95-100/95-100)
  - Return stopcock back to port/monitoring position
  - Replace dead-end cap
Once transduced...
Once transduced...

• Once transduced we should get a waveform!

• Normal arterial blood pressure produces a characteristic waveform, representing ventricular systole and diastole. The waveform has five distinct components: the anacrotic limb, systolic peak, dicrotic limb, dicrotic notch, and end diastole.

• The anacrotic limb marks the waveform's initial upstroke, which results as blood is rapidly ejected from the ventricle through the open aortic valve into the aorta. The rapid ejection causes a sharp rise in arterial pressure, which appears as the waveform's highest point. This is called the systolic peak.
Once transduced...

- As blood continues into the peripheral vessels, arterial pressure falls, and the waveform begins a downward trend. This part is called the dicrotic limb.

- The closing of the aortic valve creates the dicrotic notch which marks the beginning of diastole.
Dynamic Response/Square Wave Test

- Observing the waveform and performing a square wave test determines whether the system is damped.

- Should be performed:
  - Every 8-12 hours
  - When the system is open to air
  - When the accuracy of the reading is in question

http://www.aic.cuhk.edu.hk/web8/haemodynamic%20monitoring%20intro.htm
How to Perform a Square Wave Test

1. Hold fast flush device < 1 sec
How to Perform a Square Wave Test

1. Hold fast flush device < 1 sec
   - Holding flush device open for less than 1 second and quickly releasing it.

2. Note “square wave” on the monitor
   - When the fast flush system is activated and quickly released, a sharp upstroke terminates in a flat line at the maximal indicator on the monitor which produces a “square wave”.

How to Perform a Square Wave Test

3. Square wave should be followed by an immediate rapid downstroke
   1. Extends below baseline with 1-2 oscillations
   2. Quick return to baseline
   3. Note that waveform has all components

How to Perform a Square Wave Test

Note that the patient’s waveform has all components; anacrotic limb, dicrotic limb, dicrotic notch (Figure 3). If this is observed, no adjustment in the monitoring system is required. The system is optimally damped (Figure 4).

Square Wave Tests that Require Adjustments

• Normal Square Wave Test

• Overdamped System

• Underdamped System

Overdamped System

- Slurred upstroke
- Waveform does not extend below baseline
- No fast oscillation after the flush
- Results in falsely low systolic and falsely high diastolic readings

Normal

Overdamped

Trouble Shooting an Overdamped System

• Check for presence of blood clots, blood left in catheter, or air bubbles and remove
• Ensure all line components are securely connected
• Ensure line is free of any kinks

Underdamped System

• Numerous amplified oscillations
• Results in falsely high systolic and possibly low diastolic pressures

Normal

Underdamped

Underdamped System

• A small air bubble can lower the natural resonant frequency and cause the monitoring system to resonate or ring, resulting in an elevated systolic blood pressure.

Normal

Underdamped

Trouble Shooting an Underdamped System

• Remove ALL air bubbles from the tubing, particularly pinpoint ones, as air bubbles are the primary cause of an underdamped waveform.

Trouble Shooting an Underdamped System

• Check length of pressureized tubing – large bore, non-compliant, short tubing

Maintaining an A-line

• Assess the neurovascular and peripheral vascular status of the cannulated extremity every 4 hours, or more often if warranted.
  – cap refill, sensation, movement, warmth
Maintaining an A-line

• Assess pressure bag Q4H to ensure pressure bag device is inflated to 300mmHg and that fluid is present in the flush solution
Maintaining an A-line

- Continuously observe the arterial waveform quality on the monitor and record variances to ensure the accuracy of the waveform and to detect changes in the patient's hemodynamic status. A normal waveform has a peak systole, clear dicrotic notch, and end diastole (Figure 3).
Maintaining an A-line

• Compare the intra-arterial pressure with blood pressure readings obtained by a cuff at least once per shift or more often according to patient care setting.
Maintaining an A-line

• Evaluate the patient regularly for signs or symptoms of catheter-related infection, which can include (but are not limited to) fever, chills, tachycardia, increased white blood cell count, redness or swelling at catheter insertion site.
Maintaining an A-line

• Evaluate the intra-arterial pressure monitoring system regularly for air bubble formation, which can lead to potentially lethal air emboli. Remove air emboli by flushing through a system stopcock.
Blood Draw with Vacutainer

- Verify presence of MD order for blood draw in chart.
- Gather supplies, perform hand hygiene, and don gloves.
- Access stopcock proximal to patient, remove dead end cap and place on sterile 4x4.
- Place another sterile 4x4 under blood sampling port.
Blood Draw with Vacutainer

- Attach vacutainer
- Turn stopcock off to transducer
- Attach waste test tube and fill
- Remove waste test tube
- Attach specimen test tube and fill
- Remove specimen test tube
Blood Draw with Vacutainer

• Turn stopcock back to monitoring position
• Activate fast flush device to flush line
• Turn stopcock off to patient
• Activate fast flush to flush port
• Turn stopcock back to monitoring position
• Return dead end cap and observe monitor for return of waveform.
Removal of Non-sutured Arterial Catheter

• Verify presence of MD order
• Assess coagulation profile (PT, INR, Platelets)
• Gather supplies (sterile 4x4 gauze and pressure dressing), perform hand hygiene, and don clean gloves.
• Gently remove the dressing making sure to not place any tension on the arterial catheter
Removal of Non-sutured Arterial Catheter

• Turn the stopcock off to the flush solution
• Apply pressure 1-2 finger widths above the insertion site.
• Place sterile 4x4 gauze over the site while maintaining proximal pressure and immediately apply firm pressure over the insertion site as the catheter is removed
Removal of Non-sutured Arterial Catheter

• Apply pressure for a **minimum** of 5 minutes
• Monitor for signs of bleeding or hematoma formation and evaluate the distal extremity for color, circulation, and motion:
  – Q 5 min x 30min
  – Q 30 min x 2
  – Q 1 hour x 4

Discard used supplies in appropriate receptacle and perform hand hygiene.
Documentation

• Patient's position for zeroing the transducer
• Patient's manual blood pressure in comparison to the blood pressure obtained through the arterial catheter
• Assessment of arterial catheter site & presence of pulse, warmth, capillary refill, color, sensation, and motion
• Document dressing, tubing, flush solution changes, or discontinuation of line when appropriate
Precautions/Key Points

• Keep the arterial catheter site visible at all times. Do not allow linens to cover the site. Intra-arterial catheter dislodgement requires prompt recognition and intervention to reduce risk of exsanguination.

• Ensure that monitor and alarms are set at appropriate limits

• Obtain baseline data including vital signs, level of consciousness, and hemodynamic stability to help identify acute changes in the patient.
Precautions/Key Points

• Compare the direct arterial pressure measurements with the indirect NBP measurement.

• Assess arterial catheter site and check for pulse, warmth, capillary refill, color, sensation, and motion. If arterial catheter is threatening pt’s extremity, notify MD.

• External pressure cuff surrounding the flush solution bag should be maintained at a pressure of 300mmHg (prevents air from going into solution and catheter from clotting).
Precautions/Key Points Cont’d

• Be aware that erroneous pressure readings may result from a catheter that is clotted or malpositioned, as well as loose connections, addition of extra stopcocks or extension tubing, inadvertent entry of air into the system, or improper calibrating, leveling, or zeroing of the monitoring system.
Precautions/Key Points Cont’d

- Change the pressure tubing every 72 hours or if the integrity of the system is compromised.
- Never inject anything into an arterial cannula or arterial line. Delivery of a drug into the tissues supplied by the cannulated artery can result in tissue necrosis and ischemia.
References


