# Arterial Blood Sampling

Module B

- Read Chapter 1 : Arterial Blood Gases
- Complete exercises 1-1 to 1-4
- On Call Cases 1-1 & 1-2
- Study and Practice Arterial Line Performance Evaluation #27

## Clinical Practice Guidelines

- Sampling for Arterial Blood Gas Analysis
- Capillary Blood Gas Sampling for Neonatal and Pediatric Patients
  - AARC.org
    Resources
    Clinical Practice Guidelines

## Objectives

- List the sites used for arterial punctures and state the benefits and hazards associated with each.
- Describe the technique used for sampling blood from an artery.
- Describe infection control procedures that should be followed when drawing an arterial blood sample.
- List three possible complications of arterial punctures.

## Objectives

- Describe and demonstrate the proper procedure for drawing an ABG sample from an arterial line.
- List the sites used for placement of an indwelling arterial catheter.
- Given a stopcock assembly (or diagram of one), state the proper stopcock positions to sample arterial blood and to flush the system.
- Draw a picture of an arterial waveform and label the horizontal and vertical axis and designate the position of a dicrotic notch.
- Define the term dampened as it refers to an arterial pressure waveform.

## Topics to Be Covered

- Effect of age on $PaO_2$
- Arterial vs. Venous Samples
- Steady State
- Technique of ABG draws
- Complications of ABG draws
- Capillary Sampling
- Arterial Line Sampling

## Normal Lab Values

- Normal Values for ABG
  - 95% of population have values that fall within this range.
  - 5% of the population fall outside or normal range.
  - 95% = $\pm$ 2 S.D.
  - Although some variation may exist, the normal values presented in Table 1-1 are used.

## Effects on Oxygenation

- Oxygenation is affected by
  - Age
  - Barometric Pressure/Altitude
  - $FIO_2$
  - Body Position

## Affects of Body Position on Oxygenation

- The $PaO_2$ is 5 mm Hg higher in the sitting position.
  - Supine Position
    - $PaO_2$ = 109 – (0.43 x age) +/- 8
  - Sitting Position
    - $PaO_2$ = 104 – (0.27 x age) +/- 12
- Greater variation in the aged than in young adults.
  - $PaO_2$ = 110-$^1/_2$ age
  - Assume the $PaO_2$ is 100 mm Hg in a 10 year old & $PaO_2$ falls 5 mm Hg for every 10 years up to 90 years (0.5 mmHg/yr).

## Venous Blood Gas Values

- P $\dot{v}$ $O_2$ 35 - 45 mm Hg
- P $\dot{v}$ $CO_2$ 41- 51 mm Hg
- pH 7.32 – 7.42
- S $\dot{v}$ $O_2$ 70 – 75%
- C $\dot{v}$ $O_2$ 12 - 15 vol%

## Arterial vs. Venous Values

- ABG values are identical regardless of the specific artery from which the sample was taken.
- Venous samples reflect **local metabolism** & perfusion & will vary significantly from one vein to another.
  - Mixed Venous Sample – Pulmonary Artery

The collection of arterial blood is not only technically difficult but can be painful and hazardous. Therefore, it is essential that individuals performing arterial punctures be familiar with proper techniques, with the dangers of the procedure, and with necessary precautions.

National Committee for Clinical Laboratory Standards

## Arterial vs. Venous Blood Gas Sampling

- Arterial Sampling is technically more difficult to obtain than venous.
  - Increased Arterial Pressure
  - Arteries lie deeper than veins
  - Walls of the artery are thicker than veins
  - More pain associated with an arterial sample
- Increased rate of complications with arterial punctures than with venous.

## Contraindications for Arterial Punctures

- Abnormal results of a modified Allen's Test.
- Do not perform through a lesion, distal to a surgical shunt, or infection.
- Femoral punctures should not be performed outside the hospital setting.
- A medium-high dose of anticoagulation therapy/thrombolytic may be a relative contraindication.
  - Aspirin is not a contraindication to doing an ABG
    - May interfere with blood clotting

## Preparation

- Check for Order
- Review Chart
  - Diagnosis, oxygen order, coagulation problems.
  - Indication for sample.
  - Chest x-ray, previous ABG, electrolytes.
- Quick Physical Assessment.
  - Patient Identification.
  - Check temperature of extremities.
  - Respiratory rate, pulse strength, mental status, color.
  - Oxygen usage.
  - Ventilator settings.
- Equipment Preparation.

## Interference with Blood Clotting

- Anticoagulants
  - Heparin, Coumadin
  - Schedule puncture 30 minutes prior to next dose
- Thrombolytics
  - Streptokinase, TPA, Urokinase, Streptolase
- Hemophilia or other clotting abnormalities
  - ↓ platelet counts
  - ↑bleeding times

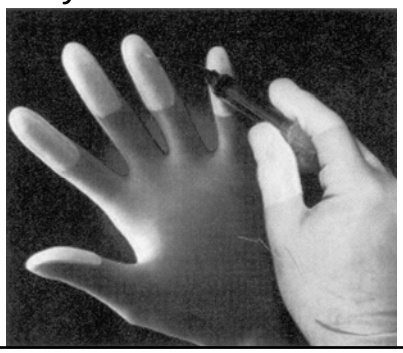
## Infection Control

- Standard Precautions: Treat all body fluid/blood as if the patient has an infectious disease.
  - AIDS (HIV virus).
    - Most patients with AIDS are undiagnosed and asymptomatic.
  - Hepatitis A, B, or C
  - Syphilis and other STD
  - Septicemia

## Infection Control

- Diligent hand washing.
- Use of gloves.
- Masks or protective eyewear and gowns if body fluids/blood may be splashed.
- Needles should never be:
  - Manually recapped
  - Bent
  - Broken by hand
  - Removed from syringes uncapped
- Place used needles/syringes in puncture resistant containers.

## Anti-Stick Surgical Glove by Trademark Medical



## Preparation

- **Golden Rule**
  - The more you know about a patient, the better prepared you will be to treat the patient appropriately.

## Steady State

- A 20 – 30 minute waiting period is recommended before drawing an ABG if:
  - Change in oxygen concentration/liter flow.
  - Change in ventilator settings.
  - An IV was started.
  - Patient removed his/her $O_2$.
  - Recently suctioned.
  - Any procedure which increased patient anxiety or caused pain.
  - History of pulmonary disease

## Documenting the ABG Procedure

- Sample Site
- Diagnosis
- Initials of person drawing the sample
- f/Ventilatory Pattern
- $FIO_2$
- Temperature
- Ventilator Parameters (including Non-Invasive)

## Materials Needed

- Lab Slip/Label
- Syringe (1- 5 ml)
  - Glass or Plastic
- Needles
  - 20 – 22 gauge (adult)
  - 25 gauge (children)
  - Longer needle for brachial or femoral
- Ice/Bag
- Alcohol/Betadine Swab
- 4 x 4 gauze
- Bandage
- Towel

## Syringe Material

- Glass Syringe
  - Less friction.
  - Easier to fill with blood – use if ↓ BP.
- Plastic Syringe
  - Gases diffuse more quickly through plastic.
    - $P_{aO_2}$ may actually rise if not analyzed immediately.
  - Air Bubbles are more difficult to expel.

## Anticoagulants in Syringes

- Blood is activated to clot upon leaving the body.
- Syringes must be coated with an anticoagulant (**Liquid or Dry Heparin**):
  - Sodium Heparin.
  - Lithium Heparin – more commonly used; will not interfere with electrolyte analysis.
  - High heparin contamination can affect pH & $Ca^{+2}$.

## Anticoagulants Used for Sampling

- Liquid Heparin
  - Concentration: 1,000 units/mL .
  - 0.05 mL needed to anticoagulate 1 mL of blood.
  - Fill deadspace of needle and syringe only.
  - Adequate for 2-4 mL sample.
- Dry Lyophilized Heparin
  - Most new ABG syringes are pre-packaged with **dry lyophilized heparin** and thus eliminates the need for liquid heparin.

## Icing the Sample

- All samples should be analyzed immediately.
- If a delay of greater than 30 minutes is anticipated, a **glass** syringe should be used and the sample should be placed in an Ice/Water slush solution capable of maintaining a temperature of 1-5 °C.
  - Barrel should be **immersed** within slush solution.
- If sample is in a plastic syringe and can be analyzed within 10-15 minutes, icing the sample is not necessary.
  - Plastic syringes have been shown to allow for an **increase** in $PaO_2$ if analysis is delayed more than 30 minutes.
- AARC CPG states that iced samples should be analyzed **within 1 hour** CPG), however it isn't stated (but implied) that those samples are in a glass syringe.

## Alcohol, Gauze, & Tape

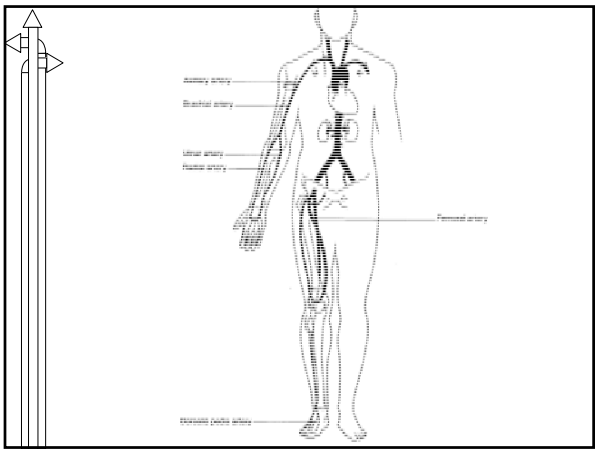
- Aseptic technique
  - Gloves
  - Alcohol swab
  - 2 x 2 gauze pad to apply manual pressure.
  - Pressure dressings? Not recommended *

## Local Anesthetic

- Sometimes used to alleviate anxiety & pain.
- Costly & may increase procedure time.
  - Some research to the contrary.
- 25 or 26 gauge needle and **0.5 - 1.0%** * **lidocaine** is used
  - Inject just under the skin and **wait 2 minutes.**

## Technique for an arterial puncture

- Use pillow or towel rolled up and placed under the wrist or elbow
- Explain procedure to the patient
- Select best site
  - Radial
  - Brachial
  - Femoral
  - Umbilical Artery
  - Axillary
  - Dorsalis pedis

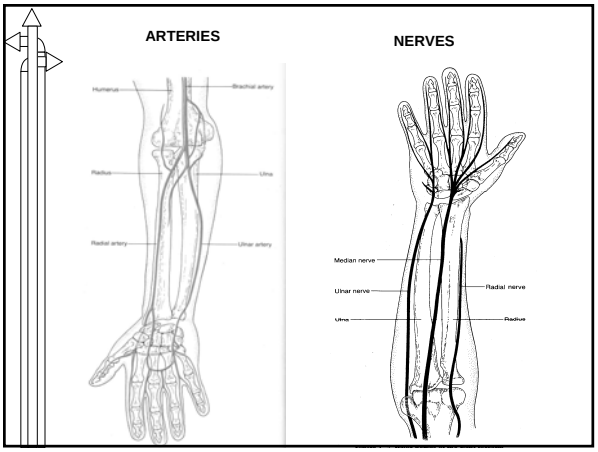


## Radial Puncture

- Radial Artery is the preferred site.
  - Collateral circulation.
  - The artery is not too deep.
  - Less nerve damage.

## Radial Puncture

- Radial Artery lies on the thumb side of the forearm.
- Pulse is strongest 1 inch from wrist crease.
- Pain occurs if puncture is made to deep or if the bone covering (periosteum) is pierced.
- Modified Allen's Test or Doppler ultrasound must be performed.



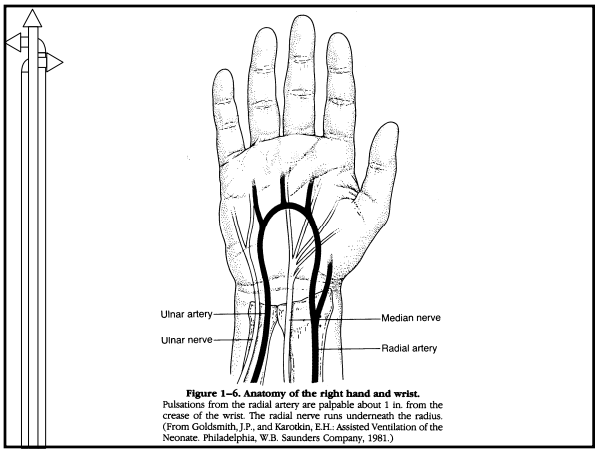




**Figure 1–6. Anatomy of the right hand and wrist.**
Pulsations from the radial artery are palpable about 1 in. from the crease of the wrist. The radial nerve runs underneath the radius. (From Goldsmith, J.P., and Karotkin, E.H.: Assisted Ventilation of the Neonate. Philadelphia, W.B. Saunders Company, 1981.)

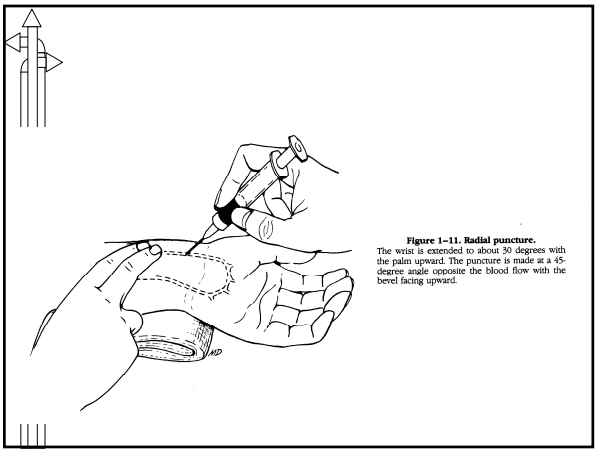
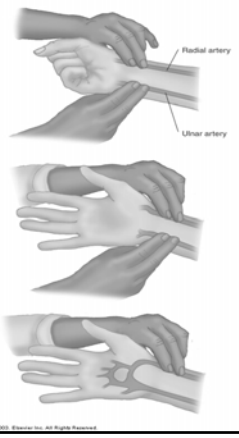


**Figure 1–11. Radial puncture.**
The wrist is extended to about 30 degrees with the palm upward. The puncture is made at a 45-degree angle opposite the blood flow with the bevel facing upward.

## Collateral Circulation

- Modified Allen's Test
  - 3-5% of population have no or minimal perfusion in the ulnar artery.
  - Do not perform the puncture if ulnar circulation is absent.
  - A normal response is a positive response.
  - Failure to flush represents a negative response.
    - Check other hand.




## Brachial Artery Puncture

- If the radial artery cannot be used, go to the brachial site.
- Internal (medial) surface of the arm where is passes over the humerous.
- Palpate a short distance above the bend of the elbow.
- The median nerve closely parallels the course.
- Large veins in the area.

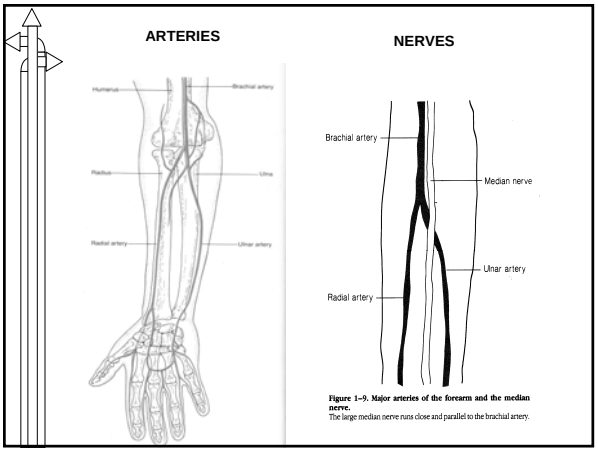
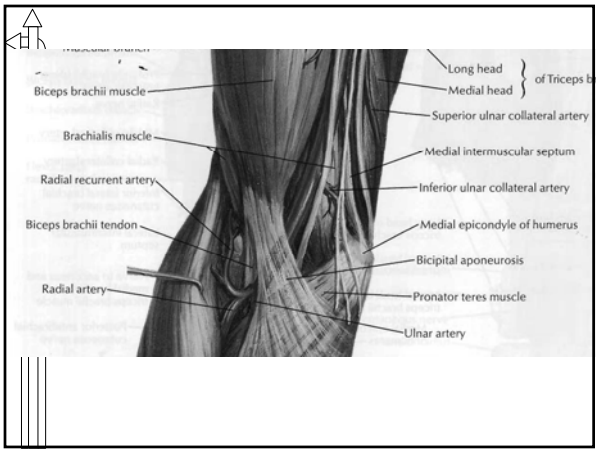
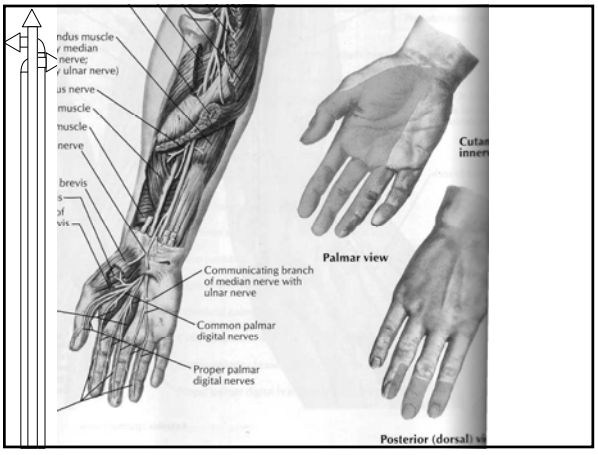



**Figure 1–9. Major arteries of the forearm and the median nerve.**
The large median nerve runs close and parallel to the brachial artery.



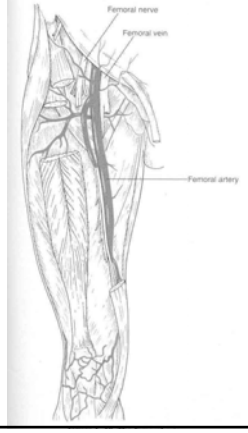



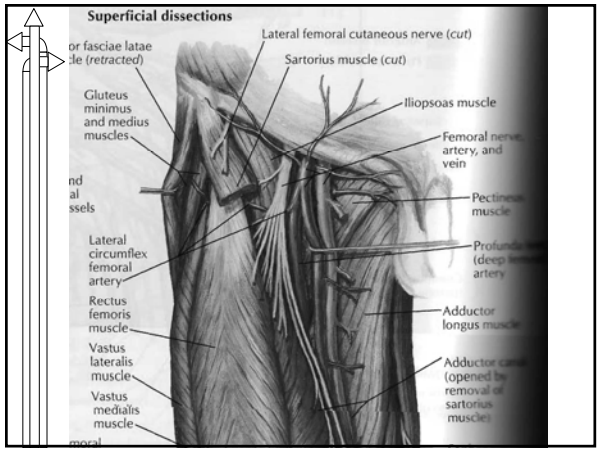
## Femoral Artery

- Least desirable site.
- Large diameter makes it an easy target.
- Vein and Nerve lie close.
  - Increased risk of nerve damage.
- Bleeding may seep from the vessel and go unnoticed.

## Femoral Artery

- Atherosclerotic plaques are common in this area and may dislodge.
  - Distal artery occlusion.
- No collateral circulation.
- May be the only option for hypotensive patients or during resuscitations.




## Following the Arterial Puncture

- Hold puncture site for a <u>minimum</u> of 5 minutes.
- Two minutes after the pressure is released, the site should be inspected.
- Check for pulse & temperature of extremity downstream from puncture site.
- Pressure dressings are not a substitute for compression of the artery.

## Following the Arterial Puncture

- Remove air bubbles.
- Mix Sample (5 seconds).
- Place in Ice/Water.
- Samples that are not placed in ice/water mixture and are obtained in plastic syringes should be analyzed within 30 minutes (**10-15 minutes** CPG).

## Unable to Obtain Sample

- If you do not hit artery, withdraw needle slowly to just below the skin and redirect.
  - Not deep enough.
  - Missed the artery.
  - Went through artery.
  - Blood Clot.
  - Arteriospasm.
- Avoid contamination of venous and arterial blood.

## Venous vs. Arterial Sample

- Arterial Sample
  - Flashing
  - Pulsation
  - Auto-filling of syringe unless patient is hypotensive or a small needle was used
  - Color
- Venous Sample
  - Slow fill – no pulsation
  - Dark Blood
  - Check pulse ox at time of draw
  - $Pa_{O_2}$ 40 mm Hg, $Sa_{O_2}$ 70 – 75%

## Complications

- Thrombosis
- Hemorrhage
- Hematoma
- Arteriospasm
- Pain
- Infection
- Anaphylaxis from local anesthetic
- Nerve Damage
- Vasovagal response
- Improper handling of sample
- Contamination of sample with venous blood
- Trauma to the vessel

## Arterial Line Sampling

- Sampling of blood through catheter placed in artery.
  - Allows for sampling of blood.
  - Allows for monitoring of blood pressure.
- Three way stopcock.
  - Components
    - Flush Solution
    - Patient
    - Sample Port
  - Sampling Position.
  - Flushing Position.
- Umbilical Artery Catheter.

## Arterial Cannulation

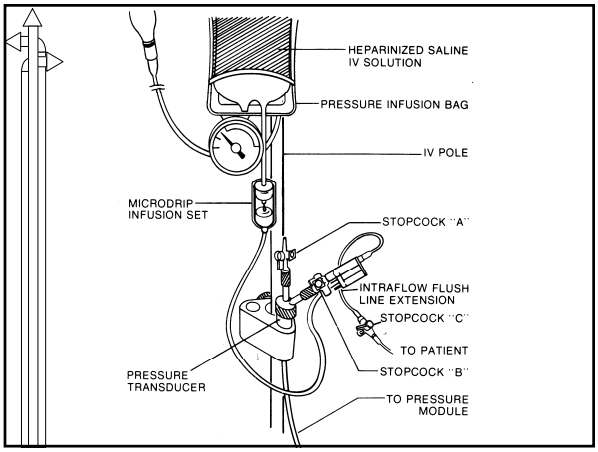
- Two reasons for placement:
  - Continuous Blood Pressure Readings
    - Larger arteries give more accurate BP readings
  - Allows for frequent ABG samples
- Sites include
  - Radial
  - Brachial
  - Femoral
  - Umbilical Artery

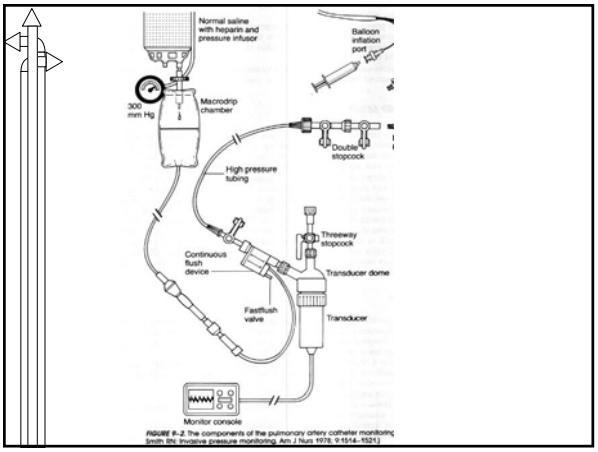
## Complications – Arterial Lines

- Hemorrhage
- Severe vascular occlusion (Clot).
  - Gangrene has resulted in amputation.
- Infection
  - Risk of infection ↑ after 3-4 days.
  - Culture tip of A-line if patient becomes septic.
- Nerve damage.
- Internal bleeding/hematoma.

## Complications

- Coolness of extremity after A-line insertion requires removal of catheter.
  - Tissue damage can occur within 2 hours.
- Check pulses downstream from insertion site frequently.
- Cyanotic extremity could also point to clot, hematoma or spasm of the artery.




## A-line Set-up

- Pressure Transducer (strain gauge)
  - Converts mechanical pressure to electrical energy and displays it digitally and graphically on an oscilloscope.
- IV bag with Heparin is pressurized to 300 mm Hg.
  - Rate of heparin infusion is 3-5 cc/hour.

## Prior to Drawing from an A-line

- Check order and the chart
- Assemble equipment.
- Identify patient.
- Follow universal precautions.
- Familiarize self with set-up.
- Check blood pressure and waveform.
- Check temperature & pulse of extremity.
- Flush A-line and note square wave.

## Pulsus Paradoxus

- Decrease in systolic blood pressure during spontaneous inspiration by 6 – 8 mm Hg or more.
- Loss of pulse strength during inspiration.
- Often seen in Status Asthmaticus and cardiac tamponade.

## Pulsus Alternans

- An alternating succession of strong and weak pulses.
- Suggests CHF or cardiac arrhythmias.
  - Bigeminy

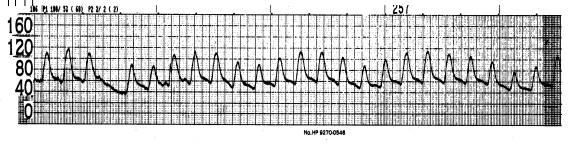
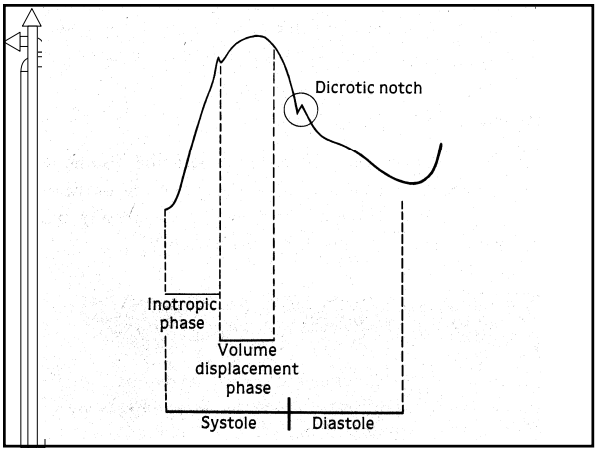
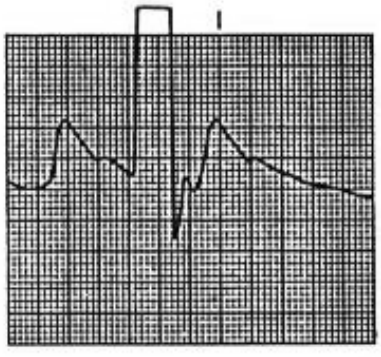



**FIGURE 15-3** Arterial pressure waveform showing respiratory-induced changes in pressure.




## Damping

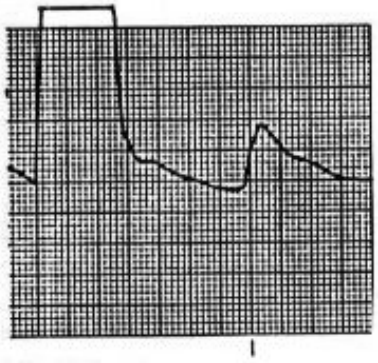
- Damping implies the pressure reading is inaccurate and you will not see a normal waveform
  - Overdamping
  - Underdamping



Optimally damped system.

## Overdamping

- No dicrotic notch.
- No under or over shoot with fast flush.
  - No oscillations.
- False low systolic pressures.
- MAP should be used to record pressure.



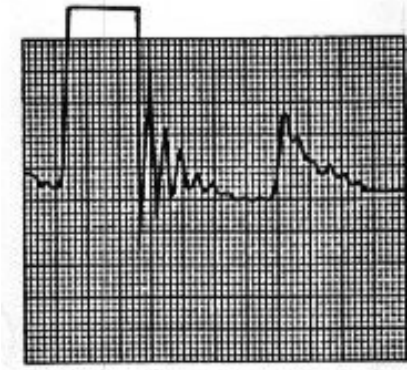
Overdamped system.

## Causes of Overdamping

- Loose Connections
- Air Bubbles
- Kinks
- Blood Clots in the line
- Spasm of artery
- Tubing too narrow

## Causes of Underdamping

- Oscillations after the fast flush.
- False high systolic reading.
- MAP will not be affected.
- Causes:
  - Catheter whip or fling.
  - Stiff noncompliant tubing.
  - Hypothermia.
  - Tachycardia or dysrhythmias.



Underdamped system.

## Normal Resting Position

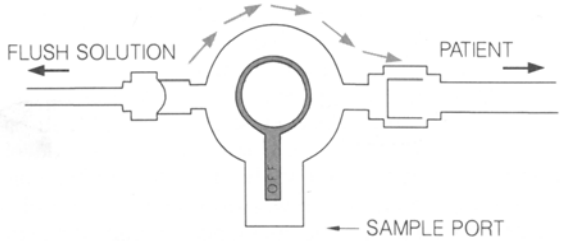



**Figure 1–14. Normal resting position of three-way stopcock.** In the normal resting position, the sample port is closed. The passage between the heparin solution and the patient remains patent.

## All Ports Closed
## Attach Syringe to Sample Port

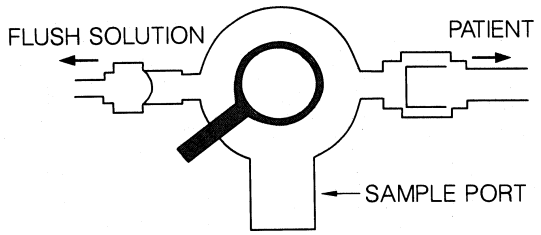



**Figure 1–13. Three-way stopcock.**
Flow is obstructed through all ports in the stopcock because the lever is not directly aligned with any of the ports.

## Turn stopcock off to flush solution & withdraw 3 cc of blood

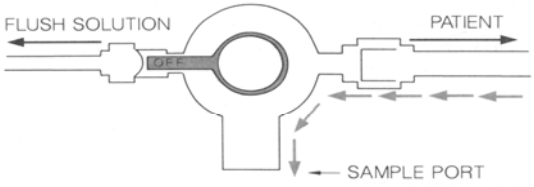



**Figure 1–15. Sampling position of three-way stopcock.**
A syringe is attached to the sample port of the three-way stopcock. The stopcock is turned off to the heparin solution, and fluid is withdrawn.

## Close All Ports
## Remove syringe and discard blood sample

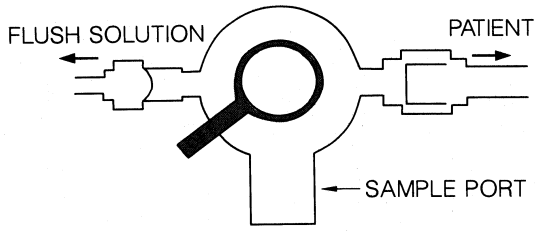



**Figure 1–13. Three-way stopcock.**
Flow is obstructed through all ports in the stopcock because the lever is not directly aligned with any of the ports.

## Place heparinized syringe on sample port

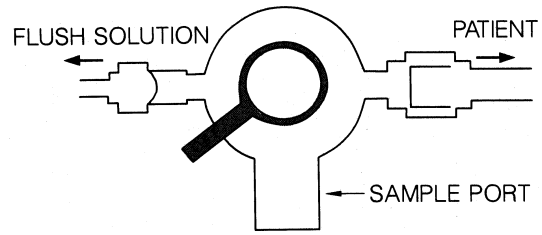



**Figure 1–13. Three-way stopcock.**
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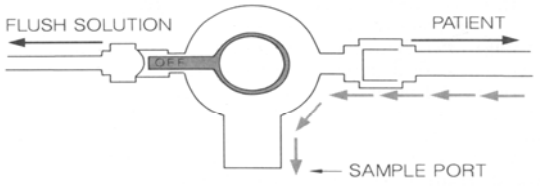



**Figure 1–15. Sampling position of three-way stopcock.**
A syringe is attached to the sample port of the three-way stopcock. The stopcock is turned off to the heparin solution, and fluid is withdrawn.

## Turn stopcock off to sample port and remove syringe


**Figure 1–14. Normal resting position of three-way stopcock.**
In the normal resting position, the sample port is closed. The passage between the heparin solution and the patient remains patent.

- Remove air bubbles from sample
- Place on ice

## Flush line to clear catheter Attach 5 cc syringe to sample port


**Figure 1–14. Normal resting position of three-way stopcock.** In the normal resting position, the sample port is closed. The passage between the heparin solution and the patient remains patent.

## Turn stopcock off to patient port and flush sample port

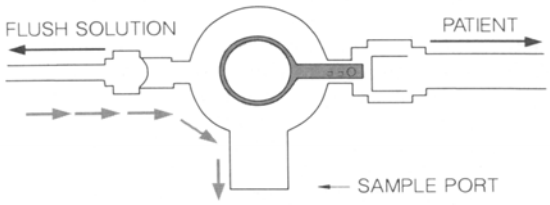



**Figure 1–16. Flush position of three-way stopcock.** If the heparinized bag to the sample port is opened briefly, solution can flow out of the sample port and rinse away all blood.

## Return stopcock to original position and flush again


**Figure 1–14. Normal resting position of three-way stopcock.** In the normal resting position, the sample port is closed. The passage between the heparin solution and the patient remains patent.

## After Drawing from the A-Line

- Observe BP reading and waveform.
- Check patient's temperature and pulse of the extremity used.
- Wash hands.
- Document.

## Oral Review Questions

- What is the normal blood pressure?
  - 120/80
- What is the normal mean blood pressure?
  - 80 – 100 mm Hg
- What is hypertension?
  - BP Greater than 140/90
- What is hypotension?
  - BP Less than 90/60

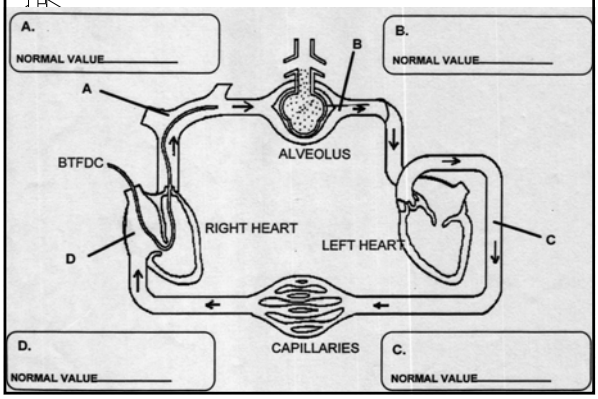
## Oral Review Questions

- How do you calculate a mean blood pressure?

$$MAP = \frac{2\,(\text{diastolic}) + \text{systolic pressure}}{3}$$

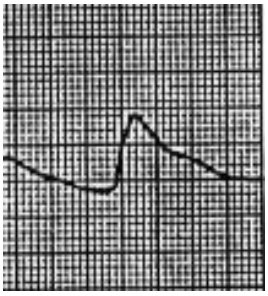
## Oral Review Questions

- Arterial Blood Pressure represents the afterload on the left side of the heart.
- Define afterload.
  - It is the resistance to left ventricular ejection of blood; how much force it takes to pump the blood out.
- What pressure is used in the infusion bag?
  - Usually set at 300 mm Hg and must always be higher than the patient's blood pressure.




## Oral Review Questions

- What kind of waveform is displayed?
  - Normal
  - Overdamped
  - Underdamped

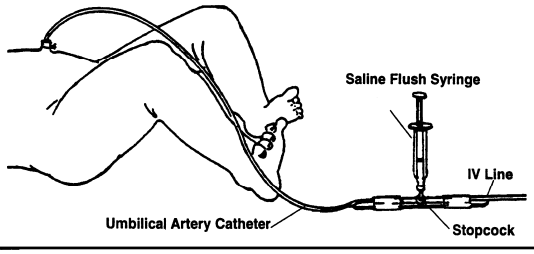


## Oral Review Questions

- Define "damped"?
  - A damped waveform means there is an occlusion in the line.
- List two causes of a catheter being overdamped?
  - Blood clot
  - Air Bubble
  - Kinked tubing

## Umbilical Artery Catheters

**C. Umbilical arterial lines are used with newborn babies**

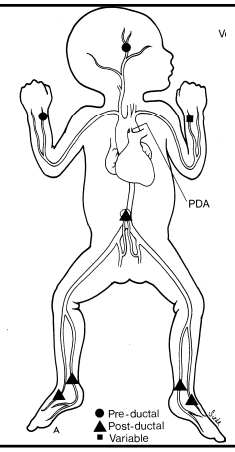


## Umbilical Artery Catheters

- Umbilical Arteries are patent during the first 24-48 hours after birth.
- Constrict rapidly if not kept open with catheterization.
- On x-ray, the catheter should be at L3-4.
- Represents post-ductal blood flow.

## Complications of Umbilical Lines

- Thrombosis
  - Decreased circulation to the leg
  - Hypertension
  - Necrotizing enterocolitis
- Perforation of the vessel wall
- Hemorrhage
- Vasospasm
- Infection




## Assessing a Patent Ductus Arteriosus

- If the Pre-ductal and Post-ductal oxygen level vary, a patent ductus arteriosus should be suspected
  - Transcutaneous Monitor
  - Pulse oximeter
  - Arterial blood gas analysis

## Capillary Sampling

- Sampling of arterialized capillary blood is a popular alternative to ABG sampling in infants.
- Site used should be highly vascular and have good peripheral perfusion.
  - Finger
  - Heel (avoid posterior medial aspect of heel)
  - Toe

## Contraindications to Capillary Sampling

- Posterior curvature of the heel.
- Previous puncture site.
- Inflamed, swollen, edematous tissue.
- Cyanotic or poorly perfused tissues.
- Localized areas of infection.
- Peripheral arteries.
- When there is a need for direct analysis of oxygenation and/or Arterial blood.

## Do NOT perform the heel stick on the end of the heel. Do as shown here (lateral).

## Relative Contraindications

- Hypotension.
- Peripheral vasoconstriction.

## Limitations

- Inadequate warming of site.
- Undue squeezing of the puncture site.
- A second puncture may be needed.
- Cannot use to assess oxygenation.
- Air bubbles must be expelled immediately.
- Analyze within 10-15 min. if left at room temperature.
- Clots prevent accurate analysis.
- Quantity of sample insufficient or analysis is delayed.

## Equipment Needed for Capillary Sampling

- Lancet
- Pre-heparinized capillary tube
- Metal “fleas”
- Magnet
- Sealant or caps
- Gauze or cotton balls
- Band-Aids
- Ice
- Gloves
- Skin Antiseptic
- Warming pads
- Labels/Lab slips
- Sharps container

## Facts to Remember!!

- Warm site (42° C) for 10 minutes.
- Clean site with alcohol or other skin antiseptic and make incision deep enough to cause a free flow of blood (less than 2.5 mm deep).
- Wipe away the first drop of blood.
- Results will correlate with $P_{aCO_2}$ and pH.
- Capillary gases should not be used to monitor oxygen therapy!!
- $PO_2$ values ***do not*** correlate with arterial $PO_2$