A. **Blood gases** are used for the diagnosis and management of respiratory disease; provides valuable information about a patient's oxygenation, ventilation and acid-base balance and include the following laboratory tests: pH, CO\textsubscript{2} and O\textsubscript{2}.

1. Capillary blood gases:
   a. Arterial blood collected by arterial puncture is specimen of choice for pH, CO\textsubscript{2} and O\textsubscript{2}.
   b. Capillary blood has blood from capillaries, venules, arterioles and tissue fluids.
   c. Requires collection in an "open system", allowing exchange of O\textsubscript{2} and CO\textsubscript{2} from air.
   d. This method is performed on children or babies from whom arterial punctures are dangerous.
   e. Sample collected in Natelson tube with heparin, NO air bubbles, both ends of tube sealed and sample placed in ice water. Deliver STAT.

2. Arterial blood gases (ABGs):
   a. Arterial punctures are usually performed by respiratory therapy. Extensive observation and training must be completed before an arterial puncture is attempted.
   b. Patient should be calm, anxiety and excitement can alter the breathing and change composition of the blood gas.
   c. Collected into syringe coated with heparin, placed in ice water, delivered or tested STAT.
   d. Selection of site is determined by circulation, size and accessibility of artery and type of tissue surrounding the site.
      1) Radial artery is artery of choice, located on the thumb side of the wrist. Disadvantage is small size, requires considerable skill.
      2) Brachial artery is second choice; large and easy to palpate. Disadvantage is its deeper and close to basilica vein and median nerve.
      3) Femoral artery is largest artery for arterial puncture; located superficially in groin; this puncture performed by physicians.
      4) Other sites include scalp and umbilical arteries in infants.
e. The *Modified Allen Test* ensures that the ulnar artery can continue to supply the hand with arterial blood if the radial draw leads to a compromised arterial blood flow (rare). If the ulnar artery is already compromised, a radial draw is not permitted. Collateral circulation by the ulnar artery must be checked by use of the Modified Allen test before puncture is made in the radial artery - **MEMORIZE THIS TEST**

1) Have patient rest hand on bed or bedside table, wrist up, fist clenched.

2) Phlebotomist uses middle and index finger of each hand to press on the radial and ulnar arteries simultaneously.

3) While continuing to hold pressure, patient relaxes the fist.

4) Obstructed blood flow causes blanching of the palm.

5) Release pressure on the ulnar artery (little finger side) only, palm and fingers should turn pink in about 15 seconds, indicating ulnar artery is providing circulation to hand, if hand remains blanched, it indicates restricted blood flow of the ulnar artery (*negative test*).

6) If a negative test is obtained that *wrist should not be used* and the opposite wrist should be checked.

f. ABG Hazards

1) Because of higher arterial pressure, a hematoma is more likely to occur, especially elderly patients and patients on anticoagulants.

2) Possibility of *arteriospasm*, a reflex condition of the artery in response to pain or to anxiety.

B. **Bleeding Time**

1. The Bleeding Time is used to assess platelet function and number as well as capillary integrity.

2. Duration of bleeding time depends upon:

   a. Quantity of platelets
   b. Quality of platelets
   c. Ability of blood vessel wall to constrict

3. The use of the bleeding time has decreased in recent years in favor or better, more specific coagulation test.

4. The following items must be discussed with the patient prior to the procedure

   a. Explanation of procedure – tell the patient that you are to perform a bleeding time and it may take 15-30 minutes to complete.
b. Discomfort - there may be discomfort from the blood pressure cuff and the incision

c. Scar Formation – patients should be informed that they may have a small scar from the incision.

d. Medication History – the patient must be asked if they have taken any of the following medications in the last two weeks, as this can cause prolonged bleeding

1) Aspirin or aspirin containing products

2) “Blood thinners” such as heparin or Coumadin

3) Other drugs, such as dextran, streptokinase, ethyl alcohol, or mithramycin

5. The bleeding time procedure involves the following steps

a. Proper patient identification and discussion of the procedure

b. A blood pressure cuff is applied to the upper arm of the patient.

c. An appropriate testing site on the lower forearm is cleansed and allowed to dry.

d. The blood pressure cuff is inflated to 40mm Hg 30 – 60 seconds before the incision is made

e. A minor incision is made with the aid of a Bleeding Time Device in the testing site at the same time a stop watch or other timing device is initiated

f. Every 30 seconds, the edge of a piece of filter paper is carefully brought in contact with the edge of the drop of blood and the blood is allowed to wick onto the paper

g. Timing stops when bleeding has completely stopped and no more blood wicks onto the filter paper OR 15 minutes have elapsed.

h. Bleeding time is reported as the last 30 second interval that any blood wicked onto the filter paper.

i. If bleeding does not cease within 15 minutes, the procedure is discontinued and is repeated on the patients other arm.

j. If bleeding on the second arm also does not cease with 15 minutes, discontinued the test; report these results as “Bleeding Time Greater than 15 minutes”

6. A blood pressure cuff is inflated to 40 mm Hg on the upper arm during the Bleeding Time

a. Is used to control capillary tone

b. Improves both sensitivity and reproducibility.

1) Sensitivity – refers to the ability of a test to detect borderline abnormalities

2) Reproducibility – when two persons perform the same procedure under identical circumstances and obtain identical test results.
7. Bleeding time devices are marketed under various names
   a. They are spring-activated and use a sterile surgical steel blade from a disposable plastic housing into which the blade automatically retracts
   b. For adults, the device will make an incision 5 mm long by 1 mm deep

7. Sources of error in performing the bleeding time
   a. Failure to ask the patient about medication history
   b. Improperly performed puncture – punctures that are too shallow, too deep or in an inappropriate location will adversely affect test results.
   c. Alcohol must be allowed to dry prior to making the puncture; residual alcohol will cause erroneously prolonged results.
   d. Timing must be initialed at the same time that the puncture is made
   e. Improper application of filter paper to blood drop. Care must be used to avoid touching the incision with the filter paper, as this can dislodge a developing clot and falsely prolong the bleeding time
   f. Calibration of the timing device must be performed on a regular basis as part of quality assurance

C. Blood Cultures

1. Indicated for patients with Fever of Unknown Origin (FUO)
   a. FUO may be the dominant clinical feature in bacteremia.
   b. Usually drawn before and after fever spike when bacteria are most likely to be present.

2. Procedure
   a. Cleansing of venipuncture site is the most critical step; most facilities use chlorhexidine gluconate.
   b. Must cleanse tops of blood culture bottles according to manufacturer’s directions and allow to air dry. Many manufactures recommend 70% Isopropyl alcohol.
   c. Draw 1 aerobic and 1 anaerobic; fill anaerobic bottle first if using a syringe.

3. Special precautions
   a. **Do not** repalpate area or wipe iodine off with alcohol before drawing the blood.
   b. Insufficient sample or air injected into the anaerobic bottle may cause false negative.
c. *ISOSTAT* inactivates HIV; ARD inactivates antimicrobial agents.

D. **Glucose Tolerance Test (GTT)**

1. Used to aid in the diagnosis of diabetes mellitus or gestational diabetes. **NOTE:** The American Diabetes Association no longer recommends the GTT for diagnosis of diabetes mellitus but it is still recommended to screen for gestational diabetes.

2. Testing
   a. Draw fasting blood sample.
   b. The patient is given a known amount of glucose to drink to challenge their system.
   c. Their blood is collected at various timed intervals.
   d. Glucose levels should return to normal within 2 hours of ingestion of glucose.
   e. Failure to return to normal suggests a problem with carbohydrate metabolism. There are a number of variations of this test.

3. Instructing the patient
   a. Well balanced meals for three days.
   b. Nothing by mouth (NPO) except water for 12 hours prior to test.
   c. Encouraged to drink plenty of water during the test.

4. Performing the traditional glucose tolerance test
   a. Draw fasting blood sample.
   b. Have patient drink glucose load which usually contains 75g of glucose; watch for signs of nausea.
   c. Draw specimens at 30”, 1 hour, 2 hours, etc. until required number of specimens are drawn. *Timing of specimen collection starts when the patient finishes the glucose load.*
   d. Some sites still require a collection of urine at the same time blood is drawn.
   e. Label specimen with appropriate information AS WELL AS the hour of the specimen; i.e., “1 hour”, “2 hour”, etc.
   f. Two hours after glucose load patient without diabetes should have glucose values return to normal.

E. **Postprandial glucose test**

1. Screening test for diabetes
   a. Patient eats high carbohydrate diet for 2-3 days prior to the test.
b. Eat breakfast of orange juice, cereal with sugar, milk and toast; roughly equivalent to 75-100 grams of glucose.

2. Glucose should return to normal two hours after a meal; if still high a GTT should be done.

F. **Other variations of the Glucose Tolerance Test**

1. Modified Oral Glucose Tolerance Test
   a. Patient is given a 75 gram glucose drink
   b. Sample drawn 2 hours later

2. Gestational Diabetes Screening
   a. Patient is given a 50 gram glucose drink
   b. Sample is drawn 1 hour later

G. **Lactose Tolerance Test**

1. Healthy people who have problems digesting lactose, a milk sugar, lack a mucosal enzyme which breaks down lactose.

2. This results in gastrointestinal (GI) discomfort and diarrhea which goes away when milk is eliminated from the diet.

3. Breath hydrogen content
   a. The preferred, non-invasive method
   b. Requires drinking a liquid that contains high levels of lactose
   c. Breath samples are collected as the patient exhales
   d. Exhaled gases tested for hydrogen, a by-product of bacteria that breaks down lactose but is not absorbed

4. Lactose Tolerance Procedure
   a. A fasting glucose level is drawn
   b. Patient is given 50 grams of lactose
   c. Specimens drawn similar to GTT
   d. Specimens tested for glucose
   e. A less than 20 mg/dL increase in glucose over the fasting level, with gastrointestinal symptoms after a lactose load is considered abnormal and consistent with lactose deficiency.
   f. Must have convenient access to restroom
H. **Therapeutic Drug Monitoring (TDM)**

1. Complex endeavor; requires coordination between lab, nursing and pharmacy
2. Used to evaluate the concentration of certain drugs for various reasons
   a. Drugs that are highly toxic
   b. When over or under dosing can have serious consequences
   c. If the use of multiple drugs may alter the action of the drug being measured
   d. When different patients metabolize drugs at different rates
   e. If the drug’s effectiveness is questionable
3. Specimens are collected and evaluated for trough and peak levels
   a. **Trough** – lowest level; **Peak** – highest level
   b. Time it takes to peak varies with mode of infusion (IM vs. IV) and rate of infusion.
4. Random level appropriate for continuous infusion.
5. Time is more critical for drugs with short half life such as gentamicin, tobramycin, procainimide than those with longer half life such as phenobarbital or digoxin.
6. Timing of collection critical. Specimen should not be collected immediately after dose is given; usually 30 minutes after a dose for peak, 15 minutes before next dose for trough.
7. Need following information
   a. Patient information, physician and test ordered
   b. Whether order is for peak, trough, continuous infusion or random sample specimen
   c. Date and time of last dose
   d. Date and time of next dose
   e. Mode of collection: venipuncture, central venous catheter collection, etc.
   f. Nurse’s verification that dose was administered
8. TDMs collected in plain red tops; no additives or serum separators (gel)
9. Keep specimens upright, away from stopper which may release interfering substances

I. **Collection for Trace Metals**

1. Must use special tubes prepared specifically for trace metal analysis
2. Special acid washed plastic syringes are suitable
3. For aluminum level the needle must be free of aluminum
4. For lead must use lead free heparinized tubes and stainless steel needles
5. Special collection guidelines must be established and followed

J. **Genetic Molecular Testing**

1. Requires special informed consent forms signed prior to testing; some require counseling
2. Collection tube requirements will vary with type of test ordered and testing methodology used
3. The types of molecular testing is constantly expanding; phlebotomist must keep up with changes in procedures related to this testing

K. **Intravenous (IV) Line Collections**

1. A *vascular access device* (VAD), also called an indwelling line, consists of tubing inserted into a main vein or artery or in the case of newborn in the umbilical cord.
   a. A variety of types are used, but the most common type is *central venous catheters* (CVC) also called *central venous line* (CVL)
   b. Another type of VAD, an *implanted port*, is a small chamber that is attached to an indwelling line
      1) The chamber is surgically implanted under the skin and is located by palpating the skin
      2) Access is gained by inserting a needle through the skin and into the self sealing septum (wall) of the chamber
   c. The latest type of VAD, a *peripherally inserted central catheter* (PICC) is inserted into the peripheral venous system and threaded into the central venous system.
      1) It does not require surgical insertion
      2) Commonly placed in either the basilica or cephalic vein with the exit in the vicinity of the elbow
      3) Because a PICC tends to collapse on aspiration, it is not recommended for drawing blood

2. VADS are used primarily for administering fluids and medications, monitoring pressures, and drawing blood
   a. VADS that are to be used for blood drawing should only be accessed by *specially trained personnel.*
   b. Phlebotomists may be trained to draw from lines, but usually nurses perform this type of collection.
3. **Procedure**
   
a. To keep blood from clotting in the line, a nurse will flush the line with heparin or saline.

b. The first sample taken from the line contains a mixture of blood and heparin or saline. It is **critical** to discard the first 5-7 mLs of blood drawn. **Not discarding the first blood drawn may cause erroneous laboratory results.**

c. After discard, the blood can be drawn as if drawing from a vein.

d. After drawing the blood from the line, a nurse will inject heparin or saline into the line until all the blood is pushed back into the patient. This keeps the line from clotting.

e. Line draws are **not** recommended for coagulation testing; however, some hospital policies allow the sample to be drawn if first 10 mLs of blood drawn is discarded.

4. A **heparin lock or saline lock** is a special winged needle set that can be left in patient’s vein for up to 48 hours. **NOTE:** Heparin locks should not be used on patients who have thrombocytopenia or uncontrollable bleeding.

a. It is used to administer medication and draw blood.

b. It is periodically flushed with heparin or saline (depending on the patient) to keep it from clotting; therefore, a 5 mL discard tube should be drawn prior to specimen collection.

c. Drawing coagulation test specimens from heparin locks is not recommended.

d. Only specially trained personnel should draw blood from a heparin lock.

e. Heparin locks are a viable alternative to a traditional IV and are very useful for patients with difficult veins who require multiple blood draws or administration of frequent doses of medication not requiring IV solution.

5. A **cannula** is a tubular instrument that is used to gain access to venous blood for dialysis or blood collection.

a. Tubing of the cannula extends to the outside surface of the arm.

b. A discard tube must be drawn prior to specimen tubes.

c. Drawing blood from a cannula should be done only by specially trained personnel with the permission of the patient’s physician.
6. A **fistula** (shunt) is created by a surgical procedure, which **permanently** fuses a vein and artery together to increase blood flow rates.
   
a. It is used for dialysis and should not be used for phlebotomy procedures.
   
b. Specimens should be drawn from the opposite arm.
   
c. If a specimen must be drawn from this arm, cleanse the site thoroughly.
      
      1) Primary risk is infection and inflammation which may shut down all veins.
      
      2) Surgery would be required to put in a new shunt.

L. **Blood Donor Collections**

1. Donor interview and physical *serves two purposes*
   
a. To protect donor by ensuring that the donation will not endanger their health.
   
b. To protect potential recipient from blood transmitted diseases.

2. Donor interview
   
a. Questions about medical history: any current infections, cancer, heart or liver disease, symptoms associated with AIDS, past or present risky behavior, all prescription and over the counter medications.
   
b. Should be done in such as manner as to ensure privacy as many questions about sexual practices and history are asked.
   
c. Blood centers have a standardized questionnaire based on criteria established by the AABB formerly known as the American Association of Blood Banks.
   
d. Deferrals may be temporary or permanent based on medical history provided by patient
      
      1) Permanent deferral: hepatitis after age 11, most cancers, heart disease, IV drug abuser, AIDS, certain medications, high risk behaviors
2) Temporary deferral (12 months or more): transfusion of blood or blood components, sexually transmitted disease (STD), recent inmate of penal institution, certain medications, accidental needle exposure

3) Temporary deferral (less than 12 months): immunizations, pregnancy, surgery that does not require blood transfusion, recent blood donation, symptoms of cold or active allergy, aspirin, other medications

3. Donor physical performed to confirm that the donor is healthy and includes the following:
   a. Weight – minimum is 110 lbs (in Austin area, minimum weight is 123 lbs. due to larger volume collection bag)
   b. Temperature – cannot exceed 99.5° F
   c. Pulse – should be strong, regular, and between 50 and 100 beats per minute (bpm)
   d. Blood pressure – cannot exceed 180 mm Hg systolic and 100 mm Hg diastolic
   e. Hematocrit – minimum of 38%
   f. Hemoglobin – minimum of 12.5 g/dL
   g. Phlebotomy site must be free of lesions. Both arms should be examined for signs of drug abuse.
   h. General appearance of donor – not excessively nervous or appear to be under the influence of drugs or alcohol

4. Collection of donor’s blood
   a. Donors should be encouraged to eat 4 to 6 hours prior to donation to minimize dizziness, fainting or other reactions. Donors must always be in a reclining position during donation.
   b. Blood for donation should be collected using sterile technique similar to that used for the collection of blood cultures. The phlebotomy site should be prepped using alcohol and iodine (traditional method) or with a product containing chlorhexidine gluconate, such as ChloraPrep or Chlorascrub.
   c. Apply tourniquet and using a 15-18 gauge needle, perform the venipuncture.
   d. A unit of blood should be collected with 10 minutes, with constant mixing of the blood and anticoagulant throughout the collection procedure.
   e. Tubing is clamped upon completion; remove needle and apply pressure.
   f. Have donor remain in seated position on donor chair for approximately 5-10 minutes after donation, then release to lounge.
   f. Donor should remain seated in lounge with refreshments offered for 10-15 minutes prior to leaving.
5. **Autologous donation**
   a. Donation of blood by the patient to be given back to the patient during elective surgeries where anticipation of excessive blood loss is high such as total hip replacement surgery.
   b. Doctor will write an order for the number of units needed, may be up to 4.
   c. Donor requirements are not as strict as this blood will only be used for this patient.
   d. Safest transfusion possible.

6. **Directed donors**
   a. Patient is unable to donate autologous blood and has friends and relatives donate blood for patient use.
   b. Expensive and the least safe type of blood to use of the options available. Social pressure to donate may compromise reliability of donor’s answers to health-history questions.
   c. Exception is the rare time when only specific individuals are compatible with the patient.

7. **Therapeutic phlebotomy**
   a. Procedure where removal of blood is beneficial to the patient, i.e., polycythemia or hereditary hemochromatosis
   b. Physician must provide a written request.
   c. May be done at the blood center or hospital depending on physical condition of the patient.

M. **The Emergency Room (ER)**

1. Phlebotomist’s role will vary from state to state, hospital to hospital
   a. Local laws may allow phlebotomists to start IVs in some states; prohibit in others.
   b. Phlebotomist needs to become familiar with limitations and expectations at their particular institution.

2. Atmosphere very different
   a. ER chronically filled with people in pain, ranging from minor illnesses or injuries to major trauma.
   b. Patients who have no regular doctor use ER for treatment of chronic illnesses.
   c. Family members who accompany the patient may be very emotional and vocal.
3. Patients are prioritized at a central reception area according to severity of illness or injury.
   a. **Triage** is a procedure whereby medical professionals evaluate each patient and
determine which patients need immediate attention and which ones can wait.
   b. Stressful for patients with minor illness or injuries, as they may continually be
   “bumped” back if more serious patients come in during the waiting period.

4. Stress level may be very high
   a. Phlebotomists have two responsibilities
      1) Be familiar with all equipment and be very skillful in blood collection
      2) When blood specimens are needed STAT, respond quickly and be able to
         successfully collect the proper volumes in the proper tubes; there may not
         be time for a recollect.
   b. It is **vital** that the phlebotomist have the ability to follow orders **exactly** and not
      require extensive, time consuming directions.
   c. Phlebotomist must be able to handle the sight and sound of traumatically injured
      patients in pain, profuse bleeding, disfigurement due to injuries, moaning and
      groaning.
   d. Due to stressful environment, tension runs high and minor personality conflicts
      occur more readily
      1) Phlebotomist and other ER personnel must learn to resolve and quickly
         dismiss irritations and loss of temper which may interfere with patient care.
      2) Requires a mature, responsible personality.
   e. The ER is not for everyone. Some work for a short time and cannot handle it.
      Others thrive on the stress and excitement and would not work anywhere else.
   f. Experienced, confident phlebotomists are best suited for these positions and must
      be able to perform their duties without distraction.

N. **Preparation of Peripheral Blood Smears**
   1. Peripheral Blood Smears are most commonly used for the **differential**.
      a. The differential requires a laboratory technologist or technician to count 100 white
         blood cells, noting the number, type, and characteristics of blood cells.
      b. The differential may be prepared from an EDTA sample or capillary blood.
      c. The differential is used to aid physicians in diagnosing viral infections, bacterial
         infections and certain blood disorders such as leukemia.
2. The ideal blood smear has the following qualities:
   a. A feathered edge that is nearly square
   b. A rainbow sheen when reflecting light
   c. Is exactly one cell thick in the feathered edge when viewed microscopically

3. The three factors that can be altered to produce the perfect blood smear are speed, angle, and drop size.
   a. The faster the spreader slide is moved, the longer and thinner the smear will be. The slower the spreader slide is moved, the shorter and thicker the smear will be.
   b. The spread slide should be held at a 30° angle when preparing the slide
      1) An angle greater than 30° makes the smear thicker
      2) An angle less than 30° makes the smear thinner
   c. A drop of blood that is too small may not be sufficient to prepare a proper smear. A drop of blood that is too large may cause the smear to be too thick.

4. Basic steps for preparation of peripheral blood smear
   a. Select two clean glass slides that are free of chipped edges.
   b. If using blood from an EDTA specimen, make sure to invert the tube at least 10 times so that it is well mixed.
   c. Place a drop of blood 2 mm in diameter centered on a line approximately ¼ inch from the frosted edge of one slide.
   d. Hold the slide with the drop of blood down with your non-dominant hand.
   e. Grasp the spreader slide with your dominant hand, letting the end of the slide rest at a 30° angle just in front of the drop of blood.
   f. Draw the spreader slide backward into the blood drop, and allow the blood to spread from side to side, filling the space created by the 30° angle
   g. Keeping the spreader slide at a 30° angle, push the spreader slide rapidly across the stationary slide in one, smooth even motion.
   h. Allow the slide to air dry. Check for acceptability
   i. Label the slide with the patient’s name, date, and identification number, following the protocol of the facility.