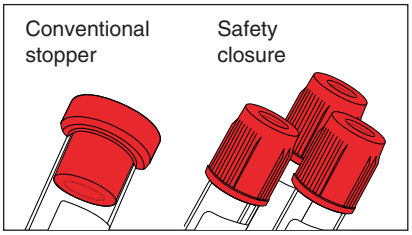
How Is Blood Collected?

Blood is usually collected into plastic tubes called *evacuated tubes* (rarely glass tubes are used because they may break). The tubes contain a vacuum, which assists in the filling of the tube. The evacuated tubes have a stopper with a septum that is punctured by a needle assembly during the blood draw. Usually a plastic safety closure surrounds the stopper. Blood also may be collected by syringe for transfer into other types of containers, such as blood culture bottles (see page 47). When filling an evacuated tube with a syringe, it is important to allow the tube to fill by vacuum instead of removing the stopper. This is most critical for laboratory tests, such as prothrombin time (PT) and activated partial thromboplastin time (APTT), where fill volume is important to ensure the proper anticoagulant-to-blood ratio. In general, the stopper should never be removed from the blood tube. Also, blood from one tube should *never* be transferred to another tube because this could affect test results.



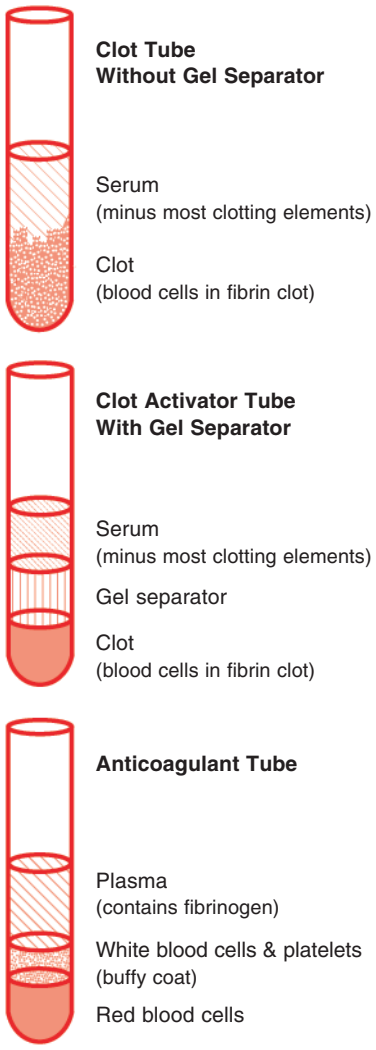
Venipuncture, using a needle and evacuated tube, is the most common method for the collection of blood. On some occasions, blood may be collected with a syringe or by puncturing the skin with a retractable lancet device. Specially trained health care professionals may obtain blood from intravascular access devices (see Appendix 1) or the bone marrow cavity (see Appendix 2) using a syringe.

Blood may be collected into a tube without any anticoagulant and then allowed to clot. To promote clotting, blood may be collected in a serum separator tube or a plain serum tube. Serum separator tubes contain a clot activator as well as a gel, the latter forming a barrier to separate the serum from the cells during and after centrifugation. Serum is used for many tests.

Blood also may be collected into a tube containing an anticoagulant, which prevents clotting. The blood then may be used in whole form, the cells suspended in the plasma just as they are in the circulation. When blood is collected with an anticoagulant, the cells may be separated by centrifugation and the plasma used for testing. Blood collected in additive tubes (anticoagulant or clot activator tubes) must be mixed by gently inverting the tube several times to ensure even distribution of the additive in the specimen (see table on page 18 for number of inversions).

Please be aware that after centrifugation the entire initial volume of a filled specimen collection tube will not be available for laboratory tests that use serum or plasma. Refer to your institution's minimum test volume requirements. Typically the amount of serum or plasma available for testing is less than 50% of the total volume of blood drawn.

Orientation of blood components following centrifugation



Due to concerns of insufficient serum or plasma available for testing, many institutions discourage the use of "pedi bullets" obtained from a heelstick or fingerstick. Also, these samples may be associated with greater degrees of breakage of red blood cells (hemolysis), which may interfere with laboratory testing. Platelet clumping can also occur more in these methods, leading to a falsely low platelet count.

Some nonroutine specimens may require special handling at the time of specimen acquisition. You should confirm with your supervisor which specimens require special handling.

For example:

- Specimens for the testing of cold agglutinins or cryoglobulins must be kept warm (37°C).
- Specimens for the testing of homocysteine, ammonia, and lactic acid must be chilled.
- Specimens for the testing of blood gases should not be chilled but must be tested within 30 minutes of collection.
- Specimens for the testing of bilirubin and certain vitamins must be wrapped in foil to prevent exposure to light. If available, amber microcollection devices should be used for bilirubin specimens from newborns.

Some specimens may require immediate centrifugation and processing (eg, organic or amino acids analysis, unfractionated heparin measurement). The phlebotomist should confirm with the laboratory that processing is available prior to collecting these samples.

Blood Collection Equipment

Blood collection systems

The evacuated tube system is the most frequently used equipment when performing venipuncture. This system consists of a double-pointed needle, an adapter to hold both the needle and the collection tube, and a variety of color-coded evacuated collection tubes. The size of the needle used for blood collection is referred to as *gauge.* The larger the gauge, the smaller the needle size. Appropriate needles for blood collection are available in gauges from 20 to 23; however, the most common needle used is 21 gauge. The needle adapters (holders) also come in a variety of sizes to accommodate different sized collection tubes. The components of the blood collection system should be from the same manufacturer and cannot be mixed with those from other manufacturers unless this has been validated (proven reliable) locally. This is an FDA regulation.

The evacuated collection tubes are usually plastic, have color-coded stoppers, and are labeled with expiration dates. Their color code is based on their contents—either no additive or the type of additive they contain. The evacuated tubes have a label indicating the type of additive they contain (such as

Needle gauge and hemolysis

A needle of 24 gauge or greater may cause lysis of red blood cells as they travel under extreme shear stress through the small bore of the needle. The rate of hemolysis varies with the degree of phlebotomy training and the method used to collect the blood specimen. The frequency varies from 3.8% for a 21-gauge needle into an evacuated blood collection tube to 100% when a 24-gauge intravenous catheter is used.

Alternatively, a butterfly needle (winged set) may be used, as appropriate, and will be described later. A winged set is available with a 25-gauge needle that has an internal diameter of 23-gauge, which will reduce the number of hemolyzed specimens compared to original 25-gauge internal diameter (BD Right Gauge).

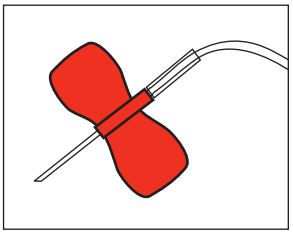
anticoagulant or clot activator), the draw volume, and the tube's expiration date. Expiration dates on evacuated tubes are based on when they may lose their vacuum and hence not fill properly or when they may no longer be sterile. Evacuated tubes fill automatically to a determined volume based on the amount of vacuum that is present in the tube. Evacuated collection tubes are sterile.

Always check the expiration date of the evacuated collection tube and other supplies prior to use. The expiration date refers to the last date the tube may be used for collection.

There are many new safety devices available for the evacuated tube collection system. Some use needle shields or self-blunting needles. Others use adapters that act as the safety shield for the used needle. The OSHA Bloodborne Pathogens Standard prohibits contaminated needles and other contaminated sharps from being bent, recapped, or removed, unless the employer demonstrates that no alternative is feasible.

Butterfly needles

Butterfly needles historically have accounted for a highly disproportionate share of needlestick injuries because they have a tendency for one end to curl/recoil and stick the individual disposing of the needle. These injuries can be reduced by the following:



Shown prior to activation of retractable safety device

- Always use a safety-engineered butterfly needle, which has been designed to reduce needlestick injuries.
- Activate the safety device immediately upon removal of the needle from the patient.
- **Do not** disassemble the tube holder from the needle assembly before disposal in a sharps container.
- Stretch out the butterfly tubing when removing it from the package to reduce recoil.
- During disposal, be sure to stabilize the butterfly tubing, holding the end with the needle by the plastic needle support, to reduce the likelihood of having the needle flip back and stab you.

Each institution should provide guidance on when to use butterfly needles.

Replace sharps containers, as appropriate, so that all items intended for disposal can be safely placed in the container. Containers must never be overfilled and must be replaced when contents reach the indicated fill line. Puncture-resistant sharps containers must meet the requirements of national or local regulations.

Additives

Additive tubes contain anticoagulants, clotting activators, or both, with or without separator gel.

Anticoagulants are substances that prevent blood from clotting. Clot activators are substances (eg, glass, silica, thrombin) that promote clot formation.

There are many different kinds of anticoagulants used in evacuated tubes. They can be in liquid or dry form, and may be difficult to see in the tube. The correct anticoagulant must be used for the specific test procedure to be performed (see the following). Using the incorrect evacuated tube or anticoagulant type is a cause for specimen rejection by the laboratory because the incorrect anticoagulant can seriously affect test results. Blood collected with one anticoagulant may be suitable for one test or group of tests, but not for others.

Anticoagulants used in blood collection tubes

Collection tubes used for blood samples are color coded. The color of the stopper indicates which type of tube it is (see table on page 18). Since color standards may change, it is essential to check the tube label. Color standards may also differ between manufacturers.

The anticoagulants most frequently used are:

- **EDTA.** This anticoagulant is used primarily when performing complete blood cell counts (CBC) and molecular diagnostics. There also are other applications, such as determining red cell folate, blood lead, and hemoglobin A1c levels; monitoring immunosuppressant drugs (eg, tacrolimus); and blood typing.
- **Sodium citrate.** This anticoagulant is used primarily when performing coagulation studies, eg, prothrombin time (PT).
- **Heparin.** This anticoagulant is used for a variety of routine and specialized tests. *Note:* Tubes containing heparin may contain either sodium heparin or lithium heparin. In general, lithium heparin is used for chemistry tests. However, a lithium heparin tube must never be used to determine a patient's blood lithium or heparin level. Lithium heparin tubes must not be used when sodium heparin is indicated. Sodium heparin is used for specimens requiring the use of viable (functional) lymphocytes, such as HLA testing. A sodium heparin tube must never be used to determine a patient's blood sodium or heparin level. The specific type of heparin will be noted on the tube label—read the label!
- **Fluoride-oxalate.** This anticoagulant is used primarily for glucose and alcohol determinations. Enzymes, which may change glucose or alcohol concentrations, are inhibited by the fluoride in the tube, and clotting is prevented by the oxalate.

Important tips to remember

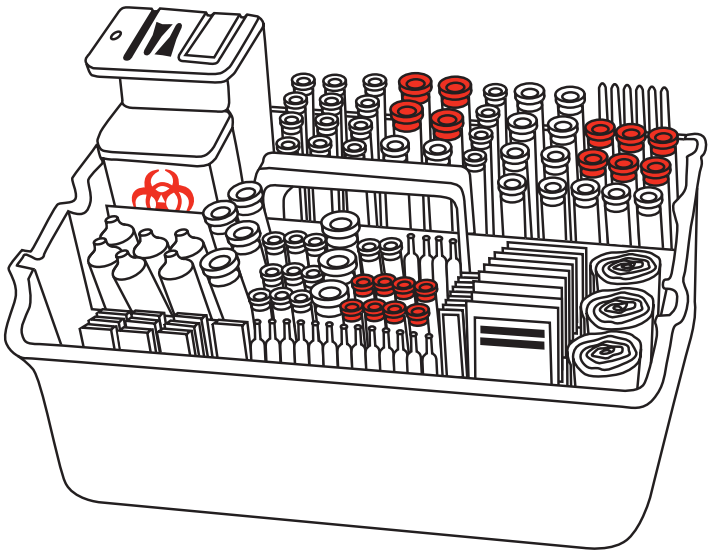
- To confirm the patient's identity prior to collecting any blood specimen, two unique patient identifiers should be used, such as patient name, date of birth, medical record number, or social security number. As an extra precautionary step, ask the patient to state the identifier, such as name or birthdate. This decreases error due to miscommunication.
- If using a hand-held barcoding device for labeling, make certain to follow procedures and label the evacuated tubes in the presence of the patient.
- The vacuum in the collection tube allows the correct amount of blood to enter the tube. Do not underfill (short draw) or overfill additive tubes because this can cause erroneous test results and is a cause of specimen rejection by the laboratory. **Never transfer blood from one tube to another blood collection tube,** even if it has the same color stopper. This also is a cause of specimen rejection by the laboratory as this practice can seriously affect test results.
- If your facility is located at a high altitude, the vacuum in the tube may be decreased. Extra care may be needed to ensure that tubes are properly filled (consult your supervisor).
- Blood collected in tubes containing an additive must be promptly and thoroughly mixed. Do not shake the tube. Mix by gently inverting the tube end-over-end so that the additive is thoroughly mixed with the blood (see diagram on page 27; see table on page 18 for number of inversions). If the blood and the anticoagulant are not thoroughly mixed, a partial clot may form and seriously interfere with the test results. One of the most common preanalytic errors is inadequate mixing.
- Many laboratories track quality metrics around specimen collection and rejection. It is important to obtain feedback on performance to identify opportunities for improvement.

The blood collection tray

A well-equipped, organized blood collection tray is necessary for successful blood collection. The blood collection tray must be kept clean and neat at all times. The tray should be checked frequently and decontaminated as needed with a freshly made 10% bleach solution or other decontaminating solution used by your institution. Supplies should be replenished as needed.

A typical tray should contain at least the following:

- Safety needle devices, including blood tube holders and sterile needles or butterfly needles
- Blood collection tubes
- Disposable, properly fitted gloves
- Packaged alcohol swabs or pads
- Chlorhexidine gluconate/alcohol pads
- Blood culture prep kits
- Gauze pads (2"×2")
- Adhesive tape or bandages
- Permanent ink marking pen
- Blood culture bottles
- Glass slides
- Microcollection tubes
- Capillary tubes and sealer, if required
- Retractable, sterile, blood lancet devices
- Tourniquets (*Note:* Single-use, disposable, preferably latex-free tourniquets are becoming the standard of care. At a minimum, tourniquets must be discarded immediately when contaminated with blood or body fluids, or if contamination is suspected.)
- Sterile syringes and safety needles
- Puncture-resistant sharps container
- Electronic barcode or RFID chip reader and printer, as applicable
- Plastic transport bags



Preprinted labels may be included if computerized order entry is used and the hospital has a centralized phlebotomy team. Labels should be appropriately separated by patient and location, and identification should be confirmed prior to the blood draw. Caution must be used to ensure that the correct label is placed on each tube in the patient's presence when using computer-generated labels. A common error is to assume that a set of labels are all for the same patient. Sometimes a patient label may be accidently left on another patient's set of labels and may be placed on the incorrect patient's tube. Avoiding this error becomes even more difficult if the patients have similar names.