

# Phlebotomy: Overview and Clinical Applications

Phlebotomy describes the act of removing blood from a patient using a needle. This can be for the purposes of laboratory testing as a diagnostic tool to narrow down a differential or can be used therapeutically for certain conditions. This activity reviews the procedure of phlebotomy and its various clinical correlations.

 by **Fertility Guidance Technologies**



# Historical Context

Phlebotomy, which used to be known as bloodletting, has been used for centuries, with its origins traced back to Greece. It was used for both curative as well as preventative treatments. These practices at the time were neither regulated nor properly understood as it is in the 21st century. It was thought that any disease or sickness was due to an imbalance of various fluids in the body, and bloodletting would be a way of restoring that balance. As a result, the practice of bloodletting often led to poor clinical outcomes. A prime example was the death of George Washington (1st president of the United States), who died after losing blood as a treatment for acute epiglottitis.



Over time, phlebotomy has evolved to be an extremely crucial diagnostic as well as therapeutic solution. Today, phlebotomy is used constantly in clinical environments to increase the understanding of a patient's clinical

# Phlebotomy Certification Levels

1

## Limited Phlebotomy Technician (LPT)

Authorized to do skin puncture blood collection only.

2

## Certified Phlebotomy Technician I (CPT I)

Authorized to do skin puncture and venipuncture blood collection. There are different requirements for applicants with no phlebotomy experience, applicants with less than 1040 hours of on-the-job phlebotomy experience, and applicants with 1040 or more hours of on-the-job phlebotomy experience in the last 5 years.

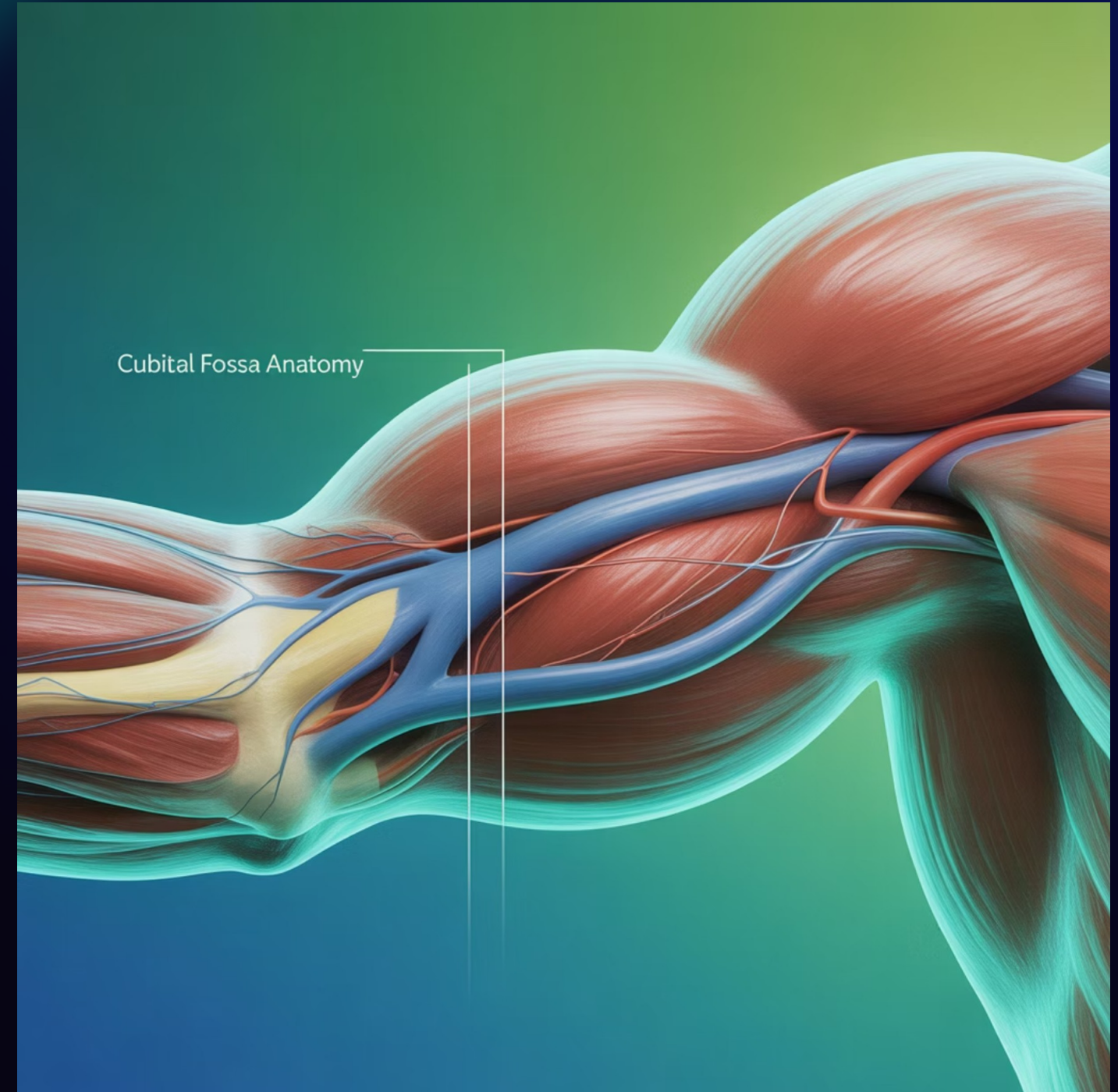
3

## Certified Phlebotomy Technician II (CPT II)

Authorized to do skin puncture, venipuncture, and arterial puncture blood collection.

# Anatomy and Physiology

When drawing blood, it is important to prioritize the efficiency of the draw and the overall comfort of the patient. Thus, drawing blood from veins is preferred compared to arteries. This is because veins run superficially. Furthermore, arteries tend to have thicker walls and have more nerves associated with them, resulting in increased pain should they be punctured. Therefore, arterial blood sampling would be indicated for gathering data on arterial blood gases. The common location for a blood draw is in the medial cubital fossa. In this area, the medial cubital vein is superficial and covers the bicipital aponeurosis in the cubital fossa. Many anatomical variants are possible. The median cubital vein is the most common choice because of the thick walls that can tolerate the negative pressures when drawing blood.



This is in contrast to the dorsum of the hand, which is the preferred location for establishing an IV site. It is extremely critical to distinguish the median cubital vein from the basilic vein, medial along the arm. Extra precaution when

# Order of the Draw

To avoid cross-contamination, blood must be drawn and collected in tubes in a specific order. This is known as the Order of Draw.

The correct order of draw for phlebotomy tubes is crucial to prevent cross-contamination of additives and ensure accurate test results. Generally, the order is: blood culture tubes, coagulation tubes (light blue), serum tubes (red, gold), heparin tubes (green), EDTA tubes (lavender), and finally, glycolytic inhibitor tubes (gray).



## Blood Culture Tubes

These are drawn first to maintain sterility and prevent contamination from other additives.



## Coagulation Tubes (Light Blue)

These tubes contain sodium citrate, which is an anticoagulant. They are drawn next to minimize the potential for contamination with other additives that could affect coagulation tests.



## Serum Tubes (Red, Gold)

These tubes may contain a clot activator or a gel separator. They are drawn after coagulation tubes to avoid interference with coagulation studies.



## Heparin Tubes (Green)

These tubes contain heparin, an anticoagulant. They are drawn after serum tubes to avoid contamination of other additives.



## EDTA Tubes (Lavender)

These tubes contain EDTA, an anticoagulant used for hematology tests. They are drawn after heparin tubes to prevent carryover that could affect other tests.



## Glycolytic Inhibitor Tubes (Gray)

These tubes contain additives like sodium fluoride and potassium oxalate, which inhibit glycolysis (breakdown of glucose). They are drawn last to minimize interference with other tests.

# Important Considerations for Order of Draw

## **Sterility**

Blood cultures must be drawn first to maintain sterility and prevent contamination.

## **Additive Interference**

The order is designed to minimize the potential for additives from one tube to contaminate another, which could affect test results.

## **Tubes with Additives**

Gently invert tubes with additives after collection to ensure proper mixing.

## **Facility-Specific Practices**

Some facilities may have specific variations to this order based on their internal studies and protocols.

## **Discard Tubes**

If a discard tube (usually a red top) is needed, it is drawn before the light blue (coagulation) tube to prevent contamination with tissue thromboplastins.

# Indications for Phlebotomy

The indications for phlebotomy can be numerous. For simplicity and effective organization, this review will distinguish the clinical scenarios into diagnostic and therapeutic.

## Diagnostic

There are endless medical conditions that can be diagnosed based on results from a blood draw. Listed are a few ways to acquire information from analyzing blood.

### Laboratory values:

Bilirubin, which is a breakdown product of red blood cells, circulates in the bloodstream in two forms - conjugated and unconjugated. A blood sample from a heel poke hours after birth or after a high degree of clinical suspicion will reveal bilirubin levels to determine an appropriate course of action for treatment. Blood draws can also be extremely useful for establishing a differential when anemia is suspected. This is because of the various laboratory values it can provide. Values such as mean corpuscular volume, lactate dehydrogenase, reticulocyte count, and haptoglobin levels are a few of many that can help distinguish a variety of types of anemias for a seemingly similar clinical presentation. Furthermore, blood testing can be critical for diagnosing pathologies of the heart, such as myocardial infarction. Cardiac enzymes can be released into the bloodstream signifying damage to the heart. Appropriate analysis can result in swift clinical action and improved clinical outcomes.

### Peripheral blood smear (PBS):

Peripheral blood smears are essential in the diagnosis of anemia. By analyzing a thin layer of blood under a microscope, accurate analysis of RBC shape, color, size, and other morphologies can help establish a differential for the various causes of why a patient can be anemic. Evidence suggests that a peripheral blood smear analysis can be more accurate in diagnosing sickle cell disease than other methods. A peripheral blood smear can also aid in the diagnosis of disordered affecting platelet quantity and morphology. Additionally, leukocytosis is prevalent in peripheral blood smear analysis requiring further workup to determine if the finding is incidental or results from a malignant cause such as leukemia.

## Therapeutic

Therapeutic phlebotomy is the practice of bloodletting passed down through generations. It is beneficial for certain conditions where removing red blood cells or serum iron improves clinical outcomes. It is important to understand what these conditions are.

### Polycythemia Vera

Polycythemia vera is a myeloproliferative disorder resulting in the excess production of red blood cells. Symptoms of this disorder, such as plethora, splenomegaly, pruritus after showering, and redness, are due to the hyperviscosity of the blood predisposing patients to thrombosis. Diagnosis can be made through elevated red blood cell mass on blood analysis. Therapeutic phlebotomy is the primary treatment of choice for Polycythemia Vera and results in improved symptoms and clinical outcomes by reducing the overall quantity of blood. It is important to note that certain pathologies can increase blood-red cell mass; these are deemed as secondary polycythemia, and phlebotomy may not be an appropriate treatment for these conditions.

### Hemochromatosis

Hemochromatosis refers to a condition of iron overload. The human body does not have the ability to get rid of iron in any amount of significance. In this condition, there is an irregular absorption of iron due to gene mutations resulting in excessive buildup. Excessive iron buildup can lead to multiple organ failures, including the heart, pancreas, and liver. Therapeutic phlebotomy is the treatment of choice. Removing blood is the most effective way of reducing iron levels in the body. Patients afflicted with this condition necessitate regular periodic phlebotomy treatments to keep iron levels in a healthy range.

### Porphyria

Porphyria encompasses a list of conditions that involve the disruption of heme synthesis. Hemoglobin can be broken down into heme, the iron carrying component, and globin chains. Heme is a porphyrin ring that holds an iron ion. Each type of porphyria is associated with a specific enzyme deficiency in the heme synthesis pathway. While the list of conditions has varying symptoms, it is thought that the production of certain enzymes in the heme synthesis pathway is inhibited by the body's own iron. Thus, research shows that phlebotomy is an excellent treatment option by reducing iron stores.

Various other conditions have been linked with phlebotomy as an appropriate treatment option. These include Hemoglobin SC disease due to the reduction in blood viscosity and sickle cell disease resulting in a potential decrease in the frequency of vaso-occlusive crisis events. These conditions require additional research and trials before being accepted as appropriate treatments, but initial trials show potential for improved clinical outcomes.

# Contraindications

Some contraindications to drawing blood can be specific to the location of the blood draw or the overall condition itself. Studies suggest that phlebotomy can be an inappropriate treatment for non-hereditary mutation association etiologies of hyperferritinemia leading to complications such as iron deficiency anemia and fatigue.

## Site-Specific Contraindications

- Previously attempted sites with residual scar tissue
- Presence of cellulitis or an abscess
- Presence of a vascular graft
- Hematoma
- Venous fibrosis on palpation

## Patient-Specific Contraindications

- History of ipsilateral radical mastectomy
- Presence of venous access devices (ports, central catheters, IV catheters)
- Non-hereditary hyperferritinemia

A thorough investigation of the patient's medical history will be necessary to minimize complications from a blood draw.

# Equipment

The basic tools required for a successful and safe blood draw include a tourniquet, an appropriate needle, gloves, alcohol wipes, and the storage device for blood collection. The tourniquet creates temporary pressure and an artificial occlusion in the blood flow, making it easier for the phlebotomist to identify the veins. Studies also show that the veins dilate and increase the surface area immediately after a tightly-placed tourniquet, making it more suitable for a blood draw. Gloves and alcohol wipes are necessary for sterility.

Equipment and materials should be available in sufficient quantities and appropriate for their intended use for venous blood collection. Collectively, the following equipment should be prepared in a collection tray in an organized manner:



1. Utility cart
2. Gloves
3. Blood collection apparatus with safety measures, including needles and holders, or needles with integrated holders
4. Blood collection tubes (a complete series of unexpired tubes of various volumes)
5. Tourniquet
6. Antiseptics
7. Dressings and gauze pads
8. Waste bin
9. Stirrer for tubes
10. Waterproof transport bags

# Personnel

Phlebotomy can be performed by a physician, a nurse, a lab technician, or a certified phlebotomist.



## Physician

Medical doctors may perform phlebotomy, especially in complex cases or when immediate analysis is needed.



## Nurse

Nurses routinely perform phlebotomy as part of patient care in hospitals and clinics.



## Lab Technician

Laboratory staff trained in blood collection procedures for diagnostic testing.



## Certified Phlebotomist

Specialists specifically trained and certified in blood collection techniques.

# Preparation - Patient Communication

Following steps should be taken precisely before start venipuncture for either the purpose of blood sampling or therapeutic phlebotomy. The appropriate and convenient mode of communication with the patients should not be underestimated, as transparent communication to describe the details for the patient explicitly is considered the key step to a successful encounter with them during the phlebotomy procedure. During the course of the procedure, empathic communication would guarantee the success of the proposed sampling and or therapeutic phlebotomy along with the patients' satisfaction.

## Introduction

The provider who is willing to obtain the blood collection should introduce him or herself to the patient by providing the first name and a brief explanation of their role in patient care.

## Identification & Purpose

Patients' identification and the purpose of the procedure, whether to collect blood samples for diagnostic measures, what specific tests to assess with the sample, or for therapeutic reasons, and the exact amount of blood to be collected should be double-checked. Accordingly, the obtained information should be shared with the patient to raise comfort and develop a competent professional atmosphere.

## Informed Consent

Following the comprehensive explanation and discussion, informed consent without any patient resistance should be obtained. The informed consent should be definitely obtained when the proper procedure-related information by the patient has been acknowledged and all the potential inquiries, including the time to return the results, are fully responded to.

# Preparation - Patient Assessment

## Special Considerations

The patient should also be asked about the convenient collection sites to be prioritized. Specific attention should be paid to identify the patients who are afraid of blood testing or have a positive history of vasovagal attack during prior similar procedures, to be prepared with all means to take action for a mishap of a vagal syncope provocatively. Simple steps like counting down might significantly decrease anxiety and optimize the condition for proceeding with the venipuncture. In case of severe history of panic attacks during the procedure, the patient might be asked to lie down. Special attention should be paid to the patients' position during the procedure. Statistically significant differences with changing patients' positioning due to several biochemistry parameters have been reported. Therefore position maintenance, whether is lying down or sitting, within at least 10 to 15 minutes of the procedure is recommended.

## Position Maintenance

The importance of position maintenance in the phlebotomy procedure should not be underestimated. The patients who are planned to undergo the procedure in an office-based setting should be advised to stay in a sitting position for at least 15 minutes before initiating the procedure. In case of inevitable change in the position, it should be well recorded to interpret the test results accordingly. All admitted hospital patients planned for phlebotomy should be identified with a ubiquitous identification measure, including ID bracelets. The patients' name and date of birth should be asked and recorded. Several consensuses have been made to identify patients in an active optimized manner. Patients' first and last name, date of birth, plus an extra general information identifier, including patients' social security number and or address, are well accepted. However, additional supplementary data might significantly decrease the risk of preventable errors.

# Preparation - Sample Identification

Before the blood is withdrawn, the patients' identification data and the tube labeling should be double-checked. In terms of any discrepancy among the mentioned data, any blood sampling should be deferred till the issue is resolved. The process of both tube identification and tube labeling should be undertaken in the presence of the subjected patient to minimize the risk of tube misidentification. According to each center's own policy, several relevant patient's identification data might be mentioned on the records, including the identification data of the provider who has requested the blood testing, patient's first, middle, and last name, date of birth, complete address, the blood sample's discrete identification characteristics, and specific time and date of the collection, and the details of the sampler's identification data.

Once the identification data has been verified, the fasting status and appropriate patients' preparation for the requested parameters should be double-checked. patients' specific factors with well-documented impact on the blood sampling results should be asked and recorded, including any distinct diet, medications, nutritional supplements, and herbal preparations.

# Preparation - Fasting Guidelines

## Standard Fasting

According to the recent guidelines, morning blood sampling on a fasting condition, which should not be less than 12 hours following the last solid meal, is recommended.

## Therapeutic Drug Monitoring

In cases of blood sampling for therapeutic drug monitoring (TDM) purposes, according to the specific reasoning for the procedure, whether for dosage justification, monitoring adverse effects, or excluding drug intoxication, the timing for phlebotomy procedure might differ.

## Diurnal Sampling

Moreover, diurnal blood sampling might be requested to evaluate specific biochemical markers with circadian rhythm. Water use during the fasting period is acceptable. However, other drinks, including energy drinks, or coffee are not allowed on the morning of the procedure.

## Restrictions

Alcoholic drinks should not be taken within 24 hours of the procedure, and all non-emergent medications should be avoided. Non-fasting conditions are rarely acceptable for a minority of patients who can't tolerate the mentioned strict settings, emergency cases, and specific parameters that are not affected. Patients in the out-patient setting should be prohibited from excessive physical activity within 24 hours of blood collection.

# Preparation - Environment & Equipment

## Environment

Providing a clean, convenient, private, and well-designed environment, specifically in those patients who are planned for outpatient basis phlebotomy, should not be underestimated. A comfortable chair for both the patient and the provider should be prepared. The armrests of the patients' chair should be specifically adjusted to a convenient position and allowing appropriate action in case of patients' mishaps with vasovagal attacks.

Appropriate hygiene and disinfection strategies should be undertaken by washing hands with soap and other approved disinfectant solutions before proceeding with the procedure. The mentioned required pieces of equipment should be provided in a prepared tray in an organized and clean manner.

## Equipment Compatibility

To respect absolute compatibility, a set of needles, tube holder, and blood tub from a similar manufacturer should be selected. Moreover, special attention to optimizing the results of the collected sample should be paid to avoid any incompatibility of storing tubes, as the total amount of the aspirated volume, stability of the gel, and other additives might be affected. Finally, environmental factors, including the room temperature and humidity, as well as the possibility of light exposure, should be controlled to minimize the hazardous environmental effects. The instrumental expiration dates should be updated as even minimal deviations might cause a great impact on the final results. For instance, the expired vacuum blood collection tubes have a decreased capability of blood aspiration, and the additives within the expired tubes might be degraded.

# Preparation - Infection Control

Despite the unclear effect of the role of personal protective equipment on the outcomes of blood sampling according to the latest Cochrane reviews, proceeding with the procedure with a new, unused pair of gloves and careful hand wash protocol both before and after the procedure for each patient is still recommended. In the occurrence of needle sticks, the gloves might potentially decrease the amount of transmitted blood and act as a simple, available measure to limit the rate of blood-borne transmitted infections. On the other hand, respecting the hand wash protocols and wearing gloves might lower the risk of patients' cross-contamination. Wearing sterile gloves is mandatory while planning for obtaining blood cultures.

To prevent a prolonged tourniquet application, wearing gloves before tourniquet application might be recommended. The needle, tube holder, and in case of utilizing blood collection systems, a blood collection tube should be prepared. Still, controversies exist to apply tourniquets for blood sampling, and avoiding tourniquets, especially in patients with prominent veins, is recommended. Otherwise, a preferably disposable tourniquet to avoid the risk of contamination with *methicillin-resistant Staphylococcus aureus* (MRSA) for both patients and providers should be applied on almost 3 inches above the targeted venipuncture loci, and the tightness should be managed to halt the venous flow while maintaining the arterial blood flow.

Recommendations include utilizing venous illumination devices instead of a prolonged tourniquet application to visualize the non-prominent veins, especially if the need for equal or more than two tubes to be collected exists. The so-called devices have the advantage of preventing venous stasis with prolonged tourniquet application, which might negatively impact the results of several parameters, including biochemistry and coagulation factors.

# Technique

## Prepare the Site

The hand not used for the blood draw will make the skin above the vein taut. To do this, use the thumb to pull the skin down and slightly away from the draw site.

## Insert the Needle

Using the other hand, slowly insert the needle at an angle between 15 and 30 degrees from the surface of the arm.

## Collect the Sample

Once the needle is inserted into the lumen of the vein, attach the storage tube to the needle and collect blood accordingly. It is important to prevent a deep insertion of the needle beyond the lumen of the vein. This will cause the formation of a hematoma which is the pooling of the blood under the skin.

## Remove Tourniquet

When the last tube is filling blood, remove the tourniquet. The tourniquet should be removed within 1 minute of placement. Prolonged constriction of veins with the tourniquet can result in hemoconcentration, which is falsely elevated lab results.

## Apply Pressure

Once the blood draw is done, use a clean gauze to apply pressure over the area as the needle is swiftly removed. Continue applying pressure to the gauze and tape it to the location of the draw to serve as continuous pressure to prevent the formation of a hematoma. Alternatively, a bandaid can be applied over the gauze.

# Complications

Complications have become far less likely since the early practice of bloodletting centuries ago. Certain issues, such as increased pain and potential nerve injury, may arise due to improper technique. Other studies have found that patient identification and improper tube labeling are the most likely errors. The formation of a hematoma can also occur if adequate pressure is not applied during and after needle draw. These complications can almost entirely be avoided with the proper technique and equipment.

## Technical Complications

- Pain due to improper technique
- Nerve injury
- Hematoma formation
- Arterial puncture

## Procedural Errors

- Patient misidentification
- Improper tube labeling
- Incorrect order of draw
- Insufficient sample volume

## Patient Reactions

- Vasovagal syncope
- Anxiety reactions
- Allergic reactions to equipment



# Clinical Significance

The practice of phlebotomy is intertwined with medicine and providing care for patients. From diagnosing various conditions, checking electrolytes levels repeatedly for tweaking management protocols, to treating patients afflicted with certain conditions, phlebotomy has an important role in improving clinical outcomes and serving as the bridge between the laboratory and the patient.

# Enhancing Healthcare Team Outcomes

Phlebotomy is a procedure that is often performed in clinical care settings. However ubiquitous the procedure may be, proper planning and execution are critical in drawing blood from the patient for its intended purpose. Whether it is for diagnosis or therapy, health care providers must work together to enhance patient outcomes.

## Physicians

Health care providers must be knowledgeable about the patient's medical history and any preexisting conditions.

## Lab Technicians

Health care providers should also be aware of the potential complications phlebotomy can present with and only perform when necessary. The entire healthcare team of nurses, physicians, lab technicians, and phlebotomists are equally responsible for complete sterility throughout the procedure.



## Nurses

Any healthcare provider speaking with the patient, whether the nurse or the physician, should inform the patient of a blood draw occurring, explain its reasons, and answer any questions they may have to ease the patient into an often uncomfortable and frightening experience.

## Pharmacists

Pharmacists should be consulted if the patient is on any blood thinners or other medications that might cause unwanted complications.

## Phlebotomists

For complex cases with difficult access points to veins, a certified phlebotomist should be consulted.