Venous blood sampling: upper extremity phlebotomy, femoral vein phlebotomy

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1. **Scope of the chapter**

This chapter shows the methods of venous blood sampling. It details the method of the vein puncture site selection and the steps of phlebotomy.

2. **Definitions**

- **Vacutainer**: Vacuum-containing blood collection tubes, which are widely used for venous blood sampling all over the world. The color of the cup depends on the type of anticoagulant.
- **Anticoagulant**: Substance that prevents clotting of blood. For laboratory use heparin, citrate, EDTA are the most frequently applied.
- **Phlebotomy**: Process of making an incision in a vein with a needle. The blood drawn from the patient is used for clinical or medical testing, transfusion, donation or research.

3. **Introduction**

Phlebotomy is one of the most frequently performed procedure in both inpatient and outpatient settings. The arm is the best site from which for drawing venous blood. The upper is the best site containing easily identifiable and accessible superficial veins, especially in the antecubital fossa, and allows the patient to control excessive bleeding at the site of venipuncture by application of local pressure.

**Indications**
1. To obtain venous blood samples for laboratory testing and blood culture.
2. To remove blood in the treatment of iron-overload or volume-overload conditions.

**Contraindications**
1. Cellulitis, phlebitis, or venous obstruction at the proposed site of veinnipuncture, or lymphangitis of the arm.
2. Phlebotomy should not be performed if an intravenous line is positioned in the same arm or if a vascular access procedure (eg, arteriovenous shunt for hemodialysis) has been performed or is anticipated in the near future on the given arm.

**Vacutainer system**

Nowadays for blood sampling vacuum-containing tubes are used all over the world, these are the Vacutainer-tubes. The tubes may contain anticoagulant. The anticoagulant can be easily identified by the color of their caps. Different color codes the tubes without anticoagulant. Table 1 shows the properties of blood collecting tubes. The figure 1 shows the blood collecting tubes and the blood collection system (needle, needle holder, rubber cuff to stop blood flow).
<table>
<thead>
<tr>
<th>Blood test</th>
<th>Color of the cup of Vacutainer tube</th>
<th>reagent</th>
<th>Volume needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>complete blood count, ESR</td>
<td>lavender</td>
<td>K-EDTA</td>
<td>5 ml, children: 2 ml</td>
</tr>
<tr>
<td>blood coagulation tests</td>
<td>light blue</td>
<td>buffered citrate</td>
<td>4.5 ml, children: 1.8 ml</td>
</tr>
<tr>
<td>elektrolytes, liver enzymes, kidney function, lipids</td>
<td>red or yellow</td>
<td>no anticoagulant</td>
<td>5 ml</td>
</tr>
<tr>
<td>glucose</td>
<td>gray</td>
<td>sodium fluoride</td>
<td>7 ml</td>
</tr>
<tr>
<td>white blood cell</td>
<td>green</td>
<td>sodium heparin</td>
<td>5 ml</td>
</tr>
<tr>
<td>trace elements</td>
<td>dark blue</td>
<td>heparin or no anticoag. no trace metals</td>
<td>7 ml</td>
</tr>
</tbody>
</table>

Table 1: Vacutainer tubes commonly used for blood sampling

I. Upper extremity phlebotomy

Equipment needed:
1. Tourniquet
2. Materials for skin disinfection
4. gloves
3. syringe or Vacutainer
4. Needle for the syringe, 20 gauge, a Vacutainer needle with an automatic valve or rubber cuff, or a butterfly needle apparatus for small veins. If a large amount of blood is to be drawn, use an 18 gauge needle; this is more comfortable for the patient. Avoid using needles smaller than 22 gauge, since the risk of hemolysis increases with decreasing needle diameter.
5. Specimen tubes or Vacutainer tubes with appropriate anticoagulants
6. gauze pads
7. self-adhesive bandage
8. labels to identify the patient
9. For therapeutic phlebotomy: 14-18 Gauge intravenous catheter, intravenous tubing, one liter vacuum bottle
10. Containers for used needles and hazardous waste

Personell requirements:
One person with appropriate experience can perform a routine phlebotomy without assistance.
Figure 1. Vacutainer blood sampling system (A) Vacutainer tubes (B) passive shielding blood collection needle (C) Blood collection needle and holder. When Vacutainer tubes are pushed into the holder, the needle’s safety shield releases automatically and the vacuum sucks blood into the tube. (D) Blood sampling with Vacutainer system.

The patient should be positioned comfortably, with the upper extremity resting on a table or bed. If the patient is in bed, the supine position is preferred, with the arm resting on the mattress. If the patient is ambulatory, the sitting position is best. Although the superficial venous anatomy of the antecubital area varies, the basilic vein, the median cubital vein, and the cephalic vein are usually detectable. Smaller, yet still accessible veins are located in the distal forearm (particularly the cephalic vein, the so-called "intern's vein," as it crosses the wrist) and in the dorsal hand (see Figure 2). The most easily palpable vein, which need not be the most visible vein, should be selected.

Method (Figure 3):
1. Apply the tourniquet above the antecubital fossa in such a manner that it may be quickly removed with one hand. The tourniquet should be snug but not so tight that it causes discomfort, and it should not be left in place for so long that the patient's arm becomes cyanotic.
2. Have the patient open and close his or her fist to help pumping blood from the muscle compartments of the arm into the superficial venous circulation.
3. Select a suitable vein by palpating the antecubital fossa with the lip of the index finger, feeling for the buoyant resilience of a distended vein. Use one of the three large antecubital veins, the cephalic, basilic, or the median cubital, otherwise, examine the forearm on both sides. If no suitable vein is found on the forearm, use one of the superficial veins on the dorsal surface of the hand. These veins, which are small and collapse easily, are often inadequate for drawing large amounts of blood, however. Do not puncture the patient's arm without feeling the vein underneath.
4. Palpate the identified vein along its length to determine the existence of any large branches and to discover how well the vein is anchored in the subcutaneous tissue. The integrity of subcutaneous tissue in older people is diminished; their veins often roll away from the needle, making venipuncture difficult.
5. Cleanse the skin around the planned injection site.
6. Hold the syringe or Vacutainer in the dominant hand while palpating the vein with the index finger of the non-dominant hand. Apply traction to the skin below the proposed site and, making sure the bevel of the needle is up, align the needle with the course of the vein. Puncture the skin at an angle of about 15-30 degrees with a quick motion. Then carefully advance the needle into the lumen of the vein.
   a. If using a syringe, blood will flow back into the needle when a small amount of negative pressure is applied to the syringe.
   b. If using a Vacutainer system, it will be necessary to press the first vacuum tube onto the needle to look for inflow of blood into the Vacutainer.
   c. If using a butterfly catheter, blood will flash back into the needle when a small amount of negative pressure is applied to the syringe. Gently hold the needle with the non-dominant hand while aspirating with the syringe in the dominant hand.
7. If venous blood is not obtained on the first attempt, leave the needle in place and reassess the course of the vein. Withdraw the needle to just below the skin and attempt venipuncture again.

8. Withdraw the required amount of blood. If too much negative pressure is applied, or if the vein is too small, the vein will collapse and the wall will occlude the needle. If this occurs, stop withdrawing blood, allow the vein to fill, and gently begin again.

9. For therapeutic phlebotomy that involves the drawing of large blood samples, it is necessary to locate a large vein and place either a 14-18-gauge intravenous catheter or a large needle of similar size into the lumen. When the vein has been cannulated, the catheter or needle should be taped in place and the venous blood drained into a one-liter vacuum bottle (Figure 4).

10. After the required amount of blood is withdrawn, stabilize the needle with one hand and release the tourniquet with the other.

11. Remove the needle quickly and smoothly, without putting any torque on it.

12. Have the patient apply direct pressure on a piece of gauze pad over the site for 3-5 minutes. If need, apply a self-adhesive bandage onto the gauze pad.

13. Label the tubes with the patient's name, date of birth, or insurance number and send them into the laboratory.

14. Throw out the needle into a special container and syringe into container for hazardous waste.
Possible complications: hematoma, phlebitis

**II. Femoral vein phlebotomy**

This procedure should be performed only when it is impossible to obtain blood samples from the arm. It has more potential risks than upper extremity phlebotomy and it is also more uncomfortable for the patient.

**Indications:**
1. If suitable veins for an upper extremity phlebotomy can not be found. Patients who have cellulitis, phlebitis, or lymphatic or venous obstruction in both arms are candidates for femoral vein phlebotomy.
2. Emergency situation in which drawing blood from the arm is impractical or impossible (eg, cardiac arrest or traumatic resuscitation).
3. Obtain a venous blood sample from a patient whose arms have been or will be used for other vascular access procedures (eg, arteriovenous shunt for hemodialysis) in the near future.

**Contraindications:**
1. Femoral vascular prosthesis or cellulitis over the venipuncture site.
2. In patients who get anticoagulant therapy or have bleeding disorders.
3. In patients with an intravenous line in the same leg or venous occlusion or lymphangitis of this leg.

**Equipment needed:**
1. materials for skin disinfection
2. latex gloves
3. gauze pads
4. syringe or Vacutainer tubes
5. needle
6. self-adhesive bandage
7. Containers for used needles and hazardous waste

**Personnel required:**
One person can perform femoral vein phlebotomy without assistance. However, an assistant can help stabilize the patient's leg.
Location of femoral vein: The relative location of vascular structures and nerves of the groin from lateral to medial may be recalled easily by the mnemonic NAVEL (Nerve, Artery, Vein, Empty space, Lymphatic). The femoral vein is medial to the femoral artery. In a patient with normal arterial pressure, the femoral artery can be easily located by palpating the femoral pulse in the groin. In a patient with cardiac arrest or a low mean arterial pressure, however, the pulse may be absent. In this case, the approximate position of the femoral vein can be determined by dividing the distance between the anterior superior iliac spine and the pubic tubercle into three equal segments. The femoral artery usually lies at the point where border of the inner and segment joins the middle segment. The femoral vein usually lies 1.5 cm medial to the artery.

Figure 5 Anatomy of the inguinal region

Procedure:
1. Location of the femoral vein by palpating the femoral arterial pulse.
2. Skin disinfection: Be careful not to contaminate the anticipated site of venipuncture during palpation of artery.
3. Insert the needle perpendicular to the skin just medial to the femoral artery, holding the syringe in the dominant hand. Push the needle toward the femoral vein using a steady motion and pulling back slightly on the plunger of the syringe (Figure 6). If no venous blood is encountered and the needle is inserted all the way to the hub, slowly withdraw the needle while continuing to apply negative pressure; look for the flow of venous blood into the syringe.
4. Withdraw the sample if venous blood appears. Bright red blood indicates probable entry into the femoral artery. Withdraw arterial blood as described for venous blood while arterial blood is as good as venous blood for most laboratory measurements.
5. Remove the needle quickly after the blood sample has been withdrawn and apply direct pressure over the site with a 4 x 4 inch gauze pad 5 minutes long, if the patient has bleeding disorder, or after arterial punctureion, 10 minutes of direct pressure on the venipuncture site is mandatory.
6. Throw out the needle into a special container and syringe into container for hazardous waste.
7. Check the groin after 15 minutes to make sure that no hematoma is forming at the site of the phlebotomy.
Figure 6 Aspiration of blood from femoral vein.

Complications:
1. Arterial puncture, laceration, or both, may occur.
2. Femoral nerve irritation is most common in patients whose femoral arteries are difficult to find.
3. Hematoma formation is relatively uncommon in venous puncture.
4. Arteriovenous fistulae may form following repeated femoral phlebotomies on the same side.

4. Self-control questions

What are the indications of upper extremity phlebotomy?
Answer: obtain venous blood for laboratory testing and blood culture or blood removal in iron-overload or volume overload

What are the contraindications of upper extremity phlebotomy?
Answer: 1. Cellulitis, phlebitis, or venous obstruction at the proposed site of venipuncture, or lymphangitis of the arm.
2. Phlebotomy should not be performed if an intravenous line is positioned in the same arm or if a vascular access procedure (eg, arteriovenous shunt for hemodialysis) has been performed or is anticipated in the near future on the given arm.

What are the contraindications of femoral vein phlebotomy?
1. Femoral vascular prosthesis or cellulitis over the venipuncture site. Femoralis érprotézis vagy cellulitis a punctio helyén
2. intravenous line, venous occlusion or lymphangitis in the same leg Ugyanazon végtagon
3. anticoagulant therapy, bleeding disorders.Antikoaguláns kezelés, vérzékenység

What are the equipment needed for upper extremity phlebotomy?
1. Tourniquet
2. Materials for skin disinfection
4. gloves
3. syringe or Vacutainer
4. Needle for the syringe, 20 gauge, a Vacutainer needle with an automatic valve or rubber cuff, or a butterfly needle apparatus for small veins. If a large amount of blood is to be drawn,
use an 18 gauge needle; this is more comfortable for the patient. Avoid using needles smaller than 22 gauge, since the risk of hemolysis increases with decreasing needle diameter.

5. Specimen tubes or Vacutainer tubes with appropriate anticoagulants
6. gauze pads
7. self-adhesive bandage
8. labels to identify the patient

What color are the most often used Vacutainer tubes? Which anticoagulant contains these tubes?
lavender – K-EDTA
red, yellow – no anticoagulant
light blue – citrate buffer
green – sodium heparin
5. Case reports

1. A 40 years old female patients comes for blood test. In the cubital area and on the distal part of forearm can be found well-palpable veins.
Which vein should be used for phlebotomy? Why?
Answer: The vein in the cubital area should be used for blood sampling, because it is less painful.

2. A 72 years old patient with breast cancer is treated with pneumonia. On the left hand she has lymphedema, she get infusion through peripheral vein catheter into the right arm. We need some blood for laboratory test.
Which vein should be used for phlebotomy?
Answer: If the patient do not get infusion through peripheral vein catheter, the phlebotomy may be carried out on the right arm (not from the vein catheter!).

3. A 76 years old patient was admitted to Intensive Care Unit after resustitation with poor peripheral circulation. Which vein should be used for phlebotomy?
Answer: The femoral vein, because the circulation of upper extremity is poor.

4. In 58 years old patient arteriovenous shunt has been performed on the left arm because of end stage renal failure. On the right distal forearm, she has phlebitis in the place of a former peripheral vein catheter. Where should be done the phlebotomy for blood test?
Answer: On the veins of the left cubital area or on the veins of the dorsal hand.

5. At a 55 years old anemic-looking man we want to draw blood for determination of Hemoglobin level. What color Vacutainer tube should be used for blood sampling?
Answer: lavender
Which anticoagulant contains the Vacutainer tube?
Answer: K-EDTA

6. Literature:


BD Vacutainer Venous Blood Collection Tube Guide
www.bd.com/vacutainer/pdfs/plus_plastic_tubes_wallchart_tubeguide_VS5229.pdf

7. Requirements venous blood sampling practice

The instructor’s role
- The practice is designed for students to perform the injection techniques several times in their own hands.
The instructor should expect from students the theoretical knowledge for practice. The practice does not serve the transfer of theoretical knowledge.

Specific tasks
- Description of equipment need for venous blood sampling
- Description of personnel requirements for venous blood sampling
- Demonstration of the methods of venous blood sampling (upper extremity, femoral vein).
- Supervision of the blood sampling carried out by students and correction of failures.
- Reviewing the video recording made of the practice with students, and the analysis of each case.

The student’s role
- The student should prepare for the practice according to the best of his knowledge.
- The practice serves testing and exercise of blood sampling on phantom device.

Specific tasks:
- Carry out upper extremity phlebotomy several times on phantom device
- Carry out the femoral vein phlebotomy several times on phantom device
- Reviewing the video recording made of the practice with the instructor, analysis of each case.
- It is recommended to carry out all the techniques several times to acquire necessary experience.
8. Test questions

Simple choice
1. Which one is not the contraindication of venous blood sampling?
   A. cellulitis on the given arm
   B. vascular access procedure is anticipated on the same side
   C. Raynaud phenomenon on the given arm
   D. deep vein thrombosis on the same extremity

2. The next equipment are need for phlebotomy, except:
   A. tourniquet
   B. materials for skin disinfection
   C. lidocain
   D. needle
   E. syringe or Vacutainer tube

3. What angle should be held the needle during phlebotomy at?
   A. 5-10°
   B. 15-30°
   C. 40-50°
   D. 60-70°
   E. 90°

4. Which Vacutainer tube need for different tests?
   A. coagulation  1. green cup
   B. glucose        2. red cup
   C. liver enzyme  3. grey cup
   D. white blood cell markers 4. lavender cup
   E. cell blood count (CBC)  5. light blue cup

A5, B3, C2, D1, E4

True or false
5. I H For blood sampling the patient need to be in supine position.
6. I H The most easily visible vein should be selected for phlebotomy
7. I H The most often indication of phlebotomy is the access of blood for laboratory examinations.
8. I H If too much negative pressure is applied during phlebotomy, the vein will collapse and the wall of the vein will occlude the needle.

Multiple choice
9. Which are the most suitable veins for phlebotomy?
   A. median cubital vein
   B. external jugular vein
   C. veins of the forearm
   D. femoral vein

10. What are the indications of phlebotomy?
A. Access of blood for blood culture
B. Blood sampling for arterial blood gas analysis
C. Blood removal in iron-overload
D. Measurement of O₂ saturation

Relation analysis
11. Femoral vein phlebotomy should be done if the blood sampling from upper extremity is impossible, because the complications occur more often than in case of upper extremity phlebotomy. (A)
12. If during phlebotomy the venous blood is not obtained on the first attempt, withdraw the needle suddenly, because there is high chance for arterial puncture. (E)
13. After the phlebotomy the place of piercing should be pushed for 3-5 minutes, because there is high risk for life-threatening bleeding. (C)
14. In case of bleeding disorder the femoral vein phlebotomy is contraindicated, because the femoral vein is medial to femoral artery. (B)
15. If during femoral vein puncture arteriotomy occurs, the blood should withdraw from the artery, because in case of arteriotomy there is high risk for embolization. (C)
9. Sources:

BD Vacutainer Venous Blood Collection Tube Guide
www.bd.com/vacutainer/pdfs/plus_plastic_tubes_wallchart_tubeguide_VS5229.pdf
BD Vacutainer Venous Collection Products
www.bd.com/vacutainer/products/venous