Peripheral venous access: percutaneous techniques, peripheral venous access using catheter over needle technique, butterfly needle, external jugular vein catheterization

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1. Scope of the chapter
The chapter shows the methods of venous access. There are described the indications and contraindications of each method, the technics and rules of implementation.

2. Definitions

Butterfly: Thin needle with plastic wings for short time peripheral venous access or catheterization of veins with small diameter.
Thrombophlebitis: Painful inflammation in place of peripheral venous catheters, which indicates the removal of venous catheter.
Peripheral vein catheter: Plastic catheter for several days long peripheral venous access.
Extravasation: The fluid exit through the wall of the vein into the tissues.
Peripheral vein: Veins situated in the subcutaneous layer of the extremities, on the neck or head, which are visible after placing of Tourniquet onto the extremities or by positioning of neck and head.
Central vein: Veins with large diameter close to the heart, which can be cannulated by large diameter venous catheters. These catheters allow rapid fluid replacement, monitoring of central venous pressure and other hemodynamic parameters. Most important central veins are the internal jugular vein, the subclavial vein and the femoral vein.

3. Introduction

Percutaneous technics of venous access include the introduction of needle into peripheral and central veins through the skin and subcutaneous layer. Some procedures indicate venous access for several days. In these cases plastic vein catheters are used instead of needle. The plastic catheters are safer, more tolerable for patients, and usable for longer time than the needles. For venous access two types of technique are used: “catheter over needle” and “catheter through needle” (Figure 1).
The most common method of venous access is the peripheral vein catheterization except special situations (hemodialysis, resuscitation). The “catheter over needle” technique is the more common used method for peripheral venous access. For insertion of peripheral vein catheters, the veins of forearm and the dorsal hand are the best because of the easy accessibility, the ease of maintenance and the low risk of phlebitis.
Special situation is the emergency venous access: In these situations, patients with circulatory shock need venous access enabling appropriate fluid replacement in really short time. It has importance in prehospital and emergency medicine and in practice of disaster medicine. Peripheral veins cannot be cannulated easy in these situations, because of instable circulation, therefore alternative venous access need. In the last years, the intraosseous access is a widely accepted method for alternative venous access. A special needle is inserted into a bone close to the skin manually or by driver.

The maximum speed of infusion through peripheral vein catheters depends on the diameter of the catheter, which parameter is color-coded. Figure 1 shows the available venous catheters, the diameters and the maximum speed of infusion. If the appropriate fluid replacement is not available through the applied peripheral venous catheter, for a second venous access should be provided. It may be time-consuming and may influence the success of medical care.

<table>
<thead>
<tr>
<th>Color</th>
<th>Gauge</th>
<th>Infusion speed (ml/min)</th>
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<tbody>
<tr>
<td>yellow</td>
<td>24G</td>
<td>13</td>
</tr>
<tr>
<td>light blue</td>
<td>22G</td>
<td>30</td>
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<tr>
<td>pink</td>
<td>20G</td>
<td>55</td>
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<tr>
<td>green</td>
<td>18G</td>
<td>80-100</td>
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<td>white</td>
<td>17G</td>
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<tr>
<td>grey</td>
<td>16G</td>
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<tr>
<td>orange or braun</td>
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Figure 1 Peripheral vein catheters with different size, and the appropriate infusion speed.

In emergency situations, where other possibilities of peripheral venous access are not available, the cannulation of external jugular vein is widely accepted. The external jugular vein is an easy accessible peripheral vein on the neck, it allows the insertion of venous catheters with larger diameter. In situations when peripheral veins are not available, but the venous access is urgent, intraosseous access is increasingly used.

I. Catheter over needle technics

Indications: intravenous administration of fluids, medication, or both.

Contraindications:
1. Phlebitis, lymphedema or pitting edema of the extremity.
2. Cellulitis over the projected site of insertion.
3. Previous mastectomy or other axillary surgery, in which ipsilateral venous drainage may be impaired.
5. Hyperosmolar fluids and agents known to cause chemical phlebitis or sclerosis of peripheral veins should not be administered through such veins

Equipment needed:
1. Tourniquet.
2. Materials for skin disinfection.
3. Tape to secure the intravenous line once it is in place.
4. Catheter-over-needle unit with sufficient diameter for the rate and type of fluid to be infused. For intravenous fluids to be infused at a low rate, a 20 gauge catheter usually will suffice. For a blood transfusion or intravenous fluid therapy at a high flow rate, an 18 gauge catheter is mandatory and a 16-gauge is preferred. In the case of trauma, when very large volumes of fluid are required, a 14-gauge catheter is ideal.
5. Bottle or bag of intravenous fluid or blood products with proper tubing and extension.
6. Gloves
7. Container for used needles and hazardous waste

Personnel requirements:
One person with appropriate experience can perform a routine phlebotomy without assistance. Positioning of the patient, and search for suitable veins: The patient should be in a comfortable supine or sitting position, upper extremity to be used should be positioned onto a solid surface. Avoid insertion of venous catheters into the veins of the antecubital area, because bending at the elbow will disturb the intravenous line. Suitable veins are found at the radial aspect of the forearm just proximal to the wrist, the volar aspect of the proximal-ulnar forearm, and the dorsal side of the hand (Figure 3).
Figure 3. Superficial venous system of the upper extremity

Procedure:
1. Assemble the proper intravenous fluid and tubing. Run fluid through the tubing to flush all air from the system. Place back the cap to the end of the tubing to avoid contamination.
2. Apply the tourniquet above the cubital area and secure it in a way that allows quick, easy removal.
3. Have the patient open and close his or her fist to help "pump" blood from the muscles into the superficial veins.
4. Select a suitable vein for catheterization. Palpation is more important than visualization in locating a vein. Gently tap over the vein; this may help distend it and make identification and catheterization easier. The junction of two veins is excellent for insertion, since here the vein is anchored and less likely to roll away from the needle.
5. Identify the course of the vein to be catheterized and make a mental picture of its course and branches. Make sure the segment chosen is long enough to accept the catheter to be used.
6. Wash hands and don gloves.
7. Cleanse the skin around the insertion site.
8. Remove the plastic stopper from the hub of the vein catheter.
9. Pull the skin distal to the vein with the non-dominant hand.
10. Grasping the catheter in the dominant hand, between thumb, index, and middle fingers, insert the needle at an angle of approximately 15-30 degrees through the skin either on top of or beside the vein (Figure 4.). Insert the needle and catheter into the vein, following the visual or palpated course of the vein. Blood will flow back into the hub when the lumen of the vein is reached.
11. Advance the needle and catheter into the vein about 4-6 mm further to ensure that both the needle and the catheter have entered the lumen of the vein.
12. Firmly anchor the hand holding the hub of the needle.
13. Slide the catheter off the needle, holding the hub of the outer needle in one hand while gently pushing the hub of the catheter forward off the needle with the other hand. Advance the catheter to its hub and remove the needle (Figure 5.). Apply pressure to the catheterized vein just proximal to the end of the catheter while pulling the needle out of the catheter. Occasionally, the catheter hit a valve or a branch of the vein, which will prevent complete advancement. In this case, remove needle holding the catheter hub in place and attach the intravenous line. Running fluid into the vein may open the valve or redirect the catheter and allow complete insertion.

![Figure 4. Insertion of the vein catheter into the lumen of the vein.](image)

14. Remove the tourniquet.
15. If flow is slow or nonexistent, slowly withdraw the catheter a few millimeters and watch for a change in the rate of flow. Occasionally, a branch vein or valve will be obstructing flow and adjusting the catheter will establish good flow. Carefully withdraw the catheter a few millimeters and recheck flow. Good flow will be established if the vein is properly cannulated. Check the insertion site for signs of extravasation of fluid before taping. If poor flow persists or fluid extravasation develops, the catheter may have slipped out of the vein or exited through the back wall of the vein. If extravasation occurs, attempt a second venipuncture proximal to the first insertion site or in another vein.
16. Secure the catheter in place with tape. (Figure 7.).
17. Throw out the needle into a special container and syringe into container for hazardous waste.
Complications: Hematoma, extravasation, chemical and suppurative phlebitis, cellulitis, and bacteremia and sepsis.
Ask the patient to alert a medical practitioner if blood appears in the intravenous tubing, if flow in the drip chamber stops, or if pain or redness develop at the insertion site.
Intravenous insertion site should be checked daily and changed every three days or at the first sign of developing thrombophlebitis.

II. Butterfly intravenous placement

Intravenous lines with a catheter-over needle unit are generally better tolerated and more durable than butterfly needles and are therefore preferable in most situations. However, advantages of butterfly intravenous lines are the easy placement and increased comfort for the patient who requires brief venous access. Butterfly intravenous line is often used when a drug is to be given with subsequent immediate removal of the line or when a patient has very few usable veins that are small and difficult to cannulate (eg, in an infant). Figure 8 shows a butterfly intravenous needle.
Figure 8. Butterfly intravenous needle.

Indications:
1. For drug or fluid administration of brief duration.
2. Other methods of peripheral venous access are impossible.

Contraindications:
1. Cellulitis over or thrombophlebitis involving the proposed vein, lymphedema, lymphangitis, or impaired venous drainage in the extremity to be used for the procedure.
2. Arteriovenous shunt is in place or if such a shunt is to be inserted in the same arm. Never use arteriovenous shunts for placement of routine intravenous lines.
3. Hyperosmolar fluids and agents known to cause chemical phlebitis or sclerosis of peripheral veins should not be administered through peripheral veins only through central veins!

Equipment needed: This method requires the same equipment as that listed for peripheral vein catheterization!

Personnel required:
One person may insert a butterfly catheter without assistance.

Anatomy review:
In adults, butterfly lines are usually placed in veins in the volar forearm or in the dorsal hand. Butterfly lines are often used when no vein is easy to palpate.

Procedure:
1. Assemble the intravenous tubing and connect to the intravenous fluid. Attach the butterfly to the tubing and run fluid through the entire system to flush all air from the tubing.
2. Disconnect the butterfly catheter and recap the extension tubing.
3. Apply the tourniquet above the cubital area and secure it in a way that allows quick, easy removal.
4. Have the patient open and close his or her fist to help "pump" blood from the muscles into the superficial veins of the forearm.
5. Select the vein to be used. Palpation is more important than visualization! Gently tap over the vein; this may help distend it and make identification and catheterization the vein easier. The junction of two veins is an excellent site for catheterization, since here the vein is anchored and less likely to roll away from the needle.
6. Identify the vein to be used and make a mental picture of its course, branches and pegging to the subcutaneous tissue. In elderly patients the subcutaneous tissues usually become loose and veins roll away from the needle, which make the vein puncture difficult. Check the segment chosen is long enough to accept the catheter to be used.

7. Wash hands and don gloves.

8. Cleanse the skin around the insertion site.

9. Pull the skin distal to the vein with the non-dominant hand.

10. Grasping the butterfly wings attached to the needle between the thumb and index finger of the dominant hand, hold the needle above and parallel to the course of the vein chosen for puncture.

11. Insert the butterfly needle into the vein at a 30 degree angle (Figure 9. panel A).

12. Carefully thread the needle up into the lumen of the vessel until the entire needle is in the vein (Figure 9. panel B).

13. Secure the catheter. A single piece of tape applied over the wings of the butterfly will secure the intravenous line yet permit continuous monitoring the insertion site and facilitate prompt recognition of extravasation. (Figure 10.)

14. Throw out the needle into a special container and syringe into container for hazardous waste.

15. Butterfly lines can be used for maximum 24 hours.

Possible complications: Hematoma, extravasation, chemical and suppurative phlebitis, cellulitis, bacteremia and sepsis.

Figure 9: Insertion of butterfly needle into the lumen of the vein (A) and threading of the needle into lumen of the vein (B).
III. External jugular vein catheterization

The external jugular vein is a superficial, easy accessible vessel in the lateral neck above the clavicle. The movement of the neck makes external jugular lines difficult to secure and inconvenient for the patient, however, there are situations, where the external jugular vein is an appropriate site for intravenous line placement.

Indications:
External jugular vein catheterization is reserved for situations where other sites of peripheral venous access are not available.
1. In case of chronic intravenous drug abuse.
2. In medical emergencies requiring immediate and reliable intravenous access.

Contraindications:
1. Difficulty securing the catheter in the neck. Movement of the patient usually makes external jugular lines short-lived.
2. Cellulitis at the insertion site.
3. A neck surgery that distorted the anatomy of the neck or involved ligation of the external jugular vein.
4. The patient cannot assume the Trendelenburg position for catheter insertion.

Equipment needed:
1. Catheter-over needle unit
2. Intravenous tubing and intravenous solution
3. Materials for skin disinfection
4. Self-adhesive bandage
5. Gloves
6. Sterile dressing preferably of the transparent variety, to allow visualization of the insertion site.
7. Containers for used needles and hazardous waste

Personnel required:
One person can successfully perform this procedure unaided. An assistant may help in positioning of the patient and in the catheter insertion, however.

Patient positioning and localization of the external jugular vein:
The patient should be placed in approximately 30 degrees of Trendelenburg position, with the face turned away from the side of insertion. The external jugular vein can be found in the subcutaneous tissue in the side of the neck superficial to the sternocleidomastoid muscle. It courses inferiorly and joins the subclavian vein under the clavicle (Figure 11, panel A). The vein in sitting position is not visible, but in lying position or during straining fills up with blood (Figure 11, panel B). In dehydrated patient, the vein is empty also in lying position, while in case of increased venous pressure it is prominent in either position.

![Figure 11. A. Anatomy of the neck: position of the external jugular vein. B. Position of the external jugular vein in lying patient.](image)

Procedure:

1. Wash hands and don gloves!
2. Clean the neck area from the clavicle to the ear using disinfectant.
3. Locate the external jugular vein by having the patient perform a Valsalva maneuver: forcibly blow against a closed glottis. During the maneuver distends the external jugular vein. Make a mental note of the position and size of the vein.
4. Inspect the catheter to make sure that it slides easily off the needle.
5. Remove the plastic stopper from the hub of the catheter.
6. Hold the needle over the skin and parallel to the course of the vein.
7. While the patient performs Valsalva maneuver again, insert the catheter into the vein (Figure 12.).
8. Attach the intravenous tubing, start fluid flow, and tape the line in place (Figure 13.).
9. Throw out the needle into a special container and syringe into container for hazardous waste.
Possible complications: Extravasation and infiltration, hematoma formation, cellulitis, phlebitis, occlusion of the external jugular vein due to clot formation, bacteremia, sepsis. Intravenous insertion site should be checked daily. The catheter must be changed in every three days or at the first sign of thrombophlebitis.

Figure 12. Insertion of venous catheter into the lumen of the external jugular vein

Figure 13. External jugular vein catheter fixed by tapes on the neck.

**IV. Intraosseous venous access**

Intraosseous venous access is a frequently used method in the emergency medicine. The intraosseous needle is injected through the bone's hard cortex and into the soft marrow interior (most often to tibia, femur, humerus), which allows immediate access to the vascular system. Bone marrow has rich vasculature, therefore high amount of infusion and drugs can be administered.

Most often the antero-medial aspect of the tibia is used for intraosseous needle insertion, the insertion site lies 2-3 cm below the tuberosity of the tibia on the inner side (Figure 14.). Other frequently used sites are the distal tibia (distal part of the tibia, 3 cm above internal ankle), the
distal part of the femur (3 cm above lateral epicondyle) and the shoulder (greater tuberosity of the humerus).

Indications:
1. This technique is mainly used for children in shock or cardiac arrest. The Current European Guideline recommends the use of intraosseous access, if the peripheral venous access is unsuccessful 3 times, or in 90 seconds.
2. In adults intraosseous access is used in emergency for patients in critical state. Application by hand is difficult, therefore automatic devices should be used for drill.

Contraindications:
1. Fracture of targeted bone or of the proximal one.
2. Infection at the insertion site (soft tissue inflammation or osteomyelitis).
3. Previous fracture or orthopedic procedures near insertion site (change of anatomy or implanted metal prosthesis).

Figure 14. The intraosseous needle is usually inserted into the proximal part of the tibia.

Equipment needed:
1. intraosseous needle: The principle is the same as the catheter over needle system used in peripheral venous access, but according to the hardness of the bone, the needle is made of stronger material. Both the catheter and the needle are made of metal, the needle can permeate the bone. There are different sizes of needles for children and adults.
2. IO Devices: The needle can be drilled by hand-powered or battery-powered devices (Figure 15). After insertion the needle should be removed, the metal catheter stays in the bone. The catheter should not be fixed, because it is tightly fixed in the bone.
3. Gloves
4. Sterile gauze pads
5. In case of alert patient, for local anesthesia 1% Lidocain solution (in 10 ml syringe with needle).
6. 10 ml syringe filled with physiological salt solution
7. three-way tap
8. filled up infusion line, positive pressure infusion set
Procedure

1. Preparing of the equipment. If the patient is alert, devices for local anesthesia should be prepared.
2. Positioning of the patient and his extremities. Lower extremities of children should be underset using a pillow or a plaid.
3. Disinfection of the insertion site and it’s environment.
4. Immobilize the chosen extremity! Staff should not hold the extremity close to the insertion site.
5. After disinfection the needle should be drilled into the bone. The needle should be removed, the metal catheter stay tightly in the bone.
6. Attach infusion tubing through a tap and aspirate the catheter. If the catheter is in right place, dense blood flows back.
7. Attach the positive pressure infusion set to the tap and let start the infusion.
8. Because of high risk of infection intraosseous catheters should be removed in 24 hours.

4. Self-control questions

1. Which are the indication of use of butterfly catheters?
   Answer: patients need short infusion, only small diameter veins are available for cannulation.

2. How should be positioned the patient for catheterization of external jugular vein?
   Answer: The patient should be placed in 30 degrees of Trendelenburg position, with the face turned away from the side of insertion.

3. What are the indications of external jugular vein catheterization?
   Answer: Other sites of peripheral venous access are not available.
   1. In case of chronic intravenous drug abuse.
   2. In medical emergencies requiring immediate and reliable intravenous access.
4. Enumerate at least 5 equipment needed for peripheral venous access!
Answer: Tourniquet.
   - Materials for skin disinfection.
   - Tape.
   - Catheter over needle unit
   - Bottle or bag of intravenous fluid
   - Gloves
   - Container for used needles and hazardous waste

5. What are the places recommended for intravenous catheter insertion?
Answer: The veins of the distal radial side of forearm, the ulnar proximal part of forearm and veins of the dorsal hand.

5. Case reports

1. A 50 years old male patient was admitted for infusion therapy because of dizziness. In the cubital area and on the distal forearm can be found veins capable for puncture. Which position should be inserted the peripheral vein catheter in? Why?
   Answer: Into the vein on the forearm, because the catheter do not break during movement.

2. A 80 years old male patient is found in circulatory shock by ambulance. The veins of the neck are filed. Where should be inserted the peripheral venous catheter?
   Answer: Into the external jugular vein, because the circulatory of the extremities is insufficient.

3. A 30 years old female patient is admitted to the Emergency Room after wasp sting. There are rash throughout the body, the patient has no dyspnoe. Which type of peripheral venous access should be chosen, if the patient probably need only a single drug administration?
   Answer: Butterfly set.
   How long can be used this needle?
   Answer: 24 hours long.

4. A 30 years old male patient is found in unconscious state. The blood sugar level is 1.3 mmol/l. There are numerous pinpoint on both upper extremities. Which position should be inserted the peripheral vein catheter in?
   Answer: Into external jugular vein

5. A 60 years old female patient was admitted for a 7 days long infusion therapy. How much type should you insert peripheral vein catheter during this time?
   Answer: At least two times.
6. Literature:


7. Requirements - peripheral venous access 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 peripheral venous access
- Description of personnel requirements for peripheral venous access
- Demonstration of the methods of peripheral venous access (“catheter over needle” and “catheter through needle” technique).
- Demonstration of method of external jugular vein catheterization
- 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 peripheral vein catheterization on the upper extremity several times on phantom device
- Carry out butterfly needle insertion several times on phantom device
- Carry out external jugular vein catheterization several times on phantom device
- Reviewing the video recording made of the practice with the instructor, analysis of each cases.
- It is recommended to carry out all the techniques several times to acquire necessary experience.
8. Test questions

Simple choice
1. How long can be used a peripheral vein catheter?
   A. 24 hours
   B. 2 day
   C. 3 day
   D. 5 day
   E. 2 day

2. How long can be used a butterfly intravenous line?
   A. only for single infusion, drug injection
   B. 1 hours
   C. 6 hours
   D. 12 hours
   E. 24 hours

3. Which is not contraindication of external jugular vein puncture?
   A. The patient cannot assume the Trendelenburg position.
   B. Cellulitis on the skin of the neck.
   C. Pulmonary embolism
   D. extensive neck surgery

4. In which case has the lowest chance for cellulitis?
   A. external jugular vein catheter
   B. Butterfly needle
   C. Peripheral venous catheter
   D. central venous catheter

True or false
5. For peripheral venous access the “catheter through needle” technique is used in most cases.
6. In elderly patients the subcutaneous tissue is usually fibrotic, therefore the peripheral veins are easily cannulated.
7. External jugular vein catheters are difficult to secure, the movement of the neck makes them short-lived.
8. Before external jugular vein catheterization the patient should be positioned in Trendelenburg position.

Multiple choice
9. In which cases is indicated the insertion of Butterfly needle?
   A. venous access for short time
   B. The patient do not want venous catheterization
   C. In circulatory shock, when the peripheral veins are empty
   D. The patient has only few veins with small diameter
10. In which cases would you use external jugular vein puncture?
   A. chronic intravenous drug abuse
   B. in circulatory shock, when stable venous access is indicated
   C. after extended neck operation
   D. in patient with head injury

Relation analysis
11. For peripheral vein catheter insertion the veins of cubital area are preferred, because the venous puncture causes less pain in this area. (D)
12. The junction of two veins is an excellent insertion site, since here the vein is anchored and less likely to roll away from the needle. (A)
13. The antecubital veins are the first choice for peripheral venous access, because during flexion of elbow the catheter is broken easily. (D)
14. Hyperosmotic fluids and drug solutions cannot be administered into peripheral vein, because high amount these fluids can cause circulatory overloading. (B)
15. Blood products cannot be administered into peripheral venous catheter, because the products should be injected fast with high pressure. (E)

9. Sources:
