# Central Venous Catheter (CVC)

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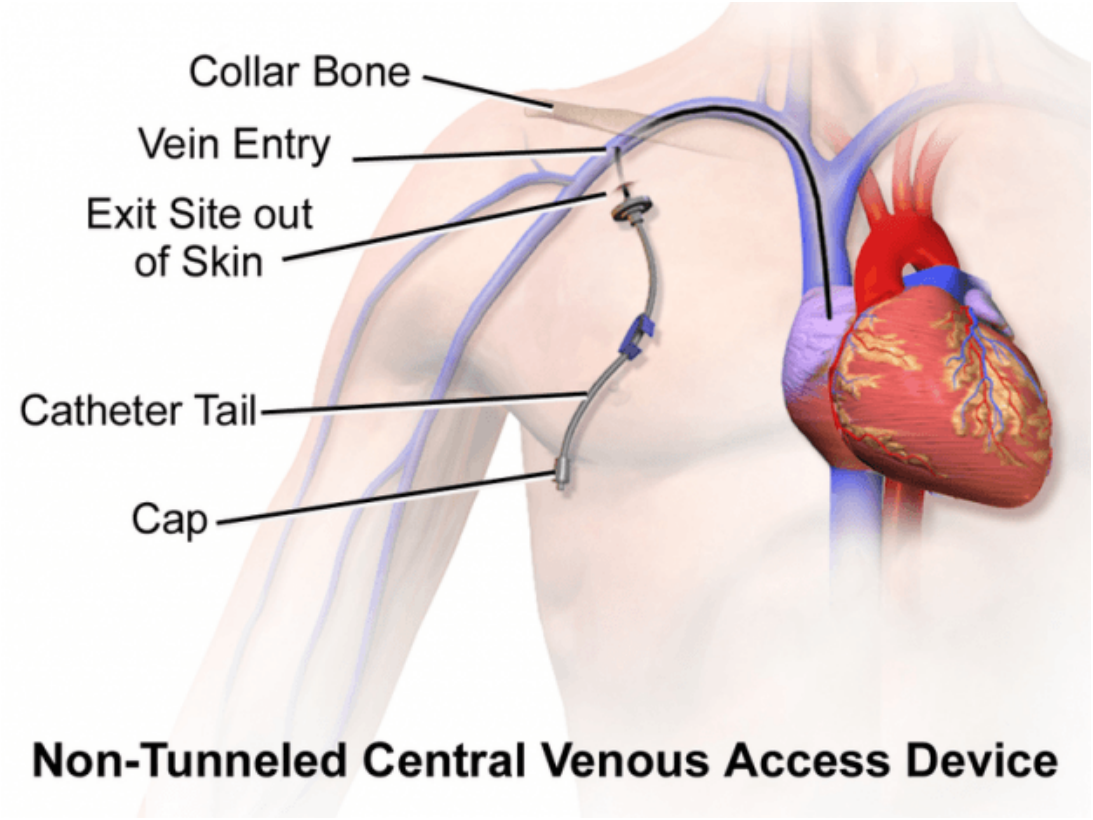
**The insertion of a central venous catheter (CVC) is a very important procedure in anesthesiology. The procedure is complex but it can be mastered. Once you have understood the principle, you can not only shine in your clinical internship but also later, as a clinical practitioner, you may have to take care of patients with a CVC where this knowledge will come in handy. In the following article, you will find a summary of all the essential facts concerning indications, complications, and maintenance of a CVC.**




## Definition of a Central Venous Catheter (CVC)

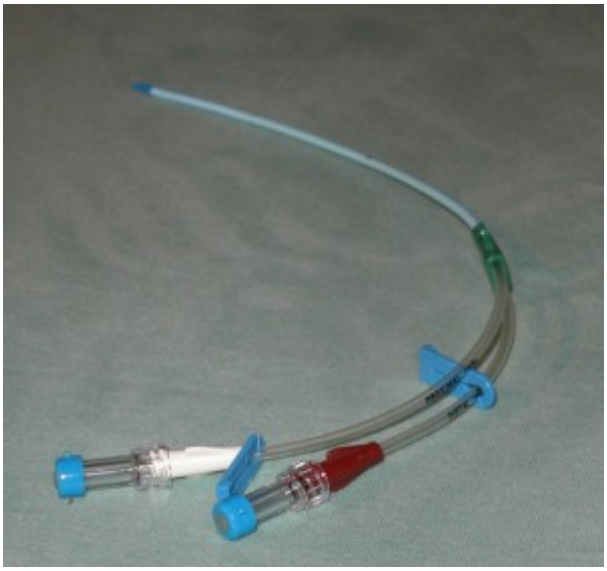


Image: Double-lumen CVC. By Florian Thillmann, License: CC BY-SA 3.0

**Central venous catheter (CVC)** – also called central venous access, central venous line, or central line – is a thin catheter that is inserted through 1 of the large veins in the neck area into the venous system. It ends in 1 of the venae cavae just before entering the right atrium. Through this access, the central venous pressure can be measured, and drugs or fluids can be administered.

A basic distinction is that between **peripherally inserted central catheters (PICC)** at a peripheral site and **central venous accesses**. The insertion of a CVC is an invasive, relatively complicated procedure, and a venous catheter harbors a certain risk of infection when it remains in place for a prolonged period of time. For this reason, a CVC should only be placed when there is a **clear indication**.

# Indications and Contraindications

## Indications for a central venous access

A typical indication for the placement of central venous access is the need for **monitoring the central venous pressure** (hemodynamic monitoring). This is particularly necessary during surgeries that involve large hemodynamic fluctuations (such as heart surgery, partial liver resections, or multiple traumas). The central venous pressure is the blood pressure in the vena cava close to the heart. With the patient in a supine position, it is about 3–9 mm Hg. It offers information about the amount of blood that is circulating and the cardiac output.

Furthermore, it is useful when the **infusion of large volumes of fluid** becomes necessary and a large-bore peripheral intravenous (IV) line cannot be established. Central venous access can also be beneficial for the infusion of solutions that cause **severe venous irritation** (parenteral nutrition, cytostatic agents, antibiotics, and

potassium), for d**rugs acting on the cardiovascular system** with a **short half-life** (catecholamine and nitroglycerine), or for **venous hemofiltration and hemodialysis**.

## Contraindications for a central venous access

There is **no absolute contraindication** for placing a CVC. Still, the following parameters should be taken into account, depending on the site of insertion. An **increased bleeding diathesis, i.e., coagulation disorder** represents a relative contraindication with regard to insertion through the subclavian vein: Should the adjacent subclavian artery be punctured in the process, direct compression of the artery to stop the bleeding would be impossible due to the close proximity of the clavicle.

In the case of **hypercoagulability**, the increased risk of thrombosis has to be considered. Furthermore, acute or chronic **pulmonary diseases**, **allergies** to materials of the CVC or insertion devices, and **tumors** or **adhesions of the tricuspid valves** that could become dislocated or embolized during the procedure all represent relative contraindications. Also, **malformations** or normal variations of the patient's anatomy must be considered in the insertion process.

# Materials and Techniques for a CVC

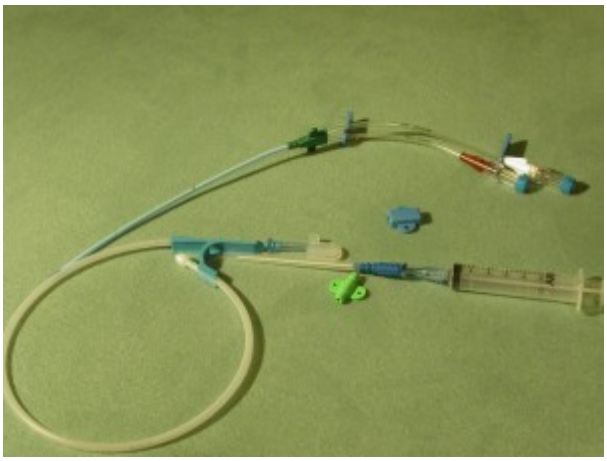


Image: CVC materials. By Florian Thillmann, License: CC BY-SA 3.0

Depending on the specific indications, there are different **CVCs** available regarding **a number of lumen** and **diameter**. Furthermore, there are various techniques for the insertion of central venous access. The most established and most used technique is the **Seldinger technique**. The Swedish radiologist Sven-Ivar Seldinger described this type of puncture for the 1st time in 1955: The catheter is inserted with the help of a guidewire. In the following, this technique will be

explained step-by-step.

## Selecting a puncturable vein for the CVC

The following veins can be used for the insertion of a CVC: **internal and external jugular vein, subclavian vein, brachiocephalic vein, and femoral vein**. In principle, there is no standard vein that is used for puncture. It is at the physician's discretion to decide in each case where the CVC should be placed.

Criteria for this decision are the **venous state** and the **anatomical accessibility** of the vessel as the insertion should be performed with the least risk for complications as possible and so that the CVC placement will be safe and function properly.

The **most common accesses** are via the **internal jugular vein** and the **subclavian vein**. Due to the higher risk for infections in the groin area, the femoral vein is used for a CVC when no other vessel remains puncturable.

The **puncture** will preferably be done on the **right side** of the patient's body. This ensures the shortest and most direct course of the catheter to the right side of the heart. The right subclavian vein, for example, merges directly into the superior vena cava, while on the left side the detour via the brachiocephalic trunk would make the course of the catheter unnecessarily long. And a puncture on the right side prevents an accidental puncture of the lymphatic vessel of the thoracic duct which is located on the left body half.

## Access routes for a CVC

The insertion is either done under **ultrasound guidance** or with **anatomical landmark techniques**. If an ultrasound device is available, it is absolutely preferable to use ultrasound guidance as this substantially lowers the risk of complications.

Because the jugular veins are not completely filled due to the hydrostatic pressure, the patient is put in a **head-down position** (Trendelenburg position). This way, the veins fill with blood and can be punctured more easily, which lowers the risk of injuries through misplaced punctures.

As the **subclavian vein** lies under the clavicle, it can be punctured using anatomical landmarks. The physician places the needle in the middle of the lower edge of the clavicle (midclavicular) and slowly inserts the needle in the direction of the jugular notch.

The **internal jugular vein** can be punctured using either anatomical landmarks or ultrasound guidance. It runs along the neck lateral to the internal carotid artery, which is easily palpable. While the internal carotid artery remains securely

palpated with 2 fingers, the
vein lateral from it is punctured at the level of the larynx with the needle pointing towards the mamilla. If an
ultrasound device is available, the transducer is also placed at the level of the larynx, pivoted, and then the
needle is introduced in-plane.

## Puncture of the vein for the CVC

For the puncture of the selected vein, a **cannula** with a **syringe** attached to it is used. The
needle is introduced under slight pressure and **constant suction** and
pushed gently towards the vein. Maintaining the syringe aspirated serves the purpose of controlling where the
cannula is.

Occasionally, the compression exerted by the needle can cause the **vein to collapse** so that the needle pierces through it and no blood can be aspirated.
When slightly pulling back the needle, it will reenter into the lumen, and the plunger of the aspiration syringe
will suddenly be easily retractable. Also, blood flowing into the syringe will indicate that the vessel has been
successfully punctured. The blood should be of a dark color, indicating that it is of venous origin. Arterial blood
would be of a light red color.

## Inserting the CVC

Now, the syringe is removed from the end of the cannula—dark red blood slowly dripping out is again an affirmation that the vein has been hit. Arterial blood would come pulsating out of the cannula.
Then, the **Seldinger wire** is pushed down the cannula and when it has
been advanced into the vessel, the cannula is removed.

Image: Seldinger set. By Florian Thillmann, License: CC BY-SA 3.0

At the entry site, an **incision** is made and
a synthetic **dilator** is passed over the guidewire in order to widen the
vein for the catheter. Now, the actual Seldinger technique is performed: The **catheter** is threaded over the wire and advanced into the vein.

At the distal end of a CVC, there are multiple **lumens** (usually 3–5). The guidewire will pass through 1 of these lumens. The guidewire has a
**black mark** – the wire will only be retracted so far that the black mark
becomes visible at the end of the lumen.

Next, the proper placement of the catheter has to be confirmed. This is done with an **intra-atrial electrocardiogram (ECG)** that is attached to the guidewire.
The ECG electrode already attached to the chest is redirected to the guidewire. Based on the ECG leads, the
anesthesiologist can now assess the positioning of the catheter on the monitor: A **high,**

**pointed P wave** indicates that the catheter has entered the right atrium. If this is the case, the catheter has to be retracted by 1–2 cm until the P wave has normalized, indicating that the distal end of the catheter is now properly placed just outside the right atrium.

Then the **guidewire** is removed and the catheter is secured to the skin with a small **suture**. On the catheter itself, there is a scale that shows how far the catheter has been advanced into the vein. This allows a caretaker or physician to monitor the proper positioning of the catheter later on.

## Possible Complications of a CVC

The placement of central venous access can lead to the following possible complications:

- **Accidental arterial puncture**
- **Lesions of lymphatic vessels**
- **Pneumothorax**
- **Infections**
- **Lesions of the brachial plexus**

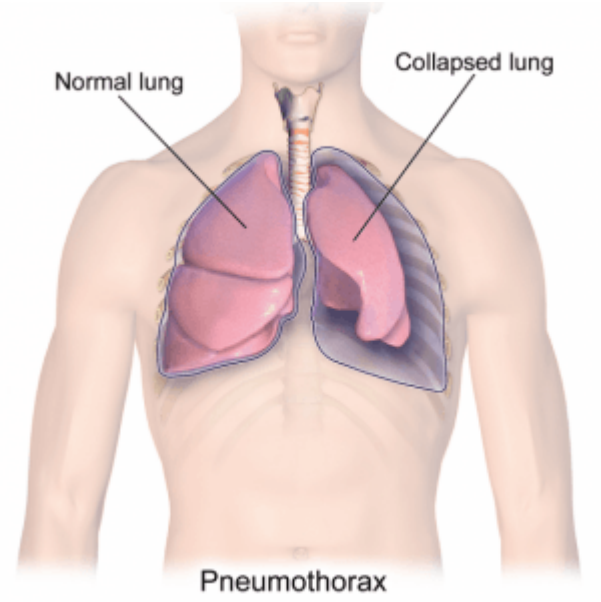



Image:
Pneumothorax. By Bruce Blaus, License: CC-BY 3.0

The most dangerous complication to be avoided is **pneumothorax**. It can occur due to the puncture site's anatomical proximity to the cupula of the pleura, i.e. the lung, which can be injured by the catheter.

During surgery, a **pulmonary lesion** is not as imminently crucial because of the intraoperative positive-pressure ventilation. Under these controlled conditions, any serious lesion could be identified and remedied right away. However, in the postoperative stage, a

lesion of the pulmonary tissue could possibly let inspiratory air into the thorax that could then lead to a
**tension pneumothorax.** The increasing amount of air in the thorax causes the heart and contralateral lung to shift, which will eventually impede their functioning. In order to exclude the complication of a pneumothorax or hematothorax, it is recommended to **always** take a **chest X-ray** after placing a CVC. The X-ray image can also be used to again control the positioning of the catheter tip.

**Note:** After every placement of a CVC, a postoperative chest x-ray should be ordered!

## Duration of Placement and Maintenance of a CVC

There is no recommended **duration of placement** for a CVC. The indication should be reassessed every day. If the **regular inspection** of the CVC brings up any signs of infection at the entry site or along the catheter's course, the catheter has to be removed immediately to minimize the risk of sepsis.

In case of fever of unknown cause, pain, or sepsis, the catheter placement should be reassessed. Possibly, the catheter will have to be newly inserted at a different site. **Routine scheduled catheter changes** are, however, *not* warranted. Only in emergency situations, where the insertion of the catheter was not performed under sterile conditions, the venous access should be changed as soon as possible.

The **maintenance of the catheter site** is the responsibility of the medical and nursing staff. The access site is covered with a **gauze dressing** or a breathable **transparent dressing**. Advantage of the transparent dressing is that the insertion site can be visually inspected for signs of infection such as redness or swelling. Dressings are usually changed after 2–3 days.
Transparent dressings are changed after 7 days at the latest. If the dressing is soaked through, dirty, or loose, it has to be changed immediately!

**Note:** If necessary, the catheter can be flushed with a sterile physiological saline solution. Because of the high risk of infection for the patient, all materials, including dressing, entry site, and catheter lumens have to be handled under sterile conditions. Any manipulation of the catheter and dressing changes should only be performed by qualified staff.

## The CVC at a Glance

| Indication | Relative contraindications | Puncture sites | Procedure | Complications | Maintenance |
|---|---|---|---|---|---|
| Infusion of large volumes | Increased bleeding diathesis | Internal /external jugular vein | Seldinger technique | Arterial lesions | Gauze dressing or transparent dressing |

| | | | | | |
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| Administration of substances with vascular toxicity or irritation / short half-lives | Hypercoagulability | Subclavian vein | Puncture under aspiration, guidewire, dilator, catheter, intra-arterial ECG for placement control, removal of guidewire, securing CVC with suture | Lesions of lymphatic vessels | Regular inspections for infections + dressing changes |
| Hemodynamic monitoring | Allergies to materials | Brachiocephalic vein | | Pneumothorax | Signs of infection: immediate removal! |
| | Tumors/injuries in the area of the puncture site | Innominate vein | | Infection | Sterile handling |
| | | Femoral vein | | Lesion of brachial plexus | |

# References


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