Come trattare le rotture del tratto esterno e del tratto intravascolare

Giuseppe Capozzoli

Vascular Access Team Anestesia Bolzano

CVC fracture: definition

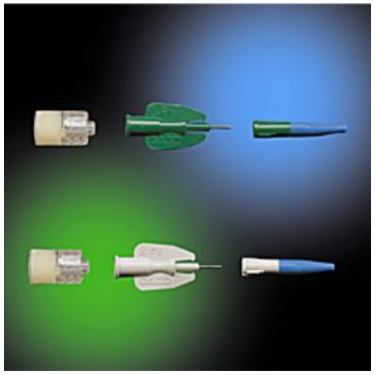
- CVC fracture can be defined as a break in the sterility of the line that allows leakage as a result of a tear, hole or shearing injury in the external line tubing.

- CVC-associated bloodstream infections (CLABSI)
- Hospital readmission
- Delays in nutritional support or drug therapy

Repair, exchange or replacement?

- Fractures can be repaired using sterile technique at the bedside with equal rates of line failure and CLABSI, eliminating the need for replacement and associated anesthetic risks (pediatric patients).

- CLABSI incidence: the importance of early recognition of catheter fracture and either replacement or repair.



- Repair has several advantages over replacement:

I. Eliminates the small intraoperative risks associated with catheter replacement including anesthetic risk (pediatric patient populations)

II. Allows central vein preservation in patients with particularly difficult access

III. Catheter can be repaired without the need of general anesthesia (pediatric patient populations).

IV. Repairing the venous line does not require confirmation of the correct position of the tip.

V. Time to repair intervention: repair can be performed quickly under sterile conditions.

VI. Catheter repair may promote catheter longevity and limit loss of vascular access sites and reduce risk of infection compared to catheter exchanges.

- Catheter exchange:

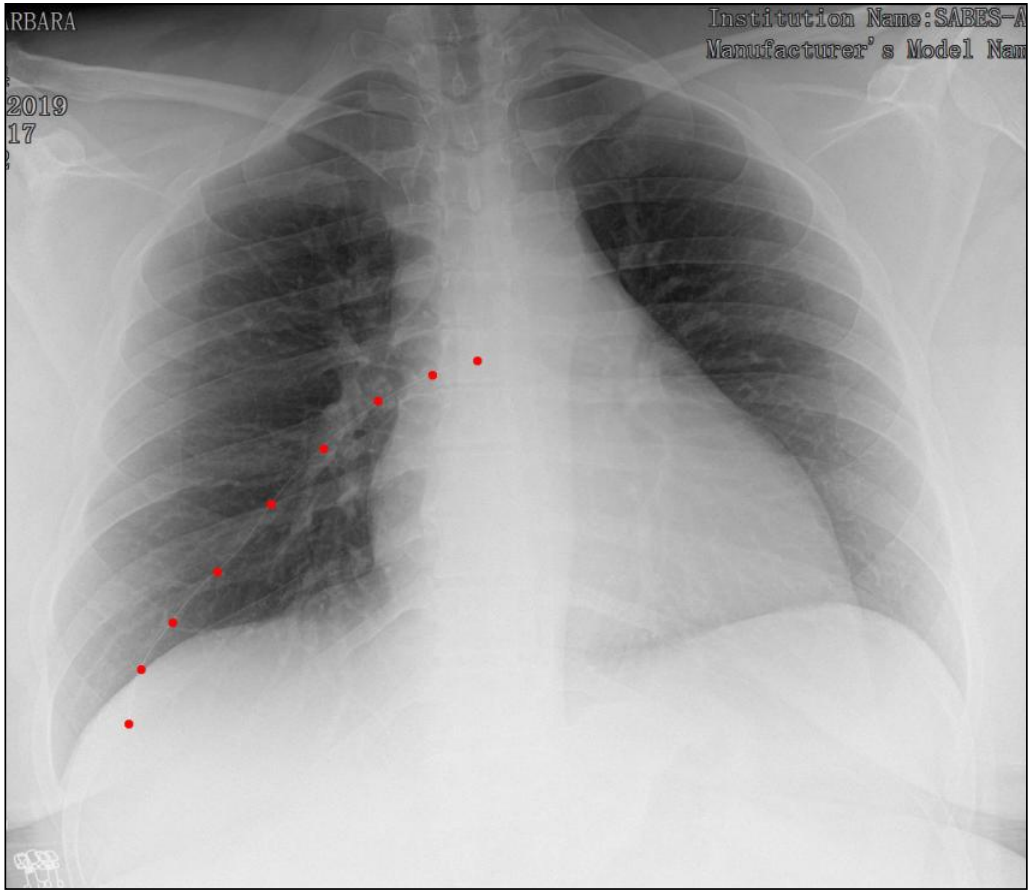
I. associated with reduced risk for technical complications of new catheter insertion (eg, pneumothorax (CTA/B-PICC), hemothorax (CTA/B-PICC, arterial puncture)

II. Peripherally inserted central catheter (PICC) exchanges have been associated with a 2-fold increased risk of thromboses compared to those without exchanges. Several explanations exist (2)

- Catheter removal and replacement

1. Zens T et al. Fractured pediatric central venous catheters — Repair or replace? Journal of Pediatric Surgery 54(2019)165–169
2. Chopra V et al. Risk of venous thromboembolism following peripherally inserted central catheter exchange: an analysis of 23,000 hospitalized patients. Am J Med. 2018;131(6):651-660.

Intravenous catheter fracture and embolization



"intracardiac foreign bodies should always be removed, for secondary complications frequently are lethal"

Cardiac Embolization of Ventriculo-Venous Shunts for Hydrocephalus. Dis Chest 1967 May;51(5):557-9.

Peripheral catheterization fracture and embolization

COMPLICATIONS

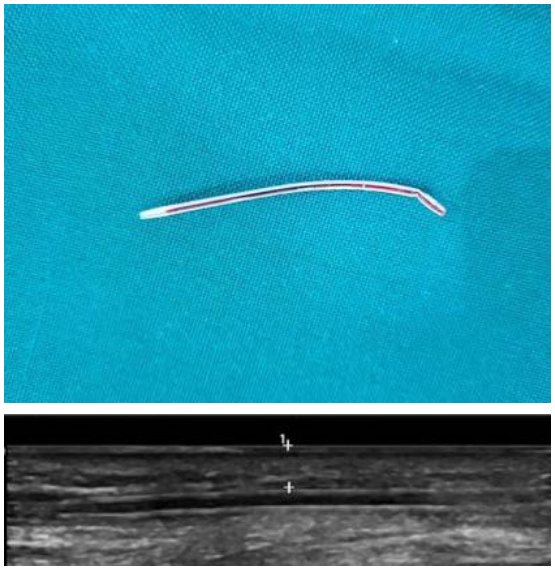
- Vein rupture
- Paravenous infusion
- Phlebitis
- Thrombosis

- **Catheter fracture**

Difficulties
-Positioning
-Removal

Failure of inspection

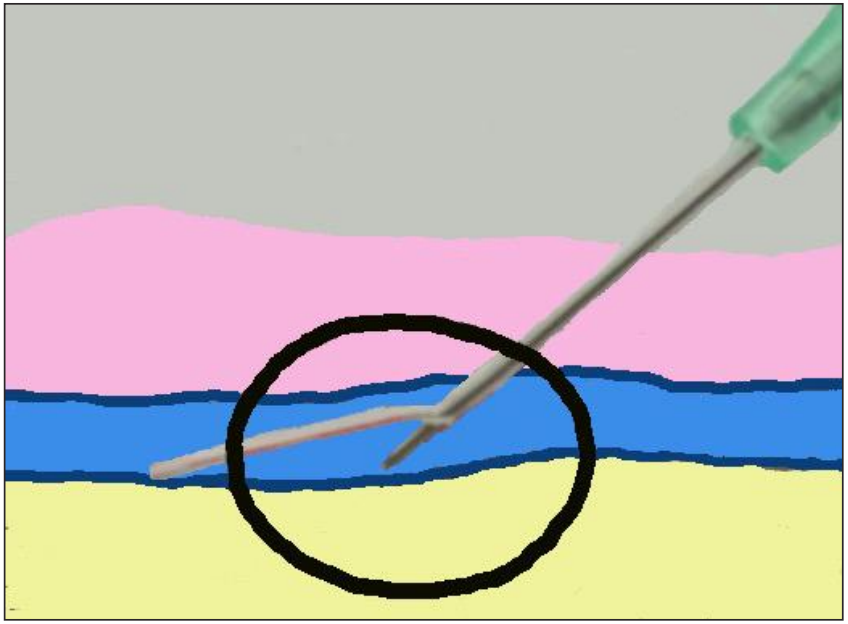
"some authors published cases to help discourage the routine use of intravenous catheters" (2)



Ultrasound Images of Cannula Fragments

BREAKING MECHANISM

reinsertion of the needle guide into an already advanced plastic sheath



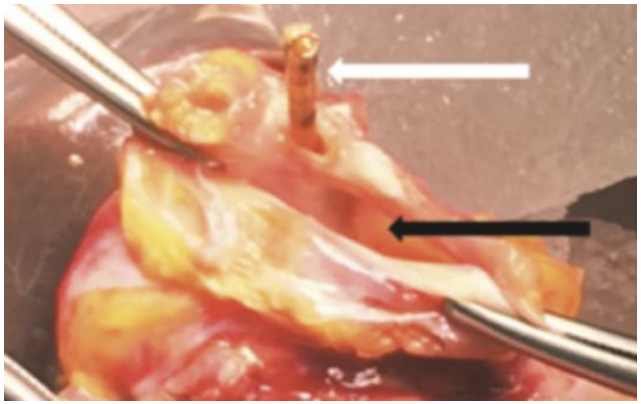
over-the-needle technique (long PIVC)

1. Denny MA. VENTRICULAR TACHYCARDIA SECONDARY TO PORT-A-CATH FRACTURE AND EMBOLIZATION. The Journal of Emergency Medicine, Vol. 24, No. 1, pp. 29–34, 2003
2. Doering RB, Stemmer EA, Connolly JE. Complications of indwelling venous catheters. Am J Surg 1967;114:259–66.

Adverse events from catheter emboli

Removal of embolized catheter
0%

- **No deaths**



chronically retained CVC

Patients with catheter lift in
25%

- perforation,
- embolus,
- thrombosis,
- dysrhythmia,
- endocarditis,
- sepsis

Major non fatal complications
20%

- dysrhythmia
- thrombosis,
- embolism
- endocarditis

Denny MA. VENTRICULAR TACHYCARDIA SECONDARY TO PORT-A-CATH FRACTURE AND EMBOLIZATION. The Journal of Emergency Medicine, Vol. 24, No. 1, pp. 29–34, 2003
Zielsdorf S. Chronically Retained Central Venous Catheter in Deceased Donor Liver Allograft. Case Reports in Transplantation Volume 2019

PICC: prolonged catheterization

- Various complications may occur: catheter rupture

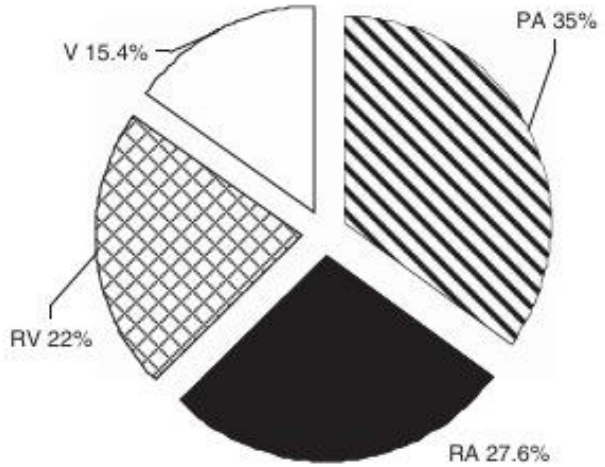
- Literature reports a rupture rate of PICC catheters ranging from 0.67% to 3.5% (1)

1. Mielke D, Wittig A, Teichgräber U. Peripherally inserted central venous catheter (PICC) in outpatient and inpatient oncological treatment. Support Care Cancer. (2020) 28(10):4753–60.

Localization of Embolized Catheter Fragments

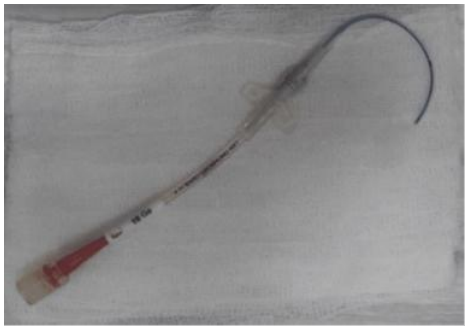
Fracture and migration are rare but potentially serious complications that can lead to arrhythmias, cardiac perforation, cardiac tamponade, pulmonary embolism, and sepsis.

Catheter fragments were found in the pulmonary artery (PA) in 35%, in the superior vena cava or in the peripheral veins (V) in 15.4%, in the right atrium (RA) in 27.6%, and in the right ventricle (RV) in 22%



Flow to the heart or pulmonary artery:

- pulmonary embolism
- arrhythmias



1. Delarbre B et al. Introduction of the use of a pediatric PICC line in a French University Hospital: review of the first 91 procedures. Diagn Interv Imaging. (2014) 95(3):277–81.
2. Surov A. Intravascular Embolization of Venous Catheter—Causes, Clinical Signs, and Management: A Systematic Review. Journal of Parenteral and Enteral Nutrition / Vol. 33, No. 6, November/December 2009
3. Kumar Upadhyay A, Prakash B, Shekhar S, et al. (August 06, 2023) Embolization of a Fractured Peripherally Inserted Central Catheter to Pulmonary Arteries: A Sporadic Life-Threatening Phenomenon. Cureus 15(8)

Clinical presentations of catheter fracture

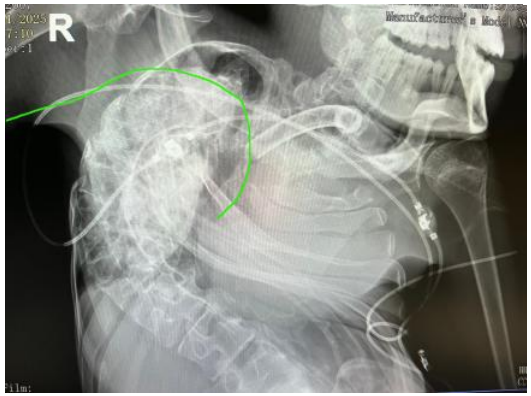
- Embolus and significant symptoms

Chest pain 5%
Palpitations 7%
Arrhythmias
Unstable vital signs

Suspect catheter/guidewire embolism when patient exhibits symptoms such as palpitations, arrhythmias, dyspnea, cough, or thoracic pain that are not associated with the patient's primary disease or comorbidities.

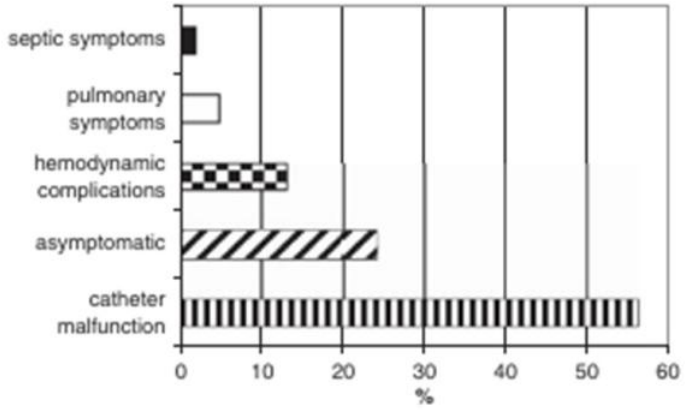
Ventricular perforation and death from tamponade (1,2)

Radiographic findings: as many as 20% of catheter fragments are missed on radiographic studies (4).



- Embolus and minimal symptoms

Asymptomatic 36%
Pain or swelling 45% (localized pain and/or swelling along CVAD pathway during infusion)
Paresthesia in the arm
Catheter dysfunction (eg, inability to aspirate blood, frequent infusion pump alarms)



1.Brown CA, Kent A. Perforation of right ventricle by polyethylene catheter. SouthMed J 1956;49:466.25.
2.Ayers WB. Fatal intracardiac embolization from indwelling intra-venous polyethylene catheter. ArchSurg1957;75:259
3.Surov A. Intravascular Embolization of Venous Catheter—Causes, Clinical Signs, and Management: A Systematic Review. Journal of Parenteral and Enteral Nutrition / Vol. 33, No. 6, November/December 2009
4. INS 2024

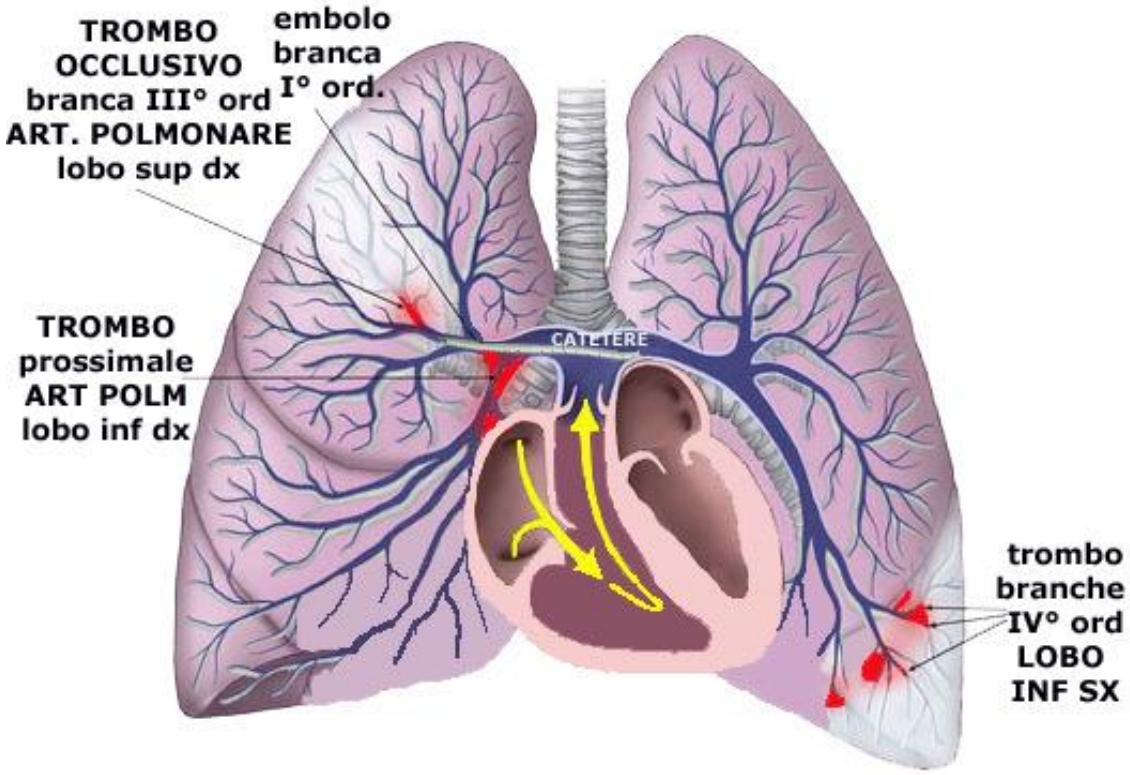
Mortality Following Catheter Embolization

Mortality rate 1,8% (1)

- incessant arrhythmia
- endocarditis
- pneumonia
- pulmonary hypertension

Catheter embolus in patients with significant comorbidity:

- high mortality and morbidity



1. Surov A. Intravascular Embolization of Venous Catheter—Causes, Clinical Signs, and Management: A Systematic Review. Journal of Parenteral and Enteral Nutrition / Vol. 33, No. 6, November/December 2009

Key to the diagnosis

- Examine guidewire, catheter tip, and length after removal, comparing the removed length to the inserted length for damage and possible fragmentation. If damage is seen or suspected, a chest radiograph or further evaluation is required (2)

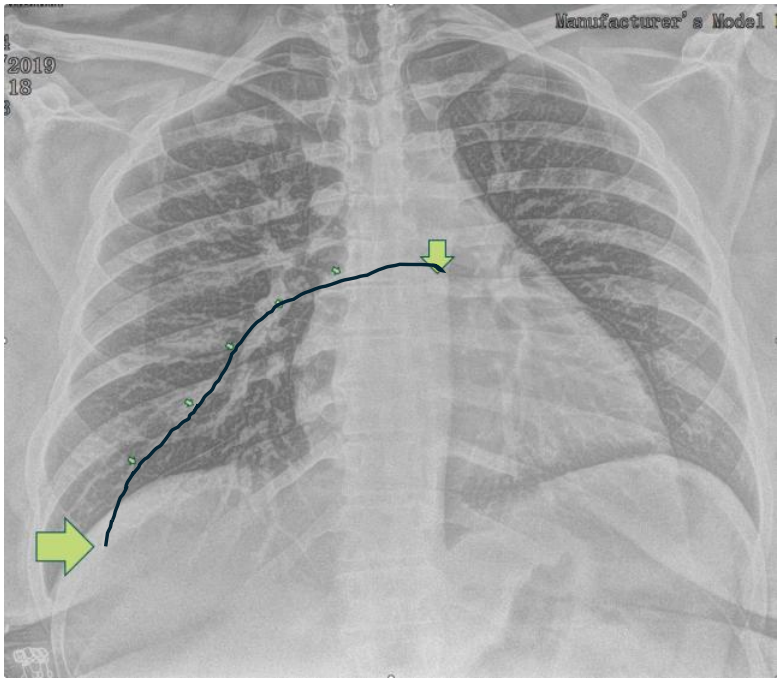
- Chest radiograph (position and length of iv catheters)
- EKG
- Catheter related history
- Inspection-palpation skin and subcutaneous tunnel (PICCt, CTA, CTB)

- Diagnosis of Asymptomatic catheter fracture and embolization:

CXR, CT

Inability to aspirate

Non functional catheter



1. Surov A. Intravascular Embolization of Venous Catheter—Causes, Clinical Signs, and Management: A Systematic Review. Journal of Parenteral and Enteral Nutrition / Vol. 33, No. 6, November/December 2009
2. INS 2024 S176

PICC breakage: possible risk factors

- PICC **fatigue** (1). Catheters commonly fractured at or near the entrance site.
- Catheter fractures were more common in **older lines** and when there was evidence of another complication with the line (eg, blockage of the line, leaking at the insertion site, history of difficulty flushing).
- Patients continue to do their **physical work** despite having a PICC in situ (2).
- The **in situ time** of a PICC is a critical factor for the fatigue and fracture of the PICC.
- Catheter fracture can happen during insertion if **excessive syringe pressure** is applied, during removal, or because of tractional force on the catheter hub junction.

- Catheter factors. A PICC is made of silicone or second- or third-generation polyurethane. Silicone presents comparatively a relatively higher risk of catheter breakage/fracture (3).

The only reasonable "strategy" to effectively reduce PICC catheter breakage is to **avoid using silicone catheters**

- Frequent bending of the limb on the punctured side causes repeated folding at the junction of the catheter and connector

In 19.1% of reported cases the mechanism of catheter fragmentation allowing embolization **could not be identified** (4).

No attempt should be made to pull the catheter forcibly. After the removal of PICC, its intactness should be meticulously checked.

When attempting to remove a PICC, if there is resistance, repeated hot soaks can be applied to the insertion site to expand the veins.

1. Chow LM et al: Peripherally inserted central catheter (PICC) fracture and embolization in the pediatric population. J Pediatr. 2003, 142:141-4.
2. Kumar Upadhyay A et al. (August 06, 2023) Embolization of a Fractured Peripherally Inserted Central Catheter to Pulmonary Arteries: A Sporadic Life-Threatening Phenomenon. Cureus 15(8)
3. Mou QQ et al: Nerve damage secondary to removal of fractured PICC fragment . J Vasc Access. 2016.
4. Surov A. Intravascular Embolization of Venous Catheter—Causes, Clinical Signs, and Management: A Systematic Review. Journal of Parenteral and Enteral Nutrition / Vol. 33, No. 6, November/December 2009

Emergency procedures for PICC line embolism and definitive management

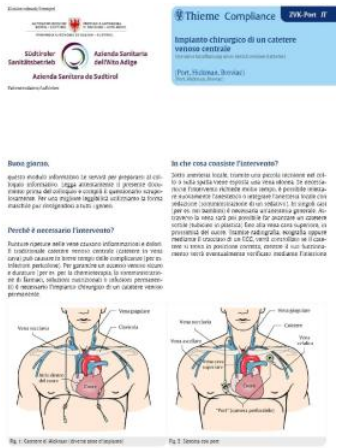
- Immediate ECG monitoring
- US examination of the upper limb to locate the fractured catheter for possible surgical removal through a small incision
- X-ray
- Place patient on left side in Trendelenburg position, unless contraindicated (eg, increased intracranial pressure, eye surgery, or severe cardiac or respiratory disease);
- Minimize movement of patient and involved limb; reassure patient;
- Call immediately for emergency medical assistance.
- Press the limb over the target vein may decrease the chance of migration of the fracture; consider immediate application of a tourniquet above site when catheter or guidewire embolization is observed.
- Notify health care team; percutaneous interventional/ surgical procedures are likely required for fragment/ catheter removal to prevent further complications.

- Removal
- Dysrhytmic therapy* (ACLS)

Interventional percutaneous techniques

- **Femoral vein** approach
- More than 90% success rate
- Minimal reported complications
- Interventional techniques: loop snares, hooked guidewires, forceps, basket catheters, and Fogarty balloon catheters, goose-neck snare method
- Importance of having interventional cardiology and radiology facilities near high-volume vascular access teams

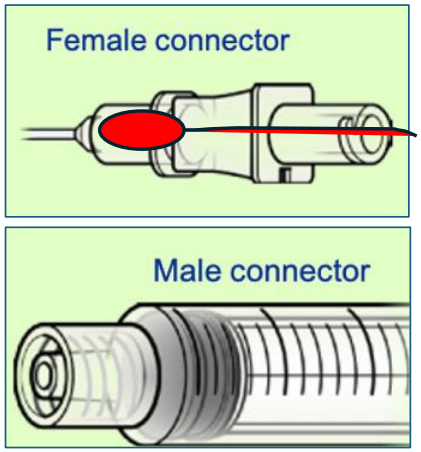
- Patients should also be taught the **possible complications**, including PICC breakage with symptoms and signs, and to report immediately to the healthcare providers in the case of breakage.

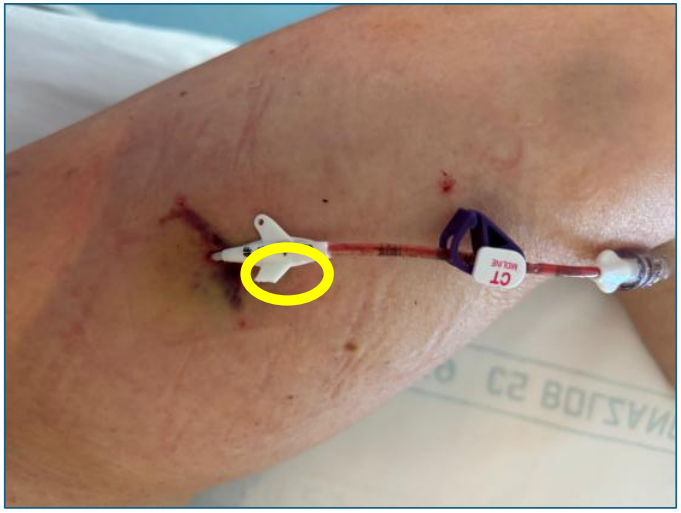


1. Gupta AK et al. A novel technique using a balloon. Interv Neuroradiol. 2005, 11:149-54
2. Surov A. Intravascular Embolization of Venous Catheter—Causes, Clinical Signs, and Management: A Systematic Review. Journal of Parenteral and Enteral Nutrition / Vol. 33, No. 6, November/December 2009

Mechanical external damage

- External portion of the catheter
- Distal female adapter





- Natural wear of material
- Catheter rupture during flushing attempts to unblock occluded catheters
- Use of sharp objects such as scissors
- Repeated clamping maneuvers
- Frequent bending of the external catheter segment
- Repair kits for broken catheters are essential in maintaining the integrity and functionality of PICCs, reducing the risk of complications associated with catheter replacement, such as infection, bleeding, or thrombosis.

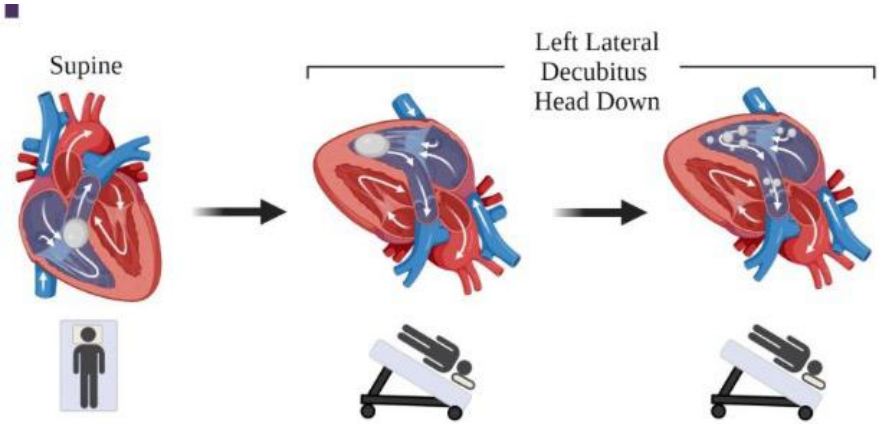
Manage catheter damage

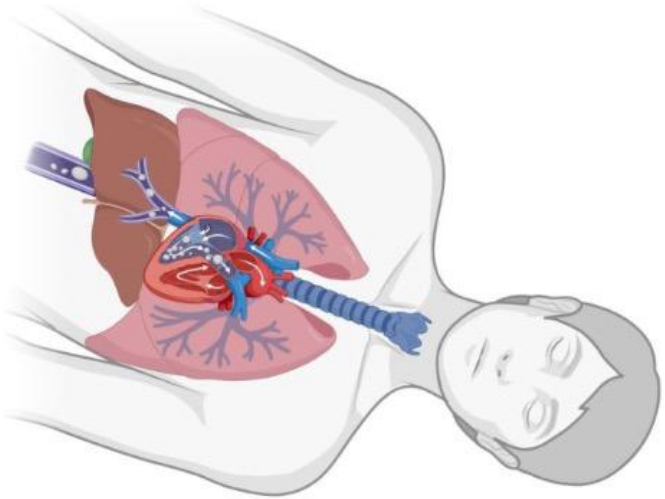
- ..ballooning, fracturing, rupturing, and cracking of the hub
- Reduce the risk of catheter fracture and embolization, air emboli, bleeding, catheter-lumen occlusion, catheter-associated bloodstream infection (CABSI), and treatment interruption or failure.
- **Stop any infusions**. Clamp or seal a damaged catheter (eg, close an existing clamp, **add a clamp (emergency clamp)**, cover the damaged area with adhesive dressing material, or fold the external segment and secure) between the catheter exit site and the damaged area to **prevent air embolism or bleeding** from the device immediately upon discovery of catheter damage. Label the damaged catheter, "Do Not Use," while waiting for the repair or exchange procedure to be performed.
- If visible damage: clamp CVC between patient and damaged area, cover with sterile gauze or pinch line with sterile gauze at site of breakage
- Minimize patient movement (2)

1. INS 2024 S176
2. Central Venous Access Devices (CVAD) and Long Peripheral Venous Catheter (PVC) Management - Clinical Practice Standard. WACHS 2024

Durant's Position: a life-saving maneuver for VAE

- Venous air embolism which occurs most commonly after damage or disconnection at the catheter hub.
- Durant’s maneuver is the act of placing a patient in the left lateral decubitus position in the event of a venous air embolism.
- Placing the patient in the left lateral decubitus with the head down allows displacement of the air from the pulmonary outflow tract.
- This maneuver allows for the air bubble to rise and stay within the heart until it reduces in size via diffusion, reducing the risk for ischemic events.





CVAD-associated complications in pediatric patients

- Peripherally inserted central catheter (PICC)
- Tunneled central venous catheter TcCVC/TCVC:

J-PICC

F-PICC

A-PICC

CTA picc

- 400000 annually
- One in four patients with CVADs will experience a significant complication or device failure before completing therapy
- Post-insertion complications
  - Central line–associated bloodstream infection (CLABSI)
  - CVAD-associated venous thromboembolism (VTE), local infection,
  - Mechanical complications, and dehiscence

1.7% of CVADs experienced breakage/rupture (3)

1. Steliarova-Foucher E et al (2017) International incidence of childhood cancer, 2001–10: a population-based registry study. Lancet Oncol 18(6):719–731. https:// doi. org/ 10. 1016/ S1470- 2045(17) 30186-9
2. Ullman AJ et al (2020) The Michigan Appropriateness Guide for Intravenous Catheters in Pediatrics: miniMAGIC. Pediatrics 145(Suppl 3):S269–S284. https:// doi. org/ 10. 1542/ peds. 2019- 3474
3. Nunn JL et al. Central venous access device adverse events in pediatric patients with cancer: a systematic review and meta-analysis. Supportive Care in Cancer (2024) 32:662

Preventative strategies to maintain catheter integrity and reduce the risk for catheter damage

- Infusion and vascular access equipment and supplies are visually inspected for product integrity and function before use.
- Avoid applying excessive force when instilling a catheter clearance agent to reduce risk of catheter damage. Use a 10-mL diameter barrel syringe to assess vascular access device (VAD) function; do not forcibly push against resistance.
- Limit contrast power injections to VAD and add-on devices with labeled indication for **power injection**
- Avoid stretch force, frequent bending, or friction against the catheter (eg, rotate location of integrated clamp[s] on central vascular access devices
- Attach luer-lock connectors carefully to the catheter hub
- SASS should be assessed during catheter care and management to ensure its integrity
- Consider and evaluate compatibility of the catheter material with the lock solution (ethanol)
- Avoid use of mupirocin ointment at the catheter insertion site due to the risks of the potential damage to polyurethane catheters.
- VASCULAR ACCESS DEVICE OCCLUSION: Assess for catheter damage (eg, catheter bulging, leaking, or swelling along CVAD pathway) and repair or replace VAD. Assess external catheter length, arm or shoulder discomfort, arrhythmias, and need to roll shoulder or raise the ipsilateral arm to allow flow or obtain blood return. If the flow is dependent upon arm position, pinch-off syndrome should be investigated through informed radiographic studies.
- **Close attention to measuring exposed catheter length (especially in disoriented or delirious patients**) (1)
- **Exchange of PICCs over guidewires may not be benign and is associated with a nearly twofold greater risk of venous thrombosis** (1).
- Do not withdraw the catheter or guidewire from the needle during insertion, as the needle bevel can damage the wire, and always maintain control of the guidewire to prevent inadvertent wire embolus.
- Recognize that younger age, femoral placement, and longer dwell times may be associated with catheter fracture.

1. Chopra V et al. Risk of venous thromboembolism following peripherally inserted central catheter exchange: an analysis of 23,000 hospitalized patients. Am J Med. 2018;131(6):651-660.
2. INS 2024 S52-S121