Placement of peripherally inserted central catheter by imaging. Experience in a children's hospital

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Purpose

MAIN OBJECTIVES:

- Describe the indications of peripherally inserted central catheters (PICC)
- Detail the image guided placement technique that we use in our center
- Detail our experience in implementing this procedure

SECONDARY OBJECTIVES

- To demonstrate the usefulness of this vascular access in children
- Detail the insertion procedure, emphasising in radiation protection and comfort for the patient
- Provide "tricks" for placement
- Describe the complications or problems that may occur during and after insertion, and how to address or minimise them
- Expose the different materials and equipment we use in our center

Analyse the indications, type of users, time of insertion, etc. of this novel technique in our center

Methods and Materials

Peripherally inserted central lines (PICC) are intravascular devices that allow the administration of intravenous drugs, blood products, fluids, etc through a peripheral vein puncture.

Their main indications are the need for intravenous antibiotics, chemotherapy, blood transfusion, blood extraction, short-term parenteral nutrition, and hydration and electrolyte replacement Fig. 1 on page 8.

They are an alternative to those inaccessible peripheral veins in children, or with great difficulty for puncture, or in cases which require multiple venopunctures during treatment Fig. 2 on page 8.

PICC lines are used in situations requiring venous access for a relatively short time (1-6 weeks), although they can last for months with proper care.
Performing puncture using ultrasound guidance allows for greater security, so there is less trauma to the vein, artery puncture is avoided, and also nonpalpable veins can be used such as those in the arms (basilic, brachial or cephalic). This last reason is very important in children, because they can retain full mobility of their arms during treatment. Fig. 3 on page 9

The use of fluoroscopy has the great advantage of being able to position the catheter tip correctly without moving the patient to the radiology department or make a portable x-ray to check. It also allows us to redirect the guide during insertion to the entrance of the right atrium. The tip of the catheter should be located approximately at the junction of the superior vena cava and right atrium, in those lines inserted in the arms. In an anteroposterior chest x-ray this union is located two vertebral bodies below the carina.

We should never forget to properly inform the person responsible for the child, or even the patient, about the procedure, risks, complications and alternatives.

We must follow all rules of radiation protection; the radiologist must be legally accredited for performing fluoroscopy-guided percutaneous procedures.

The whole procedure is performed in aseptic conditions.

Here we expose the BASIC STEPS for inserting a PICC Fig. 4 on page 10.

MATERIAL

- Equipment: Ultrasound - Fluoroscopy
- Radioprotection material: leaded apron, curtains and leaded glasses
- Sterile material for the procedure

RADIOPROTECTION

- Staff with leaded aprons and glasses
- Placement of leaded apron under the patient
- Placement of leaded curtains between x-ray tube and staff

STAFF PREPARATION

- All staff with cap and mask
- Staff inserting the PICC line:
  - surgical hand washing
  - sterile gown and gloves
PATIENT PREPARATION

- Supine position
- Monitoring with ECG and pulse oximeter
- Arm in extension and external rotation
- Perform a prior ultrasound to select the vein for access
- Washing with antiseptic the entire upper limb, axilla and pectoral-supraclavicular region

STERILE FIELD PREPARATION

- Cover with sterile drape the patient from head to toe, leaving the selected arm exposed
- Cover with sterile covers the detector of fluoroscopy and ultrasound probe

SUPPLIES FOR PICC LINE PLACEMENT

- Sterile material:
  - Tourniquet
  - 22G venopuncture needle
  - Bowl with heparinized saline
  - Gauze
  - Scalpel blade
  - 5cc syringes
  - Catheter fixation system
  - Caps
  - PICC line kit of the appropriate size (pediatric are usually 3F, 4F or 5F)
    - Nitinol guide wire
    - Peelable introducer
    - Catheter
    - Purge with heparinised saline the introducer and the catheter (leave the syringe attached to the catheter). If several lumen, the rest should be closed.

PUNCTURE by Seldinger technique Fig. 5 on page 11 Fig. 6 on page 12

- Place the tourniquet in the axilla
- Locate the vein with ultrasound guidance. Basilic, brachial, cephalic, axillary vein
- Puncture of the vein with direct view of the tip of the needle.
  - Transducer in an axial plane to the vein
  - Needle <45° to the skin
  - Entry into the skin caudal to site of the vein puncture
  - Observe the tip of the needle inside the vein
  - Check the chamber of the needle filling with blood
• Vein cannulation:
  • Advance the cannula of the needle keeping the needle fixed
  • Remove the needle
  • Introduce the guide wire through the cannula

CHECKING THE GUIDE WIRE Fig. 7 on page 13

  • Using fluoroscopy we should identify the tip of the guide wire at least in the subclavian vein

SHEATH PLACEMENT

  • Remove the cannula of venopuncture
  • Advance the introducer sheath with dilator using the guide as support

MEASURING THE CATHETER Fig. 8 on page 14

  • Under fluoroscopy vision: advance the guide wire until the tip is located two vertebral bodies below the carina, observe the movement of the guide due to the heartbeat
  • Measure the catheter:
    • With the guide wire firmly held
    • Place the tip of the catheter at the insertion point over the skin
    • Hold the catheter extended parallel to the guide wire up to the mark indicated by the manufacturer (some kits)
    • It is possible to use other methods of measurement (directly on the patient, bending the guide wire and then remove it and measure)

  • The catheter is cut one centimeter over the measurement obtained, so that there is free catheter in the insertion

CATHETER PLACEMENT

  • Remove the dilator from the peelable introducer
  • Cover the introducer with your finger, holding firmly the guide wire

  • Advance the catheter through the guide wire, holding this firmly so that it does not inadvertently advance into the heart, and prevent cardiac arrhythmias (also pay attention to ECG) (remove the syringe used to flush the catheter).
  • Break the peelable introducer and open it out of the skin as we advance the catheter

CHECKING THE CATHETER Fig. 9 on page 15

  • Using fluoroscopy, visualise the tip of the catheter in its intended location
  • Remove the guide wire
  • Place the caps in each of the catheter lumen
• Purge each of the lumen with heparinised saline, aspirate first until we get blood
• Infuse approximately 2 cc of saline with care not to introduce air bubbles

FIXING THE CENTRAL VENOUS LINE

• Clean and dry the entire area around the insertion point with saline
• Clean the insertion point with an antiseptic solution
• Attach the fixation system without impeding the mobility of the upper limb
• Cover the insertion site with a sterile dressing

The purpose of these steps lead to:

• proper functioning of the catheter during the estimated time of treatment
• minimize the bacteriemia secondary to a central venous line
• provide the child the best comfort with the least risk

The choice of the caliber of the catheter depends on the size of the vein, which in general is related to weight and age of the child. As a guide: for children under 12 months we use 3F, in over 4-5 years old we use 5F, and in the rest 4F. As a general rule, you should use the smallest size possible, but that suits the use to which it will provide. Table 1 on page

Sometimes advancing the guide wire into the superior vena cava can be difficult, for example in case of a mass in the mediastinum, or the previous presence of central lines that produced venous stenosis. In these cases, the insertion under fluoroscopy is critical because it allows us to redirect the guide and correctly position the catheter. Fig. 10 on page 17

In children under one year, due to the small size of veins of the arms and the fragility of these, sometimes it is not possible to get them cannulated; an alternative is the puncture of the axillary vein in its infraclavicular section before it is denominated subclavian vein. Fig. 6 on page 12

Sometimes it is not indicated to place the central line in the upper venous territories, as when there is a thoracic mass due to the risk of producing a superior vena cava syndrome. An alternative is to cannulate the superficial femoral vein, and leave the tip of the catheter into the suprarenal inferior vena cava Fig. 11 on page 18. This prevents the insertion in the inguinal region, so minimising the risk of bacteriemia in children, especially in those using diaper.
The causes of technique failure are due in most cases to the inability of peripheral vein cannulation, especially because of its small size. The puncture of veins of 2 mm increases the probability of perivenous haematoma formation Fig. 12 on page 19. The solution to this mishap could be to try a more cranial puncture or try, as mentioned before, the cannulation of the infraclavicular axillary vein or internal jugular vein; in this case it would be a centrally inserted central line. Another cause of failure could be vasospasm Fig. 13 on page 20 due to repeated manipulation of the vein with the needle or guide wire; a solution for this is to wait a few minutes until it recovers or insert the catheter in the other arm.

Among the complications of puncture, we can find a ruptured vein or an artery puncture with the risk of forming a pseudoaneurysm. To avoid these, we must be very careful in the initial choice of the vein and the puncture site, using the Doppler of the ultrasound to confirm a venous flow, and the needle as thin as possible to produce less trauma to the vessels.

The most feared complication of any central venous line, regardless of the method of insertion or whoever is placing it, is a catheter-associated bacteriemia. It can be caused by contamination of the entry site during placement, or later during handling and care of the central line. We can directly influence in the placement part, so we use aseptic techniques as described above (ex. surgical hand washing or cleaning the entry site with antiseptic solutions). We can minimise medium to long term bacteriemia indirectly if we use venous territories with less colony formation as the arm, or if we use methods of catheter fixation to the skin that are comfortable to handle and change by the nursing staff.

If you would like to have more information about this subject, we recommend the following readings:

Images for this section:

Fig. 1: Indications of a peripherally inserted central lines

- Short term endovenous treatment
- Anticipating future shortages peripheral lines
- Needle phobia
- Infusion of hyperosmolar solutions or parenteral nutrition
- Parenteral antibiotics
- Repeat blood samples
Fig. 2: Advantages of a peripherally inserted central lines

- Decreased repeated venipunctures
- Whole child mobility
- Low rate of complications, infections, thrombosis and thrombophlebitis
- Preserve veins
- Possibility of outpatient treatment
Fig. 3: Schemes of deep (A) and surface (B) venous systems of the right upper limb, and central venous structures of the upper chest.
Fig. 4: Animation of insertion of peripherally inserted central line
Fig. 5: Insertion of a peripherally inserted central line in right basilica vein.
Fig. 6: Insertion of a peripherally inserted central line in right axillary vein
Fig. 7: Insertion of a peripherally inserted central line in right arm vein. Checking the guidewire
Fig. 8: Insertion of a peripherally inserted central line in right arm vein. Measuring the catheter.
Fig. 9: Insertion of a peripherally inserted central line in right arm vein. Checking the tip of catheter.
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Table 1
Fig. 10: Insertion of a peripherally inserted central line in left upper limb vein. Replacing the guidewire.
Fig. 11: Insertion of a peripherally inserted central line in right femoral vein.
Fig. 12: Hematoma around brachial vein.
Fig. 13: Spasm of brachial and axillary veins.
Results

From June 2010 until October 2011 we placed 63 peripherally inserted central lines (PICC), all of them with ultrasound guidance for venopuncture, and in all fluoroscopy was used for catheter placement, except in a case in which the procedure was performed in the intensive care unit.

The age of patients ranged from 7 months to 19 years, with a mean age of 7 years.

Gender distribution was 43 males (64%) and 20 women (36%) Fig. 14 on page 24.

In half of the cases, 29 (48%), the central line was exclusively for the administration of antibiotics, especially in children with cystic fibrosis who went to their home with the central line and received care in their health centre or referral hospital. In 26 patients, 43%, it was for several simultaneous uses such as chemotherapy, antibiotics (infants with septic arthritis, osteomyelitis, etc), blood transfusion, blood extractions, etc. Fig. 15 on page 24.

44% of PICC lines were requested by the Oncology department, in some cases to be used in the meantime until the placement of a subcutaneous port. Followed by the Orthopaedic department and Cystic Fibrosis unit Fig. 16 on page 25.

In terms of priority, half of the patients were non-urgent and scheduled, and half were "urgent", defined as those inserted in the same day or the following to the requisition. 86% of children were inpatients at the time of insertion Fig. 16 on page 25.

Almost all patients required the collaboration of the anaesthetist, who employed either laryngeal mask airway or endotracheal tube. Of the 14 children who were not anesthetized, two were sedated and were younger than one year old, one in the PICU (peripheral vein insertion was not achieved) and the other one was sedated by her physician in the interventional radiology suite, with satisfactory results. The other 12 patients cooperated enough to perform the procedure, and were aged between 8 and 19 years. For various reasons (nervousness, simultaneously performance of biopsy / bone marrow aspirate, etc.) other children in this age range required anaesthesia Fig. 17 on page 26.

In all patients we used ultrasound and fluoroscopy guidance. In most some vein of the arm above the elbow was cannulated (basilica = 28, brachial=23 or cephalic = 8); this is a priority in our service to provide a better quality of life for the patient, because at this age...
it is essential that the child can play, draw, write, read, etc. In a seven months old infant with a mediastinal mass, the right superficial femoral vein was used to leave the catheter tip in the suprarrenal inferior vena cava; in this case it was not possible to place a central line into a vein in the chest or upper limb, or neither the placement of a subcutaneous port at the time of diagnosis. Fig. 18 on page 27

In 92% of cases the catheter tip was placed at the entrance of the right atrium, in the lower 1/3 of the superior vena cava or in the suprarrenal inferior vena cava, considering the procedure as GOOD. In 2 children the procedure was ACCEPTABLE since the tip was left in the subclavian vein, a localization that enables a regular use of the catheter. In 3 patients the technique was not satisfactorily completed: in two of them due to venospasm and in the other patient the insertion could not be finished in a peripheral vein in a child sedated in the PICU. Fig. 19 on page 28

It should be noted that, like in any interventional procedure, a learning curve is required, those cases of technique failure occurred at the beginning of implementing the procedure in our service. Currently all insertions are acceptable; in the cases that a peripheral vein approach is not achieved in the arm, we try to use the internal jugular vein or infraclavicular axillary vein, leaving the outer end of the catheter fixed to the anterior chest wall. These approaches allow us to decrease the age of insertion of a central line up to a month old in our unit, and in cases in which we think that venospasm or perivenous hematoma have happened during puncture of a vein, we can nowadays ensure that the child leaves the interventional radiology suite with a central line.

The average time of the procedure during the study period was 30 minutes, not including the time required for anaesthesia (induction and awakening). Fig. 19 on page 28

Most catheters were single lumen, only in 4 patients two-lumen catheter were placed at the request of the attending physicians, according to the use that was planned for those central lines, especially cases requiring parenteral nutrition and simultaneous administration of other medication. The calibre of the catheters was always greater than 3F, which allows blood extraction. The diameter depends on the child's age and the use planned for the central line. Fig. 20 on page 29

In our experience, apart from the technical difficulties to implement a new procedure in a Radiology service, we have the difficulty of demonstrating to our clinical colleagues the benefits of inserting a central line in peripheral veins of the arm. These benefits must be greater than the risks of bacteraemia and thrombosis of any central venous catheter, complication that did not occur in our sample for reasons attributable to the insertion technique in the first days after placement.
Images for this section:

Fig. 14
In "OTHER" includes most cancer patients (especially for chemotherapy, antibiotics, blood samples, etc.)
Fig. 16
The children without anesthesia were aged between 8 and 19.

Fig. 17
Fig. 18
**RESULTS**

**GOOD**: catheter tip at the entrance of the right atrium, in the lower 1/3 of the superior caval vein or in inferior caval vein

**ACCEPTABLE**: in subclavian vein

**BAD**: two venospasms, and one bad clinical conditions

**Fig. 19**
Most of the catheters used were of one lumen and 4F, in relation to the use of the central line and the age of patients.
Conclusion

Peripherally inserted central lines are useful in the treatment of many diseases requiring antibiotic therapy, chemotherapy, nutritional support, etc.

Upon insertion and placement it is very important the use of fluoroscopy, for a correct positioning of the tip of the catheter, and ultrasound.

Ultrasonography enables the access in nonpalpable veins with greater safety and fewer complications. With adequate training it is possible to cannulate even vessels of 2 mm of diameter in the arms, and thus being able to use at least 3F catheters (1 mm).

The cannulation of veins in the upper limb above the elbow increases the comfort and autonomy of the child, and facilitates nursing care.

In our centre there has been a major change in the management of certain diseases, which sometimes until we introduced this technique were solved with peripheral lines, with the discomfort and morbidity that entails.

We should emphasize that all central venous lines have their complications, the most feared is catheter-related bacteraemia. To minimize it is in our hand, this requires aseptic insertion techniques and the use of body regions with less chance of contamination (such as the arm). Therefore we must agree on the indication, use and suitability of the central line with the attending physician, according to the clinical context of the child.

References

Personal Information

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