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A GAVeCeLT bundle for PICC-port insertion: The SIP-Port protocol

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Abstract

In the last decade, a new type of brachial port has been introduced in clinical practice, the so-called "PICC-port." This is a brachial port, but inserted according to the methodologies and technologies currently adopted for the insertion of peripherally inserted central catheters (PICCs). Several studies have shown that PICC-port insertion is safe, not associated with any relevant immediate or early complication, and that the expected incidence of late complications is significantly lower if compared to "traditional" brachial ports (i.e. inserted without ultrasound guidance). Furthermore, PICC-ports yield excellent esthetic results and are associated with optimal patient compliance. This paper describes an insertion bundle—developed by GAVeCeLT, the Italian Group of Long Term Venous Access Devices, and nicknamed "SIP-Port" (Safe Insertion of PICC-Ports)—which consists of few evidence-based strategies aiming to further minimize all immediate, early, or late complications potentially associated with PICC-port insertion. Also, this insertion bundle has been developed for the purpose of defining more closely the differences between a traditional brachial port and a PICC-port. The SIP-Port bundle is currently adopted by all training courses on PICC-port insertion held by GAVeCeLT. It includes eight steps: (1) preprocedural ultrasound assessment utilizing the RaPeVA (Rapid Peripheral Venous Assessment) protocol; (2) appropriate skin antiseptic technique and maximal barrier precautions; (3) choice of appropriate vein, in terms of caliber and site; (4) clear identification of the median nerve and of the brachial artery during the venipuncture; (5) ultrasound-guided puncture and cannulation of the vein; (6) ultrasound-guided tip navigation; (7) intra-procedural assessment of tip location by intracavitary ECG or by trans-thoracic echocardiography; (8) appropriate creation and closure of the subcutaneous pocket.

Keywords

Ultrasound guidance, standardized assessment, central venous access, patient safety, peripherally inserted central catheters, PICC-ports, brachial ports, arm port

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Introduction

The insertion of totally implantable venous access devices with subcutaneous reservoir (ports) is a widely used procedure in clinical practice. Ports are usually preferred in cancer patients undergoing chemotherapy and requiring infrequent access (less than once per week).

In the last four decades, ports have been inserted mostly by direct cannulation of deep veins of the supra/infraclavicular area, with subcutaneous placement of the reservoir above the major pectoral muscle (so-called "chest-port"). Since its introduction in clinical practice in the 80s, chest-port insertion has been regarded as a relatively invasive procedure potentially associated with immediate complications (pneumothorax, hemothorax, arterial puncture,

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arrhythmias, air embolism) and late complications (thrombosis, occlusion, infection, catheter pinch-off).[1,2]

Therefore, in the 90s, a new type of port was developed, with the intent of reducing the invasiveness of chest ports. This new device was meant to be implanted in the arm and it was called "brachial port" or "arm port." In the beginning, brachial ports gained some popularity among patients and nurses, since they were less invasive, and they were associated with good cosmetic results.[3,4] Though, since the catheter was inserted by direct puncture of the superficial veins of the antecubital area or by fluoroscopy-guided puncture of deep veins of the arm or even by venous cutdown, brachial ports were inevitably associated with increased risk of venous thrombosis, and high risk of failure of venous cannulation, as shown by several meta-analyses.[5,6] Very soon, the use of brachial ports was largely abandoned in most oncologic hospitals, with the only exception of few centers in Germany, Japan, and France.[7–9]

In the last decade, a new type of brachial port has been introduced in clinical practice, that is, the so-called "PICC-port." As the name suggests, we define "PICC-port" as a brachial port which is inserted according to the methodologies currently adopted for peripherally inserted central catheters (PICCs): preprocedural ultrasound evaluation of the deep veins of the arm, so to choose a vein of appropriate caliber; ultrasound-guided venipuncture using micro-introducer kits; insertion of a small bore (5 Fr) catheter using the modified Seldinger technique; intraprocedural assessment of the location of the catheter tip (preferably by intracavitary ECG or echocardiography); creation of the pocket for the reservoir above the biceps muscle.

Several studies have shown that insertion of PICC ports is safe (since is not associated with any relevant immediate complication), it yields very good cosmetic result, it is associated with optimal patient compliance, and it is relatively inexpensive (since it does not require fluoroscopy and it can be performed under local anesthesia in a low-cost procedure room). Furthermore, the overall incidence of late complications (thrombosis, infection, occlusion, etc.) is similar for PICC-ports and chest ports.[10–14]

Over the last 20 years, The GAVeCeLT (the Italian Group of Long-Term Venous Access Devices) has developed many protocols and bundles—based on the current best available evidence—so to standardize different venous access procedures. Specific bundles have been proposed for the insertion of Centrally Inserted Central Catheters (CICCs),[15] of Femorally Inserted Central Catheters (FICCs)[16] and of PICCs.[17,18]

The aim of this paper is to present a novel insertion protocol for PICC-port, nicknamed "Safe Insertion of PICC-Port (SIP-Port)." It consists of eight different steps which correspond to evidence-based recommendations that, if applied correctly and systematically, may guarantee a safe, successful, and cost-effective procedure (Table 1).

Preprocedural assessment

Proper pre-procedural assessment begins with an adequate anamnestic evaluation. It is important to learn whether the patients had previous venous access devices, or history of difficult venipuncture, or previous venous thrombosis. The coagulation status of the patient, as well as use of antithrombotic therapies, should be considered before inserting the port.[19] Specific contraindication to PICC-port insertion should also be excluded. As for PICC insertion, bilateral contraindications include the evidence of an obstruction/compression of the superior vena cava (or of both innominate veins), or the presence of chronic renal disease of stage 3b, 4, or 5. Local contraindications (paresis of the arm, previous dissection of the axillary lymphatics, major orthopedic abnormalities, etc.) are the same as for PICCs.

The most appropriate vein for cannulation should be chosen after a systematic ultrasound evaluation of the deep veins of the arm.[15–18,20,21] In this regard, we suggest using the same protocol adopted before PICC insertion, the Rapid Peripheral Vein Assessment (RaPeVA): this is a systematic ultrasound evaluation of the veins of the arms and of the cervico-thoracic area (bilaterally), and it has been previously described.[17,18] Ultrasound assessment of the superficial and deep veins of the forearm and arm is performed using a 7–12 MHz linear transducer. The probe is placed transverse to the main axis of the arm, so to obtain a panoramic view of the veins and of other relevant structures such as arteries and nerves.[18–20]

The RaPeVA is performed according to a systematic approach, consisting in seven steps: (1) visualization of the cephalic vein at the antecubital fossa; (2) sliding of the probe from the radial side to the ulnar side, identification of the brachial artery and brachial veins, and of the confluence between antecubital vein and basilic vein; (3) sliding the probe upwards, identification of the basilic vein in the bicipital-humeral groove; (4) examination of the nerve-vascular bundle of the arm; (5) moving laterally over the biceps muscle, visualization of the cephalic vein at midarm; (6) visualization of the axillary vein in the infraclavicular area; (7) visualization of the internal jugular, subclavian, and brachiocephalic vein in the supraclavicular area.

The RaPeVA protocol ensures that the clinician systematically considers all possible venous options, choosing the best vessel and puncture site, based upon a real-time assessment. According to the suggestions by Nifong and McDevitt,[22] the ratio between caliber of the catheter and caliber of the vein should be 1:3 or less. Considering that the PICC-port catheter is usually 5 Fr, a vein of at least 5 mm should be chosen. As described below (step 3), the Zone Insertion Method[23] and the RAVESTO protocol[24] (RAVESTO = Rapid Assessment of the Venous Exit Site and Tunneling Options) will be used for evaluating the best site for the subcutaneous pocket.

Table 1. The eight steps of the SIP-P protocol.

Step 1	Pre-procedural assessment—systematic ultrasound examination of the veins of the arms (according to the RaPeVA protocol) so to choose the most appropriate vein and the best location for the reservoir
Step 2	Appropriate antiseptic technique—strict policy of hand hygiene, skin antisepsis with 2% chlorhexidine in 70% isopropyl alcohol, and use of maximal barrier precautions
Step 3	Choice of vein size and tunneling options—assessment of the diameter of the vein (considering that the ideal catheter-vein ratio should be of 1:3 or less), and evaluation of the opportunity of tunneling the catheter (considering that the reservoir should be in the green zone or on the border between yellow and green zone—according to Dawson's ZIM: thus, if the most appropriate vein is in the yellow zone the catheter must be tunneled)
Step 4	Clear identification of median nerve and brachial artery—identify each structure before venipuncture, using ultrasound
Step 5	Ultrasound-guided venipuncture—ultrasound-guided puncture and cannulation of a deep vein of the arm (either basilic, brachial, or axillary vein), preferably adopting the short axis/out-of-plane approach, always using a micro-introducer kit
Step 6	Ultrasound-based tip navigation—assess the correct direction of the guidewire by a supra-clavicular ultrasound scan (see the ECHOTIP protocol)
Step 7	Intra-procedural assessment of tip location—use intracavitary ECG and/or ultrasound (subcostal or apical view, using the "bubble test": see the ECHOTIP protocol)
Step 8	Appropriate placement of the reservoir—subcutaneous placement of the reservoir above the biceps muscle, creating the pocket by hydro-dissection with local anesthetic and normal saline), closing the incision with intradermal absorbable sutures and cyanoacrylate glue

RaPeVA: Rapid Peripheral Vein Assessment; ZIM: Zone Insertion Method; ECHOTIP: protocol of ultrasound-based tip navigation and tip location (see text).

Appropriate aseptic technique

The second step of the protocol addresses the antiseptic technique required during placement of a PICC-port.

Hand hygiene should be preferably performed by hydroalcoholic gel. In special cases, or when the hands are visibly dirty, the hydroalcoholic gel must be preceded by washing with antiseptic soap and water, according to current international guidelines on infection prevention.

For skin antisepsis prior to device insertion, 2% chlorhexidine in 70% isopropyl alcohol should be used.[25] Iodine povidone, in either aqueous or alcohol solution, may have a role only in case of known allergy to chlorhexidine. Regarding the application technique of the antiseptic, no clinical difference in microorganism reduction between the concentric circle versus the back-and-forth techniques has been demonstrated when both techniques are used equally on clean and healthy skin.[26]

As recommended by all current guidelines, the risk of bacterial contamination must be reduced by adopting maximal barrier precautions, which consist of non-sterile cap and facemask, sterile gown and gloves, full-size sterile drape over the patient, plus sterile cover for the ultrasound probe (long enough to cover both the probe and the cable when on the sterile field).[26–29]

These three cornerstones of infection prevention during insertion of venous access devices are the same recommended in the other insertion bundles developed by GAVeCeLT.[15–18]

Choice of vein size and tunneling options

The choice of the optimal vein to cannulate is crucial. As for PICC insertion,[17,18] an essential parameter to consider is the inner diameter of the vein (measured without tourniquet), which should be at least three times the outer diameter of the catheter. The intent is to maintain an ideal catheter-vein ratio (1:3 or less), so to reduce the risk of catheter-related thrombosis. Considering that the catheter of PICC-ports is usually 5 Fr, a vein of 5 mm (= 15 Fr) is required. Though, a vein of 5 mm may not be available at mid-arm. In this case, a larger vein (basilic or axillary) in the yellow zone is accessed, and the catheter tunneled to the green zone. The site of the pocket creation can be either in the green zone or on the border between the yellow and the green zone according to Dawson's ZIM[22,30,31] (Figure 1). A blunt tunneler should be preferred for tunneling the catheter. Insertion kits for PICC-ports usually provide this type of tunneler.[32] This approach is similar to the one adopted for PICCs (see the RAVESTO protocol)[24]: the decision whether tunneling or not tunneling the catheter depends on the presence of the best available vein in the yellow zone or in the green zone.

If no vein of at least 5 mm is available in the arm, the other arm may be considered. In case of bilateral contraindications to PICC-port insertion, an alternative option may be a chest port or a "chest-to-arm" port, that is, the creation of a long tunnel from a supra/infraclavicular puncture site to a subcutaneous pocket at midarm.[24]

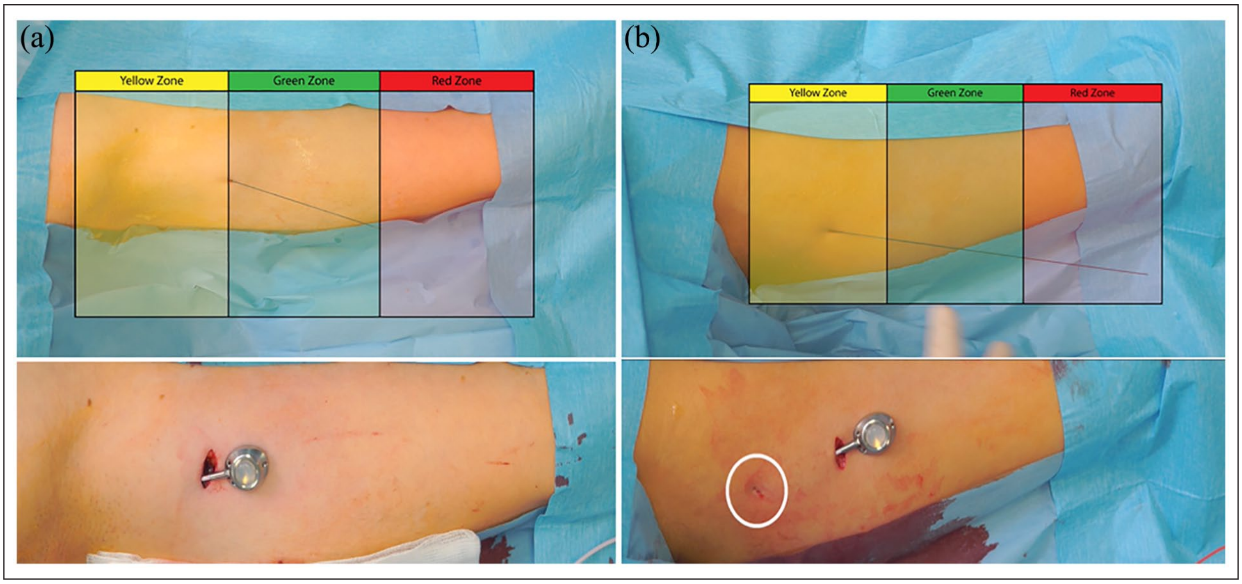

Figure 1. (a) If a vein of adequate caliber is available in the green zone, the subcutaneous pocket can be created directly at the venipuncture site and (b) if a vein of adequate caliber is available only in the yellow zone, the catheter is tunneled so to reach the subcutaneous pocket created in the green zone.

Clear identification of median nerve and brachial artery

As for PICC insertion,[17,18] clear ultrasound-based identification of the median nerve and brachial artery is an important step during the preliminary assessment and during the venipuncture. The median nerve is usually located close to the brachial artery (often above it), and appears as a hyperechogenic, non-compressible structure with an internal multiloculated texture. Accidental arterial punctures may be associated with local hematomas of varying degrees, but always reversible, while accidental injury to the median nerve may be associated with serious, even permanent sequelae.[27,31]

The ultrasound identification of these structures requires adequate ultrasound instrumentation (especially for the proper visualization of the nerve) and appropriate training.[15–18] (Figure 2)

Ultrasound-guided venipuncture

Ultrasound-guided venipuncture is now considered the gold standard for any catheterization of deep veins in adults and in children.[28] As regards the ultrasound-guided insertion of PICC-ports, a short axis view of the vein with an out-of-plane venipuncture is the preferred technique, being associated with an optimal panoramic view of all surrounding structures.[33]

Venous cannulation is performed using the modified Seldinger technique ("catheter through introducer"). The use of a micro-introducer kit—consisting of 21 G echogenic needle, 0.018″ nitinol-tipped guidewire, and micro-introducer/dilator of correct size (5.5 Fr) and length (5–7 cm)—is strongly recommended, since it allows a minimally invasive approach during vessel puncture and tissue dilation (Figure 3).

Ultrasound-based tip navigation

After catheter insertion into the micro-introducer, ultrasound is also used for assessing the correct direction of the catheter toward the ipsilateral brachiocephalic vein (ultrasound-based "tip navigation"), by scanning the veins of the supraclavicular area. This maneuver can be performed with the same linear transducer used for the venipuncture, as described in the ECHOTIP protocol.[34,35] Tip navigation with ultrasound has proven to be safer, easier, more widely applicable, and less expensive than fluoroscopy or electromagnetic tip navigation.[36] Tip navigation may not always be necessary: if the position of the tip is rapidly verified, for example by intracavitary electrocardiography (see below), tip navigation may be redundant and time consuming. On the contrary, if tip location is not immediate, it is wise to assess that the catheter has taken the proper direction toward the brachio-cephalic vein.

Intra-procedural tip location

The central location of the catheter tip must be assessed during the insertion procedure: post-procedural verification and secondary adjustment of catheter tip are overtly discouraged by current guidelines[27,28] and are regarded as a waste of time and resources, not excluding potential harm to the patient. The safest, simplest, most cost-effective, and most accurate intra-procedural method for tip location is intracavitary electrocardiography (IC-ECG).[37] Fluoroscopy-based tip location

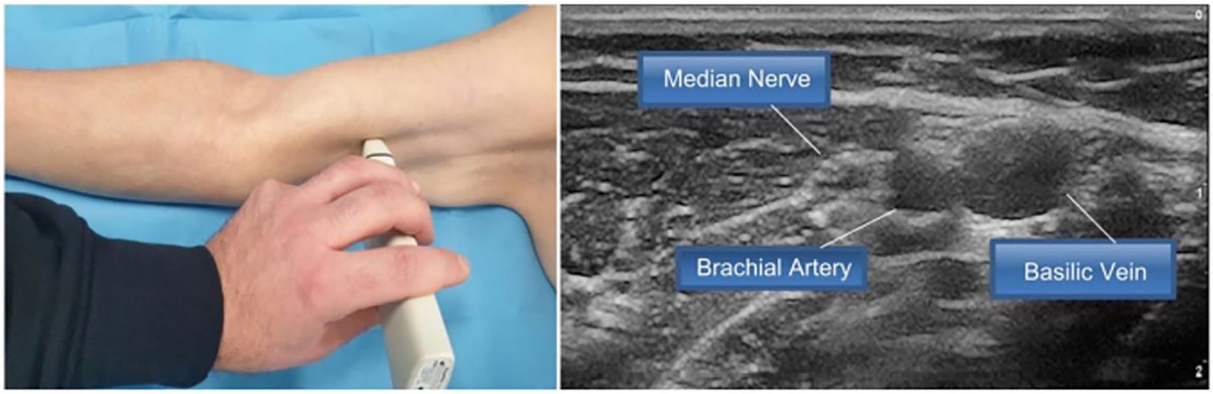

Figure 2. Clear identification of median nerve and brachial artery.

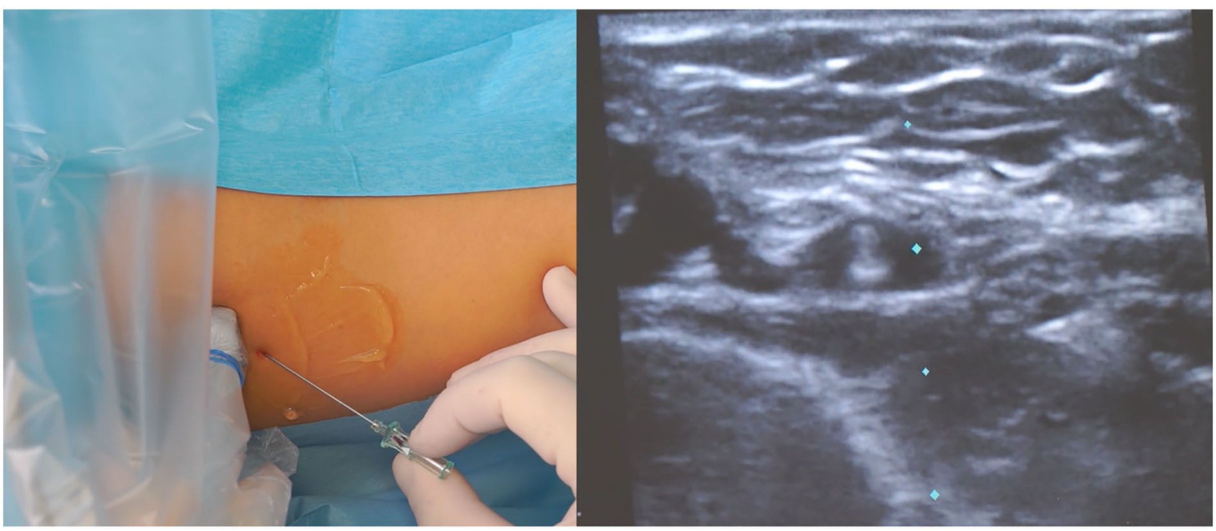

Figure 3. Short axis view of the vein and out-of-plane venipuncture technique.

is inaccurate, expensive, logistically difficult, and inevitably unsafe because it implies exposure to ionizing radiation.[27,28] The applicability of the IC-ECG method has been recently extended also to patients with atrial fibrillation.[38] In patients with absent P wave not because of atrial fibrillation but because of other causes (pacemaker and/or implantable cardioverter-defibrillator; some rare arrhythmias; etc.), an effective, inexpensive, and non-invasive intraprocedural method for tip location is trans-thoracic echocardiography, preferably using the "bubble test," according to a technique previously described in many studies.[28,39,40] Ultrasound-based tip location requires a convex or phased-array transducer, using either a subcostal or apical view.[34,35] However, this technique cannot replace IC-ECG in routinary clinical practice, since it is somehow less accurate than IC-ECG, and it requires more training; also, its applicability/feasibility is sub-optimal in adult patients.[28,34,35,39]

Appropriate placement of the reservoir

For this maneuver, we recommend using customized insertion packs, provided with disposable surgical tools, so to reduce manipulations, risks of bacterial contamination, and costs. An adequate subcutaneous pocket must be created above the biceps muscle, by hydro-dissection (subcutaneous infusion of long-acting local anesthetic and/or normal saline). The pocket should always be created with a "blunt" technique, avoiding sharp tools, to minimize the risk of injury to local structures and bleeding. The dimension of the reservoir—though mostly in the range of "very low profile" (approximately 8 mm high)—should be chosen on the basis of the size of the arm. A very small reservoir may be appropriate in a skinny arm, to minimize the esthetic impact of the device; bigger reservoirs may be appropriate in fatty arm, to facilitate the identification and the puncture of the septum.

Figure 4. The skin over the reservoir is closed with adsorbable intradermal sutures and cyanoacrylate glue.

After placing the reservoir into the subcutaneous pocket, the catheter is connected to the reservoir, and the proper function of the device (easy infusion of saline and easy aspiration of blood) is checked by accessing the reservoir with a Huber needle. It is advisable to trim the catheter 2 cm longer than the distance recorded by the IC-ECG, since 1 cm of catheter will be used for the connection to the reservoir, and the other extra cm will take into account that an approximate 1 cm sliding of the tip of the catheter far from the heart always occur when the patient moves from the supine to the upward posture.

The skin over the reservoir is closed with adsorbable, inverted intradermal sutures and with cyanoacrylate glue. The use of absorbable and inverted intradermal sutures yields a better cosmetic result of the scar and reduces the risk of infection.[41] Skin closure and sealing with glue has been proven effective in several patient populations, from neonates to adults,[42,43] in terms both of cosmetic result and of hemostatic and antimicrobial activity.[42–47] (Figure 4) N-Butyl-2 cyanoacrylate (NBCA) is documented to be faster to solidify and with higher tensile strength than 2-octyl cyanoacrylate (OCA). A recent study on ports has investigated the outcome of closing the skin with skin suture versus cyanoacrylate glue, finding that the latter technique did not increase the risk of local complications.[48]

At the end of the procedure, we recommend the local application of dry ice to reduce the risk of local ecchymosis, a frequent but clinically harmless event after positioning a PICC-port.[12] Though there is no strong supporting evidence, we commonly recommend the patients to keep the wound covered for 3 days and avoid immersion in water for at least 10 days.

Conclusions

PICC-ports are currently regarded as a safe and cost-effective alternative to chest ports. An insertion protocol as the one above proposed, which consists in a bundle of evidence-based strategies, may facilitate the appropriateness of the maneuvers, and protect the patient from insertion-related complications, either immediate (puncture failure, arterial injury, hematoma, nerve damage, etc.) or late (infection, venous thrombosis, etc.). Also, the definition of such bundle is essential to discriminate what is meant by "PICC-port" as opposed to a traditional brachial port: such differentiation is highly needed, since the overall performance of PICC-ports (particularly in terms of late complications and duration) are far superior to the performance of old-fashioned brachial ports. The correct implantation of the PICC-port respecting all these strategies allows the immediate use of the device for any type of infusion.

The use of a standardized insertion bundle is always a clinician-friendly strategy: it saves time and resources, improves safety, and ensures cost effectiveness. A consistent systematic adoption of all eight recommendations of the SIP-Port protocol may improve clinician performance while also providing a useful and evidence-based educational tool when teaching the fundamentals of PICC-Port insertion.

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