Recommendations from a formalized expert consensus

Good practice and risk management for the use of PICC
(Peripherally inserted central catheter)

December 2013
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- AFITCH-OR  French association of nurses for cellular and hematology therapy, oncology and radiotherapy
- FNEHAD  National federation of home hospital establishments
- FNI  National federation of nurses
- SFAP  French society for the accompaniment of palliative care
- SFAR  French anesthesia – critical care society
- SFM  French cystic fibrosis society
- SFNEP  French clinical and metabolism nutrition society
- SFP  French pediatrics society
- SFR  French radiology society
- SPILF  French language society for infectious pathology
- SRLF  French language society for critical care
- UNICANCER  National federation of cancer control centers

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## MAIN ABREVIATIONS

<table>
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<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>ABP</td>
<td>Alcohol based product</td>
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<tr>
<td>BAC</td>
<td>Bacteremia associated with a catheter</td>
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<td>CCC</td>
<td>Cancer control centre</td>
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<td>CDC</td>
<td>Centres for disease control and prevention</td>
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<td>CLABSI</td>
<td>Central line associated bloodstream infection</td>
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<tr>
<td>CRB</td>
<td>Catheter-related bacteremia <em>(BLC in Fr)</em></td>
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<td>CRI</td>
<td>Catheter related infection</td>
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<tr>
<td>CVC</td>
<td>Central venous catheter</td>
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<td>DVT</td>
<td>Deep venous thrombosis</td>
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<tr>
<td>Fr</td>
<td>French</td>
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<tr>
<td>GPR</td>
<td>Good practice recommendations</td>
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<td>HAS</td>
<td>French National Authority for Health</td>
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<td>HH</td>
<td>Home hospitalisation</td>
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<td>HMC</td>
<td>Hospital medical commission</td>
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<tr>
<td>ICU</td>
<td>Intensive care unit</td>
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<tr>
<td>MA</td>
<td>Moderate agreement</td>
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<td>PICC</td>
<td>Peripherally inserted central catheter</td>
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<td>PN</td>
<td>Parenteral Nutrition</td>
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<tr>
<td>PVC</td>
<td>Peripheral venous catheter</td>
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<td>SA</td>
<td>Strong agreement</td>
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<td>SU</td>
<td>Single use</td>
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<td>TIVC</td>
<td>Totally implantable venous catheter</td>
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Preface

Eighteen months after publishing a volume describing the "Prevention of infections associated with totally implanted venous catheters", the present recommendations deal with good practice and risk management related to the use of PICC (peripherally inserted central catheter). Using the same methodology, the working group elaborated these recommendations, which had become necessary as a result of the absence of any other reference documents on the subject, and the rapid dissemination of the technique, which has again become of current interest.

Indeed, our predecessors used this technique more than thirty years ago, and then abandoned its application in adults. Only intensive care neonatologists, confronted with venous access problems in premature babies, have continued to use PICC. Progress in materials and insertion techniques have brought these devices back into favour with physicians. As in the case of any new means of healthcare, it became important to define their indications and conditions of use, to ensure the safety and benefits of this technique, by limiting the risks associated with its use. These devices are indeed central venous catheters, and some studies, French in particular, have been able to show that complications associated with their use were not so uncommon [1-3]. It thus became indispensable that the SF2H establish a pluridisciplinary working group, for the purposes of elaborating an appropriate set of recommendations. Based on the model used for the recommendations drawn up for totally implantable venous catheters (TIVC), the present recommendations have been drafted while taking into account the different steps of PICC use, including their indications and contraindications, the choice of materials, their insertion, utilisation, and maintenance. As in the case of TIVC, these devices can be used in hospitals, and in the home care of patients. The same logic for the prevention of complications, infectious complications in particular, must prevail through the traceability of healthcare. The recommendations in this guide have been intentionally drafted in considerable detail, in order to harmonise and manage their modes of use. In the name of the SF2H, I would like to warmly thank the working group which prepared these recommendations, and extend my specific thanks to the three coordinators: Pascale Chaize, Anne Savey and Jean-Christophe Lucet.

Pr. Philippe BERTHELOT
PRESIDENT OF THE SF2H

REFERENCES
"PICC" are central catheters, whose peripheral insertion relies on access via a sufficiently large brachial vein. The anglo-saxon origin of this technique has led to the dedicated term of "PICC" or Peripherally-Inserted Central Catheter to wrongly describe these catheters.

The use if the PICC has encountered a recent revival in France. This device has nevertheless been well known for many years, and intensive care workers used it in the 1960s as a replacement for central venous catheters (CVC), at a time when there were often complications arising from the use of the latter devices. They were, and are still used in neonatology, and under these circumstances are known as a Jonathan catheter.

The success of PICC in the United States is not recent, since relevant publications date back to before the 2000s. The initial enthusiasm for these catheters has also been due to financial considerations, since it can be inserted by a nurse in the United States, as opposed to the insertion of a central venous catheter, which requires the presence of physicians and their associated costs.

Following this initial enthusiasm, and as in the case of any new technique, a progressively better understanding was gained of the advantages and drawbacks of PICC. Recent reviews of the literature moderate these opinions, showing that the rates of infection are of the same order as those associated with CVC, and that thrombotic complications are more frequent.

Mechanical complications are more frequent than in the case of CVC, and are due on the one hand to the small internal diameter of PICC, leading to a risk of catheter occlusion, and on the other hand to the fact that the catheters are inserted via a peripheral route, with an increased risk of thrombosis with respect to central venous access to a large venous trunk.

The third element to be taken into account when choosing to use a PICC, rather than another form of venous access, is that of the patient's comfort. The small number of studies dealing with this show that the use of a PICC reduces the pain associated with the regular re-insertion of a peripheral venous catheter (PVC), in children in particular.

In addition to any mechanical or infectious complications, there are risks when using a new technique. This involves, for example, the need to master the pulsed rinsing technique, and to ensure that the PICC stabilisation system is correctly serviced. Finally, the emergence of arm-level PICC could lead medical teams to believe that this type of device is a peripheral catheter, whereas the risk of it becoming infected is similar to that of a CVC, justifying the use of strict preventive measures during the manipulation of the venous line and the dressing.

It was thus necessary to draft recommendations on the indications for PICC, with respect to other forms of venous access, to control their use, and to provide recommendations on the specificities of these devices. This is a vast topic, and to our knowledge these are the first recommendations to provide a detailed description of the indications for, and insertion and maintenance of PICC.

Indeed, only a small number of international recommendations can be found, for example those of the Centers for Disease Control (CDC) drafted in 2011. Although these lines
were adopted by the French society for hospital hygiene (SF2H) in 2012, to provide an indication of the main elements of prevention, they cannot replace a detailed set of recommendations.

Some explanations can be found for the scarcity of literature and recommendations concerning PICC. Firstly, they correspond to a venous route that is rarely used in intensive care in France.

The literature on its epidemiology, the risk factors, and preventive measures are largely based on those relevant to short-term CVC used in intensive care.

PICC are used in many very different situations, in hospitals and external healthcare establishments, for short periods of a few days, or prolonged periods of several months, in services, which may or may not be competent in the care of immunosuppressed patients. It is thus understandable that it is more difficult to conduct studies and generalise their conclusions, when they are carried out with diverse services or patients.

In response to their utilisation in various situations, recommendations are needed for the benefit of many different healthcare professionals. Firstly, one needs to consider the PICC "inserters", reanimation-anaesthetist physicians and radiologists, following which the "users" are numerous, in hospitals dealing with haematology, cancerology, infectious diseases, paediatrics, surgery, intensive care, etc., with their medical and paramedical healthcare teams, as well as liberal professional nurses or those working in HH. Particular attention has been paid to the provision of recommendations that can be used in all fields of healthcare, and tools allowing PICC to be followed from one structure to another.

Two specific points warranted in-depth scrutiny: on the one hand the definition of indications allowing the use of PICC to be distinguished from other venous access devices, i.e. CVC, TIVC and PVC, in particular the duration of insertion beyond which PICC can replace a PVC, and beyond which it is preferable to use a long-term intravenous device (CVC or TIVC). On the other hand, it was necessary to propose appropriate recommendations for the insertion and cleaning of this device.
Methodology

Method selection

These questions led the SF2H to organise a working group in March 2012. A steering committee including the main relevant learned societies was created; it first defined the method to be used to elaborate the recommendations, and selected the most appropriate of these using a formal expert consensus, proposed by the French National Authority for Health (HAS) in 2010. This method was preferred to that of good practice recommendations (GPR), because it was applicable to a field in which the level of evidence for good practice recommendations is low, the literature is disparate and scarce, and because it was considered desirable to reach a consensus from a range of different horizons. Its main advantage resides in its ability to identify the degree of agreement between experts, with a recommendation development process associating an independent rating, followed by discussions within a rating group.

Theme boundaries

The steering committee also defined the domain for the elaboration of recommendations. It thus excluded the use of PICC in neonatology, for which the insertion and management are specific to the case of newborn babies. It was also considered that the rules for the management of lines should be perfectly coherent with those applicable to the management of TIVC lines, for which recommendations were published in 2011. Most of the recommendations on this theme could be transposed from TIVC to PICC. It would have been unacceptable for the healthcare teams if the recommendations for PICC and TIVC lines were discordant. However, the recommendations specific to PICC were drafted as a result of their specificities, for example the management of the fixation system (stabilizer).

Diagnostic criteria for infections, and the management of either infectious or mechanical PICC complications, were also excluded from the scope of the group's work.

The steering committee broke the group's work down into six major questions:

1. What are the insertion techniques, what equipment is available, and what are the costs of PICC?
2. What are the risks, when not only infectious complications, but also occlusive and thromboembolic complications are considered?
3. What are the indications, contraindications and selection criteria for PICC as opposed to other vascular access devices?
4. What are the preventive measures to be taken during the insertion of PICC?
5. What are the preventive measures to be taken during the use of PICC?
6. How should PICC be followed and monitored?

Bibliographical search and preparation of the tools

In addition to defining the boundaries of the recommendations, with the assistance of a certain number of experts on the subject, the steering committee elaborated a rationale.

To assist with the drafting of the rationale, the person responsible for the bibliography – assisted by a (NosoBase) documentalist – revised the levels of evidence found in the literature, in order to answer two questions, one dealing with the risks of infection related to the use of PICC, when compared to other vascular access devices, the other dealing with preventive measures during PICC insertion. The GRADE method was used to rate the relevant levels of evidence in the literature.

In parallel with the rationale, the steering committee constructed recommendation proposals, broken down into proposals that were submitted to experts for their rating.
Rating of the recommendations

The rating group included 23 experts, representing all fields of healthcare in which PICC are inserted or managed, and associating physicians and nurses, inserters and users, as well as the various relevant specialists.

The experts rated each of the 260 proposals from 1 to 9, according to whether they wished to absolutely exclude (rating 1), or absolutely retain (rating 9) this proposal.

Each of the two rating rounds was conducted independently by each expert; two meetings associating the experts with the steering committee were organised at the end of 2012, to debate opinions and reformulate the proposals, with the aim of reaching a consensus for the recommendations.

The principles for rating notation were those retained by the HAS in 2010: if all but 10% of the ratings (i.e. two notes in the case of this group made up from 23 experts) is rated between 7 and 9 (on a scale from 1 to 9), the ratings are already considered to have a strong agreement in the first round. In the second round, the ratings between 7 and 9 (with the exception of 10%) remain in strong agreement, and are considered to have a moderate agreement if they lie (with the exception of 10%) between 5 and 9.

The first and second rounds received 23 and 21 responses, respectively, from the 23 experts who were consulted. The rating led to the drafting of 112 recommendations having received a strong or moderate agreement. The working group also requested that the proposals and recommendations that had not reached an expert consensus, be retained and presented in italics.

Proofreading

Finally, a reading group was established, to give its opinion on the content and form of these recommendations, in particular their validity and applicability. The partner societies associated with the preparation of these recommendations were consulted, to identify proofreaders other than the members of the rating group, and some other learned societies also identified certain proofreaders.

Conclusion

These recommendations are valid at the present time, for equipment that is still hardly used in French hospitals. As is often the case, after an initial phase of enthusiasm, reasonable indications will appear, based on experience and the dissemination of knowledge.

It is also certain that the frequency of certain complications, in particular catheter occlusions, will decrease with the use of this equipment, training with the use of the pulsed rinsing technique in healthcare teams, and also the development of training programs for nursing students.

Other experiments are under way, for example the delegation of PICC insertion to trained nurses. The future will tell us whether these forms of organisation have been beneficial.

From all of these future changes, whether they be rapid or distant, one can anticipate that updated recommendations will become necessary in the coming years. For this reason, the SF2H will make these recommendations available to users through a frequently asked questions (FAQ) forum, in order to allow these recommendations to remain dynamic, and to prepare for their future evolution.
Recommendations

Indications for the use of PICC

**SELECTION CRITERIA FOR THE INDICATIONS (EXCLUDING NEONATOLOGY)**

1. In all medical disciplines, the use of a PICC may be proposed:
   - whenever a reliable venous access is necessary (rather than a peripheral access), for an expected length of time greater than or equal to 7 consecutive days, and if the duration of the foreseen treatment is less than or equal to 3 months (SA),
   - for adults and children (SA) (reminder: neonatology is excluded from these recommendations),
   - for a patient affected by thrombocytopenia or neutropenia (SA),
   - for a patient who refuses an TIVC or in the case of temporary contraindication for an TIVC (SA),
   - in an adult or a child

There is no consensus on the insertion of a PICC for perioperative care, in the case of a patient who is already fitted with an TIVC (to protect the TIVC from any risk of infection).

**SELECTION CRITERIA FOR THE EQUIPMENT**

2. If a multi lumen PICC is not necessary, a single lumen PICC should be selected.

3. Before inserting a PICC, verify that the selected vein is permeable, compressible and has a diameter compatible with that of the catheter (SA).

There is no consensus on the need to use Doppler echography to verify the presence of a variable flux in the selected vein, before insertion of a PICC.

4. To prevent deep vein thrombosis (DVT) phenomena, and superficial thrombophlebitis:
   - select a PICC having a diameter smaller or equal to one third of the diameter (measured when an axillary tourniquet is applied) of the vein to be punctured (SA),
   - for a single lumen PICC, select, preferably, a diameter less than or equal to 4 Fr (SA), and for a multi lumen PICC select a diameter less than or equal to 5 Fr (MA).

5. A "high pressure" PICC is indicated whenever it is foreseen to inject a contrast agent at an injection rate of 5 ml/sec (SA).

**SELECTION CRITERIA IN SURGERY, ANESTHESIA, CRITICAL CARE, AND ICU**

6. A PICC can be proposed:
   - instead of a CVC in a subclavian, non-tunneled internal jugular, or non-tunneled femoral position (SA),
   - in a patient with a tracheotomy, with a fistula or cervical stoma, instead of a non tunneled internal jugular CVC (SA).

7. To avoid the mechanical risks associated with a percutaneous subclavicular or internal jugular access, a PICC is indicated in the case of a patient with any hemostatic disorders (SA).
8. To avoid the mechanical risks associated with a percutaneous subclavicular access, a PICC is indicated in patients with a major respiratory insufficiency (SA). There is no consensus concerning the indication for a PICC in patients with a major respiratory insufficiency, to avoid the mechanical risks related to an internal jugular access.

9. The insertion of a PICC is not indicated in the case of a shock requiring rapid filling (SA).

10. In the care of severe burn victims, a PICC may be indicated, whenever the patient is in a stable hemodynamic situation (SA).

11. A PICC allows CVP (central venous pressure) to be measured (SA).

12. A PICC should not be inserted for parenteral nutrition, if enteral nutrition is possible (SA).

13. A PICC can be used instead of a CVC in patients under temporary continuous parenteral nutrition for a period of 7 days or more (e.g. a patient with temporary digestive exclusion) (SA). The insertion of a PICC should be preferred to that of a totally implanted venous catheter, for less than 1 month of parenteral nutrition (SA).

14. In parenteral nutrition, and in the absence of any simultaneous intravenous treatment, it is preferable to fuse a single lumen PICC or the administration of a nutrient mixture (SA). There is no consensus on the absolute need to use a dual lumen PICC, simultaneously with parenteral nutrition, in the case of intravenous treatment. There is no consensus:
   - on the recommendation not to use a PICC for prolonged cyclic parenteral nutrition, in homecare for a period of more than three months,
   - on the use of a PICC being preferable to the that of an already inserted TIVC, for parenteral nutrition for a period of less than one month.
   - on the recommendation not to use a PICC for parenteral nutrition, if the patient (or his/her relatives) wishes to handle the delivery line connection and disconnection techniques himself/herself.

15. In hematology, a PICC can be proposed:
   - in the case of a therapeutic emergency (SA),
   - for induction therapy for acute leukemia (SA),
   - for the treatment of idiopathic myelosuppression (SA),
   - to provide therapeutic intensification of an already treated hematological affection (Hodgkin's lymphoma, non-Hodgkin's lymphoma, myeloma, …) (MA),
   - in the case of an autograft or allograft of the hematopoietic stem cells (MA).

16. In oncology, a PICC is not the preferred device for the prolonged (greater than 6 months) or discontinuous treatment of solid tumors (SA).

17. In oncology, a PICC can be indicated in the case of thoracic cutaneous metastases (e.g. breast cancer) preventing the insertion of an TIVC access (SA).
**OTHER SELECTION CRITERIA**

18. A PICC can be proposed:
   - to ensure continuous or discontinuous antibiotic delivery at home, including the case of patients affected by cystic fibrosis (SA),
   - to improve the comfort of an end-of-life patient (SA).

19. If a central venous line is necessary, a PICC can be proposed even in the case of non-controlled bacteremia (MA).

**CONTRAINDICATIONS FOR PICC**

20. The insertion of PICC is contraindicated:
   - in patients affected by kidney failure, for whom the need for an arteriovenous fistula is expected (SA),
   - close to an old or recent site of axillary node dissection (SA),
   - in the case of lymphedema of the upper limb (SA),
   - in the case of infectious lesions of the upper limb (SA),
   - close to chronic skin lesions (SA),
   - a thromboembolic disease associated with a known genetic anomaly (SA),
   - locoregional radiotherapy with homolateral irradiation of the upper trunk or the scapular girdle (SA),
   - a thrombophlebitic history of the upper limb (MA).

There is no consensus concerning the insertion of a PICC, for the following contraindications:

- a history of deep venous thrombosis,
- insertion on the side affected by a tumour, in the case of breast cancer,
- insertion, in the case of bilateral breast cancer,
- insertion, in the case of motor, peripheral sensory, or upper limb disorders.

**Insertion of a PICC**

22. All PICC used in healthcare must have a class 3 medical device CE marking (regulatory).

23. A collegial decision should be implemented, concerning the PICC to be used in a healthcare establishment (pharmacy, inserters, users, infection control team, … ) (SA),

24. Reserve the use of dual lumen PICC for specific indications (e.g. the need to deliver products that are incompatible or require different flow rates (SA),

25. Select a PICC allowing the use of high pressures, if iterative CT imaging is foreseen with the injection of a contrast agent (SA),

There is no consensus concerning a preference for:

- a polyurethane PICC,
- a PICC with an integrated valve, whether it be proximal or distal (Groshong type) to reduce the risks of infection or occlusion,
- a PICC of previously adjusted length, to avoid shortening of the catheter; or in the case of shortening, no consensus on the
type of cut (proximal or distal), nor on the use of a "guillotine" (as opposed to a craft knife or scissors).

**CHOICE OF INSERTION SITE**

26. A PICC is inserted in the veins of the upper limb, with a preference for the basilic vein, if not the brachial vein. As a last resort, the cephalic vein can be used (SA),

There is no consensus on the choice of the nondominant arm.

**PREPARATION**

27. Outside emergency situations, the insertion of a PICC should be a planned act (SA).

28. The insertion of a PICC can be carried out:
   - in a dust-controlled environment (operating room) (SA),
   - in a room for interventional radiology (SA),
   - in intensive care (SA),

There is no consensus on the possibility of inserting a PICC in the patient's room (outside an intensive care situation).

29. In the case of topical local anesthesia, this should be carried before the application of antiseptic (SA).

30. The insertion of a PICC is carried out under conditions of surgical asepsis (hand hygiene, operator's garments). The patient is given skin preparation in accordance with the SF2H recommendations (pre-operative preparation, hair removal techniques, large surgical drapes, alcohol-based antiseptic, compliance with recommended durations, …). The patient must wear a surgical mask and a surgical cap (SA).

31. The insertion of a PICC is carried out together with cardiac monitoring (SA).

32. When outpatient care is used, its organization must allow the recommendations for insertion site preparation to be respected (SA).

**INSERTION TECHNIQUE**

33. The choice of vein and puncture site is made using ultrasound guidance. The puncture is carried out above the crook of the elbow, so as to avoid hindering elbow flexion (SA).

34. During insertion, real-time ultrasound guidance shall be used. The ultrasound guidance is carried out in accordance with ultrasound recommendations, in a sterile zone (single-dose gel and sterile sheaths) (SA).

Although there are techniques allowing its movements to be observed, there is no consensus on monitoring the progression of the PICC's distal end during insertion.

35. The end of the PICC is positioned at the junction of the superior vena cava with the right atrium. Its external length is to be minimized. The position of the distal end is verified at the end of the procedure (radioscopy, ultrasound, ECG guide, chest x-ray, …). Its correct positioning, inserted length, and external length are noted at the end of the procedure (traceability in the patient's medical file) (SA).
36. Antibio prophylaxis is not necessary for the insertion of a PICC (SA).

There is no consensus on the systematic screening for Staphylococcus aureus carriers before insertion of the PICC, nor on the decontamination of carriers.

37. The PICC must be retained in such a way as to avoid any accidental mobilization. It is attached to the skin by means of a specific fixation system ("stabilizer") (SA).

38. The initial dressing used to protect the PICC insertion site must be sterile and absorbent, on account of the exudation or bleeding to be expected during insertion (SA).

Cleaning and use of PICC

GENERALITIES AND EQUIPMENT

39. The dressing must not remain wet (SA CCI-R50). Showering is thus authorized, in the absence of an infusion delivery system, provided waterproof protection is worn (SA). If a shower or exposure to water is foreseen, the dressing (whatever its type) is protected with an impermeable material, and its integrity is checked beforehand and afterwards (SA CCI-R50). Daily cleansing of the patient must include his/her arm fitted with the PICC (SA).

40. Disinfection of the hands using an alcohol-based handrub is carried out before any manipulation of the dressing (SA CCI-R54). All gauze compresses used during manipulations must be sterile (SA CCI-R41).

41. The use of a prepackaged set facilitates care, in particular when it is carried out in the home (SA CCI-R40).

42. The insertion tip and the support system (excluding the clamp) of the PICC are protected using the same sterile dressing (SA). The dressing must be sufficiently large to ensure that it is watertight and can be cleaned (SA CCI-R52).

43. It is preferable to use a sterile, semi-permeable transparent dressing (complying with the EN 13726-2 standard), since it allows the insertion site to be inspected (SA CCI-R51).

44. In the case of discontinuous use, the end of the catheter is protected by a device that is sterile and protects it from being pulled off (SA). In the case of continuous use, the venous line connectors are protected by a sterile dressing (MA).

45. The application of an antimicrobial cream at the insertion site is not indicated (SA CCI-R50). The application of a degreasing agent or any irritating skin product is discouraged (SA). In the case of high-risk skin (GVH / graft-versus-host disease, children), film-forming agents can be proposed (SA).

46. Dressings soaked in antiseptic are not systematically indicated for the prevention of infections (SA).
**DRESSING REPLACEMENT FREQUENCY**

47. The first dressing replacement following PICC insertion is made the next day, if gauze was used. During the first dressing replacement, the specific support system ("stabilizer") is changed only if it is visibly soiled or has come loose (SA).

48. A sterile, semi-permeable transparent dressing can remain in place for a maximum of 8 days (SA). A non-transparent dressing (or in the case of the additional use of gauze for exudation) can remain in place for a maximum of 4 days (SA).

49. Any soiled or loose dressing must be replaced without delay (SA CCI-R58).

**DRESSING REPLACEMENT TECHNIQUE**

50. The operator wears clean professional garments; in the absence of professional garments, he/she wears a disposable smock (SA TIVC-R45). It is recommended to wear a sterile gown only if the patient is placed in protective isolation in a dust-controlled environment (Simple agreement TIVC-R45). The operator wears a surgical type of mask (SA TIVC-R45) and a cap (Simple agreement TIVC-R45). The operator wears disposable non sterile gloves for the removal of the dressing (standard precautions) (SA).

51. The patient wears a surgical type of mask (SA). This is installed in such a way as to optimize the care ergonomics (SA); sufficient removal of clothing is needed, to ensure skin preparation and for the safety of all manipulations (SA TIVC-R45). During replacement of the specific support system ("stabilizer"), the patient is placed in the lateral decubitus (otherwise in the dorsal decubitus) position on the side used by the PICC, with his/her arm abducted (SA).

52. In order to restrict accidental mobilization of the PICC, the semi-permeable transparent dressing must be removed by pulling it off (SA).

53. However, if sterile gloves have been used for the removal of the support system, they are changed for the following manipulations (SA).

54. The dressing replacement technique corresponds to the same principles of skin preparation at the time of insertion, whilst observing the required antiseptic durations (detersive cleaning, rinsing, drying, alcohol-based antiseptic application) (SA). For antisepsis of the skin, during the installation of a new specific support system ("stabilizer") and application of the dressing, the operator must wear sterile gloves (SA).
55. The specific support system ("stabilizer") (SA), followed by the dressing, are applied following spontaneous and complete drying of the antiseptic (SA TIVC-R56).

56. The programmed replacement of the dressing includes changing of the stabilizer and the proximal bidirectional valve, if present, in accordance with the manufacturer's recommendations (SA).

MANIPULATIONS AND MANAGEMENT OF THE INFUSION LINES

57. All manipulations are carried out under aseptic conditions, and following disinfection of the hands using an alcohol-based handrub. Whenever possible, these should be kept to a minimum and carried out at the same time, (SA TIVC-R71).

58. For the manipulation of any connector on the venous line, sterile gauze soaked in an alcohol-based antiseptic is to be used (SA TIVC-R71).

59. The simplest possible line assembly is implemented aseptically and the main line is changed not more than once every four days. It is preferred to use active injection systems, which reduce the risk of blood reflux, rather than gravity infusion systems (SA TIVC-R62).

60. If a safety connector is used, a system with a pre-split septum is preferred to certain systems that have a mechanical valve, in view of the risk of infection associated with these devices. It is thus necessary to implement monitoring of the incidence of bacteremia associated with the PICC (Simple agreement TIVC-R39). Choose a model with a (flat) connection surface that is easy to disinfect, that allows rinsing to be evaluated (transparent), and that is resistant to successive injections (impermeable) (SA).

61. For proximal manipulations, the operator wears clean professional garments; if clean professional garments are not available, a single-use gown should be worn in a hospital setting (Strong agreement TIVC-R73) and for community-based care (Simple agreement TIVC-R73).

62. For proximal manipulations, wherever these are performed, in addition to clean garments, the operator shall wear a surgical type of mask (Strong agreement TIVC-R74) and sterile gloves (Simple agreement TIVC-R74). For proximal injection into the infusion line, the patient shall wear a surgical type of mask. If he/she cannot wear a mask, he/she will be asked to turn his/her head towards the side opposite to that of the PICC (Simple agreement TIVC-R75).

63. The replacement frequency of the associated devices (stopcocks, stopcock ramps, valves or safety connectors) located at a distance from the insertion site shall match that of the venous line. These items should not be left in place for more than 4 days (SA TIVC-R78).

64. Use safe equipment (regulatory) compatible with the GERES (French Working Group on the Risk of Blood Exposure) criteria, and ensure that all devices used to make up the line are compatible, in order to minimize any variations in flow rate, leakage and breakage (SA TIVC-R34).
In cases where the PICC is not used (for a period equal to or greater than 4 days), the extension shall be removed and the line closed. The PICC shall be systematically rinsed whenever the dressing is replaced (SA).

Rinsing the PICC

Efficient rinsing involves the pulsed injection of 10 ml of 0.9% NaCl, through the use of successive impulses. Increase the rinsing volume to 20 ml of 0.9% NaCl in the case of a highly viscous product: following the administration of labile blood products, lipids, mannitol, or a x-ray contrast agent (SA). The use of syringes prefilled with 0.9% NaCl simplifies compliance with good practice (Simple agreement TIVC-R43). The rinsing efficiency is verified by the absence of any visible residues (Simple agreement TIVC-R42).

For the rinsing of positive pressure bidirectional valves: use pulsed rinsing and disconnect the syringe without clamping it, to maintain positive pressure (SA). For the rinsing of negative or neutral pressure bidirectional valves: use pulsed rinsing and clamp as long as the syringe is disconnected, to avoid any reflux at the distal end of the PICC (SA).

There is no consensus on the discontinuous use of a positive pressure bidirectional valve, when the there is no clamp or it is not accessible.

Injections and infusions

If a stopcock is inserted at the proximal end, it shall not be connected directly to the Luer tip of the PICC (SA).

The injection ports on the main line shall be kept at a distance from the drapes, through the use of an extension and a ramp support. The proximal connections and injection ports shall be protected and kept at a distance from any source of contamination (SA).

Verify the compatibility of the PICC and the components used on the infusion line (extension) and bidirectional valves) whenever products are injected at a high flow rate (CT scan, MRI) (SA).

Correct operation of the device is verified by the following indicators: presence of venous reflux, absence of spontaneous pain or pain during injection, good infusion flow rate (observed flow rate = expected flow rate), ease of injection when using a syringe (SA TIVC-R49).

The injection ports must always be disinfected before use. If the injection is made into a stopcock (without a safety connector or a bidirectional valve), it must be closed immediately after use with a new sterile cap. Each unused line is closed with a sterile device (SA TIVC-R80). When a safety connector (bidirectional valve) is used, efficient disinfection must be carried out using an alcohol-based antiseptic, before any use. It is essential to rinse the internal lumen whenever it has been used (SA TIVC-R81).

In order to limit the risk of obstruction during the administration of medication, an active infusion system shall be used (diffuser, volume pump, syringe pump). (SA). For all manual injections, use a syringe with a volume greater than or equal to 10 ml or a piston with a diameter greater than or equal to 10 ml.
than or equal to 1.5 cm (SA). Any injection of medication must be followed by efficient rinsing (SA).

**INFUSION TECHNIQUE**

74. Disinfection of the hands using a hydro-alcoholic handrub shall be performed before beginning any preparations for infusion. The preparation date and the additives shall be noted on the bottle or bag (SA TIVC-R64), whilst avoiding the use of markers or felt pens that could damage the plastic bags (Simple agreement TIVC-R64). Single-dose additives shall be used whenever possible (with the remaining liquid being discarded). Any turbid, cracked, broken or expired vial is unusable. Vial caps are disinfected using sterile gauze impregnated with an alcohol-based antiseptic (SA TIVC-R64).

75. Solutes prepared outside pharmacy departments should be used extemporaneously (SA TIVC-R65).

76. It is possible to pass blood or blood components through the PICC, provided thorough rinsing is applied following the infusion of these products (SA TIVC-R66). However, if another venous access is available, this alternative access should be preferred for the transfusion (SA TIVC-R66).

77. Connect blood and blood components to the proximal site (the closest to the patient) in order to simplify rinsing of the infusion device. The tubing of the infusion bag shall be replaced, for each new labile product. The length of time that may be spent administering a bag is less than or equal to 4 hours (SA TIVC-R67).

78. Connect lipid emulsions to the proximal site (as close as possible to the patient) in order to facilitate rinsing of the infusion device. The tubing shall be replaced at the same time as the bag (SA TIVC-R68).

79. In the case of pure lipids, the time spent administering a lipid emulsion is 12 hours or less. However, an administration duration of 24 hours is acceptable in the case of large volumes. In the case of combined lipid emulsions (administration of 3 in 1 volumes of amino acids and glucose), the administration duration is less than or equal to 24 hours (SA TIVC-R69).

80. With the exception of blood components and lipid emulsions, the tubing of secondary lines shall be replaced between two different products (SA TIVC-R70). Thorough rinsing should be performed in the vicinity of the connectors immediately after each tubing replacement, whenever a different product is used. In the case of continuous infusion of the same product, the tubing shall be replaced every 4 days (SA TIVC-R70). In the case of non-continuous infusion of the same product, the tubing shall be replaced immediately after each bag (simple agreement TIVC-R70).

81. There is no evidence of any advantage to be gained by routinely using a heparin lock, an antibiotic lock or an antibacterial lock (taurolidine, citrate) (SA).

**BLOOD SAMPLING**

82. It is possible to sample blood from the PICC, provided that: a well-defined procedure is available for the
technique, the asepsis and staff protection rules chosen for manipulating the proximal connection are observed, a single-use pump body is used for all sampling, including blood cultures, and the purged liquid is not re-injected (SA TIVC-R82).

83. When taking blood samples, the patient is asked to turn his/her head towards the side opposite to that of the PICC with his/her arm abducted, to facilitate venous return. In the absence of an antibiotic lock do not use the first 5 to 10 ml of blood, except for the purposes of blood culture (SA).

84. In the case of continuous infusion, blood samples are taken at the level of the proximal stopcock (to facilitate rinsing of the infusion line and the PICC, and to avoid any degradation of the sample) (SA).

PICC REMOVAL

85. The PICC is removed as soon as it is no longer needed (SA). The PICC may remain in place for sequential treatments (SA).

86. In the case of complications associated with a PICC (demonstrated PICC infections, venous thrombosis with an infectious syndrome, irretrievable obstructions of the internal lumen, uncontrollable pain), the PICC must be removed (SA).

There is no consensus on the room to be used for PICC removal, whether it be performed in the patient’s home, in a hospital environment, or in an independent practice.

87. Removal of the device is performed under conditions of strict asepsis, whilst observing standard precautions (SA). The operator shall wear a surgical mask (SA). He/she wears non-sterile disposable gloves for removal of the PICC, when the catheter is not cultured, or sterile gloves (and sterile scissors) when it is cultured (SA).

88. The patient is installed in the dorsal decubitus position (SA). He/she wears a surgical mask if the PICC is to be cultured (SA).

89. Antisepsis with an alcohol-based antiseptic, followed by the necessary drying time, is sufficient for PICC removal, with or without culturing (SA).

90. The PICC shall be pulled carefully, and as soon as its distal end has been removed, following which a pressure point is applied to prevent bleeding. Apply a sterile, absorbent and occlusive dressing for one hour, after having disinfected the skin. Note the length of the PICC and compare this with the initial length, in order to verify its integrity. If any resistance is encountered during the removal, do not apply strong traction since this could lead to breakage of the catheter (SA).
**General policy aspects**

**INFORMING AND EDUCATING THE PATIENT**

91. The patient shall be informed of the risks associated with the use of a PICC (including the risk of infection) *(regulatory)*. He/she is informed of any incidents which occurred following the insertion or use of the PICC (including infectious complications).

92. The PICC must be inserted only once the patient has given his/her approval. The patient's refusal constitutes a contraindication to the installation of a PICC, such that alternative solutions must be considered *(regulatory)*.

93. The patient or his/her close relatives shall be involved in the prevention (associated with tearing and infections, in particular) and in the detection of incidents (thromboembolic, infectious, etc., in particular) associated with the use of the PICC, through the use of an appropriate educative approach. They shall be informed about the conduct to be followed in the case of complications and shall be given telephone numbers to call. The information provided to the patient or close relatives shall be evaluated and, if necessary, re-adjusted on a regular basis during his/her hospital stay *(SA TIVC-R91)*.

94. For patients at home, a tracking form or surveillance notebook is given to the patient; the reasons for recording notes in the tracking form or surveillance notebook shall be explained to the patient or his/her close relatives *(SA)*.

95. The use of PICC for care in the home, involving parenteral nutrition, imposes specific education of the patient and/or his/her close relatives (as a consequence of the patient's use of the PICC in the absence of any nursing staff) *(SA)*.

**PROFESSIONAL TRAINING**

96. The insertion of a PICC constitutes a medical act *(regulatory)*. It is carried out by a trained or supervised operator *(SA TIVC-R18)*. The use of a PICC constitutes a nursing act *(regulatory)*. The removal of a PICC constitutes a nursing act, provided a physician is able to intervene at all times *(regulatory)*.

97. The personnel in charge of PICC use must receive specific training. A PICC is contraindicated whenever the healthcare teams in charge of the patient, in the hospital or in the home, have not received appropriate training. The healthcare structures in charge of PICC-wearing patients must identify the referent person in charge of the use of these devices *(AF)*.

98. Any change in the modalities for patient care or the use of equipment leads to the provision of information or training, to all professionals involved in the care network *(SA TIVC-R92)*.

99. The operators have access to good practice protocols dealing with the prevention of the risk of infection,
written, updated protocols dealing with the insertion, care/use and monitoring of PICC. Common protocols are to be shared within a given healthcare network (SA TIVC-R93).

**CLINICAL MONITORING AND TRACEABILITY**

100. Traceability is a legal obligation, whatever the premises in which the PICC-wearing patient is cared for. The traceability / accounting of PICC insertion is based on the patient's medical record AND the tracking form or surveillance notebook. In hospitals (including HH), the traceability of care is based on the patient's medical record AND the tracking form or surveillance notebook. For the patient at home, traceability is based on the tracking form or surveillance notebook (SA).

101. Sharing of the tracking form or surveillance notebook with all hospital or community-based actors is recommended (SA). All professionals who take care of a patient must be made aware of the importance of conscientiously making entries in the tracking form or surveillance notebook (simple agreement TIVC-R95). The administered treatment, medical acts, difficulties encountered and information given to the patient are recorded (SA).

102. The externalized length of the PICC is noted by the healthcare worker, whenever the dressing is changed. If the PICC is accidentally pulled, any impact on the position of its extremity should be evaluated, by comparing the externalized length with that initially recorded at the time of insertion. The externalized portion must not be reintroduced. In the absence of initial values or in the case of any doubt concerning the position of the PICC’s extremity, make an x-ray without opacification (SA).

103. It is indispensible to regularly perform clinical monitoring, in the search for any local or general complications inherent to the insertion or use of a PICC (SA TIVC-R94). The clinical monitoring, observed complications, PICC removal, and reason for its removal are to be recorded (SA).

104. Clinical monitoring shall search for any sign of complication (displacement, obstruction, thromboembolic complication, local / general / bacteremic infectious complication). Any local anomaly (poor permeability, edema, redness, pain, exudation, bleeding, … ) or the presence of general signs (fever +/- shivering, abnormal breathlessness, painful infusion, … ) must be reported as soon as possible (SA).

105. In the case of any clinical suspicion of thrombosis in a patient wearing a PICC, a Doppler ultrasound examination must be performed (SA). Whenever an infection is suspected, in the case of the decision to remove the PICC, it is necessary to send the PICC extremity to a bacteriological laboratory for culturing (SA).

**EPIDEMIOLOGICAL MONITORING, REPORTING, EVALUATION OF PRACTICES**

106. The knowledge and practices of professionals in charge of the insertion and use of PICC are evaluated on a regular basis (SA TIVC-R95). The use of a checklist during PICC insertion constitutes a
form of support for the compliance with measures for the prevention of infections (SA TIVC-R18).

107. In hospitals, a program for monitoring the risk of infection associated with PICC is established by the authority in charge of the control of nosocomial infections, and the infection control team in consultation with the relevant clinical departments (SA TIVC-R96).

108. The definitions for infections / bacteremia associated with a PICC used in epidemiological monitoring are those recommended by the CTINILS en 2007 (= ECDC 2012). The frequency – or cumulated incidence – of associated complications (infectious or not) is expressed per 100 PICC-wearing patients or per 100 PICC (percentage of complications) (SA). The incidence of associated complications (infectious or not) is expressed per 1000 days of exposure to PICC (incidence of complications/1000 days of PICC presence) (SA).

109. It is not recommended to systematically culture a PICC when it is removed at the end of treatment. However, if the monitoring of colonization or infection is envisaged, the systematic culturing of PICC after their removal can be recommended, provided a standardized technique (semi-quantitative or quantitative) is available for their analysis (SA TIVC-R97).

110. The need to maintain a PICC in place must be evaluated every day in healthcare institutions (including HH), and at a minimum, every time the dressing is replaced in the patient's home (SA). In the case of the implementation of a bundle (set of preventive measures), the daily evaluation of the need to maintain the PICC must be included (MA).

111. In the patient's home, the occurrence of a serious complication associated with a PICC (bacteremia, occlusion, thrombosis with clinical impact, death, infection justifying removal) must be reported to the reference hospitalization team (SA).

112. In a healthcare institution (including HH), the occurrence of a serious infection associated with a PICC (bacteremia, death, infection justifying removal) must be reported internally to the infection control team; the decision to make an external report is the responsibility of the hygiene specialist. The occurrence of an undesirable event associated with a PICC provokes a warning signal, in accordance with the provisions foreseen by the Hospital Medical Committee and the risk management coordinator. The occurrence of a serious undesirable event (bacteremia, death, infection or complication justifying removal) must be analyzed in terms of its cause (SA). Any incident related to the medical devices used for patient care = equipment monitoring, must be reported (regulatory TIVC-R33).
Rationale

Question 1

Characteristics of PICC catheters

This description of currently available equipment was made in October 2013. The materials described in this section have been included only as an example of the more commonly used types of material. This does not correspond to any preferential choice with respect to any other material that may be currently available or become available on the market.

Material

Two polymers can be used for the manufacture of PICC: silicone and polyurethane.

- Silicone has the advantage of its considerable flexibility and its better long-term tolerance. However, silicone catheters have a thick wall: for the same external diameter, the internal diameter of a lumen will be smaller, thus restricting its maximum flow rate.

- Silicone catheters are also less resistant to pressure.

- Polyurethane catheters have a thinner wall; therefore a wider internal lumen for the same external diameter, permitting greater flow rates.

  The greater resistance to pressure of polyurethane allows catheters resisting higher injection pressures to be manufactured.

  The flexibility of certain polyurethane PICC is now very similar to that of silicone catheters.

  One supplier (VYGON) proposes a silver-impregnated polyurethane PICC for antiseptic applications ("expert" technology) and the ANGIODYNAMICS company recently commercialised the BIOFLO PICC® catheter, whose polyurethane is modified by so-called Endexo technology (addition of fluorinated oligomers to the polyurethane polymer), and is reputed to reduce the risk of thrombosis.

Material

The catheter’s length lies in the range between 50 and 60 cm, and for all suppliers, with the exception of TÉLÉFLEX, this must be adjusted to the patient's anatomy.

The length is adjusted by cutting:

- the intravascular distal end (general case),
- the proximal end for the Bard GROSHING® catheter, which has a valve at its distal end. Cutting of the proximal end imposes the installation of a connector, once the catheter's length has been adjusted.

The catheter can be cut with scissors, a scalpel or the guillotine proposed in the insertion kit supplied with certain catheters. TÉLÉFLEX proposes several catheter lengths (40, 50 and 55 cm) in order to avoid the need to cut their flexible extremity (FLEXTIP®) and, in the case of multi-lumen catheters, to avoid having all of the lumens reaching the distal end of the catheter.

Number of lumens

All suppliers propose catheters with 1, 2 and 3 lumens, with the exception of B.BRAUN (CELSITE® PICC-Cel) who do not offer 3-lumen catheters.
Diameter

The standard diameters proposed by all suppliers are 4 Fr, 5 Fr and 6 Fr, although there are single lumen catheters with diameters equal to 2 Fr and 3 Fr, as well as 2-lumen catheters in 4.5 Fr and 7 Fr.

The diameter varies as a function of the number of lumens:
1 lumen: 2 Fr to 6 Fr (standard values are 4 and 5 Fr)
2 lumens: 4 Fr to 7 Fr (standard = 5 Fr)
3 lumens: 6 Fr

High pressure / maximum flow rate

All suppliers now produce PICC made with "high-pressure" polyurethane; compatible with high pressure injection (300 to 325 psi) and a high flow rate (5 ml/s) of contrast agents used in radiology.

The maximum flow rate and injection pressure are systematically indicated, either on the extension, the Luer tip, or the clamp.

The purple colour of the catheter is however not systematic.

The number of high-pressure injections that can be made with a catheter can be limited by the manufacturer (PEROUSE: 9 possible injections).

Valves

A bidirectional valve may be integrated into the catheter, or proposed separately:

Integrated into the catheter: it may be positioned at the distal end of the catheter (BARD GROSHONG®), or at the proximal end (BARD PICC SOLO2®, ANGIODYNAMICS BIOFLO®). In this case, the valve, which cannot be removed, will have a service life equivalent to that of the catheter.

Separate: the suppliers propose bidirectional valves with their catheters.

Similarly, when changing the valve, the user can replace it with:
- Another valve (for example, a valve referenced by the supplier)
- A stopper.

Depending on the supplier, the valves can be:
- with slightly negative flush (examples: MICROCLAVE [COOK and TÉLÉFLEX], BIONECITOR® [VYGON]).

Contrary to split septum valves, which are opened simply by piercing the valve with the connected Luer tip, these valves (indicated by the term "inverse split septum") have an internal trocar. When the Luer tip is connected the septum is pushed by the trocar, which cuts through it, thereby becoming inserted into the internal lumen of the Luer tip (mechanism comparable to that of the latex sleeves on Vacutainer® type vacuum sampling needles).

With this type of valve, referred to by the manufacturer as "neutral", disconnection of the Luer tip nevertheless leads to a small reflux of blood at the distal end of the catheter, thus requiring clamping during disconnection.

- with positive flush (examples: ULTRASITE® [B.BRAUN and BARD], MAXPLUS® [PEROUSE]).

Connection of the Luer is tip, achieved by compressing an internal elastomer, creates a small opening for the infusion solution, between the valve’s shell and the elastomer component. With this type of valve, disconnection generates a flush of a few microliters of liquid, from the valve to the distal end of the catheter: a positive flush.

Disconnection must therefore be made without clamping the catheter, in order to take advantage of this positive flush.

Attachment systems

PICC can be attached by conventional means, using sutures. However, all suppliers propose attachment systems.

The STATLOCK® (BARD) is the most common system, although other systems such as GRIP-LOCK® can also be found.
There are several Grip-Lock references sold by several companies (B.BRAN, TÉLÉFLEX, VYGON).

Depending on the brands and references, the shape of the recess made to receive the catheter hub can vary: it is thus important to verify the Grip-Lock's compatibility with the selected catheter. The Grip-Lock sold by VYGON has emerged as a multipurpose device, able to accept most catheters found on the market. Téléflex markets a Grip-Lock without a recess, which is thus a multipurpose device.

These attachment systems can be supplied separately, at both the hospital and in cities, for outpatients.

The Grip-Lock is also available in pre-packaged catheter maintenance sets (HARTMANN, VYGON) included on the list of French Social Security refundable products and services. These pre-packaged sets also contain a bi-directional valve.

A third system, KT Fix® (Safe Tee Fix), proposes a version with a 7-day service life (KTFIX MINI®) and a version which can be kept in place for 28 days (KTFIX PLUS®).

Insertion techniques and equipment

In their instructions, B. BRAUN and VYGON recommend the use of ultrasound guidance to locate the vein and guide venipuncture.

Venipuncture

All pre-packaged kits contain an approximately 7 cm long, 21G echogenic puncture needle.

This needle can be secured (PEROUSE, VYGON).

Some suppliers still propose devices for venipuncture without ultrasound guidance: short catheter (BARD), peel-apart cannula (BARD, VYGON).

Placement of a peel-apart Desilet

All suppliers propose a peel-apart Desilet with a dilator: length 5 to 10 cm, diameter: one half size larger than the catheter.

There are three techniques, and these justify the use of different types of guidewire:

- a) Measurement of the catheter's outer diameter: makes use of an approximately 50 cm long guidewire.
  Patient in lateral decubitus, arm extended at 90°: using a ruler supplied with the kit (B.BRAUN, PEROUSE, VYGON) the distance between the insertion site and the desired position of the catheter's distal tip is measured. The first 15 to 20 cm of the guidewire are inserted into the needle. The peel-apart Desilet is inserted onto the guidewire.

- b) Measurement of the catheter's inner diameter: makes use of a 60 to 80 cm graduated guidewire. Using fluoroscopy, introduce the guidewire until it reaches the desired distal position. Install the Desilet. Determine the length of guidewire: note the graduation or attach a clamp to the guidewire.

- c) Use of an approximately 30 cm guidewire: this allows the catheter to be inserted with the guidewire [Over The Wire OTW) technique]. It also allows the catheter to be changed on the guidewire.

Catheter fitting

Most catheters have a stylus in their lumen: this stylus must be pulled back from the cutting point by approximately 1 cm, to ensure that it is not crushed by the catheter cutting tool.

Catheter insertion

With the exception of the third case, involving a 130 cm guidewire / OTW technique, the guidewire and dilator are withdrawn and the catheter is inserted into the Desilet sheath. Once the catheter is in place, the peel-apart sheath and the mandrel are removed.

Graduated, 0.018 diameter guidewires can be made of steel or nitinol, with a floppy distal end made of tungsten or platinum, which is sometimes gold-coated to improve its visibility under fluoroscopy (B.BRAUN, and VYGON in the near future).
Cost comparison scale for PICC vs CVC or TIVC

Accurate costs cannot be indicated in this guide, in view of their rapid fluctuations, depending on market forces and/or technical innovations.

However, it is possible to indicate an order of magnitude: the cost of a CVC is approximately 10 € (5-15), whereas that of a TIVC, Broviac or PICC is approximately 75 € (70-80).

Variations are encountered, depending on the number of devices ordered, the number of lumens, the presence of an integrated valve, the accessories supplied with the pre-packaged kit, etc.

The cost of placement must also be included, and this is higher for a TIVC than for a CVC or a PICC.
Rationale

Question 2

Risks associated with the use of a PICC

Epidemiology, infectious, thromboembolic and mechanical complications (obstruction, accidental removal, displacement, air embolism, cracking, rupture, …).

PICC-associated risks compared with other vascular approaches

Introduction

Peripherally inserted central catheters (PICC) are now offered as a replacement for tunneled or non-tunneled central venous catheters (CVC), in various clinical situations. The concept of a PICC is not new, since it was initially proposed almost 100 years ago, before the large central trunk, subclavian, jugular or femoral vein routes were proposed for central venous access. Later, PICC were used and have continued to be used in the newborn.

More recently, the use of PICC was developed in children and adults, as a replacement for central venous approaches, although the respective roles of PICC, CVC and totally implantable venous catheters (TIVC) are not clearly defined. The CDC (Centres for Disease Control and Prevention) have recently proposed PICC as an alternative to peripheral venous catheters, whenever the expected duration is greater than 6 days.

This enthusiasm for PICC has several explanations: an infectious risk perceived as being lower for PICC when compared to CVC, more simple placement, less risk of immediate complications, and also less costly when they are entrusted to specialised nurses (I.V. teams in Anglo-saxon countries) rather than to physicians, as compared to the iterative placement of peripheral venous catheters (PVC).

Analysis of the literature

The review of the literature evaluated infectious as well as thrombotic, dysfunction and malplacement complications. PICC inserted in newborn have been excluded. The rates were expressed either in the form of incidence rates, i.e. the number of complications compared with the number of catheter days, or in terms of cumulative incidence, that is the proportion of PICC having an infection or thrombosis. Only those studies comparing PICC with other forms of vascular, short-term CVC, TIVC or PVC access were retained. Papers presenting complications restricted to PICC, with no comparison with other forms of vascular access were excluded.

Randomized studies (Table 1)

Thirteen studies are available, of which only two are randomized. The first of these compared 51 PICC with 51 CVC inserted using subclavian access [1] in patients receiving parenteral nutrition. The mean period of use was approximately 10 days, for both the PICC and the CVC; the rate of catheter-related infection was identical in both groups (4.1 for the PICC, 5.6 for the CVC, per 1000 catheter days), whereas the incidence rates for malplacement, thrombosis and dysfunction were higher by a factor of 4 to 8 for PICC when compared to CVC.

The second randomized study compared 31 PICC and 29 peripheral venous catheters (CVP) in patients receiving intravenous treatment for more than 5 days. The mean
durations of PICC and PVC usage were similar (9.4 and 7.3 days) [2]. The rate of thrombosis was 4 times higher for PICC than for PVC, as for the cumulative rate of all complications. However, the patient satisfaction survey was in favour of the use of a PICC, with a lower number of vascular insertions than for PVC.

A third randomized study showed that post-operative placement of a PICC in children was accompanied by a higher level of satisfaction than in the case of PVC placement; other complications were rare in both populations, probably as a consequence of the short duration of their use [3].

### Table I – PICC-related risks – randomized studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Type of study</th>
<th>Patients</th>
<th>Catheters</th>
<th>Total duration (average)</th>
<th>Method</th>
<th>Malplacement</th>
<th>Thrombosis</th>
<th>Dysfunction</th>
<th>Infection</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>COWL CT, 2000 [1]</td>
<td>Prospective, randomized</td>
<td>Adults, TPN Total parenteral nutrition (TPN)</td>
<td>51 PICC</td>
<td>482 PICC (9.5 d) 533 CVC (10.5 d)</td>
<td>Thrombosis: symptomatic Infection: local or general</td>
<td>5 (10) vs 1 (2)</td>
<td>8 (16.6) vs 1 (1.9), 16% vs 2%</td>
<td>8 (16.6) vs 2 (3.8), 16% vs 4%</td>
<td>2 (4.1) vs 3 (5.6), 4% vs 6%</td>
<td>Only 60 patients in 16 months. All complications: 24 vs 7/1000 d. Cost of PICC &gt; PVC Patient satisfaction: PICC &gt; PVC</td>
</tr>
<tr>
<td>PERIARD D, 2008 [2]</td>
<td>Prospective randomized</td>
<td>Adults requiring a catheter for at least 5 days</td>
<td>51 PICC 51 CVC (subclavian)</td>
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</table>

The data are presented in the form of rate if incidence per 1000 days (number of events) and cumulative incidence per 100 devices.

### Quasi experimental or observational studies (Table II)

The 11 remaining studies were observational and compared all PICC with tunneled or non-tunneled, short-term CVC, placed at various insertion sites. The mean period of use of the PICC and CVC was variable, ranging from approximately ten days to more than 50 days, with generally similar average procedure durations for both PICC and CVC.

The definitions of an infection were variable, ranging from a precise definition such as that used in France, associated with catheter culture, to bacteremia more or less directly associated with a catheter infection. The rates of infection were very similar for PICC and CVC, for catheters kept in place and used for similar lengths of time [1,4-9].

Concerning the risk of infection, two studies did not provide rates, but rather risk factors, with the first of these [10] indicating that the infection is more frequent for tunneled catheters and PICC than for TIVC. The second study, using a better methodology [11], compared 807 PICC and 320 tunneled or non-tunneled CVC, with catheter-associated bacteremia (2.5 per 1000 days) and catheter-related bacteremia (1.05 per 1000 days). By comparison with PICC, the catheter-related rates of bacteremia were significantly higher for non-tunneled CVC (HR: 8.69, p<0.0001) and tunneled CVC (HR: 2.78; p=0.0035). However, the PICC were most often placed in oncology patients, whereas the tunneled or non-tunneled CVC were used for malignant haematological pathologies. In the latter group, the risk associated with a non-tunneled CVC was higher (HR: 3.9; p<0.0001) than for PICC, whereas there was no significant difference with tunneled CVC. This is one of the rare publications suggesting that the risk of PICC-related infection is lower than that of short-term CVC.

Four studies dealt with the problem of catheter malplacement: one study found a comparable rate of 3-4% for PICC and CVC [5], two other studies found a malplacement rate of 10% for PICC and 2% for CVC [1,7], one of which included a sufficiently large number of cases to identify a significant difference. The latter study found a 33% rate of malplacement...
for PICC and 6% for CVC [10].

The data on venous thrombosis indicates that, under the most favourable conditions, it occurs twice as frequently for PICC as for the compared technique, with some studies suggesting a tenfold higher risk. The methods used to identify thrombosis are variable, ranging from a basic clinical suspicion to a systematic search for thrombosis using an ultrasound device.

Two studies warrant specific mention. The first of these, in a before-after study of intensive care patients, systematically evaluated the frequency of thrombosis using an echography on days 7, 15 and 30. The rate of thrombosis was 7.7 per 1000 days for the PICC vs 4.4 for 1000 days with the CVC [12]. The second [9] investigated the frequency of occlusion of at least one lumen in onco-haematology patients (75 PICC, 31 non-tunneled CVC) with an incidence rate that was twice as high for PICC as for CVC.
<table>
<thead>
<tr>
<th>Author</th>
<th>Type of study</th>
<th>Patients</th>
<th>Catheters</th>
<th>Total duration (average)</th>
<th>Method</th>
<th>Malplacement</th>
<th>Thrombosis</th>
<th>Dys-function</th>
<th>Infection</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL RAY B, 2010</td>
<td>Prospective, observational</td>
<td>Adults, excluding intensive care</td>
<td>622 PICC 628 CVC</td>
<td>PICC 5 703 (9.2 j) CVC 4 917 (7.8 j)</td>
<td>Infection: primary bacteremia</td>
<td>5 (4) vs 4 (3)</td>
<td>3 (2.2) vs 0</td>
<td>5 (3.6) vs 0</td>
<td>4% vs 0%</td>
<td>2.3 (12) vs 2.4 (13) 2% vs 2%</td>
</tr>
<tr>
<td>ALHIMYARI A, 1996</td>
<td>Retrospective</td>
<td>Adults, excluding intensive care, TPN</td>
<td>135 PICC 135 CVC</td>
<td>1 381 PICC (10.2 j) 1 056 CVC (7.8 j)</td>
<td>Thrombosis: only if symptomatic, Infection: “sepsis”</td>
<td>31 (7.7) vs 12 (4.4) 27.2 vs 9.6%</td>
<td>0 (0) vs 3 (1.9)</td>
<td></td>
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</tr>
<tr>
<td>BONIZZOLI M, 2011</td>
<td>Prospective before-after</td>
<td>Adults in continuing care, TPN</td>
<td>114 PICC 125 CVC</td>
<td>4 024 PICC (35.3 j) 2 747 CVC (22.0 j)</td>
<td>Thrombosis: systematic repeated ultrasound</td>
<td>20 (9.6%) vs 5 (1.8%) 3 (0.9) vs 8 (2.2) 1% vs 2.6%</td>
<td>29 (13.1) vs 5 (1.4) 14% vs 2% 2 (0.9) vs 8 (2.2) 1% vs 3%</td>
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<tr>
<td>GIUFFRIDA, DJ, 1986</td>
<td>Prospective</td>
<td>Adults in intensive care, TPN</td>
<td>472 PICC 713 CVC</td>
<td>2 313 PICC (4.9 j) 4 421 CVC (7.7 j)</td>
<td>Criteria all inaccurate 57 (24.6) vs 18 (4.1) 12% vs 3% 35 (15.1) vs 66 (14.9) 7% vs 9% 2 (0.9) vs 0</td>
<td>1 (2.2) vs 13 (6.0)</td>
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</tr>
<tr>
<td>GUNST M, 2011</td>
<td>Retrospective</td>
<td>Adults in intensive care, TPN</td>
<td>37 PICC 263 CVC</td>
<td>465 PICC (12.6 j) 2 167 CVC (8.2 j)</td>
<td>Infection: French criteria</td>
<td>12% vs 0%</td>
<td>1% vs 2%</td>
<td>7% vs 9%</td>
<td>2% vs 2%</td>
<td>2% vs 2%</td>
</tr>
<tr>
<td>KIM HU, 2010</td>
<td>Prospective</td>
<td>Adults in onco-haematology, Subclavian CVC, PICC and TIVC</td>
<td>24 PICC 83 CVC 72 CCI</td>
<td>Durations not available</td>
<td>PICC:8 (33%) vs CVC 10 (6%)</td>
<td>CVC risk &gt; PICC and PAC</td>
<td>0% vs 0%</td>
<td>0% vs 2%</td>
<td>0% vs 2%</td>
<td>0% vs 2%</td>
</tr>
<tr>
<td>MOLLER P, 2011</td>
<td>Prospective, observational</td>
<td>Adults in onco-haematology, consecutive patients</td>
<td>807 PICC vs 320 CVC (tunneled or non-tunneled)</td>
<td>41876 PICC (51.9 j) 9638 CVC (30.1 j)</td>
<td>Infection: primary bacteremia Bacteremia: non-tunneled CVC &gt; PICC (HR 5.69) Tunneled CVC &gt; PICC (HR 2.78) Different population with PICC and CVC</td>
<td>14 (7.7) vs 2 (3.4) 19% vs 6% 12 (6.6) vs 6 (10.3) 16% vs 19%</td>
<td>0% vs 0%</td>
<td>0% vs 2%</td>
<td>0% vs 2%</td>
<td>0% vs 2%</td>
</tr>
<tr>
<td>WORTH LI, 2009</td>
<td>Prospective</td>
<td>Adults in onco-haematology</td>
<td>75 PICC vs 31 CVC NTun</td>
<td>1815 PICC (24.2 j) 583 CVC (174.4 j)</td>
<td>Clinical infection definition 50 (4.2) vs 2 (0.04) 9% vs 1% 65 (5.8) vs 11 (0.2) 12% vs 4% 45 (3.8) vs 33 (0.7) 8% vs 12%</td>
<td>14 (7.7) vs 2 (3.4) 19% vs 6% 12 (6.6) vs 6 (10.3) 16% vs 19%</td>
<td>0% vs 0%</td>
<td>0% vs 2%</td>
<td>0% vs 2%</td>
<td>0% vs 2%</td>
</tr>
<tr>
<td>SMITH JR, 1998</td>
<td>Retrospective</td>
<td>Adults excluding intensive care</td>
<td>555 PICC vs 283 CVC CCI or Tun</td>
<td>11814 PICC (21.3 j) 49365 CVC (174.4 j)</td>
<td>Clinical infection definition</td>
<td>50 (4.2) vs 2 (0.04) 9% vs 1% 65 (5.8) vs 11 (0.2) 12% vs 4% 45 (3.8) vs 33 (0.7) 8% vs 12%</td>
<td>14 (7.7) vs 2 (3.4) 19% vs 6% 12 (6.6) vs 6 (10.3) 16% vs 19%</td>
<td>0% vs 0%</td>
<td>0% vs 2%</td>
<td>0% vs 2%</td>
</tr>
<tr>
<td>MOUREAU N, 2002</td>
<td>Prospective, multicentric observational</td>
<td>Adult home care</td>
<td>25 590 PICC</td>
<td>database datas</td>
<td>PICC 0.4 vs CVC 0.006 vs CCI 0.06 PICC 0.98 vs CVC 0.23 vs CCI 0.16 PICC 0.36 CVC Tun 0.70, CCI 0.30</td>
<td>14 (7.7) vs 2 (3.4) 19% vs 6% 12 (6.6) vs 6 (10.3) 16% vs 19%</td>
<td>0% vs 0%</td>
<td>0% vs 2%</td>
<td>0% vs 2%</td>
<td>0% vs 2%</td>
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</tbody>
</table>
Thrombosis of a lumen is close to the notion of catheter dysfunction, most commonly defined by occlusion of the catheter or leakage of the solute. In general, these criteria are not described very accurately; most studies observe a higher frequency for PICC than for the compared devices. In a randomized study of parenteral nutrition [1], the incidence rate was 4 times higher for PICC (16.6 vs 3.8 for 100 catheter days).

Special mention should be made of the paper of MOUREAU et al. [13], who present the results determined by monitoring complications in homecare patients fitted with a catheter, from a healthcare network in California. The data was taken from a database created for other purposes, with the inherent limitations of this mode of surveillance, in particular the definition of undesirable events; nevertheless, the catheter durations were available. By comparison with tunneled or non-tunneled CVC, the global rate of complication was twice as high for the PICC (2.02 for 1000 days vs 1.01 and 1.08). The rate of infection was 0.36 for 1000 days for the PICC vs 0.70 and 0.57 for the tunneled and non-tunneled CVC. The rate of thrombosis and catheter dysfunction was higher for the PICC (0.4 and 0.98) than for the tunneled CVC (0.06 and 0.23) and the non-tunneled CVC (0.08 and 0.39).

Reviews of the literature (Table III)

Five reviews of the literature are available, dealing with PICC or more generally vascular access.

The review of MAKI et al. provides a compilation of all publications dealing with infectious complications on a vascular access up, until mid-2005 [14]. Fifteen studies concerned PICC, with a rate of catheter-related bacteremia of 1.1 for 1000 days, which were higher when the PICC were used in the hospital (2.1) than outside the hospital (1.0). This rate should be compared with that compiled for non-tunneled (2.7) or tunneled (1.7) CVC and with the rate for peripheral venous catheters (0.5).

A more detailed review of the literature observed a rate of incidence of PICC-related bacteremia equal to 1.9 for 1000 patient-days in adults [15]. In their conclusions, the authors search for explanations for the growing use of PICC, as a replacement for CVC, and raised the issue of its justification, in particular when confronted by the risks of thrombosis, dysfunction and difficulties with blood sampling. They added that the implantation of PICC is not recommended in patients with kidney failure and the possibility of requiring dialysis, which imposes the preservation of access to the venous trunks of the superior vena cava system.

Table III – PICC-related risks – general reviews

<table>
<thead>
<tr>
<th>Author</th>
<th>Dates</th>
<th>Material</th>
<th>Method</th>
<th>Malplacement</th>
<th>Thrombosis</th>
<th>Dysfunction</th>
<th>Infection</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHOPRA V,</td>
<td>1996-2012</td>
<td>Review of the literature PICC vs CVC Risk of thrombosis</td>
<td>PICC: 51/807</td>
<td>(6.3%)</td>
<td>CVC: 4/320</td>
<td>(1.3%)</td>
<td>Meta-analysis: OR=2.55 (1.54-4.23)</td>
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<tr>
<td>2013 [19]</td>
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<tr>
<td>CHOPRA V,</td>
<td>1991-2012</td>
<td>Review of the literature PICC vs CVC Risk of CLABSI</td>
<td></td>
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<td>Meta-analysis: RR=0.62 (0.40-0.84)</td>
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<tr>
<td>2013 [18]</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(23 studies of incidence)</td>
<td></td>
</tr>
<tr>
<td>PIKWER A,</td>
<td>1996-2011</td>
<td>12 studies Prospective and retrospective comparative studies PICC vs CVC Incidence rates available</td>
<td>9.3% vs 2.4%</td>
<td>75 vs 7.5</td>
<td>78 vs 14</td>
<td>75 vs 7.5</td>
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<tr>
<td>2012 [17]</td>
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<tr>
<td>MAKI DG,</td>
<td>1966-2005</td>
<td>200 studies Adults, Prospective studies, all catheters, Incidence rates available Clear criteria for infection (bacteremia)</td>
<td>CVP: 0.5</td>
<td>Cath. Art: 1.7</td>
<td>PICC: 1.0</td>
<td>CVC tun.: 1.7</td>
<td>CVC non tun.: 2.7</td>
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<tr>
<td>2006 [14]</td>
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<tr>
<td>TURCOTTE S,</td>
<td>1979-2004</td>
<td>48 papers Surgery patients, all studies, all catheters</td>
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<tr>
<td>2006 [16]</td>
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<tr>
<td>SAFAI N,</td>
<td>1972-2003</td>
<td>33 studies Adults and newborn, PICC only, Prospective and retrospective studies Rates of incidence available Clear criteria for infection (bacteremia)</td>
<td>PICC: 2,11/1 000 j.</td>
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<td>Infectious risk related to PICC during hospitalisation identical to that of short-term CVC</td>
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<td>2005 [15]</td>
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</tbody>
</table>
Two reviews are more recent [17,18]. The first of these [17] includes studies comparing complications arising on PICC with TIVC and tunneled or non-tunneled CVC, whenever the periods of catheterization are available. Twelve papers were included with a review of malplacements, thrombophlebitis, catheter infections and dysfunctions. Their conclusion is that “the risk of incorrect placement of the catheter, thrombophlebitis and catheter dysfunction argues in favour of the use of centrally placed catheters, rather than PICC, and that there is no difference between these two types of catheter as far as the risk of catheter infection is concerned.

The second [18] is a non-systematic review, which analyses separately the risk of infection and thrombosis in patients with and without a cancerous pathology. After recalling that these two risks were higher in cancer patients, the authors indicated that the risk of infection and thrombosis was higher during the use of PICC than for other forms of vascular access in patients without cancer. For cancer patients, the risk of thrombosis is also higher, but the risk of infection varies from one study to another.

Two meta-analyses were published in 2013 by the same group, one dealing with thrombotic complications [19] and the other dealing with infectious complications [20]. For the 12 studies comparing the frequency of thrombosis on PICC with those on CVC in adults, the rate was 6.3% and 1.3%, which is statistically higher for PICC than for CVC. The meta-analysis evaluating catheter-related bacteremia (CLABSI) indicated that from 23 studies published between 1991 and 2012, the risk of catheter infection was significantly smaller for PICC than for CVC (relative risk of 0.62), but that it was not significantly different for the 13 studies reporting infections in terms of rates of incidence (IRR equal to 0.91). These two studies are described in further detail later in this document.

Complication risk factors for PICC

Introduction

The use of peripherally inserted central catheters (PICC) is increasing rapidly. Their advantages are simplicity of placement, low risk of haemorrhage, absence of pneumothoracic and/or haemothoracic risk, ease of removal, improved comfort for the patient, lower cost, and the possibility of home use. However, the incidence of PICC-related complications is high, varying between 30% and 40%, depending on studies. The most common complications are deep and superficial venous thrombosis, infections and mechanical complications: obstruction, malplacement, displacement, accidental removal …).

In order to improve the evaluation of the risk-benefit ratio associated with the indication and use of these catheters, it is important to determine the incidence rate and risk factors of these complications.

Analysis of the literature

The review of the literature dealt with thrombotic, infectious and mechanical complications. PICC placed in the newborn were excluded. Approximately one hundred recent papers (published since 2000), excluding case studies, were analysed. Most of these are prospective or retrospective observational studies, including one major cohort study of patients fitted with PICC and followed up in their homes [13]. Three reviews of the literature investigate all types of PICC-related infectious complications [16-18]; another two reviews focus on their infectious complications [14,15]. In the most recent review, the authors identify cancer patients as being at a particularly high risk, insist on the importance of evaluating the use of PICC, and propose a preventive strategy [18].

In the following, we successively address the main types of complication and their associated risk factors.
Table IV – PICC-related risks – other studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Type of study</th>
<th>Patients</th>
<th>Type of catheter</th>
<th>Total duration (mean)</th>
<th>Method</th>
<th>Malplacement</th>
<th>Thrombosis</th>
<th>Dysfunction</th>
<th>Infection</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIEM T, 2012</td>
<td>Retrospective, observational</td>
<td>PICC only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>57 deep throm.: basal: 3.1% brachial: 2.2% 219 superficial throm.: basal: 1.9%, brachial: 0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADVANI S, 2011</td>
<td>Observational prospective</td>
<td>all children in and outside the intensive care unit (ICU)</td>
<td>2 592 PICC (1 463 outside the ICU)</td>
<td></td>
<td></td>
<td></td>
<td>1,49/1 000 j outside the ICU</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deep venous thrombosis and phlebitis associated with PICC

Thrombotic complications with PICC include deep venous thrombosis, phlebitis, and occasionally catheter occlusion. The frequency of thrombotic complications is expressed either in the form of incidence rate (number of thrombotic complications compared with number of catheter days), or in the form of cumulative incidence (percentage of PICC with complications) [21].

The incidence of PICC-related thrombosis varies considerably between studies, from 1.1% to 38.5% [1,2,9,12,13,22,24-28]. Thrombotic complications have an incidence rate varying from 0.4 to 61.4 per 100 catheter days [1,2,9,12,13,17,24-34]. These results are presented in Tables IV and V. Several explanations can be found for the significant differences in incidence rate: absence of a standardised definition, confusion between deep venous thrombosis, phlebitis and PICC occlusion, study methodology (prospective vs retrospective), selected diagnostic technique (clinical signs or systematic paraclinical examination).

The main PICC-related thrombosis risk factors are presented in Table VI. The most frequent of these are as follows: history of deep thrombosis, cancer patient, large diameter catheter (> 5 Fr), surgery for more than one hour with a catheter in place, catheterization via the cephalic vein.

As a consequence of the high risk of PICC-related thrombosis, and in order to preserve the venous capital of the upper limbs, it is unreasonable to place a PICC in patients with chronic kidney failure, who in the future could require haemodialysis [15].

Another way to handle risk is to establish thrombosis risk factors in the general population. In a retrospective analysis based on the digitized medical records of 145 000 patients, four thrombosis risk factors were identified: a history of venous thrombosis, prescription for bed rest, cancer and the presence of a PICC [35]. Finally, a meta-analysis of five randomized trials and seven prospective studies in 5636 patients suggested that, besides other risk factors, the risk of thrombosis was diminished by more than 50% by the use of a TIVC, when compared to that of a PICC [36].
Table V – Incidence rates of PICC-related deep venous thrombosis and phlebitis

<table>
<thead>
<tr>
<th>Study</th>
<th>Type of study</th>
<th>Patient population</th>
<th>PICC N</th>
<th>TVP or phlebitis N</th>
<th>Events</th>
<th>Catheter days N</th>
<th>(above the last 2 columns: “PICC-related DVT or phlebitis”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liem T, 2012 [22]</td>
<td>Retrospective</td>
<td>Entire hospital</td>
<td>2638</td>
<td>154</td>
<td>DVT</td>
<td>NR</td>
<td>5.8 (NR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>219</td>
<td>SVT</td>
<td>NR</td>
<td>8.3 (NR)</td>
</tr>
<tr>
<td>Power A, 2012 [17]</td>
<td>Review of literature</td>
<td>All</td>
<td>-</td>
<td>188</td>
<td>All</td>
<td>24038</td>
<td>7.8 (NR)</td>
</tr>
<tr>
<td>Walshe Lj, 2012 [26]</td>
<td>Retrospective</td>
<td>Entire hospital, children and adults</td>
<td>351</td>
<td>12</td>
<td>DVT</td>
<td>10562</td>
<td>3.4 (1.14, 6.6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23</td>
<td>SVT</td>
<td>NR</td>
<td>8.4 (5.5)</td>
</tr>
<tr>
<td>Bonizzoli M, 2011 [12]</td>
<td>Prospective</td>
<td>Adults - intensive care</td>
<td>114</td>
<td>31</td>
<td>DVT</td>
<td>4024</td>
<td>27.7 (7.7)</td>
</tr>
<tr>
<td>Evans RJ, 2010 [25]</td>
<td>Observational prospective</td>
<td>Entire hospital</td>
<td>2014</td>
<td>60</td>
<td>DVT</td>
<td>15115</td>
<td>3.0 (3.9)</td>
</tr>
<tr>
<td>Fletcher JJ, 2011 [29]</td>
<td>Retrospective</td>
<td>Neurology - intensive care</td>
<td>479</td>
<td>39</td>
<td>DVT</td>
<td>NR</td>
<td>8.0 (NR)</td>
</tr>
<tr>
<td>Tran H, 2010 [34]</td>
<td>Retrospective</td>
<td>Haematology patients</td>
<td>899</td>
<td>39</td>
<td>All</td>
<td>NR</td>
<td>7.8 (NR)</td>
</tr>
<tr>
<td>Frerottola SC, 2012 [27]</td>
<td>Retrospective, monocentric</td>
<td>Intensive care</td>
<td>50</td>
<td>10</td>
<td>All</td>
<td>NR</td>
<td>20.0 (11.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9</td>
<td>SVT</td>
<td>NR</td>
<td>29 (61.4)</td>
</tr>
<tr>
<td>Worth LJ, 2008 [9]</td>
<td>Prospective</td>
<td>Adults – malignant haemopathy</td>
<td>75</td>
<td>14</td>
<td>DVT</td>
<td>1815</td>
<td>19 (7.7)</td>
</tr>
<tr>
<td>Ong, 2006 [33]</td>
<td>Prospective</td>
<td>Entire hospital</td>
<td>2882</td>
<td>76</td>
<td>All</td>
<td>NR</td>
<td>2.6 (NR)</td>
</tr>
<tr>
<td>Abdullah BJ, 2005 [30]</td>
<td>Prospective</td>
<td>Entire hospital</td>
<td>26</td>
<td>10</td>
<td>All</td>
<td>NR</td>
<td>38.5 (NR)</td>
</tr>
<tr>
<td>Chellamly RF, 2002 [31]</td>
<td>Retrospective</td>
<td>Entire hospital</td>
<td>2063</td>
<td>29</td>
<td>DVT</td>
<td>NR</td>
<td>1.4 (NR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23</td>
<td>SVT</td>
<td>NR</td>
<td>7.7 (NR)</td>
</tr>
<tr>
<td>Moureau N, 2002 [13]</td>
<td>Surveillance network</td>
<td>City</td>
<td>25590</td>
<td>411</td>
<td>DVT</td>
<td>1026637</td>
<td>1.6 (0.40)</td>
</tr>
<tr>
<td>Grove JR, 2000 [28]</td>
<td>Retrospective</td>
<td>Entire hospital</td>
<td>813</td>
<td>32</td>
<td>All</td>
<td>NR</td>
<td>3.9 (NR)</td>
</tr>
<tr>
<td>Cowl CT, 2000 [1]</td>
<td>Prospective, randomized</td>
<td>Entire hospital, adults, for nutrition</td>
<td>51</td>
<td>8</td>
<td>All</td>
<td>482</td>
<td>16 (16.6)</td>
</tr>
<tr>
<td>Jumani K, 2013 [44]</td>
<td>Prospective</td>
<td>Hospitalised children &gt; 1 year</td>
<td>2574</td>
<td>32</td>
<td>Phlebitis, thrombosis</td>
<td>46021</td>
<td>1.8 (1.00)</td>
</tr>
</tbody>
</table>

N: number; PICC = Peripherally Inserted Central Catheter; DVT: Deep Vein Thrombosis; SVT: Superficial Venous Thrombosis; NR: Not Reported

A review of the literature using a meta-analysis was published in 2013, after recommendations had been established [19]. Sixty-four studies concerning adult patients were included, of which 12 compared PICC complications with those of other central venous catheters, and 52 made no comparison with any other types of venous access. The diagnosis of thrombosis was established by examining imagery, obtained mainly with ultrasound. In the studies with no comparisons, the global incidence rate of deep thrombosis was 4.7%, but higher in intensive care (13.9%) and in cancer patients (6.7%). In the 12 comparative studies, the risk of thrombosis was significantly higher in patients fitted with a PICC (6.3%), than in patients fitted with a CVC (1.3%).

**Infectious PICC-related complications**

Infectious complications of PICC include infections of the insertion site and catheter-related bacteremia. As for the case of thrombosis, rates of infection are expressed either in the form of incidence rate (number of infections compared with the number of catheter days), or in the form of cumulative incidence (percentage of infected PICC). For PICC, these rates of infection are only slightly different to those corresponding to short-term central venous catheters [14]. The incidence rate of PICC-related bacteremia varies between studies, from 0.11 to 6.6 per 1000 catheter days. This variability can be explained by the applied methodologies (retrospective studies tend to underestimate the rates, sometimes differing diagnostic criteria), the heterogeneity of the studied patient populations (age, pathology, severity, city, hospital), and the periods of catheterization [15]. In the large cohort of MOUREAU, concerning a surveillance network of homecare patients fitted with catheters, the PICC-related incidence rates of local and systemic infections are low (respectively, 0.25 and 0.11 for 1000 catheter days) [13]. In a review of the literature published by MAKI, analysing 200 studies of catheter-related bacteremia, of which 15 concerned PICC, the incidence of PICC-related bacteremia is 1 per 1000 catheter days (CI95: 0.8-1.2) (Table VII) [14].
PICC-related risk factors do not appear to be different to CVC-related risk factors. This depends on the type of patient (higher risk in intensive care or cancer patients), and on the period of catheterization. There are very few specific studies dealing with risk factors for the development of a PICC-related infection. These studies are described in Table VIII [14,15,33,37,38].

Several notions should be considered. The risk of a PICC infection is not linearly related to the period of catheterization [39,40]. There is probably a decrease in the risk of infection in favour of antiseptic- or antibiotic-impregnated PICC [41]. Finally, the presence of a PICC in chronic kidney dialysis patients fitted with a dialysis catheter is probably a risk factor for catheter infection [40,42].

Two recent studies have provided a detailed description of the risk factors for PICC infection [43,44]. In a first study of hospitalised adults [43], the incidence rate of bacteremia was 3.13 / 1000 PICC days. The independent risk factors were related to the patient (chemotherapy, intraabdominal perforation and C. difficile infection, tracheostomy), to the number of PICC lumens, but not to its insertion site. The second study was carried out in 1807 hospitalised children [44]. The rate of complications requiring removal of the PICC was 20.8% (11.6 for 1000 PICC days), and was equal for displacement (4.6%), infection (4.3%), occlusion (3.7%) and local infiltration (3.0%). The rate of complications decreased between 2003 and 2009, in particular that of non-infectious complications, which decreased from 14.5% to 3.6%. The two main risk factors were the patient's young age and PICC placement in a central position.

A meta-analysed review of the literature was published in 2013, after these recommendations were established [20]. Twenty-three studies comparing the occurrence of catheter-related bacteremia, in 57,250 patients wearing a PICC or a CVC between 1991 and 2012, were included. Ten of these were prospective, 12 were retrospective, and only one was randomised and controlled. They included followed outpatients and/or hospitalised patients. The 20 studies providing raw data showed that the risk of CLABSI was lower for PICC wearers (RR=0.62 [0.40-0.94]), with this result being explained mainly by patients followed up in outpatient care (0.5% and 2.1%), whereas the incidence rates were identical for hospitalised patients (5.2% and 5.8%). There was a high degree of heterogeneity between studies reporting infections during hospitalisation. The 13 studies providing incidence rate data were also heterogeneous, with identical global risks of infection in both groups (IRR=0.91 [0.46-1.79]).
### Table VI – Risk factors for PICC-related deep venous thrombosis (DVT).

<table>
<thead>
<tr>
<th>Study</th>
<th>Type of study</th>
<th>Patient population</th>
<th>Patients N</th>
<th>PICC N</th>
<th>Risk factor</th>
<th>OR (CI)</th>
<th>P</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHOPRA V, 2012 [18]</td>
<td>Review</td>
<td>All</td>
<td></td>
<td></td>
<td>Cancer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WILSON TJ, 2012 [24]</td>
<td>Retrospective, monocentric</td>
<td>Neurology – intensive care</td>
<td>38 TVP</td>
<td>431</td>
<td>Placement on paralysed arm</td>
<td>9.85 (4.42-21.95)</td>
<td>&lt; 0.001</td>
<td>Without cancer, incidence: 2.0 to 5.5%. With cancer: incidence: 3.4 to 7.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Surgery &gt; 1h</td>
<td>3.26 (1.48-7.17)</td>
<td>&lt; 0.003</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Previous medical history of DVP</td>
<td>6.66 (2.38-18.62)</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Use of mannitol</td>
<td>3.27 (1.27-8.43)</td>
<td>&lt; 0.014</td>
<td></td>
</tr>
<tr>
<td>LIEM TK, 2012 [22]</td>
<td>Retrospective</td>
<td>Entire hospital</td>
<td>154 TVP</td>
<td>2638</td>
<td>Catheterization via basil vein</td>
<td>NR</td>
<td>0.047</td>
<td>NS in multivariate analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PICC diameter 5 Fr</td>
<td>3.9 (1.1-13.9)</td>
<td>0.037</td>
<td>Evaluation of medical records based on DVT imagery</td>
</tr>
<tr>
<td>EVANS RS, 2010 [25]</td>
<td>Prospective, observational</td>
<td>Entire hospital</td>
<td>1728</td>
<td>2014</td>
<td>Malignant pathology</td>
<td>4.1 (1.9-8.9)</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>History of DVT</td>
<td>9.92 (5.08-21.25)</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Use of a 5Fr dual lumen</td>
<td>7.54 (1.61-100)</td>
<td>&lt; 0.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Use of a 6Fr triple lumen</td>
<td>19.50 (3.54- &gt; 100)</td>
<td>&lt; 0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Surgery &gt; 1h</td>
<td>1.66 (0.91-3.01)</td>
<td>&lt; 0.1</td>
<td>NS</td>
</tr>
<tr>
<td>ONG CK, 2010 [22]</td>
<td>Prospective, randomised</td>
<td>Entire hospital</td>
<td>326</td>
<td>326</td>
<td>Type of catheter: silicone PICC with distal valve vs polyurethane PICC with proximal valve</td>
<td>NR</td>
<td>0.003</td>
<td>Rate of phlebitis 23.2% vs 11.6%</td>
</tr>
<tr>
<td>TREROTOLA SO, 2010 [27]</td>
<td>Retrospective, monocentric</td>
<td>Intensive care</td>
<td>50</td>
<td>50</td>
<td>Number of PICC lumens: 3, catheter diameter 6Fr</td>
<td>NR</td>
<td></td>
<td>Premature discontinuation of study due to very high incidence of DVT</td>
</tr>
<tr>
<td>ONG CK, 2006 [46]</td>
<td>Retrospective</td>
<td>Entire hospital</td>
<td>115 TVP</td>
<td>2882</td>
<td>PICC for chemotherapy</td>
<td>NR</td>
<td></td>
<td>Evaluation of medical records based on DVT imagery</td>
</tr>
<tr>
<td>ABDULLAH BJ, 2005 [30]</td>
<td>Prospective</td>
<td>None</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Short series</td>
</tr>
<tr>
<td>CHEMALLY RF, 2002 [31]</td>
<td>Retrospective</td>
<td></td>
<td>2063</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Case-control study</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Young age</td>
<td>1.34 (1.06-1.70)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DVT ATCD</td>
<td>4.53 (1.22-16.84)</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Amphotericin B treatment</td>
<td>10.26 (1.98-53.14)</td>
<td>0.006</td>
<td></td>
</tr>
<tr>
<td>ALLEN AW, 2000 [32]</td>
<td>Retrospective</td>
<td>Entire hospital</td>
<td>119</td>
<td>354</td>
<td>Catheterization via cephalic vein</td>
<td>NR</td>
<td>&lt; 0.0001</td>
<td></td>
</tr>
</tbody>
</table>

DVP: Deep Vein Thrombosis; PICC = Peripherally Inserted Central Catheter; Fr: French; NS: Non-significant; NR: Not Reported

### Mechanical complications with PICC

In two reviews of the literature [16,17], the incidence rates of other complications are non-negligible. The most frequent are:

- catheter occlusions: 2 to 18 [45],
- malplacement of the catheter tip (from 1 to 27% of cases) [16,17],
- catheter dysfunction (from 36 to 55 per 1000 catheter days [13,17], and
- premature catheter removal (from 12% to 38% of PICC during the first week following insertion, and up to 60% thereafter) [16].

### Case report

Although they are rare, several severe PICC-related complications have been reported in the literature. We note for example, embolism of a section of the catheter, air embolism, cardiac arrhythmia with death, cardiac tamponade by perforation of the right ventricle.

### Conclusion

Peripherally inserted central venous catheters are a "novel" tool among the many devices allowing intravenous products to be administered. However, their complications, thrombotic and mechanical in particular, are relatively frequent. It is thus advisable to evaluate the risk-benefit ratio associated with the indications for such catheters. In addition, it appears indispensable to continue evaluating the rapidly growing usage of these devices (indications, relevance, safety).
Table VII – incidence of PICC-related infections

<table>
<thead>
<tr>
<th>Study</th>
<th>Type of study</th>
<th>Patient population</th>
<th>PICC N</th>
<th>N° PICC-related bacteremia or insertion site infections</th>
<th>Type of infection</th>
<th>N° catheter days</th>
<th>PICC-related bacteremia or insertion site infections /100 PICC /1000 days of catheterization</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIKWER A, 2012 [17]</td>
<td>Review literature</td>
<td>All</td>
<td>NR</td>
<td>153</td>
<td>All</td>
<td>68048</td>
<td>NR</td>
</tr>
<tr>
<td>WALSHE LJ, 2012 [26]</td>
<td>Prospective</td>
<td>Entire hospital, Children and adults</td>
<td>351</td>
<td>26</td>
<td>All</td>
<td>10562</td>
<td>7.4</td>
</tr>
<tr>
<td>AGENJO MC, 2011 [38]</td>
<td>Retrospective</td>
<td>Entire hospital</td>
<td>NR</td>
<td>163</td>
<td>PRB</td>
<td>52098</td>
<td>NR</td>
</tr>
<tr>
<td>GUNST M, 2011 [8]</td>
<td>Prospective</td>
<td>Intensive care, adult surgery</td>
<td>37</td>
<td>1</td>
<td>PRB</td>
<td>455</td>
<td>3</td>
</tr>
<tr>
<td>KASSY Y, 2010 [47]</td>
<td>Prospective</td>
<td>Adult onco-haematology</td>
<td>52</td>
<td>1</td>
<td>All</td>
<td>NR</td>
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</tr>
<tr>
<td>HAIDER G, 2009 [48]</td>
<td>Prospective</td>
<td>Adult onco-haematology</td>
<td>146</td>
<td>37</td>
<td>All</td>
<td>3329</td>
<td>25.3</td>
</tr>
<tr>
<td>PERIARDO D, 2008 [2]</td>
<td>Randomised</td>
<td>Adult</td>
<td>31</td>
<td>0</td>
<td>PRB</td>
<td>NR</td>
<td>0</td>
</tr>
<tr>
<td>VIDAL V, 2009 [49]</td>
<td>Prospective</td>
<td>Entire hospital</td>
<td>127</td>
<td>4</td>
<td>All</td>
<td>NR</td>
<td>3.1</td>
</tr>
<tr>
<td>WORTH LJ, 2008 [9]</td>
<td>Prospective</td>
<td>Adult, malignant haemopathy</td>
<td>75</td>
<td>12</td>
<td>PRB</td>
<td>1815</td>
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</tr>
<tr>
<td>MAKI DM, 2006 [14]</td>
<td>Review literature</td>
<td>All</td>
<td>3566</td>
<td>112</td>
<td>PRB</td>
<td>NR</td>
<td>3.1</td>
</tr>
<tr>
<td>SAFDAR N, 2005 [52]</td>
<td>Prospective</td>
<td>Adult</td>
<td>251</td>
<td>6</td>
<td>PRB</td>
<td>1673</td>
<td>2.4</td>
</tr>
<tr>
<td>CHLEBICKI MP, 2003 [50]</td>
<td>Retrospective</td>
<td>Adult</td>
<td>94</td>
<td>3</td>
<td>PRB</td>
<td>1598</td>
<td>3.2</td>
</tr>
<tr>
<td>CARTER C, 2003 [51]</td>
<td>Prospective</td>
<td>Adult, malignant haemopathy</td>
<td>65</td>
<td>1</td>
<td>All</td>
<td>455</td>
<td>1.5</td>
</tr>
<tr>
<td>OGURA JM, 2003 [55]</td>
<td>Retrospective</td>
<td>Pregnant women</td>
<td>52</td>
<td>9</td>
<td>All</td>
<td>1375</td>
<td>17.3</td>
</tr>
<tr>
<td>GRIFFITHS VR, 2002 [53]</td>
<td>Prospective</td>
<td>Adults, intensive care</td>
<td>29</td>
<td>2</td>
<td>All</td>
<td>435</td>
<td>6.8</td>
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<tr>
<td>FUNK D, 2001 [54]</td>
<td>Prospective</td>
<td>Adult</td>
<td>167</td>
<td>4</td>
<td>All</td>
<td>789</td>
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</tr>
<tr>
<td>COWL CT, 2000 [1]</td>
<td>Randomised</td>
<td>Adult, for parenteral nutrition</td>
<td>51</td>
<td>2</td>
<td>All</td>
<td>482</td>
<td>3.9</td>
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<tr>
<td>JUMANI K, 2013 [44]</td>
<td>Prospective</td>
<td>Hospitalised children &gt; 1 yr</td>
<td>2574</td>
<td>112</td>
<td>All</td>
<td>46021</td>
<td>4.4</td>
</tr>
</tbody>
</table>

PICC = Peripherally Inserted Central Catheter; PRB: PICC-related bacteremia; PRISI: PICC-related insertion site infections; NR: Not Reported
Table VIII – PICC-related infection risk factors

<table>
<thead>
<tr>
<th>Study</th>
<th>Type of study</th>
<th>Patient population</th>
<th>PICC N</th>
<th>Type of infection</th>
<th>Risk factor</th>
<th>ORa (CI95)</th>
<th>P</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHOPRA V, 2012 [18]</td>
<td>Review</td>
<td>All</td>
<td></td>
<td>PRB</td>
<td>Cancer</td>
<td></td>
<td></td>
<td>Without cancer, incidence: 1.0 to 2.1 for 1000 catheter days; With cancer: incidence: 1.81 to 7.71 for 1000 catheter days</td>
</tr>
<tr>
<td>DANEMANN N, 2012 [37]</td>
<td>Prospective</td>
<td>Adults, bacteremia since less than 6 weeks</td>
<td>348</td>
<td>PRB</td>
<td>Delay, following bacteremia (2 days vs 3 days), before PICC placement</td>
<td>0.02</td>
<td></td>
<td>Risk of bacteremia relapse 6.5% versus 0.5%</td>
</tr>
<tr>
<td>AJENJO MC, 2011 [38]</td>
<td>Retrospective</td>
<td>Entire hospital</td>
<td>163</td>
<td>PRB</td>
<td>Intensive care patients</td>
<td>NR</td>
<td></td>
<td>Rate of infection 6.2% versus 2%</td>
</tr>
<tr>
<td>ONG CK, 2010 [33]</td>
<td>Randomised prospective</td>
<td>Entire hospital</td>
<td>326</td>
<td>All</td>
<td>Type of catheter; silicone PICC with distal valve vs polyurethane PICC with proximal valve</td>
<td>0.043</td>
<td></td>
<td>Risk of PICC infection close to that of CVC in hospitalised patients</td>
</tr>
<tr>
<td>MAKI DM, 2006 [14]</td>
<td>Review literature</td>
<td>All</td>
<td>3566</td>
<td>PRB</td>
<td>- Severity of underlying disease - type of patient: immunosuppressed vs immunocompetent; Hospital vs domicile</td>
<td>NR</td>
<td>NR</td>
<td>Risk of infection similar to that of CVC, and greater for the risk of thrombosis and displacement</td>
</tr>
<tr>
<td>SAFGAR N, 2005 [15]</td>
<td>Prospective and review of literature</td>
<td>Adult</td>
<td>251</td>
<td>PRB</td>
<td>Age (adults and children versus newborn)</td>
<td>NR</td>
<td></td>
<td>Case-control study</td>
</tr>
<tr>
<td>PONGRUANPORN M, 2013 [43]</td>
<td>Prospective</td>
<td>Adult, hospitalised patients</td>
<td>162 infected PICC</td>
<td>PRB</td>
<td>predisposition (chemotherapy, intra-abdominal perforation, C. difficile infection, tracheostomy), Number of lumens</td>
<td>0.01</td>
<td>0.004</td>
<td></td>
</tr>
<tr>
<td>JUMANI K, 2013 [44]</td>
<td>Prospective</td>
<td>Hospitalised children &gt; 1 yr</td>
<td>257A, of whom 112 infected</td>
<td>All</td>
<td>Age &lt; 1 yr - Non-central placement of PICC</td>
<td>&lt; 0.001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PICC = Peripherally Inserted Central Catheter; PRB: PICC-related bacteremia; PRISI: PICC-related insertion site infections; NR: Not Reported
REFERENCES


Rationale

Question 3

Indications for PICC

What are the indications, contraindications and selection criteria for PICC with respect to other types of vascular access (TIVC, standard CVC, PVC, Hickman …), including the patient's quality of life, and types of material: valves, routes, material.

PICC and placement duration

With the aim of preserving the venous capital of patients, the 2011 North American recommendations (CDC) propose to stop using superficial venous routes (short cannulae or needles) in favour of PICC, whenever the foreseen period of venous access is ≥ 6 days (category II recommendation of the CDC) [1].

In line with these recommendations, some technical datasheets for PICC propose a placement duration ≥ 6 days [2].

Although a minimal length of use appears to be accepted, the optimal duration of PICC placement, in terms of risk-benefit, is unknown. The analysis of the literature does not provide clear indications concerning this point. A prospective study dealing with 2014 PICC in medico-surgical patients reports a median period of use equal to 7.5 days [3]. Depending on the studies and related pathologies, the period of use varies from a few days to several months [3-6].

However, these studies rarely indicate the length of time after which complications arise, whether they be infectious, thrombotic or mechanical. Only a small number of studies in neonatology have analysed the period of use / risk-of-infection relationship for a PICC. For some, following a transitional increase, there is reported to be a decrease in PICC-related risk of infection, probably as a result of the premature newborn's growth and maturation of its immune system [7]. Conversely, for others, in neonatology there is reported to be an exponential growth of infectious complications as a function of the duration of PICC placement [8].

In paediatrics, from a series of 2592 PICC, ADVANI et al. observed an increase in the risk of infection for the PICC group having a placement duration ≥ 21 days, versus the PICC group having a placement duration < 21 days [9].

In adults, the same observation is made in intensive care units (ICU), where it is observed that the placement duration is the only independent risk factor for infectious complications observed in PICC and other non-tunneled central venous catheters (CVC) [10].

In onco-haematology, the median placement duration is greater than in other sectors [5,6,11,12]; it varies from 2 weeks to a little less than 6 months, depending on the pathologies involved [5,6,11].

Finally, it also appears that in these units the use of PICC for transfusions or blood sampling reduces their service life. This is what is suggested by the work of Y. KASBY et al., who observed median service lives of 70 days (PICC used only for chemo.) vs 23 days (RR=2.9, p=0.001), when more than two samples per week were taken through the PICC.

Similarly, the placement duration of a PICC varies according to its indication; when the indication is to ensure the presence of a device for transfusion, the length of use is considerably reduced with respect to that of a PICC intended for chemotherapy only (median duration: 26 days vs 58 days, RR=1.3; p=0.02) [12].

In conclusion, PICC placement duration varies between studies and pathologies, from 6 days to 6 months, or even longer. It should be recalled that, with the exception of newborn and infants for whom venous access is problematic, like any other short-term catheter, a PICC must be removed as soon as its presence is no longer indispensible [1,13,14].
Advantages and drawbacks of a PICC, depending on the types of complication observed

Infectious and non-infectious complications (Tables I to IV)

**PICC versus peripherally inserted venous catheters (PVC)**

During a monocentric randomised prospective study, comparing PICC with peripheral venous access with short catheters (PVC) placed for a period of ≥ 5 days, PÉRIARD *et al.* observed 22.6% of so-called "major" complications, implying the need to maintain the patient in hospital for anticoagulant (6 deep venous thrombosis or DVT) or antibiotic (1 cellulitis) treatment, vs 3.4% (1 DVT) in the PVC group [RR >6.6; p=0.03].

When these results are expressed as an incidence rate per 1000 catheter days, the incidence of major complications is 24/1000 PICC-day vs 4.7/1000 PVC-day (p < 0.01) [15].

Moreover, the rate of superficial thrombophlebitis was very high in both groups: 29% in the PICC group and 38% in the PVC group, which in terms of incidence rate leads to 30.9/1000 PICC-days vs 61.4/1000 PVC-days (p < 0.01). Thus, despite the observed complications, the patients were very much in favour of the use of a PICC. In conclusion, as a consequence of the cases of (frequently asymptomatic) deep venous thrombosis observed in this study, the authors are cautious with respect to the use of PICC as a first line solution [15].

One other randomised study of a very young child compared the complications that occurred on a PICC (silicone 2 Fr) and on a peripheral venous access line (24 G VIALON® or 27 G BUTTERFLY® needles) [16]. Although the authors did not observe any significant difference in terms of infectious complications, they reported four times more cases of peripheral phlebitis in the PVC group than in the PICC group (40.8% vs 10.8%; p=0.007). The same observation was made by HORATTAS, who estimated the rate of phlebitis on peripheral venous access lines to be 63%, vs 2% to 10% on PICC [17].

**PICC vs central venous catheters (CVC)**

A recent review of the literature initially comprising 488 papers published between 1966 and 2011 (Medline database) finally retained 12 studies dealing with complications related to 3116 PICC, compared with complications related to 2193 non-tunneled "pooled" CVC with a mixture of 819 tunneled catheters and totally implantable venous catheters (TIVC). Only those studies clearly reporting the duration of catheter use were included in this study [18].

Four types of complication were compared: malplacement of the distal extremity of the catheter, thrombophlebitis, catheter-related infections (CRI), and dysfunction of the device.

This comparison did not favour the PICC, for 3 out of 4 of these complications:

- malplacement (9.3% vs 3.4%, p=0.0007)
- thrombophlebitis (7.8 vs 0.75/1000 cath.-day, p=0.0001)
- dysfunction (7.8 vs 1.4/1000 cath.-day, p=0.04).

On the other hand, there was no significant difference between the two groups in terms of infectious complications. However, it is clear that the combination of non-tunneled CVC and TIVC in the comparative group considerably modifies the data related to infectious complications, by artificially reducing the incidence of infections on CVC. In addition, this study has limitations since it is based on old studies during which PICC placement was carried out without ultrasound guidance. Finally, from the compilation of 12 studies, only the study of COWL *et al.* was randomized [19].
In a study dealing with surgery patients, comparing 37 PICC and 263 CVC, the incidence of infectious complications was three times lower on PICC than on non-tunneled CVC (2.2/1000 cath.-day for the PICC and 6/1000 cath.-day for the CVC) [10].

In two major reviews of the literature (more than 200 prospective/review studies), MAKI et al. compared infectious complications related to the main types of venous device [20,21]. Whereas in 2001, the incidences of infectious complications on PICC and on TIVC were relatively similar (0.2/1000 cath.-day for TIVC and 0.4 for PICC), in 2006, these authors reported a significant increase in PICC-related infectious complications: the incidence was 1.1/1000 cath.-day when the patients received homecare, and 2.1/1000 cath.-day when they were hospitalised. In the hospitalised patients, the infectious complications were thus more frequent on the PICC than on the tunneled central venous catheters with a cuff (Hickman-Broviac type) (1.7/1000 cath.-day) Table II).

However, with the exception of TIVC, the infectious complications also increased dramatically between 2001 and 2006 for all other categories of device [21].

It should be noted that these results deal with studies made prior to the implementation and dissemination of bundles or checklists in all healthcare units [22,23].
In 2002, using a file pertaining to 50 470 patients followed under homecare hospitalisation, MOUREAU et al. reported similar incidences of infectious complication for PICC, midline catheters (antebrachial catheter inserted via a peripheral access, the end of which is not centrally positioned), and TIVC (respectively 0.36; 0.30 and 0.30/1000 cath.-days) [24].

However, in this study the results are very different when one takes into account the various complications observed on these different devices: venous thrombosis, mechanical complications (displacements, leaks, extravasations ..) and infectious complications. Indeed, the complications on PICC are then twice as frequent as on tunneled central catheters, and four times as frequent as on TIVC (Table II).

Finally, a randomised study of parenteral nutrition, comparing subclavian central catheters vs PICC, reports eight times more thrombophlebitic complications on PICC than on subclavian catheters (16.6 vs 1.9/1000 cath.-day), and three times more mechanical complications [29]. More recently, BONIZZOLI et al. observed deep venous thrombosis (DVP) on PICC in 27.2% of cases vs 9.6% on CVC, (p=0.0012), i.e. a DVT incidence of 4.4/1000 cath.-day for CVC and 7.7/1000 cath.-day for the PICC. [25] (Table III).

Finally, among the material selection criteria, although an analysis of device-related infectious risk is necessary, it is not sufficient. Thrombotic and mechanical risks must also been taken into account, for PICC in particular. This is exactly the conclusion reached in the review of the literature published by TURCOTTE et al., comparing CVC and PICC: there is no difference in the infectious complications between these two types of device, however thrombotic complications are considerably more frequent, and occur earlier on PICC than on CVC [26].

What type of PICC? Single lumen or multi-lumen? with an integrated valve?

Single lumen or multi-lumen PICC

More than infectious complications, the specific risk associated with PICC is that of thrombosis.

In the prospective study of Evans et al. [3] dealing with 2014 PICC, the risk factors for thrombosis were:

- DVT history prior to PICC placement (OR: 9.92, p<0.01),
- PICC diameter and the use of multi-lumen PICC vs 4 Fr single lumen PICC (5 Fr dual lumen, OR: 7.54, p<0.05, 6 Fr triple lumen, OR: 19.50, p<0.001) [3].

The same observation is made by Grove et al. [28] who, on a series of 813 PICC evaluating the risk factors for thrombosis on PICC, report 3.9% of DVT. Using multivariate analysis, the only identified DVT risk factor was the catheter diameter: no thrombosis on 3 Fr PICC, 1% for 4 Fr PICC, 6.6% on 5 Fr PICC, and 9.8% on 6 Fr PICC [28].

Finally, TREROTOLA et al. [29] observed thrombosis in 58% of cases (of which 20% were symptomatic) in 50 intensive care patients included in a prospective study of the use of 6 Fr triple lumen PICC. This study, which was planned to include 167 patients, was interrupted prematurely as a result of these thrombotic complications [29].

Some authors insist on comparatively evaluating venous and PICC diameters [30], and do not endorse the use of large diameter catheters; others recommend selecting a PICC whose diameter is smaller or equal to one third of the venous diameter [31].

As a result of the frequent occurrence of superficial and, in particular deep thrombotic complications arising from the use of large diameter (and/or multi-lumen) PICC, it appears justified, unless otherwise indicated, to prefer small diameter PICC whilst favouring single lumen devices (e.g.: cystic fibrosis, medicine, onco-haematology, paediatrics, palliative treatments, ..).

PICC with an integrated valve

Together with thrombotic and obstructive complications, mechanical complications (displacements, rupture, leaks and extravasations) represent a high proportion of complications observed during the use of PICC.

In order to minimize obstructive phenomena, the manufacturers have developed devices equipped with integrated valves to restrict blood reflux, in particular during the disconnection of venous lines. For several years a silicone PICC fitted with an anti-reflux system at its distal end has been available on the market. There is also a polyurethane PICC fitted with a valve at its proximal end (in the catheter hub).
In a randomized study, these two types of valve PICC were compared [32]. They all had the same outer diameter (4 Fr). All of the catheters were placed under ultrasound guidance in a radiology room. The indication for these PICC was an extended period of antibiotherapy in 76% of the patients. In this study, it appears that the PICC with a proximal valve led to less complications than the PICC with a distal valve (26.8% vs 47.9%, p<0.001), not only in terms of infectious complications (0.7/1000 cath.-days for the former and 2.7 for the distal valve PICC), but also in terms of thrombotic complications (11.6% vs 23.2%, p=0.043). According to the authors, a valve positioned at the proximal end is less exposed to blood clot deposits than a valve fitted at the distal end. However, as this comparison is based on catheters made from two different materials (polyurethane vs silicone), which thus have different internal PICC diameters, the reliability of its results could be questioned.

High pressure PICC

Confronted by the need to use PICC during CT scans requiring contrast agent injection, the manufacturers have developed "high pressure" PICC allowing the contrast agent to be injected at a 5 ml/second flow rate. These purple- or red-coloured "HP" PICC, depending on manufacturer, exist in single- (5 Fr), dual- (5 and 6 Fr) and tri-lumen (6 Fr) variants. A recent study made in various ICU verified that "HP" PICC could be used with no risk of rupture or lesion from the catheter, during the high pressure injection of a contrast agent at a 5 ml/sec flow rate [31].

Indications in the context of surgery, anaesthesia, critical care, intensive care

■ To our knowledge, no randomised studies have been made allowing PICC to be recommended as a replacement for central venous access via direct puncture of the jugular or subclavian veins. The following proposals are thus based on the analysis of a small number of studies made in ICU [9,10,25,27,29,31,33-38].

For the prevention of immediate incidents and mechanical accidents resulting from percutaneous access to the subclavian vein, PICC are undeniably useful [17].

In addition, in view of the infectious complications observed on non-tunneled central catheters placed via an internal jugular or femoral access (zones at risk, as a result of their high degree of skin colonisation, difficulty in maintaining occlusive dressings, proximity of colonised cavities, use of many different types of catheter ...), some ICU have started to make use of PICC [3,10,29,31,33]. In practice, the anterior side of the arm, which is less highly colonised, is distant from the zones at risk and should allow the risk of infection associated with these devices to be decreased [31,38].

The results observed in these units reveal variable incidence rates, from 0 [31] to 4.79/1000 cath.-day [38]. Some authors report less infectious complications on PICC than on non-tunneled CVC [10,27,39]. Furthermore, the delay preceding the appearance of any infectious complication appears to be significantly longer on PICC than on CVC [27]. However, all of these results correspond to studies evaluating infectious and/or thrombotic risks on PICC and CVC, but involving no randomisation of either of these two devices [10,27,33].

■ In patients with respiratory failure, an emphysematous condition, tracheotomy, ENT tumour, radiation necrosis, or maxillofacial tumour [40], the use of a PICC, rather than a subclavian or non-tunneled internal jugular access, appears to be justified [41]. Moreover, in these patients, it is clearly more straightforward to maintain and observe the catheter and dressings. However, in critical care or ICU, the need for multi-lumen catheters restricts the use of the antebrachial vein. Several studies have demonstrated the accrued risk of thrombotic complications with large diameter or multi-lumen PICC [3,29].

■ Concerning the use of emergency venous access in a patient with hypovolemic shock, whether it be septic or haemorrhagic, common sense should lead to the choice of central venous access, rather than that of a peripheral vein, which in view of the context will be "flat" and difficult to catheterize, even with ultrasound guidance. To our knowledge, there is no accurate literature dealing with this point; however, teams dealing with serious burn patients consider that a PICC should not be recommended during the initial phase of haemodynamic instability [36]. Nevertheless, once haemodynamic stability has been restored, a PICC can be placed without hesitation. These authors did not observe PICC-related infectious complications, whereas they noted a 6.6/1000 cath.-day incidence on CVC placed on a comparable control population in terms of age, burn severity, and ventilation period [36].
PICC and the measurement of central venous pressure (CVP): Two studies carried out during liver transplants on the one hand, and abdominal aortic aneurysm surgery on the other hand, have reported on the reliability of CVP measurements with PICC, as compared to those achieved with CVC [34,37]. A different study carried out in vitro confirms these results [42].

Indications in parenteral nutrition

In its Guidelines edited in 2009, the ESPEN (European Society for Clinical Nutrition and Metabolism) retained the possibility of administering parenteral nutrition through a PICC [41]. The PICC is considered to be appropriate, in the case of other central or peripheral catheters, for short duration hospital nutrition, as well as for moderate duration parenteral nutrition in the home (just as for the case of tunneled venous catheters). For parenteral nutrition lasting more than three months, the PICC is not proposed (only an implantable venous device or a tunneled catheter). The level of this recommendation is B, and the references it cites are somewhat old (two from the 1990s, one from 2005 [33]).

In the opinion of COWL [19], in a randomized trial comprising two groups of 50 patients, the use of a PICC (measured in free intervals without complications), at the hospital and for short-term parenteral nutrition, is shorter with the PICC than with the non-tunneled, single or dual-lumen subclavian catheter. The incidence of complications is practically the same (4.9% vs 5.6%); complications arise earlier with PICC. The most noteworthy difference has to do with venous thrombosis occurring in 15% of patients with a PICC vs 2% of patients fitted with a CVC. In total, only 48% of patients with a PICC received the entire intravenous treatment with the first catheter, vs 65% of those fitted with a CVC.

A contrario, in a large, non-randomized study outside intensive care, Al Raiy [27] observed a greater service life for PICC vs CVC – noting however that the group of CVC patients included a high proportion of femoral catheters. The median period before the occurrence of the first catheter infection (CLABSI) was shorter with the central catheter (13 vs 23 days). A significant proportion of patients with a PICC left the hospital with their PICC still in place.

The decision to use implantable catheters placed for treatment in oncology, and for the purposes of parenteral nutrition, must take the high frequency of infection in these devices into account [43].

Table IV – PICC and other intravenous devices in onco-haematology

<table>
<thead>
<tr>
<th>Authors</th>
<th>Type of study</th>
<th>Type of catheter (N°)</th>
<th>Infectious complications / 1000 cath.-days</th>
<th>Thrombotic complications / 1000 cath.-days</th>
<th>Mechanical complications / 1000 cath.-days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walsh 2002</td>
<td>Prospective cohort</td>
<td>PICC:351</td>
<td>2.46</td>
<td>3.32</td>
<td>5.12</td>
</tr>
<tr>
<td>Worth 2009</td>
<td>Prospective</td>
<td>PICC:75</td>
<td>6.6</td>
<td>7.7</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CVC:31</td>
<td>10.3</td>
<td>3.4</td>
<td>NR</td>
</tr>
<tr>
<td>Fagnani 2009</td>
<td>Multicentre retrospective cohort</td>
<td>PICC:144 CVC:242 TIVC:1004</td>
<td>0.353</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>Oncology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haider 2009</td>
<td>Prospective</td>
<td>PICC:146</td>
<td>11.1</td>
<td>0.3</td>
<td>3</td>
</tr>
<tr>
<td>Mollee 2011</td>
<td>Prospective cohort</td>
<td>PICC:807 CVC:320 Total:1127</td>
<td>1.81</td>
<td>5.49</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>Oncohaematology</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BREAKDOWN FOR THE 320 CVC: NTVC: 154 TCVC: 154 TIVC: 12</td>
<td>DEPENDING ON TYPE OF CVC: 12.0 NTVC: 8.08 TCVC: 0.97 J-CCI</td>
<td></td>
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<tr>
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<td></td>
<td>NTCVC: non-tunneled CVC TCVC: tunneled CVC TIVC: totally implantable venous catheter</td>
<td>NR</td>
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</table>

NR: not reported.
All in all, the decision to use a PICC rather than a conventional CVC (non-tunneled for short durations, and tunneled for moderate durations) is based on the risk-benefit assessment of the PICC, involving a lower risk during insertion, but a considerably higher risk of superficial or deep venous thrombosis [44].

**Indications in oncohaematology**

For more than thirty years, the use of long-duration venous devices (Hickman-Broviac catheters in haematology and TIVC in oncology) was standard practice. For economical reasons, the use of PICC was developed in these units, in the USA and Great Britain [5,11,12,45-48].

For these teams, the requirement for continuous access, patients affected by serious haemostasis disorders, and induction therapy for acute leukaemia, are indications for the use of PICC [5,6,11,12,39,45-48].

Contrary to other specialties, probably as the result of frequent thrombo-neutropenia in patients, publications insist more strongly on infectious complications than on thrombotic complications. In haematology, PICC-related infectious complications vary according to author, from 0.74 to 11.1/1000 cath.-day [6-11].

MOLLEE et al. [48] analysed the risk factors associated with different central venous devices, in a prospective cohort of 1127 oncohaematology patients. The incidence of infectious complications, for all devices, was 2.50/1000 cath.-day, whereas it was 12.6 for non-tunneled CVC. 8.08 for tunneled CVC, 1.81 for PICC and 0.97 for TIVC [48] (Table IV).

Thus, from this study, in oncohaematology the risk of infection was significantly higher for non-tunneled CVC [hazard ratio (HR): 3.50; p<0.0001] and for tunneled CVC (HR: 1.77; p=0.011), than for PICC. Furthermore, in the case of "aggressive" haemopathy, the risk of a CRI was greater when the patient was fitted with a non-tunneled CVC than when he/she was fitted with a TIVC (HR: 3.9; p<0.001) [48].

To our knowledge, no study has evaluated the PICC-related thrombotic risk during chemotherapy infusions, which are known to be "thrombogenous" (L-asparaginase for example). However, the question of a contraindication concerning the use of a PICC under these circumstances must be raised.

Although the choice of a PICC appears to be indicated in patients who are thrombocytopenic or have severe haemostasis disorders [17], it is more questionable for an oncology patient for whom a TIVC would appear to be preferable [49]. Nevertheless, the placement of a PICC can be envisaged if the patient is fearful of the placement of a TIVC (phobia of punctures, indwelling foreign bodies, scars …), if the number of chemotherapy treatments is limited [46], or following the removal of another type of venous access.

Similarly, the concurrent radiochemotherapy of inoperable ENT patients (who however respond to chemotherapy) is a good indication for the use of a PICC [50].

**Table V – Indications for PICC in paediatrics**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Type of study</th>
<th>Catheters (N°)</th>
<th>Infectious complications n (%) / 1000 cath.-d</th>
<th>Thrombotic complications n (%) / 1000 cath.-d</th>
<th>Mechanical complications n (%) / 1000 cath.-d</th>
<th>All complications n (%) / 1000 cath.-d</th>
</tr>
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<tbody>
<tr>
<td>VAN WINKLE 2008 [53]</td>
<td>Retrospective</td>
<td>PICC:39 Duration 21 d (3-79)</td>
<td>2 (local) (5,1 %) Incidence : 2,3</td>
<td>0</td>
<td>11 (28,2 %) Incidence : 12,9 %</td>
<td>13 (33,3 %) Incidence : 15,3</td>
</tr>
<tr>
<td>LEVY 2010 [54]</td>
<td>Prospective</td>
<td>PICC:279 Median duration 21 d (2-191)</td>
<td>38 (13,6 %) Incidence : 4 (CRI: 0.47)</td>
<td>13 thrombophlebitis* (4,6 %) Incidence : 0,06</td>
<td>64 (26 %) Incidence : 7,5 %</td>
<td>102 (36,6 %) Incidence : 11,9</td>
</tr>
<tr>
<td>HATAKEYAMA 2011 [6]</td>
<td>Retrospective</td>
<td>PICC: 93 Median duration 162 d (6-575)</td>
<td>12 (13 %) Incidence : 0,74</td>
<td>1 (1,07 %) Incidence : 0,06</td>
<td>5 (5,37 %) Incidence : 0,30</td>
<td>18 (19,4 %) Incidence : 1,11</td>
</tr>
<tr>
<td>ADVANI 2011 [9] (ICU and non ICU)</td>
<td>Retrospective cohort</td>
<td>PICC: 2592 Median duration 13 d (7-21)</td>
<td>116 (4,47 %) Incidence : 2,58</td>
<td>Risk factors of infection Duration &gt;= 21 d (RR: 1.53) PN (RR: 2.24) ICU + (RR: 1.80) Local infection on a previous PICC (RR: 2.46)</td>
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<td>BARRIER 2012 [55] Antibiotics (cystic fibrosis and various infections)</td>
<td>Retrospective</td>
<td>PICC: 610 duration: NR</td>
<td>Risk factors (all complications combined) - Age &lt; 1 yr → Incidence : 30,7 - Age &gt; 10 yrs → Incidence : 8,5 - dual-lumen PICC - N° of doses ABl &gt; 4</td>
<td>207 (34 %) Incidence : 19,3</td>
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</tbody>
</table>

CRI: catheter related infection. PN: parenteral nutrition. * In the series of Lévy et al., the authors counted 13 thrombophlebites in the infectious complications. All complications combined, there are 102 complications on PICC (38+64), i.e. a, incidence of 11.9/1000 cath.-d.

**Table V – Indications for PICC in paediatrics**

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<td>VAN WINKLE 2008 [53] (34 children at home, AB)</td>
<td>Retrospective</td>
<td>PICC:39 Duration 21 d (3-79)</td>
<td>2 (local) (5,1 %) Incidence : 2,3</td>
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Other indications: paediatrics, antibiotherapy, palliative care

Antibiotherapy

According to the studies, the (continuous or discontinuous) parenteral administration of antibiotic treatments for relatively prolonged periods of time represents the first, or one of the first, indications for the use of PICC in paediatrics [52-55], and in adults [17,40,47,56,57].

These are continuous, prolonged, IV treatments for bone or osteoarticular infections, cellulites [56], endocarditis [57] or homecare infusions of several antibiotics per day for the treatment of pulmonary superinfections with multiresistant germs, in patients affected by cystic fibrosis [58,59]. It appears that in the latter patients, *Burkholderia cepacia complex* (BCC) superinfections and their associated inflammatory syndrome could constitute a risk factor for deep venous thrombosis. This is at least what is reported by Nash et al. in a study of 376 PICC (all with a 5 Fr diameter) placed in 147 patients with cystic fibrosis [59]. In this study, the authors observed DVT (11.6%); in addition, they reported significantly more DVT in patients carrying BCC than in BCC-negative patients: respectively 20.9% vs 7.7%, (p=0.02). In addition, before placing the PICC (and therefore before the occurrence of PICC thrombosis), the inflammatory syndrome was significantly higher in BCC-positive patients than in BCC-negative patients.

Paediatrics

In paediatrics, most complications are of a mechanical nature, which is not so surprising when one observes the attachment system of these devices. The recent study of BARRIER et al. [55] confirms that a very young age is the first risk factor for complications observed in PICC; although an incidence of 19.3/1000 cath.-d is reported for this cohort of 610 PICC, this parameter is 30.7 in children aged one or less, and 8.5 in children over the age of 10 (Table V).

Thrombotic complications in children appear to be less frequent than in adults. A prospective study of 214 clinically followed children, systematically using Doppler ultrasound (and phlebography in the case of DVT) reports an incidence of venous thrombosis equal to 3.85/1000 cath.-d. In this study, the only DVT risk factor was the presence of thrombophilia (factor II mutation G20210A, OR: 7.08; p=0.04) [52].

Palliative care

PICC appear to be usable in patients at an advanced stage of their disease, in particular if they are receiving palliative chemotherapy infusions or other intravenous treatment in the home. Surveys carried out with these patients revealed the device’s very good level of acceptability and the impression of an improvement in the patients’ quality of life [60]. In a Japanese study, 18% of patients receiving care for one year in a palliative care unit – i.e. 38 patients – were fitted with a PICC for a median period of 15 days. The catheter placement procedure was considered to be non-distressing by three quarters of the patients; venous access was judged to be more comfortable by 85% of the patients [61].

Contraindications for PICC

In a programme for the improvement of quality of life and the reduction of PICC-related infections, the Seattle Children’s Hospital team elaborated a programme limiting the prescription and placement of PICC in their structure [14]. The following contraindications were included in their programme:

1- No PICC if the subject is destined to receive haemodialysis in the more or less long term.
2- No PICC for parenteral nutrition if enteral nutrition is possible or if nutrition is possible via a peripheral vein.
3- No PICC in the case of documented active bacteremia; the placement of a PICC is to be implemented only after 72 hours of efficient treatment (with controlled negativation of the haemocultures).

In 2009, the International Society of Nephrology [ISN] emphasized the deleterious role of PICC in patients with chronic severe kidney failure [62]. In these patients, often undetected thrombophlebitis on PICC are the cause of venous sclerosis, which makes it very difficult to implement arteriovenous fistula or other venous shunts [14,33,63].

The ISN recommendations thus advise prohibiting the use of PICC in patients with severe kidney failure, for whom the use of a vascular fistula is highly predictable (patients having a glomerular filtration rate < 60 ml/min) [62].

Furthermore, in a study of 713 tunneled catheters used for haemodialysis, BUTLER et al. [64] showed that patients who had already "received" a PICC had a significantly higher risk of developing an infection on their haemodialysis catheter (OR: 2.46 [CI95: 1.71-3.53], p<0.001). In
addition, in these patients, the duration of haemodialysis catheter use was significantly shorter than in patients having never received a PICC [64].

References


64- Butler PJ, Sood S, Mojibian H, Tal MG. Previous PICC placement may be associated with catheter-related infections in hemodialysis patients. Cardiovasc Intervent Radiol 2011; 34(1): 120-123.
Rationale

Question 4

Prevention during PICC insertion

Choice of device

Existing regulations and recommendations

- The NF EN ISO 13485 standard of September 2012 entitled "Medical devices – Quality management systems – Requirements for regulatory purposes" describes requirements related to the quality management system when an organisation must demonstrate its ability to supply medical devices and associated services on a regular basis, meeting the requirements of its customers and the regulations applicable to medical devices and associated services [1].

- Among the various current recommendations, silicone and polyurethane devices should be preferred, since they are less frequently associated with infectious complications than polyvinylchloride or polyethylene [2,3].

  Antiseptic or antibiotic impregnated catheters must not be used on a routine basis [4].

  It is recommended to use the minimum number of lumens needed for the patient (cat. IB) [5].

Analysis of the literature

External diameter of the device

LIEM identifies a TIVC diameter ≥ 5 Fr as a significant risk factor for deep venous thrombosis [6], and proposes the use of the smallest possible PICC diameter in order to reduce the incidence of deep venous thrombosis.

EVANS makes similar observations by stating that the size of the catheter and the number of lumens must be based on clinical indications and not on the simplest solution or purchasing habits [7].

GROVE confirms these results: no thrombosis observed with 3 Fr catheters, 1% thrombosis incidence with 4 Fr, 6.6% with 5 Fr, and 9.8% with 6 Fr catheters [8]. Other authors, in particular PITTIRUTI, insist on the contraindication for PICC insertion when the ultrasound diameter of the puncturable vein is less than 4 mm [9]. Similarly, the diameter of the inserted catheter must be adapted to the diameter of the vein: 4 Fr for a vein having a diameter greater than or equal to 4 mm, 5 Fr for a vein greater than or equal to 5 mm, and 6 Fr catheters should be reserved for vein diameters greater than or equal to 6 mm, in other words a vein diameter at least three times greater than the PICC diameter (it should be noted that this refers to the diameter of the vein under axillary tourniquet).

Multi-lumen PICC

For the reasons given above, dual lumen PICC must be avoided, and TRÉROTOLA reported an unacceptable rate of thrombosis with the triple-lumen PICC (6 Fr) used in intensive care (20% of patients) [10].

It is interesting to note that Black has shown that PICC, in particular 4 Fr, could be used to monitor central venous pressure, provided they were not dysfunctional, thus explaining the usefulness of dual-lumen PICC in certain cases [11].

Silicone or polyurethane

For the same external diameter, the internal diameter of a polyurethane catheter is greater, thus allowing greater flow rates and offering less resistance (but also higher potential fragility). For an equivalent length, a 4 Fr PICC allows a flow rate of 2 to 3 ml/minute, and up to 10 ml when a pump is used.

High flow rate or standard PICC

High flow rate PICC can develop pressures up to 300 psi, thus have a minimal risk of breakage or rupture, and can tolerate flow rates of 5 ml/s (180 to 300 ml/minute) when associated with a pump. This is their main
advantage when they are used in critical care or radiology.

DI GIACOMO has shown by comparing standard silicone and polyurethane PICC with high flow rate PICC that the prevalence of occlusion or rupture was lower with power-PICC, thus making it the preferred device for chemotherapy and intensive care [12]. It is even more critical than in the case of standard PICC to check the position of the catheter's distal end (± prior injection contrast test) before carrying out any high flow rate injection, in order to avoid any risk of extravasation or pericardial tamponade, in particular in the case of staged emergence multi-lumen catheters used in the superior vena cava [13,14].

Proximal or distal shortening

Each material has its advantages and disadvantages: distal shortening permits industrial fastening of the connexion, and proximal shortening with a narrower extremity is less traumatising. In order to achieve the best possible cut at the distal end, the use of a guillotine type of instrument is recommended [15].

Some manufacturers also propose PICC with several different lengths, in order to avoid the drawbacks of catheter shortening.

Usefulness of integrated distal or proximal valves

Although two studies have revealed the advantages of proximal valve catheters [16,17], the observed differences could be related to the catheter material: silicone for distal valve catheters, polyurethane for the proximal valve catheter. In a recent study comparing PICC with no valves with PICC having a distal or proximal valve, JOHNSTONE did not observe any difference.

Choice of insertion site

Existing regulations and recommendations

In 2010, in the "Infections associated with intravascular devices" chapter of Surveillance and prevention of healthcare-associated infections [4], although the SF2H does not deal directly with PICC, it recalls (R106) that "Do not insert a catheter in the vicinity of weeping infectious skin lesions, or into a limb on which lymph node dissection or radiotherapy has been carried out, or on which a malignant tumour has been diagnosed, or with an arterial venous fistula, or next to a joint, or with an orthopaedic prosthesis or into a paralyzed limb. [4].

Analysis of the literature

Choice of vein

Access must be carried out from inside to outside and top to bottom, and be restricted to not more than four attempts [19,20]. The basal vein is the vein of choice, provided it is accessed via the lower or intermediate third of the arm, at a safe distance from the brachial artery and from the antero-externally situated median nerve. "Modified Seldinger" (mono parietal) puncture using ultrasound guidance or venography makes it possible to reduce the risk of haematoma, and thus of venous stasis and secondary sepsis [21]. Ideally, venous compression using an axillary tourniquet and preferably the puncture of a venous valvule should be used, thereby improving the initial technical success rate.

The brachial vein has the drawback of being split and retro-arterial in 8% of cases, as well as being close to the median nerve. BUSCH has described up to 0.6% paresis of the median nerve following percutaneous access to the brachial vein [22]. The cephalic vein is useful only in the case of obese patients (since the basal or brachial veins may be too deep). The difficulty in crossing the arch of the cephalic vein, and its strongly undulating, thrombogenic and spastic nature, make it a third-line choice, following the basal and brachial veins.

The brachioaxillary venous network distribution has various anatomical variants [23,24], a good knowledge of which is useful in the case of difficulties in identification or insertion.

The thrombotic risks associated with venous access are respectively 57% (cephalic vein), vs. 14% (basal vein), and 10% (brachial vein) [19].

Contraindications and choice of the side to be used for access

It is of capital importance to define the patient's so-called "non symptomatic" implantation side, before any procedure [21]. Some authors describe a heightened risk of thrombosis when insertion is carried out on the right side, which could be related to the more frequent movements of the dominant arm [19,25]. Conversely, Marnejon has reported an increased risk of thrombosis associated with left-sided insertion. The suspected mechanism is the greater length of the traversed venous system and slowing of venous flux on the left side [26].
The foregoing confirms two aspects: the importance of choosing the arm for implantation whenever possible, following ultrasound visualisation of the considered vein, and monitoring the correct positioning of the catheter's distal end, which can be more readily achieved on the right than on the left side, and is more difficult in obese patients and in the case of a large mediastinum without a superior vena cava syndrome.

A recent observation underlines the increased left-side risk of the catheter adopting an abnormal position, in the left superior vena cava in particular [27].

WILSON insists on the contraindication for insertion into a paralysed arm [28].

To avert the risk of lymphedema, there is a plethora of radical recommendations forbidding venous puncture following axillary node dissection or radiotherapy. The literature confirming this attitude is rather scarce.

**Skin preparation and insertion conditions**

**Existing regulations and recommendations**

- The decree n° 2004-802 of July 29th, 2004 [29] stipulates:
  - Article R 4311-7 "The nurse is authorised to carry out the following acts, in accordance either with a medical prescription [...], or with a protocol [...] written by a doctor:
    - the monitoring of central venous catheters and implantable venous access systems installed by a doctor;
    - injections and infusions, excluding the first of these, in catheters as well as central venous catheters and these systems;
  - Article R 4311-9 "The nurse is authorised to carry out, in accordance with a medical prescription [...], provided a doctor is able to intervene at any moment [...]:
    - Removal of central and intrathecal catheters [...]

- In 2013, in its guide *Preoperative management of infectious risk*, the SF2H recommends [30]:
  - In relation to hair removal: "In order to reduce the risk of SSI, it is recommended not to carry out routine hair removal (mechanical shaving, clipping or chemical hair removal) (B2). If hair removal is carried out, it is strongly recommended not to make use of mechanical shaving (E1). No recommendation can be made concerning the use of depilatory creams (C2)."
  - Concerning body hygiene or preoperative cleansing, "It is recommended to take at least one preoperative shower (B3). No recommendation can be made concerning the type of soap (antiseptic soap or non antiseptic soap) to be used for the preoperative shower (C2)."
  - Concerning local skin preparation, before carrying out antisepsis: "It is recommended to carry out cleansing of soiled skin (C3)."
  - For antisepsis: "It is strongly recommended to implement disinfection of a large area surrounding the surgical site (A1). It is recommended to prefer the use of an alcohol-based antiseptic (B3)."
In 2013, the Centre for Healthcare related infection surveillance and prevention – Queensland Health [31] recommends inserting PICC in a dedicated room or in an interventional radiology room. Maximum barrier precautions must be taken: surgical dressing for operators and all persons entering the operating area, and the use of a large sterile drape.

In 2010, in Surveillance and Prevention of healthcare-associated infections the SF2H recommends [4]:

- "R110: Insertion is to be carried out by a trained operator wearing surgical garments (cap, surgical mask, sterile gown), with the help, in the case of TIVC, of an assistant wearing a clean gown, a head cap and a surgical facemask. Prior to insertion, the operator carries out a surgical handrub and then puts on a pair of sterile gloves.
- "R111: Skin preparation of the insertion site is performed in four steps: cleaning (antiseptic soap), rinsing (with sterile water), drying (with sterile pads) and antisepsis (with an alcohol-based antiseptic). Sterile drapes much larger than the catheterization area are positioned after the antiseptic has dried without being touched.

In 2011, the CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections [5] recommend implementing the highest level of precautions: cap, mask, sterile gown and gloves, and a large drape for the insertion of CVC or PICC (cat. IB).

Analysis of the literature

Qualification of the operating room

There is no reference recommending the use of an ISO 6 or ISO 7 level of asepsis.

Operator training

In an observational study, the use of a simulator training program can lead to a statistically significant reduction in the risk of postoperative infectious complications during the placement of a CVC in a critical care unit (0.50 vs. 3.2 infections for 1000 catheter-days) [32].

ANDREATTA compares two training techniques for PICC insertion, and concludes that simulations lead to better results than classical companion training techniques at the patient's bedside [33].

Profession of the person carrying out PICC placement

The French legal context entrusts doctors with the insertion of PICC. For several years, Anglo-Saxon literature has described medical acts carried out by specialised nurses, and studies insist on the importance of dedicated teams [34,35].

Insertion technique

Existing regulations and recommendations

In 2009, the European Society for Clinical Nutrition and Metabolism [36] recommends that, whatever the type of central venous catheter, insertion be carried out under ultrasound guidance and does not recommend surgical technique for reasons of cost and the risk of infection (Grade A).

In 2008, in the CDC HICPAC Guidelines for Disinfection and Sterilization in Healthcare Facilities [37]:

The recommendations for preoperative ultrasound imaging recommend using a sterile protection to cover the probe; following removal of the probe, either its sterilisation or a high-level of disinfection is required.

In 2011, in Ultrasonography on loco-regional anaesthesia [38], the French SFAR recommends the use of a dedicated and appropriate sterile, disposable protective sheath, and a single-dose sterile gel, during the use of an ultrasound probe; during its removal, in the absence of perforation of the sheath, it recommends the use of low-level disinfection, and in the case of rupture or soiling of the sheath, use of the highest possible level of disinfection.

In 2009, in Cross-contamination prevention [39] the SF2H recommends: "R79 – It is highly recommended not to make use of the antibiotics used in systemic treatments for the eradication of MRSA carriers.

The 2010 SF2H guide Surveillance and prevention of healthcare-associated infections [4], as well as the 2011 CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections [5], stated that: "It is not recommended to use antibiotic prophylaxis during the insertion of a CVC".
Analysis of the literature

Venipuncture

Percutaneous access is to be preferred to the longer and more invasive alternative of surgical stripping.

Avoidance of the elbow

Insertion at the elbow crease must be avoided: According to Polak, PICC acceptance varies, depending on interference with the patient's activities, and patient degree satisfaction is 17% when the puncture is made below the elbow, and reaches 90% when the PICC is positioned above the elbow [40]. Apart from patient satisfaction, there is a greater risk of catheter occlusion, and probably thrombosis, associated with arm flexure and movements, or even shearing of the distal end.

Choice of guidance technique during venous puncture

Ultrasound imagery is the only technique allowing suitable veins to be located above the elbow. Several authors have shown that this technique may increase insertion success rate and lead to a reduction in the frequency of complications [41,42]. The use of ultrasound guidance improves insertion and reduces the risk of thrombosis [43]. Ultrasound guidance reduces the number of unsuccessful attempts at insertion (1.2/procedure), the length of procedures (22 minutes) and the rate of complications. It is the first-line PICC insertion procedure, and has a technical success rate ranging between 99% and 100% [44,45].

Schweickert recommends the use of ultrasound for PICC insertion at the patient's bedside, or even the injection of an ultrasound contrast medium, in neonatology in particular [46].

The indications for a venography are limited to patients having a history with a homolateral catheter, involving suspected asymptomatic downstream thrombosis with venous spasms (2% of cases) and obese patients for whom it is difficult for ultrasound to differentiate between a fat lobule and a superficial vein.

Catheter distal end positioning technique

This is based on a frontal, or even an oblique left anterior, thoracic image, ultrasound ± contrast agent injection test (in paediatrics in particular), or even ECG guidance [47]. The arm's position and elbow flexure can lead to distal end migration: 20 mm descent in 58% of cases, during abduction followed by abduction of the arm [48].

Basal or cephalic vein access could also have an early influence on variations in the position of the catheter's distal end, in paediatrics in particular [49].

Duration of insertion and number of attempts at puncturing the vein

Although it is likely that these factors play a role in the risk of early infection and thrombosis, Wilson has shown that an insertion procedure lasting more than one hour is a risk factor for thrombosis [28].

Antibioprophylaxis

As the aim of antibioprophylaxis is to prevent early infections, it is probably valid to extrapolate data from standard catheterisations. Similarly, as in the case of the recommendations for totally implantable venous catheters in immunosuppressed patients and/or MRSA carriers, the impact of antibioprophylaxis would be of only limited interest. It could be more relevant to discuss the use of antibioprophylaxis in diabetic patients treated with insulin, with a high risk of Staphylococcus aureus sepsis, and in patients with a history of staphylococcus sepsis (furunculosis, anthrax, staphylococcus sepsis on a central line).

PICC attachment systems

Existing regulations and recommendations

- In 2010, in Surveillance and prevention of healthcare-associated infections [4]:
  - “R113: Cover the IVD insertion site by using a transparent, semipermeable, sterile dressing made of polyurethane, to allow visual inspection of the IVD. Use sterile gauze with the sterile adhesive dressing in case of bleeding or exudation.”

- In 2011, the CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections [5] recommend the use of a catheter-stabilising dressing in order to reduce the risk of infection for intravascular catheters.

Analysis of the literature

According to Schears and Yamamoto, the use of a securement dressing to fasten a PICC carries a lower risk of infection than the use of sutures [50,51].
It is preferable, in particular if the aseptic dressing is not perfectly free of blood, that the first dressing be absorbent. Thereafter, the use of a semi-permeable transparent dressing allows the puncture site to be monitored.

References


31- Centre for healthcare related infection surveillance and prevention & tuberculosis control (Queensland Health). Guideline Peripherally inserted central venous catheter (PICC). 2013: 1-18


Rationale

Question 5

Maintenance and use of PICC

The literature dealing with daily manipulations of PICC, and in particular dressings for PICC is scarce and of mediocre quality. The recommendations for PICC are mainly included within recommendations for the prevention of infections associated with other central venous access systems. The specificity of PICC dressings lies in the use of a sutureless attachment system.

Choice of infusion equipment and technical aspects

Existing regulations and recommendations

In the French law n° 94-43 of January 18th, 1994 relating to public health and social protection, Article L5212-2 of the Public Health code, Chapter II of book II, the dispositions relating to medical devices stipulate that: “The manufacturer and users of a device, as well as third parties aware of an incident or the risk of an incident arising from a device having led to, or which may lead to, the death or serious impairment of the health of a patient, a user or a third party, must without delay report this to the administrative authority.”[1].

The decree n° 94-352 of May 4th, 1994, relating to the protection of workers against the risks resulting from their exposure to biological agents, holds the employer responsible for the safety of his/her personnel with respect to the biological risk, and states: "It is compulsory for the hospital director to evaluate the risks of biological exposure in order to implement the necessary preventive and protective measures" [2].

The circular letter DH/EM/1996-2517 of May 24th, 1996 relative to the safety of medical devices, states that: "Whatever its implantation site, an implanted catheter should never be cleared with a small diameter syringe: indeed, there is a risk of breakage and embolization of the catheter, whenever an attempt is made to unblock it using any sort of liquid under pressure" [3].

The circular letter DGS/DH/98/249 of April 20th, 1998, pertaining to the prevention of contamination by infectious agents borne by blood or biological fluids during hospital care, recalls the hospital director's responsibility in terms of the protection of workers. It states that: "In agreement with the CLIN, the occupational physician and the CHSCT, the hospital director must define a preventive strategy including the use of so-called safe medical equipment. These medical devices (sampling needles, catheters, containers, ...) allow the risk of BBFE to be reduced. They must be considered as additional preventive means, with respect to the general hygiene precautions" [4].

In 2010, in the chapter "Infections associated with intravascular devices" of the Surveillance and Prevention of healthcare-associated infections guide, recommendation R104 states "Prefer safety devices when available and train caregivers in the use of such equipment." [5].

Also in 2010, in its Guide on safety Equipment, the GERES recommends that: "In general, in the case of invasive acts whenever they exist, medical devices should be preferred which:

- have an integrated safety system with irreversible activation;
- automatically provide safety, without user intervention, or allow single-handed triggering with the simplest possible procedure, call for gesture continuity and allow the earliest possible use of a safety mechanism following the act, ideally when the needle is still under the skin;
- otherwise, allow the user to single-handedly trigger a safety mechanism with the simplest possible procedure, and are equipped with an audible or visual safety locking indicator”[6].
The Council directive 2010/32/UE of May 10th, 2010 enforcing the framework agreement between the HOSPEEM and the FSESP, relating to the prevention of injuries by sharp objects in the hospital and health sector, was published on June 1st, 2010. One of the purposes of this directive is "to prevent injuries caused to workers (including needlestick injuries) by any sharp objects intended for medical use" [7].

In the 2009 - 2013 national Program for the prevention of nosocomial infections, it is stated: "Local action program: Improve the safety of procedures exposing persons to high blood exposure risks (training, sufficient supply of protective and safety equipment), during insertion and removal of needles on a TIVC, subcutaneous injections, placement of intravenous catheters, …)" [8].

In 2011, the document Guidelines for the prevention of Intravascular Catheter-related Infections", the CDC recommend the use of needleless connectors to access the venous line, in order to prevent blood exposure accidents (Cat. IC). Moreover, they also add that if such needleless connectors are used, a system with a pre-split septum should be preferred to a mechanical system, due to the increased risk of infection associated with the latter (Cat. II). It is important to ensure that all of the system's devices are compatible, in order to minimize leakage and breakage (Cat. II) [9].

Analysis of the literature

Central line access

Access is achieved through the use of two types of device:

- either a blocking plug, which requires opening of the central line in order to make a syringe injection or install a drip,
- or a needleless connector, also referred to as a safety connector or closed needleless system, or even a bidirectional valve, initially designed to prevent the risk of BBFE, since it removes the need for the healthcare provider to use a needle.

After having been used for approximately fifteen years in North America, these devices have been developed with different generations of materials, and although some studies have shown a reduction in the contamination of the catheter hub, the bibliographic rationale presented in the recent CDC recommendations call for caution [9,10]. Indeed, several studies have reported an increase in bacteremia on TIVC, associated with the introduction of certain types of such devices with a mechanical valve.

Several explanations have been proposed: internal technical configuration of the device making it more or less difficult to flush, lower disinfection efficiency resulting from the membrane design, lower observance of membrane or septum disinfection before using the valve, insufficient replacement frequency, or utilization for blood sampling [9,11-14]. Various devices available on the market still remain to be evaluated.

Finally, the use of a syringe with a volume of less than 5 ml generates pressure in the chamber and connected catheter that is incompatible with the strength claimed by the manufacturers To avoid any "forced" manoeuver and preserve the integrity of the device, it is recommended to use syringes having a volume of at least 10 ml [15].

Prepackaged set

In the field of the care of patients suffering from cystic fibrosis, in its notice produced in June 2006, the product and service evaluation commission of the HAS recognizes the service provided by the use of an individual care set for domestic infusions. This can simplify care, in particular in situations where it is difficult to ensure aseptic conditions [16].

PICC flushing

PICC obstruction is a frequent event, an infectious complication risk factor, and can arise through various mechanisms: thrombosis, precipitates resulting from the use of incompatible medications, blood or lipid deposition. PICC flushing before and after use allows this risk to be reduced. However, the following questions arise: which product, what volume, and what flow rate? As in many other situations, the available data is derived from literature dealing with TIVC, however this is particularly important in the case of PICC since there is a higher risk of occlusion.

There is no consensus on whether to use heparin or 0.9% NaCl.

Many reasons are given not to use heparin: its limited useful life, hypocalcemia, induced thrombocytopenia, incompatibility with the perfusate [17-20].

Experimental studies have tried to determine the ideal volume of 0.9% NaCl for TIVC flushing. After blood sampling, the density of red blood cells remaining in the TIVC progressively
decreases, with an inflexion point in the curve at a cumulated flush volume equal to 7 ml. The results reveal the significant dilution effect produced by the first millilitres of flushing solution, and suggest recommending the association of a large flush volume (at least five times the device's internal volume) with a pressure effect, in order to minimize the risk of thrombosis of the implantable device [21].

Finally, another study tried to determine the most efficient method for maintaining the permeability of an intravascular catheter. The authors showed that "venous guard" flushing (using a 500 ml pouch of 0.9% NaCl, at a flow rate of 0.35 ml/mn) was relatively inefficient during the first 12 hours (< 30%) and that the efficiency was not improved when the flushing was carried out with the help of a 10 ml continuous flow syringe with 10 successive 0.5 second pulses at a 150 ml/min flow rate, thus corresponding to a total flow time of 5 seconds [22].

Finally, to limit the risk of contaminating injectable medication, prefilled 0.9% NaCl syringes are a useful alternative to the preparation in the hospital ward of a "multidose" flushing solution [17,23,24].

Dressings

Existing regulations and recommendations

In 2000, in the reference document entitled Evaluation of the quality of totally implantable venous catheter use and surveillance, the ANAES cites the CTIN recommendation n° 86: "It is imperative to use an attached, hermetically sealed, sterile dressing. Semi-permeable, transparent dressings allow for daily inspections and palpation of the insertion site. The optimal interval for dressing replacement is not precisely defined: a minimum of 48 hours is recommended, which may be extended to 5 or even 7 days in the absence of soiling and loosening"; however, the APHP recommendations for clinical practice also state: "for patients in oncology-haematology: dressing replacement every 7 days; for HIV infected patients: dressing replacement every 72 hours; following disconnection of the port, a clean dressing shall be applied for several hours. It is not useful for a dressing to be worn in situations other than those involving catheter connection [25].

In 2006, the Health Ministry’s Guide for the prevention of healthcare-related infections outside hospitals recommends changing the dressing without delay in the case of soiling or loosening. The systematic or preventive application of an antimicrobial cream to the insertion site is not useful [26].

In a notice published in 2007, the HAS commission for the evaluation of products and services defines semi-permeable adhesive dressings as being indicated for: the protection of intravenous catheter sites. The minimum technical specifications for this type of dressing must comply with the EN 13726-2 standard, i.e. have properties allowing the passage of $\geq 500$ g of water vapour per m$^2$ in 24 hours [27].

In 2007, the British Committee for Standards in Haematology recommended that dressings be changed 24 hours after application, and then once a week, without indicating the type of dressing or the type of catheter used [28].

In 2009, the European Society for Clinical Nutrition and Metabolism proposed that the dressing be changed every 7 days, as soon as the insertion site has healed. It prefers the use of semi-permeable dressings for all types of catheter [29].

In 2010, in the chapter entitled “Infections associated with intravascular devices” of the Surveillance and prevention of healthcare-related infections guide, the SF2H recommends in R113 “Cover the IVD insertion site by using a transparent, semi-permeable, sterile dressing made of polyurethane, to allow visual inspection of the IVD. Use sterile gauze with the sterile adhesive dressing in the case of bleeding or exudation. Before exposure to water, temporarily protect the dressing with an impermeable material. Before manipulating the dressing, disinfect the hands (handrub). Proceed with dressing replacement only when it becomes loosened or soiled, or when inspection of the site is necessary, under the same conditions as during dressing application. Indicate the date of dressing replacement in the patient's medical file."[5].

In 2011, in Guidelines for the Prevention of Intravascular Catheter-Related Infections, the CDC recommend:

- Observing hand hygiene procedure, by washing with mild soap or an alcohol-based product (ABP). Practicing such hand hygiene before and after palpation of the insertion site,
..., or before catheter dressing replacement (Cat. IB).

- Disinfecting clean skin [...] with > 0.5% alcoholic chlorhexidine [...] and whenever dressings are changed. In the case of a chlorhexidine contraindication, an iodine derivative or 70% alcohol can be used (Cat. IA). No comparison has been made between alcoholic chlorhexidine preparations and alcoholic povidone-iodine for the disinfection of clean skin. This question remains unresolved.

- Not exposing the catheter to water. Showering is permitted if all precautions are taken to minimize the probability of introducing microorganisms into the catheter (example: during a shower, the catheter and tubing must be protected by an impermeable dressing) (Cat. IB).

- Changing transparent dressings used on totally implanted venous catheters or tunneled CVCs not more than once a week, except when the dressing is soiled or loose, until such time as the insertion site has healed (Cat. II).

- Visually examining the catheter insertion site whenever the dressing is changed or by palpation through the dressing, in order to detect any sensitivity, in accordance with the clinical condition of each patient. If the patients have any sensitivity at the insertion site, fever of no obvious origin, or any other local manifestations suggesting the presence of an infection, the dressing must be removed to allow close examination of the site (Cat. IB) [9].

- In 2013 in Australia, in its Guidelines for Peripherally Inserted Central Venous Catheter (PICC), the CHRISP (Centre for Healthcare Related Infection Surveillance and Prevention & tuberculosis control, Queensland Government) proposes:
  - for the dressing: use aseptic technique with a care set and sterile gloves. Use alcoholic chlorhexidine. Carry out cleansing of the skin and proximal junction, using a circular motion in concentric circles, three times. Use a semi-permeable, transparent sterile dressing. Replace the dressing as soon as it becomes damp, soiled, no longer occlusive, or as soon as there is accumulation of fluid (especially blood) under the dressing, and as soon as there is evidence of an inflammation at the insertion site.
  - In order to secure the PICC: use suturing or a sutureless fastening system. When attaching the PICC, the latter has the advantage of: reducing the length of time required to secure the catheter; avoiding the additional risk of needlestick injury; and potentially reducing the risk of infection through the elimination of sutures and minimisation of catheter movements [...].

### Analysis of the literature

There are no studies that have specifically dealt with dressings for PICC (choice, replacement frequency, ...), such that most protocols extrapolate from other existing central venous catheter recommendations.

- However, one specificity of PICC dressings is their securement system, which makes use either of suture securement, or more frequently, adhesive, sutureless securement systems such as STAT-LOK® or GRIP-LOK® in 2012. Securement with the sutureless system has the theoretical advantage of reducing the risk of infection, through the absence of sutures, and minimising to-and-fro movements of the catheter, which may promote contamination of the catheter. There is only one study having dealt with this point. This open, randomised study found less general complications (42/85 vs. 61/85) and less bacteremia (2/85 vs. 10/85) in the group with sutureless securement [30]. Another study is in favour of PICC securement in paediatrics, although securement systems with and without sutures were not compared [31]. A recent publication [32] identifies a low risk of thrombotic complications for PICC, which the authors attribute to a sutureless securement, without however presenting any data justifying this affirmation.

The systematic use of sutureless securement systems with PICCs is thus not justified by solid scientific evidence, and in France these systems are not used for conventional CVC which, using the same reasoning, could in principle make use of the same type of securement system. The convenience of using sutureless systems, commonly encountered in the case of children in the home, can justify the additional cost of such systems.

- A recent meta-analysis made using the Cochrane system concluded that transparent, semi-permeable dressings could increase the risk of infection, with respect to “gauze” dressings, but this result is based on a broad confidence interval that does not conclude in favour of one or the other of these two types of dressing, for the prevention of CVC-related infections [5]. However, the semi-permeable dressing has the advantage for the patient of allowing less frequent dressing replacements,
and allowing visual monitoring of the puncture in the case of CVC.

- Antiseptic impregnated sponges or dressings that have been proposed until now, in the context of a high incidence rate of infectious complications [9,29], have recently been analysed in two studies, the results of which are strongly in favour of their routine use for the prevention of CVC-related infections in critical care [33,34]. However, until now no study has been carried out for PICC.

- The optimal frequency for replacing dressings is not accurately known. Recent recommendations tend to be in favour of replacing them as infrequently as possible, provided they remain adherent and clean. This attitude is based on several studies carried out in haematology, revealing lower skin [35] and critical care [34,36] toxicity; the latter study revealed a heightened risk of catheter colonisation in the case of more frequent dressing replacements. Replacement of the dressing once a week, at the same time as the main line, could be proposed.

- An essential element for the limitation of PICC complications is education and training of the healthcare teams in charge of this equipment. Several studies confirm this observation. The first study to make a historical comparison shows that the rate of bleeding (7% vs. 24.7%), of infection and phlebitis (4.2% vs. 9.7%), and of occlusion (2.8% vs. 6.7%), decreases following staff education and training [37]. Another study led to the same conclusions [38].

### Preparation and management of administered products

There are no specific recommendations for PICC, and the recommendations pertaining to CVC are thus applied to the specific case of PICC. One can note that PICC belong to the group of long duration catheters, as opposed to short duration central venous catheters that have a mean lifetime of 7-10 days, and a maximum lifetime of less than 3 weeks. As a consequence, their use requires considerable observance of the relevant precautions, on account of the overriding risk of endogenous contamination for this type of catheter. The distant location of the cutaneous entrance site and the length of the catheter do not afford protection, since numerous studies have observed identical infection rates for traditional central venous lines and PICC.

### Existing regulations and recommendations

- The circular letter n° 377 of June 13th, 1967, relating to the use of infusion bottles, recommends "no matter what their form of packaging":

  "1 – Disinfecting the outer surface of the rubber plug before use. This measure should be applied to all solutes, whatever their origin. After having removed the protective stopper, dry the surface of the plug if necessary, rinse with alcohol, leave the alcohol for approximately one minute and remove the excess by tipping the bottle. Any truly effective disinfectant (for example alcoholic iodine) may be used."

  2 – Install the infusion equipment. Air enters through a sterile cotton wool plug. Any other air admission device must be fitted with an analogous filtration system.

  3 – In cases where any medication is added to the solute, this should be injected into the bottle only when step 2 has been completed.

  4 – Any thus-prepared infusion must be used within one hour.

  In the case of vacuum packaged bottles, check before any procedure that the seal is intact by verifying the presence of a vacuum in the bottle, using the following technique: use the fist to tap on the bottom of the inverted bottle. If the vacuum has been preserved, a characteristic clicking sound can be heard. Eliminate any bottle which does not have this characteristic" [39].

- The circular letter DH-EM 1 n° 96-5852 of October 18th, 1996, relating to the safe use of medical devices, recommends in the case of (unidirectional) anti-return valves for infusion lines:

  "[...] The function of the anti-return valve in an infusion line is to allow the infusion solute to flow in only one direction (from the solute storage device to the patient) and to prevent any retrograde reflux. It can be used on just one infusion line, but is normally indicated for the case of parallel infusions making use, for example, of a continuous gravity-fed infusion and a patient-controlled analgesia (PCA) infusion pump. In the latter case, the valve is placed upstream of the Y-tubing or the 3-line stopcock, on the gravity-fed infusion line, thus making it possible to prevent any reflux of morphine solute towards the gravity-fed infusion storage device [...] " [40].
GOOD PRACTICE AND RISK MANAGEMENT FOR THE USE OF PICC - 2014

The circular letter DGS/DHOS/AFSSAPS n° 03/582 of December 15th, 2003 indicates that:
"In order to avoid the conservation of blood products in the ward or the hospital’s blood transfusion centre, it is recommended to transfuse within the shortest possible time following delivery, without exceeding a delay of 6 hours … “ [41].

The AFSSAPS good practice preparation recommendations define guidelines for the preparation of sterile medication containing, in particular, dangerous or radiopharmaceutical substances… "preparation is carried out in an internal pharmacy, in a zone having a controlled atmosphere [42].

In 1997, in its recommendations entitled Prevention of infections associated with indwelling intravascular access devices, the Canadian public health agency states that “it is advisable to select the most simple possible configuration (minimal number of openings, connections, and access lines) with respect to the intended use of the catheter (BII) “ [43].

In 2000, in the reference document entitled Evaluation of the quality of use and surveillance of totally implantable catheters, the ANAES states that:
- “The maintenance of the venous line must be strictly aseptic, by respecting the notion of a closed system, whenever possible,
- preferably isotonic saline solutes, rather than glucose solutes, should be used for continuous infusion of the main line,
- in the case of blood deposits or reflux, the tubing must be changed immediately,
- the use of inserted antibacterial filters has not been shown to be efficient” [25].

In 2006, the Guide for the prevention of infections associated with healthcare dispensed outside health facilities states that “All infusion tubing and auxiliary equipment (excluding extension tubing – first junction) should be replaced every 72 to 96 hours. The infusion line shall be changed daily in the case of parenteral nutrition and after each infusion of blood, blood products or lipid emulsions” [26].

In 2008, in its “Parenteral nutrition in the home” evaluation report, the HAS indicates that “in this particular case, the administration of nutritious mixtures in the home must be carried out via a central venous line by means of a programmable infusion pump” [44].

In 2010, in the chapter entitled “Infections associated with intravascular devices” in its “Surveillance and prevention of healthcare-related infections” guide, the authors recommend:
- “Preparing infused fluids whilst observing the rules of asepsis. Never use any solute with visible turbidity, leaks, cracks or material particles, or whose use-by date has expired. Prefer the use of disposable vials. Eliminate the unused contents of disposable vials. Handle multidose vials with strict asepsis precautions, and respect the storage conditions and durations. Clean the plugs of multidose vials with 70% alcohol before inserting any equipment into the vial. Use sterile equipment to puncture multidose vials. Eliminate any multidose vial whose sterility has been compromised (R115).
- Complete the infusion of labile blood products within 4 hours after beginning its administration. Complete the infusion of lipid emulsions within 24 hours of beginning infusion. Replace used tubing after each administration of labile blood products and within 24 hours of the administration of lipid emulsions (R116).
- Respect the rules of asepsis whenever a heparin lock, continuous heparinization, a saline lock, or a valve is used” [5].

In 2011, in Guidelines for the prevention of intravascular catheter-related infections the CDC recommend:
- “In patients who are not receiving labile blood products or lipid emulsions, replace the main infusion delivery line, including the secondary tubing and associated devices, no more frequently than every 96 hours, but at least every 7 days (Category IA),
- Replace the tubing used for the flow of blood or blood derivatives or lipid emulsions (those combined with amino acids and glucose, delivered together or separately) within 24 hours of injection (Category IB),
- Replace tubing used for the flow of Propofol every 6 to 12 hours following use, according to the manufacturer’s recommendations (Category IA),
- There are no recommendations concerning the replacement frequency for tubing used for the intermittent delivery of products” [9].

Analysis of the literature

No specific studies were found dealing with the risk of infection associated with the
preparation and administration of PICC solutes. For the purposes of coherency, some recommendations relating to short-term CVC have been extended to the case of PICC. Thus, the good practice for the preparation and administration of medications must be applied, whatever type of vascular access is used.

All of these active injection systems that reduce the risk of blood reflux and catheter obstruction (electric syringes, volumetric pumps) are ordinarily preferred to gravity-fed systems, since they are in principle associated with a reduced risk of infection.

As a consequence of the risk of bacterial proliferation, some products must be administered extemporaneously, i.e. immediately following their preparation. The tubing used for the infusion of certain products must be replaced following administration, and the length of time during which some products are infused must be restricted. It has been shown that there is no advantage to be found in replacing the venous line more often than once every 96 hours [45].

Although there are no studies having compared the consequences of the infusion device configuration in terms of risk of PICC-related infection, the infusion device configuration shall be as simple as possible with respect to its intended use (minimum number of connectors and access lines) and the use of a short extension tube will allow manipulations of the needle tip to be reduced (see proposed assembly setups in the annexe).

Finally, a *Burkholderia cepacia* septicaemia epidemic was reported in premature babies having received lipid emulsions via parenteral nutrition. Investigations showed that the elastomer stoppers on the food bottles had not been disinfected before puncturing. The microorganisms present between the plastic capsule and the stopper had thus been introduced and administered [46].

### Manipulations and management of connections

#### Existing regulations and recommendations

- The decree 2004-802 of July 29th, 2004 stipulates: “the nurse is in charge of the design, use and management of the healthcare documentation” [47].

- In 1997, in its guide for the *Prevention of infections associated with indwelling intravascular access devices*, the Public Health Agency of Canada recommends that:
  - “any staff member affected by exudative dermatitis or having open lesions should wear gloves whenever he/she manipulates catheters and connectors,
  - the frequency with which the stopper is manipulated should be reduced to a minimum in order to reduce the risk of contamination,
  - every injection site or open stopcock should be correctly closed,
  - injection sites and stoppers should be disinfected with 70% isopropanol or another suitable disinfectant. Cotton-wool pads that have been used to clean the skin must not be used” [43].

- In 2000, in its reference document entitled *Evaluation of the quality of use and surveillance of totally implantable venous catheters*, the ANAES recommends:
  - “manipulations must be reduced to a minimum,
  - wings and connectors are disinfected before any injection. Permanent protection of connectors and tubing could be beneficial, especially when they remain in contact with the patient's bed, although the efficiency of the different systems proposed has not been well established”.

- Finally, the AP-HP recommendations for clinical practice are recalled. Manipulations made at a safe distance from the site are to be carried out while using sterile dressings soaked in antiseptic, and it is recommended to wear gloves in the case of neutropenic patients. It is recommended to use a ramp protector that may be soaked in antiseptic every 6 hours, and is replaced at the same time as the ramp [25].

- In 2001, in its Good Practice Guide “Venous catheterism. Recommendations for the elaboration of protocols for the care of venous lines*, the Paris-north CCLIN recommends “Disinfecting the hands either by hygienic (antiseptic) rinsing, or with an alcohol-based handrub, before and after palpation of the insertion site, and manipulation of the venous line. Minimize these manipulations and protect the injection sites. Disinfect connectors using dressings soaked in antiseptic and reseal with a new sterile stopper” [48].
In 2005, in its document Prevention of peripheral venous catheter-related infections, the SF2H indicates that:

- "Before any manipulation of the catheter and any element of the infusion device, it is recommended to carry out hygienic treatment of the hands, either by means of hygienic washing with an antiseptic soap (or antiseptic washing), or by means of a disinfectant handrub using an alcohol-based gel or solution R35 [B2].
- Before manipulating the tips and stopcocks, it is recommended to disinfect them with a sterile dressing soaked in an alcoholic chlorhexidine, alcoholic povidone-iodine, or 70° alcohol solution, R36 [B2].
- It is recommended to install a new sterile stopper, whenever the access site or the stopcock is opened R37 [B3].
- It is recommended to keep the ramps at a safe distance from any source of contamination (bedding, wounds, stoma, ...) R38 [B3].
- It is possible to use needleless connectors, provided they are disinfected before any access to the system R39 [C2][49].

In 2006, the Guide for the prevention of healthcare-related infections outside hospitals advocates:

- Rigorously observing asepsis for all manipulations of the first connector or the insertion site: sterile gloves, sterile dressings, a sterile drape, antiseptic, mask for the operator and the patient (if the latter is not able turn his/her head in the direction opposite to the side being treated).
- Disinfecting the connectors before any injection; it is advised to protect these, if there is any possibility they could come into contact with the patient’s bed (boxes or dressings regularly soaked in antiseptic).
- Disinfecting the connectors using dressings soaked in antiseptic, before any injection, and then closing them by means of a new sterile stopper.
- Limiting the number of times a venous line is opened by combining manipulations. Lines should not be left open when waiting for any manipulations" [26].

In 2007, the British Committee for Standards in Haematology specified "using injection sites (connectors, valves) to reduce the risk of infection for patients and blood exposure accidents for staff" [28].

In 2007, Queensland Health’s "Centre for Healthcare related infection surveillance and prevention" stipulates "the use of dressings soaked in alcohol when accessing the lines" [51].

In 2007, in the chapter entitled “Infections associated with intravascular devices” of the Surveillance and prevention of healthcare-related infections guide, recommendation R114 indicates: “Reduce the number of manipulations as far as possible. Carry out an alcohol-based handrub of the hands prior to any manipulation of the IVD or components of the infusion device. Perform manipulations in an aseptic manner, disinfect the tips and stopcocks using a sterile gauze soaked in an alcoholic antiseptic. The use of needleless connectors is possible as long as they are disinfected before use. Install a new sterile stopper whenever the access site or the stopcock is opened. Place a sterile stopper on any unused stopcock [5].

In 2008, in its document entitled Hygiene and the prevention of infectious risk in medical and paramedical practices, the HAS recommends "the disinfection of injection ports and connectors using a sterile dressing soaked in an antiseptic, using either alcoholic chlorhexidine or alcoholic PVPI" [50].

In 2010, in the chapter entitled “Infections associated with intravascular catheter-related infections” of the Surveillance and prevention of healthcare-related infections guide, recommendation R114 indicates: “Reduce the number of manipulations as far as possible. Carry out an alcohol-based handrub of the hands prior to any manipulation of the IVD or components of the infusion device. Perform manipulations in an aseptic manner, disinfect the tips and stopcocks using a sterile gauze soaked in an alcoholic antiseptic. The use of needleless connectors is possible as long as they are disinfected before use. Install a new sterile stopper whenever the access site or the stopcock is opened. Place a sterile stopper on any unused stopcock [5].

Analysis of the literature

In the absence of specific studies, and in the interests of coherency, some recommendations relating to short-term CVC have been extended to PICC.
The various connectors or connections of the venous line, whatever their nature and position, represent an entry point that is potentially at risk of endoluminal contamination; it is thus important to organize treatment in such a way as to restrict the number of openings of the infusion system. Its manipulation and management must therefore be carried out under optimally aseptic conditions, and it must be kept at a distance from any source of contamination (bedding, wounds, stoma, …). In terms of preventing the risk of infection, there is no demonstrated advantage in using protective boxes soaked in an antiseptic [52]. The selection criteria for a protective device and the modalities for its use, for the purposes of reducing the risk of infection, have not been established.

Hand hygiene through the use of an alcohol-based handrub as well as the manipulation of connectors or connections, with a dressing soaked in an alcoholic antiseptic or in 70° alcohol, are essential preventive measures. The evaluation of the efficacy of disinfecting solutions, following the experimental contamination of catheter hubs, was in favour of using an antiseptic in the form of an alcoholic solution [53].

A recent study, carried out with both in vitro and real-life data, suggests that a 5 second duration for the disinfection of the valve is sufficient, with longer contact durations leading to no improvement in efficacy [54]. Other previous studies of lesser scientific quality suggest that a longer duration, typically 15 seconds, should be used [55,56].

The question of the choice of the type of gloves to be worn during injections and manipulations (excluding proximal manipulations) was analysed in a 36-month before-after study in paediatric oncology, by comparing the frequency of bacteremia during a certain period with the wearing of sterile gloves, and during a different period without sterile gloves. The observed frequency (0.0075, followed by 0.0098 bacteremia per 1000 days) was not statistically significant between the two periods (RR: 0.765) [57].

By extrapolating from typical practice with CVC, treatment protocols normally distinguish between proximal (PICC tip and extension tube) and distal manipulations, as a result of the probably different risks of infection. When blood samples are authorised with PICC, for the patient's comfort, these are taken under strictly defined conditions.

### Periodic maintenance

In studies dealing with PICC, two different notions are sometimes confused: that of a flush, which involves a single rinsing operation that can be followed by immediate use of the catheter, and that of a preventive lock, the principle of which is to instil into the catheter a high concentration of a product, which is left in place for several hours or days. These rinsing and locking techniques are used in order to obtain high concentrations of antimicrobial products (antibiotics: vancomycin, gentamicin, minocycline… or not: taurodilide, citrate, …) that are expected to prevent the intraluminal fixation of microorganisms, or high concentrations of anticoagulants that are expected to prevent the formation of thrombi (heparin, urokinase, …).

### Existing regulations and recommendations

In 2007, in its recommendations for the insertion and management of central venous lines in adults, the British Committee for Standards in Haematology recommends restricting the use of heparin in order to avoid thrombocytopenia secondary to over-frequent flushing. Nevertheless, heparin flushes can be used according to the manufacturer’s recommendations, in the case of intermittent use in particular. The latter propose flushing with 10 ml of 0.9% saline ± 5 ml of heparin, following each access to the venous line, or once a month. The pulsatile flush technique must used whilst maintaining positive pressure with a calibrated syringe larger than 10 ml in order to avoid high pressure that could lead to catheter rupture [28].

In 2008, according to the SHEA/IDSA, preventive antibiotic locks must be strictly limited to two situations: patients having a limited venous access and a recurrent history of bacteremia on a central catheter, or patients with an implanted intravascular device (prosthetic valve, aortic graft, …) [58].

In 2013, the Centre for Healthcare related infection surveillance and prevention – Queensland Health recommended not to use an antimicrobial lock as a result of the risk of toxicity and the emergence of bacterial resistance [51].

In 2011, the CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections have certain reservations concerning the antibiotic lock – as a consequence of the risks of resistance selection, or even toxicity.
through extraluminal dissemination of the solution, the indications for a lock are restricted to special circumstances: patients with a long-term catheter and having a recurrent history of catheter bacteremia, despite optimal compliance with maximum hygiene precautions (Category II).

Similarly, it is recommended not to make routine use of an anticoagulant treatment for the purposes of reducing the risk of infection in the general patient population (Category II) [9].

Analysis of the literature

The use of an antimicrobial lock to prevent haemodialysis catheter infections has been studied in several meta-analyses, of which three were published in 2008. The most comprehensive of these includes 16 studies, and concludes on the effectiveness of a preventive lock in reducing bacteremia (relative risk 0.44; 95 CI: 0.38-0.5) [59]. There is less data available on other types of catheter.

A meta-analysis published in 2006 dealt with locks or flushes using vancomycin [60]. From the seven studies included in this analysis, three used a lock, four used a flush, and only one dealt with adults. A decrease in the risk of bacteremia was also revealed (RR 0.49, 95 CI: 0.26-0.95; p=0.03) [61-67].

It has been proposed to use vancomycin, with results also in favour of the use of this antibiotic in a lock solution, in a population of new-born patients: this was a randomised clinical trial dealing with 86 patients, with a relative risk of 0.16 (Cl95: 0.04-0.66) [67].

A recent meta-analysis evaluated the efficacy of antibiotic locks in 16 randomised studies, of which 9 dealt with haemodialysis and 6 with oncology [68]. Although the locks appeared to be efficient in haemodialysis, the authors concluded that the data was too limited in oncology for a routine recommendation to be established. As in the case of all antibiotics, there is a risk of developing resistance, which is currently identified with the prophylactic use of gentamicin locks in haemodialysis [69].

However, it is difficult to propose a reference protocol, since in these studies there is considerable variability in terms of the molecules used (gentamicin, amikacin, minocycline, cefotaxime, cefazolin, vancomycin), their concentrations (e.g. amikacin: 1.5 mg/ml diluted in 3 ml of saline; vancomycin: 2 mg/ml diluted in 3 ml of saline), and the locking techniques (time left in place, replacement frequency, use or not of a catheter between lock sequences). The lock is aspirated before installing the infusion, but is not "flushed", as a consequence of the toxic risk of certain molecules. Finally, in the case of multi-lumen catheters, each lumen must be instilled.

Several non-antibiotic products, with no antimicrobial activity, are currently proposed and appear to give promising results, since they carry no risk of selecting resistant strains.

Taurolidine, which was initially used for haemodialysis catheters [70] has been studied in a before/after cohort in paediatric oncology. The incidence rate of bacteremia was reduced from 2.3 to 0.45 per 1000 days (p=0.004) [71]. In two recent, controlled randomised studies in paediatric oncology, these results were confirmed, with a significant reduction in catheter-related bacteremia (0.4 vs 1.4 per 1000 days in one study and 0.3 vs 1.3 in the other) [72,73].

Recent studies have proposed the use of alcoholic locks in various types of catheter. In the retrospective study in paediatrics published by Jones [74], involving a small number of patients and PICC, a reduced rate of infection was noted.

Other products with an antibacterial action, such as citrate, have also been proposed in haemodialysis [75]. More recent randomised controlled studies in haemodialysis lead to conflicting results [76,77]. Finally, antimicrobial associations have been tested, with significant positive results [78,79].

In other words, the data on the prevention of infections through the use of an antimicrobial lock, whether it be antibiotic or not, can be found mainly for the case of haemodialysis catheters. In the case of PICC, only scanty data can be found, often in paediatrics, which do not currently allow this technique to be recommended.

Later studies may lead to a change in this point of view, in particular with respect to the intermittent use of PICC.

It is important to note that in the case of the two national recommendations that propose the possibility of using preventive locks, the justification is that of repetitive bacteremia, but not that of non-bacteremia infections, and no particular antibiotic is specifically recommended. In a patient repeatedly affected by bacteremia, it would be logical to try to deal with the isolated pathogens at the time of the previous bacteremia. For patients fitted with intravascular devices, it is only possible to base this treatment on the local ecology of prolonged catheter infections.
The use of a heparin flush as opposed to a saline flush remains controversial. Three meta-analyses of randomised controlled trials have evaluated the influence of heparin on maintaining the permeability of peripheral or central venous catheters, and conclude that there is no advantage to be had with an intermittent heparin vs. saline flush, except in certain specific cases such as the use of haemodialysis/apheresis catheters, or in the case of infrequent venous access [80-82].

No randomised trial was able to determine the ideal heparin concentration, nor the frequency of heparinization of catheters which remain unused for prolonged periods. Nevertheless, the authors are in agreement concerning the use of heparin concentrations ranging from 50 to 500 units per ml, weekly maintenance for small calibre devices, and once every three to four weeks for larger calibre devices [55]. A meta-analysis of randomised trials published in 2008 compared the efficacy of a lock or flush associating urokinase and heparin, with a lock or flush containing heparin only, for the prevention of TIVC-related infectious complications. A significantly lower risk was found in the case of the urokinase – heparin association (RR=0.77 [0.60-0.98]) [83].

Finally, an Italian multicentre study designed to determine the frequency of late complications in 1076 patients fitted with a TIVC shows that the use of a monthly heparin flush could lead to complications; in 561 patients for whom the TIVC was used only for flushing, the frequency of complications was 0.15 per 1000 catheter-days [84].

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Rationale

Question 6

Surveillance, training and monitoring of TIVC

By way of an introduction, it is important to recall the general measures proposed in 2010 by the SF2H, in Surveillance and prevention of healthcare-associated infections, relating to the use of invasive intravascular devices (IVD), whatever the type of catheter under consideration:

"A prevention program allows a reduction to be achieved in the avoidable proportion of infections associated with IVDs, through the implementation of technical recommendations, the training of doctors and authorized paramedics, the education and evaluation of the practices of personnel (auditing of practices), and the surveillance of infections associated with such devices. Recent studies have demonstrated the effectiveness of these measures, when grouped together in a bundle strategy. Evaluation of the implementation of measures can also be carried out in the form of a checklist at the time of insertion, consisting of both a reminder of the important preventive measures, as well as their degree of observance. A CVC checklist, such as that used in surgery, is in the process of being drawn up under the auspices of the French National Authority for Health (HAS). The regulations designate the personnel authorized to carry out IVD insertion, as well as the rules for informing patients, in particular with regard to the infectious risk associated with the insertion of IVDs.

Patient information and education

Existing regulations and recommendations

A priori information

A priori information falls under the obligation to obtain the informed consent for healthcare as well as the caregivers’ duty to inform the patient. These notions are also present in the French code of medical deontology (CDM art. 34, 35, 36, 42, 64).

The law of March 4th, 2002 (art. L1111-2 and following of the public health code), concerning the obligation to inform the patient and to collect his/her informed consent for care, stipulates that: "[…] all persons have the right to be informed of their state of health […]" and that "[…] this information is related to the various investigations, treatments or preventive actions which are proposed, their usefulness, their consequences, the frequent or serious risks which they normally imply, as well as other possible solutions and foreseeable consequences in the case of refusal […]" [1].

The circular letter n° 2006-90 of March 2nd, 2006, concerning the rights of hospitalized persons, and comprising a charter for the hospitalized person, devoted several chapters to this topic:

III. – The information provided to the patient must be accessible and loyal

"Hospitals must ensure that hospitalized persons are medically and socially informed and that the means employed are suitably adapted to any possible difficulties in communication or comprehension experienced by the patients, in order to guarantee the equality of access to information for all.

It is also the hospital and professional's responsibility to provide proof that said information has been delivered to the persons concerned."

This chapter adds that "the doctor shall reply tactfully and appropriately to any questions he is asked". It also mentions the notion of medical secrecy and of a trusted person.

IV. – A medical act may not be carried out without the free and informed consent of the patient:

" he/she must be informed, i.e. the person must have been previously informed of the acts he/she was about to undergo, the frequent or serious risks that could normally be foreseen in view of current scientific knowledge, and of their
potential consequences. If new risks appear, following medical investigations, treatment or preventive acts, all possible measures must be taken to inform the person concerned" [2].

In the V2010 hospital certification manual, modified in 2011, the French National Authority for Health (HAS) includes a criterion dedicated to this in chapter 2 "Care of patients", Part 1 "Rights and role of patients", by providing details of the information system.

"Criterion 11.a Informing the patient of the state of his/her health and the proposed healthcare.

[...] The information measures include:

- Interviews, that may be renewed as required, are adapted to the nature of the information to be supplied (bad news, etc.) and to the characteristics of the persons concerned (age, physical condition, etc.). In particular, in addition to the information provided to their parents, children must receive appropriate information concerning their diagnosis and foreseeable care. The interviews must be carried out under suitable conditions (confidential consultation, calm location, sufficient time dedicated to the patient, attentive disposition of the staff, etc.);
- Full oral information, if necessary supplemented by written material and explained to the patient;
- Establishing appropriate coordination between the different professionals dealing with the communication of information and elaborating the patient's healthcare project, which are to be personalised following the interview (nominating a reference staff member, etc.) whilst respecting the principle of confidentiality;
- Possibility for the patient to gain access to information resources external to the immediate healthcare context (patient associations, users, volunteers, dedicated areas for patient information, Internet resources, etc.)" [3].

In addition, in May 2012, the HAS published recommendations on the Delivery of Information to the patient, concerning his/her state of health.

These provide concrete guidelines for information procedures, and take into account all possible situations, including those which are sometimes complex, involving minors, protected adults, or even situations in which the information cannot be provided to the person, because they expressly state they do not want to receive it or are not able to receive it. They emphasize the notion of personal interviews, and the fact that the healthcare professional must ensure that the person has understood the information, and takes the time to explain the preferred procedure, whilst insisting on the importance of inviting him/her to discuss his case and ask any questions [4].

Information concerning the risk of infection

When this information is related to the risk of infection, more specific modalities are described in the circular letter DHOS/E2-DGS/SD5C n° 21 of January 22nd, 2004, concerning the reporting of nosocomial infections and information supplied to patients in hospitals [5].

A posteriori information

The law of March 4th, 2002 introduces article 1142-2 into the Public Health code: "Any person who is the victim or considers himself/herself to be the victim of harm attributable to a preventive, diagnostic or healthcare activity, or if said person is deceased his/her beneficiary, as appropriate, his/her legal representative, must be informed by the professional, the hospital, the health services or the relevant organization, of the circumstances and causes of this harm. This information is delivered to him/her not more than 15 days following the discovery of the harm or following his/her specific request, by way of an interview during which the person may be assisted by a doctor or another person of his/her choice" [1].

The modified version, V2010, of the French Hospital Manual of Certification published by the HAS (2011) grants a second criterion for a posteriori information and provides details of the dispositions to be taken:

"Criterion 11.c Information supplied to the patient in the case of healthcare-related harm

[...] The hospital must be prepared to provide the patient with information as soon as possible, and in any situation in which the healthcare team is itself affected, and the patient’s confidence may potentially be shaken. In these cases, the patient is also entitled to expect particularly attentive and accessible presence on the part of the healthcare professionals. The information system must provide:

- the designation of a senior healthcare professional to supply the information;
- the presence of those persons whom the patient would like to be informed;
- appropriate conditions to allow a dialogue to be established;
• explanations adapted to the patient's ability to comprehend this information, and his/her physical condition" [3].

Patient education

In 2010, in the chapter dealing with "Infections associated with intravascular devices" of the SF2H guide "Surveillance and prevention of healthcare-associated infections", recommendation R101 indicates that:

R101. [...]The patient shall be informed about the IVD-related infectious risk and should take part, in association with his/her relatives, in the prevention and detection of IVD-related infections through adapted educational methods. [6].

In 2011, the CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections recommends "encouraging the patient to report to the staff any change or discomfort related to the catheter site" (cat. II) [7].

In 2009, the recommendation of the European Council (concerning the safety of patients, including the prevention of healthcare-associated infections and the fight against them), in a more global context of patient safety, insists on the usefulness of encouraging citizens and patients to become self-reliant and well-informed:

"[...] b) by communicating with patients on information relating to:

- (i) enforced patient safety standards;
- (ii) risks, and enforced safety standards designed to reduce or avoid errors and prejudice, including best practice and the right to provide one's informed consent for a given treatment, as well as to facilitate the patient's preferences and decisions;
- (iii) available claims, appeal and damages procedures, as well as the relevant applicable conditions;

(c) by studying the possibilities of providing patients with basic competencies in the field of patient safety, i.e. the basic, essential knowledge, attitudes and aptitudes required in order to achieve the objective of greater healthcare safety" [8].

In 2011, in the CVC check-list user's guide, it is stated that for the purposes of patient education: "Some specialities hand over various documents to (ambulatory) patients. The aim is to inform the patient that he/she carries an implanted vascular device and that this device increases the risk of infection and mechanical risks. Elementary safety rules must be given to patients wearing a catheter. Depending on the speciality, any of the following items may be delivered: the operation report, an information booklet, a description of the type of device, post-interventional prescriptions (analgesics, suture removal, etc.), as well as the telephone numbers of team members and the modalities for emergency calls" [9].

Analysis of the literature

In his 2009, GENG-TIAN introduced a multifaceted approach to the systematic use of a factsheet intended for patients fitted with a PICC, recalling the following main principles: the importance of hygiene, what the patient must and must not do during his/her daily life, how to detect and report problems and complications, by identifying signs such as pain, discharge, oedema, redness, … [10].

Training of professionals

Existing regulations and recommendations

The decree 2004-802 of July 29th, 2004 concerning professional acts related to the nursing profession stipulates:

• "Article R.4351-2, medical electrocardiology operator:

[...] The oral or rectal administration, using intramuscular, subcutaneous and superficial vein injections, in implantable vascular access setups and central catheters, …

• Article R.4311-5, nurses: Surveillance related to the role of the nurse:

- 30. Surveillance of scarification, injections and infusions mentioned in articles R.4311-7 and R.4311-9;
- 35. Surveillance of catheters, probes and drains;

• Article R.4311-7, nurses: Surveillance related to the use of medical prescriptions:

- 4. Surveillance of central venous catheters and implantable vascular access devices placed by a doctor;
- 5. Injections and infusions, excluding the first of these in catheters as well as in central venous catheters and the following setups:

  a) products other than those mentioned in the second paragraph of article R.4311-9;

  b) products that do not contribute to the general anaesthesia or locoregional techniques mentioned in article R.4311-12.

- Article R.4311-7, nurses: Blood sampling related to the nursing role, in accordance with a medical prescription:

- 35. Blood sampling by means of venipuncture, capillary puncture or a venous catheter”[11].

The circular letter DGS/DH/DRT n° 98-228 of April 9th, 1998, concerning standard precautions indicates: "These protocols must be known by the staff and their application be regularly evaluated”[12].

In 2010, in the chapter "Infections associated with intravascular devices" of Surveillance and prevention of healthcare-associated infections, the SF2H proposes the following recommendations:

- "R100. The techniques for placing, managing and monitoring IVDs are disclosed in technical specifications or protocols, and are updated once new recommendations have been published. IVD placement and surveillance are carried out by authorized personnel. Ensure traceability of IVD placement in the patient's file: placement date, removal date, catheter type, insertion site, operator. Clinical surveillance of the IVD insertion site should be done on an at least daily basis (search for local symptoms).”

- "R101. Healthcare workers should be trained for IVD indications, placement procedures and IVD maintenance as well as for the prevention of IVD-associated infections [...]” [6].

In 2003, the SRLF (French language Society for Critical Care) consensus conference on CVC-related infections in critical care stipulated that "the restriction of indications for the placement of CVC … as well as their earliest possible removal are efficient primary prevention methods (1-b). The placement, maintenance and utilisation modalities for the venous line must be defined by written protocols, jointly elaborated and observed by all members of the team (1-b).”

The document continues by asserting that "CRI risk factors are mainly exogenous (related to devices and the environment). Continuous improvement programs for healthcare quality have the best chances of being successful for this type of nosocomial infection.

- The beneficial impact of teams trained in the management of catheters for the purposes of reducing their infection has been demonstrated (1-a).

- Learning programs designed to prevent CRI have been shown to be efficient. They include training in good practice in hygiene and precise directives for the placement of various forms of vascular access (preparation of the equipment, skin disinfection, maximum sterile precautions, detailed insertion techniques), their use (systematic disinfection of the hands, manipulation of ramps), and the care they must be given (renewal plan, type and frequency of dressing replacements) (1-b)”[13].

The 2010 SFAR-SRLF consensus conference on the prevention of cross-contamination in critical care mentions that a "training and educational program, dealing with the elementary rules of hygiene as well as all specific procedures, is needed for all healthcare actors. In each field of application, service practices should be standardised and formalised in a multi-professional manner. These procedures must then be disseminated to all teams, to ensure they are correctly assimilated before being applied."

Moreover, it is emphasized that "a reduction in patients' exposure to risk must be favoured, by means of a daily evaluation of the indications demonstrating the need to keep invasive devices in place".

In 1997, in its recommendations for the Prevention of indwelling intravascular access device-related infections, the Canadian Public Health Agency indicates that:

- "Each hospital or organisation should ensure that nurses and doctors, in particular those who intervene under emergency conditions, take part in regular training courses and respect the policies and protocols related to intravascular catheters. The presence of a specialised team for the placement and management of intravascular catheters facilitates maintaining a high degree of competence (AI).

- Patients should have timely access to trained professionals, throughout the full period of use of an intravascular device (AIII)”[14].
In 2011, in its Guidelines for the prevention of intravascular catheter-related infections, the CDC recommends:

1. Training the healthcare personnel in the indication, placement, and maintenance of intravascular catheters, and taking appropriate measures to prevent catheter-related infections (Cat. IA).
2. Regularly verifying the knowledge and observance of recommendations by all professionals who insert and use intravascular catheters (Cat. IA).
3. Designating only qualified personnel having demonstrated their competencies in the insertion and maintenance of peripheral and central venous catheters (Cat. IA).
4. Ensuring that healthcare personnel in critical care are suitably qualified. Observational studies suggest that a high proportion of pool nurses and a high patient/nurse ratio are associated with catheter-related infections (Cat. IB) [7].

In a technical note written on June 2011, the SF2H stipulates that for the case of PICC, "all staff members who are called on to make use of a catheter must have previously followed a specific training course" [15].

Analysis of the literature

Some hospitals have implemented specialised IV-therapy or vascular access teams, in particular for the insertion of PICC and renewal of their (first and also subsequent) dressings, and also for assistance with the placement of difficult PVC (thereby restricting the use of alternative solutions such as PICC or CVC) [16].

Specialised IV teams have indeed demonstrated their efficiency in reducing infectious complications (CR-BSI) and other associated difficulties, such as those of cost [7,17,18].

In France, although it is not regulatory for nursing staff to be responsible for PICC placement, some experiments are being carried out through the adoption of the American model.

A study made in 2011 [16] revealed that when the use of this type of team was discontinued, following a reorganisation of the personnel, the use of PICC increased, although with no increase in PICC-related bacteremia; the study issued a warning concerning the need to establish clear indications for the use of PICC, to improve the insertion and maintenance techniques used with PICC, and to propose training courses for all of the hospital staff.

Traceability and clinical surveillance

Existing regulations and recommendations

Traceability

In its CVC check-list user’s guide, the HAS (2011) proposes the following traceability following device placement: "Traceability / written reports shall include, depending on speciality, the date, identity of the patient and operator, the type of material and its batch number, the insertion conditions, the insertion site, the number of punctures and any resulting complications encountered during placement or immediately thereafter." The report (written or digitally recorded) is conserved in the patient’s medical file."

There are regulatory measures for the surveillance of patients fitted with an implantable catheter (TIVC). The circular letter DH/EM 1, n° 96-6225 of October 26th, 1996 recommends that "the surveillance notebook should contain the following elements: the patients name, the hospital where the device was implanted, the model and batch number of the implanted device, the essential precautions to be taken whenever the inserted device is used, as well as the dates on which any infusions and injections are carried out. The notebook must be returned to the patient, who must systematically present the notebook to the medical teams who manipulate his/her catheter […]" [19].

Although this type of obligation has no formal basis for the surveillance of PICC, it can readily be transposed, on the basis of medical experience with TIVC, to an archive form or a surveillance notebook.

It represents a form of correspondence between the city and the hospital in which each healthcare professional, who may be responsible for the PICC, can contribute his/her comments, thus facilitating the liaison between healthcare professionals. As a consequence, it is not reserved for ambulatory use, but also for hospitals.

In 2011, the various guides printed by the Arlin (French Regional Branches for Healthcare-associated Infection Control) propose to keep track, in the patient’s file and/or archive form,
the following information related to the maintenance and monitoring of the PICC: "The patient's identity, the name of the RN, the date of dressing replacement, the clinical state of the puncture site, the application of a procedure if required (in the case of any complications).

Any incident or anomaly (poor permeability, redness, induration, pain, oedema, bleeding or discharge) must be reported to the doctor as soon as possible."

**Clinical surveillance**

- In 2003, the SRLF consensus conference on CVC-related infections in critical care recalls that "the diagnostic attitude and initial treatment of a CVC infection result from the confrontation of three elements: local signs, general clinical manifestations, and the results from microbiological (local and blood culture) samples. Blood culture samples must be taken systematically, at least at the periphery, and preferably via the catheter and at the periphery, when faced with any suspected CVC-related infection" [13].

- In 2011, in Guidelines for the prevention of intravascular catheter-related infections, the CDC recommends:
  - "Regular visual monitoring, or palpation through an intact dressing, of catheter insertion sites. If the patient presents with induration at the insertion site, an otherwise unexplained fever, or any other signs indicating a local or systemic infection associated with the catheter, the dressing must be opened to permit more thorough scrutiny of the site (Cat. IB).
  - "Quickly remove any intravascular catheter, as soon as its presence is no longer essential (Cat. IA)" [7].

- Similarly, in 2010, in its guidelines for intravascular devices, the SF2H recommends: R99. The indications for the insertion and maintenance of an intravascular device (IVD) are restricted whenever this is possible, by systematically preferring the oral or enteral route to the venous route, for the administration of medication or nutrients. The IVD should be removed as soon as its presence is no longer indispensable. [6].

- In 2011, the good practice guide for the use and maintenance of PICC (HCL/APHP, Arlin IDF, APHM, Institut Curie) proposes as a basis for daily clinical surveillance "6 indicators of correct operation" to be used to detect the main forms of complication (risk of obstruction, infection, and thromboembolism):
  1. Absence of inflammatory signs at the PICC insertion site, or along its path of insertion
  2. Presence of venous reflux
  3. Absence of pain in the arm at the PICC insertion site prior to, during, and following injections
  4. Straightforward injection using a syringe
  5. Good infusion flow rate
  6. Absence of oedema in the arm or the hand on the side used for the PICC" [20].

**Analysis of the literature**

In 2010, using a multifaceted approach applied in an adult oncology unit, GENG-TIAN introduced the systematic use of an archive form for the insertion and maintenance of PICC [10].

In a randomised controlled study comparing the use of PICC vs. peripheral venous catheters (PVC), D. PERIARD et al. insist on the need for the thorough, daily clinical surveillance of PICC, in view of the frequency of thrombotic complications; similarly, they recommend that PICC be removed as soon as they are no longer used, in order to reduce the period of exposure to a minimum [21].

**Epidemiological surveillance and assessment of practices**

**Existing regulations and recommendations**

- The decree 2001-671 of July 26th, 2001, concerning the reporting of nosocomial infections states that: "Hospitals anonymously report the occurrence of any nosocomial infection, in accordance with the criteria described in article R.711-1-12" [22].

- In 2010, in the chapter "Infections associated with intravascular devices" of the Surveillance and Prevention of healthcare-associated infections guide, the SF2H proposes the following recommendations:
  - "R102. The practice of professionals in charge of IVD placement and maintenance is reviewed on a regular basis. Practice auditing is carried out using adapted tools, including a checklist both serving as a reminder and as an appraisal tool for the adherence to recommendations. The identification of practice..."
errors, as well as information feedback to the healthcare team, are indispensable.

- R103. Continuous surveillance of IVD-related infections (bacteremia) is implemented in high-risk wards (critical care, intensive care units). The results are expressed in the form of the number of IVD-related bacteremia per 1000 catheter-days" [6].

In the 2009-2013 French national program for the prevention of nosocomial infections, the objectives and indicators proposed for CVC are also applicable to PICC, as a result of their proximal position in large vessels [23]. Several of these are also related to PICC as a result of these similarities:

- Quantified objectives in terms of means:
  "- In 2012, 100% of hospitals practicing critical care (in line with the decree) use tools to provide assistance (for example, check-lists) with the observance of preventive measures to prevent CVC infections during placement and surveillance. The criteria to be taken into account are related in particular to the insertion site, the use of "surgical" aseptic conditions during insertion, the daily re-evaluation of the usefulness of keeping a CVC in place, and surveillance.

- In 2012, 100% of hospitals used techniques to analyse the cause, in the case of the occurrence of serious infectious events."

- Quantified objective in terms of results:
  "- In 2012, the incidence rate* of central venous (CVC) catheter-related bacteremia in critical care per 1000 days of CVC exposure decreased by one quarter; [conference data: REA RAISIN 2008]."

* The target value used was the third interquartile of the rate distribution (P75, reflecting the maximum value of 75% of all rates observed in the network), which could be expected to tend towards the median (maximum value observed for 50% of rates) value observed prior to the period covered by the 2009-2012 program.

On January 27th, 2011, the HAS made a check-list available, for all professionals, concerning the placement of central venous catheters (CVC) and other vascular devices (VD), as well as user’s instructions and a rationale [9]:

http://www.has-sante.fr/portail/jcms/c_1020563/check-list-catheters-veineux-centraux

In its certification manual, in criterion 8G – "Controlling the risk of infection", the HAS defines:

- "With the aim of controlling the risk of infection, a policy, an organisation, and appropriate resources in terms of the hospital's activities, are established in consultation with the CME, the hospital medical committee, the healthcare-associated risk management coordinator, and the infection control team.

Surveillance and risk prevention procedures and protocols are implemented.

- Surveillance and infectious risk prevention actions, including those resulting from reporting, are implemented by professionals, in liaison with the infection control team. The hospital participates in exchange and inter-hospital exchange activities, in particular the CClin (Regional Nosocomial Infection Control Coordinating Centre) programs.

- The training of professionals in hygiene and the prevention of infectious risk must be ensured" [3].

The 2010 SFAR-SRLF consensus conference found that "global strategies for the prevention of NI represent major contributions towards the improvement of the quality of healthcare, by reducing the avoidable proportion of NI. Observance of the regulatory healthcare personnel ratio is a fundamental prerequisite for the implementation of such an approach.

Global strategies result from the combination of several contributions: epidemiological surveillance, multidisciplinary educational program, general measures (hospital hygiene, policy for the use of anti-infectious products, decrease in the risk of exposure) and specific measures. These contributions, which are applicable to the main infections encountered in critical care, have been evaluated mainly for CRI and MVAP. The exact definition of the infection under consideration must be initially defined. Although there is a low level of evidence in each study of global strategies, there is a high number of coherent results in each of the relevant fields" [24].

For epidemiological surveillance, the European recommendations established by the ECDC (2012) have adopted the American CDC recommendations (2011) for the definition of what should be included under the term "central venous catheter".
**DEFINITION OF CENTRAL VENOUS CATHETER-RELATED INFECTIONS [CTINILS 2009]**

1) **BACTEREMIA ASSOCIATED WITH A CATHETER = BAC (POSITIVE HAEMOCULTURES)**

CVC-associated bacteremia/fungemia is defined by:

- The association of bacteremia / fungemia occurring within 48 hours of CVC removal (or diagnostic suspicion of a catheter infection if it has not been immediately removed). And:
  - either a positive culture with the same microorganism on one of the following samples: culture from the insertion site or culture of the CVC, greater than or equal to $10^3$ UFC/ml;
  - or positive peripheral and central blood cultures with the same microorganism with a quantitative blood culture / peripheral blood culture ratio greater than 5, or a differential positivity delay between central / peripheral blood cultures greater than two hours, with faster positivity for the central blood culture.

In the absence of bacteremia (negative blood cultures) the diagnosis of CRI is based on:

2) **LOCAL CRI**

- CVC culture greater than or equal to $10^3$ UFC/ml;
- and purulence of the catheter entrance or tunnelitis.

3) **GENERAL CRI**

- CVC culture greater than or equal to $10^3$ UFC/ml;
- and total or partial regression of the general infectious signs, within 48 hours following removal of the catheter.

This definition was reproduced by the ECDC at the European level [26] in order to characterise catheter-related infections (CRI-1: local CR, 2: general, CRI-3: bacteremia) and also corresponds to that used in the French national REA-Raison surveillance network for nosocomial infections in adult critical care [25,27].

In the European definitions, criterion (CRI-3) still corresponds to what is referred to in the literature as CR-BSI or catheter-related bloodstream infections.

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**GOOD PRACTICE AND RISK MANAGEMENT FOR THE USE OF PICC - 2014**

**ECDC 2012**

« Central line: An intravascular catheter that terminates at or close to the heart or in one of the great vessels, which is used for infusion, withdrawal of blood, or hemodynamic monitoring.

The following are considered great vessels for the purpose of reporting central-line BSI and counting central-line days in the NHSN system: Aorta, pulmonary artery, superior vena cava, inferior vena cava, brachiocephalic veins, internal jugular veins, subclavian veins, external iliac veins, common iliac veins, femoral veins, and in neonates, the umbilical artery/vein.

Notes:

1. Neither the insertion site nor the type of device may be used to determine if a line qualifies as a central line. The device must terminate in one of these vessels or in or near the heart to qualify as a central line.

2. An introducer is considered an intravascular catheter, and depending on the location of its tip, may be a central line.

3. A Hemodialysis Reliable Outflow dialysis catheter (HERO), that is located in one of the great vessels and used for purposes outlined above, is considered a central line.

4. Pacemaker wires and other non-lumened devices inserted into central blood vessels or the heart are not considered central lines, because fluids are not infused, pushed, nor withdrawn through such devices.

5. The following devices are not considered central lines: extra-corpooreal membrane oxygenation (ECMO), femoral arterial catheters and intraaortic balloon pump (IABP) devices. »

This definition confirms the fact that PICC are CVC in their own right, and must be included as such in epidemiological surveillance.

The definition of catheter-related colonisations/infections/bacteremia is that recommended by the CTINILS in 2009 [25], which reproduces that of the SRLF consensus conference held in 2003 [13].

This is also applicable to PICC. The quantitative method proposed by Brun-Buisson is recommended.

This definition was reproduced by the ECDC at the European level [26] in order to characterise catheter-related infections (CRI-1: local CR, 2: general, CRI-3: bacteremia) and also corresponds to that used in the French national REA-Raison surveillance network for nosocomial infections in adult critical care [25,27].

In the European definitions, criterion (CRI-3) still corresponds to what is referred to in the literature as CR-BSI or catheter-related bloodstream infections.
CR-BSI provide microbiological evidence of the responsibility of the central catheter.

In the literature there is often a confusion between the terms used to describe epidemiological surveillance.

It is thus important to differentiate between the different types of CR-BSI (catheter-related bloodstream infections):

- Primary BSI or primary bacteremia (= with no known or identified infectious site), a notion developed by the CDC, but rarely used in France.

By definition, these are not secondary to an infection at another site.

NB: A bacteremia with an infection localised at a catheter (again, with no other infection) is also considered by the CDC to be primary.

- CLABSI, or central line-associated BSI, still referred to as "catheter-associated bacteremia".

A CLABSI is a primary bacteremia (= with no known infectious site) occurring in a patient exposed for more than two days to a CVC (at the time of the bacteremia), and whose CVC was still in place the day before, or the day of the bacteremia, whether or not the CVC was cultured.

As some infectious sites are occasionally difficult to identify or poorly understood (e.g. pancreatitis, intra-abdominal abscess, digestive translocation in a neutropenic patient, …) in patients wearing a catheter, it is likely that the definition of CLABSI over-estimates the frequency of CR-BSI.

In 2011, in its Guidelines for the prevention of intravascular catheter-related infections for the purposes of improving performance, the CDC recommends:

- "Implementing local, collaborative initiatives, in which composite or "multifacet" approaches are bundled together, to improve compliance through evidence-based recommendations for good practice (CatIB)" [7].

Analysis of the literature

In 2010, using a multifaceted approach applied in an adult oncology unit, GENG-TIAN introduced the systematic use of an archive form for the insertion and maintenance of PICC [10].

Definition of complications

In a meta-analysis of 200 studies dealing with the risk of CR-BSI in adults, MAKI addresses the debate over the difference or even the confusion between various definitions for (CR-BSI) related or associated bacteremia, used for the epidemiological surveillance of infectious complications [28].

This author confirms that the definition now recommended in the USA (by the Centers for Disease Control and Prevention, the Joint Commission on Accreditation of Healthcare Organizations and the Agency for Healthcare Research and Quality) correspond to an "associated" risk (CLABSI) and overestimate the true risk "related" to the catheter.

Indeed, many bacteremia that cannot be related to an localised infectious site are attributed to the central catheter by default, whereas they are truly secondary to an unknown infectious site (intra-abdominal abscess, nosocomial pneumopathy or urinary tract infection, translocation in particular in immunosuppressed patients, …).

In addition, the concomitant use of arterial devices (that have a non-negligible risk, but often are not taken into account in this type of study) has the effect that a bacteremia, that may be related to an arterial catheter, is systematically attributed to the CVC. This author thus encourages the surveillance of all types of catheter.

For PICC, as for CVC, the results can differ, depending on whether surveillance is arranged for CR-BSI or CLABSI, with in general a higher rate of occurrence for CLABSI, which have a less demanding microbiological definition [25,29].

MAKI thus recommends the use of more rigorous diagnostic criteria and methods, and the compilation of real "CVC-related bacteremia" (CR-BSI) in trend studies (self-comparison over time), or benchmarking (comparison with others).

In 2011, O'Grady adapted the IDSA definition (2009) for CVC-related bacteremia, which is very close to the French definition (bacteremia with a CVC in place, presence of clinical signs, absence of any other infectious site and at least one microbiological criterion: positive catheter culture (> 15 UFC or > 10^2 UFC/ml, depending on the method), or positive peripheral blood cultures, or even a microorganism with either a differential positivity delay > 2 hours, or a central/peripheral ratio > 3) [30].
**Exposure to an invasive device**

For a given medical unit or hospital, the degree of exposure is expressed:

- as a percentage of patients wearing a PICC,
- or even in combination with the length of exposure, by means of an exposure ratio (DUR or device utilisation ratio) [16]:

\[
 \frac{\text{number of days of exposure to the PICC with respect to the number } \times 100}{\text{number of patient-days of hospitalisation}}
\]

**Frequency of complications (including infectious episodes)**

The clinical surveillance of infectious or other (displacement, accidental removal, obstruction, thrombo-phlebitis, local or general infection, CR-BSI, CLABSI) complications can be measured with the help of the following indicators:

- **cumulative impact**: number of episodes for 100 exposed patients, or for 100 PICC placements;
  
  e.g. 17.2 deep thromboses / 100 patients, (often expressed directly in the form of a percentage, i.e. 17.2%);

- **incidence rate**: number of episodes for 1000 days of exposure to an invasive device;

  e.g. 1.05 CR-BSI / 1000 PICC days.

The cumulative incidence (percentage for 100 patients or 100 PICC) is more commonly used in the literature for non-infectious complications.

In the case of infectious complications, the trend is to prefer the use of incidence rates, taking the length of exposure to the invasive device into account [16,21,28,29,31-35].

These two approaches are complementary in terms of expressing the risk of complications.

- The team of Evans (2007) describes the computerised application developed for the recording of PICC-related complications (in particular, deep venous thromboses) and their risk factors, thus simplifying the epidemiological surveillance activity and the implementation of analysis sessions to determine the root causes of these episodes. [36].

- Many papers report the advantages of bundles in the prevention of CVC-related infectious complications, but very few of these are specific to the case of PICC.

The possibilities for intervention are numerous: dedicated insertion / maintenance team, measures related to the highest level of observance of good practice (hand hygiene, maximum barrier precautions, surgical asepsis, …), specific techniques (systematic ultrasound guidance, radiographic verifications, dressings soaked in antiseptics, use of needleless connectors, flushing, locks, …), daily evaluation of the indication for removal as soon as the PICC is no longer needed, staff training, use of a check-list, use of a traceability / follow-up form, patient information leaflet, … [10,37].

One study has even proposed to increase the use of PICC, as a bundled measure to promote the reduction of CLABSI [37].

**References**


25- Comité technique des infections nosocomiales et des infections liées aux...


Appendix I

Drawings showing the different setups for PICC utilisation

Venous line with a valve for continuous infusion &

Venous line without a valve for continuous infusion (sketches)

Venous line for discontinuous infusion (sketch)
Appendix II

Explanation of the GRADE Method for critical analysis of the literature

Summary of the GRADE method

1. PICO Method

A critical analysis of the literature according to the GRADE method must answer a precise question that has been posed according to the "PICO" method (Population, Intervention, Comparison, Outcome)

Example:
Population: Acute pyelonephritis in children
Intervention: Orally administered cefixim treatment
Comparison: Cefixim IV treatment
Outcome: Damage to the kidneys

A PICO question is associated with a set of references.

2. Notation

Randomised studies start with a note equal to 4/4 (★★★★)
Observational studies start with a note equal to 2/4 (★☆☆☆)

<table>
<thead>
<tr>
<th>Criterion for degradation of the level of evidence</th>
<th>Criterion for improvement in the level of evidence</th>
</tr>
</thead>
</table>
| • Risks of bias: strong risk of bias (-1) or very strong risk of bias (-2)  
  Example: absence of blinding, poor allocation, lost to follow-up, absence of any analysis of intention to treat, poor observance, early discontinuation of treatment for benefit …  
  • Incoherence of the results (applicable to randomised studies): (-1) Heterogeneity or variability of the results from different studies suggesting that there are real differences in the effects of the treatment. If this heterogeneity is not explained, the quality of evidence decreases.  
  • Inaccuracy of the results (-1):  
    When the study includes a small number of patients or events  
  • Indirect character of the evidence: (-1) or (-2)  
    By using indirect or intermediate comparative criteria  
    Examples:  
    - Paediatric study population, whereas an adult population is formulated in the PICO.  
    - Results based on clinical criteria, whereas the PICO is formulated with biological criteria.  
  • Publication bias (-1): sponsored trials, absence of a study report.  
  | Magnitude of the effect: this is the most common criterion leading to an increase in the quality of evidence of an observational study (+1) when RR is < 0.5 or > 2 in at least 2 studies, with no possible confusing factors. (+2) when RR is < 0.2 or > 5 with no obvious bias.  
  • Existence of a dose-response effect (+1)  
  • Existence of confounding factors reducing the effect (+1)  

Each reference obtains a grade ranging from 1/4 to 4/4:  
★★★★ Strong level of evidence  
★★★- Medium level of evidence  
★★☆- Low level of evidence  
★☆☆- Very low level of evidence  

An overall grade ranging from 1/4 to 4/4 is given to the full set of references to a PICO question.
Summary of the quality of evidence, depending on the grade

**PICC vs other catheters**

**Methodology**
- PICC literature from 2000 to the end of 2012, dealing with PICC +4 references prior to 2000.
- Questions dealing with the choice of access to a venous line for the purpose of preventing infectious and mechanical complications.
- Inclusion criteria

- Exclusion criteria
  - neonatology,
  - studies dealing with PICC only
  - case-reports.

**Results**
- 17 references from 285 publications
- Overall quality of the literature: low

<table>
<thead>
<tr>
<th>Question</th>
<th>Outcome</th>
<th>Comparison</th>
<th>Patients</th>
<th>Number of references</th>
<th>In favour of</th>
<th>Overall quality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infections</strong></td>
<td></td>
<td>PICC vs CVC</td>
<td>Parenteral undernourishment</td>
<td>3</td>
<td>PICC</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>In critical care</td>
<td>3</td>
<td>PICC</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>In onco-haematology</td>
<td>3</td>
<td>PICC</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>In home hospitalisation</td>
<td>3</td>
<td>PICC</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>Outside critical care</td>
<td>4</td>
<td>NS</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs PVC</td>
<td>Therapy IV &gt; 6 days</td>
<td>2</td>
<td>PVC</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs TIVC</td>
<td>Having (requiring) a central line</td>
<td>5</td>
<td>TIVC</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Thromboses</strong></td>
<td></td>
<td>PICC vs CVC</td>
<td>Parenteral undernourishment</td>
<td>3</td>
<td>CVC</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>In onco-haematology</td>
<td>1</td>
<td>CVC</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>In critical care</td>
<td>1</td>
<td>CVC</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>Outside critical care</td>
<td>4</td>
<td>CVC</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Malplacement</strong></td>
<td></td>
<td>PICC vs CVC</td>
<td>Parenteral undernourishment</td>
<td>3</td>
<td>CVC</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>In onco-haematology</td>
<td>1</td>
<td>PICC</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Other complications</strong></td>
<td></td>
<td>PICC vs CVC</td>
<td>Having (requiring) a central line</td>
<td>3</td>
<td>CVC</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>In home hospitalisation</td>
<td>1</td>
<td>TIVC</td>
<td>Very low</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td></td>
<td>PICC vs CVC</td>
<td>All patients with therapy IV &gt; 6 days</td>
<td>2</td>
<td>PICC</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>All patients with therapy IV &gt; 6 days</td>
<td>1</td>
<td>PVC</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PICC vs CVC</td>
<td>With a central line</td>
<td>2</td>
<td>PICC</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Satisfaction</strong></td>
<td></td>
<td>PICC vs PVC</td>
<td>All patients with therapy IV &gt; 6 days</td>
<td>1</td>
<td>PICC</td>
<td>Low</td>
</tr>
</tbody>
</table>

*Extravasation, catheter breakage, accidental removal, occlusion, drug precipitation, infiltration, pain, bleeding*
Measures for the prevention of complications

Methodology
- Questions dealing with the choice of materials or techniques permitting the prevention of infectious or mechanical complications (example: choice of PICC diameter, choice between Groshong® vs valve-less PICC, securement technique, etc…)
- Inclusion criteria
  Studies evaluating an impact on infectious or mechanical complications having compared different:

### Table of Results

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Question</th>
<th>Comparison</th>
<th>Patients</th>
<th>Number of references</th>
<th>In favour of</th>
<th>Overall quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infections</td>
<td>Groshong PICC vs standard PICC</td>
<td>Having (requiring) a central line</td>
<td>3</td>
<td>Standard PICC</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power PICC vs standard PICC</td>
<td>Having (requiring) a central line</td>
<td>1</td>
<td>NS</td>
<td>Very low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delay prior to placement following bacteremia ≤ 2 d vs &gt; 2 d</td>
<td>Having (requiring) a central line</td>
<td>1</td>
<td>&gt; 2 d</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bundle vs absence of a bundle</td>
<td>Having (requiring) a central line</td>
<td>1</td>
<td>Bundle</td>
<td>Very low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Right vs left insertion</td>
<td>Having (requiring) a central line</td>
<td>1</td>
<td>NS</td>
<td>Very low</td>
<td></td>
</tr>
<tr>
<td>Thromboses</td>
<td>Groshong PICC vs standard PICC</td>
<td>Having (requiring) a central line</td>
<td>3</td>
<td>Standard PICC</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power PICC vs standard PICC</td>
<td>Having (requiring) a central line</td>
<td>1</td>
<td>NS</td>
<td>Very low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 F PICC vs &gt; 4 F PICC</td>
<td>Having (requiring) a central line</td>
<td>2</td>
<td>≤ 4 F</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Single lumen vs multi-lumen PICC</td>
<td>Having (requiring) a central line</td>
<td>2</td>
<td>Single lumen</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Right vs left insertion</td>
<td>Having (requiring) a central line</td>
<td>4</td>
<td>Left insertion</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cephalic vs basal insertion</td>
<td>Having (requiring) a central line</td>
<td>2</td>
<td>Basal insertion</td>
<td>Medium</td>
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<tr>
<td>Occlusion</td>
<td>Groshong PICC vs standard PICC</td>
<td>Having (requiring) a central line</td>
<td>3</td>
<td>NS</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Breakage</td>
<td>Groshong PICC vs standard PICC</td>
<td>Having (requiring) a central line</td>
<td>2</td>
<td>Standard PICC</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>
Appendix III

Tables of results from the Grade analysis

**PICC versus other types of vascular access**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Intervention</th>
<th>Comparison</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients requiring a IV &gt; 6 d therapy</td>
<td>PICC</td>
<td>Central venous catheter (tunneled / non tunneled / all?)</td>
<td>Infection incidence rate</td>
</tr>
<tr>
<td>Critical care patients</td>
<td>PICC</td>
<td>Central venous catheter</td>
<td>Thrombosis incidence rate</td>
</tr>
<tr>
<td>Patients receiving chemotherapy</td>
<td>PICC</td>
<td>Totally implanted venous catheter (TIVC)</td>
<td>Occlusion</td>
</tr>
<tr>
<td>Burn patients</td>
<td>PICC</td>
<td>Peripheral catheter</td>
<td>Malplacement</td>
</tr>
<tr>
<td>Patients requiring the use of a PVC</td>
<td></td>
<td></td>
<td>Cost</td>
</tr>
</tbody>
</table>

Children: no data for comparison.

**PICC vs CVC in patients receiving parenteral nutrition**

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clin Nutr 2000; 19(4): 237-243</td>
<td>COWL CT</td>
<td>Complications and cost associated with parenteral nutrition delivered to hospitalized patients through either subclavian CVC or PICC</td>
<td>Randomised</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>/</td>
<td>No</td>
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<tr>
<td>Nutr Clin Pract 1996; 11(5): 199-203</td>
<td>ALHIMARY A</td>
<td>Safety and efficacy of total parenteral nutrition delivered via a peripherally inserted central venous catheter</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>J Parenter Enteral Nutr 1999; 23(2): 85-89</td>
<td>DUERKSEN DR</td>
<td>Peripherally inserted central catheters for parenteral nutrition: a comparison with centrally inserted catheters</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
</tbody>
</table>

**PICC vs CVC infection in critical care patients**

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
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</thead>
<tbody>
<tr>
<td>Am J Infect Control 2010; 38(2): 149-153</td>
<td>AL RAY B</td>
<td>PICC in the acute care setting: a safe alternative to high-risk short-term central venous catheters</td>
<td>Prospective observational</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
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<tr>
<td>Surg Infect (Larchmt) 2011; 12(4): 279-282</td>
<td>GUNST M</td>
<td>Peripherally inserted central catheters may lower the incidence of catheter-related blood stream infections in patients in surgical intensive care units</td>
<td>Retrospective</td>
<td>(-1)*</td>
<td>No</td>
<td>(-1)**</td>
<td>No</td>
<td>/</td>
<td>No</td>
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<tr>
<td>Chest 1986; 90(6): 806-809</td>
<td>GIUFFRIDA</td>
<td>Central vs peripheral venous catheters in critically ill patients</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>(-1)**</td>
<td>No</td>
<td>/</td>
<td>(+1)</td>
</tr>
</tbody>
</table>
### Complication (%)

<table>
<thead>
<tr>
<th>Complication (%)</th>
<th>Infections / 1000 catheter-days</th>
<th>Less than / 1000 catheter-days</th>
<th>p</th>
<th>CVC</th>
<th>PICC</th>
<th>Remark 1</th>
<th>Remark 2</th>
<th>Remark 3</th>
<th>Note</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/51 (3.9%)</td>
<td>3/51 (5.9%)</td>
<td>4.2</td>
<td>NS</td>
<td>CVC</td>
<td>PICC</td>
<td>*Sample size</td>
<td>NS non-significant</td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>2/135 (1.5%)</td>
<td>0/135 (0%)</td>
<td>1.4</td>
<td>NS</td>
<td>CVC</td>
<td>PICC</td>
<td>No definition for &quot;catheter sepsis&quot; infection</td>
<td>2 cases of catheter sepsis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8/285 (6.4%)</td>
<td>2/209 (1.0%)</td>
<td>2.2</td>
<td>NS</td>
<td>CVC</td>
<td>PICC</td>
<td>Definition of infection: CRBSI</td>
<td></td>
<td></td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

### Infection Definition:
- CLABSI
- CRBSI

**Note:**
- *Comparison: 17 months CVC excluding critical care vs 8 months PICC including critical care
- Definition of infection: CLABSI
- * CVC group cannot be compared with the PICC group
- **Critical care surgery patients
- ***No statistical comparison
- Only independent factor related to infection = catheter duration
- Infection definition: CRBSI

**Remark 1:**
- OR = 0.86 0.86 0 OR = 9.56***
- *Imprecise criteria
- **Critical care patients

**Remark 2:**
- *Critical care patients

**Remark 3:**
- *Critical care patients

**Overall level of evidence:**
- Low
- Very low
<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
<th>CVC</th>
<th>PICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>J Hosp Infect 2011; 78(1): 26-30</td>
<td>MOLLEE P</td>
<td>Catheter-associated BSI incidence and risk factors: a prospective cohort study</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>(+2)</td>
<td>12/154</td>
<td>76/807</td>
</tr>
<tr>
<td>J Hosp Infect 2011; 78(1): 35-40</td>
<td>MOLLEE P</td>
<td>Catheter-associated BSI incidence and risk factors: a prospective cohort study</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>(+1)</td>
<td>37/154</td>
<td>76/807</td>
</tr>
<tr>
<td>Blood Coagul Fibrinolysis 2009; 20(1): 35-40</td>
<td>FAGNANI D</td>
<td>The impact of antithrombotic prophylaxis on infectious complications in cancer patients with central venous catheter: an observational study</td>
<td>Multi-centre retrospective</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>20/242 (8,3%)</td>
<td>15/144 (10,4%)</td>
</tr>
<tr>
<td>Support Care Cancer 2009; 17(7): 811-818</td>
<td>WORTH LJ</td>
<td>Infective and thrombotic complications of central venous catheters in patients with haematological malignancy: prospective evaluation of nontunneled devices</td>
<td>Prospective observational</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
<td>6/31 (19%)</td>
<td>12/75 (16%)</td>
</tr>
<tr>
<td>Support Care Cancer 2009; 17(7): 811-818</td>
<td>WORTH LJ</td>
<td>Infective and thrombotic complications of central venous catheters in patients with haematological malignancy: prospective evaluation of nontunneled devices</td>
<td>Prospective observational</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
<td>1/31 (3,2%)</td>
<td>1/75 (1,3%)</td>
</tr>
<tr>
<td>J Korean Med Sci 2010; 25(12): 1748-1753</td>
<td>Kim HJ</td>
<td>Safety and effectiveness of central venous catheterization in patients with cancer: prospective observational study</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PICC vs CVC Infections in home hospitalization**

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
<th>CVC</th>
<th>PICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>J Vasc Interv Radiol 2002; 13(10): 1009-1016</td>
<td>MOUREAU N</td>
<td>Central venous catheters in home infusion care: outcomes analysis in 50,470 patients.</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J Vasc Interv Radiol 2002; 13(10): 1009-1016</td>
<td>MOUREAU N</td>
<td>Central venous catheters in home infusion care: outcomes analysis in 50,470 patients.</td>
<td>Prospective observational</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mayo Clin Proc 2006; 81(9): 1159-1171</td>
<td>MAKI DG</td>
<td>The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies</td>
<td>Review of literature</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
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</table>
### Incidence/1000 catheter-days

<table>
<thead>
<tr>
<th>CVC</th>
<th>PICC</th>
<th>p</th>
<th>Remark 1</th>
<th>Remark 2</th>
<th>Remark 3</th>
<th>Note</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,6</td>
<td>1,81</td>
<td></td>
<td>HR=8,69 Onco-haematology patients</td>
<td>Characteristics of different groups (PICC: solid cancers + haemato; CVC = haemato only)</td>
<td>Results for non-tunneled CVC Infection definition: CRBSI</td>
<td>⬤⬤⬤ -</td>
<td>⬤ - Low</td>
</tr>
<tr>
<td>8,06</td>
<td>1,81</td>
<td></td>
<td>HR=2,78 Onco-haematology patients</td>
<td>Characteristics of different groups (PICC: solid cancers + haemato; CVC = haemato only)</td>
<td>Results for non-tunneled CVC Infection definition: CRBSI</td>
<td>⬤⬤ - -</td>
<td></td>
</tr>
<tr>
<td>0,410</td>
<td>0,353</td>
<td></td>
<td>NR Oncology</td>
<td>Definition of infection: systemic and local infections</td>
<td></td>
<td>⬤⬤ - -</td>
<td></td>
</tr>
<tr>
<td>10,27 (3,42-11,55)</td>
<td>6,61 (3,77-22,36)</td>
<td>p=0,78 NS</td>
<td>Haematology patients</td>
<td>CRBSI Non-tunneled CVC</td>
<td></td>
<td>⬤ - - -</td>
<td></td>
</tr>
<tr>
<td>1,77</td>
<td>0,55</td>
<td></td>
<td>NS Haematology patients</td>
<td>Local infections Non-tunneled CVC</td>
<td></td>
<td>⬤ - - -</td>
<td></td>
</tr>
</tbody>
</table>

### Complication (%)

<table>
<thead>
<tr>
<th>CVC</th>
<th>PICC</th>
<th>Incidence/1000 catheter-days</th>
<th>Remark 1</th>
<th>Remark 2</th>
<th>Remark 3</th>
<th>Note</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>534/8345**</td>
<td>375/25 590</td>
<td>0,70</td>
<td>0,36 Home hospitalisation, adults and paediatrics</td>
<td>Local + systemic infections Tunneled CVC</td>
<td>⬤ - -</td>
<td>⬤ - - - Very low</td>
<td></td>
</tr>
<tr>
<td>104/2982**</td>
<td>375/25 590</td>
<td>0,54</td>
<td>0,36 Home hospitalisation, adults and paediatrics</td>
<td>Local + systemic infections Non-tunneled CVC</td>
<td>⬤ - -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35/741* (4,7 %)</td>
<td>97/2813 (3,5 %)</td>
<td>1,70*</td>
<td>1,00 Tunneled CVC, hospitalised patient</td>
<td>All BSI</td>
<td>⬤⬤ - -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## PICC vs CVC Infections in patients, excluding critical care

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaesthesia 2012; 67(1):65-71</td>
<td>PIKWER A</td>
<td>Complications associated with peripheral or central routes for central venous cannulation</td>
<td>Literature search</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>Chest 2005; 128(2):489-495</td>
<td>SAFDAR N</td>
<td>Risk of catheter-related bloodstream infection with peripherally inserted central venous catheter used in hospitalized patients</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>Am J Infect Control 2010; 38(2):149-153</td>
<td>AL RAJ B</td>
<td>PICC in the acute care setting: A safe alternative to high-risk short-term central venous catheters</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>Indirect (-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>Am J Surg 1998; 176(2):208-211</td>
<td>SMITH JR</td>
<td>Peripherally inserted central catheters revisited</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
</tbody>
</table>

## Thrombotic complications in patients receiving parenteral nutrition

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clin Nutr 2000; 19(4):237-243</td>
<td>COWL CT</td>
<td>Complications and cost associated with parenteral nutrition delivered to hospitalized patients through either subclavian CVC or PICC</td>
<td>Randomised</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>Nutr Clin Pract 1996; 11(5):199-203</td>
<td>ALHIMYARY A</td>
<td>Safety and efficacy of total parenteral nutrition delivered via a peripherally inserted central venous catheter</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>J Parenter Enteral Nutr 1999; 23(2): 85-89</td>
<td>DUERKSEN DR</td>
<td>Peripherally inserted central catheters for parenteral nutrition: a comparison with centrally inserted catheters</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
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</tbody>
</table>

## Thrombotic complications in onco-haematology patients

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support Care Cancer 2009; 17(7): 811-818</td>
<td>WORTH LJ</td>
<td>Infective and thrombotic complications of central venous catheters in patients with haematological malignancy: prospective evaluation of nontunneled devices</td>
<td>Prospective observational</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
</tbody>
</table>

## Thrombotic complications in critical care patients

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiology 2010; 256(1): 312-320</td>
<td>TREROTOLA SO</td>
<td>Triple-lumen peripherally inserted central catheter in patients in the critical care unit: prospective evaluation</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>(+2)</td>
</tr>
<tr>
<td>Complication (%)</td>
<td>Incidence/1000 catheter-days</td>
<td>p</td>
<td>Remark 1</td>
<td>Remark 2</td>
<td>Remark 3</td>
<td>Note</td>
<td>Overall level of evidence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------</td>
<td>---</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>------</td>
<td>-------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
<td></td>
</tr>
<tr>
<td>2.25</td>
<td>1.7</td>
<td>0.83</td>
<td>0.17</td>
<td>Heterogeneous results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>3.5</td>
<td>Not indicated</td>
<td>0.93</td>
<td>Data produced by a study comparing a dressing soaked in CHX with a CHX solution</td>
<td>For CVC: results of a previous study</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.44</td>
<td>2.3</td>
<td>0.93</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

33/283 | 45/555 | 0.7 | 3.8 | p=0.24 | Adults, excluding intensive care cases | | |

<table>
<thead>
<tr>
<th>Complication (%)</th>
<th>Incidence/1000 catheter-days</th>
<th>p</th>
<th>Remark 1</th>
<th>Remark 2</th>
<th>Note</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
<td>CVC</td>
</tr>
<tr>
<td>1/51 (0.10%)</td>
<td>8/51 (0.16%)</td>
<td>0.01</td>
<td>7.8</td>
<td>0.04</td>
<td>Sample size</td>
<td></td>
</tr>
<tr>
<td>0/105 (0%)</td>
<td>3/126 (2.2%)</td>
<td>Not indicated</td>
<td>2.17</td>
<td>Not indicated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4%</td>
<td>12%</td>
<td>3.33</td>
<td>11.3</td>
<td>0.17</td>
<td></td>
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<table>
<thead>
<tr>
<th>Complication (%)</th>
<th>Incidence/1000 catheter-days</th>
<th>p</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
<td>CVC</td>
</tr>
<tr>
<td>2/31 (0.06%)</td>
<td>14/75 (0.19%)</td>
<td>3.42 (0.41-12.37)</td>
<td>7.71 (4.22-12.94)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Complication (%)</th>
<th>Incidence/1000 catheter-days</th>
<th>p</th>
<th>Remark 1</th>
<th>Remark 2</th>
<th>Note</th>
</tr>
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<tbody>
<tr>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
</tr>
<tr>
<td>&quot;No CVC Design changed during the study&quot;</td>
<td>10/50 (20%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Study interrupted due to a thrombotic incident excluding use of PICC&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average</td>
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### Thrombotic complications in patients excluding critical care

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
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<th>Design</th>
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<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
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<tbody>
<tr>
<td>Intensive Care Med 2011; 37(2): 284-289</td>
<td>BONIZZOLI M</td>
<td>Peripherally inserted central venous catheters and central venous catheters related thrombosis in post-critical patients</td>
<td>Prospective before-after</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
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<tr>
<td>Anesthesia 2012; 67(1): 65-71</td>
<td>PIKWER A</td>
<td>Complications associated with peripheral or central routes for central venous cannulation</td>
<td>Review of literature (12 studies included)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>+1</td>
</tr>
<tr>
<td>Am J Surg 1998; 176(2): 208-211</td>
<td>SMITH JR</td>
<td>Peripherally inserted central catheters revisited</td>
<td>Retrospective</td>
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<td>No</td>
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<td>/</td>
<td>No</td>
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<tr>
<td>Am J Surg 1998; 176(2): 208-211</td>
<td>SMITH JR</td>
<td>Peripherally inserted central catheters revisited</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>/</td>
<td>+1</td>
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</tbody>
</table>

### Malplacement in patients receiving parenteral nutrition

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<tr>
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<th>Risk of bias</th>
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<td>No</td>
<td>(-1)*</td>
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<td></td>
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<td>Nutr Clin Pract 1996; 11(5): 199-203</td>
<td>ALHIMYAR A</td>
<td>Safety and efficacy of total parenteral nutrition delivered via a peripherally inserted central venous catheter</td>
<td>Retrospective</td>
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<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>J Parenter Enteral Nutr 1999; 23(2): 85-89</td>
<td>DUERKSEN DR</td>
<td>Peripherally inserted central catheters for parenteral nutrition: a comparison with centrally inserted catheters</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td></td>
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### Malplacement in patients in onco-haematology

<table>
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<tr>
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<th>Author</th>
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<th>Design</th>
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<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
</tr>
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</table>

### Other complications

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
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<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>J Vasc Interv Radiol 2002; 13(10): 1009-1016</td>
<td>MOUREAU N</td>
<td>Central venous catheters in home infusion care: outcomes analysis in 50,470 patients</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>Anesthesia 2012; 67(1): 65-71</td>
<td>PIKWER A</td>
<td>Complications associated with peripheral or central routes for central venous cannulation</td>
<td>Review of literature (12 studies included)</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>Am J Surg 1998; 176(2): 208-211</td>
<td>SMITH JR</td>
<td>Peripherally inserted central catheters revisited</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>Complication (%)</td>
<td>Incidence/1000 catheter-days</td>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
<td>Remark 1</td>
<td>Remark 2</td>
<td>Remark 3</td>
<td>Note</td>
<td>Overall level of evidence</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------</td>
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<td>------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
<td>CVC</td>
<td>PICC</td>
<td>p</td>
<td>Remark 1</td>
<td>Note</td>
<td>Overall level of evidence</td>
<td></td>
</tr>
<tr>
<td>12/125 (0,10%)</td>
<td>31/114 (0,27%)</td>
<td>0,0012</td>
<td>4,4</td>
<td>7,7</td>
<td></td>
<td></td>
<td>0,75</td>
<td>7,8</td>
<td>OR=5,82</td>
</tr>
<tr>
<td>2/283*</td>
<td>14/555*</td>
<td>0,14</td>
<td>0,04</td>
<td>1,19</td>
<td>*Thrombosis</td>
<td>@@@ - -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0/283*</td>
<td>36/555*</td>
<td>0,0004</td>
<td>0</td>
<td>3,05</td>
<td>*Phlebitis</td>
<td>@@@ - -</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Complication (%)</th>
<th>CVC</th>
<th>PICC</th>
<th>p</th>
<th>Remark 1</th>
<th>Remark 2</th>
<th>Remark 3</th>
<th>Note</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/51 (2%)</td>
<td>5/51 (10%)</td>
<td>p&lt;0,05</td>
<td>TPN</td>
<td>*Sample size</td>
<td>Malplacement</td>
<td>@@@ - -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/135 (4%)</td>
<td>3/135 (3%)</td>
<td>NS</td>
<td>TPN</td>
<td>Malplacement</td>
<td>@@@ - -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6%)</td>
<td>(33%)</td>
<td>TPN</td>
<td>Malplacement</td>
<td>@@@ - -</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Complication (%)</th>
<th>CVC</th>
<th>PICC</th>
<th>p</th>
<th>Remark 1</th>
<th>Remark 2</th>
<th>Remark 3</th>
<th>Note</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/24 (33%)</td>
<td>10/155 (6%)</td>
<td>OR=7,25</td>
<td>Nb CVC&lt;&lt;PICC</td>
<td>**Comparison betw. CCI vs CVC + PICC</td>
<td>Malplacement</td>
<td>@@@ - - Low</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Complication (%)</th>
<th>CVC</th>
<th>PICC</th>
<th>p</th>
<th>Remark 1</th>
<th>Remark 2</th>
<th>Remark 3</th>
<th>Note</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>767/2 982**</td>
<td>2 077/25 590</td>
<td>Home hospitalisation, adults and paediatrics</td>
<td>**Non-tunneled CVC</td>
<td>Other complications: extravasation, catheter breakage, accidental removal, occlusion, drug precipitation, infiltration</td>
<td>@ - -</td>
<td>Very low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,4/1 000 catheter-days</td>
<td>7,8/1 000 catheter-days</td>
<td>Heterogeneity</td>
<td>Complications = leakage, breakage, occlusion, malplacement</td>
<td>@ - -</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7/283 (4%)</td>
<td>37/555 (12%)</td>
<td>0,02</td>
<td>Displacement, pain, bleeding</td>
<td>@@@ - -</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Cost of PICC vs CVC

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clin Nutr 2000; 19(4): 237-243</td>
<td>COWL CT</td>
<td>Complications and cost associated with parenteral nutrition delivered to hospitalized patients through either subclavian CVC or PICC</td>
<td>Randomised</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>(-1)</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>Am J Surg 1998; 176(2):208-211</td>
<td>SMITH JR</td>
<td>Peripherally inserted central catheters revisited</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
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</tbody>
</table>

### PICC vs CVC infection

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
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<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>J Hosp Infect 2011;78(1): 26-30</td>
<td>MOLLEE P</td>
<td>Catheter-associated BSI incidence and risk factors in adults with cancer: a prospective cohort study</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Blood Coagul Fibrinolysis 2009; 20(1): 35-40</td>
<td>FAGNANI D</td>
<td>The impact of antithrombotic prophylaxis on infectious complications in cancer patients with central venous catheters: an observational study</td>
<td>Multi-centre prospective observational</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>J Korean Med Sci 2010; 25(12): 1748-1753</td>
<td>KIM HJ</td>
<td>Safety and effectiveness of central venous catheterization in patients with cancer: prospective observational study</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>J Vasc Interv Radiol 2002; 13(10): 1009-16</td>
<td>MOUREAU N</td>
<td>Central venous catheters in home infusion care: outcomes analysis in 50,470 patients</td>
<td>Retrospective</td>
<td>(-1)*</td>
<td>No</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Mayo Clin Proc 2006; 81(9): 1159-1171</td>
<td>MARI DG</td>
<td>The risk of bloodstream infection in adults with different intravascular devices: A systematic review of 200 published prospective studies</td>
<td>Literature review</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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### Other complications, PICC vs TIVC

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
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<td>MOUREAU N</td>
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<td>Retrospective</td>
<td>(-1)*</td>
<td>No</td>
<td>Indirect (-1)*</td>
<td>No</td>
<td>/</td>
<td>No</td>
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</tbody>
</table>

### Cost of PICC vs TIVC

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
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<td>Complications and cost associated with parenteral nutrition delivered to hospitalized patients through either subclavian CVC or PICC</td>
<td>Randomised</td>
<td>No</td>
<td>No</td>
<td>Indirect (-1)*</td>
<td>(-1)**</td>
<td>/</td>
<td>No</td>
</tr>
<tr>
<td>Am J Surg 1998; 176(2):208-211</td>
<td>SMITH JR</td>
<td>Peripherally inserted central catheters revisited</td>
<td>Retrospective</td>
<td>(-1)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
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</table>
## Complication (%)

<table>
<thead>
<tr>
<th>PICC</th>
<th>KTC</th>
<th>p</th>
<th>Remark 1</th>
<th>Note</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>16,20 +/- 2.96</td>
<td>22.32 +/- 2.74</td>
<td>p&lt;0.05</td>
<td>$/day</td>
<td>@@@ -</td>
<td>@@ - - Low</td>
</tr>
<tr>
<td>500</td>
<td>2500</td>
<td>Not indicated</td>
<td>Cost of placement in $</td>
<td>@ -</td>
<td></td>
</tr>
</tbody>
</table>

## Incidence/1000 catheter-days

<table>
<thead>
<tr>
<th>TIVC</th>
<th>PICC</th>
<th>TIVC</th>
<th>PICC</th>
<th>p</th>
<th>Note</th>
<th>Remark 1</th>
<th>Remark 2</th>
<th>Remark 3</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/12 (33.3%)</td>
<td>76/807 (9.4%)</td>
<td>0.97</td>
<td>1.81</td>
<td>0.48</td>
<td>@ - -</td>
<td>PICC rarely placed in patients with solid tumours</td>
<td>*12 TIVC for 807 PICC</td>
<td>**Patients in onco-haematology</td>
<td>@@@ - Low</td>
</tr>
<tr>
<td>0.073</td>
<td>0.353</td>
<td>&lt;0.0001</td>
<td>@@@ -</td>
<td>Oncology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.028</td>
<td></td>
<td></td>
<td>@ - -</td>
<td>No accurate data (no mean catheter duration, no incidence rate)</td>
<td>**Comparison: TIVC vs CVC + PICC</td>
<td>No comparison, but risk factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>208/1,556 (2.6%)</td>
<td>375/25,590 (1.5%)</td>
<td>0.30</td>
<td>0.36</td>
<td>@ - -</td>
<td>*Home hospitalisation, adults, and paediatrics</td>
<td>**Local + systemic infections</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>81/3,007 (2.7%)</td>
<td>112/3,566 (3.1%)</td>
<td>0.1</td>
<td>1.1</td>
<td>@@@ -</td>
<td></td>
<td></td>
<td></td>
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## Costs

<table>
<thead>
<tr>
<th>PICC</th>
<th>TIVC</th>
<th>Remark 1</th>
<th>Remark 2</th>
<th>Remark 3</th>
<th>Note</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>16,20 +/- 2.96</td>
<td>22.32 +/- 2.74</td>
<td>Dollars/days</td>
<td></td>
<td></td>
<td>@@@ -</td>
<td>@@ - - Low</td>
</tr>
<tr>
<td>500*</td>
<td>3500*</td>
<td>Cost of placement in dollars</td>
<td>*In case of occlusion: $160 urokinase</td>
<td>Non-invasive diagnosis Thrombo-phlebitis: 350 $</td>
<td>@ -</td>
<td></td>
</tr>
</tbody>
</table>

Overall level of evidence: Low
PICC vs PVC infections

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
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<th>Design</th>
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<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
<th>Other</th>
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</thead>
<tbody>
<tr>
<td>J Thromb Haemost 2008; 6(8): 1281-1288</td>
<td>PERIARD D</td>
<td>Randomized controlled trial of peripherally inserted central catheters vs peripheral catheters for middle duration in-hospital intravenous therapy</td>
<td>Randomised</td>
<td>(-2)*</td>
<td>No</td>
<td>No</td>
<td>(-1)**</td>
<td>/</td>
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<td>Maki DG</td>
<td>The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies</td>
<td>Review of literature</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
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</table>

Cost of PICC vs PVC

<table>
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<td>Randomised</td>
<td>(-2)*</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</tbody>
</table>

Patient satisfaction PICC vs PVC

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
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<td>Randomised</td>
<td>(-2)*</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
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</tbody>
</table>

Prevention: choice of materials and techniques

<table>
<thead>
<tr>
<th>Patients</th>
<th>Surgery</th>
<th>Comparison</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient requiring a PICC</td>
<td>Placement under conditions of surgical asepsis</td>
<td>Placement with the patient in bed</td>
<td>Infectious complications</td>
</tr>
<tr>
<td>Patient requiring a PICC</td>
<td>Placement by a trained team</td>
<td>Placement by any healthcare worker</td>
<td>Infectious complications</td>
</tr>
<tr>
<td>Patient fitted with a PICC</td>
<td>Securement using an adhesive system</td>
<td>Securement using sutures</td>
<td>Infectious complications</td>
</tr>
<tr>
<td>Patient requiring a PICC</td>
<td>Basal insertion</td>
<td>Brachial insertion</td>
<td>Infectious complications</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thromboembolic complications</td>
</tr>
<tr>
<td>Complication (%)</td>
<td>Incidence/100 0 catheter-days</td>
<td>Result</td>
<td>Remark 1</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td>PVC</td>
<td>PICC</td>
<td>0/29</td>
<td>1/31</td>
</tr>
<tr>
<td>13/10910 (0,1%)</td>
<td>112/3568 (3,1%)</td>
<td>0,5</td>
<td>2,1</td>
</tr>
</tbody>
</table>

| PVC              | PICC                          | 237    | 690      | No statistics | *Patients requiring IV therapy > 5 days | *60 patients | 31 PICC, 29 PVC | Low   |

| PVC              | PICC                          | 24/31  | 6/29     | p < 0,001   | *Patients requiring IV therapy > 5 days | *60 patients 31 PICC, 29 PVC | *4-level satisfaction questionnaire: highly satisfied, satisfied, somewhat dissatisfied, highly dissatisfied | Low   |
### Infectious complications – Groshong vs PICC with proximal valve

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
<th>Title</th>
<th>Design</th>
<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
</tr>
</thead>
<tbody>
<tr>
<td>J Vasc Interv Radiol 2010; 21(8): 1191-1196</td>
<td>ONG CK</td>
<td>Prospective randomized comparative evaluation of proximal valve polyurethane and distal valve silicone peripherally inserted central catheters</td>
<td>Randomised prospective</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
</tr>
<tr>
<td>J Vasc Interv Radiol 2001; 12(10): 1173-1177</td>
<td>HOFFER EK</td>
<td>Peripherally inserted central catheters with distal versus proximal valves: prospective randomized trial</td>
<td>Randomised prospective</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
</tr>
</tbody>
</table>

### Thrombophlebitic complications – Groshong vs PICC with proximal valve

<table>
<thead>
<tr>
<th>Journal</th>
<th>Author</th>
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<th>Risk of bias</th>
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<td>Randomised prospective</td>
<td>No</td>
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<td>Peripherally inserted central catheters with distal versus proximal valves: prospective randomized trial</td>
<td>Randomised prospective</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
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</tbody>
</table>

### Other complications – Groshong vs PICC with proximal valve: occlusion

<table>
<thead>
<tr>
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<td>J Vasc Interv Radiol 2010; 21(8): 1191-1196</td>
<td>ONG CK</td>
<td>Prospective randomized comparative evaluation of proximal valve polyurethane and distal valve silicone peripherally inserted central catheters</td>
<td>Randomised prospective</td>
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<td>J Vasc Interv Radiol 2001; 12(10): 1173-1177</td>
<td>HOFFER EK</td>
<td>Peripherally inserted central catheters with distal versus proximal valves: prospective randomized trial</td>
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### Other complications – Groshong vs PICC with proximal valve: breakage

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<td>Peripherally inserted central catheters with distal versus proximal valves: prospective randomized trial</td>
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<tr>
<td>Inaccuracy</td>
<td>Other</td>
<td>Note</td>
<td>Groshong (%)</td>
<td>PICC (%)</td>
<td>p</td>
<td>Remark 1</td>
</tr>
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<td>-----------</td>
<td>-------</td>
<td>------</td>
<td>--------------</td>
<td>----------</td>
<td>-------</td>
<td>----------</td>
</tr>
<tr>
<td>(-1)**</td>
<td>/ No</td>
<td></td>
<td>1/11</td>
<td>0/14</td>
<td>0.440</td>
<td>NS</td>
</tr>
<tr>
<td>No</td>
<td>/ No</td>
<td></td>
<td>12/194 (6.2%)</td>
<td>4/198 (2.0%)</td>
<td>0.043</td>
<td>@@@ -</td>
</tr>
<tr>
<td>No</td>
<td>/ No</td>
<td></td>
<td>4/48 (8.3%)</td>
<td>1/52 (1.9%)</td>
<td>NS</td>
<td>@@@ -</td>
</tr>
<tr>
<td>(-1)**</td>
<td>/ No</td>
<td></td>
<td>0/11</td>
<td>2/14</td>
<td>1.000</td>
<td>**26 patients</td>
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<td>/ No</td>
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<td>45/194 (23.2%)</td>
<td>23/198 (11.6%)</td>
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<td>/ No</td>
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<td>1/48 (2.1%)</td>
<td>0/52 (0%)</td>
<td>NS</td>
<td>@@@ -</td>
</tr>
<tr>
<td>(-1)**</td>
<td>/ No</td>
<td></td>
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<td>2/14</td>
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<td>23/194 (9.6%)</td>
<td>19/198 (11.9%)</td>
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<td>7/48 (14.6%)</td>
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<td>/ No</td>
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<td>7/194 (3.6%)</td>
<td>2/197 (1.0%)</td>
<td>0.102</td>
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<td>No</td>
<td>/ No</td>
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<td>25/48 (52.1%)</td>
<td>3/52 (5.8%)</td>
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### Thromboses: Single lumen vs multi-lumen

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<tr>
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<th>Inaccuracy</th>
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<tr>
<td>Radiology 2010; 256(1): 312-320</td>
<td>TREROTOLA SO</td>
<td>Triple-lumen peripherally inserted central catheter in patients in the critical care unit: prospective evaluation</td>
<td>Prospective observational</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>No</td>
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<tr>
<td>Chest 2010; 138(4): 803-810</td>
<td>EVANS RS</td>
<td>Risk of symptomatic DVT associated with PICC</td>
<td>Prospective observational</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>(+2)*</td>
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<tr>
<td>Chest 2010; 138(4): 803-810</td>
<td>EVANS RS</td>
<td>Risk of symptomatic DVT associated with PICC</td>
<td>Prospective observational</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>(+2)*</td>
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</table>

### Thromboses: Small vs large diameter

<table>
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<tr>
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<th>Inaccuracy</th>
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<tr>
<td>J Vasc Interv Radiol 2000; 11(7): 837-840</td>
<td>GROVE JR</td>
<td>Venous thrombosis related to peripherally inserted central catheters</td>
<td>Retrospective</td>
<td>No</td>
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<td>(-1)*</td>
<td>No</td>
<td>(+1)*</td>
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<tr>
<td>Chest 2012; 1. doi: 10.1378/chest.12-0923. [Epub ahead of print]</td>
<td>EVANS RS</td>
<td>Reduction of peripherally inserted central catheter associated deep venous thrombosis</td>
<td>Prospective observational</td>
<td>No</td>
<td>No</td>
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<td>(+1)*</td>
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### Infectious complications with adhesive vs suture securement

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<th>Risk of bias</th>
<th>Inconsistency</th>
<th>Indirect character</th>
<th>Inaccuracy</th>
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<tr>
<td>J Vasc Interv Radiol 2002; 13(1): 77-81</td>
<td>YAMAMOTO AJ</td>
<td>Sutureless securement device reduces complications of peripherally inserted central venous catheters</td>
<td>Prospective randomised</td>
<td>(-1)*</td>
<td>No</td>
<td>No</td>
<td>/</td>
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### Infectious complications power PICC vs PICC

<table>
<thead>
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<th>Inconsistency</th>
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<th>Inaccuracy</th>
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<tr>
<td>Critical Care 2012; 16: R21</td>
<td>PITTIRUTI M</td>
<td>Clinical experience with power injectable PICC in intensive care unit</td>
<td>Prospective observational</td>
<td>(-2)*</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>/</td>
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### Thrombotic complications power PICC vs PICC

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<td>Clinical experience with power injectable PICC in intensive care unit</td>
<td>Prospective observational</td>
<td>(-2)*</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>/</td>
<td>No</td>
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### Infectious complications in the case of PICC placement < 2 days following bacteremia

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<tr>
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<th>Inaccuracy</th>
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<tr>
<td>J Vasc Interv Radiol 2012; 23(1): 123-125</td>
<td>DANEMAN N</td>
<td>How long should peripherally inserted central catheterization be delayed in the context of recently documented bloodstream infection?</td>
<td>Prospective observational</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>/</td>
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</table>
### Complication (%)

<table>
<thead>
<tr>
<th>Incidence/1000 catheter-days</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>Multi</td>
</tr>
<tr>
<td>-</td>
<td>20%</td>
</tr>
<tr>
<td>0,6%</td>
<td>2,9%</td>
</tr>
<tr>
<td>0,6</td>
<td>8,8%</td>
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### Complication (%)

<table>
<thead>
<tr>
<th>Incidence/1000 catheter-days</th>
<th>Overall level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 4 Fr</td>
<td>&gt; 4 Fr</td>
</tr>
<tr>
<td>(1%)</td>
<td>(9,8%)</td>
</tr>
<tr>
<td>2/79</td>
<td>16/192</td>
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### Suture

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<tr>
<th>Adhesive</th>
<th>p</th>
<th>Remark</th>
<th>Note</th>
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<tbody>
<tr>
<td>2/85</td>
<td>10/85</td>
<td>0,032</td>
<td>Lack of blinding</td>
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### Power PICC

<table>
<thead>
<tr>
<th>PICC</th>
<th>Note</th>
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<tbody>
<tr>
<td>0/89</td>
<td>No comparison</td>
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### Power PICC

<table>
<thead>
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<th>PICC</th>
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<td>1/89</td>
<td>No comparison</td>
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### ≤ 2 days

<table>
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<tbody>
<tr>
<td>0,02</td>
<td>@@@ - Low</td>
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### Infectious complications with untrained personnel (bundle)

<table>
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<th>Inaccuracy</th>
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<tbody>
<tr>
<td>Support Care Cancer 2010; 18(10): 1293-1298</td>
<td>TIAN G</td>
<td>Efficacy of multifaceted interventions in reducing complications of peripherally inserted central catheter in adult oncology patients</td>
<td>Prospective observational</td>
<td>-1*</td>
<td>No</td>
<td>No</td>
<td>No</td>
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### Thrombotic complications left vs right insertion

<table>
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<tbody>
<tr>
<td>Intensive Care Med 2011; 37(2): 284-289</td>
<td>BONIZZOLI M</td>
<td>Peripherally inserted central venous catheters and central venous catheters related thrombosis in post-critical patients</td>
<td>Prospective observational</td>
<td>-1*</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>/</td>
<td>(+1)*</td>
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<td>J Vasc Interv Radiol 2010; 21(8): 1191-1196</td>
<td>ALLEN AW</td>
<td>Venous thrombosis associated with the placement of peripherally inserted central catheters</td>
<td>Retrospective</td>
<td>No</td>
<td>No</td>
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<tbody>
<tr>
<td>J Vasc Access 2011, [Epub ahead of print]</td>
<td>SPERRY BW</td>
<td>The effect of laterality on venous thromboembolism formation after peripherally inserted central catheter placement</td>
<td>Retrospective</td>
<td>No</td>
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### Infectious complications left vs right insertion

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<th>Inaccuracy</th>
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<tr>
<td>J Hosp Infect 2011; 78(1): 26-30</td>
<td>MOLLEE P</td>
<td>Catheter-associated bloodstream infection incidence and risk factors in adults with cancer: a prospective cohort study</td>
<td>Prospective observational</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>(-1)*</td>
<td>/</td>
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<td>Prospective observational</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>(+1)*</td>
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### Thrombotic complications basal vs cephalic

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<tr>
<td>J Vasc Interv Radiol 2000; 11(10): 1309-1314</td>
<td>ALLEN AW</td>
<td>Venous thrombosis associated with the placement of peripherally inserted central catheters</td>
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<td>(+2)*</td>
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<td>No</td>
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<tr>
<td>13,4%</td>
<td>4,24%</td>
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<td>p=0,015</td>
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<td></td>
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<td>Insertion G</td>
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<tr>
<td>Insertion D</td>
<td>Insertion G</td>
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<table>
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<tr>
<td>Cephalic</td>
<td>Basal</td>
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<td>Basal</td>
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<td></td>
<td>Remark 2</td>
</tr>
<tr>
<td></td>
<td>Note</td>
</tr>
<tr>
<td>Overall level of evidence</td>
<td></td>
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