Editorial

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The SIC protocol: A seven-step strategy to minimize complications potentially related to the insertion of centrally inserted central catheters

Fabrizio Brescia[1], Mauro Pittiruti[2], Matthew Ostroff[3], Timothy R Spencer[4] and Robert B Dawson[5]

Abstract

Insertion of central venous catheters in the cervico-thoracic area is potentially associated with the risk of immediate/early untoward events, some of them negligible (repeated punctures), some relevant (accidental arterial puncture), and some severe (pneumothorax). Furthermore, different strategies adopted during insertion may reduce or increase the incidence of late catheter-related complications (infection, venous thrombosis, dislodgment). This paper describes a standardized protocol (S.I.C.: Safe Insertion of Centrally Inserted Central Catheters) for the systematic application of seven basic beneficial strategies to be adopted during insertion of central venous catheters in the cervico-thoracic region, aiming to minimize immediate, early, or late insertion-related complications. These strategies include: preprocedural evaluation, appropriate aseptic technique, ultrasound guided insertion, intra-procedural assessment of the tip position, adequate protection of the exit site, proper securement of the catheter, and adequate coverage of the exit site.

Keywords

Techniques and procedures, ultrasound guidance, standardized assessment, central venous access, patient safety, centrally inserted central catheters

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Introduction

The insertion of Centrally Inserted Central Catheters (CICC) is a widely used procedure in clinical practice, currently associated with a decreased risk of complications than in the past. Many factors have contributed to improve the safety of this clinical practice, the most important being the increasingly widespread use of ultrasound (US) in the different phases of CICC insertion. Ultrasound may be used for the preliminary assessment of veins, real-time venipuncture, and immediate detection of possible puncture-related complications (such as tissue hematomas, intramural hematomas of the vein, pneumothorax, others). Ultrasound also allows for "tip navigation" (i.e. to verify the correct direction of the guidewire and/or catheter while they progress into the vascular system), for "tip location" (i.e. to assess the central position of the tip), and for the diagnosis of many late non-infective complications (fibroblastic sleeve, catheter-related venous thrombosis, tip migration, others).[1–8]

Ultrasound is of paramount importance but is not the unique solution for the reduction of all catheter-related

[1]Unit of Anesthesia and Intensive Care Medicine, Vascular Access Team, Centro di Riferimento Oncologico di Aviano, IRCCS, Aviano, Italy
[2]Department of Surgery, Fondazione Policlinico Universitario "A.Gemelli" IRCCS, Rome, Italy
[3]Saint Joseph's University Medical Center, Paterson, NJ, USA
[4]Global Vascular Access, LLC, Scottsdale, AZ, USA
[5]Catholic Medical Center – Upper Connecticut Valley Hospital, Colebrook, NH, USA

Corresponding author:
Fabrizio Brescia, Unit of Anesthesia and Intensive Care Medicine, Vascular Access Team, Centro di Riferimento Oncologico di Aviano, IRCCS, Via Gallini 2, Aviano 33081, Italy.
Email: fabriziobrescia@gmail.com

Table 1. The seven steps of the SIC protocol.

Step 1	*Preprocedural evaluation*—choice of the vein by systematic ultrasound examination of the veins of the neck and of the supra/infraclavicular region (RaCeVA protocol) and choice of the ideal exit site (Central ZIM)
Step 2	*Appropriate aseptic technique*—hand hygiene, skin antisepsis with 2% chlorhexidine in 70% alcohol, maximal barrier precautions
Step 3	*Ultrasound-guided insertion*—ultrasound-guided venipuncture, ultrasound verification of the correct direction of the guidewire (tip navigation) and of the absence of pneumothorax (pleural scan)
Step 4	*Intra-procedural assessment of tip location*—verification of the central position of the tip by intracavitary ECG and/or by transthoracic echocardiography, using the "bubble test"
Step 5	*Adequate protection of the exit site*—reduction of the risk of bleeding and risk of contamination by sealing with cyanoacrylate glue
Step 6	*Proper securement of the catheter*—stabilization of the catheter using skin-adhesive sutureless devices, transparent dressing with integrated securement or subcutaneous anchorage
Step 7	*Appropriate coverage of the exit site*—use of semi-permeable transparent dressing, preferably with high breathability

complications. Other evidence-based strategies (proper choice of the exit site, skin antisepsis with 2% chlorhexidine in alcohol, maximal barrier precautions, intracavitary ECG for tip positioning, sutureless securement, others) are also known to increase the safety and the cost-effectiveness of the procedure.[1–5]

An insertion bundle consists of clear recommendations based on scientific evidence, capable of acting synergistically to provide maximal safety, positive outcomes, and cost-effectiveness of a given procedure. When placing a CICC, the purpose of an insertion bundle is to minimize any complication directly or indirectly related to the maneuver (accidental injury, incorrect tip location, arrhythmias, catheter-related venous thrombosis, catheter-related infections, others).

A similar insertion bundle has already been proposed for peripherally inserted central catheters (PICCs), the so-called SIP protocol.[9] In the following paragraphs, the authors will describe a seven-step strategy for minimizing insertion-related complications associated with CICCs, the "SIC" protocol (Safe Insertion of Central Catheters). It consists of seven different steps which summarize those evidence-based recommendations that, if applied correctly and systematically, allow to guarantee a safe, successful, and cost-effective procedure (Table 1).

Preprocedural evaluation: The rapid central vein assessment (RaCeVA) and the central zone insertion method (Central ZIM)

Proper pre-procedural evaluation obviously begins with an adequate anamnestic evaluation. It is important to consider whether the patients had previous vascular devices or repeated difficult venipunctures. Also, it is important to evaluate the patient's coagulation and platelet status, although the incidence of major bleeding complications after central venous catheter placement is low, even in coagulopathic patients.[10]

Before starting the procedure, two important issues of concern are the selection of the appropriate vein and the location of the exit site of the catheter.

The choice of the vein must be carefully considered before proceeding with CICC insertion. The preference or personal experience of the operator should not be considered as adequate criteria, as they do not guarantee maximal safety for the patient. On the contrary, a rational and objective systematic evaluation of the anatomical characteristics of the vascular system of each patient is possible through adoption of a pre-procedural ultrasound scan of the anatomical area in which the central venous access device will be inserted.[11]

The Rapid Central Vein Assessment (RaCeVA) protocol is a systematic approach of US evaluation of the veins of the neck and of the supra/infraclavicular area before CICC insertion.[12] RaCeVA follows a series of steps that can be performed in a short time, and should always be performed bilaterally. The RaCeVA is designed for an easy, rapid, and systematic assessment of the six central veins that can be theoretically punctured and cannulated by US in the supra/infraclavicular area: internal jugular vein (IJV), external jugular vein (EJV), brachiocephalic vein (BCV), and subclavian vein (SV) in the supraclavicular area; axillary vein (AV) and cephalic vein (CV) in the infraclavicular area. During the RaCeVA, the operator can rule out venous abnormalities such as thrombosis, stenosis, external compression, anatomical variations of size and shape of the veins, choose an appropriate catheter/vein (ideal 1:3 or less) so to reduce the risk of catheter-related thrombosis, and obtain a full anatomic evaluation for optimum site selection and the best insertion approach for each patient.[2,12,13] Also, RaCeVA visualizes the surrounding arterial or nervous structures that could be accidentally injured during venous catheterization.[12] The seventh and last step of RaCeVA involves the assessment of pleural space in the pre-insertion phase, providing an accurate baseline assessment of pleural function prior to the insertion of a CICC.[12] This protocol is useful for teaching the

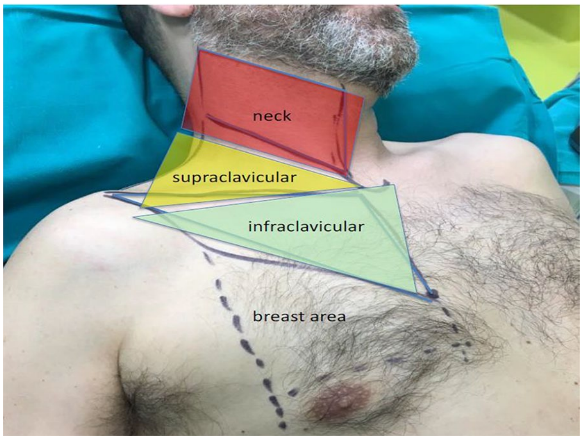

Figure 1. Central Zone Insertion Method.

different US-guided approaches to the central veins. RaCeVA ensures the operator systematically considers all possible venous options allowing the most appropriate vein to be accessed while also maintaining the patient safety benefits.

The risk of infection or dislodgment of a central venous access also depends on the choice of the exit site. This protocol suggests the opportunity of applying Dawson's[14] Zone Insertion Method (ZIM) for Peripherally Inserted Central Catheters (PICCs) to the cervico-thoracic region (so called "Central ZIM"). As demonstrated in the arm, the cervico-thoracic region can be divided into three different zones, red, yellow, and green, that correspond to the neck, supraclavicular and infraclavicular regions (Figure 1).

The *red zone* is an area with high bacterial contamination of the skin, due to the proximity of the oropharyngeal secretions. It is also an area with a high risk of catheter dislodgment because of the movements of the neck. For this reason, the neck region is to be avoided both as a venipuncture site and as an exit site.

The *yellow zone* corresponds to the supraclavicular area, where US-guided venipuncture of internal jugular, external jugular, brachio-cephalic, or subclavian vein is feasible. An exit site in the supraclavicular area is acceptable but not always ideal.

The *green zone* corresponds to the infraclavicular area, where US-guided venipuncture of axillary or cephalic vein is usually feasible. An exit site in the infraclavicular area is ideal because of the low bacterial contamination and the low risk of dislodgment.

Therefore, an optimal venipuncture site may not correspond to an ideal exit site (Figure 2(a) and (b)).

Tunneling is a strategy that enables movement of the catheter away from an area at high risk of infection or dislodgment toward a safer exit site, providing both an optimal insertion site and an optimal location of the exit site.[15] As regards to CICC insertion, two main types of tunneling are particularly useful: tunneling from the supraclavicular area to the infraclavicular area (tunneling type A) (Figure 3(a)) and tunneling from the infraclavicular area to the breast area (tunneling B) (Figure 3(b)). The latter might be useful, for example, in patients with skin problems of the chest area or in patients with tracheostomy (i.e. when it to advisable to place the exit site as far as possible from respiratory or oral secretions).

For the tunneling of the catheter, it is preferable to use blunt tunnelers, as they are associated with minimal risk of local bleeding even in patients with coagulation disorders or with reduced platelet counts.[16]

In short, RaCeVA permits clinicians to choose the optimal venipuncture site while the Central ZIM compliments RaCeVA to plan the optimal exit site.

Appropriate aseptic technique

The second very important step concerns the aseptic technique to be used during the placement of a CICC. Hand hygiene must be preferably performed with hydroalcoholic gel. In special cases, or when the hands are visibly dirty, the hydroalcoholic gel must be preceded by washing with soap and water, according to current international infection prevention guidelines. For skin antisepsis, 2% chlorhexidine in 70% alcohol should be used: iodine povidone in alcohol has a role only in case of known allergy to chlorhexidine. Regarding the antiseptic application technique, no clinical difference in microorganism reduction between the concentric circle and the back-and-forth techniques has been documented, both techniques should be used equally on clean and healthy skin.[17]

As recommended by all current guidelines, the risk of bacterial contamination must be reduced by adopting the maximal barrier precautions, non-sterile cap, non-sterile mask, sterile gown, sterile gloves, full-size sterile drape over the patient, plus adequate sterile protection of the ultrasound probe that is long enough to cover the probe and the ultrasound wire.[2,4,18,19]

Ultrasound-guided insertion

Ultrasound-guided venipuncture is considered mandatory for any central venous catheterization.[1] In the supraclavicular area, the IJV can be accessed by ultrasound guidance, preferably with vein visualization in short axis and in-plane puncture, so as to minimize any risk of arterial injury. Other possible approaches in the supraclavicular are the ultrasound-guided venipuncture of BCV, SV, or EJV, with vein visualization in long axis and in-plane puncture.[12]

In the infraclavicular area, the axillary vein can be visualized in short axis, in long axis, or in oblique axis. The oblique axis view is obtained rotating the probe to almost halfway between the short axis and the long axis view.

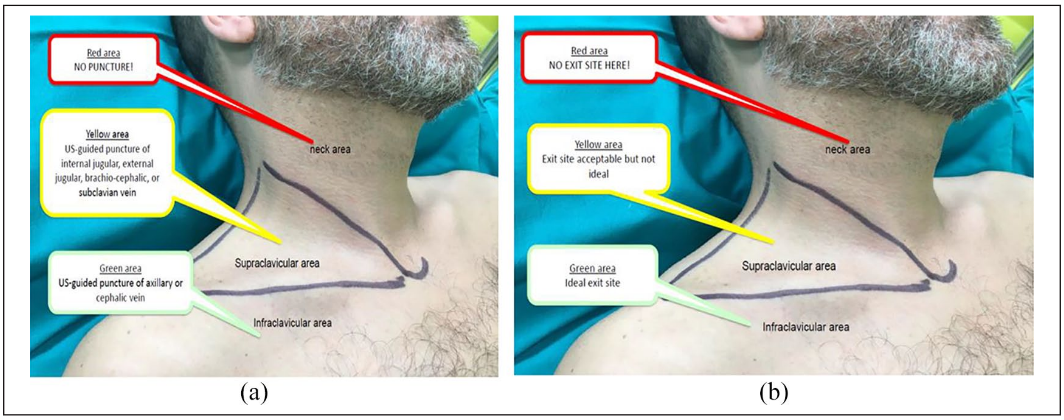

Figure 2. (a) Venipuncture site for US guided CICCs (b) Exit-site for US guided CICCs.

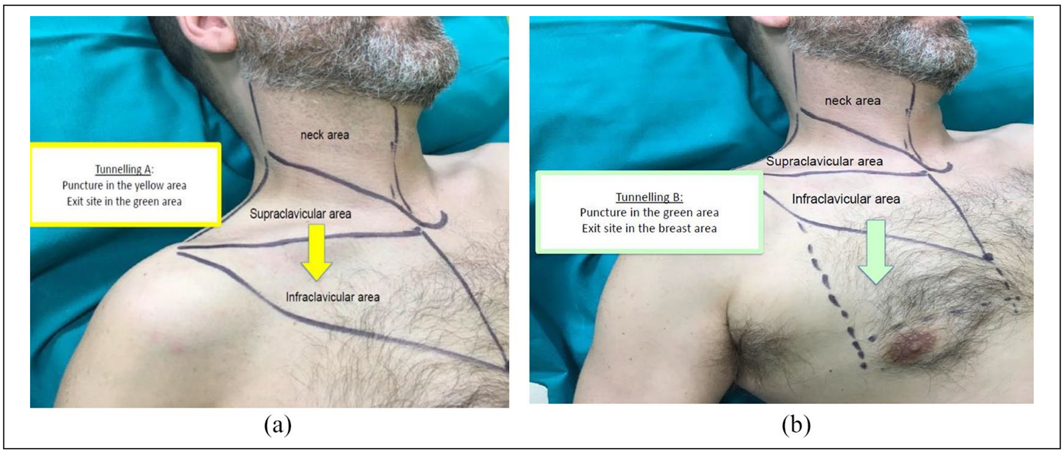

Figure 3. (a) Tunneling of from supraclavicular area to infraclavicular area (b) Tunneling of from infraclavicular area to breast area.

This oblique axis approach visualizes the axillary vein, the axillary artery, the pleura, and the other surrounding structures, making possible to perform a safe in-plane puncture. The oblique axis + in-plane technique combines the advantages of the panoramic view with the optimal visualization of the needle tip obtained by the in-plane puncture.[20,21]

The authors recommend the use of a micro-introducer kit consisting of a 21G echogenic needle (for minimally invasive venipuncture), a 0.018″ nitinol guidewire with straight soft tip, and a micro-introducer/dilator allows a less traumatic vein dilation.

Soon after the ultrasound-guided venipuncture, ultrasound should also be used for assessing the correct direction of the guidewire toward the SVC (ultrasound-based "tip navigation," by scanning the veins of the supraclavicular area), and for ruling out pneumothorax, by detecting the "sliding sign" in the pleural space or other ultrasound signs that exclude the presence of pneumothorax such as the "seashore sign" using M-mode.[13,22] Both maneuvers can be performed with the same linear probe used for venipuncture. Assessment of the absence of ultrasound signs suggestive of pneumothorax should be performed after any central venipuncture.[12]

Intra-procedural assessment of tip location

The fourth important step of the SIC bundle is the intraprocedural assessment of the central position of the tip ("tip location"). Post-procedural control of tip location is discouraged by current guidelines,[4] as it is associated with inefficiencies in procedural time and resources, as well as potential harm to the patient. The most cost-effective and accurate intra-procedural method for tip location is intracavitary ECG.[23] Fluoroscopy is an acceptable intra-procedural method, but is often inaccurate, expensive, logistically difficult, and even unsafe as it exposes patients and operators to ionizing radiation.[4] The applicability of the intracavitary ECG method has also been extended more recently to atrial fibrillation patients.[24] Intracavitary ECG has some limitations of applicability, for example in those situations in which the patient has no atrial fibrillation, but the P wave is nonetheless not evident, because of a pacemaker or some other abnormalities of cardiac rhythm. In these cases, another effective, inexpensive, and non-invasive intraprocedural method for tip location is transthoracic echocardiography using the “bubble test” (a rapid infusion of a few milliliters of “agitated” saline solution that allows for better visualization of the catheter tip).[1,13,25,26]

Adequate protection of the exit site

The choice of an adequate exit site constitutes the first part of a series of actions that make it possible to protect it. Tunneling is a fundamental technique that allows to choose the appropriate exit site and the most suitable venipuncture site.[4]

At the time of CICC insertion, the best protection of the exit site from bleeding and from extraluminal bacterial contamination is the sealing with a cyanoacrylate glue. In addition, glue may reduce “micro-movements” of the catheter at the exit site, reducing local damage to the endothelium of the vein, potentially reducing the risk of intravenous thrombus formation.[27] Gilardi et al.[28] recommend using glue only at the time of insertion; at the first dressing change, antibacterial protection of the exit site will be ensured using chlorhexidine-impregnated sponge dressing. In the case of tunneling, glue will also be used for closing the skin at the site of venipuncture and tunneling puncture points.

Proper securement of the catheter

Securement by sutures is discouraged by all current guidelines.[3,4,6,19] Suture-based securement of venous access devices is associated with high risk of exit site infection and catheter dislodgment, as well as risk of accidental needlestick puncture for the operator. Current alternative options for securement are skin-adhesive sutureless devices, transparent dressing with integrated securement, and subcutaneous anchorage. In any patients at high risk for catheter dislodgment (non-collaborative patients, skin abnormalities, relevant perspiration, others) it is preferable to use a subcutaneously anchored sutureless device.[29,30] Subcutaneously anchored securement is safer and more effective than skin-adhesive devices. It is also theoretically associated with less risk of infection, since it allows more complete skin antisepsis around the exit site.[29–32]

Exit site coverage

The exit site should always be covered with a semi-permeable transparent dressing—preferably with a high breathability factor—so to ensure adequate protection of the exit site and stabilization of the catheter. Appropriate catheter securement and appropriate protection of the exit site are key factors for reducing the incidence of dislodgment, infection, and venous thrombosis.[3,4]

Conclusions

When placing a CICC, a certain number of evidence-based strategies will protect against the risk of insertion-related complications, either immediate (puncture failure, arterial injury, hematoma, nerve injury, pneumothorax, hemothorax, others) or early (arrhythmias, dislodgment, tip malposition, others) or late (infection, venous thrombosis, others). These safe and beneficial strategies include the use of ultrasound in different phases of the maneuver (choice of the vein, venipuncture, tip navigation, tip location, others), the adoption of standardized protocols for choosing the vein (RaCeVA) and the exit site (Central ZIM), the adoption of proper measures for infection prevention (hand hygiene, skin antisepsis with 2% chlorhexidine in alcohol, maximal barrier precautions), the preferential use of intracavitary ECG for catheter tip location, and an appropriate protocol for sutureless securement and exit site protection. In this regard, the adoption of cyanoacrylate glue and subcutaneously anchored sutureless device may be a perfect combination in terms of cost-effectiveness.

Many complications, even some late complications, are caused by wrong choices at the time of insertion. For example, avoidance of ultrasound-guided venipuncture may increase the risk of accidental arterial puncture and pneumothorax. Failure to verify the proper location of the tip may increase the risk of venous thrombosis. The choice of a suboptimal exit site may expose the device to bacterial contamination increasing the infectious risk.[1–8] The use of a standardized, systematic protocol—such as the one described here—may improve the performance of CICC insertion. The consistent and systematic adoption of all seven recommendations of the SIC protocol will help to save time and resources, safeguarding patient safety, and ensuring cost-effectiveness.

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ORCID iDs

Fabrizio Brescia https://orcid.org/0000-0002-6892-474X
Mauro Pittiruti https://orcid.org/0000-0002-2225-7654
Matthew Ostroff https://orcid.org/0000-0001-5417-5621
Timothy R Spencer https://orcid.org/0000-0002-3128-2034

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