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ORIGINAL ARTICLE – PALLIATIVE CARE

Peripherally Inserted Central Catheter Tip Position: A Novel Empirical-Ultrasonographical Index in a Modern Surgical Oncology Department

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ABSTRACT

Background. The correct positioning of ultrasound-guided, peripherally inserted central catheters (UGPICCs) is essential to avoid multiple complications. We describe for the first time a retrospective study to evaluate a novel and easy transabdominal ultrasound-guided approach, so-called "Marano index," to place the UGPICCs tip correctly, making oncological surgeons able to obtain a high successful initial placement rate without postinsertion chest radiography.

Methods. We examined the placement of UGPICCs applying, in 53 patients, the "Marano index." The tip catheter location was controlled by postprocedural chest radiography. Sensitivity, positive predictive value, and accuracy of index application also were calculated and compared with radiographic findings.

Results. The ultrasonographic-guided insertion was successful in all patients (100 %). The identification of catheter inside the inferior vena cava was registered in 50 patients (94.3 %), and in all cases it was clear the precise catheter placement, after Marano index application, with the real tip position and the concordance between postprocedural radiography in 100 % of cases. The overall accuracy of this novel empirical-ultrasonographical index was 94 %, with positive predictive value of 94 % and sensitivity of 100 %.

Conclusions. This technique, once validated in a larger cohort, would allow the insertion of UGPICC without radiologic confirmation in selected patients with an adequate ultrasound body habitus. This would avoid unneeded radiation exposure from chest X-rays and would potentially save cost and time. This strategy provides only minimal deviation from the current practice and it is hence technically easy to learn and perform accurately with basic training by digestive oncological surgeons.

Central venous access is essential in most gastrointestinal, surgical-oncological patients with feeding difficulties and candidates for parenteral nutrition, to allow the administration of solution with osmolarity >600 mOsm/L; central venous access also is needed in patients undergoing chemotherapy to consent vesicant and irritant drugs dosing.[1] Based on United States estimations, more than 5 million central venous catheters (CVCs) are positioned every year; approximately 15 % are inserted in patients with neoplastic diseases to fulfill curative or palliative care.[2,3] Recently, a novel approach to obtain central venous access has been described using ultrasound-guided, deep brachial or basilic veins cannulation.[4] Ultrasound-guided, peripherally inserted central catheters (UGPICCs) represent an invaluable tool to provide long-term vascular access, also described in oncological surgery, reproducing a less-invasive alternative to traditional CVCs: introduction at the bedside, minimal pain at insertion, low rate of infectious and noninfectious complications, reduction time-to-cannulation, and ease of placement preventing delays in therapy, and low insertion cost.[5–12] Nevertheless, the malposition of catheter tip represents a common UGPICCs

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complication that requires catheter manipulations to achieve correct tip position, with additional time, cost, and radiation exposure.[13–15] The ideal position of the catheter tip is considered to be in the superior vena cava (SVC) just above the pericardial reflection to reduce the risks of cardiac tamponade and venous thrombosis.[16–18] Although several techniques to localize the catheter-tip position after UGPICCs insertion have been assessed, chest radiography after placement is currently considered the "gold standard" of imaging.[19–24] However, this diagnostic tool involves a nonimmediate recognition of malposition and implies a postponed replacement. Recent evidences have demonstrated that cardiac and thoracic ultrasound examinations performed by noncardiologists are considered feasible diagnostic modalities.[25–28] Furthermore, because of difficulty visualizing the lower part of SVC at the cavoatrial junction, transthoracic echocardiography does not represent a more accurate approach to localize the tip of CVCs.[29,30]

In light of such evidences, we describe for the first time a retrospective study to evaluate the novel and easy transabdominal ultrasound-guided approach, applying the so-called "Marano index" aimed at a correct positioning of UGPICCs tip, making oncological surgeons able to obtain a high successful initial placement rate without postinsertion chest radiography.

MATERIALS AND METHODS

Patient Eligibility

Fifty-three consecutive Caucasian patients with diagnosis of digestive system cancer, who underwent UGPICC placement for chemotherapy and/or perioperative intravenous nutritional support between March 2013 and June 2013, were enrolled in the study. Subjects younger than age 20 years and subjects with known anatomic abnormality of the central venous system or past history of pulmonary embolism or deep vein thrombosis or endocarditis, anticoagulant, and/or antiplatelet therapy within 15 days of an insertion day were ruled out. Before catheter positioning, each patient gave informed, written consent. The study was approved by the ethics committee of Second University of Naples and conducted according to the ethical standards of the Helsinki Declaration.

Ultrasound Technique

The study was performed by two oncological surgeons who were skilled in ultrasound-guided intravenous access, with a personal experience of more than 25 ultrasound-guided peripherally inserted central catheters and basic ultrasonography attended course. At the distal arm, approximately 2–5 cm proximal to the ulnar aspects of the elbow, the basilic vein is identified as a superficial compressible vascular structure lateral to the deep brachial veins, visualized as the compressible vascular structure adjacent to the pulsatile and incompressible brachial artery. The upper extremities of the subject were ultrasonographically studied for optimal vein size and selection without a tourniquet in place. The patient was positioned in supine position with the arm extended and abducted at 90° to expose the ulnar side. The inserter located the basilic vein and prepared the insertion area with povidone-iodine and a maximal sterile barrier. A Toshiba Xario SSA-660A with a 7.5-MHz ultrasound linear transducer (Toshiba Medical Systems Corporations, Tochigi, Japan) was used for the procedure, applying a sterile ultrasound jelly (Sterile Aquasonic 100®, Parker Laboratories, Inc., Fairfield, NJ) to improve the acoustic window. A Groshong NXT PICC (Bard Access Systems, inc., Salt Lake City, UT) was used as endovascular catheter. The vessel was visualized in the long-axis plane and confirmed with compression testing after application of a tourniquet proximally. The one-operator technique was adopted: a single operator held the transducer in the nondominant hand while attempting cannulation with the opposite hand. Under ultrasound dynamic guidance, the 21-gauge introducer needle was advanced into to the vessel and the echogenic needle profile visualized entering the vessel, confirmed by a flash blood return. The guidewire was passed several centimeters into the cannula and cannula was removed, leaving the guidewire in place. The guidewire was not advanced past the shoulder. An introducer sheath with a dilator was introduced over the guidewire after a small incision was made on the skin near the wire; the guidewire and dilator were removed; the catheter was advanced through the introducer sheath up to 50 cm, asking the patient to put the chin to the maneuver side shoulder to reduce the internal jugular vein and/or innominate vein cannulation rate; the introducer was then pulled back and removed.

"Marano Index" Application

The correct position of the catheter tip was considered to be in the lower third of the SVC close to its entrance to the right atrium (RA), outside the pericardial reflection.[31,32] Chest radiography after placement is currently considered the "gold standard" of catheter tip location: this diagnostic tool involves a nonimmediate recognition of catheter tip malposition and implies a postponed replacement. Moreover, these anatomic structures sometimes cannot be visualized by real-time nonradiographic techniques compared with transthoracic echocardiography. Therefore, we introduced and applied the novel empirical-ultrasonographical index named "Marano Index" to place the tip of catheter correctly. This index application consists in

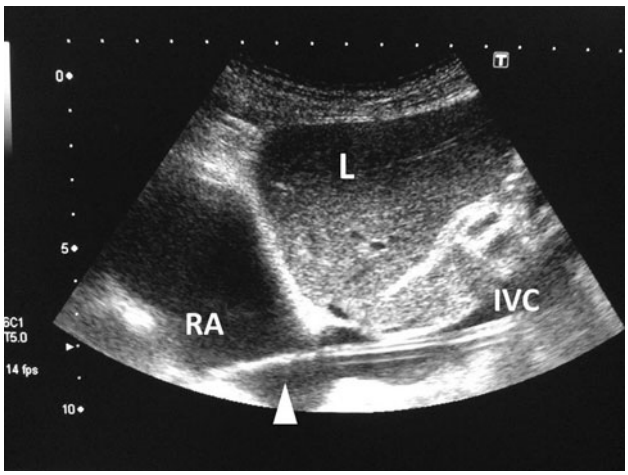

FIG. 1 Position of the catheter (*white arrow*) within the inferior vena cava, as assessed using subxiphoid longitudinal view. *IVC* inferior vena cava; *RA* right atrium; *L* liver. 154-mm × 115-mm (150 × 150 DPI)

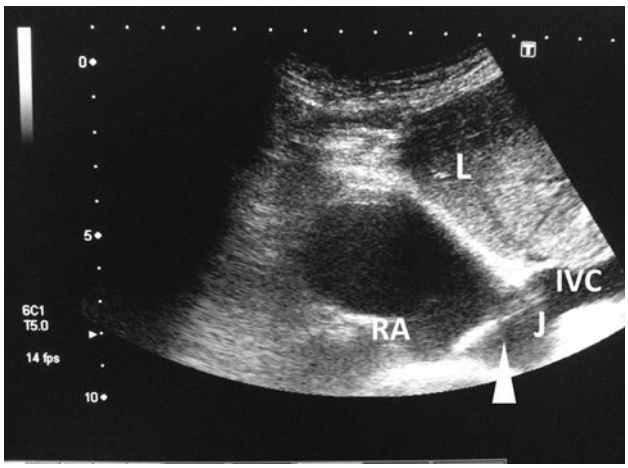

FIG. 2 Position of the catheter (*white arrow*) at inferior vena cava-right atrium junction, as assessed using subxiphoid longitudinal view. *IVC* inferior vena cava; *RA* right atrium; *L* liver; *J* inferior vena cava/right atrium junction. 153-mm × 113-mm (150 × 150 DPI)

retracting the catheter, positioned with the tip at inferior vena cava (IVC)–RA junction, for a length equal to the right atrial long axis measurement and the SVC intrapericardial length. Right-heart dimensions are commonly used for echocardiographic assessment of right-heart measurements. Yet normal reference values for these measurements are based on results from numerous but small studies. In a strong study based on 1,625 echocardiographic exams of normal adult subjects, D'Oronzio et al.[33] defined reference ranges for right atrial long axis dimensions, demonstrating statistically significant gender differences (4.4 cm in females and 4.7 cm in males), without substantial effect of biometric parameters. Furthermore, Kwon et al. accurately measured the intrapericardial length of SVC on the blood-filled vessels in vivo in average of 3 cm.[34] Based on these studies, we can define the approximate length of the RA/intrapericardial superior cava vein complex as 7.5 cm in women and 8 cm in men. With the 3.5-MHz ultrasound convex transducer, a subxiphoid longitudinal view of the IVC was visualized and presence of catheter inside this vein was assessed by the same surgeon sonographer, with the shoulder in adduction and the elbow in flexion (Fig. 1). The catheter tip was then pulled back up to IVC/RA junction (Fig. 2), and the catheter length from the skin incision was registered. The definitive catheter position was finally established by means of Marano index application: catheter length in centimeters (from the tip at IVC/RA junction to skin incision) minus 7.5 cm in the female patients and minus 8 cm in the male patients.

The catheter was then secured in its optimal position with a StatLock Stabilization Device™. The access site was cleaned and covered with a clear sterile dressing. After UGPICC placement, the tip position was checked by expert radiologists using postprocedural plain supine chest radiography (with the shoulder in adduction and the elbow in flexion).

Data Collection

Subjects' demographic data, including age, gender, and reason for UGPICC positioning, were collected. The endpoints measured were: arm used, success rate of sonographic-guided insertion, insertion time, and overall procedure time. All times were recorded by the surgeon with a study stopwatch and were self-reported. Overall procedure time started at the time of ultrasonographically basilic vein identification and stopped after the access site had been covered with a sterile dressing. Insertion time was the period from the first needle stick until blood return was noted from intravenous insertion. Tip location at supine chest radiography confirmation, sensitivity, positive predictive value, and accuracy of Marano index application also were calculated and compared with radiographic findings.

Calculations and Statistical Analysis

The observed data were presented as mean ± standard deviation or median ± standard deviation. A statistical data analysis was performed using SPSS 20 (SPSS Inc., Chicago, IL).

RESULTS

UGPICC placement with "Marano index" technique was performed on 53 Caucasian subjects with diagnosis of digestive surgery during the 4 months of the study period. Subjects' demographic characteristics and primary indications for central catheter are summarized in Table 1. The

TABLE 1 Demographic characteristics of subjects and primary indications for central catheter

	Included patients ($n = 53$)
Age, mean ± SD (year)	60.6 ± 15.2
Male/female (n)	25/28
Indications for central catheter (*n*) (%)	
Chemotherapy	37 (69.8 %)
Perioperative intravenous nutritional support	16 (30.1 %)

SD standard deviation; *n* number of patients

ultrasonographic-guided insertion was successful in all patients (100 %). In 86.8 % ($n = 46$) of subjects, access was obtained on the right arm and in 13.2 % ($n = 7$) on the left arm. The median insertion time was 52 ± 8 s, and the median total procedure time was 578 ± 71 s. UGPICC positioning was not associated with any complications. The identification of catheter inside the IVC was registered in 50 subjects (94.3 %). Chest radiography performed after UGPICC placement to assess the feasibility of Marano index application showed a correctly placed endovascular catheter with the tip in the lower third of SVC in 94.3 % of cases ($n = 50$). There were only three cases of catheter-tip malpositions (5.6 %) identified at radiographic control; these catheter-tips were found to be located in the middle third of SVC and were repositioned correctly. In these cases, the technically difficult ultrasonographic examinations of the abdomen due to bad acoustic windows effected the misidentification of IVC–RA junction and then the catheter tip position making inaccurate the Marano index application. The overall accuracy of this novel empirical-ultrasonographical index was 94 %, with positive predictive value of 94 % and sensitivity of 100 %.

DISCUSSION

Placement of UGPICCs is common not only in the emergency departments but also in the modern surgical-oncological departments primarily to allow administration of chemotherapeutic agents or perioperative intravenous nutritional support.[12,35–39] Ultrasound-guided venous access technique was first introduced in 1984; however, despite wide literature support of the use of UGPICC, relatively few studies have analyzed the exact tip placement and related techniques.[40] Although in 1989 the Food and Drug Administration declared that "catheter tips should not be placed in or allowed to migrate into the heart" and in 2001 The National Kidney Foundation stated that "catheter tips should be placed at the junction of the SVC and the RA or in the RA," actually in the literature there is a consensus that "the most appropriate location for the tip of PICCs is the lower one-third of the SVC, close to the junction of the SVC and the RA" to reduce the risks of complications, including infection, thrombosis, catheter occlusion, phlebitis, arrhythmia, and cardiac tamponade.[41–45] Furthermore, a debate exists concerning the methods to place correctly the catheter-tip as fluoroscopic guidance, intravenous electrocardiographic guidance, echocardiographic check of tip position, and electromagnetic detection, even if currently the postprocedural chest X-ray seems to be the "gold standard" method.[12–14,19–24, 46,47]

In this study, for the first time, we demonstrated the value of a novel empirical-ultrasonographical "Marano index" to correctly place the tip of UGPICC without radiographic confirmation. Using this easy, nonradiographic technique, a transabdominal ultrasonography performing subxiphoid longitudinal view of the IVC allows to visualize the catheter inside this vein in order to apply the empirical index, opening the door of this approach even to oncological surgeons with basic skills in ultrasound-guided intravenous access. Substantially, this index is based on the catheter retraction for a length equal to the right atrial long axis measurement and the SVC intrapericardial length, when the catheter tip is positioned at IVC–RA junction. Our data show that the ultrasonographic identification of catheter inside the IVC was registered in 94.3 % of cases and in all these cases it was clear the precise catheter placement, after Marano index application, with the real tip position and the concordance between postprocedural radiography in 100 % of cases. We experienced only 5.6 % inaccurate tip locations; in these cases, the technically difficult ultrasonographic examinations due to bad ultrasound body habitus made difficult the IVC–RA junction complex landmarks detection, with the consequential inapplicability of our index. The overall accuracy of this novel empirical-ultrasonographical index was 94 %, sensitivity of 100 %.

This technique, once validated in a larger cohort, would allow for insertion of PICC lines without the need for radiologic confirmation in selected patients with an adequate ultrasound body habitus. This would avoid unneeded radiation exposure from chest X-rays and would potentially allow for savings in cost and time (eliminating the time to position confirmation), which may be especially important in the care of oncological and surgical patients. This index may offer an improvement in the accuracy of initial central line placement without the need for readjustment of the catheter location which limits the potential for some of the serious complications associated with central line placement. Indeed, this strategy of PICC line placement provides only minimal deviation from the current practice and hence is technically easy to learn and perform accurately with basic training by digestive oncological surgeons.

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