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Ultrasound guided versus direct vein puncture in central venous port placement

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ABSTRACT: ***Introduction:*** **This study will report our experience on positioning of totally implanted venous catheter system (port-a-cath) as compared to ultrasound guidance versus blind technique.**
Materials and methods: **From July 1996 to November 1999 in the vascular suite of the Europen Institute of Oncology, 427 port-a-cath were implanted in patients with neoplastic disease. All devices were implanted through the subclavian vein. 198 with ultrasound guided puncture and 229 following anatomical landmarks. All patients underwent a close and specific clinical and instrumental follow-up to evaluate possible complications.**
Results: **Use of Ultrasound (US) in subclavian vein catheterization has reduced the number of puncture attempts, with a better patient complicance, allowing a faster procedure and reducing peri-procedural complications. Ultrasound technique has shown reduction in early complications. In fact in our experience we had no pneumothorax events by using ultrasound guidance, versus 11 events with blind technique. US has shown no reduction in late complications: 3 thrombosis versus 6 thrombosis with US guidance, and 3 fractured and embolized catheter versus 2 cases. Fibrin-cuff percentage was the same in the two groups with only 1 case, as the dislocation of the catheter tip in the jugular vein with 2 cases in both groups. Moreover US let us to avoid the arterial puncture and to perform a more peripheral puncture of the subclavian vein, reducing the risk of "pinch-off" phenomenon and of haematoma, with no cases reported under US guidance versus 1 case respectively in direct vein puncture.**
Conclusions: **US guided puncture of subclavian vein for the implantation of venous catheter system is faster by reducing procedure time, it is easier for the operator and safer for the patient than blind technique by exposing anatomical structures. Morevover US guidance reduces early complications and limits costs.**

KEY WORDS: *Venous access, US guidance, Port-a-cath®, Complications*

INTRODUCTION

The need for central venous access has found wide application in i.v. administration of medicaments, hemoderivates, in parenteral nutrition and in blood sampling (1).
Most transjugular and trans-subclavian catheters are only positioned by referring to the anatomical landmarks. This method might have some disadvantages, such as complications (i.e. repeated vein puncture, pneumothorax and accidental puncture of the artery) and prolonged procedural times (2, 3).
The use of ultrasound (US) guidance for jugular and subclavian vein puncture provides a preliminary study of vessels anatomy by detecting possible abnormal pathways and allowing the diagnosis of asymptomatic venous thrombosis patterns (4).
US guidance enables to reduce the number of puncture attempts, diminishes the incidence of complications, thus eliminating a lot of patient discomfort (7, 9, 10).

The aim of this study is to report our experience on US guided positioning procedures of permanent infusional vein systems as compared to the direct puncture procedure by describing the differences in terms of complications between the two different approaches.

MATERIALS AND METHODS

In 427 patients, 137 men (32%) and 290 women with an average age of 53y (age range 22-84), 427 port-a-cath have been positioned between July 1996 and November 1999, in the Vascular Radiology Unit of the Division of Diagnostic Radiology at the European Institute of Oncology.
Each case presented an oncological indication (Tab. I) for parenteral administration of chemotherapeutic medicaments, through several cycles.
The trans-subclavian approach was used in all patients: in 339 cases from the right (79%) and in 88

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Fig. 1 - ***The echogenic needle tip is clearly visible in the lumen of the subclavian vein.***

TABLE I - ONCOLOGICAL INDICATIONS FOR PORT-A-CATH PLACEMENT

Diagnosis	Number of patients
Breast ca	197 (46%)
GI tract ca	138 (32.3%)
Uro-genital ca	32 (7.5%)
Respiratory tract ca	26 (6%)
Haemolymphatic neoplasm	13 (3%)
Other tumors	13 (3%)
Unknown primary site ca	8 (2%)

from the left side (21%).
The blood clotting factor and an antibiotic premedication (Totacef® 2gr i.v.) were evaluated before implantation.
The subclavian vein was approached in two different ways: either by following only the anatomical marks, 3 cm below the limit between the middle and the lateral third of the clavicle, or by reaching the vein under US guidance (4,7,9).
All 427 cases may be split into two groups of patients: the first group of 229 pts (53.6%), where the port-a-cath was positioned by direct puncture; the second group of 198 pts (46.4%) where the port-a-cath was positioned under US guidance (Fig. 1).
In all patients it was necessary to set a precautionary peripheral venous access. For the patients in the first group the venous line was preferably positioned on the same side as the port placement. This allows for a possible flebographic examination, should the vessel puncture be too difficult. The contrast enhancement of the vessel, in fact, eases its puncture by detecting the presence of possible anatomical abnormalities and unknown thrombotic patterns.
For the patients in the second group, thanks to the use of US guidance, it is indifferent on which side the peripheral venous access is positioned; this also allows to visualise the vascular anatomy with less radiation exposure for both patient and operator. The preliminary US examination is performed using high frequency probes (7.5MHz).
The Eco-power-Doppler device is useful in detecting any presence of asymptomatic venous thrombosis.
We used two different port-a-cath models: for most patients the Titanium Dome Port (Bard®) connected to an 8 Fr Groshong catheter (22G needle for vein puncture); for the rest of the patients the Titanium Dome Port (Bard®) connected to a single lumen 9.6 Fr silicon catheter (18G needle) (4).

ANATOMICAL FINDINGS

The subclavian vein begins as the direct prosecution of the axillary vein, in correspondence with the lateral margin of the first rib, and ends behind the sternoclavicular joint, joining the internal jugular vein to form the brachiocefalic venous trunk.
It runs on a lower-anterior level, adjacent to the subclavian artery, from which it is separated by the anterior scalenus muscle. The approach used for the US-guided puncture implies the positioning of the probe parallel to the vein itself; the needle is inserted using the lateral margin of the transducer as reference mark (3,9).
When the tip of the needle reaches the anterior wall of the vein the push on its surface causes the vein to collapse temporarily before the needle pierces the wall. In order to help the needle reach the lumen, it can be useful to make the patient increase his intrabdominal and intrathoracic pressure (Valsalva manoeuvre); this, by reducing the venous flow towards the heart, results in expansion of the vessel and better resistance of the wall when pierced.

TECHNICAL FINDINGS

After reaching the subclavian vein lumen, a guide wire is advanced along the superior vena cava under fluoroscopic guidance. A subcutaneous pouch, that will host the reservoir, is created between the subcutaneous tissues and the sheath of the major pectoralis muscle, 4 cm below the venous access.
The catheter, whose distal extremity is positioned in the superior vena cava, is advanced by means of an introducer. At this point, tunnelling, enabling the junction between catheter and reservoir, is performed. After checking the correct working of the system with saline solution using a Huber needle, the cutaneous layers are sutured.
A back projection in expire chest X-ray is performed at the end of this procedure to exclude the possible presence of PNX, and to verify the catheter's correct pathway.

RESULTS

The method of vessel puncture under US guidance has significantly reduced the average number of punctures required for a single procedure: 2.5 using anatomical marks vs. 1.1 using US guidance. This method also shortens procedure times and reduces the risk of complications.
Early complications are pneumothorax, pinch off and haematoma (5,6,7,8).
We recorded 11 apical pneumothorax (Tab. II) with minimal clinical impact, where drainage was not required. This complication happened only in patients undergoing the procedure without the support of US guidance: the patients were hospitalized to allow accurate monitoring, both clinically and instrumentally. The high frequency of this complication should also be ascribed to the operators' initial low experience.
Only in 1 case (with no US guidance) we recorded catheter compression between the first rib and the costo-clavicular ligament ("pinch-off"), caused by "too medial" access to the vein (Fig. 2). US guidance, in fact, allows a more lateral puncture of the vessel, and excludes such a complication.
A single case of haematoma, due to accidental puncture of the artery, also occurred while using the method of direct vessel puncture.

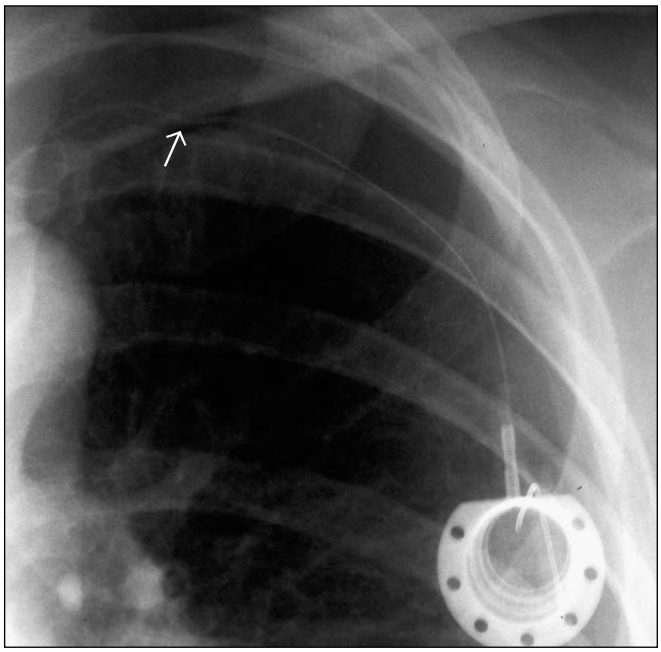


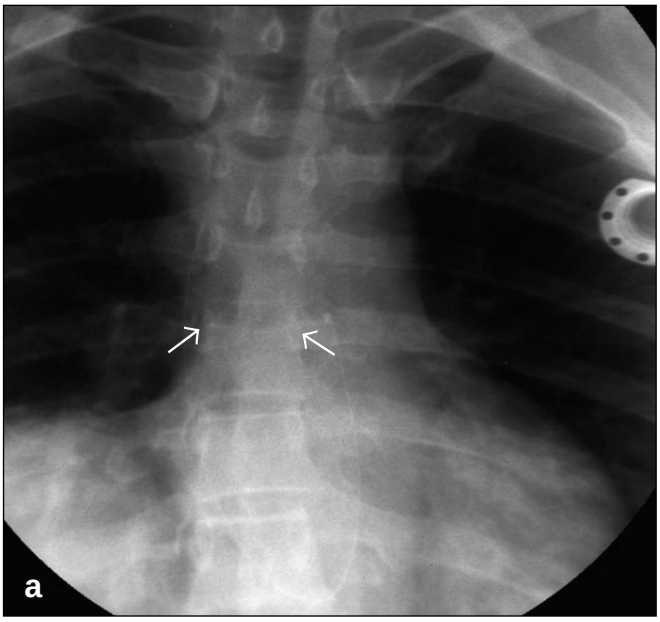
Fig. 2 - ***Pinch-off syndrome. Catheter compression between the first rib and the clavicle is clear.***

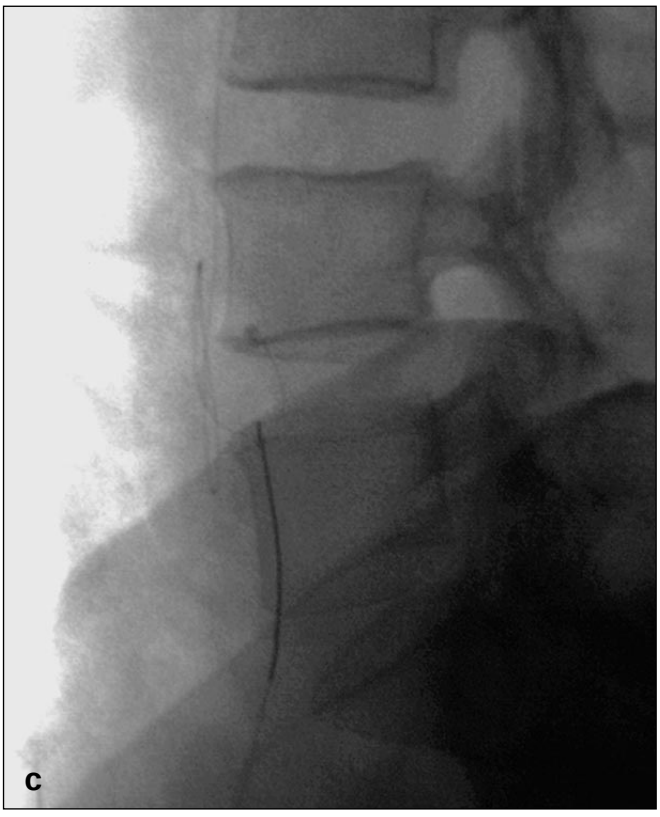
TABLE II - EARLY COMPLICATION DATA

Early complications	Direct puncture	US guidance
Pneumothorax	11 (4.8%)	0
Pinch-off	1 (0.4%)	0
Haematoma	1 (0.4%)	0

TABLE III - LATE COMPLICATION DATA

Late complications	Direct puncture	US guidance	Total
Venous thrombosis	3	6	9 (2.1%)
Pouch infection	6	3	9 (2.1%)
Catheter breakage	3	2	5 (1.2%)
Fibrin cuff	1	1	2 (0.5%)
Thrombus at the tip of the catheter	2	0	2 (0.5%)
Catheter migration	2	2	4 (0.9%)





Late complications (see Tab. III) include: venous thrombosis, breaking of the catheter with consequent embolization (Fig. 3), catheter tip migration, formation of a fibrin cuff around the catheter, thrombus at the tip of the catheter, and infection of the subcutaneous pouch. Late complications appear evenly distributed in both groups with a total of 22 out of 427 cases.

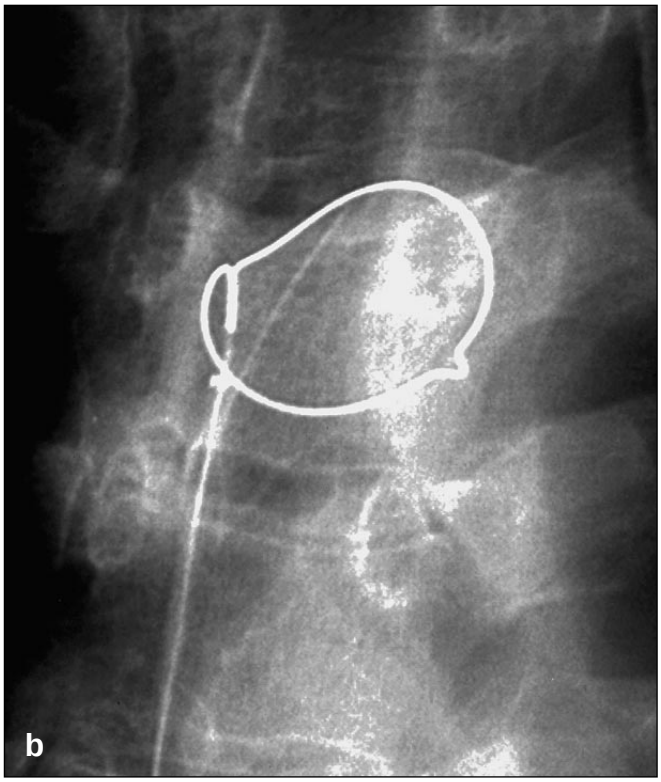


Fig. 3 - ***Dislodged catheter retrieval. The tip of the fragmented catheter has migrated in the right ventriculum (Fig. 3a); the embolized catheter is then retrieved (Fig. 3b-3c) by percutaneous right femoral vein approach.***

DISCUSSION

The use of US for vein access offers several advantages: vessel examination before the procedure, reduced number of punctures and faster execution time.

As already mentioned, in those cases where US guidance was used, there was no need for positioning the peripheral venous access ipsilateral to the port-a-cath side: in fact, US images provide the operator with real time tomographic evidence of the vessel puncture.

With direct puncture technique, arm flebography is usually used when the operator fails to reach the vein after several attempts. The US-guided procedure enables to avoid any attempt when the selected vein to be punctured is occluded or has an abnormal pathway. As for the operator, he will have the advantage of using dynamic US images, which in contrast to flebographic images also allow the evaluation of the depth of the layers examined. This permits the puncture of only the anterior wall of the vessel; the hyperechoic tip inside the vascular lumen pattern, confirms the correct position of the needle (Fig. 1).

Another important advantage in the use of US is the reduction in pain during the procedure; when direct puncture is used the pain is significantly higher, also related to the puncture of the costo-clavicular muscle-ligament. Even the simple contact between the needle and the clavicular periostium is a considerable source of pain. All these possible painful stimulations are excluded by the use of US, which allows a more peripheral puncture of the subclavian vein.

It is our experience that the use of US guidance is much more profitable than direct puncture in terms of early complications (pneumothorax, hematoma, pinch-off). In particular the risk of accidental puncture of the pleura, thus pneumothorax, is practically eliminated. Even without the need for pleural drainage, patients with this complication (anatomical marks puncture method), were kept under clinical and instrumental observation (1 projection in expire chest X-ray every 24h), until complete remission of the PNX. This leads to prolonged hospitalization and higher costs. US guidance, also allowing a more lateral puncture of the subclavian vein, eliminated the risk of pinch-off.

The preliminary study of the vascular anatomy helps the operator in the direct puncture of the subclavian vein, excluding the risk, also in this case, of any puncture of the subclavian artery and consequent haematoma.

As far as late complications are concerned (venous thrombosis, infections, formation of a fibrin cuff catheter, breakage and migration), there seem to be no statistically significant differences between direct and US-guided implant (8). Venous thrombosis and pouch infection seems to be independent of the technique, as these complications occurred more than 60 days after implantation time.

Catheter breakage occurred only in one patient with the "pinch off" sign radiologically evident. Three other events occurred for a minimal lesion on the catheter at its connection with the port at the implantation time.

It should also be considered that the procedural time reduction with the US-guided technique enables the performance of a larger number of procedures per day.

Our results have proven consistent with the data reported in the literature, although there still are very few similar studies for comparison to yet. As a matter of fact this subject is relatively new, and similar studies performed elsewhere still have limited data.

In conclusion, the placement of a port-a-cath under US guidance enables to shorten execution times, reduces the number and risks of early complications, thus avoiding a lot of patient discomfort, such as procedural pain.

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