How to perform of upper limb ct venography preparing arterio venous fistula for hemodialysis?

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Learning objectives

Patients with chronic renal failure at the stage of dialysis require blood access through arteriovenous fistula (AVF) at the upper limb. Venous mapping is then performed in order to choose the appropriate site for creating AVF. For long-time, venoography was considered as the reference technique for venous mapping. CT venography can be an alternative non-invasive tool for the assessment of venous network. The learning aims of this exhibit are to detail the technical realization of CT venography of upper limb to obtain a venous mapping and list the main venous variant in upper limb and their implication for possible AVF.
Background

A deep knowledge of venous anatomy and their variant is undeniable for understanding vascular access functionality and preventing critical complications by selecting the appropriate site for arteriovenous anastomosis. The CT venography of upper limb constitutes an imaging technique among other reserved for this purpose.

Veins are conveniently grouped as superficial and deep, but these are widely interconnected. The superficial fascia is the boundary to separate superficial from deep veins. The superficial veins are variable and include the cephalic, basilic, median cubital, and antebrachial veins and their tributaries. Most of these veins begin in the subcutaneous tissue from the dorsal venous network located in the dorsum of the hand.
Findings and procedure details

I) Technique details

For CT veinography, distal peripheral venous access is performed of the upper limb to be studied (One of the veins of the back of the hand). Patients are installed supine, arms along the body (anatomical position).

The contrast medium injection speed is 3cc/sec. Low osmolarity iodinated contrast agent is used with a biphasic injection (driven by a saline bolus 30ml). The total volume of contrast medium injected is 20cc diluted in 80cc of saline. A caudo-cranial acquisition covering the entire vascular tree of the member to explore and also the venous arrival in the right atrial appendage is carried out with a delay of 5 seconds after the start of the contrast medium injection.

The reconstructed images are transferred to a specific treatment console with image processing software dedicated to angiographic procedures. Image analysis are made in "Maximum Intensity Projection" (MIP) mode in two and three dimensions (2D and 3D) as well as in "Volume Rendering" (VR).

I) Results and interpretation

We obtain the opacification of both superficial and deep venous systems of the upper limb and the superior vena cava. We can measure the diameter of the superficial veins and search class disparity. Variants of the venous pathway which may be detrimental to the proper functioning of the AVF are researched and will be considered in the choice of the AVF site.

1) Pattern types of superficial veins of the middle upper extremity

Many types of superficial veins of the middle upper extremity were described and most of these models have subgroups consisting of minor variations. These variations cause different methods and criteria of classification among authors. Two basic types are present and most common in different studies.

The first one is also known as M shaped pattern. It consists in a median antebrachial vein which continues with two terminal branches, median cephalic, and median basilic vein, which join cephalic and basilic vein, respectively (Fig. 1).
The second type is known as N shaped arrangement or embryonal type. In this case, median antebrachial vein ends into median cubital vein which connect cephalic and basilic vein (Fig. 2).

This classification below is based on recent study of Vu#ini# et al.

* Type 3: M shaped arrangement with one or two more veins in front of the forearm, which ends in basilic vein.

* Type 4: modified N shaped arrangement wherein median antebrachial vein ends in basilic vein. Median cubital vein is present and as in type 2 connect cephalic and basilic vein.

* Type 5: modified M shaped pattern with one or two more veins in front of the forearm, which ends in median cephalic or median basilic vein (Fig 3).

* Type 6: cephalic and basilic vein are not connected. Median antebrachial and other accessary veins drain into basilic or cephalic vein (Fig. 4).

* Type 7: presence of double median cubital veins over and under the crease of the elbow. Median antebrachial vein ends in median cubital or basilic vein (Fig. 5).

* Type 8: modified N shaped arrangement wherein proximal cephalic vein is absent and distal cephalic vein continues superomedially as the median cubital vein.

* Type 9: Model with double brachial cephalic vein.

The main feature of superficial veins is their variability. Several variant of each model can be found (Fig. 6-7) and combination of models can be described (Fig. 8).

2) **Anatomical venous variation in upper arm**

The usual description of veins anatomy of the upper arm involves brachial veins which are placed one on either side of the brachial artery, near the lower margin of the subscapularis muscle, they join the axillary vein; the medial one frequently joins the basilic vein that runs upward along the medial border of the biceps brachii, perforates the deep fascia a little below the middle of the arm, and ascending on the medial side of the brachial artery.

The cephalic vein ascends in the groove along the lateral border of the biceps brachii. In the upper third of the arm it passes between the pectoralis major and deltoideus. It pierces the coracoclavicular fascia and, crossing the axillary artery, ends in the axillary vein just below the clavicle. This pattern is less suitable for basilic vein transposition.

The proximal segment of cephalic vein is predisposed to stenosis (compression by fascia and the pectoralis major muscle, or passage over the clavicle (Fig. 9) which is a contributing factor of brachiocephalic fistula failure or nonmaturation.
Cephalic vein layout can vary at this level (Fig. 10). But the most variable venous configuration on the upper arm is those of the brachial vein and the basilic vein forming the axillary vein. The first anatomic variant has the basilic vein running as an independent deep vein without communication with brachial vein, then joining the axillary vein just before the cephalic arch vein (Fig. 10). This situation is a safer situation for basilica vein transposition. Recently, a high prevalence of this pattern was reported in studies. The second variant consists of a basilic vein that unifies with single unpaired brachial vein at the mid-upper arm, forming one trunk vein up to the junction with the axillary vein (Fig. 11).

3) **Caliber variation**

The variable anatomy of superficial veins does not restrict possibility of AVF creation. The major limitations are small caliber and vein destruction. CT allows the assessment of vascular caliber and provides accurate measurements.

*Stenosis: current concepts in its pathophysiology consider that it is the response to vessel injury model, emphasizing the process of trauma, inflammation, intimal hyperplasia, and a fibrotic response (Fig. 12-13).

*Thrombosis: resulting as the injurious effects of phlebotomy and peripheral venous catheters (Fig. 14-16).

*Aneurysm: the most important and feared complication of an anterior AVF (Fig. 12).
Fig. 1: M shaped pattern of superficial veins of the middle upper extremity.

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Fig. 2: N shaped arrangement of superficial veins of the middle upper extremity.

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Fig. 3: Type 5 of superficial veins of the middle upper extremity.

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Fig. 4: Cephalic and basilic vein are not connected. Median antebrachial and other accessory veins drain into cephalic vein.

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Fig. 5: Type 7 of superficial veins of the middle upper extremity.

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Fig. 6: Close to type 4 with other veins which ends in both cephalic and basilic veins.

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Fig. 7: Close to type 8: Proximal basilic vein is absent and distal basilic vein continues superolaterally as the median cubital vein.

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Fig. 8: Combination of type 1 and 7: M shaped pattern with median cubital vein over the crease of the elbow.

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Fig. 9: Passage of cephalic arch over the clavicle.

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Fig. 10: N shaped arrangement with double proximal cephalic vein in upper arm.

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**Fig. 11:** Basilic vein joining the brachial vein at the mid upper arm.

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**Fig. 12:** Stenosis of axillary vein with aneurysmal dilatation.

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Fig. 13: Stenosis of cephalic arch.

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**Fig. 14:** Subclavian vein thrombosis with collateral circulation.

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**Fig. 15:** Thrombosis of the basilic vein.

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Fig. 16: Thrombosis of deep and basilic veins. Only cephalic vein is available.

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Conclusion

The upper limb CT venography is a non-invasive technique easily performed and interpreted. It can provide an excellent vein mapping of both superficial and deep systems and allow the assessment of pattern venous types of each region in order to avoid complications by selecting the appropriate site for arteriovenous anastomosis before making an AVF for haemodialysis.
References


