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Multi-slice CT angiography versus duplex ultrasound in detection of stenosis of access arteriovenous fistulas and grafts in dysfunctional hemodialysis ☆

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ABSTRACT

Purpose: To assess the accuracy of MS-CTA for the detection and grading of stenosis in AVF and AVG in comparison with colored Duplex.

Patients and methods: Prospective analysis of vascular access related data was obtained from 30 patients (10 Males, 20 Females and age range 18–62 years) referred from hemodialysis unit for CTA and CDUS examination in upper limbs.

Results: There were no statistically significant differences between mean Stenosis%, mean Length of stenosis segment and mean Narrowest part as measured by the two modalities (*P*-values = 0.115, = 0.271 & = 0.233 respectively).

Results: Subclavian vein occlusion: detected in 7 cases (23.3%) by CTA and only 4 out of the 7 cases were detected by Doppler (13.3%). SVC occlusion: not detected by Doppler (0.0%) and detected in 4 cases (13.3%) by CTA. Chest wall venous collateralization: not detected by Doppler (0.0%) and detected in 10 cases (33.3%) by CTA. Innominate vein occlusion: not detected by Doppler (0.0%) and detected in 2 cases (6.7%) by CTA.

Conclusions: CDUS by an experienced hand is an adequate diagnostic tool except for evaluation of central veins, whereas, the MSCTA plays an important role as a minimally invasive modality for evaluating the AVFs especially the central veins.

1. Introduction

Chronic renal disease (CRD) is currently a well known major public health problem, associated with structural changes of the kidney parenchyma and consequent decline in renal functions that persist over 3 months.

Multiple etiologies had been incriminated in this problem including arteriosclerosis, DM and hypertension with eventual loss of number and functions of the nephrons, and finally the end-stage kidney disease (ESKD) supervene [1].

The cornerstone of hemodialysis in end stage kidney disease (ESKD) is a functioning access. Unfortunately, this vascular access may carry high risk of obstruction by thrombosis due to stenoses that affect patency [2].

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Neo-intimal hyperplasia is the most common cause of stenoses that jeopardize the flow, with the stenosis distribution differing e.g. in radio-cephalic arterio-venous fistulas (RCAVF), 55–75% of stenosis were juxta-anastomotic and 25% anywhere along the fistula draining venous pathway while in the brachiocephalic and/or basilic AVFs, stenosis sites (55%) are at the cephalic-subclavian vein junction and at the basilic-axillary vein junction, respectively [3].

In AV grafts 50–70% of the venous stenoses occur within few cms of the vein-to-graft anastomosis.

However, feeding artery stenosis more than 2 cm distant to the AVF anastomosis is uncommon, but may be of utmost importance as it may jeopardize the flow in the fistula [4].

Duplex examination has a special value in flow volume measurement and in stenosis detection in mal-functioning AVFs. Moreover, it could share in the treatment plans, as duplex-guided balloon venoplasty of failing or non-maturing AVFs is currently being feasible and could be done safely, even as simple as an office-based procedure [5].

The recently developed MS-CTA technology with improved resolution gives greater anatomic coverage, allowing an expanded evaluation of vascular diseases.

Nevertheless, MS-CTA is clinically feasible for evaluating the complete vascular pathway of failing AVFs and detecting unlikely encountered complications, such as arterial aneurisms, pseudo aneurisms and central vein lesions [6].

The 3D reconstructed images of MS-CTA with free rotation projection angiogram show vascular lesions from the appropriate perspective and the examinations can be accomplished in a quick time (for patient preparation, CT examination and post processing session) all taking about 15 min [7]. The access stenosis evaluations are usually performed in current clinical practice, by duplex examination and/or diagnostic catheter through digital subtraction angiography (DSA), the latter has difficulties in image analysis due to vessel overlap, mainly at the juxta anastomotic level with multiple crossing vessels, so, MS-CTA could be an alternative diagnostic tool for localizing access stenosis, assessing the degree of severity, with an ability to acquire three-dimensional (3D) data, overcoming the problem of vessel overlap and establishing an accurate diagnosis; however, the experience with MS-CTA for imaging of stenotic and malfunctioning access, till now, shows some limitation [8].

Early referral of chronic kidney disease (CKD) patients to the nephrologist and/or vascular surgeon is crucial to start a policy for appropriate vascular access creation (with preferential order), maturation and access salvage in failing and non maturing AVFs [9], and 200 ml/min is the minimally required flow volume for an adequate hemodialysis session that could be obtained through surgical construction of an arterio-venous fistula\graft [10].

Hemodialysis access placement in preferential order is demonstrated in Table 1. [11]

1.1. Aim of the work

The aim of this work was to assess the accuracy of MS-CTA for the detection and grading of stenosis in AVF and AVG in comparison with Colored Duplex Ultrasound and finally an algorithm with the addition of both techniques (MS CTA and CDUS) as complementary studies, and in certain cases will be appropriate.

Table 1
Hemodialysis access placement in preferential order[11].

Hemodialysis access placement in preferential order, from most to least desirable	
Access placement type	Description of access placement
Forearm AVF	Radial artery to cephalic vein or radial artery to basilic or other suitable forearm vein (transposition*)
Upper arm AVF	Brachial artery to cephalic or brachial artery to basilic or other suitable upper arm vein (transposition*)
Forearm graft	Brachial artery and antecubital vein, a “loop” graft
Upper arm graft	Brachial artery and high brachial or basilic vein, a “straight ”graft
Thigh graft	Common femoral artery to common femoral vein

2. Patients and methods

2.1. Study design and population

This prospective randomized controlled trial study was conducted in the radiology department.

The patients were referred from Nephrology – Dialysis – Transplantation unit, within a period of 7 months from March 2015 up to September 2015. The study included sample size of thirty patients aged from 18 to 62 years and included both males and females with an upper limb arterio-venous fistula for hemodialysis when their access was considered at risk for thrombosis or suspected malfunction like dialysis needle puncture difficulties, distorted anatomy, enlarging aneurisms, suspected source of infection/abscess, thrombosed access or extremity swelling/edema. For color Doppler ultrasound there were no exclusion criteria but for CTA, the pregnancy was there. We also excluded patients with histories of severe allergy to contrast media in CTA.

2.2. Ethics committee approval

Ethics committee approval has been obtained besides patients’ consent after informing the patients with full details of our clinical trial.

2.2.1. Patient assessment

All patients were subjected to the following:

(A) Before examination
(a) Obtained a complete history by interviewing the patient and reviewing the patient’s medical records, (b) through clinical examination of the dialysis access, (c) explained the procedure to the patient (including table movements, voice messages, sensation of contrast injection and how to breath hold in case of CTA), (d) took into consideration the age and mental status of