Case Report

Evaluation of arteriovenous fistula-bilateral computed tomography venography combining diluted and undiluted contrast media injection: A case study

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Abstract

A 45-year-old female dialysis patient with sudden onset of severe pain in the left shoulder and chest was referred for computed tomography of her left arm and thoracic veins. The computed tomography venography revealed 2 completely occluded venous grafts and 2 pronounced stenoses of the subclavian vein. By using a dual injection of diluted and undiluted contrast medium, artifact-free visualization of arteriovenous fistula, arm veins and adequate enhancement of thoracic veins were obtained.

Keywords:
Computed tomography
Arteriovenous fistula
Contrast agents-intravenous

Introduction

In end stage renal disease an arteriovenous fistula (AVF) is often referred to as “the lifeline of a patient.” Thrombosis, inadequate maturation, and infection are the most common causes of hemodialysis access point failure [1–3]. The most commonly used diagnostic imaging methods today for the assessment of AVF are digital subtraction angiography (DSA), Colour Doppler ultrasonography (US), magnetic resonance imaging (MRI) and computed tomography (CT). DSA is considered the gold standard for the assessment of AVF and, if necessary, can be combined with angiographic intervention. Color Doppler US is noninvasive, without ionizing radiation, inexpensive, and provides dynamic information of the AVF. However, Color Doppler US is user dependent and often requires experienced operator and interpreter. MRI is a noninvasive alternative requiring no ionizing radiation and the assessment of the AVF can be performed without intravenous contrast media (CM). The disadvantage of MRI is mainly its limited

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availability. Depending on scanner, CT can be performed as a sub second examination with high accuracy that is well comparable to DSA. The main disadvantages of CT are the use of ionizing radiation and CM [4–6].

At standard CT there is a potential risk of artifacts from the high concentration when injecting CM in the affected arm. To avoid that risk, CM can be injected through the other arm and imaging is then performed in the parenchymal phase, ie, after circulation through the whole body. Despite a relatively high amount of CM, approximately 40 g, the resulting CM concentration in the vessels is low. Differentiation between arteries and veins is also cumbersome as they both are enhanced.

Here we present an alternative imaging option for computed tomography venography using bilateral injection of diluted and undiluted CM in a patient with occluded AVF.

**Case study**

A 45-year-old female dialysis patient without residual renal function was referred for CT of her left arm and thoracic veins. The patient had previously undergone several surgical procedures due to stenosis of her arterio-venous graft in the left upper arm. Two prior grafts in the lower arm had previously failed and dialysis had previously been made through a central dialysis catheter placed through the right jugular vein. Now, the patient sought emergency care for severe pain in the left shoulder and chest region. Duplex ultrasound revealed reduced flow in the left brachial artery as well as stenosis of the AVF adjacent to the subclavian vein.

The computed tomography venography was performed using a dual source multidetector Somatom Definition Flash (Siemens Healthcare, Forchheim, Germany). Scan parameters included helical scanning using $128 \times 0.6$ mm detector collimation at a pitch of 0.9, 100 kVp, and automatic tube current modulation. The patient was scanned in lateral positioning with the left arm above the head in cranio-caudal direction starting above left hand and ending at the diaphragm. Intravenous contrast media (CM) administration was performed using 2 separate bolus injections. First injection was performed in the right antecubital vein using 60 mL CM at 4 mL per second, (Iomeprol 400 mg iodine per mL, Bracco Imaging, Milan, Italy). Second injection was performed in a vein on the dorsal side of the left hand, starting immediately after the first injection using 60 mL of diluted CM at 3 mL per second. The dilution consisted of 5 mL CM (iomeprol 400) dispersed in 100 mL saline. The CM dilution was based on previous clinical experience [7]. In this case study a total dose of 1.1 grams of iodine was used during second injection. All injections were performed using a dual head auto injector (Medrad Stellant®),

![Fig. 1 – Computed tomography venography (CTV). Vessel tracking showing occluded arterio-venous (AV) graft in the left arm (arrows)](image1)

![Fig. 2 – a, b. Volume rendering (VR) images showing two stenoses (arrows) at the transition of the subclavian vein to the axillary vein](image2)
Bayer, PA, USA). Scan delay was set at 35 seconds after the start of the first CM injection.

All images were reconstructed with 0.75-mm slice thickness and 0.7-mm reconstruction increment. All reconstructed image series were sent to a dedicated workstation (Advantage Work Station® 4.6, GE Healthcare, Milwaukee, WI, USA) for 3D volume rendering (VR) post-processing.

The CT revealed 2 completely occluded venous grafts ventrally in the proximal half of the forearm (Fig. 1) and 2 pronounced stenoses of the subclavian vein at the transition to the axillary vein (Fig. 2a, b). The CT findings were later confirmed by DSA (Fig. 3) and were resolved with balloon dilatation (Fig. 4).

Discussion

In this case study, both thoracic and left arm veins could be visualized by using bilateral injections of undiluted (right arm) and diluted CM (left arm) (Fig. 5). By diluting the CM when injecting through the affected arm high density artifacts could be avoided. However, such a low concentration would not have enabled visualization of the central veins. This was solved by injecting 60 mL undiluted CM through the unaffected arm. The natural dilution resulted in an attenuation in left subclavian, brachiocephalic and jugular veins of approximately 250 Hounsfield units. The attenuation in the arm veins was 500 Hounsfield units. CT findings in our case study corresponded to those later found by DSA (Fig. 2a, b, 3). Previous studies have demonstrated a CT accuracy to detect stenoses in association with AVF by 90%-99% compared to DSA [5,6]. VR enables 3D imaging of the vascularity and the AVF. The 3D VR data set can also be rotated freely to visualise the anatomy and pathology in the most optimal projection.

Conclusion

By using a dual injection consisting of diluted and undiluted contrast medium, artifact-free visualization of arm veins and sufficient enhancement of thoracic veins can be achieved.

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