CONTROVERSY ABOUT COMPUTED TOMOGRAPHY ANGIOGRAPHY (CTA), MAGNETIC RESONANCE ANGIOGRAPHY (MRA), DIGITAL SUBTRACTION ANGIOGRAPHY (DSA), AND ULTRASONOGRAPHY (US) IN DIAGNOSTICS OF VASCULAR ACCESS FOR HAEMODIALYSIS

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INTRODUCTION

On the field of vascular access diagnostic we have those diagnostics possibilities*:*

Ultrasound imaging (US), also known as ultrasound scanning or sonography, is a method of obtaining images from inside the human body through the use of high frequency sound waves. The sound waves' echoes are recorded and displayed as a real-time, visual image. No ionizing radiation is involved in ultrasound imaging. Duplex sonography is the combination of 2D imaging in conjunction with pulsed wave Doppler study to assess blood flow within vessels. Colour Doppler is useful in determination of flow direction and maximal jet velocity facilitating pulse wave Doppler analysis. The colour duplex method (CDUS) can allow a valid statement about the haemodynamic relevance of an artery stenosis or other functional characteristics based on the intrarenal flow patterns. Arterial and venous examinations are usually lengthy in the order of 45-90 minutes, and require differing ultrasound techniques. Therefore arterial and venous systems are not assessed concurrently. Preliminary results indicate that duplex scanning is a reasonably accurate screening technique for size, patency, and direction of blood flow although duplex sonography is less expensive with lower exposure to radiation.

Computed tomography angiography (CTA) is an examination that uses x-rays to visualize blood flow in arterial and venous vessels throughout the body, from arteries serving the brain to those bringing blood to the lungs, kidneys, and arms and legs. CT combines the use of x-rays with computerized analysis of the images. Beams of x-rays are passed from a rotating device through the area of interest in the patient's body from several different angles to create cross-sectional images, which then are assembled by computer into a three-dimensional picture of the area being studied. Compared to catheter angiography, which involves placing a sizable catheter and injecting contrast material into a large artery or vein, CTA is a much less invasive and more patient-friendly procedure—contrast material is injected into a small peripheral vein by using a small needle or catheter. This type of exam has been used to screen large numbers of individuals for arterial disease. Most patients undergo CT angiography without being admitted to a hospital. CTA can be used to examine blood vessels in many key areas of the body, including the brain, kidneys, pelvis, and the lungs. The procedure is able to detect narrowing of blood vessels in time for corrective therapy to be done. This method displays the anatomical detail of blood vessels more precisely than magnetic resonance imaging (MRI) or ultrasound. Today, many patients can undergo CTA in place of a conventional catheter angiogram. CTA is a useful way of screening for arterial disease because it is safer and much less time-consuming than catheter angiography and is a cost-effective procedure. There is also less discomfort because contrast material is injected into an arm vein rather than into a large artery in the groin. There is a risk of an allergic reaction—which may be serious—whenever contrast material containing iodine is injected. If you have a history of allergy to x-ray dye, your radiologist may advise that you take special medication for 24 hours before CTA to lessen the risk of allergic reaction. Another option is to undergo a different exam that does not call for contrast material injection. CTA should be avoided in patients with kidney disease or severe diabetes, because x-ray contrast material can further harm kidney function.

Magnetic resonance imaging (MRI) is diagnostic radiological modality, using nuclear magnetic resonance technology, in which the magnetic nuclei (especially protons) of a patient are aligned in a strong, uniform magnetic field, absorb energy from tuned radiofrequency pulses, and emit radiofrequency signals as their excitation decays. These signals are converted into sets of tomographic (selected planes) images by using field gradients in the magnetic field, which permits 3-dimensional localization of the point sources of the signals. ***Magnetic resonance angiography*** **(**MRA) is an MRI study of the blood vessels. It utilizes MR technology to detect, diagnose and guide the treatment of heart disorders, stroke and blood vessel diseases. MRA provides detailed images of blood vessels even without intravenous contrast medium, although we frequently use a special form of contrast (gadolinium) which markedly improves the quality of the MR images of the vessels.

Digital subtraction arteriography (DSA*)*, sometimes called angiography, is performed by the interventional radiologist. Local and intravenous sedation are used to make the procedure nearly pain-free. A small tube is placed into the artery in the groin without a surgical incision. X-ray contrast is injected into the area of interest and pictures taken to assess for blockages in the arteries. If the narrowing or blockage can be treated with angioplasty or stent placement, this is usually performed at the same time. If a surgical bypass is needed, the arteriogram acts as a roadmap to the surgeon who will perform the bypass. Angioplasty is the use of a balloon catheter to open narrowed or blocked segments of artery. Angioplasty and stent placement can be performed at the time of arteriography. The procedure is usually performed on an outpatient basis.

PRO AND CONTRA

Preoperative vessel assessment enhances the success of creation and the outcome of autogenous arteriovenous fistula (AVF). Preoperative mapping is indicated in cases where superficial **veins** are clinically not well developed. The second indication is the evaluation of central veins, especially in patients in whom central catheters had previously been placed while they were being treated in intensive care units or to initiate emergency dialysis. **CDUS** is method of choice for detection of non-visible veins, for measurements of internal diameter, and for evaluation of functional status of the veins, evaluated by percentage of the vein diameter increasing after application of a proximal tourniquet. The shape of venous Doppler waveform and respiratory filling are also very useful for evaluation of functional properties of the veins. DSUS is not useful to study the **intrathoracic veins**. **Venography** remains the most reliable examination in such cases. Conventional iodine venography may cause deterioration of renal function, but CO2/angio/venography can be employed. **MRA** results in a good visualization of arm veins but is potentially toxic when used together with contrast. Nephrogenic systemic fibrosis (NSF) is now a major concern for nephrologists. The trigger for NSF is unknown, but MRI contrast agent gadolinium has become the leading suspect. It may act in patients with kidney disease on the basis of its reduced clearance. Attainability is different in different regions and the same is about the price. **MRA** provides detailed images of blood vessels and blood flow without having to insert a catheter directly into an artery. The procedure itself and the time needed to recover are much shorter and less costly. Contrast medium may be injected, but unlike catheter angiography or **CT angiography**, which makes use of iodine-based contrast medium, a very small amount of gadolinium based contrast is utilized instead. Although extremely efficacious in detecting and characterizing pathologic tissue, clinical development of these agents has been limited by potential toxicity concerns from incomplete clearance. There is growing recognition of the association between the use of gadolinium-containing radiocontrast agents for magnetic resonance imaging and the serious dermal and systemic disease nephrogenic fibrosing dermopathy/nephrogenic systemic fibrosis (NFD/NSF). The pathogenesis of this entity remains unclear; however,

recent observations suggest a likely mechanism for the initial dermal manifestations of this gadolinium toxicity. At angiographic concentrations, gadolinium-based contrast agents do not induce fewer cytotoxic effects on cultured renal tubular cells than does iodinated contrast medium at concentrations used for angiography. Haemodialysis immediately after examination is helpful to prevent toxic effect of gadolinium.
Preoperative **arterial** imaging is also very important. Morphological characteristics of arteries (internal diameter, quality of arterial wall) could be evaluated by all methods, included CTA and MRA. Functional characteristics (blood flow, distensibility of artery etc.) could be evaluated only by DSUS.
Beside clinical evaluation, non-invasive ultrasonography of upper extremity artery and veins should be performed before vascular access creation. In case of possibility for deep veins stenosis, venography or MRA are the methods of choice.

Detection of stenosis in AVF or AV grafts by clinical examination should remain the key method. The decision about additional imaging examination must be performed before treatment and depends on local customs and practice. CDUS can be performed to locate and to quantify the degree of diameter reduction due to stenosis and Doppler evaluation for evaluation of haemodynamic importance of stenosis. On the base of DSUS complete access should be depicted at DSA and angioplasty to detect all significant stenosis. MRA should be considered only if DSA is inconclusive. Doelman C, et.al prospectively compared **CDUS** and **MRA** with **DSA** for the detection of significant (> or = 50%) stenoses in failing dialysis accesses, and determined whether the interventionalist would benefit from CDUS performed before DSA and endovascular intervention. DSA detected 111 significant (> or = 50%) stenoses in 433 vascular segments. Sensitivity and specificity of CDUS for the detection of significant stenosed vessel segments were 91% (95% CI, 84%-95%) and 97% (95% CI, 94%-98%), respectively. They found a positive predictive value of 91% (95% CI, 84%-95%) and a negative predictive value of 97% (95% CI, 94%-98%). The sensitivity, specificity, positive predictive value, and negative predictive value of MRA were 96% (95% CI, 90%-98%), 98% (95% CI, 96%-99%), 94% (95% CI, 88%-97%), and 98% (95% CI, 96%-99%), respectively. CDUS and CE-MRA depicted respectively three and four significant stenoses in six non diagnostic DSA segments. The interventionalist would have chosen an alternative cannulation site in 38% of patients if the CDUS results had been available. They suggest that CDUS should be used as initial preoperative imaging modality of vessels and also of dysfunctional shunts.

Diagnosis of central venous obstruction is based on clinical signs like pain, paraesthesia, chronic swelling, and collaterals. **DSA** of the access and complete venous outflow tract must be performed, since the central veins cannot be examined with CDUS. DSA can be done with direct antegrade puncture of the access. Percutaneous intervention with stent insertion is indicated. When anamnestic data excluded possibility of central venous stenosis and other causes like compression of mediastinal veins are more likely CT or MRI may be helpful for the differential diagnosis.

CONCLUSION

Beside clinical evaluation, non-invasive **CDUS** of upper extremity arteries and veins should be performed before vascular access creation. **Venography** can be employed in cases of clinical suspicious for central vein stenosis. **MRA with contrast** has been rarely used for access planning despite the fact that results in a good visualisation of arm veins. Limitation for both methods is possible influence on renal function.
Whenever stenosis is suspected, DSUS in the hand of an experienced clinician is an adequate diagnostic tool except for hand arteries and central veins. Recently, DSUS is suggested as the initial imaging modality of dysfunctional fistulae, but complete access should be depicted at **DSA** and **angioplasty** to detect all significant stenosis eligible for intervention.

MRA should be considered only if DSA is inconclusive. MRA is an elaborate procedure and therefore not possible in every hospital.

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