2. Pre-operative evaluation

Guideline 2.1. Clinical evaluation and non-invasive ultrasonography of upper extremity arteries and veins should be performed before vascular access creation (Evidence level II).

Guideline 2.2. Central vein imaging is indicated in patients with a history of previous central vein catheters (Evidence level IV).

Rationale

There is a significant failure rate for autogenous arteriovenous fistulae (AVFs), estimated at 0.2 events per patient/year. For graft AVF, this increases to 0.8–1.0 events per patient/year. In a recent meta-analysis, the primary failure rate for autogenous wrist AVF was 15.3%. Primary and secondary 1-year patency rates were 62.5 and 66.0% [1]. Nowadays, the chronic dialysis population is becoming elderly and is increasingly likely to have diabetes, peripheral arterial obstructive disease (PAOD) or coronary artery disease. Many of these patients have poor vessels for construction of autogenous fistulae and this may be the major reason for the high primary failure and moderate long-term patency.

Physical examination

Careful selection of suitable vessels based on objective evaluation, is required for successful creation of a functioning AVF. Physical examination is used for pre-operative assessment and access planning. This includes assessment of the distal arterial pulse and the presence, diameter and course of the superficial fore- and upper arm veins. Physical examination may be difficult in obese patients and depends on the experience of the examiner.

Ultrasonography

Pre-operative vessel assessment with ultrasonography enhances the success of creation and the outcome of autogenous AVF. In a randomized trial, the primary AVF failure rate was 25% when pre-operative assessment depended on physical examination alone, compared with 6% (P = 0.002) when ultrasonography was used [2]. In the study performed by Silva et al.[3] strategies for vascular access creation were based on pre-operative duplex scanning. Patients with a radial artery diameter of $\geq$2 mm and a cephalic vein diameter of $\geq$2.5 mm received radial-cephalic AVFs (RCAVF). Grafts were used in patients with insufficient radial arteries or cephalic veins and in those with outflow vein in the elbow with a diameter of $\geq$4 mm. The percentage of RCAVF creation increased from 14% to 63%, while the early failure rate decreased from 36% to 8% [3].

In other studies, the fistula rate increased from 17–35% to 58–85% [4–7]. All studies were performed in American dialysis facilities with their historical low autogenous fistula creation rate in past years.

One study showed that the functional maturation rate of AVFs decreased from 73% to 57% as the autogenous fistula creation rate increased from 61% to 73% after the implementation of pre-operative duplex scanning [8]. This outcome suggests that other selection criteria based on findings at pre-operative imaging are needed to further refine and optimize arteriovenous access surgery. Pre-operative ultrasound screening is especially useful in obese patients. AVF rates were similar in 50 patients with body mass index (BMI) >27 kg/m^2 compared with 130 patients with lower BMI when pre-operative vein mapping was employed [9].

Arterial imaging

Radial artery diameter predicts the outcome (failure or dysmaturation) of RCAVF and influences the strategy for vascular access creation. Wong et al. [10] observed either thrombosis or failure to maturation in all RCAVFs created in patients with a radial artery diameter of <1.6 mm. In another study, successful RCAVFs had a pre-operatively measured radial artery diameter of 2.7 mm vs 1.9 mm in failed RCAVFs [11]. Malovrh discriminated between RCAVFs created with radial arteries, with a diameter >1.5 mm vs $\leq$1.5 mm. Immediate patency rate in the >1.5 mm group was 92 vs 45% in the $\leq$1.5 mm group, while the patency rates after 12 weeks were 83% vs 36%, respectively [12]. The predictive value of the radial artery peak systolic velocity (PSV) and resistance index (RI), calculated from pre-operative ultrasonographic parameters, is uncertain [10,13,14]. However, Malovrh showed a significant correlation between radial artery RI (0.50 vs 0.70), diameter (0.294 vs 0.171 cm), and flow (90 vs 33 ml/min) during pre-operative hyperaemia testing and the outcome of AVF creation [15].

Venous imaging

Vein diameters of <1.6 mm have been associated with AVF failure [10], while good patency rates were obtained in patients with RCAVFs where the diameter of the cephalic vein at the wrist was >2–2.6 mm or upper arm veins >3 mm) [16]. The cephalic vein diameter increase after application of a proximal tourniquet is an important predictor of success. In a group of successfully created AV fistulae, the vein diameter increased by 48%, while vein diameter only increased by 11.8% in the group of failed AV fistulae [15].

Table 1. Vessel diameters for successful RCAVF creation

Author	Radial artery (mm)	Cephalic vein (mm)
Wong et al. [10]	1.6	1.6
Malovrh [12]	1.5	1.6
Silva et al. [3]	2.0	2.5
Ascher et al. [21]	– 2	.5

Arterial and venous vessel selection

From the available literature (Table 1) a minimal diameter of the anastomosed vessels (radial artery and cephalic vein) of 2.0 mm is advisable for the creation of successful RCAVFs. Critical minimal diameters of cubital and/or upper arm vessels for the creation of successful elbow/upper arm fistula creation are not established.

Venous preservation with additional handgrip exercise may enhance the quality and diameters of arteries and veins for fistula creation [17].

Venography and magnetic resonance angiography

Conventional iodine venography may cause permanent deterioration in renal function in patients with severe renal damage. It is, therefore, not suitable for patients who are preparing for dialysis or for dialysis patients with some residual renal function. Gadolinium is a safe alternative to iodine venography with acceptable inter-observer correlation regarding imaging quality (k = 0.62) and strategy planning (k = 0.64) [18]. CO_2 angio/venography can also be employed, because of its low risk of renal function deterioration.

Magnetic resonance angiography (MRA), with either time-of-flight (TOF) or contrast-enhanced (Gadolinium) technique (CE-MRA) has been rarely used for access planning. CE-MRA results in a good visualization of arm veins. Diameter measurements were closely correlated overall (r = 0.91) and on a vein-to-vein basis (r = 0.84–0.98) compared with conventional venography [19]. Studies on the diagnostic accuracy of preoperative MRA vs duplex scanning, however, are lacking. Central vein imaging can be accurately performed by CE-MRA [20]. Alternatively, MRA has the potential for imaging of both arterial and venous vessels.

Recommendations for future research

Detection of significant pre-operative parameters for successful fistula creation and maturation remains a major issue for further investigation. Newer imaging techniques with high-resolution quality should be further developed.

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