INTRODUCTION

End Stage Renal disease (ESRD), or Stage 5 chronic kidney disease (CKD) means that a patient requires renal replacement therapy, which may involve a form of dialysis, but ideally constitutes a kidney transplant. Data from the United States Renal Data System (USRDS) in 2010 showed that there were 594,374 prevalent and 116,946 incident cases of ESRD. Notably, this represents more than tenfold increase from 1980, and it has been estimated that this trend will continue, with estimated prevalent and incident counts of 784,613 and 150,772, respectively by 2020 ***(Beathard, 2008)***.

The majority of patients with ESRD are on hemodialysis. So, the creation and maintenance of vascular access for hemodialysis in chronic renal failure patients is very crucial. The access of first choice is the native arterio-venous (AV) fistula. The implantation of poly-tetra-fluoroethylene (PTFE) grafts is the next choice when the construction of a native fistula is not possible. The vascular access, despite being the lifeline for patients on dialysis, yet a significant failure rate has been reported. The cumulative patency rates of radio-cephalic fistulas at 1 and 2 years were 69% and 66%, respectively, whereas PTFE grafts have a shorter longevity than native AV fistulas ***(Koh et al., 2004).***

An arteriovenous fistula (AVF) is abnormal connection between an artery and vein, This may be congenital, acquired due to pathological process like trauma, or surgically created fistula for haemodyalsis. Surgically created AVF for haemodialysis is considered to be the most common surgical procedure performed by vascular surgeon. The selection of a particular location is based on the recommended sequence of using the nondominant arm before the dominant arm, the forearm before the upper arm, and the upper extremity before the lower extremity ***(Jindal et al., 2006).***

Autogenous arteriovenous fistulas have several different configurations. In the forearm, the common type is the Brescia-Cimino radiocephalic fistula constructed at the wrist between the radial artery and the cephalic vein, usually in an end to-side configuration. Prosthetic arteriovenous grafts also have several configurations. An arm graft, which is created by surgically interposing a PTFE connector between the brachial artery and an arm vein, may have either a looped or straight configuration. Other configurations involve a position in the thigh in which a loop of PTFE is connected end-to-side with superficial femoral artery and end-to-end with the greater saphenous vein ***(Weiswasser et al., 2005).***

In order to understand the complications of AV access, some terms need to be defined. **Inadequate maturation** is defined as insufficient access flow to maintain dialysis or the inability to cannulate an arteriovenous fistula (AVF), if required, at 6 wk after surgery. **Primary failure** (PF) was defined as an AVF that did not develop to maintain dialysis or thrombosed before the first successful cannulation for hemodialysis treatment, regardless of eventual AVF abandonment. This definition includes: (1) inadequate maturation, (2) early thrombosis, (3) failure of first cannulation, and (4) other complications such as ischemia or infection. **Secondary failure** (SF) was defined as permanent failure of the AVF, after it had achieved adequacy for hemodialysis ***(Sidawy et al., 2002).***

Juxta-arterial anastomosis segment refers to the initial 5 cm of the AVF starting at the arterial anastomosis. **Peripheral vein** refers to the venous outflow tract of the AVF that starts proximal to the juxta-arterial segment and ends at the distal edge of the subclavian vein. **Central vein** refers to subclavian vein, innominate vein, or superior vena cava ***(Nassar et al., 2006).***

Primary patency (intervention-free access survival) is defined as the interval from time of access placement to any intervention designed to maintain or reestablish patency or to access thrombosis or the time of measurement of patency. **Assisted primary patency** (thrombosis-free access survival) was defined as the interval from time of access placement to access thrombosis or time of measurement of patency, including intervening manipulations (surgical or endovascular interventions) designed to "maintain" the functionality of apatent access ***(Sidawy, 2002).***

Secondary patency (access survival until abandonment) was defined as the interval from time of access placement to access abandonment or time of measurement of patency, including intervening manipulations (surgical or endovascular interventions) designed to "reestablish" the functionality of thrombosed access ***(Sidawy et al., 2002).***

The word **"functional**" is added to patency to indicate that patency interval started at date of first successful cannulation for hemodialysis treatment instead of date of access placement. A functional AVF is an access that is able to deliver a flow rate of 350 to 400 ml/min without recirculation for the total duration of dialysis. A nonfunctional AVF is an access that is not being successfully used for hemodialysis, regardless of whether it is patent ***(Sidawy et al., 2002).***

Angioplasty remains the most common method of treating obstructive vascular stenoses associated with hemodialysis fistulas and grafts. Working through the vascular sheath, an angiographic catheter is used to manipulate a guidewire through the stenosis. This guidewire will be used subsequently to position the angioplasty balloon across the lesion. Catheter treatment of hemodialysis accesses is generally safe ***(Beathard, 2008).***

In this study we aim at reviewing the literature about the current status of endovascular management of failing dialysis access. Special attention will be paid to indications, techniques and outcomes in comparison to conventional surgicalprocedures with discussion of the anatomical and pathophysiological aspects of this subject.

AIM OF THE WORK

In this study we aim at reviewing the literature about the current status of endovascular management of failing dialysis access. Special attention will be paid to indications, techniques and outcomes in comparison to conventional surgical procedures with discussion of the anatomical and pathophysiological aspects of this subject.

Chapter one

GENERAL CONSIDERATIONS AND SITES FOR CREATION AN OPTIMUM VASCULAR ACCESS

The requirements for an ideal AV access include a flow rate sufficient for effective dialysis, excellent long-term patency, minimal access-related complications, and a cosmetic appearance acceptable to patients. Unfortunately, no access type fulfills all of these requirements. A mature autogenous AV access satisfies most of these criteria and is likely the optimal access choice, as emphasized by the national guidelines and initiatives previously detailed. Indeed, most developed countries outside the United States have already achieved the KDOQI targets. However, it is important to emphasize that the ultimate goal is a functional access with minimal complications, not necessarily an autogenous access ***(Ethier et al., 2008).***

The construction of autogenous AV access requires an obligatory time for the access to "mature" or to become suitable for dialysis. During this maturation period, the vein that constitutes the access dilates, the wall thickens (or becomes "arterialized"), and the flow through the access circuit increases. The National Kidney Foundation / Kidney Disease Outcomes Quality Initiative *(NKF/ KDOQI)* guidelines have defined the "rule of 6s" as the criteria for access maturation and/or suitability for cannulation; they include a vein diameter of 6 mm, an access flow rate of 600 mL/min, and an access depth of 6 mm below the skin. Unfortunately, a significant proportion of the autogenous accesses fail to mature to suitability for cannulation. This inability of some autogenous AV accesses to mature represents the major limitation. This inability to “mature” can be multifactorial and related to early thrombosis, failure of the vein to dilate, or the inability to cannulate ***(NKF/ KDOQI, 2006).***

A variety of factors have been identified to predict whether an autogenous AV access will mature and/or maintain patency. Unfortunately, the reports in the literature have been somewhat contradictory and/or inconsistent. These include several non-modifiable and modifiable factors. The non-modifiable factors include increased age, diabetes, predialysis hypotension, artery diameter, arteriosclerosis, vein diameter, and vein distensibility. The modifiable factors include smoking, timing of referral for access, preoperative ultrasound imaging, anastomotic configuration, anastomotic technique, flow assessment, antiplatelet agents, far-infrared therapy, and the timing of cannulation. Notably, gender, body mass index, access surveillance, and the various needle cannulation techniques were not found to be predictive of autogenous access success ***(Smith et al., 2012).***

Table (1): Factors Influencing vascular access selection and success ***(Cull, 2011)***.

Factors Influencing Vascular Access Selection and Success	
Clinical scenarios favoring autogenous success	Young patient age Favorable vascular anatomy (artery >2.0 mm; vein >3.0 mm) Chronic skin diseases History of multiple previous access infections Immunosuppression/human immunodeficiency virus Hypercoagulability Multiple prior prosthetic access failures
Clinical scenarios favoring prosthetic access	Imminent need for or currently undergoing hemodialysis Short life expectancy Morbid obesity Unfavorable vascular anatomy
Factors that adversely influence autogenous access maturation	Diabetes mellitus (radial and ulnar-based accesses) Arterial diameter <2.0 mm Calcified radial artery Vein diameter <3.0 mm Congestive heart failure Advance patient age Female gender

Age: Advanced age has consistently been associated with autogenous AV access failure, particularly with regard to the radial-cephalic configuration. Indeed, it has been suggested that the national initiatives may need to be reevaluated for elderly patients. Advanced age and life expectancy are interrelated in terms of access choice because the improved long-term patency attributed to autogenous accesses may not be as relevant for elderly patients, particularly if one considers that the obligatory period from access creation to cannulation can be prolonged ***(Lok et al., 2005).***

Diabetes: Diabetes has also been associated with failure of autogenous access. As for advanced age, the negative predictor for the presence of diabetes has been associated primarily with the radial-cephalic configuration. Indeed, the overall success rate for this configuration has been somewhat poor, particularly in the presence of advanced age, diabetes, and female gender. Why the success rate for diabetic patients is compromised is not completely clear, but the reason is likely related to the characteristic distribution of arterial occlusive disease in the forearm in such patients. Interestingly, diabetic patients have been shown to have comparable success rates for autogenous access procedures in the upper arm and comparable access options as shown by noninvasive imaging ***(Murphy et al., 2002).***

Obesity: Obesity has not been shown to be a consistent predictor of autogenous access failure except perhaps for patients in the highest quartile. However, the presence of obesity clearly affects the decision about the most appropriate access choice and increases the likelihood of postoperative complications, particularly wound complications. Obese patients have been found to have the same number of autogenous access options on noninvasive imaging. However, the cephalic vein, which usually courses superficially, may be somewhat deep relative to the skin and mandate elevation and/or transposition in an obese patient ***(Chan et al., 2008).***

Vessel Characteristics: The quality of the inflow artery and the outflow vein has consistently been associated with AV access success. Arterial diameters smaller than 2 mm have consistently been associated with poor autogenous maturation rates. These threshold radial artery diameters and their associated poor maturation rates likely reflect the presence of forearm arterial occlusive disease and the inability of the forearm vessels to dilate in response to the AV fistula rather than the absolute diameter measurement, because smaller-diameter arteries in children (without atherosclerosis) can frequently yield successful, mature autogenous AV accesses. The early or high bifurcation of the brachial artery (i.e., early takeoff of the radial artery), seen in up to 20% of individuals, has also been associated with lower success rates for both autogenous and prosthetic accesses. The absolute vein diameter that has been predictive of a successful autogenous access have varied, with minimum criteria ranging from more than 2.0 mm to more than 3.0 mm ***(Mendes et al., 2002)***.

Patient Preference: Patient preference should also be factored into the decision algorithm about the most appropriate access type or configuration. As already noted, physicians prefer the autogenous access because of its better long-term outcome, whereas the dialysis staff prefers the prosthetic access because the ease of cannulation. However, patients prefer a superficial access in the forearm and are more concerned about the ease of cannulation, cosmetic appearance, and impact on daily life than about the distinction between autogenous and prosthetic accesses ***(Bay et al., 1998).***

Sites for creation arteriovenous access

The approach to dialysis patients is based on adequate inflow (arterial), adequate outflow (vein), and an appropriate conduit (vein or prosthetic) with a vein conduit being optimal in most Access Configuration. Criteria for an adequate artery include no hemodynamically significant arterial inflow stenoses and a diameter greater than 2 mm, and those for the vein include no outflow stenoses and a peripheral vein segment of suitable length and diameter (>3 mm). The possible access configurations can be distilled down to autogenous radial-cephalic, other forearm autogenous, autogenous brachial-cephalic, autogenous brachial-basilic, other upper arm autogenous, forearm prosthetic and upper arm prosthetic ***(Sidawy et al., 2002).***

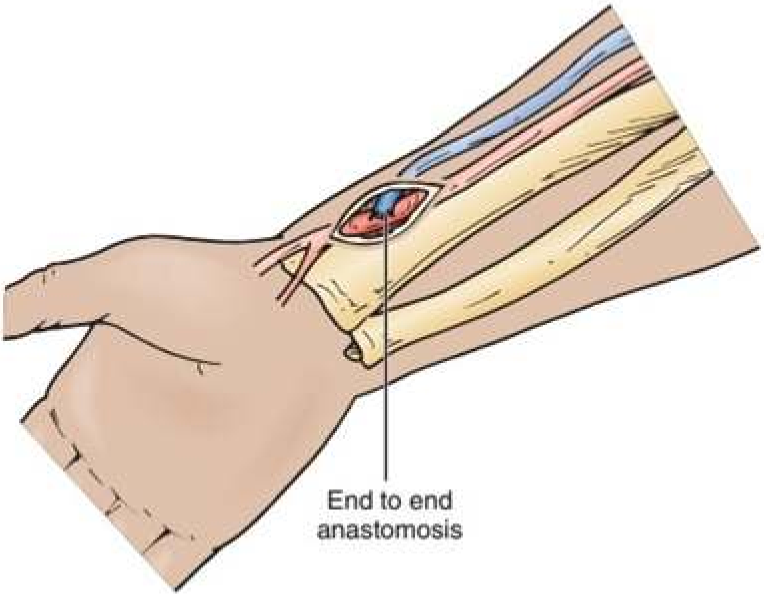

Figure (1): Radial-cephalic autogenous arteriovenous access ***(Englesbe et al., 2005)***

1. ***Distal Radial- Cephalic Autogenous Arteriovenous Acces:***

The autogenous radial-cephalic AV access at the wrist was the earliest autogenous accesses described and can be an excellent option for certain patients. The success rates for the autogenous radial-cephalic AV access are lower than those reported for brachial artery–based procedures and are likely lower for women, diabetics, and older patients. The poor success rates in these cohorts of patients likely reflects the presence of forearm arterial occlusive disease and the inability of the forearm vessels to dilate in response to the AV communication sufficient to increase flow and sustain effective dialysis. \The anastomosis for the autogenous radialcephalic

AV access is traditionally configured in an end (vein)-to-side (artery) configuration to reduce the likelihood of venous hypertension in the hand from retrograde venous flow ***(Vachharajani et al., 2011).***

2. ***<u>Other Forearm Autogenous Arteriovenous Accesses.</u>***

There are a variety of other autogenous options in the forearm. The radial-basilic configuration is a reasonable option provided that the artery and vein are large enough. The ulnar artery can be used for autogenous access, but the reported series are small, and access failure potentially puts the hand at some risk, given the fact that most patients are ulnar dominant. The radial artery in the forearm can also be used to construct a radial–median antecubital vein AV access (i.e., middle-arm AV access), preserving bidirectional flow in the vein with a side-to-side anastomotic configuration. Alternatively, the cephalic or basilic vein in the forearm can be transposed in a loop configuration with the arterial anastomosis on the brachial artery in the antecubital fossa ***(Gefen et al., 2002).***

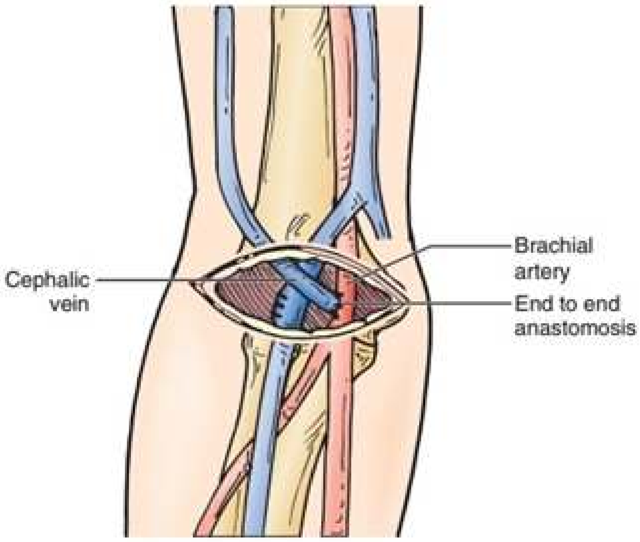

Figure (2): Brachial-Cephalic Autogenous Arteriovenous Fistula ***(Englesbe et al., 2005).***

3. ***Upper Arm Autogenous Arteriovenous Access.***

The brachial-cephalic and brachial-basilic are the traditional or common upper arm autogenous access options and are associated with better patency rates than the forearm autogenous AV accesses as already noted. The proximal radial artery can be used as an alternative to the brachial artery at the antecubital fossa, and essentially all the same access configurations can be constructed. Access procedures based on the proximal radial artery may have a lower incidence of access-related ischemia, commonly referred to as “steal syndrome”, than the brachial artery, although the obvious tradeoffs are the absolute size of the artery and the quantity of arterial inflow. The basilic vein is an attractive choice for an autogenous access because it is relatively thick walled, large in diameter, and well preserved in terms of cannulation for venipunctures and intravenous catheters due to its relatively deep course. The transposed brachial-basilic AV access can be performed as either a single or a two-stage procedure. The other autogenous AV access options in the upper arm include the brachial-brachial and brachial-median antecubital AV accesses ***(Vachharajani et al., 2011).***

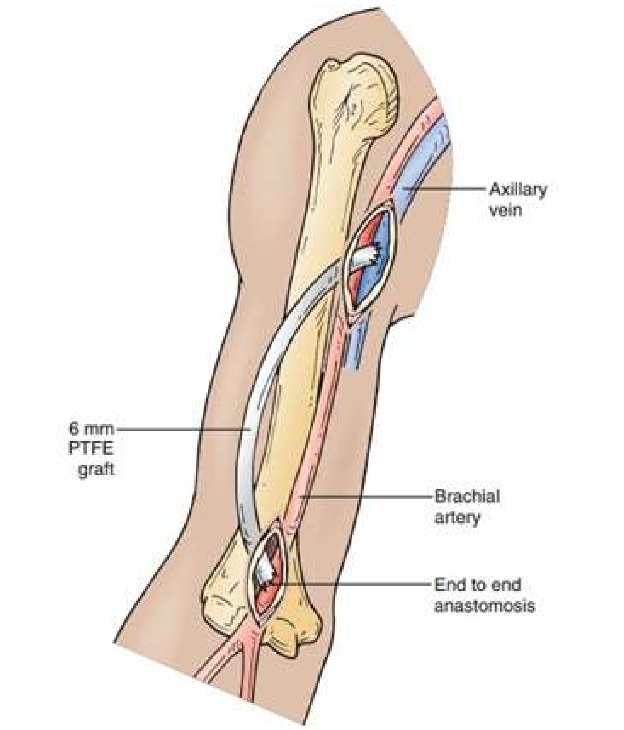

Figure (3): Prosthetic Upper arm arteriovenous access ***(Englesbe et al., 2005).***