Endovascular management of failure of maturation of natural vascular access

Essay

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by

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List of Contents

List of Abbreviations

AVF	arteriovenous fistula.
AVG	Arteriovenous graft
BAM	Balloon assisted maturation
BBF	brachiobasilic fistula
BCF	brachiocephalic fistula
CDUS	colour-Doppler ultrasonography.
CE-MRA	Contrast enhanced magnetic resonance angiography.
CIED	cardiac implantable electronic device.
CVC	central venous catheter.
DOPPS	Dialysis Outcomes and Practice Patterns Study
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DOQI	Disease Outcomes Quality Initiative
DSA	Digital subtraction angiography.
ESRD	End stage renal disease
GFR	Glomerular filtration rate
HD	Hemodialysis
NKF-DOQI	National Kidney Foundation - Disease Outcomes Quality Initiative
PDGF	Platelets derived growth factor
PTA	percutaneous transluminal angioplasty
TPA	
RCF	Radiocephalic fistula
TGF-β	Transforming growth factor beta

List of figures

INTRODUCTION

Vascular access for maintenance hemodialysis is provided with an autogenousarteriovenous (AV) fistula, synthetic AV graft, or central venous catheter. The fistula is preferred because complication rates and health care expenditures are lower for patients with functioning fistulas than for those with synthetic grafts or central venous catheters. ***(George et al., 2008)***

Despite successful efforts to increase the use of fistulas among patients undergoing maintenance hemodialysis, only 60% of patients are dialyzed with a fistula, An important contributor to the low prevalence of fistulas is the failure of many newly created fistulas to mature adequately for use.***(Collins et al.,2012)***

Vascular access dysfunction is a major cause of morbidity and mortality in dialysis patients. With their unique perspective on dialysis patients and their problems, an increasing number of nephrologists are safely and effectively performing endovascular procedures to assist in the maintenance of hemodialysis accesses.***(Vandana et al., 2012)***

The “failing to mature” arteriovenous fistula (AVF) can be defined as a surgically created AVF that failed to properly grow to become usable for the purpose of hemodialysis (HD) in 8 to 12 weeks after its creation. Such failure is clinically

manifest as difficult cannulation, inadequate AVF flow characteristics, or both. ***.(George et al, 2008)***

Fistula maturation is a complex vascular remodeling process that requires vessel dilation, marked increases in blood flow rates in the feeding artery and draining vein, and structural changes in the vessel walls. Our current understanding of these processes and the factors promoting and impeding successful maturation is limited. Major areas requiring research include identification of clinically useful preoperative predictors of fistula outcome, elucidation of the pathophysiology of fistula maturation, identification of early postoperative indicators of fistula outcome, and development of interventions to facilitate maturation. ***(Dixon et al., 2006)***

Current practice has focused on the prevention of delayed fistula maturation and early fistula failure by means of the appropriate preoperative examinations and investigations for properselection of arterial and venous vessels as well as the appropriate procedures most suitable for the individual patient***.(Han et al 2013)***

If poorly matured or immature AVF could be successfully salvaged, increased prevalence of native haemodialysis access would ensue. Therefore, aggressive assessment and interventional treatment of immature AVFs for correctable lesions should be included to achieve fistula function.***(Nassar etal.,2006)***

The goal of intervention is to convert the “failing to mature” AVF to a usable access that lends itself to easy cannulation and provides enough blood flow to sustain HD. It is critical to understand the anatomy and flow dynamics of the AVF and identify all AVF-associated derangements before any inter-vention is initiated. This means one needs to evaluate the feeding artery, arterial anastomosis, juxta-arterial segment, body of the AVF (cannulation sites), accessory veins, venous outflow tract, and central veins. Intervention usually involves balloon angioplasty of all significant vascular stenoses and obliteration of sizable accessory veins. A necessary requirement for balloon angioplasty is successful passage of a guide wire through the vessel requiring dilation***.(Coentrao etal., 2012)***

As with any procedure, complications do arise. These were categorized as formation of wall hematoma, extravasation or rupture, spasm, thrombosis, and formation of puncture-site hematoma.However, The data suggest that office-based BAM procedures are safe. Fortunately, major complications are not seen at an alarming rate. While increased complications are seen in BAM procedures performed in the forearm and with larger balloons.

AIM OF WORK

To define and discuss the possible causes of failure of maturation of natural vascular access and discuss role of endovascular intervention in management of such cases and to highlight the new modalities and various techniques of the procedure.

Chapter (1):

TYPES OF VASCULAR ACCESS

The venous system of Permanent vascular access in the patient with ESRD on hemodialysis is provided through a central venous catheter (CVC), arteriovenous graft (AVG), or AVF. The central venous access is provided by a cuffed catheter placed subcutaneously in the internal jugular vein. The most frequent complications of CVC with significant clinical consequences include infection and thrombosis; therefore this access is not a recommendedoption for permanent vascular access. .*(Rodriguez et al., 2000)*

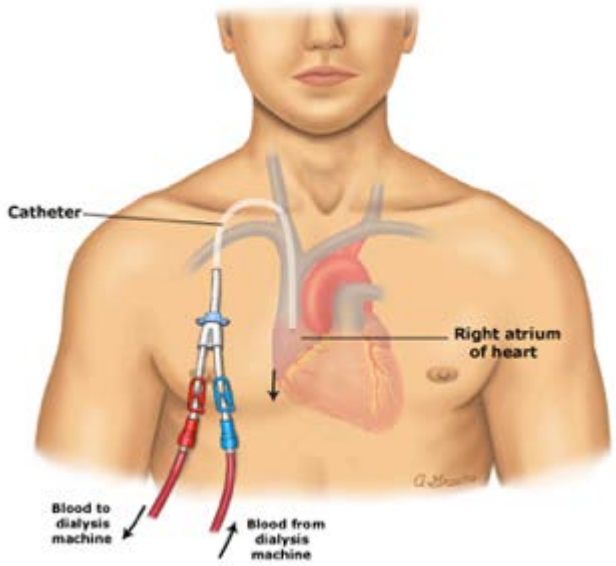

Fig. (1) Central venous catheter

An AVG is placed if the venous or arterial supply is inadequate. It is created by insertion of a synthetic conduit usually polytetrafluororthylene between an artery and vein. AV grafts have a high rate of thrombosis and infection with an average survival of only 2-3 years *(Perera et al., 2004)*

Fig. (2) Forearm PTFE loop graft

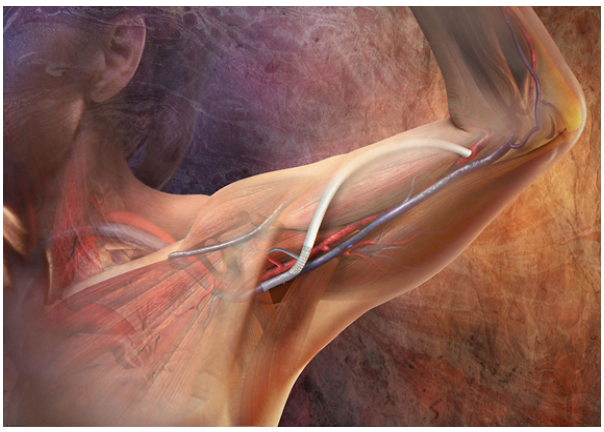

Fig. (3) Brachio Axillary PTFE graft

An AV fistula is created by a surgical anastomosis between and artery and vein. When a fistula is created the vein and artery may be in their normal positions, or the distal end of the vein is moved to a position that is better located for cannulation (vein transposition). A translocation is done when the entire vein is moved from one anatomic location to another requiring an arterial and venous anastomosis. *(Rodriguez et al., 2000)*

The fistula with the best outcome is the lower arm radiocephalic (RCF); however this access often fails to mature in the elderly patient with underlying vascular disease, particularly in diabetics. The second recommended fistula is the upper arm brachiocephalic fistula (BCF). This type of fistula is being placed with increased frequency because of the high failure rate of RCF. The third recommended fistula is the brachiobasilic fistula (BBF), which usually involves a two step surgical procedure and may be difficult to cannulate given the medial location of the basilic vein.*(Rodriguez et al., 2000)*

The benefits of AVFs over other forms of chronic access are:

●AVFs are associated with decreased morbidity and mortality among hemodialysis patients compared with AV grafts and central venous catheters.

●AVFs have the superior primary patency rates, the lowest rates of thrombosis, and require the fewest secondary interventions.

●AVFs generally provide longer hemodialysis access survival rates.

●The total number of interventions during the life of the access is considerably lower for AVFs compared with AV grafts.

●AVFs have lower rates of infection than AV grafts and significantly lower infection rates compared with percutaneous catheters.

●Patients with AVFs have lower hospitalization rates than patients with AV grafts or catheters.

●The cost of implantation and maintenance of AVFs is the lowest of the three types of access. *(Perera et al., 2004)*

Radial-cephalic fistul

The RCF was the first fistula designed in 1966 by Brescia (Brescia, 1966). The RCF is created by an anastomosis between a radial artery and a cephalic vein.

This access is easy to place and once mature and used for dialysis has a low complication rate. The classic Cimino fistula is constructed with a side to side anastomosis but this design may lead to venous hypertension. Therefore an end-to-side anastomosis is commonly used. The most frequent clinical problem is that this access has a higher primary failure rate when compared to BCF or BBF *(Miller et al., 1999).*

However, if a RCF matures, the 5 to 10 year cumulative patency rate is 53 and 45 percent respectively. Placement of a lower arm fistula is desirable as it preserves the upper arm for future use. *(Rodriguez et al., 2000)*

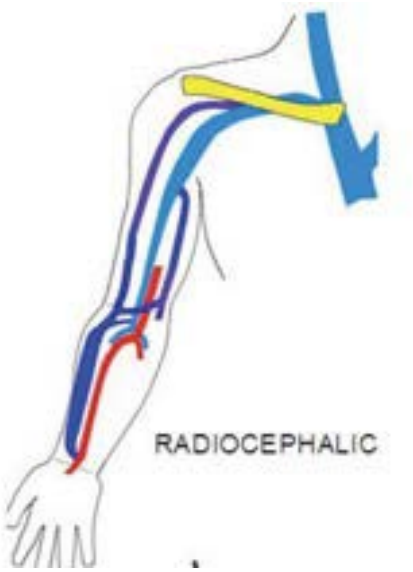

Fig. (4) Radio Cephalic AVF

Brachial-cephalic fistula

The BCF is a suitable second choice for access.The cephalic vein in the upper arm is larger with increased flow as compared to the lower arm. The anastomosis for a BCF is usually in the antecubital fossa between the brachial artery and cephalic vein. The location of the BCF enables ease of cannulation with the benefit of a large surface area. The major complication with a BCF is the steal syndromeas compared to RCF or BBF.*(Ruebens etal., 1993)*

In a retrospective review of 2,422 patients with vascular access, the BBF had a superior patency rate in diabetic pateints when compared to diabetic pateints who had a RCF The authors even went so far as to argue that the BCF may be the best access option for the older diabetic patient on hemodialysis.*(Papanikolaou et al., 2009)*

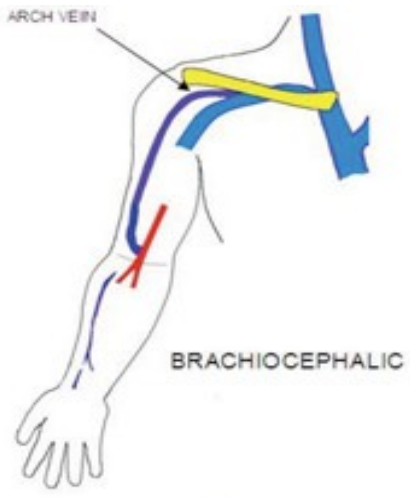

Fig.(5) Brachio cephalic fistula

Brachial-basilic fistula

The BBF is the third choice for fistula placement Because the basilic vein is less accessible to venipuncture it tends to be better preserved and less involved with Technical Problems in Patients on Hemodialysis traumatic post-phlebitic changes when compared to the cephalic vein.*(Dagher et al., 1976)*

When the BBF is placed more surgical skill is required with an initial anastomosis deep between the brachial artery and basilic vein. The BBF is left to mature for two months and then a second surgical procedure is preformed to "lift" the vein to allow ease of cannulation. The anatomic location of this fistula is often located in a position which is difficult to cannulate. Overall, the failure rate of the BBF is worse than BCF or RCF*(Taghizadah et al., 2003)*

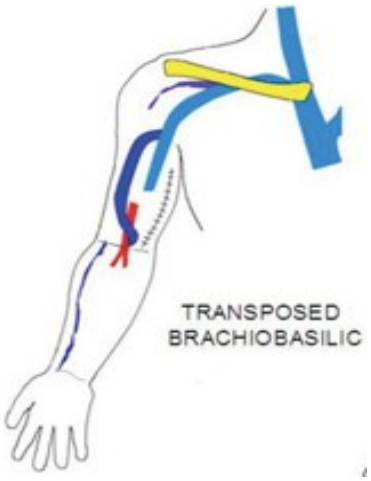

Fig. (6) Transposed Brachio-basilic fistula