Endovascular Procedures in Nephrology

Introduction

The scope of diagnostic and interventional nephrology (IN) has been well defined.[1] Endo is a prefix from Greek ἔνδον *endon* meaning "inside the blood vessel." There has been a marked change in the vascular access profile of patients receiving hemodialysis (HD). As patients are surviving longer on HD, maintaining a functional vascular access has become a major clinical challenge. Until recently, the dialysis vascular access care was mainly "reactive" and dependent on surgical methods. The suitability of HD patients for open surgical techniques and timely interventions are two major barriers to maintaining vascular access patency and avoid disruption of HD. The evolution of endovascular procedures became essential to improve overall quality of care. These endovascular procedures have traditionally been the domain of interventional radiology or vascular surgery, but in the last two decades, the field of IN has established itself as a subspecialty in the developed countries and gaining momentum in the developing countries.

Percutaneous Endovascular Procedures

Arteriovenous fistula (AVF) is preferred over arteriovenous graft (AVG) as a long-term vascular access and needs monitoring for maturation and early dysfunction. The common underlying pathology is development of neointimal hyperplasia that results in stenosis, decreased blood flow, and eventual thrombosis. The endovascular methods including angioplasty, thrombectomy, mechanical or pharmaco-mechanical thrombolysis, and stent placement, have become a first-line treatment option to salvage a failing access.[2] As per 2019 KDOQI Vascular Access Practice Guidelines,[3] access stenosis of ≥50% when associated with clinical or physiologic abnormalities such as an altered venous/arterial circuit pressure (venous pressure >250 mm Hg, arterial line pressure <250 mm Hg), prolonged bleeding (>30 min) after needle removal, trends suggesting decreased access flow (<500 mL in AVF, <600 mL in AVG or >20% reduction in flow from baseline) and "inadequate dialysis" (kt/v <1.2 or persistent URR <65%) should be considered for endovascular intervention [Table 1].

Interventional nephrology (IN) is an evolving field in India and would suggest using this commentary to highlight critical elements to developing a new field and maintaining collegiality and professionalism with colleagues from the multidisciplinary team.

Scope of endovascular procedures includes

1. Primary access failure:
   a. Percutaneous angioplasty (PTA) of stenosis
   b. Embolization of accessory veins
   c. Ligation of accessory veins
2. Maintenance procedures:
   a. PTA
   b. Thrombectomy—mechanical and pharmaco-mechanical
   c. Stent placement—various types, role of bare metal vs. covered stents
   d. Endovascular therapy for steal/high flow access
3. Treatment of Central vein stenosis
   a. PTA/stent therapy (Primarily)
   b. Inside out technique/device (Newer technique for total central venous occlusion)
4. Advanced procedures—Endovascular AVF
5. Endovascular treatment of aneurysms/pseudoaneurysm
6. Managing complications—team approach including vascular surgeon and interventional radiologist is helpful.

"Don't nephrologists perform any procedures?" is a usually asked question. As more nephrologists get involved in the procedures, volume and expertise improve. Several opportunities exist in India for training, including in centre training, and several workshops conducted all-round the year. International Society of Nephrology sponsored fellowship in IN may be explored by interested candidates. The goal should be to train in those procedures, relevant to the location of practice. The young nephrologists are very much interested in learning these procedures, as per author's personal experience.

1. Training and Certification—Procedural, radiation safety, conscious sedation
   a. Role of standardizing training programs, curriculum, and a certifying body
   b. CME—programs—meeting, and hands-on workshops
2. Safety—Role of Quality improvement process
3. Maintaining a multidisciplinary approach to care
4. Maintaining records

Failure to mature (FTM) of AVF occurs in 20%–60% of AVFs.[4] Beathard showed the causes of FTM as either venous stenosis or secondary vein which takes the blood away from main AVF circuit. The PTA of stenosis and obliteration of secondary vein can be performed by a nephrologist.[5]

The AVF angioplasty can be performed under fluoroscopic or ultrasound guidance in select cases. New techniques of PTA using drug-eluting balloon (DEB) is thought to work due to the antiproliferative effects of drugs on the smooth muscle cells in blood vessels. *In vivo*, venous smooth

Table 1: Suggested interventions in hemodialysis vascular access

Problem	Intervention	Comment
Failure to mature	Balloon assisted maturation (BAM)	AVF 4-8 weeks, AVG 3-6 weeks (for PTFE graft material), (With newer materials offering the benefit of early postoperative cannulation, an AVG can be ready for first cannulation ("mature") after a period of hours to days)
Hand ischemia	Percutaneous balloon angioplasty, intravascular stent or coil insertion, MILLER procedure	Subacute dialysis access steal syndrome (delayed but within 1 month of surgery); Chronic: 2-10 months
Stenosis and thrombosis	Percutaneous balloon angioplasty, pharmacological or mechanical thrombectomy, stenting	100% of all thrombosed AVFs, and 85%-90% of AVGs, are associated with an anatomic lesion
Aneurysms and pseudoaneurysms	The aneurysm can be treated with a covered stent or stent graft to exclude the sac; The management of pseudoaneurysmal AVFs is similar to true aneurysms although small saccular pseudoaneurysms with narrow necks may be amenable to thrombin injection or ultrasound compression	Endovascular techniques either alone or combined with surgery have been used to treat AVF aneurysms
High blood flow: flow reduction techniques	Banding, fistula plication or clipping, graft interposition, graft inclusion technique	

Adapted[14]

muscle cells are thought to be more susceptible to these effects,[6] and can slow down the growth of new smooth muscle cells in the vessel wall that may lead to restenosis.

Nitinol and polytetrafluoroethylene covered stent placement to treat HD arteriovenous access stenosis have been tried. Stent grafts can convert unusable upper arm AVF into a functioning HD access as reported by Bavare *et al*.[7] The authors of this article have used drug-eluting coronary stent (DES) on the venous side of AVF venous outflow, with mixed success, where the juxta-anastomotic vein was found to be of adequate size (3–3.5 mm diameter and 15-20 mm length) to be able to accommodate these DES. (Abstract presented at 16th Annual ASDIN Scientific Meeting, February 21-23, 2020, in Las Vegas, NV).

Coil embolization of competing collateral vessels as a salvage treatment for non-functioning autologous AVFs is a viable treatment option in the majority of patients.[8] Angioplasty and coil embolization are successful and safe procedures that can convert a non-mature fistula into a mature one in more than 80% of patients. Accessory vein embolization may be more important than collateral vein embolization in the presence of stenosis.[9]

Sometimes, high-flow access may cause heart failure, aneurysm or cephalic arch stenosis (CAS). A low urea reduction ratio in an otherwise "well-functioning access" is a simple measurement to determine if an access has pathologically high flow. Clinically asymptomatic central and peripheral venous stenosis can become symptomatic when high flow is generated in the circulation due to AVF. The symptoms of HD vascular access patients associated with non-correctable central venous lesions can resolve successfully and their access is maintained using a precision inflow banding procedure called Minimally Invasive Limited Ligation Endoluminal Assisted Revision (MILLER), as shown by Miller *et al*.[10,11] A braided cobalt-chromium external support is also feasible, safe, and effective for flow reduction in high-flow AVF patients.[12]

The AVF embolization is also performed to close the AVF in patients presenting with arm oedema due to chronic central vein occlusion not amenable to any intervention. This has been described in the article in the current issue of the journal, where the authors have used amplatzer vascular plug for embolization as well as flow reduction, though techniques for embolization also include coils, detachable and occluding balloons, and liquid embolic agents, such as n-Butyl cyanoacrylate (NBCA) and ethyl-vinyl alcohol. When no lesions within the vein are visualized, then the cause of fistula failure may be arterial stenosis. Angioplasty may be safely performed on the brachial artery to a primary patency rate of 83% at 1 year and 74% at 2 years.[13]

Central venous stenosis can be tackled with angioplasty with plain balloons or drug-eluting balloons and if there is recurrence of lesion, covered stent can be used. Another endovascular intervention is the balloon-assisted disruption of catheter-related fibrin sheath for dysfunctional tunneled cuff HD catheters. Catheter-related atrial clot (CRAT) can be tackled with thrombolysis, and if adherent to atrial wall, either surgically or with endovascular AngioVac® suction thrombectomy device. An exciting area in endovascular procedures is the creation of AVF. There are two available systems, and they hold good future for HD patients. The Ellipsys® endovascular arteriovenous fistula (endoAVF) system and the WavelinQ endoAVF® system.

Conclusion

Intervention nephrology is an emerging subspecialty of nephrology, which provides an opportunity to nephrologists to undergo training in this area to develop the procedural skills to perform interventions to optimize the care of their patients. Nephrology fellowship programs must take

the initiative to promote the development of such skills. Interventional nephrology can be viewed as a refined and resurrected combination of several procedures, which has brought the nephrologist from the periphery to the center.

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