https://doi.org/10.48047/AFJBS.6.2.2024.3575-3587

AFJBS

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Surgical and endovascular management for the repair of stenosis in Arterio-Venous Fistula

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Article History

Volume 6, Issue 2, Apr-Aug 2024

Received: 5 August 2024

Accepted: 15 August 2024

Published: 15 August 2024

doi: 10.48047/AFJBS.6.2.2024.3575-3587

Abstract: AVF is the preferred hemodialysis access type because it has better patency rates and fewer complications than other access types. Surgical and endovascular management are both established treatment options for the repair of stenosis in AVFs. Endovascular management has become the first line of treatment for AVF dysfunction and replaced the surgical approach in many centers. Open surgical revision of stenotic segment within the AV access can improve both flow and function. As with all access interventions, complete fluoroscopic imaging from the arterial inflow to the right atrium is necessary, and this is generally done at the time of operative revision, and is compared with previous diagnostic imaging to determine the target lesion. Surgical revision for stenosis is generally performed using an interposition graft or a patch angioplasty. Patch angioplasty simply enlarges the area of stenosis without removing the local disease process (or consuming any available length of the vein), theoretically leading to a higher incidence of recurrent stenosis. Despite the similarities, the lesions encountered in AV access are much different from arterial lesions, typically resulting from atherosclerosis. The fibrotic, rubbery stenosis characteristic of IH do not routinely dissect, like atherosclerotic stenosis, but more commonly tear or are disrupted as a result of the obligatory higher insufflation pressures applied during balloon angioplasty. The choice for PTA or surgery for the treatment of stenosis of AVFs depends on the experience of the vascular surgeon. However, many centers around the world report an increased number of PTAs over surgery. In any case, the target of both techniques has to be 50% for primary patency during the first 6-month period.

Keywords: *Surgical, endovascular management, repair of stenosis, Arterio-Venous Fistula*

Introduction

Surgical and endovascular management are both established treatment options for the repair of stenosis in AVFs. Endovascular management has become the first line of treatment for AVF dysfunction and replaced the surgical approach in many centers [1].

Open Surgical Techniques:

Open surgical revision of the stenotic segment within the AV access can improve both flow and function. As with all access interventions, complete fluoroscopic imaging from the arterial inflow to the right atrium is necessary, and this is generally done at the time of operative revision, and is compared with previous diagnostic imaging to determine the target lesion. Surgical revision for stenosis is generally performed using an interposition graft or a patch angioplasty. Patch angioplasty simply enlarges the area of stenosis without removing the local disease process (or consuming any available length of the vein), theoretically leading to a higher incidence of recurrent stenosis [2].

Surgical management of anastomotic stenosis includes [3]:

Creating a more proximal neo-anastomosis.

Vein to vein re-anastomosis,

Vein patching.

Short vein or polytetrafluoroethylene (PTFE) graft interposition.

Percutaneous Technique:

Despite the similarities, the lesions encountered in AV access are much different from arterial lesions, typically resulting from atherosclerosis. The fibrotic, rubbery stenosis characteristic of IH do not routinely dissect, like atherosclerotic stenosis, but more commonly tear or are disrupted as a result of the obligatory higher insufflation pressures applied during balloon angioplasty [4].

Angioplasty is strongly indicated in stenosis of the needling area located at the middle & upper forearm or in the arm. PTA is performed by either puncture of the radial or brachial artery, in case of anastomotic problems, or direct venous puncture above the anastomosis [5].

The balloon is placed within the area of stenosis and insufflated to a pressure that will eliminate any focal stenosis or “waist” seen on the distended balloon. Treatment is repeated until all areas of presumed outflow stenosis are adequately treated. In contrast to arterial lesions, venous stenosis caused by IH routinely require high pressures to resolve, often 20 atmospheres or more. With these increased pressures, trauma to the vein can occur, which can stimulate the IH process, leading to recurrent stenosis. For this reason, some physicians advocate switching to a cutting balloon before high-pressure dilation, allowing subsequent balloon angioplasty to be performed at much lower pressures [6].

An intraluminal stent may be used to treat any residual stenosis or dissections after balloon angioplasty. However, in-stent restenosis is quite common with the use of BMSs and their use in dialysis access conduits has increasingly fallen out of favor. Conversely, covered stents offer several advantages. These devices are essentially fabric-covered stents designed to prevent the ingrowth of hyperplastic tissue, and thus avoid the early failures seen with bare metal stents [4].

PERCUTANEOUS TRANSLUMINAL ANGIOPLASTY (PTA) OF FAILING AVF

Balloon angioplasty is the first option of management of stenotic lesions. Obliteration of accessory veins or ligation is important in some conditions. Complications related to the procedure are low and could be reduced by caution and experience [7].

In comparison with surgery, PTA has many advantages; it results in lowered morbidity in comparison to standard surgical options with less postoperative pain and wound edema, less invasive and excellent success

rates. Endovascular Management of dysfunctional hemodialysis Access (EMDA) usually takes place on an outpatient basis and the patient goes back to home or to the dialysis unit. EMDA preserves other access sites and ensures the immediate use of the access for dialysis after the procedure, and it is also suitable for CVS [8].
Success rate of Percutaneous angioplasty:
Percutaneous angioplasty has a 90% initial technical success rate for both graft and fistula stenosis. The primary unassisted patency is worse for graft than fistula with 25% to 30% patency at 1 year for graft as compared with 67% patency for fistula. The secondary (assisted) patency rates are similar for both graft and fistula at approximately 82% patency at 1 year and 70% patency at 2 years. The complication rate for angioplasty is approximately 4% with hematoma formation as the most common side effect followed by oxygen desaturation and reaction to medication [9].
Indications for Angioplasty of Vascular Access Sites:
The basic indication for angioplasty of AVF in a HD patient is when there:
Stenosis > 50% of lumen's diameter which is accompanied by previous thrombosis.
Increased venous pressure during HD.
Worsening laboratory findings such as hyperkalemia and uremia.
Diminished murmur on auscultation of the vascular access, and finally drop of blood flow in color Doppler of the site [10].
PTA includes these indications but are not limited to this:
Stenosis without presence of thrombosis occurring if the stenosis is exceeding 50% of the reduction in the luminal diameter and is considered functionally significant [11].
Stenosis with presence of thrombosis which is associated with the underlying venous stenosis in much more than 85% of cases [12].
CVS exceeding 50% of the lumen reduction when the VA is hemodynamically compromised and the clinical parameters (as: presence of an arm swelling or frequent failing access). The endovascular intervention with a transluminal angioplasty is the deal of choice for CVS [13].

Balloon angioplasty of the inflow artery, AV anastomosis, juxta anastomotic segment or the outflow segments to enhance the blood flow toward the native vein. Multiple stenotic areas may exist in non-maturing fistulae [14].

Options for percutaneous angioplasty of recurring stenotic lesions:

Angioplasty using high or ultra-high pressure balloons has an improved immediate success rate (100%) compared with standard pressure balloon (92%) but a higher risk of vein rupture. Angioplasty using a cutting balloon may increase the time to next intervention and may eliminate the need for the use of a high-pressure balloon. However, a recent randomized trial reported patency rates equivalent to those of conventional angioplasty, but a greater risk of venous rupture and dissections with the use of a cutting balloon [15].

Angioplasty with a DEBs provides an antiproliferative medication such as paclitaxel to the entire area of the stenosis. This technique may have a higher 6-month patency rates (70% vs 20%) using paclitaxel eluting balloon angioplasty as compared with standard balloon angioplasty; in 1 small randomized study. At this time, longer term data are lacking, but a large randomized trial is underway [16].

Angioplasty using stents does not appear to improve the patency rate for AV access. The main types of stents used in dialysis vascular access include self-expandable stents, covered stents (stent grafts), or drug-eluting stents. Stent grafts are increasingly used for pseudoaneurysms or in areas that are to be cannulated. Stents are only recommended when the stenotic lesion has failed conventional angioplasty with a significant amount of recoil postplasty and if surgery is not an option. Stents are also used as a treatment for vessel rupture associated with angioplasty. Drug-eluting stents (sirolimus, paclitaxel, nitinol, and others) may reduce NIH and improve patency. [17].

The main concerns regarding the use of stents include possible vein depletion with reduced options for future surgeries, limited area of cannulation, stent migration or stent fracture, and intrastent thrombosis. There are no guidelines or studies on the use of anticoagulation or antiplatelet agents as prophylaxis. Furthermore, the cost of stents is prohibitive in some programs [13].

Angioplasty versus Surgery:

The choice for PTA or surgery for the treatment of stenosis of AVFs depends on the experience of the vascular surgeon. However, many centers around the world report an increased number of PTAs over surgery. In any case, the target of both techniques has to be 50% for primary patency during the first 6-month period [18].

Angioplasty is a quick intervention with a low risk of infection. There is no need for placement of a permanent catheter and HD is feasible during the same day after intervention. In a retrospective study of 1987, the annual patency was 19.3% for the surgical method while it was 31.3% for angioplasty. However, many researchers believe in the superiority of surgical management with the placement of graft over PTA. There is a need for less re-procedures with the surgical method, but primary patency of the two methods is the same. In three studies, angioplasty is suggested as the method of choice in the management of AVF stenosis, while the surgical method is suggested in case of PTA failure [19].

Primary and Secondary Patency after PTA:

Most studies report 6-month and even one-year primary patency of 50%. However, there is a need for repeated angioplasty because of the unavoidable hyperplasia of the vessel wall that is caused by the balloon use. In Bountouris et al. study, repeated PTA resulted in assisted primary patency of 85% and surgery resulted in secondary patency of 91%, at one year [20].

The patency of the new angioplasty is the same as that of the initial angioplasty, a finding that is different from the opinion that the surgical method should follow in case of restenosis three months after angioplasty. Ayez et al. showed in their study that repeated PTAs result in secondary patency of 77.8%, at two years [21].

It is believed that an early performed angioplasty is vulnerable to restenosis and this increases the number of possible new angioplasties. Interestingly, Manninen et al. showed that the age of fistula Brescia Cimino at the time of the first angioplasty does not affect the result and that the most important predicting factors for future restenosis are the site of stenosis and the existence of stenosis in the region of anastomosis or in a small diameter vessel. In another study, it is reported that stenosis of length greater than 2 cm is also a predisposing factor for restenosis after angioplasty [22].

There are few studies in literature comparing balloons with stents. It is possible that the use of cutting balloons was associated with better patency in comparison with high-pressure balloons and standard PTA [23].

Post intervention patency:

Continuing normal hemodialysis for at least three sessions after management of an access-related stenosis, a continuous palpable thrill with minimal or no pulsation extending from the arterial anastomosis can be considered an indicator of clinical success [24].

Continuous patency without interruption post-procedure till the next access thrombosis or re-intervention [25].

Cumulative Patency is the total time that the access remains patent (regardless of the number of interventions and/or Thrombectomies) during the given time period. Cumulative Patency begins at the time that the graft or fistula is first placed [7].

Monitoring of Vascular Access Sites:

There are studies supporting the need for monitoring of AVFs with U/S every three months. The same studies support the idea of preventive angioplasty in asymptomatic stenosis. However, the appropriate cooperation between nephrologists, surgeons, and nursing staff, when accompanied by increased surveillance, leads to favorable outcomes, too [26].

Technique

Initial access to the AVF and evaluation:

One of the many challenges faced by the interventionist when evaluating hemodialysis access is the ability to obtain the best access point to the fistula to both diagnose and adequately treat the AVF in a safe, effective, and time-efficient manner. [27]

Physical examination helps direct initial cannulation:

For suspicion of inflow stenosis, the needle is directed upstream (toward the arterial anastomosis).

For suspicion of outflow stenosis, the initial cannulation is directed downstream (toward the venous outflow) [14].

 Many access sites could be used for AVF cannulation and there is no consensus about the best approach for endovascular AVFs salvage procedures:

Direct into the vein either antegrade or retrograde.

Transradial artery approach.

Transbrachial artery approach.

Transjagular approach [27].

It is generally advised that cannulation be done using a 21-gauge needle that allows the introduction of a 0.018 inch guide wire over which a 5-F dilator sheath is inserted and exchanged for a larger sheath if necessary. When initial cannulation is directed upstream, a guide wire is advanced to the arterial anastomosis and, if technically possible, it should be advanced upstream in the feeding artery. A 4- or 5-F infusion catheter is then advanced over the wire across the arterial anastomosis and an arteriogram and full antegrade fistulogram are obtained. This is the most ideal method to obtain the necessary images of the AVF and has the added advantage of evaluating distal arterial flow, which becomes important in cases of distal hypoperfusion syndromes [28].

At times, however, the wire may not advance upstream in the feeding artery due to technical difficulties, and in such cases, one may derive the necessary images by injecting contrast as close to the arterial anastomosis as possible. Injecting contrast in the artery distal to the arterial anastomosis can be very helpful as some contrast often refluxes back to the AVF thereby outlining the arterial anastomosis and the initial segment of the vein [14].

It is noteworthy to mention that when initial cannulation is directed downstream, the arterial and juxta-arterial segments of the AVF can only be seen in a retrograde manner. While in many instances this retrograde approach provides sufficient information, it is a less desired method to evaluate the arterial inflow for several reasons as it may not correspond to actual blood flow leads to underestimation of the degree of stenosis, it does not evaluate for vascular steal, and it may completely fail to provide any information in the presence of upstream accessory veins [14].

In all instances, a full fistulogram should be performed and radio contrast should be traced to the central veins. This allows identification of all vascular lesions contributing to dysfunction of the AVF [14].

It is critical to understand the anatomy and flow dynamics of the AVF and identify all AVF-associated derangements before any intervention is initiated. This means one needs to evaluate: The feeding artery, Arterial anastomosis, Venous outflow, And central veins [14].

Juxta-Anastomosis and Anastomotic Stenosis Management

The most common location for stenosis is the juxta-anastomotic segment of the AVF, and stenosis of the arterial anastomosis is also frequent (Figure 1) [28].

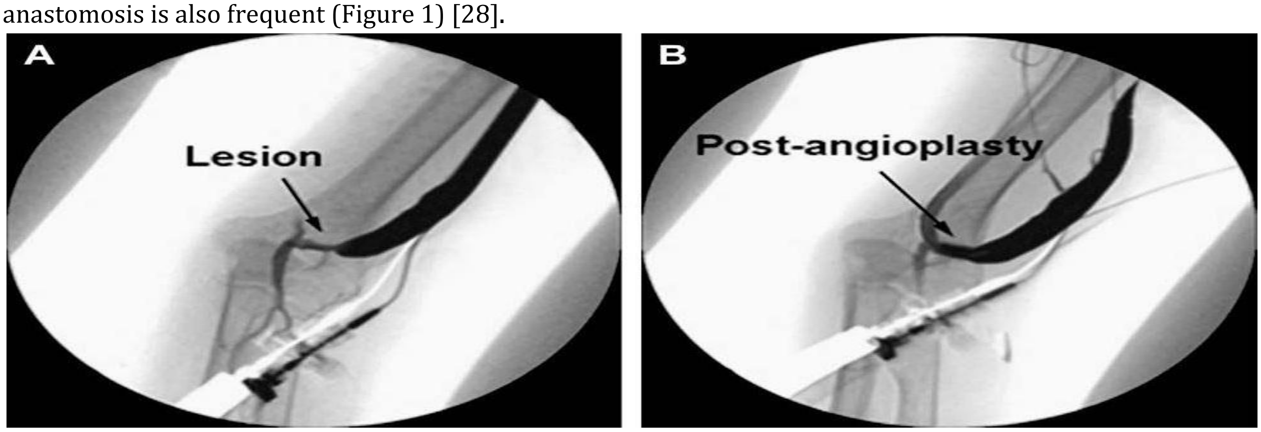

Figure (1): Juxta-anastomotic stenosis. (A) Before treatment (the lesion) and (B) after angioplasty

This is best managed with a retrograde cannulation. In some cases, the segment of AVF that could be punctured is too short to allow for a retrograde cannulation. In this instance, either an arterial approach or retrograde venous approach using sonar-guided puncture of the vein or balloon guidewire entrapment technique [29].

Once the AVF has been cannulated in the desired manner, an angiogram should be performed to evaluate and accurately localize the lesion. This can be easily accomplished by occluding the upper AVF and performing a retrograde injection to reflux radiocontrast into the feeding artery. This should allow identification of all of the pertinent structures [30].

For a lesion to qualify as significant enough to warrant treatment, it should be 50% stenotic or greater. Stenosis is judged by a comparison with the adjacent normal segment [31].

To judge the size of the anastomosis, its diameter should be compared with the diameter of the adjacent normal artery [31].
The first step in treating a juxta-anastomotic or anastomotic lesion is to pass a guidewire across the anastomosis and into the artery far enough to allow optimal positioning of the angioplasty balloon. [30].
Because of the angle of the vein to the artery at the anastomosis and the fact that the area is stenotic, difficulty may be encountered in passing the guidewire. Cannulation of the artery across the anastomosis may be facilitated by the use of a vascular guiding catheter. In some instances, it is possible to safely and effectively treat the lesion that is present with the guidewire passing downward in an antegrade direction. However, in many cases, it is better to have it pass up the artery. Making this turn is difficult at times. The use of a 5-Fr Rosch Inferior Mesenteric (RIM) catheter may facilitate the process. A 25-cm catheter is available and is especially useful in these types of cases [14].
Although the use of a single angioplasty balloon is possible for a juxta-anastomotic lesion that does not involve the anastomosis, when the anastomosis is also affected two sizes of balloons are often necessary. If the angioplasty balloon crosses the anastomosis to lie within the artery, it should be sized to match the diameter of the artery. In most instances, a 4-mm balloon will be found to be appropriate for a radial artery and a 6-mm balloon for a brachial artery, but individual variations exist and should be followed [31].
When treating the lesion within the AVF, oversizing the balloon 20% to 30% is appropriate. Care should be taken to avoid allowing this balloon to enter the anastomosis and adjacent artery [31].
After dilatation, a post-treatment angiogram should be performed to assess the result and check for complications. Although upstream occlusion and a retrograde injection of radiocontrast are permissible for the pretreatment evaluation, this should not be performed after treatment. To be effective, angioplasty tears the vessel. The pressure created with a retrograde injection after a successful angioplasty can result in venous rupture and extravasation. This unfortunate complication can be avoided by passing a vascular catheter over the guidewire into the artery immediately adjacent to the anastomosis and using this to inject the radiocontrast [31].

Proximal Vein Stenosis Management

The management of stenosis in the vein proximal to the anastomosis (excluding the juxta anastomotic variety) is generally more easily accomplished. The same process as described previously should be followed. The major difference is that these lesions can, in most instances, be treated with an antegrade cannulation. The major problem that is encountered relates to the development of collaterals. At times, the anatomy presented is very complex due to the presence of multiple collaterals. This may require considerable time and effort just to determine the location and status of the normal vein. A careful comparison of the physical examination findings and the appearance of the angiogram is often very illuminating [33].

The first step is to pass a guidewire. If the guidewire goes up following the expected path of the normal vein, it is very helpful, especially if it passes up into the central veins. This may occur at times even when the vascular structure through which it passes is not opacified by the radiocontrast [34].

When this occurs, the passage of a vascular catheter (5Fr straight) followed by injections of radiocontrast through the catheter as it is slowly withdrawn is often very helpful in ensuring that the path of the guidewire is indeed the normal vessel [34].

Once the guidewire is up and its proper location has been ensured, an angioplasty balloon can be introduced. The balloon should be sized according to the normal portion of the vein [34].

Some of the lesions that are encountered are resistant to dilatation and require ultra-high pressure balloons [14].

Trerotola et al. found that 20% of lesions in native AVFs required balloon inflation pressures that exceeded 20 atm [35]. However, two major problems have not been solved in conventional high-pressure balloon angioplasty.

a) One is a strong tendency of reobstruction within a short time.

b) The other problem is balloon-resistant stenosis, which represents the major cause of technical failure and inevitably requires surgical intervention. Development of a new device is necessary to overcome such problems.

Cutting balloons are a better alternative to resistant lesions, taking into consideration the higher risk of complication [36].

Once the stenosis has been resolved, the anatomy observed on angiography should become considerably simplified as the collaterals observed initially disappear. [36].

In cases in which the main lumen of the AVF is totally obstructed, dilatation of a collateral may suffice to salvage the access. This must be performed with care because collateral veins are frequently thin-walled and more easily ruptured than normal vessels [37].

Additionally, multiple treatment sessions with increasing balloon sizes may be necessary to arrive at a satisfactory conclusion. In some instances, it is not possible or perhaps even wise to address all the lesions and anomalies associated with early fistula failure [38].

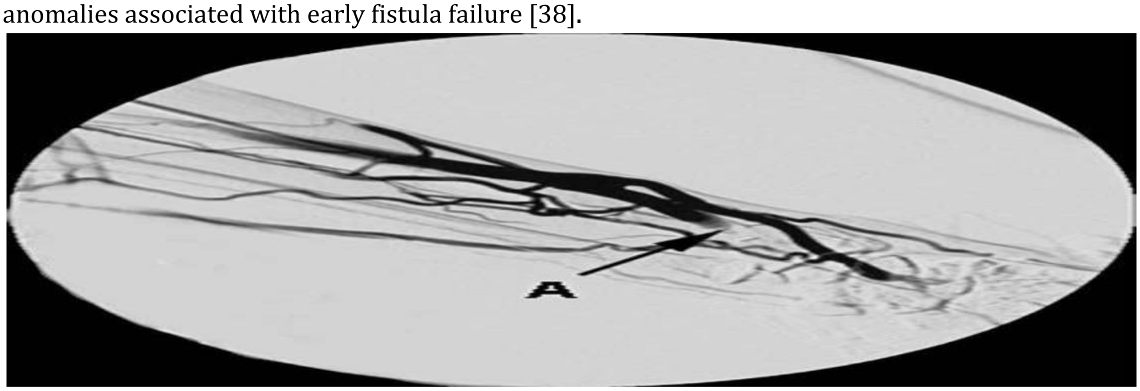

Figure (2): Multiple collaterals because of a proximal stenosis in a radial-cephalic fistula. A (arrow) indicates the site of the anastomosis [39].

Cephalic arch stenosis

Cephalic arch stenosis is a significant cause of brachio-cephalic AVF malfunction. Balloon angioplasty carries a very high rate of restenosis [40].

Balloon angioplasty with stenting provides a better patency if compared to balloon only. And stenting by a stent graft is better than stenting by BMS [41].

Central Venous Stenosis

PTA of CVO in HD patients has been reported since the early 1980s. There is a frequent restenosis after balloon angioplasty and one-year primary patency of PTA alone was less than 40% in most of the studies. To reduce the number of re-interventions, several groups have routinely performed stent placement with each PTA procedure, and most reported improved primary patency rates when compared to PTA alone.

A more moderate use of stents (only for significant restenosis or elastic recoil after PTA, and for early or frequent re-stenoses) has been practiced by other investigators with satisfying results. The use of covered stents or endovascular brachytherapy following stent placement does not enhance patency rates [42].

Type of the balloon used in PTA of failing AVF:

High-pressure balloons are routinely used in balloon angioplasty of venous outflow in failing AVF as we may need to inflate the balloon up to 20 atm [43].

Conventional balloons could be used in balloon angioplasty of failing AVF but paclitaxel-coated balloons are used with higher patency, so we can use DCBs in failing AVF with recurrent restenosis [44].

Cutting balloons could be used in resistant lesions that could not be dilated by high-pressure balloons [36].

Types of Stents

A) Bare metal stents (BMSs)

BMSs were first placed in the dialysis access circuit, for refractory stenoses unresponsive to PTA by Gunther et al. in 1989, [45].

BMSs provide a fixed mechanical support to a site of stenosis, which is resistant or unresponsive to PTA secondary to elastic recoil or NIH. BMSs are potentially useful in CVS in the setting of kinked stenoses, collapsing or elastic stenoses post-PTA, sealing dissections or circumscribed perforations post-PTA, establishing and maintaining patency of early recurrent stenoses after PTA [46].

Box (2): Tips for stenting [47]

Indications
Elastic recoil of stenosis after angioplasty
Early interval symptomatic restenosis
Vessel rupture (consider covered stent)
Initial total occlusion
Stent sizing
Oversize by 10-20%*
Use stent > 4 cm in length*
Stent choice
Self-expanding nitinol preferred
Avoid wallstents*
Avoid balloon-expandable stents*
Location
Avoid stenting over contralateral innominant vein†
Avoid placing stent at thoracic inlet

* Helps prevent stent migration.
† Consider kissing stents site of extrinsic and repeated compression.

Either self-expanding Nitinol stents or wallstents have been widely used in this location. The stent should be extended more peripherally than centrally to achieve more stability and to prevent central displacement or slippage. In younger, more active patients, there may be concern about stent damage in the thoracic outlet region. This has not been reported as a problem for most hemodialysis patients. Placement of a guide wire in the inferior vena cava prevents the stent's possible migration to the right side of the heart or the pulmonary artery should it move during deployment; this also facilitates its removal by snare through the femoral approach by avoiding embolization of the stent into the ventricle, [48].

When stenting is added as an adjunct to angioplasty, immediate results improve to between 76% and 100%, with most studies demonstrating 90% to 100% success rates. Primary patency at 6 months remains relatively good in most studies, ranging between 65% and 68%, [49].

However, there are significant limitations to BMSs. During deployment, BMSs may migrate or shorten and fracture on a short or long term basis. BMS placement may preclude future endovascular procedures, central venous line placement, surgical treatment options, or hamper future AV access creation. It is also clearly evident that BMSs can incite intimal hyperplasia, leading to recurrent stenoses and/or occlusions requiring multiple repeat interventions to maintain patency, [50].

B) Covered stents (CSs):

CSs, also known as peripheral endografts, have been proposed as a new treatment option. The potential advantages of CSs would include providing a relatively inert and stable intravascular matrix for endothelialization, while providing the mechanical advantages of BMSs. This could potentially reduce the NIH, causing restenosis post-PTA or BMS placement [51].

The disadvantages of CSs include their significantly higher cost, the large profile of the delivery systems (7 to 10 Fr), and the limited availability of larger diameter CSs, [52].

Terms for outcome of Treatment of failing AVF

Before the results of angioplasty are evaluated and used to guide therapy, it is necessary to define terms that can be used to measure outcome. The following definitions will be used.

Success Rate

The success rate is the percentage of patients with an initial positive outcome from the procedure. The success rate has two components: technical and clinical.

Technical success is the substantial relief of stenosis or occlusion with residual narrowing of 30% or less, significant hemodynamic improvement, and no major morbidity [53].

Clinical success includes at least one subsequent successful hemodialysis session [54].

Patency Rate

The patency rate is the percentage of patients who have undergone an initially successful procedure for whom flow at the treatment site and symptomatic improvement are uninterrupted in any specified time period. Patency is ended when there is recurrence of symptoms to the same degree as present previously, with angiographic or noninvasive evidence indicating recurrence in the same vessel segment [53].

Primary patency was considered to begin on the day of initial angioplasty and end on the date of fistula failure or further reintervention, whichever came sooner [54].

Secondary patency was defined as patency achieved by means of all repeated endovascular interventions and ended with surgical revision or creation of a new fistula [54].

The results gained by the treatment of failing AVFs have been variable. Nevertheless, when compared with the alternative of abandonment, one is forced to conclude that the results are extraordinarily good. It is very possible that the outcome variations in reported series are caused by variations in the populations studied. Prescreening of cases may have led to case selection favoring a successful outcome. The degree to which this was done is not clear in most reports [55].

References

[1] Tessitore N, Bedogna V, Gammaro L, et al. Diagnostic accuracy of ultrasound dilution access blood flow measurement in detecting stenosis and predicting thrombosis in native forearm arteriovenous fistulae for hemodialysis. Am J Kidney Dis. 2003;42(2):331-41.

[2] Muchayi T, Salman L, Tamariz LJ, et al. A Meta-analysis of Randomized Clinical Trials Assessing Hemodialysis Access Thrombosis Based on Access Flow Monitoring: Where Do We Stand?. Semin Dial. 2015;28(2):E23-E29.

[3] Georgiadis GS, Nikolopoulos E, Papanas N, et al. A hybrid approach to salvage a failing long-standing autogenous aneurysmal fistula in a hemodialysis patient. Int J Artif Organs. 2010;33(11):819-23.

[4] Carmona J, Rits Y, Jones B, et al. Patency of the Viabahn stent graft for the treatment of outflow stenosis in hemodialysis grafts. Am J Surg. 2016;211(3):551-4.

[5] Chen M, Yang S, Zhang T, et al. Clinical application of percutaneous transluminal angioplasty for the treatment of hemodialysis access stenosis: a retrospective analysis. J Vasc Access. 2015;16(6):469-73.

[6] Saleh HM, Gabr AK, Tawfik MM, et al. Prospective, randomized study of cutting balloon angioplasty versus conventional balloon angioplasty for the treatment of hemodialysis access stenoses. J Vasc Surg. 2014;60(3):735-40.

[7] Lok CE, Huber TS, Lee T, et al. KDOQI clinical practice guideline for vascular access: 2019 update. Am J Kidney Dis. 2020;75(4):S1-64.

[8] Nassar GM. Endovascular management of dysfunctional hemodialysis access. Semin Dial. 2008;21(3):278-81.

[9] Luo F, Huang C, Yao G, et al. Comparison of percutaneous transluminal angioplasty and surgical revision after intraoperative dilatation with biliary tract probes for arteriovenous fistula stenosis at juxta-anastomosis. Vascular. 2022;5:17085381221140179.

[10] Khawaja T, Mahmood A, Baig S, et al. Angiographic and Doppler Assessment of Arteriovenous Fistula. J Coll Physicians Surg Pak. 2016;26(11):808-10.

[11] Kundu S. Review of central venous disease in hemodialysis patients. J Vasc Interv Radiol. 2010;21(9):963-8.

[12] Arbab-Zadeh A, Fuster V. Central venous stenosis in hemodialysis patients. J Vasc Interv Radiol. 2016;27(6):959-65.

[13] MacRae JM, Dipchand C, Oliver M, et al. Arteriovenous access failure, stenosis, and thrombosis. Can J Kidney Health Dis. 2016;3:2054358116669126.

[14] Nassar GM, Ayus JC. Infectious complications of the hemodialysis access. Kidney Int. 2001;60(1):1-13.

[15] Depietro DM, Trerotola SO. Choosing the right treatment for the right lesion, part I: a narrative review of the role of plain balloon angioplasty in dialysis access maintenance Background and Objective: The majority of patients with end-stage renal disease (ESRD) requiring. 2017; https://doi.org/10.21037/cdt-22-375.

[16] Karunanithy N, Mesa IR, Dorling A, et al. Paclitaxel-coated balloon fistuloplasty versus plain balloon fistuloplasty only to preserve the patency of arteriovenous fistulae used for haemodialysis (PAVE): study protocol for a randomised controlled trial. Trials. 2016;17(1):1-2.

[17] Fu N, Joachim E, Yevzlin AS, et al. A Meta-analysis of Stent Placement vs. Angioplasty for Dialysis Vascular Access Stenosis. Semin Dial. 2015;28(3):311-7.

[18] Malik J, Lomonte C, Meola M, et al. The role of Doppler ultrasonography in vascular access surveillance—controversies continue. J Vasc Access. 2021;22(1_suppl):63-70.

[19] Azwan MZ, Putra AAN. Percutaneous transluminal angioplasty procedure for central venous stenosis inpatient undergoing hemodialysis in Pelni Hospital: case series. J Indonesia Vasc Access. 2021;1(1):19-23. https://doi.org/10.51559/JINAVA.V1I1.8

[20] Bountouris I, Kristmundsson T, Dias N, et al. Is repeat PTA of a failing hemodialysis fistula durable?. Int J Vasc Med. 2014;2014.

[21] Ayez N, Fioole B, Aarts RA, et al. Secondary interventions in patients with autologous arteriovenous fistulas strongly improve patency rates. J Vasc Surg. 2011;54(4):1095-9.

[22] Romann A, Beaulieu MC, Rhéaume P, et al. Risk factors associated with arteriovenous fistula failure after first radiologic intervention. J Vasc Access. 2016;17(2):167-74.

[23] Agarwal SK, Nadkarni GN, Yacoub R, et al. Comparison of cutting balloon angioplasty and percutaneous balloon angioplasty of arteriovenous fistula stenosis: A meta-analysis and systematic review of randomized clinical trials. J Interv Cardiol. 2015;28(3):288-95.

[24] Trerotola SO, Allon M, Asif A, et al. Definitions and end points for interventional studies for arteriovenous dialysis access: a consensus report from the Society of Interventional Radiology. J Vasc Interv Radiol. 2003;14(9):S247-53.

[25] Allam S, Asfour M, El-Beshbeshy A. Effect of balloon angioplasty on the patency rate of arteriovenous fistulae for hemodialysis. J Vasc Access. 2020;21(2):141-5.

[26] Bountouris I, Kritikou G, Degermetzoglou N, et al. A review of percutaneous transluminal angioplasty in hemodialysis fistula. Int J Vasc Med. 2018;2018.

[27] Rundback JH, Herman GS. Vascular Access for Hemodialysis. In: Hemodialysis Vascular Access. Elsevier; 2011. pp. 1-21.

[28] Higashiura W, Takara H, Kitamura R, et al. Factors associated with secondary functional patency after percutaneous transluminal angioplasty of the early failing or immature hemodialysis arteriovenous fistula. Cardiovasc Intervent Radiol. 2019;42(1):34-40.

[29] Alsheekh A, Hingorani A, Aurshina A, et al. Early Results of Duplex-Guided Transradial Artery Fistuloplasties. Ann Vasc Surg. 2019;60:178-81.

[30] Beathard GA. Angiographic Technique. In: Dialysis Access: A Multidisciplinary Approach. Lippincott Williams & Wilkins; 2004. pp. 151-88.

[31] Asif A, Gadalean FN, Merrill D, et al. Inflow stenosis in arteriovenous fistulas and grafts: a multicenter, prospective study. Kidney Int. 2005;67(5):1986-92.

[32] Alhaizaey A, Alghamdi M, Azazy A, et al. Durability of percutaneous transluminal angioplasty for failing hemodialysis vascular access, retrospective cohort study. Int J Surg Open. 2020;24:185-8.

[33] Elramah A, Asif A, Abu-Alfa A, et al. Radial artery anatomy as a factor influencing arteriovenous fistula maturity: a review of the literature.

[34] Taal MW, Chertow GM, Marsden PA, et al. Brenner and Rector‟s The Kidney E-Book. Elsevier Health Sciences; 2011.

[35] Trerotola SO, Allon M, Asif A, et al. Definitions and end points for interventional studies for arteriovenous dialysis access: a consensus report from the Society of Interventional Radiology. J Vasc Interv Radiol. 2005;16(9):S247-53.

[36] Aftab SA, Tay KH, Irani FG, et al. Randomized clinical trial of cutting balloon angioplasty versus high-pressure balloon angioplasty in hemodialysis arteriovenousfistula stenoses resistant to conventional balloon angioplasty. J Vasc Interv Radiol. 2014;25(2):190-8.

[37] Ahmad A. Management of failed hemodialysis access. J Vasc Surg. 2007;46(5):994-1005.

[38] Falk A. Maintenance and salvage of arteriovenous fistulas. J Vasc Interv Radiol. 2006;17(5):807-13.

[39] Malovrh M. Non-matured arteriovenous fistulae for haemodialysis: diagnosis, endovascular and surgical treatment. Bosnian J Basic Med Sci. 2010;10(Suppl 1):S13.

[40] Davies MG, Flinn WR, Cunningham F. Hemodialysis access: complications and surgical management. Vascular Surgery. 2016;10(4):185-94.

[41] Shemesh J, Koren G, Mor E, et al. Covered stent graft placement for cephalic arch stenosis in hemodialysis access: initial experience. J Vasc Surg. 2008;48(4):860-5.

[42] Mickley V. Central vein obstruction in vascular access. Eur J Vasc Endovasc Surg. 2006;32(4):439-44.

[43] Rasuli P, Chennur VS, Connolly MJ, et al. Randomized trial comparing the primary patency following cutting versus high-pressure balloon angioplasty for treatment of de novo venous ste- noses in hemodialysis arteriovenousfistulae. J Vasc Interv Radiol. 2015;26(12):1840-46.

[44] Kitrou PM, Spiliopoulos S, Katsanos K, et al. Paclitaxel-coated versus plain balloon angioplasty for dysfunctional arteriovenousfistulae: one-year results of a prospective randomized controlled trial. J Vasc Interv Radiol. 2015;26(3):348-54.

[45] Gunther RW, Haage P, Vorwerk D, et al. Percutaneous treatment of thrombosed primary arteriovenous hemodialysis access fistulae. Kidney Int. 1989;35(3):1169-75.

[46] Sanjoy K, Milad M. Treatment of Central Venous Obstruction in the Dialysis Patient: Patient Considerations and Treatment Options. J Radiol Nurs. 2011;30:55-61. Available at www.radiologynursing.org.

[47] Masahiro H, Keith BQ. Central Venous Interventions. Elsevier Inc. http://dx.doi.org/10.1053/j.tvir.2016.11.006

[48] Stavropoulos SW, Pan JJ, Clark TW, et al. Percutaneous transhepatic venous access for hemodialysis. J Vasc Interv Radiol. 2003;14:1187-90.

[49] Hasan H. Dosluoglu, Linda M. Harris. Hemodialysis Access: Non-thrombotic Complications In: Ratherford' Vascular Surgery. 8Th edition, Library of Congress Cataloging-in-Publication Data; chapter 77, p 1135 to 1153.

[50] Vogel PM, Parise CP. SMART stent for salvage of hemodialysis access grafts. J Vasc Interv Radiol. 2004;15:1051-60.

[51] Ananthakrishan G, Bhat R, Severn A, et al. Stent graft exclusion of pseudoanuerysm arising from the PTFE hemodialysis graft after recurrence following ultrasound guided thrombin injection. J Vasc Access. 2008;9(4):293-5.

[52] Keeling W, Hasty J, Asif A, et al. The VIABAHN stent graft: a systematic review of its use in hemodialysis access. J Vasc Access. 2008;9(3):198-206.

[53] SIR Standards Committee. Recommended standards for reports dealing with arteriovenous hemodialysis accesses. J Vasc Surg. 2003;35:603-10.

[54] Maeda K, Tanaka H, Matsuo T, et al. Percutaneous transluminal angioplasty for stenosis of arteriovenous fistulae for hemodialysis access: long-term results and factors affecting patency. J Vasc Interv Radiol. 2005;16(3):335-40.

[55] Beathard GA. Physical examination: The forgotten tool. In: Gray RJ, Sands JJ, editors. Dialysis access: a multidisciplinary approach. Philadelphia, PA: Lippincott Williams & Wilkins; 2002. p. 111e8.