Review

JVA The Journal of Vascular Access

The role of surgery for assisted maturation after endovascular and percutaneous arteriovenous fistula creation

The Journal of Vascular Access
1–9

DOI: 10.1177/1129729820954724
journals.sagepub.com/home/jva
SAGE

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Abstract

Even in the best of circumstances, a significant number of patients will require adjunctive endovascular and/or surgical revision prior to achieving functional patency after endovascular or percutaneous AVF creation, at least within the United States. This rate appears to be higher after percutaneous AVF than after endovascular AVF, although because published reports of the former are mostly derived from American experience and those of the latter derived from experience outside the United States, it is unclear whether these differences are due to the technique itself or cultural and/or anatomic differences in dialysis access practices and patient populations. If arterial inflow is poor, this should be corrected first. When flow is adequate (perhaps 900 cc/min) but no single vein is cannulatable, a dominant suitable vein can be superficialized or transposed. If no suitable vein is dominant (most accurately assessed by using an intraoperative flowmeter), the best vein can be used, with or without occlusion of the other veins or reimplantation into the brachial artery. Finally, if the original anastomosis remains the sole supply to the cannulated vein, the original fistula has achieved assisted primary maturation (and assisted primary patency continues), while if a new arteriovenous anastomosis has been constructed, the original fistula has failed. We point out that for this reason as well as to best utilize the upper arm for later access, endovascular and percutaneous AVFs should be constructed and maintained within an atmosphere where both surgeons and non-surgeons work together on the overall access plan.

Keywords

Percutaneous AV fistula, endovascular AV fistula, brachial vein transposition, basilic vein transposition, access maturation

Date received: 24 March 2020; accepted: 8 August 2020

Introduction

In the past several years, two unique devices to create an arteriovenous fistula using endovascular and percutaneous techniques (endo-AVF and perc-AVF) have been reported. Described in more detail below, the WavelinQ device (formerly EverlinQ, created by TVA Medical, now owned by BD, Murray Hill, NJ) is an endovascular technique used to create an anastomosis between the ulnar or radial artery and adjacent vein,[1,2] while the Ellipsys system (Avenu Medical, San Juan Capistrano, CA) is a technique to percutaneously create an anastomosis between the proximal radial artery and perforating vein.[3] Both devices create an anastomosis between deep arteries and veins in the forearm and rely on flow reaching the superficial veins through

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the perforating or deep communicating vein. In successful cases enough flow will occur in the median antecubial, peripheral basilic, and/or cephalic vein to allow repetitive cannulation. Published experience now consists of somewhere in the range of 400 procedures, performed in the United States, Canada, Paraguay, Mexico, Australia, and New Zealand, with generally encouraging outcomes.

Both procedures are similar in that the fistula itself is peripheral to the antecubital fossa, and flow is not specifically directed into a specific vein. Both rely on the assumption that enough flow will occur in accessible veins to allow repetitive cannulation to deliver the prescribed dialysis. The entry brachial vein may be coiled at the completion of the WavelinQ endovascular procedure to encourage this, but as there are usually paired veins, the other one remains patent. By contrast, the Ellipsys percutaneous system has from the beginning encouraged the use of secondary procedures to direct flow into a target vein suitable for dialysis cannulation (Jeff Hull, personal communication). In some patients, however, despite an apparently normal cephalic vein at mapping, eventual cephalic vein flow is poor and the bulk of the flow is directed through the basilic and/or brachial veins.

Current data from outside the United States suggest that both the WavelinQ endo-AVF and Ellipsys perc-AVF are commonly usable without further intervention (Alexandros Mallios, personal communication).[1,2,4] The experience in the United States has been significantly different, with the majority of these requiring endovascular and/or surgical intervention prior to attaining functionality.[3] The discrepancies between these data has created some confusion and frustration in the adoption of these procedures. This manuscript, therefore, has two goals:

1. To explore the issues surrounding the probability that many perc-AVFs and probably endo-AVFs will require adjunctive procedures (endovascular or surgical) to be ready of use, given current cannulation practices, in the United States, and
2. To describe endovascular and surgical techniques that have been shown to be needed for assisted maturation after endo- and perc-AVF creation.

A note on terminology: There is debate as to the proper terminology for these two techniques. To emphasize that they are two different procedures, in this manuscript we will use the term "endovascular (endo-AVF)" to denote the endovascularly created WavelinQ procedure, and "percutaneous (perc-AVF)" to denote the direct puncture Ellipsys procedure.

Endovascular and percutaneous arteriovenous fistula creation

The WavelinQ (formerly EverlinQ, created by TVA medical, now owned by BD (formerly Bard, Murray Hill, NJ)) is a dual catheter system for creation of an endo-AVF in the proximal forearm.[1,2] The device originally required six French sheath antegrade arterial access via the upper arm brachial artery, but although not yet approved as such in the United States, can also be performed using retrograde four French access from the radial or ulnar artery,[5] with venous access via brachial or forearm veins. Conversely, the Ellipsys system (Avenu Medical, San Juan Capistrano, CA) creates an anastomosis by percutaneous access of the radial artery at the antecubital fossa via the adjacent perforating vein, which is then sealed and dilated according to the amount of flow desired.[3] Initial technical success and maturation have been favorable for both technologies.[6,7] In the WavelinQ system superficial flow is encouraged by coil embolization of one of the paired brachial veins at the time of creation, and in both the target vein(s) for dialysis cannulation are later prepared as needed by obstruction of competing veins by banding, ligation or embolization and/or by superficialization or transposition of matured deeper veins as needed.

Fistulas created by both techniques are described as being low- to moderate-flow, and are similar to surgically created proximal radial artery fistulae which typically have lower flow than brachial artery-based fistulas.[8] It has been shown that brachial artery flow of 500 mL/min is usually required for maturation, and brachial artery flow is usually greater than 900 mL/min in a functional endo- or perc-AVF.[2,3] Similar to established guidelines for surgical fistulas, it is felt that flow in the target access vein for dialysis in endo- and perc-AVFs should have a mean flow volume greater than 500 mL/min.[4,6,9] It should be kept in mind that brachial artery flow is total flow (with flow to the hand, at 50–80 cc/min, assumed to be relatively negligible), which is shared among multiple vessels (described by some as a "polyfistula").

In the United States and Mexico essentially all perc-AVF created using the Ellipsys device have required some combination of surgical and endovascular procedures to provide successful dialysis (Jeff Hull, personal communication).[3,10] By contrast, the rate of endovascular and surgical intervention (excluding planned brachial vein coiling at the time of creation) after creation of an endo-AVF using the WavelinQ device seems to be lower, perhaps significantly so, although data are almost exclusively derived from procedures done outside of the United States,[2,5] and a series from Europe currently in press describing a large series (234 patients) of patients undergoing perc-AVF using the Ellipsys device describes only 11% requiring surgical conversion or elevation. In other words, either procedure done in the US seems to require a greater late intervention rate, although because data are as yet sparse (especially with regard to the 4Fr WavelinQ system) it is completely unknown whether this difference is due to the technique itself or cultural (dialysis access practices) or anatomic (obesity) differences, as discussed more fully below.

For background, the reader should be reminded that most of the basilic (other than at the antecubital fossa in nonobese persons) and all of the brachial veins are typically too deep to directly cannulate, and must be superficialized or transposed to a subdermal location before they can be used. The basilic vein has been so used for decades, and excellent results are universally reported.[11,12] Although dissection is more difficult, equally good results have been achieved after utilization of the brachial vein.[13] In essentially all cases where the brachial vein is used and, currently, in the majority of cases where the basilic vein is used, a two-stage procedure is used.[11,13,14] The first stage is simply a local arteriovenous fistula at the antecubital fossa, while the second is superficialization or transposition of the matured vein, typically 6 to 8 weeks later. The reason for this strategy is to allow maturation of the vein before the extensive dissection required for superficialization.

A significant number of patients undergoing perc- (and likely endo) AVFs could require one or more adjunctive procedures to achieve cannulatability in the United States

While results of endo-AVF and perc-AVF creation have been encouraging, neither of these techniques are always a "single-stage" procedure. First, in the initial report describing the WavelinQ endovascular AVF series, 19 of the 60 patients (32%) required "secondary" procedures to facilitate maturation, and five (8%) required basilic vein transposition.[2] In a more recent series of 35 patients, 54% of patients required additional procedures (41% endovascular and 13% surgical).[15] Similarly, in the initial Ellipsys series, 99 patients (93%) underwent one or more secondary maturation procedures in preparation for dialysis access within the first 6 weeks. The maturation procedures included percutaneous balloon angioplasty (PTA) in 77 (72%), deep embolization in 34 (32%), cubital vein ligation in 33 (31%) and transposition in 28 (26%) patients.[3] Note that all procedures were performed in the postoperative period; to our knowledge no dilation of the anastomosis was performed at the index procedure in this series. Brachial vein embolization at the time of the procedure (mostly during endo-AVF creation) are felt to be beneficial in limiting future secondary procedures, although this has not been proven. The mean time to two needle dialysis was 100 days in the Ellipsys patients and 112 days for the WavelinQ patients.[2–4] While this compares favorably with the USRDS data of 136 days,[16] it should be noted that the URDS data include *all* types of patients with *any* type of fistulas, while both endo- and perc-AVF series comprise select patients who meet the study designs' guidelines. Finally, despite these adjunctive procedures, very roughly 50% of patients who had initiated dialysis with a catheter still had their catheters at 3 months in the Ellipsys series.

Data regarding the Ellipsys perc-AVF show that a high rate of interventions are needed for maturation in cases done in America.[3,8] Interestingly, early European results following perc-AVF creation using the Ellipsys device[4] suggest that a lower rate of interventions (18% endovascular and one superficialization) are needed than in the American experience; ongoing experiences support this trend with only 11% requiring superficialization in an update of Mallos' series.[7] By contrast, while data show lower rates of interventions (other than planned brachial vein embolization) following WavelinQ endo-AVF creation, published cases have exclusively been done in Australia, New Zealand, Canada, and Paraguay.[1,2,5] Update after resolving WavelinQ info.[15] Awaiting results of the WavelinQ procedure in Americans, it seems (perc-AVF) and we suspect (endo-AVF) that more interventions would be needed following fistula creation using either device in American patients versus non-American patients.

Why this difference? We will assume that equally skilled physicians perform the procedures in identical fashion. We propose two reasons for this disparity: First, cannulation practices differ in America versus elsewhere, and, second, the patient population may be significantly different (the fact that the anastomoses are created using different energy types in slightly different vessels may also explain some of this, but this is as yet unknown). With regards to cannulation practices, European centers are much more likely to use ultrasound-guided access, plastic cannulation needles, and highly experienced staff who have been cannulating veins for many years.[17] European access creation providers seem to deal with fewer dialysis centers, in general, and those centers are often geographically closer together, allowing the access provider to be able to attend, in person, initial access attempts (Alexandros Mallios, personal communication). With regard to flow, there are no data to suggest that any anatomic differences exist between techniques, assuming the procedure is performed in a similar fashion, although as the anastomosis is in a different location differences are possible. However, patient and clinician attitudes about dialysis session duration and center capacity to cannulate various vessels differ.[17] Furthermore, what defines "adequate dialysis" differs amongst jurisdictions (e.g. small solute clearance in the United States vs more encompassing views that include middle molecule and volume targets in other countries).

Secondly, patient factors differ. Most importantly, patients in Europe are, on the average, less obese than those in America.[18] Pre-dialysis attitudes are markedly different, leading to the well-known disparity in catheter rates at the onset of dialysis – 80% of patients in North America begin dialysis with a catheter, as compared to numbers that are much lower elsewhere.[19] This late referral pattern actually affects endo- and perc-AVF decision-making in two ways – first, by prolonging the catheter dwell time, and second, by leading to superficial vein injury due to prolonged delay and

repeated phlebotomy. While subjectively some practices in the United States feel that a third or more of their patients are candidates, the patient population in Orangeburg, SC, USA (Dialysis Access Institute) is heavily black, obese, and medically underserved; despite an aggressive attitude toward both procedures (albeit within a very strong "catheter last" atmosphere) less than 5% of our patients evaluated are candidates due to these factors.

Why does the concept that many perc- and endo-AVFs done in the United States will require secondary procedures prior to maturation matter? First, to best manage patient expectations. In the United States it is incorrect to describe a perc-or endo-AVF (to patients and referring physicians) as a "single procedure." While those at the academic forefront of both of these procedures have not taken this point of view, there are many with varying stakes in this arena who have. As above, the majority of patients undergoing perc-AVF (and, we suspect, endo-AVF) will require one or more adjunctive procedures to achieve maturation, and ignoring this may eventually create resentment among patients who "did not expect" further intervention. Secondly, everyone performing either procedure should have an algorithm firmly in mind, and have resources (personally or with colleagues) available to perform whatever procedures are needed. Finally, the need for adjunctive procedures, as clearly shown by the different experiences between the United States and elsewhere will be significantly driven by the ability of the dialysis centers to cannulate an appropriate vein and deliver adequate dialysis at the prescribed dose.

The role of surgery for maturation and assisted maturation following endo- and perc-AVF creation

Figure 1 shows our suggested algorithm for achieving functional maturation following fistula creation by either technique.

First, following a technically successful endo- or perc-AVF, time is needed for anatomic maturation. This is typically between 4 and 8 weeks following conventional fistula creation.[20] The corresponding time needed for maturation following endo- or perc-AVF creation is not well described, but is likely to be the same (if dilation is caused simply by turbulence) or longer (if dilation is proportional to the flow rate) as after conventional AV access creation. Again, keep in mind that while the flow through the fistula itself can initially be as high as that after surgical fistula creation, this flow is shared by more than one vessel after endo- or perc-AVF creation (again, leading to the descriptive term "polyfistula"). In addition, while to our knowledge valves in the perforators of the arms have not been described, flow in the legs, at least, is directed from the superficial to deep systems in normal individuals, and this situation may also occur in the arm ("ties go to the deep system"). The risks of catheter complications are well established, and it thus follows that earlier removal of a catheter is beneficial in both this regard and with regard to decreasing the risk of central vein stenosis.[21] In a qualitative sense, then, the time tolerated (or tolerable) for maturation will be less in patients with catheters, and greater in those without.

Once the arm has been given enough time for maturation (as roughly judged by the presence of visible and palpable veins), duplex flow should be measured in the brachial artery. It has been shown that this brachial artery flow – representing total flow in all veins in addition to nutritive flow to the hand – should be at least 500 cc/min for maturation and approximately 900 cc/min for conventional dialysis. If flow is NOT high enough, three steps should be followed:

- First, adequacy of inflow should be reassessed. Unfortunately, once created, an endo- or perc-AVF cannot easily be compressed, so measurement of resting forearm blood pressure is not feasible. Direct duplex examination of the inflow arteries should be repeated (obviously this should have been done prior to initial access), as it is cost effective and noninvasive, and obviously preoperative hemodynamics (bilateral blood pressures) should be reviewed, as should the history (to look for, for example, evidence of potential atherosclerotic disease or other, rarer entities). Inflow stenosis, especially if preoperative blood pressures were equal, is a relatively rare cause of problems, and we do not advocate routine invasive or CT/MR angiography unless suspicion is high.
- Second, is the anastomotic opening itself large enough? The anastomosis created by the WavelinQ system is 5 mm in diameter, leading to immediate flows of approximately 900 mL/min, and is not usually considered modifiable. By contrast, those created by the Ellipsys system are intentionally modifiable, based on balloon size, and range up to 6 mm, leading to immediate flows of approximately 6 to 900 mL/min. As both of these exceed our 500 cc/min threshold, a total flow of less than this (given normal inflow) implies stenosis of the anastomosis. In this situation catheter-directed imaging should take place. A venous approach may be difficult due to the valves as well as the potential multiplicity of branches; because femoral artery access is very distant from the anastomosis, a brachial or retrograde radial approach may be used. If the anastomosis created after an Ellipsys perc-AVF is stenotic, it can be ballooned up to 6 mm or so; to our knowledge this has not yet been described following WavelinQ endo-AVF creation but likely can be performed after initial healing. Following this, the brachial artery flow should be reassessed; if now

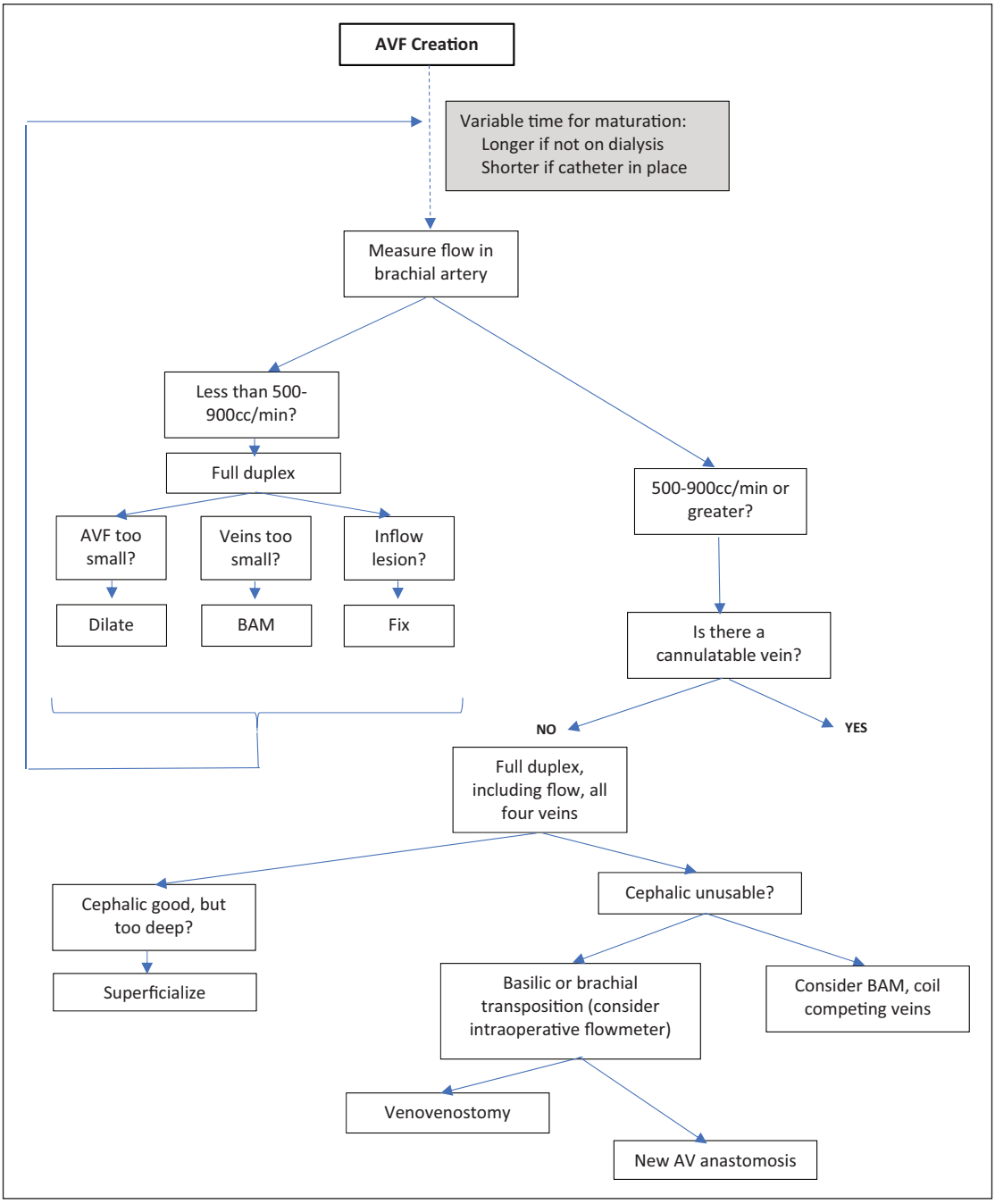

Figure 1. Suggested algorithm for assessment of an endovascular or percutaneous AVF (arteriovenous fistula), and further steps and options for revision if not maturing.

greater than 500 cc/min the algorithm below can be followed, while if less, further time and/or assessment below can be the next step.

- Third, are the outflow veins of adequate quality to allow high flow overall? Even if the anastomosis itself is of optimal size, if the veins are too small and/or noncompliant, adequate flow for dialysis will not occur. Unfortunately there is no objective measurement for this factor. Assessment should be made of the size and distensibility of each vein, the presence of obstruction or thrombus, and the adequacy of outflow to the heart. Unless unsolvable problems are present, two options are available. First is, again, to allow more time, again this being most favorable in patients without a catheter. The second option is to intervene. In general, two options are available, and both can be used together. First is to perform balloon-assisted maturation

(BAM) of the most favorable (ideally superficial) vein if no discrete lesions exist (which obviously should be treated if found), and second is to coil embolize (or surgically ligate) any vein which will not be used for cannulation but may be competing for flow with the optimal vein. It should be noted that this situation is less likely in this branch of the algorithm (overall low flow) but is an ideal option in patients with high overall flow described below).

The better situation is one in which overall brachial artery flow is potentially adequate for dialysis (greater than 900 cc/min). In this situation, the next step is to determine whether there is a "cannulatable" vein by physical exam, which will vary according to patient and situational factors. The NIH Hemodialysis Fistula Maturation (HFM) study suggests that depth ideally should be 4 mm or even less,[22] and most look for size of at least 5 mm. Critically important is the attitudes and skill of the cannulator – be it a nurse, technician, patient, family member, or other caregiver. In certain situations, such as when two median antecubital veins have dilated, the cannulatable length of each (one for each needle) can be fairly short, although this necessitates even more care and skill.

In situations where overall flow is high, but no single vein is felt to be cannulatable, each vein should be assessed using duplex ultrasound. *Four* veins should be examined – the cephalic vein, the basilic vein, and both of the paired brachial veins, and any accessible veins can be compressed (cephalic and occasionally antecubital basilic) to gain more information. Examination should include volume flow, size, and whether or not any anatomic problems exist. Again, three general outcomes are possible:

- First, the cephalic vein is usable (flow greater than 4–500 cc/min, size 6 mm or greater) but too deep. In this situation, it should be superficialized, using any one of several techniques.[23] Consideration can be given to endovascular or surgical occlusion of a vein that is felt to be significantly competing with the cephalic, but this may not be necessary.
- Second, the cephalic vein has inadequate flow, but the brachial or basilic vein has adequate flow and size. In this situation the best vein should be selected and superficialized directly or transposed (division and retunneling). At times deciding which is "best" is not obvious; we (KAI, JA, MJL, JRR) have used an intraoperative flowmeter (Transonic, Ithaca, NY) to make this distinction. Again, any significantly competing vein can be surgically ligated (while in the OR) or occluded using endovascular techniques.
- Finally, while overall upper extremity flow is good, no single vein is obviously dominant. In this case, the access provider should make a decision and commit to this vein. If the cephalic is superficial, this is usually the best option. To "force" flow through this vein, it should be balloon dilated to 6 to 8 mm diameter, and endovascular or surgical reduction of completing flow in other veins should be considered.

Discussion should be made at this point of the anastomosis. If the cephalic vein has excellent flow and is simply superficialized, no new anastomosis is necessary. However, if the basilic or brachial vein is transposed, this is an important issue. Unfortunately, as the anastomosis of an endo- or perc-pAVF is peripheral to the antecubial fossa, flow will continue in multiple veins despite ligation of competing veins at the fossa itself. If there is a single dominant vein with flow over about 500 cc/min, we feel that a veno-venostomy is reasonable. However, if after exploration and occlusion of any competing veins flow remains less than 500 cc/min, we suggest reimplanting the chosen vein into the brachial artery, creating a fresh arteriovenous anastomosis.

Extensive experience following the use of the brachial vein for access (assuming the cephalic and basilic veins are occluded) shows that arm swelling is highly unusual in the absence of central stenosis.[24] Note that balloon-assisted maturation of a deep vein when later transposition is planned is strongly discouraged, as it usually results in a virtually ruptured, chronically non-dissectible/transposable vein (personal experience, JRR). Again, if this decision is being made at exploration, an intraoperative flow measurement is extremely helpful. Finally, we emphasize that the strategy of coiling a competing vein while waiting for further maturation is a better strategy in a patient without a catheter, while direct surgical transposition with ligation of competing veins is a better strategy in a patient who has a catheter.

A note describing the maturation process

Because the maturation process after endo- and perc-AVF is likely more complex than after surgically created access, we feel special attention should be paid to this process. It is tempting to label patients in whom adjunctive procedures are needed for maturation to have "failed" the endo- or perc-AVF, in the purest sense, but also to claim that an endo- or perc-AVF that has undergone a procedure to assist in maturation has "succeeded." We propose that terminology exactly parallel that used in reports describing both access[25] and lower extremity bypass.[26] Absolute success (maturation and beyond) of an endo- or perc-AVF depends on whether the original anastomosis continues to supply flow to the cannulatable vein. In other words, if the anastomosis remains patent and the access is being used, it has matured. If endovascular or surgical procedures have been needed to allow use but the original anastomosis continues

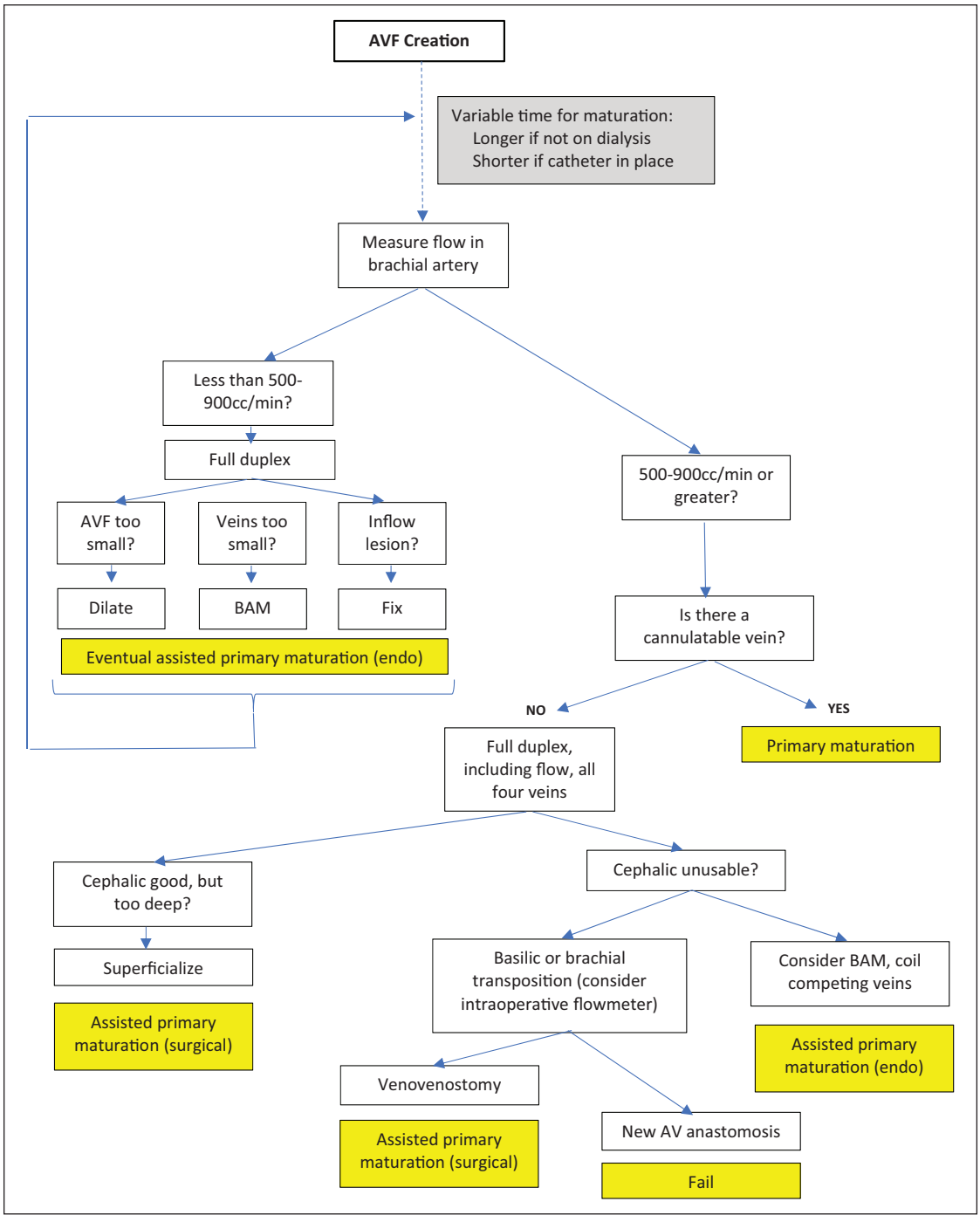

Figure 2. Figure 1 with relevant terminology (as per text) assigned.

to supply the access vein, maturation can be described as assisted. Finally, if a new anastomosis has been created, the original e- or pAVF has failed (Figure 2).

A significant issue arises as to terminology following a planned staged procedure – in this context, performance of an endo- or perc-AVF when it is certain that only a deep vein will mature, and a subsequent transposition or elevation will be needed. The analogous situation is that of a surgically created staged brachiobasilic transposition. This situation was not addressed in the 2002 Reporting Standards document[25] as staged basilic vein transposition was not yet widely performed, but the document does emphasize, as do all descriptions of vessel patency, that *any intervention needed to achieve functional success causes primary patency to end*. Most authors feel the same standards must be applied to endo- and perc-AVFs, even if intentionally

staged. Just as the primary patency of the original brachiobasilic fistula ends (while assisted primary patency continues) at the time that it is transposed, so too will the primary patency of the original endo- or perc-AVF when it is intervened upon. As above, however, if the original anastomosis continues to supply the cannulatable vein, assisted primary maturation (and ongoing assisted primary patency) has been achieved, while if a new arteriovenous anastomosis is necessary, the original fistula has failed.

Finally, a recent manuscript from a committee including interventional nephrologists and vascular surgeons provides interesting terminology and concepts. An access is divided into five phases: Creation, maturation, clinically functional, sustained use, and dysfunction.[27] While this does not alter the mathematics of determining maturation and patency, it provides a useful framework for conceptualizing this process (our paper, obviously, is directed at the maturation process, stage 2).

Real-world single center experience

"Real-world" results from one center not having participated in either trial (Dialysis Access Institute, Orangeburg, SC) but with access to both systems are illustrative. Between September 2018 and June 2019, a total of 19 procedures were performed.

Of 11 perc-AVFs using the Ellipsys system, one patient primarily matured. Another four patients required interventions (one endovascular, two surgical, and one both), while three patients have failed (one entirely abandoned, two undergoing deep vein transposition with an entirely new anastomosis due to insufficient flow). One fistula is patent but not yet mature, while two are patent but not yet being used. Of the eight perc-AVFs created in arms eventually used for dialysis, our primary maturation rate is thus 13% (one of eight), our assisted primary maturation rate 50% (four of eight), and our failure rate is 37% (three of eight).

Of eight endo-AVFs using the WavelinQ system (all 6Fr access using the ulnar artery), no patient has primarily matured. Three patients required interventions (one endovascular, two surgical), while three patients have failed (all three undergoing deep vein transposition with an entirely new anastomosis due to insufficient flow). One patient has been entirely lost to followup, and one procedure was not completed due to heavy vessel calcification. Of the six endo-AVFs that have been created in arms eventually used for dialysis, our primary maturation rate is thus zero, our assisted primary maturation rate 50% (three of six), and our failure rate 50% (three of six).

A question of intent

Finally in certain cases, the endo- or perc-AVF can be performed as an *intentional* first stage of a two-stage BBTx (this is, of course, equivalent to the discussion above, but the difference is that of intent). There are several potential advantages. The endo- or perc-AVF procedure is minimally invasive, and has at least equivalent technical success as compared to that after first stage BBTx (both 90% or more).[28] A drawback of staged surgical BBTx is loss of length. After endo- or perc-AVF there is no scar at the antecubital fossa which may compromise the lie and length of the vein upon transposition. These factors can all be considered in a patient with an inadequate cephalic vein who is otherwise a good candidate for endo- or perc-AVF. This is not an entirely academic discussion; preoperative discussion that a second operation may be required will very often improve patient expectations and satisfaction.

Important in this context, finally, is the supposition that an endo- or perc-AVF "saves the arm" for later conventional access should it fail. Unfortunately, while attractive in theory, if a significant number of interventions are needed many of these arms could subsequently undergo coiling of deep veins, ligation of various veins, and/or stenting or other procedures designed to achieve success of the original fistula but that may worsen or even eliminate subsequent surgical options. This also should be considered, ideally by performing all of these procedures within an atmosphere of collaboration and discussion between surgeons and non-surgeons together.

Conclusion

Even in the best of circumstances (experienced operators with stringent patient selection), a significant number of patients in the United States require adjunctive endovascular and/or surgical revision prior to achieving functional patency after an endo- or perc-AVF. As long as the original anastomosis remains the supply to the fistula, these patients should not be considered to have failed, but rather to have achieved assisted primary maturation. Direct knowledge of maturation rates and procedures needed to achieve them will be critical to assess overall success of endo- and perc-AVF, to properly counsel patients prior to surgery, to manage expectations of referring physicians, and, once correlates are determined, to better assess which patients are ideal candidates for this strategy, especially in those who are already on dialysis with a catheter in place.

Acknowledgements

The authors would like to thank Alexandros Mallios, MD and Nicholas Inston, MD for their helpful comments and criticisms.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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