Approach to an Arteriovenous Access with a Faint Thrill

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A well-functioning dialysis vascular access is crucial for providing adequate hemodialysis treatment. Arteriovenous fistula (AVF) remains the preferred vascular access among all the other available options, which include arteriovenous graft (AVG), central venous catheters (CVC), or a hybrid access (combination of AVF-AVG or AVG-CVC). Low incidence of infections and thrombosis and lower maintenance costs are the primary reasons to prefer AVF over other vascular access types [1–4]. Once the initial challenge to attain a mature and functional AVF is overcome, maintaining its patency is relatively easy as compared to AVG.

Arteriovenous fistula is commonly created in the upper extremity either in the forearm or in the upper arm using native vessels. AVF in the lower extremity is uncommon but can be created in select group of patients. The common sites for AVF creation are listed in Table 15.1 [5, 6].

The clinical practice guidelines from the Kidney Dialysis Outcomes and Quality Initiatives recommend establishing a monitoring program for early identification of dysfunctional AVF [7]. Monitoring is defined as performing a detailed physical examination of the vascular access and remains a key component in the evaluation of an AVF. Physical examination is a simple, cost-effective, reproducible, and a validated tool that can be effectively utilized for the assessment of an AVF. Physical examination can be easily performed on every dialysis patient and is mandated in the USA as per 2008 requirements established by the Centers for Medicare and Medicaid Services [6, 8]. An experienced dialysis nurse can diagnose a mature AVF with 80 % accuracy by physical examination alone, a fact validated with ultrasound evaluation of 69 patients with a newly placed AVF [9].

Several studies have confirmed the value of this bedside tool in accurately diagnosing both the inflow and outflow stenoses in an AVF with 85–90 % sensitivity and 75–80 % specificity [10–12]. The physical examination performed by a nephrology fellow after 4 weeks of intense training has been shown to be 100 % sensitive and 78 % specific for inflow stenosis and 76 % sensitive and 68 % specific for outflow stenosis [13].

15.1 Components of an Arteriovenous Fistula

An AVF is a continuous circuit and not merely a surgical anastomosis between an artery and vein. The circuit starts at the heart and ends at the heart, and examining the entire circuit is absolutely essential to evaluate an AVF. Besides the right and left side of the heart, the other components of AVF are the entire arterial and venous system of the extremity and the central veins. An AVF can be examined in three segments (Fig. 15.1): (a) the inflow segment includes the feeding artery, the arteriovenous anastomosis, and the juxta-anastomotic region; (b) the main body includes the cannulation segment that is used to access an AVF during hemodialysis; and (c) the outflow segment includes the veins (including the central veins) proximal to the main body that return the blood to the heart.

15.2 Physical Examination of an Arteriovenous Fistula

15.2.1 Normal Findings

A normal AVF is soft and compressible. A distinct pulse with a continuous thrill is present at the inflow segment and along the majority of the body of the AVF. The thrill tends to dissipate as the palpating finger is moved proximally along the outflow segment. On auscultation the bruit is a low-pitch sound heard during the entire cardiac cycle. The bruit is loudest at the arterial anastomosis and fades along the outflow segment.

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Table 15.1 Common sites for arteriovenous fistula creation

Site	Artery	Vein
Upper extremity – *forearm*		
Snuff-box	Radial	Forearm cephalic
Radiocephalic	Radial	Forearm cephalic
Transposed radio-basilic	Radial	Forearm basilic (transposed to volar surface)
Proximal forearm	Proximal radial	Deep forearm perforating
Transposed brachiocephalic	Brachial	Forearm cephalic (transposed as loop)
Upper extremity – *upper arm*		
Brachiocephalic	Brachial	Upper arm cephalic
Transposed brachiobasilic	Brachial	Transposed basilic
Lower extremity		
Saphenofemoral	Femoral	Saphenous

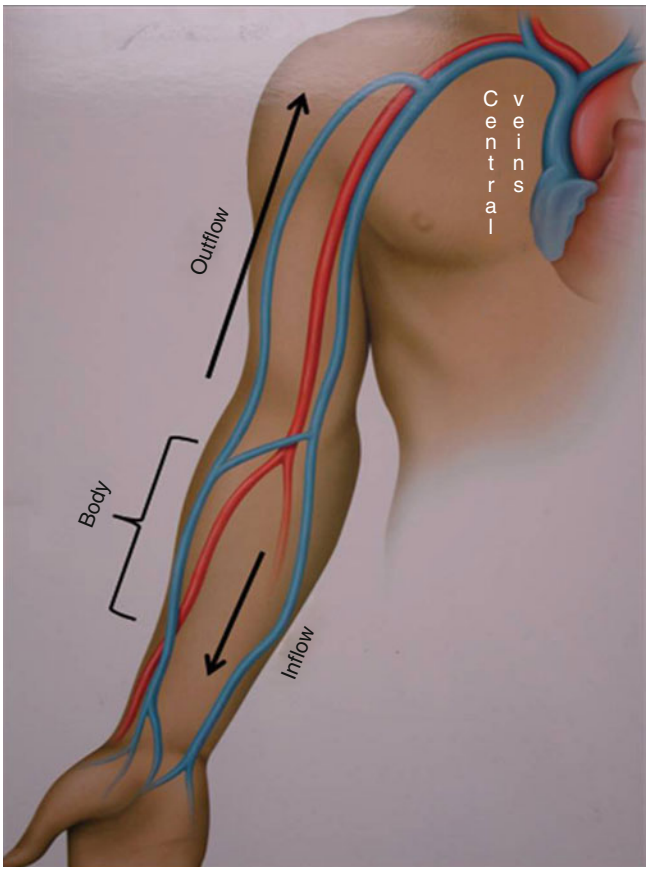

Fig. 15.1 Three segments of an arteriovenous fistula – inflow, body, and outflow

15.2.2 Augmentation Test

A feeble pulse at the inflow segment accompanied by a faint thrill is an abnormal finding that needs further evaluation

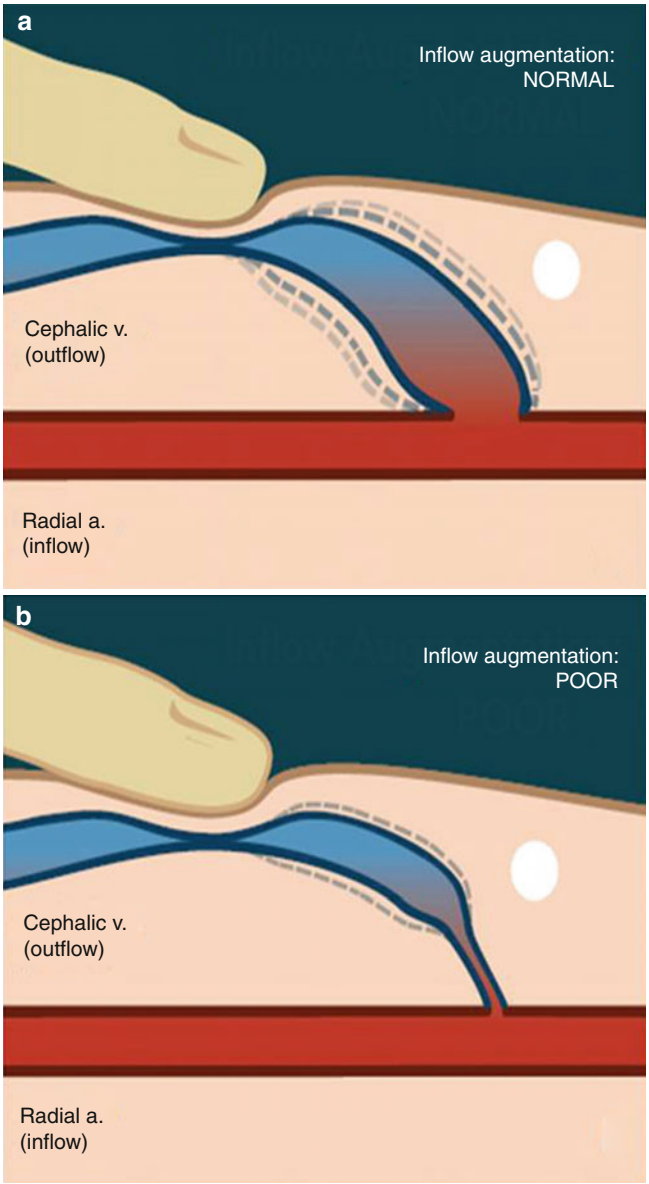

Fig. 15.2 Augmentation test – palpate the segment of the vein between the point of manual occlusion and the anastomosis. Panel **a** – Hyperpulsatile segment shown as distended and dashed segment with patent inflow segment. Panel **b** – Poor augmentation in presence of inflow stenosis

with an "augmentation" test. The test is performed by manually occluding the outflow in the main body of the AVF. The pulse in the inflow segment gets strong and forceful, also called "water hammer pulse" in a normal well-functioning AVF. In a dysfunctional AVF, the manual occlusion of the outflow fails to augment the inflow segment suggestive of inflow pathology. The augmentation test is schematically shown in Fig. 15.2. The thrill and bruit accompanying a feeble pulse are proportionately faint. Additionally, the bruit may be heard only during the systolic phase of the cardiac cycle [14].

Table 15.2 Etiological factors for a faint thrill in an arteriovenous fistula (AVF)

Cardiac
Poor left ventricular function and low ejection fraction
Congestive heart failure
Feeding arteries
Extensive atherosclerotic peripheral arterial disease
Localized stenosis in the proximal arteries
Stenosis at the arteriovenous anastomosis
Poor surgical technique in a new AVF
Neointimal hyperplasia in an established AVF
Stenosis in the juxta-anastomotic segment
"Swing-site" segment stenosis
Neointimal hyperplasia

15.3 Etiology of a Faint Thrill

A faint thrill on physical examination with failed augmentation test localizes the pathology to the inflow segment. The thrill is produced because of the turbulence created by the blood flowing from an artery with high pressure across the arteriovenous anastomosis into a thin-walled vein with low pressure. The high pressure in the artery is maintained by a well-functioning cardiac pump. Any pathology that can compromise any of these components will lead to a physical examination finding of weak pulse and faint thrill. The common etiological factors are listed in Table 15.2.

Hemodynamic status and uremic milieu are key components to maintaining AVF patency. A generally accepted clinical practice dogma is for patients to have a minimum systolic blood pressure of 100 mmHg for AVF to mature. Once an AVF matures, the incidence of AVF dysfunction, especially thrombosis, is frequent with hypotensive episodes during dialysis, highlighting the importance of hemodynamic factors [15].

In a newly created AVF, small vessel size and poor surgical technique often lead to early development of stenosis at the anastomosis site resulting in faint thrill on clinical examination [16]. "Swing site" is the segment of the vessel that is mobilized to create the anastomosis, which for radiocephalic and brachiocephalic fistulas is the juxta-anastomotic region. "Swing site" segment stenosis accounts for 65–70 % of early AVF maturation failures [17].

A fully matured AVF generally needs much less attention compared to AVG. Nevertheless, stenosis remains a major hurdle for long-term patency of AVF. Stenosis is frequently seen at the juxta-anastomotic region secondary to neointimal hyperplasia and smooth muscle cell proliferation. As yet, the exact pathophysiology behind neointimal hyperplasia remains unclear [18, 19].

15.4 Practical Approach for Timely Intervention

Inflow segment pathology can be identified with frequent physical examination of an AVF. A newly created AVF generally matures to support hemodialysis treatment in 8–12 weeks after the surgery. An AVF with blood flow of 500–600 ml/min and luminal diameter of 6 mm is considered to be mature enough to support regular dialysis treatments. KDOQI clinical practice guidelines recommend everyone involved in the care of dialysis patients to be proficient in the physical examination of an AVF. A simple algorithm based on whether an AVF is new or established can assist with identifying the problem sooner for timely intervention.

15.4.1 New AVF

A successful AVF undergoes changes that are predictable with incremental increase in blood flow and vessel size over a 4–6-week period after the surgery. All newly created AVFs need to be examined at least by 6 weeks to identify a failing maturity process. Further management and intervention in a newly created AVF with faint thrill is outlined in Fig. 15.3. The examination of a newly created AVF should be performed by a skilled personnel and include an "augmentation test." If the augmentation test is negative, further testing involving either an ultrasonography or an angiography can help identify the problem for timely intervention. Ultrasound evaluation is a noninvasive test but can help only with confirming the physical examination findings. Moreover, the test adds to the overall cost of care. Angiography is a definitive test that can help identify the stenosis and correct the pathology by simultaneously performing an angioplasty. Inflow stenosis is a very commonly diagnosed problem, and early intervention has helped salvage a great majority of early failed AVF. In a study of 100 cases with early AVF failure, 78 % had significant stenosis identified as an etiology for poor maturation. Percutaneous angioplasty was successful in 98 % of these cases, and 92 % of AVFs were successfully salvaged following intervention [20].

If the augmentation test is positive at 6 weeks, an AVF can be monitored regularly at 1–2-week intervals for a maximum of 12 weeks. If at the end of 12 weeks, an AVF remains immature, then further investigation with fistulography should be considered. Waiting longer than 12 weeks, hoping for an AVF to mature, is generally not in the patient's best interest. Active and aggressive intervention can help salvage these immature fistulas and shorten the duration of alternate vascular access, which is invariably a tunneled central venous catheter. If a fistulogram fails to identify any correctable pathology to assist with AVF maturation process, alternate

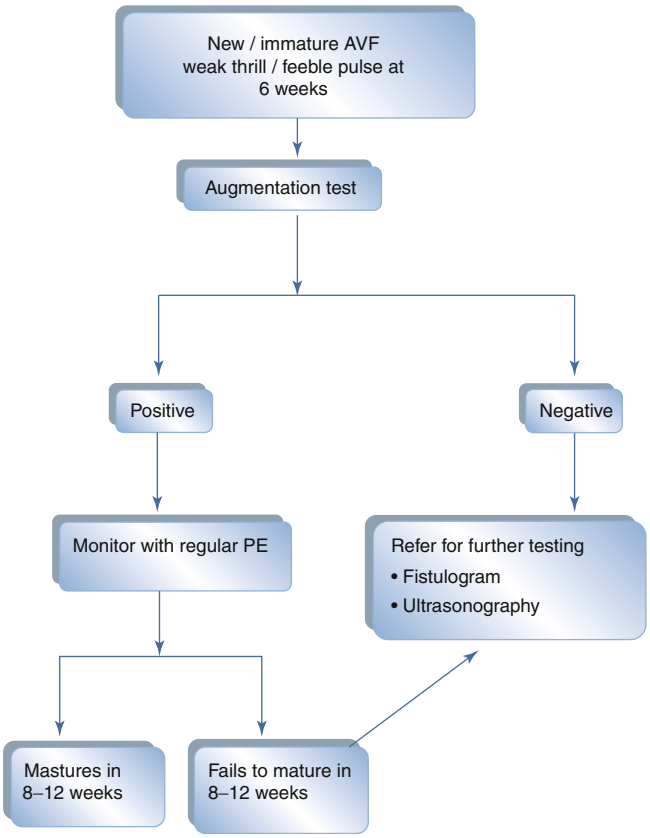

Fig. 15.3 Management algorithm for a newly created arteriovenous fistula with weak thrill or pulse

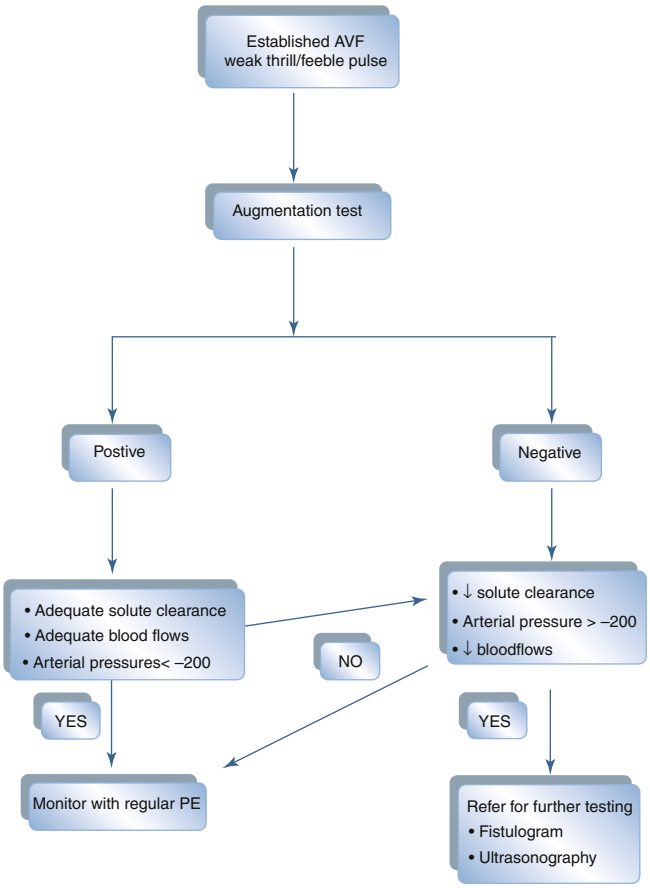

Fig. 15.4 Management algorithm for an established arteriovenous fistula with weak thrill or pulse

plans to create another permanent vascular access should be made immediately, and the patient needs to be referred back to the surgeon.

15.4.2 Established AVF

Hemodialysis process is complex and involves constant monitoring of the patient as well as the hemodialysis machine. A complete and thorough physical examination of an established AVF should be performed before each dialysis treatment by skilled dialysis personnel. During the treatment process, various settings on the hemodialysis machines, such as speed of the blood pump, and arterial and venous pressure monitoring are routinely performed by the dialysis staff. The quality of the dialysis treatment is judged by measuring the solute clearance from blood tests performed on a monthly basis. Figure 15.4 outlines the clinical approach for evaluating an established AVF with faint thrill. The algorithm incorporates the physical examination findings and other hemodialysis machine parameters and provides a practical approach to identify a failing AVF. The average blood flow prescribed for hemodialysis treatment in the USA is around 350–400 ml/min. The dialysis arterial pressure recorded with 350–400 ml/min blood flow from a well-functioning AVF is generally less than negative 200 mmHg. Inflow segment stenosis is less than likely, if the prescribed blood flow is not achieved or the arterial pressure is more than negative 200, along with faint thrill at inflow.

A significant inflow segment stenosis is unable to support the high blood flows necessary to provide adequate dialysis treatment. The inability to achieve the prescribed blood flow during treatment leads to high arterial pressures on hemodialysis machine and frequent tripping of arterial alarm limits. The end result is high recirculation rate with inadequate solute clearances on monthly blood tests. Timely identification of these abnormal findings can assist with early intervention of the underlying stenosis. Vascular stenosis is a progressive process that will ultimately culminate in complete occlusion and thrombosis and eventual loss of flow. The next step in the management is confirming the physical examination findings with either an ultrasonography or an invasive angiography. Fistulogram remains the gold standard test to confirm stenosis. Once the diagnosis is confirmed, simultaneous angioplasty can help maintain the access patency.

15.5 Summary

Inflow segment stenosis in both new and established AVF can be diagnosed with a well-performed physical examination by skilled dialysis personnel. Regular monitoring of an AVF can help with early diagnosis for timely intervention to maintain access patency. A simple algorithm utilizing clues obtained from physical examination, blood flows and arterial pressures from dialysis machines, and monthly laboratory test results can effectively help diagnose inflow segment pathology.

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