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Review Article

Safety Measures for Hemodialysis Vascular Access to Save the Lifeline of Hemodialysis Patients

Ahmed Salama Al-Adl

Department of Internal Medicine, Damietta Faculty of Medicine, Al-Azhar University, Damietta, Egypt

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Corresponding author

Email: salama76@gmail.com

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ABSTRACT

Background: Chronic kidney disease (CKD) patients need efficient vascular access once they progress to end-stage renal disease (ESRD) and require hemodialysis (HD). The most common forms of vascular access used in clinical practice are arterio-venous fistula (AVF), arterio-venous graft (AVG), and central venous catheters (CVC). AV Fistula is preferred over AVG and CVC because it provides better patient and Access survival owing to fewer access-related complications.

Vascular access is the lifeline of the hemodialysis patient., vascular access malfunctions remain one of the extreme challenges in caring for hemodialysis patients, early fistula creation is very important because avoidance of early cannulation and complications of temporary catheter insertion, vascular access care is an essential especially physical examination and care by a nephrologist, nursing staff and by the patients. The review aims to highlight the importance of hemodialysis vascular access, prevention of its complications, to decrease the morbidity and mortality related to hemodialysis vascular access complications.

Keywords: Chronic Kidney Disease (CKD); Hemodialysis (HD); Arterio-Venous Fistula (AVF).

Introduction

Chronic kidney disease (CKD) patients require efficient vascular access once they develop the end-stage renal disease (ESRD) and necessitate hemodialysis (HD). Vascular access is considered the lifeline of the hemodialysis patient [1]. HD treatment provides a life-saving option for patients with CKD and enables them to survive for many years with a good quality of life [2]. The ideal choice of vascular access in patients requiring hemodialysis is an arteriovenous fistula [3].

Vascular access malfunction is associated with increased morbidity and mortality, such that plans to prevent these consequences are essential [4].

Types of hemodialysis Vascular access

The most common forms of vascular access used in clinical practice are arterio-venous fistula (AVF), arterio-venous graft (AVG), and central venous catheters (CVC) [5].

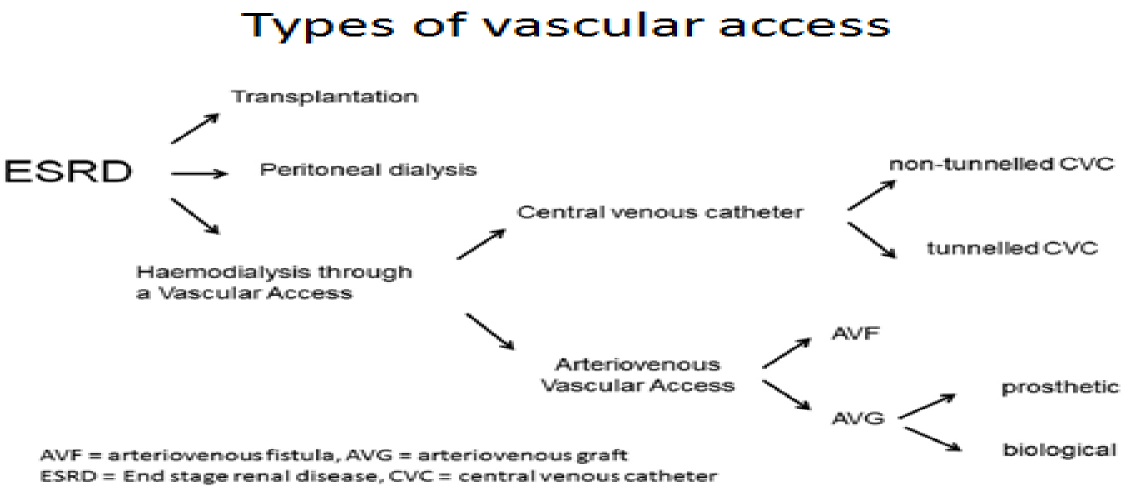


Figure [1]: Types of hemodialysis vascular access

AV Fistula is favored over AVG and CVC for the reason that it provides better patient and Access survival owing to fewer access-related complications [6].

A- Arterio-venous fistula: Advantages; reduced risk of Mortality, lowest infection hazard, decrease risk of hospitalization, longer patency once created, not expensive particularly if no primary failure, sufficient blood flow once mature [7]. Disadvantages of AVF include high-rate primary failure, prolonged maturation time, ischemic steal, and not being suitable for all patients as the elderly.

B- Arterio-venous graft: Advantages; no long maturation time, patency when compared to AVF if involved primary failure, lesser infection hazard, excellent Choice in elderly, reduced line exposure time. Drawbacks include greater infection risk compared to AVF, need for (multiple) interventions to preserve the patency, vascular Steal, and expense.

Fistula first program

The National Kidney Foundation (NFK) initiated the Dialysis Outcomes and Quality Initiative (DOQI) in 1995, currently stated as the Kidney Disease Outcomes and Quality Initiative (KDOQI), which issued a great evidence-based set of clinical guidelines to support advanced healthcare consequences among patients with end-stage renal disease (ESRD) [8].

One chief concentration of KDOQI is optimal arteriovenous (AV) access supervision, which has led to the design of the National Vascular Access Improvement Initiative (NAVII) and its Fistula First campaign [8].

KDOQI makes up it obvious that all patients with stage IV (GFR: 15-29 ml/min/1.73m2) or stage V (GFR: ↓15 ml/min/1.73m2) chronic kidney disease (CKD) who opt for hemodialysis must undergo autologous fistula creation. To conserve viable access locations, they advise a radio-cephalic arteriovenous fistula (RCAVF) as the earliest and most excellent choice. If not achievable, then a brachiocephalic arteriovenous fistula, followed by a basilic vein transposition has to be generated in the non-dominant arm [8].

Prosthetic arteriovenous bridge grafts and tunneled dialysis catheters are stated as the last option in patients with no autologous choices [9].

Arterio-Venous Graft

Both synthetic and biological grafts are accessible and have been applied for VA. Biological grafts such as a bovine carotid artery or bovine mesenteric vein, which have been considered immunologically inactive, have been applied broadly in several units but their relatively high expenses and worries of long-term aneurysm formation and rupture have restricted their use [10].

Tissue-engineered grafts have been applied in a slight number of patients, but it is too early to decide whether these have any benefits over other grafts [10].

Complication of arterio-venous fistula includes [11]:

- Non - development, and secondary failure.
- Inadequate blood flow
- Steal syndrome (ischemic injury) (hemodialysis access induced distal ischemia).
- Infection of cannulation site.
- Stricture (narrowing of the arterial or venous lumen).
- Bleeding.
- Thrombosis (disturbance or obstruction of VA bloodstream).
- Ischemic Neuropathy.
- Aneurysm at the cannulation site.
- Venous hypertension (sore thumb or sore hand syndrome).
- Excessive blood flow, increased stress on cardiac function (high-output failure).
- Recirculation.

Attempts for prevention of AVF complications

1. Examination of arteriovenous fistula.
2. Prophylactic antiplatelet.
3. Using fish oil to enhance vascular access outcomes.
4. Using statins to increase vascular access outcomes.
5. Using ACEI/ARB to improve vascular access outcomes.
6. Novel and future treatment strategies.

Examination of arterio-venous fistula for detection of early dysfunction (Look, feel, listen)

■ **Look (inspections)**

► Type of fistula: Radio-cephalic: at wrist Brachiocephalic, at elbow crease, Upper arm transposed basilica fistula

► Scars.

► Signs of inflammation: rash, erythema, swelling arm elevation test (for outflow obstruction): fistula should collapse on arm elevation.

► Hands: edema, ischemia (Steal syndrome = vascular insufficiency secondary to AV fistula).

■ **Feel (palpation)**

► Thrill: shouldn't be pulsatile: should be soft in consistency and easily compressible.

► Augmentation test (for anastomotic stenosis): occlude vein 1-2 cm above anastomosis. If arterial pressure is adequately conducted (i.e. there is no anastomotic stenosis), pulsation in the vein will be seen.

NB. If the vein is pulsatile anyway, there is venous outflow stenosis.

■ **Listen (auscultation)**

► Bruit: should be soft thrill (high pitched = stenosis) [12].

Prophylactic antiplatelet

The clinical trials of antiplatelet agents and vascular access outcomes in hemodialysis patients suggested that inhibition of platelet function can decrease AVF thrombosis [4].

Antiplatelet therapy was linked with lower in-hospital mortality. Aspirin benefits among AVG patients revealed improved primary patency rates compared to no antiplatelet therapy. It is recommended to use antiplatelet treatment, especially in patients on AVG [13].

Utilizing fish oil to enhance vascular access outcomes

Omega-3 fatty acids are usually observed in fish and fish oils. These polyunsaturated fatty acids, principally eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), have been revealed to reduce blood viscosity and enhance red blood cell deformability, promote vasodilation, prevent smooth muscle proliferation and platelet aggregation, and decrease inflammation, all of which have the chance to improve vascular access maturation and lessen access stenosis and thrombosis [4].

Statins usage for enhancing vascular access outcomes

Statins have pleiotropic actions away from lipid lowering that could lessen vascular access stenosis and thrombosis. Statins decrease neointimal hyperplasia by reducing vascular endothelial growth factor-A (VEGF-A). Statins may also stimulate vasodilation by raising endothelial-derived NO and reduction of endothelin1 release. Multiple anti-inflammatory effects involving a decline in C-reactive protein levels, pro-inflammatory cytokines (IL-6 and 8) and adhesion molecules, and antithrombotic effects could decrease stenosis and thrombosis [15].

There are 13% decline in vascular access occlusive incidents in patients treated with simvastatin (20 mg) plus ezetimibe (10 mg) [16].

The use of statin was correlated with increased primary and secondary patency after primary successful percutaneous transluminal angioplasty [17].

ACEI/ARB for enhancing vascular access outcomes

The RAAS performs a significant role in vascular proliferation through stimulation of extracellular matrix and smooth muscle cell proliferation. Established on predominantly preclinical studies, RAAS blockade by ACEI or ARB has been demonstrated to decrease intimal hyperplasia formation, promote vasodilation and inhibit platelet activation and adhesion [18].

Table [1]: Different local interventions to improve hemodialysis vascular access outcomes [4]

Intervention	Mode of action	The expected effect on HD vascular access
Recombinant human type-1 pancreatic elastase	- Vasodilation through the destruction of elastin in the blood vessel wall - Inhibition of adventitial myofibroblast migration to intima	-Enhancement of access patency -Enhancement of access maturation
Far infrared therapy	- Inhibition of vascular smooth muscle cell proliferation - Vasodilation in addition to Inhibition of platelet aggregation -Decline in oxidative stress	-Increase access patency And access maturation -decrease in access thrombosis
Vascugel (Perivascular placement of implants containing allogeneic aortic endothelial cells	- Inhibition of thrombus formation (Decrease in matrix metalloproteinase-2 expression, besides neovascularization, and adventitial fibrosis)	- Lessening in access thrombosis - Increase access patency and access maturation
Paclitaxel-coated balloon angioplasty	Inhibition of vascular smooth muscle cell proliferation	- Decline in access restenosis - Enhancement of access patency
Drug-eluted combination product of collagen membrane and sirolimus	Inhibition of vascular smooth muscle cell proliferation	- Improvement of access patency - Improvement of access maturation
Optiflow device (T-shaped device inserted into the end of a vein on one side, the other side is inserted wall of an artery	Optimizing flow as well as shear stress by fixation of the anastomotic angle of AVF at 60 degrees Shielding of peri anastomotic region	- Improvement of access patency - Improvement of access maturation
Endovascular AVF creation (endovascular creation of an AV anastomosis using a radiofrequency magnetic catheter-based system)	Decrease in vessel trauma and resulting triggers for neointimal hyperplasia formation.	- Improvement in access patency - Improvement of access maturation - Reduction in access interventions

Treatment values with the usage of ACEI and/or ARB have been described for primary and secondary fistula and graft patency [4]. The application of mixed systemic and local methods may be used targeting together the upstream injury pathways (e.g., novel surgical or endovascular techniques) as well as downstream responses to injury pathways (e.g., 3FA supplementation or statins) [4].

Types of central venous catheter [CVC] for hemodialysis

- Temporary non-tunneled (classically used for less than 21 days, smaller in size, are placed completely into the vein), or
- Permanent catheters (tunneled hemodialysis catheters) are bigger, have a cuff that is tunneled beneath the skin away from the vein puncture site, and are only presented with two lumens.

Complications of CVC

- Catheter-related bacteremia, exit site infection, and catheter tunnel infection.
- Catheter dysfunction: malposition/kinking.
- Arterial puncture.
- Damage to central veins, including injury, bleeding, and hematoma.
- Pneumothorax, hemothorax, air embolism, Arrhythmias [10].

Attempts for prevention of CVC complications

Ultrasound-guided catheter insertion

The advantage of ultrasound (US) has been intended to decrease number of complications, and raise the safety and quality of central venous catheter (CVC) placement. Based on data from clinical studies, various guidelines of medical societies greatly recommend the use of the US for CVC placement [19].

Tip design of tunneled hemodialysis catheters

Split or shotgun tip: Patients may benefit from shotgun catheters over Split catheters wherever the replacement rates and thrombolytic treatment are declined [20].

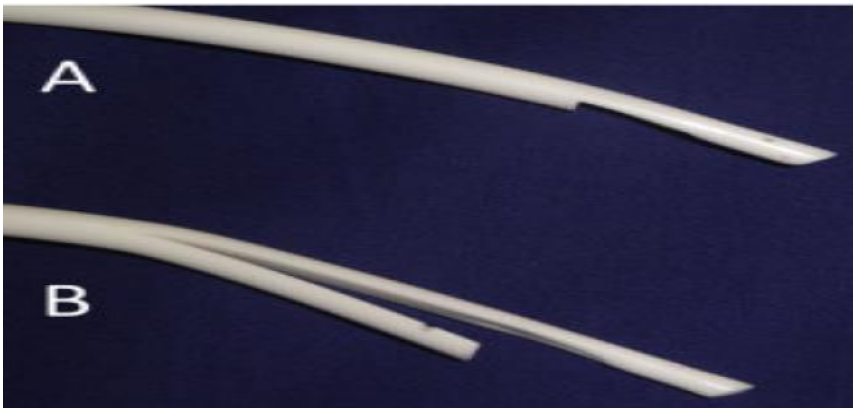
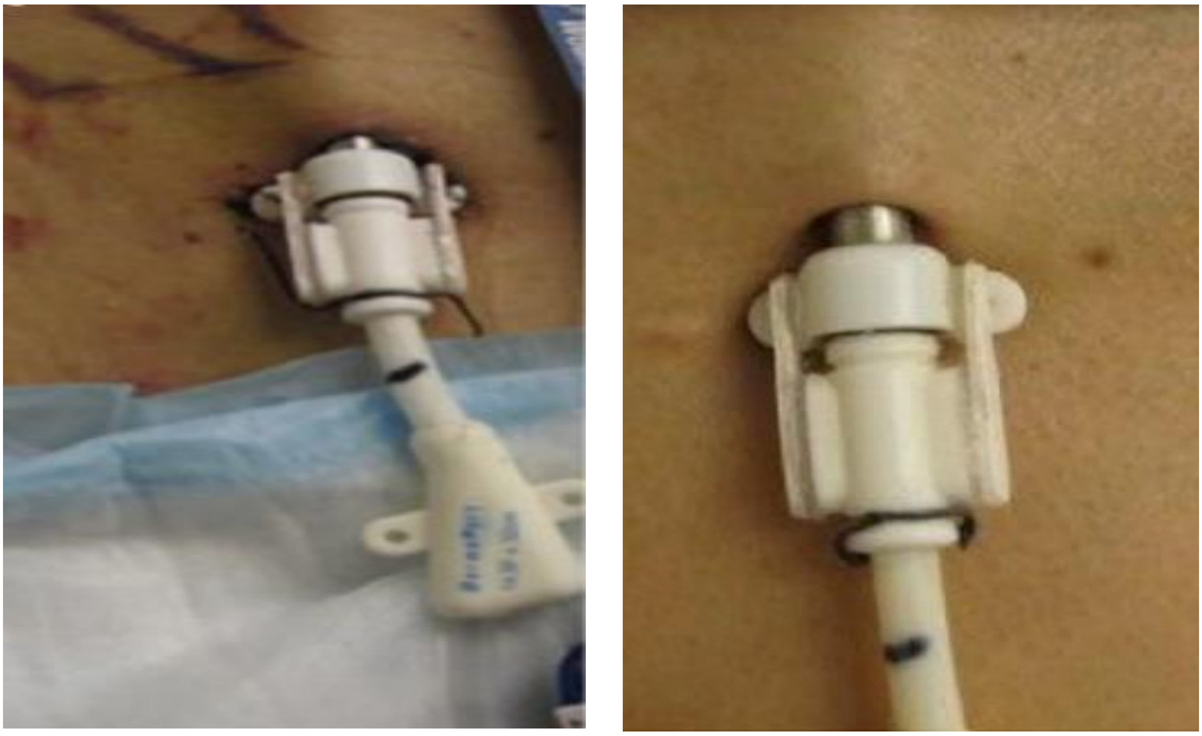


Figure [2]: (A) The shotgun tip and (B) the split-tip catheters

Percutaneous vascular access system (PVAS)

The percutaneous vascular access system (PVAS; DermaPort TM) was intended to incorporate a tissue-integrating slidable device into a long-term hemodialysis catheter to facilitate easy catheter repositioning and exchange while delivering fixation and infection-resisting properties [21].

Figure [3]: PVAS system [21]



A B

Figure [4]: PVAS system [A]: After insertion; [B]: 3 months after insertion [21]

Device-related infection rates were lesser than historical outcomes with traditional TDC. The PVAS system facilitates efficient catheter repositioning and exchanges, frequently directed at the patient's bedside. These outcomes may offer clinical and cost advantages for patients that are dialysis catheter-dependent [21].

Catheter Lock

Taurolidine is an antimicrobial that is used to avoid infections in catheters. Side effects and the induction of bacterial resistance are infrequent. Taurolidine-based catheter lock regimen significantly decreases the overall costs, infection, and dysfunction rates of tunneled hemodialysis catheters [22].

The use of taurolidine-based catheter lock solutions (taurolidine-citrate-heparin twice weekly and taurolidine-citrate-urokinase once weekly) considerably lowered the incidence of catheter-related bacteremia and catheter malfunction. Low-dose heparin lock (1000 U/mL) maintains tunneled hemodialysis catheter patency [23].

Conclusion

- Vascular access failure remains one of the extreme challenges in caring for hemodialysis patients.
- Fistula first program is very important because of the avoidance of early cannulation and complications of temporary catheter insertion.
- Vascular Access Care is essential especially physical examination and care by a nephrologist, nursing staff, and the patients.
- New technology is important in some patients for the avoidance of vascular access complications.

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