Review Article

Hemodialysis Access for Chronic Renal Failure

Kanoklada Srikuea

Abstract

The well-functioning vascular access (VA) is the mainstay to perform an efficient hemodialysis. There are three types of vascular access that consist of arteriovenous fistula, arteriovenous graft and central venous catheters. Many guidelines from different countries recommend the fistula first and the catheter late approach because fistula has high patency rates, longevity and lowest comorbidity and mortality. Also, the upper extremity access should be preferred than lower extremity access. However, the VA- related outcomes may be optimized by considering individual patient characteristic, comorbidity and life expectancy. The good team should include a nephrologist, vascular surgeon and dialysis nurse team. Early referral and venous preservation lead to the good outcomes.

Key words: vascular access, arteriovenous fistula, arteriovenous graft, central venous catheters

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Introduction

The vascular access (VA) is one of renal replacement therapies for end stage renal disease apart from kidney transplantation and peritoneal dialysis. The definition of vascular access is that the patient are on hemodialysis (HD) via arteriovenous fistula (AVF), arteriovenous graft (AVG) or central venous catheters (CVCs). The optimal condition for VA is blood flow rate should be at least 300 ml/min and preferably 500 ml/min depending on the VA modality to allow effective HD and therefore minimizes recirculation.[1]

Types of vascular access

Three difference types of VA (Figure 1) which consist of

1. Arteriovenous fistula (AVF) is defined as an autogenous anastomosis between vein and artery. After the creation of a fistula, vein will develop arterialization which allows HD cannulation.

2. Arteriovenous graft (AVG) is defined as VA using prosthetic graft which includes biological material or synthetic conduit. The most common material for bridge graft is expanded polytetrafluoroethylene (ePTFE)[2] as there are lower risks for disintegration with infection, longer patency, better availability, and improved surgical handling.

3. Central venous catheters (CVCs) have two categories which allows lower rate of blood flow during HD than that in fistulas and grafts. Non-cuffed, non-tunneled catheters are temporary catheter which are used in hospitalized patients for less than 1 - 2 weeks.[2, 3] The tip of the catheters should be in the superior vena cava (SVC) if it is inserted via the internal jugular vein or the subclavian vein. If the entry site is femoral vein, the tip should be in the inferior vena cava. On the other hand, tunneled-cuff catheters or permanent catheters are used in long term HD. The tip of catheters should be in the right atrium. Preferred routes of insertion are internal jugular vein, especially the right internal jugular vein because this site is more of a direct route to the SVC. The second one is femoral vein and the last one is subclavian vein. Furthermore, catheters inserted in the femoral vein has the highest infection rates compared to the other sites and should not be placed in waiting list patient for kidney transplantation. Non-cuffed femoral catheters should only be used in bed-bound patients. Catheters should not be placed in the subclavian vessels on either side because of the risk for stenosis which can lead to immature upper-extremity permanent fistulas or grafts.[2, 4] Catheter-induced central vein stenosis is related to the site of insertion, number and duration of catheter used, and occurrences of infection.[5] Ultrasound guidance should be used for all insertion because it minimizes inadvertent arterial cannulation.[6]

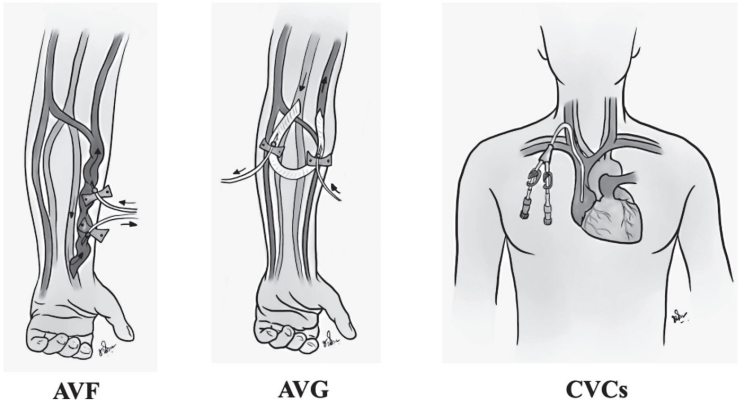

Figure 1 Types of vascular access

Timing of hemodialysis vascular access creation

Following the National Kidney Foundation (NKF) issued the Kidney Disease Outcomes Quality Initiative (KDOQI) CPGs recommend that patients with a glomerular filtration rate (GFR) less than 30 ml/min/1.73 m^2 (CKD stage 4) should commence HD.[2] Some organizations determine the initiation of HD by rate of the declining renal function, co-morbidity and by the surgical pathway such as surgeon experience and process of care.[7] All patients should be referred to experienced surgeons at 3 - 6 months before the expected start of HD to create VA.[1]

Decision making for access creation

All major society guidelines recommend AVF as the first option for construction of a VA. Second option is prosthesis AVG if fistula placement is not possible. The CVCs should be avoided and be used only when other options listed above are not available.[1, 2] The overall primary patency at two years was higher for fistula than or graft and catheters (55%, 40% and 50% respectively) and mortality was highest with catheters, followed by graft than fistula (26%, 17% and 15%, respectively).[8] Also, primary patency at one, two and three years of VA for Thai HD patients has shown 78%, 70%, and 60.% in AVF and 63%, 43%, and 36% in AVG, respectively.[9] Fistula has few related complications such as infection and thrombosis, less endovascular intervention and cost effective.[10 - 13] However, VA related outcome may be optimized by considering individual patient characteristics. Diabetes, atherosclerosis, obesity had negative influences on successful use of the fistulas.[14] Patency was lower in diabetes, coronary artery disease, elderly, and woman.[8] AVF are superior than other VAs in regards with mortality and cost, especially in younger men without diabetes.[11] Elderly patients may benefit from AVG as there is high primary AVF failure rate in these patients.[15] The recent Thai data showed increase in the use of AVF (65.2%) and decline in the use of AVG and CVCs (14.7%, 24.2%)[16]. These results following the guideline from KDOQI that prefers “fistula first” and the target fistula creation was seen in greater than 65% of patients.[2]

AVF and AVG should be placed distally and preferably in the non-dominant upper extremity whenever possible.[1, 2] If a pacemaker or CVC is present, the contralateral side is preferred because of the risk of venous hypertension and possibility reduced access patency.[1] The radiocephalic AVF (RCAVF) at the level of wrist is considered first, followed by brachiocephalic AVF (BCAVF) if RCAVF is not possible or failed and brachiobasilc AVF (BBAVF) is the last choice when the upper arm cephalic vein is unavailable. On the aspect of AVG, forearm loop AVG is considered first.

The second alternative access is arm AVG with either loop or straight configurations depending on surgeon's preference. Also, the last choice of upper extremity access is chest wall AVG.[1, 2] The indications for lower extremity VA are bilateral central venous occlusive disease or inability to create access in the upper extremity. This access is preserved as the last option as it has greater infection risk, is less comfortable and less convenient for the patient. Primary options are autogenous great saphenous vein and femoral vein (FV) transpositions and thigh AVG.[1] Thigh VAs have acceptable patency but they have increased risks of ischemia (FV transposition 21%, thigh AVG 7.1%) and infection (FV transposition 1.6%, thigh AVG 18%).[17] The recent guidelines prefer femoral vein transposition before thigh AVG.

Indications for temporary catheters are acute HD or bridging VA during fistula maturation and complications or waiting list for kidney transplantation. Permanent catheters or tunneled cuffed catheters may be indicated in patient who cannot have AVF/AVG creation, severe VA induced ischemia, cardiac failure or limited life expectancy.[1]

Table 1 Advantages and disadvantages of types of vascular access[2]

Type of Vascular access	Advantages	Disadvantages
Arteriovenous fistula	- Low rate of thrombosis and infection - Few intervention - Superior patency - Increase survival - Low hospitalization	- High primary failure rate - Long maturation time
Arteriovenous graft	- Short maturation time (time to cannulation 3-6 weeks) - Easy to cannulate - Multiple insertion site - Easy to surgical and endovascular correction	- High rate of thrombosis (most common cause is intimal hyperplasia at venous anastomosis) - High rate of infection - High intervention rate - Risk of steal syndrome
Tunneled cuffed catheter	- Universally applicable - Multiple puncture site - Easy to insertion - No short term hemodynamic consequence; change in cardiac output or myocardial load - Temporary hemodialysis during fistula maturation	- High rate of infection and thrombosis - Risk of central vein stenosis - Discomfort and less cosmetic - Short expected use-life - Low Blood flow rate - Long dialysis time

Table 2 Advantages and disadvantaged of commonly fistula placement[2, 18]

Type of fistula	Advantages	Disadvantages
Radiocepahlic	- Relatively simple to create - Preserve proximal vessel for the future use - Low incidence of steal syndrome (1 - 2%)[19] and cephalic arch stenosis (2 - 10%)[20] - 1- year primary patency rates 30 - 62%.[21, 23] Comparable to BCAVF - High long-term functional rate[24] - Cumulative patency 1 and 2-y : 40 - 80, and 20 - 76%[22 - 25]	- Low blood flow rates compared to BCAVF - Primary failure rate 15 - 59%[23, 25] - Higher number of procedure/ year to maintain patency[22]
Brachiocephalic	- Higher blood flows compared to RCAVF - Low incidence of infection and thrombosis - Shorter maturation time compared to RCAVF - Cosmetic benefit - 1-year primary patency rates 33 - 69[21, 22, 26] - Cumulative patency rates at 1 and 2 y: 77 and 75%[22]	- Difficult to create compared to RCAVF - High incidence of steal syndrome (11 - 36%)[27, 28] and cephalic arch stenosis (39 - 77%)[20] - Primary failure rate 17 - 38%[24, 29]
Transposed bachiobasilic	- High blood flows compared to RCAVF More likely to mature when compared to BCAVF[27] - Cosmetic benefit - 1-year primary patency rates 33 - 90%[21, 26, 30] - Higher cumulative patency rates at 1 and 2-y: 97 and 94%[22, 29]	- Challenging to create - Longer healing time - Significant arm swelling and pain - Longer maturation time[24] - Require interventional procedure for maturation and maintenance[22,30] - High incidence of swing vein site stenosis - Prone for steal syndrome 4%[28] - Primary failure rate 20 - 26%[22, 24, 29] - Increased risk of thrombosis[27, 30]

Point of concern for vascular access creation

1. Venous preservation[1, 18]

Empowering patients to increase awareness in avoiding venipuncture in cephalic, basilic and antecubital veins of either arms. If intravenous cannulation is unavoidable, it should preferably be done at dorsum of the hand to avoid thrombophlebitis of forearm and upper arm veins. Avoiding peripherally inserted central catheter (PICC) and midline catheter.

2. Prophylactic antibiotic[1]

Broad spectrum antibiotic should be given prior all VA operations to cover *Staphylococcus aureus*, especially in diabetics or prosthetic graft insertion.

3. Initial history and physical examination[2, 4]

The initial questions should include attention to which is the patient's dominant extremity and any history of prior upper extremity interventions or symptom of arm claudication. The physical examination should document any evidence of central venous catheter, upper extremity pulse examination, difference blood pressure measurement and assessment of the palmar arch and Allen test. Furthermore, the central venous occlusive disease appearance should be evaluated that presence of swelling of arm, shoulder and chest wall with tortuous collateral veins.

4. Role of vascular mapping

Duplex ultrasound of bilateral upper extremity arteries and veins is recommended in all patients when planning for the creation of vascular access. It should be performed with tourniquet in a warm room. Preoperative luminal vessel diameter can effect AVF maturation rates. Several studies suggest luminal venous and arterial diameter for RCAVF is more than 2 - 2.5 mm and 2 mm, respectively.[1, 2] For BCAVF and BBAVF, a minimum arterial and venous diameter of 3 mm is sufficient. Venous diameter is more than 4 mm for forearm AVG.[1]

Maturation and cannulation[1, 2, 18]

A fistula is considered mature when it is thought to be appropriate for cannulation with minimal complications and to deliver the prescribed blood flow throughout the HD. Maturation is established by physical examination or duplex ultrasound by experienced staff before VA. Some studies define fistula maturation as having diameter of at least 4 mm and flow more than 500 ml/min. On the contrary, KDOQI recommends the rule of 6's to define maturation (at least 6 mm vein diameter and 600 ml/min flow, and less than 6 mm vein depth). In generally, the time to reach maturation of AVF is 4 - 6 weeks and AVG is 2 - 4 weeks after VA creation. If AVF maturation has not occurred by 6 weeks, causes of poor functionality should be considered and additional investigations should be performed to achieve prompt diagnosis and treatment. Cannulation should be considered only in mature VA because of the risks of complications from cannulation, VA failure or insufficient HD quality.

Conclusion

A vascular access is the important and essential for HD, since a good VA represents to an efficient HD procedure. Early referral to vascular surgeon and the venous preservation can reduce rates of central venous catheter insertion. The decision making for creation of VA depend on many factors as the patients, surgeon and disease factor. Also, the complete physical examination and good planning by duplex ultrasound are recommended in all patients before creation of the access. Moreover, the fistula first and catheter late approach to the optimal access type of HD that still practice and good strategy.

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บทคัดย่อ

การผ่าตัดหลอดเลือดฟอกเลือดในภาวะไตวายเรื้อรัง

กนกลดา ศรีเกื้อ

การผ่าตัดหลอดเลือดฟอกเลือดได้ดี เป็นปัจจัยสำคัญที่ทำให้การฟอกเลือดด้วยเครื่องไตเทียมมีประสิทธิภาพ ชนิดของการผ่าตัดหลอดเลือดฟอกเลือด ได้แก่ การผ่าตัดโดยใช้หลอดเลือดตนเอง การใช้หลอดเลือดเทียม การใส่สายสวนหลอดเลือด แนวทางการผ่าตัดแนะนำการใช้หลอดเลือดตนเองเป็นอันดับแรก และการใส่สายสวนเป็นลำดับสุดท้าย เนื่องจากหลอดเลือดตนเอง มีอัตราการใช้งานที่คงทน ยาวนาน และมีภาวะทุพพลภาพและอัตราการตายน้อยกว่าชนิดการผ่าตัดอื่น แนะนำให้ทำการผ่าตัดหลอดเลือดที่แขนก่อนขา ผลการผ่าตัดยังขึ้นกับลักษณะผู้ป่วย โรคประจำตัวและอายุคาดเฉลี่ย ระยะเวลาที่ส่งตัวผู้ป่วยไตวายระยะสุดท้ายมาพบศัลยแพทย์ การหลีกเลี่ยงการทำหัตถการที่แขน

คำสำคัญ: ไตวายเรื้อรัง, การผ่าตัดหลอดเลือดฟอกเลือด, ฟอกเลือดด้วยเครื่องไตเทียม, การใส่สายสวนหลอดเลือด