

Factors Affecting Arteriovenous Fistula (AVF) Maturation

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Abstract

AVF requires postoperative maturation before cannulation to initiate hemodialysis treatment. AVF maturation usually takes about six weeks and depends on the development of vascular remodeling. However, AVF surgery is not always followed by successful maturation. Recent studies have shown that the rate of maturation failure in patients with chronic kidney disease undergoing AVF-type vascular access establishment is very high, ranging from 20% to 60%. The source search was carried out on the online portal of journal publications as many as 12 sources from Medscape, Google Scholar, National Center for Biotechnology Information (NCBI) with the keywords chronic kidney disease, hemodialysis, AVF, and maturation. Many factors are involved in the functional maturation of AVF, including age, sex, coagulation factors, lipid profile, hypoalbumin, venous diameter, diabetes, hypertension, peripheral vascular disease, smoking, obesity, and dialysis. Failure of AVF maturation results in insufficient blood flow to allow cannulation and initiation of hemodialysis.

Keywords: *Chronic kidney disease; Hemodialysis; AVF ; Maturation;*

Introduction

An arteriovenous fistula (AVF) is an abnormal connection between an artery and a vein. AVF was originally described by William Hunter as early as 1757. Much of the experience in managing AVF comes from the traumatic injuries that resulted in AVF from the Second World War, the Korean War, and the Vietnam War. Congenital fistulas are generally rare and are found in case reports and small studies. The National Institute of Diabetes and Digestive and Kidney Diseases reported that in 2013, more than 468,000 patients underwent hemodialysis (Rodgers, 2018). Twenty percent of these patients received dialysis via a surgically created AVF (Jayroe & Foley, 2020)

Patients with end-stage renal disease (*End-Stage Renal Disease /ESRD*) undergoing regular hemodialysis require vascular access (Robbin et al., 2018) and (Nojima & Motomiya, 2021, pp. 36–46). The number of chronic dialysis patients in Japan is increasing every year and has reached 344, and 640 by the end of 2019 (Annual Dialysis Data Report 201, *JSDT Renal Data Registry*) (Scholz, 2016). After the creation of an AVF, the volume of blood flow from the AVF gradually increases and can provide the blood flow needed for hemodialysis (Nojima & Motomiya, 2021)

The proper function of the AVF is critical Hemodialysis treatment is an important focus of nephrologists and vascular surgeons. For ESRD patients, autologous fistula is the most suitable choice of vascular access. Compared with arteriovenous graft (AVG) and central venous catheter (CVC), it has the lowest mortality rate and the lowest re-intervention rate. With these advantages, the *National Kidney Foundation Guidelines* support the use of AVF, which has a major success rate of 65% among patients starting hemodialysis (Siddiqui, Ashraff, & Carline, 2017, p. 318)

Although arteriovenous fistula (AVF) is considered the preferred type of access, 20%-60% of AVFs fail to mature for dialysis use (Nojima and Motomiya, 2021). Thus, to improve vascular access outcomes, a more comprehensive description of the factors involved in efficient fistula maturation is needed (Siddiqui et al., 2017)

Method

(Segal & Qaja, 2018) The writing of this article includes various sources originating from scientific journals and government guidelines and related agencies. Subject titles, keyword searches, and sources were carried out on the online portal of journal publications as many as 12 sources from Google Scholar and the Nation Center for Biotechnology Information / NCBI, with the keywords "chronic kidney disease", "hemodialysis", "AVF", "maturation". "

Research Result

Several factors are thought to be involved in the successful functional maturation of AVF, including age, sex, coagulation factors, lipid profile, hypoalbumin, vein diameter, diabetes, hypertension, peripheral vascular disease, smoking, obesity, and dialysis (Oprea et al., 2018, p. 399) and (Siddiqui et al., 2017)

Discussion

a. Age

A meta-analysis of 13 cohort studies (11 were retrospective) provided the best available evidence and demonstrated that elderly individuals with radiocephalic AVF have higher rates of primary failure and decreased patency. However, the definition of “elderly” in the included studies ranged from 50 to 70 years, and the review is specific to wrist AVF (Siddiqui et al., 2017)

b. Gender

A longitudinal study examined the vascular access complications of a large number of hemodialysis patients (n = 833) who had permanent access one month after starting hemodialysis treatment, and compared the complications in men and women. The study found that females and 1.58 (95% confidence interval [CI], 1.05-2.35) in AVF patients compared to male AVF patients (Zadeh & Negahi, 2014).

c. Coagulation factors

The most common cause of AVF maturation failure is stenosis of the vein segment. In 20-40% of cases, it occurs within the first few centimeters of the distal vein (upstream) to the anastomosis, which is called the "swing segment". The infiltration of macrophages and lymphocytes in the blocked AVF vascular layer leads to a significant increase in inflammatory activity. The endothelium plays an important role in preventing thrombosis, regulating blood clotting and lipid transport. Atherosclerosis can cause the destruction of the vascular endothelium, allowing platelets to accumulate on the endothelium and cause blood clotting. This may turn into a blocked blood vessel. When the endothelium degenerates, endothelial cells will produce and release a variety of substances, including plasminogen activator inhibitor-1, von Willebrand factor, thromboxane A2, fibrinogen and tissue factor, which can be used as the degree of endothelial damage index of (Siddiqui et al., 2017)

d. Lipid profile

The role of serum lipid profile in AVF maturation remains largely unknown. Kirkpantur et al. conducted a three-year retrospective study on a group of 99 patients to analyze the association between serum lipid profiles and fistula thrombosis. The results of the study showed that patients with fistula thrombosis

and functional fistula patients had similar serum cholesterol and triglyceride levels. Nevertheless, compared with the latter group of patients, the previous patients had significantly lower levels of high-density lipoprotein and albumin, as well as low-density lipoprotein and serum C-reactive protein

e. Hypoalbumin

In AVF, thrombosis can also be caused by inflammation. Churchill et al. found that AVF obstruction is most often determined by hypoalbuminemia. Further studies have shown that hypoalbuminemia is not only a sign of lack of diet in uremic patients, but also a symptom of inflammation. An indirect conclusion drawn from these results is that inflammation is related to AVF thrombosis

f. Vein diameter

There is a high correlation between the flow velocity through the AVF and the vein diameter, indicating that the flow velocity is the main determinant of the final vein diameter. Khavanin et al. conducted a cross-sectional study using samples from 96 hemodialysis patients with natural AVF to determine the relationship between AVF diameter and maturity. The results of the study found a correlation between vein diameter (average vein diameter of 2.40 mm) and the success rate of fistula formation; however, no similar relationship was observed between fistula maturity and arterial diameter (average artery diameter of 2.57 mm). Clinical examination and Doppler ultrasound measurement are the main methods of current preoperative evaluation

g. Diabetes

There has been an increase in the rate of AVF failure in the last three decades, due to the increasing number of elderly patients with CKD who also have diabetes or vascular disease. Metabolic changes that accompany diabetes can manifest as a pro-thrombotic situation, endothelial damage, deregulated growth factors, and increased extracellular matrix deposition. Inflammation may participate in the early development of AVF stenosis and thrombosis

h. Hypertension

Risk factors such as cardiovascular disease, hyperlipidemia, and hypertension are less predictive of immature AVF, prompting the investigation of other risk factors (such as the hemodynamic characteristics of vascular morphology). Endothelial function is impaired in hypertension, which reduces vasodilation and initiates inflammatory cell infiltration in blood vessels. Macrophages and T cells are the basic pathological features of the development of atherosclerosis. From their initial location in elastic arteries in spaces not subject to stress *shear* extreme, these features then propagate to the innermost membrane of smooth muscle cells, where they deposit connective tissue and initiate neovascularization. Other studies, however, do not support hypertension as a major risk factor for AVF maturation.

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i. Peripheral vascular disease (PVD)

PVD together with coronary artery disease and cerebrovascular disease is one of the three main manifestations of atherosclerotic thrombosis. Atherosclerotic thrombosis is a blood clot that forms on a ruptured plaque located in the affected part of an artery. Atherosclerotic plaques also form at the bifurcation points of blood vessels, possibly due to defective protective mechanisms and impaired blood flow at these sites. In the case of AVF used for hemodialysis access, vascular thrombosis is the main factor in determining AVF failure. Chang et al. believe that vascular inflammation may be involved in this process because it is an important symptom of vascular disease. PVD gradually develops as a result of systemic atherosclerosis (Siddiqui et al., 2017). Consistent with previous studies, Woodside et al. found that for women, blacks, and those with peripheral arterial disease, there was more difficulty in successfully establishing a functional mature AVF (Woodside et al., 2018, pp. 793–801)

j. Smoke

Wetzig et al. have shown previously that smokers undergoing hemodialysis show an increased prevalence of early or late AVF failure. The observed difference in results could be because peripheral vascular disorders in previous and current smokers may trigger acute AVF obstruction

k. Obesity

This group of patients has a higher AVF failure rate because they are more prone to arteriosclerosis, and the veins of the forearm are more difficult to reach due to thicker fatty tissue. This also increases the difficulty of performing a phlebotomy on a fistula located at a considerable depth. Chan et al. conducted a retrospective cohort study of 1,486 patients, using a BMI of less than 30 kg/m² as an obesity reference to analyze the association between obesity and vascular access complications. The results found no association between obesity and a higher rate of fistula failure; However, an association between insufficient fistula development and high BMI has been observed

l. Dialysis

Late referral of patients starting dialysis therapy with CVC may temporarily impair AVF patency and maturation. If a fistula is formed after the patient has started dialysis therapy, hemodialysis treatment may be extended with a temporary CVC. This can lead to the development of a number of complications, such as insufficient blood flow, hematoma formation, thrombosis or recurrent failure, fibrosis, vascular wall damage, and bacteremia

Conclusion

An arteriovenous fistula (AVF) is defined as a surgical connection between an artery and a vein. Fistulas are created when long-term hemodialysis is required. Many factors are involved in the functional maturation of AVF, such as age, gender, blood markers, comorbidities such as diabetes, hypertension, cardiovascular disease, obesity, smoking, and other factors such as endothelial function, vein diameter, and history of dialysis. Various interdependent factors influence arterial and venous changes, different end states can occur. Although arteriovenous fistula (AVF) is considered the preferred type of access, 20%-60% of AVFs fail to mature for use of dialysis.

REFERENCES

- Jayroe, Hannah, & Foley, Katie. (2020). Arteriovenous Fistula. *StatPearls [Internet]*.
- Nojima, Takehisa, & Motomiya, Yasuki. (2021). Pathophysiology of High Flow Access and Surgical Flow Reduction Procedures. *Kidney and Dialysis, 1*(1), 36–46.
- Oprea, Alexandru, Molnar, Adrian, Vlăduțiu, Dan, Scridon, Traian, Trifan, Cătălin, Săcui, Diana, Săsărman, Vasile, & Mircea, Petru Adrian. (2018). Correlation between preoperative vein and artery diameters and arteriovenous fistula outcome in patients with end-stage renal disease. *Clujul Medical, 91*(4), 399.
- Robbin, Michelle L., Greene, Tom, Allon, Michael, Dember, Laura M., Imrey, Peter B., Cheung, Alfred K., Himmelfarb, Jonathan, Huber, Thomas S., Kaufman, James S., & Radeva, Milena K. (2018). Prediction of arteriovenous fistula clinical maturation from postoperative ultrasound measurements: findings from the hemodialysis fistula maturation study. *Journal of the American Society of Nephrology, 29*(11), 2735–2744.
- Rodgers, G. P. (2018). *The National Institute of Diabetes and Digestive and Kidney Diseases*. Obtenido de <https://www.niddk.nih.gov/health-information/diabetes>
- Scholz, Hans. (2016). *Arteriovenous access surgery*. Springer.
- Segal, Michael, & Qaja, Erion. (2018). *Types of arteriovenous fistulas*.
- Siddiqui, Muhammad A., Ashraff, Suhel, & Carline, Thomas. (2017). Maturation of arteriovenous fistula: analysis of key factors. *Kidney Research and Clinical Practice, 36*(4), 318.
- Woodside, Kenneth J., Bell, Sarah, Mukhopadhyay, Purna, Repeck, Kaitlyn J., Robinson, Ian T., Eckard, Ashley R., Dasmunshi, Sudipta, Plattner, Brett W., Pearson, Jeffrey, & Schaubel, Douglas E. (2018). Arteriovenous fistula maturation in prevalent hemodialysis patients in the United States: a national study. *American Journal of Kidney Diseases, 71*(6), 793–801.
- Zadeh, Morteza Khavanin, & Negahi, Alireza. (2014). Factors affecting the maturation of arterio-venous fistula in patients with end-stage renal disease. *Saudi Journal of Kidney Diseases and Transplantation, 25*(1), 161.

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