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Original Article

Incidence of steal syndrome following arteriovenous fistula and arteriovenous graft

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Abstract: Background: Renal failure is one of the dangerous chronic diseases that different solutions are used for dialysis in these patients. Arteriovenous graft (AVG) and arteriovenous fistula (AVF) are two communication methods for dialysis in these patients, associated with pain, sensory and Pulse disturbances, and even limb necrosis. Using cubital AVF and AVG for hemodialysis is a critical issue in vascular surgery. Arterial steal syndrome is an essential medical condition requiring surgical interventions. In this research project, we decided to measure the incidence of steal syndrome among AVF and AVG patients and compare them with each other. Methods: This cohort study was performed in Al-Zahra Hospital, Isfahan, Iran, from 2018 to 2020. Two hundred one patients undergoing AVF or AVG were included, and patients were followed for six months. The frequency of pain symptoms, anesthesia and pulse disorders, necrosis of the limbs, and the frequency of steal syndrome were assessed. Results: Among the studied patients, 2 cases in the AVF group and 10 cases in the AVG group had steal syndrome, and there was a significant difference between the two groups based on the frequency of steal syndrome (P=0.007). Also, there was a considerable difference between the two groups based on the pulse disorder (P<0.05), but there was no significant difference between the two groups in terms of symptoms of sensory impairment, pain, and evidence of necrosis (P>0.05). Conclusion: AVF technique is better than AVG in creating symptoms of steal syndrome, and also, the number of symptoms such as pulse disorder was relatively less seen in the AVF method.

Keywords: Graft, fistula, dialysis, renal failure, Steel syndrome

Introduction

Chronic renal failure is one of the most common kidney diseases that involve 2-3% of the general population. Also, in Iran, nearly 43,000 patients are being treated for kidney failure and hemodialysis, and the number of patients is increasing by 20% annually [1-3]. Hemodialysis is currently the most common treatment for this disease globally [4-7].

Recently there has been some long-term access for blood connection between patent and hemodialysis; arteriovenous fistula (AVF) and arteriovenous graft (AVG) are common access for hemodialysis [8]. AVF is still the best long-term intravenous access to hemodialysis despite thrombosis, infection, steal syndrome, venous hypertension, fistula site aneurysm, congestive heart failure (CHF), and neurological complications [9]. The K-DOQI (Quality Initiative Kidney Disease Outcomes) recommends the insertion of AVF at least six months before the scheduled date of hemodialysis to provide fistula maturation and minor complication [10].

Low resistance AVF creates pressure due to the contraction of defense vessels. This may reduce or even reverse blood flow in the distal artery. A “vascular steal” disease occurs when several arteries have stenotic lesions. When one vascular network dilates (for example, during exercise or vasodilator therapy), blood flow is “stolen” from another part of the organ that is already maximally dilated due to the existence of proximal lesions [11]. When this happens, distal tissue perfusion will depend on the adequacy of collateral blood flow. Fortunately, in most cases, a steady stream of collateral arteries is sufficient to prevent post-AVF steal syndrome. However, ischemic symptoms or steal syndrome are seen in 1 to 8% of patients

after AVF [12]. Symptoms of Steal Syndrome in the early stages are pain, loss of sensation, and weakness, and can even lead to ischemia and gangrene of the limbs [13]. Sometimes symptoms may be lost due to the maturation of the collaterals, and the affected hand is usually cold, pale, and the radial pulse is not palpable [9]. An accurate history and physical examination are used diagnose steal, which is then validated with tests such as an arteriogram, duplex Doppler ultrasonography (DDU) evaluation with finger pressures, and waveform analysis [14]. Access ligation, banding, proximalization of the arterial inflow, and distal revascularization with interval ligation technique are currently reported therapy for steal syndrome. Patients with distal radiocephalic AVFs have also ligated their radial arteries [15].

As mentioned above, using cubital AVF and AVG for hemodialysis is a critical issue in vascular surgery. On the other hand, arterial steal syndrome is a prevalent and important medical condition that requires surgical interventions. The symptoms of steal syndrome range from moderate ischemia with rest discomfort to severe ischemia with rest pain, and others like neurological deficits, and tissue loss. Mild steal syndrome can be improved with conservative treatment, with an increase in collateral flow around the elbow.

In this research project, we decided to measure the incidence of steal syndrome among AVF and AVG patients and compare them with each other.

Materials and methods

Study design

This prospective cohort study was performed on 201 AVF or AVG candidate patients referred to Al-Zahra Hospital in Isfahan-Iran from early 2018 to 2020 for 18 months. The study protocol was approved by the Research Committee of Isfahan University of Medical Sciences and the Ethics committee has confirmed it (Ethics code: IR.MUI.MED.REC.1398.044).

Inclusion and exclusion criteria

The inclusion criteria were age more than 18 years, diagnosis of renal impairment leading to end-stage read disease (ESRD), being a candidate for future hemodialysis, undergoing AVF or AVG implant surgery and signing the written informed consent to participate in this study. The exclusion criteria were kidney transplant during the study course, lack of proper follow-up or death during the study, undergoing other treatments such as AVF or AVG manipulations, and patients with another chronic systemic disease such as malignancy with a life expectancy of fewer than six months.

Data gathering

After considering inclusion criteria, the patients underwent AVF or AVG implant surgery and were followed up two weeks and six months after surgery. During this period, the patients were visited and examined every month.

A pre-prepared checklist for patients included age and gender, comorbidities including smoking and alcohol consumption.

Evaluation of steal syndrome

We also assessed the presence of steal syndrome by color-coded duplex-ultrasound, and access flows ≤250 ml/min were considered hypoperfusion. If the clinical symptoms and physical examination were suggestive of steal syndrome, the AV access flow, and digital blood pressure should be measured using Doppler ultrasonography with and without AV access compression. Relief of symptoms on compression of the AV access was highly suggestive of steal syndrome, as occlusion of flow in the AV access improves distal perfusion.

Assessments of variables

Patients were evaluated for the presence of steal syndrome symptoms based on clinical signs and using pulse oximetry of the index finger in the upper limb with AVF or AVG and compared with the opposite upper limb. Pressures were measured when the AVF or AVG was open and manually closed with a fistula or graft.

After assessing the presence of steal syndrome, we evaluated data regarding pulse disorders, presence of pain (ischemic pain including distal limb and finger pain), sensory impairments and evidence of necrosis.

Pulse disorders were assessed by clinical examinations and defined as absence of pulse

Table 1. Variables of study between two groups

Variables	AVF	AVG	*P*-value
Age (mean ± SD)	60.18±10.14	61.52±11.26	0.37*
Gender (m/f)	69/41	52/39	0.25**
Smoking	24 (21.8%)	19 (20.9%)	0.50**
Alcohol consumption	14 (12.7%)	8 (8.8%)	0.25**
Pulse disorder	2 (1.8%)	7 (11%)	0.007**
Pain	1 (0.9%)	1 (1.1%)	0.70**
Sensory impairment	2 (1.8%)	3 (3.3%)	0.41**
Necrosis evidence	0	0	-
Steal syndrome	2 (1.8%)	10 (11%)	0.007**

*Independent T-test, **Chi-Square.

Table 2. Variables of study between patients with and without steal syndrome

Variables	With Steal syndrome	Without steal syndrome	*P*-value
Age (mean ± SD)	60.66±15.77	60.79±10.31	0.96*
Gender (m/f)	9/3	116/73	0.26**
Smoking	10 (83.3%)	33 (17.5%)	<0.001**
Alcohol consumption	4 (33.3%)	18 (9.5%)	0.03**
Pulse disorder	12 (100%)	0	<0.001**
Pain	2 (16.7%)	0	0.003**
Sensory impairment	5 (41.7%)	0	<0.001**
Necrosis evidence	0	0	-

*Independent T-test, **Chi-Square.

or reduced pulse compared to the opposite limb. Sensory impairments were also assessed by upper limb neurological examination. During examinations, different areas of upper limb nerves (C5-T1) were assessed. Evidence of necrosis and gangrene was also evaluated based on physical examinations.

Presence of these clinical data were compared based on patient's age, gender, smoking and alcohol consumption.

Statistical analysis

The collected data were entered into SPSS statistical software version 24. The data of this study were shown as numbers or percentages for qualitative data and mean (SD) for quantitative data. The tests used in this study included the chi-square test and Fisher's exact test to examine the relationship between qualitative variables between the two groups and the independent t-test to examine the relationship between quantitative variables between the two groups. *P*-value less than 0.05 was considered a significant level.

Results

Study population

In this study, 110 patients underwent AVF (69 males and 41 females), and 91 patients underwent AVG (52 males and 39 females). There was no significant difference between the two groups regarding demographic variables, including age, sex, smoking, and alcohol consumption (P>0.05).

Complications and steal syndrome after surgeries

In the AVG group, 11% of cases of pulse disorder, 1.1% of pain, 3.3% of sensory impairment, and 0% of evidence of necrosis were observed. In the AVF group, 1.8% cases of pulse disorder, 0.9% of pain, 1.8% of sensory impairment, and 0% of evidence of necrosis were observed, two patients in the AVF group and ten patients in the AVG group had steal syndrome, and there was a significant difference between the two groups based on the frequency of steal syndrome (P=0.007). The frequency of pulse disorder symptoms in the AVF group was significantly lower than in AVG. Still, there was no significant difference based on sensory disturbance and pain and evidence of necrosis (P>0.05) (**Table 1**).

Further assessments

There was no significant difference between patients with and without steal syndrome based on gender and mean age (P>0.05). Still, there was a considerable difference between the two groups based on smoking and alcohol consumption, pulse disorder, pain, and sensory impairment (P<0.05) (**Table 2**).

Discussion

This study showed that steal syndrome in the AVF technique was relatively lower than AVG. In addition; there was a significant difference between the two groups based on pulse disorder. Still, the incidence of sensory impairment, pain, and evidence of necrosis in both groups was similar. In addition, in cases with steal syndrome, the incidence of pulse disorder, sensory impairment, and smoking and alcohol consumption were higher than in patients without

steal syndrome. These results indicate the importance and usefulness of both methods in these patients. Two patients with steal syndrome in the AVF group and one with steal syndrome in the AVG group underwent surgery. Other cases underwent conservative treatment, including drug therapy with vitamin B1 and gabapentin.

There have been previous studies on the occurrence of this syndrome. A survey by Plumb and colleagues in 2008 Found that steal syndrome occurred in more than 4% of cases with AVF and was dependent on the characteristics of the fistula. The prevalence may be raised to 40% [16]. Suding and others investigated patients with AVF, and the symptoms of steal syndrome were seen in 10-20% of patients and indicated treatment of steal syndrome is essential in hemodialysis patients [17]. In the present study, we found that 1.8% of patients with AVF and 11% of patients with AVG developed steal syndrome.

In the other study with Akoh in 2009, the incidence of occurring steal syndrome in AVG was similar to AVF. Still, the difference was in features and clinical using methods that AVG have comfortable hemodialysis for patients [18]. However, subsequent studies have reported conflicting results, but our results also show a significant difference between the occurrence of steal syndrome in AVG and AVF. Asif and coleagues also showed that arterial steal syndrome is one of the most critical problems in hemodialysis patients, occurring in 10-20% of patients with AVG [19].

Studies have shown that the treatment and management of steal syndrome are essential and also that this problem can occur in both AVF and AVG methods (16). Another study by Zamani and others in 2009 found that steal syndrome can be seen in about 15-30% of patients undergoing AVF [20]. These results were in line with the results of our study. Goff and others also stated that pulse disorder, pain, and sensory disturbances are among the most acute symptoms of steal syndrome, found in almost all cases [21]. These results have been shown in other studies [22, 23]. Although not many studies have compared the prevalence of steal syndrome in AVF and AVG, our study has shown a difference between the two methods. One of the limitations of this study is the small sample size, the lack of long-term examination of patients, and non-examination of other patients' symptoms.

The formation of stenosis is a crucial reason for the loss of vascular access function in hemodialysis, and central venous occlusive diseases (CVOD) are essential for the loss of arteriovenous fistula function in uremic patients. Long-term use of dialysis tubes is closely related to central vein stenosis. Although angiography is the gold standard for diagnosing vascular diseases, digital subtraction angiography is an invasive examination, which can only show the blood flow in the cavity and cannot show the spatial relationship of adjacent tissue structures. Therefore, it is necessary to check CT angiography with a robust segmentation algorithm before CVOD intervention for the survival of hemodialysis patients. Thus performing fine segmentation of the renal region could be crucial. In 2011, a study was conducted by Dakua and colleagues in India. This study stated that inaccurate segmentation resulted from applying the approach to ischemic cardiac magnetic resonanceimages. This type of image bear multi labeled blood pool, and the manual seed(s) selection in these images introduces variability in the results. Automatic seed(s) selection and introduction of Laplacian of difference of Gaussian weighting function were the two main modifications in the algorithm [24]. In a review article by Dakua and colleagues in 2013, they showed that image segmentation has a critical role in image-guided surgical interventions [25]. In another study, Dakua and others stated that cardiac Magnetic Resonance (CMR) image segmentation is a crucial step before physicians go for patient diagnoses, related image-guided surgery, or medical data visualization. Most existing algorithms are practical under certain circumstances [26-28]. All these data show the importance of this issue in CVOD.

It could be considered that steal syndrome in the AVF technique was relatively lower than AVG. These data have high clinical importance, however it is believed that the restricted study population and performing this study in a single center are two important shortcomings of this survey. Therefore, we recommend further investigations should be conducted in this regard in hemodialysis patients.

Conclusion

In general, based on the results of this study, the difference between AVG and AVF methods is beneficial and good. Still, the use of AVF in causing steal syndrome was relatively less than AVG, and the symptoms of lack of pulse in the AVF group were significantly less than AVG.

Disclosure of conflict of interest

None.

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