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Original Article

Comparison of use of central venous catheter and arteriovenous fistula as initial vascular access in 735 patıents with end-stage renal disease

Son dönem böbrek yetmezliği olan 735 hastada ilk vasküler erişim yolu olarak santral venöz kateter ile arteriyovenöz fistülün karşılaştırılması

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Abstract

Aim: Although arteriovenous fistula (AVF) has been shown as the first choice for hemodialysis (HD), its superiority over central venous catheter (CVC) is still controversial considering the risk factors. Aim was to compare AVF and CVC, which should be is used as the first vascular access in HD.

Material and Methods: Patients were divided into two groups according to the use of AVF and CVC. The groups were compared in terms of age, gender, body mass index (BMI), comorbidities, use of antiplatelet and anticoagulant agents, HD sessions per week, end stage renal disease (ESRD) duration, HD treatment duration, patency of vascular acces and number of changes.

Results: When patients were grouped, 499 patients were in the CVC group and 235 patients were in the AVF group. The mean age of patients in the AVF group was higher than that of the CVC group (p=0.010). The difference between the median ESRD duration of the patients in the CVC and AVF groups was statistically significant (5 vs 6 months) (p=0.004). The duration of HD treatment was significantly longer in the AVF group (p=0.031). The median patency of their CVC was 3 months, while the median patency of their AVF was 48 months (p<0.001). The median number of changes was 1in the CVC group and 0 in the AVF group, this difference was statistically significant (p<0.001).

Conclusions: AVF is superior to CVC in terms of patency and number of changes, and it is the vascular access that should be preferred in first HD.

Keywords: Kidney failure; renal dialysis; arteriovenous fistula; central venous catheters; hemodialysis.

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ÖZ

Amaç: Arteriyovenöz fistül (AVF), hemodiyaliz (HD) için ilk seçenek olarak gösterilse de risk faktörleri göz önüne alındığında santral venöz kateter (CVC)'ye üstünlüğü halen tartışma konusudur. Bu çalışmanın amacı ile HD de ilk vasküler erişim yolu olarak kullanılması gereken AVF ile CVC'nin karşılaştırılmasıydı.

Gereç ve Yöntemler: Hastalar AVF ve CVC kullanımına göre iki gruba ayrıldı. Gruplar yaş, cinsiyet, vücut kitle endeksi (BMI), komorbiditeleri, antiplatelet ve antikoagülan ajan kullanımı, haftalık HD seansı, son dönem böbrek yetmezliği (ESRD) süresi, HD tedavi süresi, vasküler erişim yolu patens süresi ve değişim sayıları açısından karşılaştırıldı.

Bulgular: 499 hasta CVC grubunda, 235 hasta AVF grubunda idi. AVF grubunun yaş ortalaması CVC grubundan daha fazla idi (p=0.010). CVC ve AVF grubu arasındaki ESRD süresideki farklılık anlamlı idi (5 ve 6 ay) (p=0.004). AVF grubunun HD tedavi süresi anlamlı olarak daha uzun idi (p=0.031). CVC'lerin median patens süresi 3 ay iken AVF'lerin patens süresi48 ay idi (p<0.001). CVC grubunda ortalama değişim sayısı 1 iken AVF grubunun ortalama değişim süresi 0 idi ve bu fark istatistiksel olarak anlamlı idi (p<0.001).

Sonuçlar: AVF, patens süresi ve değişim sayısın açısından CVC'den daha üstindür ve HD tedavisinde ilk vasküler erişim yolu olarak tercih edilmelidir.

Anahtar kelimeler: Böbrek yetmezliği; renal diyaliz; arteriyovenöz fistül; santral venöz kateter; hemodiyaliz

Introduction

Hemodialysis is the most common treatment method used for end-stage renal failure (ESRD). Approximately 70% of 300 million ESRD patients worldwide are treated with hemodialysis [1]. Vascular access needed for an effective HD is usually established by a central venous catheter (CVC) or arteriovenous fistula (AVF) [2]. CVC is used as the vascular access in the first HD session in approximately 80% of ESRD patients in the Unites States of America [3]. However, the current guidelines recommend the creation of an AVF as a preparation for future HD in patients who have stage 4 chronic kidney disease (CKD) [4,5]. Although this view has gained acceptance by the majority, considering the advantages and disadvantages of CVC and AVF, it has been a matter of debate which vascular access method would be preferred in the first HD [6]. Although AVF has some advantages over CVC such as a lower infection rate and freedom of central venous injury, it also has some disadvantages such as being a surgical procedure and causing aneurysms and serious life-threatening bleeding [6] (Figure 1). In addition, some of the stage 4 CKD patients do not undergo HD for a long time despite having an AVF, which leads to complete AVF thrombosis during that period [7].

In the present study, we aimed to compare AVF and CVC regarding patency rates and the number of replacements in patients undergoing HD for the first time. We also aimed to find the most advantageous vascular access in order to determine the most cost-effective method and to increase patients' quality of life by performing the minimum number of invasive procedures.

Figure 1: Aneurysm in the cephalic vein in the upper arm

Material and Methods

Our study was approved by Başkent University Clinical Research Ethics Committee under the project number KA21/423 at 19/10/2021. We retrospectively reviewed the medical records of CKD patients who underwent HD for the first time between January 2010 and September 2020. We excluded patients

whose medical records could not be accessed, who attended follow-up at another center, and for whom an arteriovenous graft (AVG) was used. The patients enrolled by our study were grouped into 2 groups as those for whom a CVC was used (CVC group) and those for whom an AVF was used (AVF group) as the vascular access in the first HD (Figure 2).

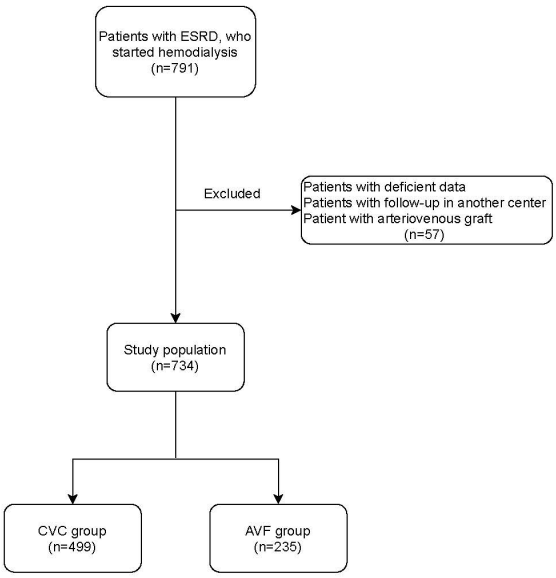

Figure 2: Flowchart of the study (ESRD: end stage renal disease, CVC: central venous catheter, AVF: arteriovenous fistula)

The two groups were compared with respect to patient age, gender, body mass index (BMI), comorbidities (heart failure (HF), coronary artery disease (CAD), diabetes mellitus (DM), peripheral vascular disease (PAD)), duration of ESRD and HD, weekly number of HD sessions, and anticoagulant or antiplatelet use. The patency rates and the number of AVF procedures and the patency rates and the number of CVC replacements were compared between the two groups.

Statistical Analysis

Descriptive statistics were presented as mean ± standard deviation or median (minimum-maximum) depending on parametric test assumptions for numerical variables, and number (n) and percentage (%) for categorical variables. Inter-group comparisons of numerical variables were carried out using Student's t test for variables meeting the parametric test assumptions and Mann-Whitney U test for those not meeting the parametric test assumptions. Categoric variables were compared using Pearson Chi-square test or Fisher's exact test. A p value of less than 0.05 was considered statistically significant for all statistical analyses. Statistical analyses were performed using IBM SPSS v22 software package.

Results

The data of a total of 791 patients were retrospectively analyzed. Fifty-seven patients were excluded due to inability to access to their data, follow-up at another center, or AVG use. Therefore, a total of 734 patients were included in the final analysis of the study results. When the patients were grouped with respect to vascular access, 499 patients were grouped in the CVC group and 235 patients in the AVF group (Figure 2).

The mean age of the patients was calculated as 57.8 ±16 years in the CVC group and 60.9 ±14.5 years in the AVF group (p=0.010). In the CVC group, 226 (45.3%) patients were female and 273 (54.7%) were male; 105 (44.7%) of the patients in the AVF group was female and 130 (55.3%) were male. There was no significant difference between the two groups in terms of gender distribution (p=0.877). The mean BMI was 25.4 ±5.3 kg/m2 in the CVC group and 25.3 ± 5.3 kg/m2 in the AVF group. There was no significant difference between the two groups regarding their BMI values (p=0.796).

A comparison of the study groups regarding PAD, DM, CAD, and HF revealed no significant difference (Table 1). When antiplatelet and/or anticoagulant use of the study groups was questioned, there were 308 (61.7%) patients using these agents in the CVC group and 149 (63.4%) patients in the AVF group, and there was no significant difference between the study groups in this regard (p=0.661).

Table 1: Distribution of comorbidities in groups

Comorbidity		CVC	AVF	p
Peripheral artery disease	yes	5 (1%)	5 (2.1%)	0.304[a]
	no	494 (99%)	230 (97.9%)	
Diabetes mellitus	yes	166 (33.3%)	82 (34.9%)	0.664[b]
	no	333 (66.7%)	153 (65.1%)	
Coronary artery disease	yes	38 (7.6%)	15 (6.4%)	0.547[b]
	no	461 (92.4%)	220 (93.6%)	
Heart failure	yes	32 (6.4%)	14 (6%)	0.812[b]
		467 (93.6%)	221 (94%)	

CVC: central venous catheter; AVF: arteriovenous fistula; [a]: Fisher's Exact test; n(%); [b]: Pearson Chi-Square test; n(%)

The median duration of ESRD was 5 (1-47) months in the CVC group and 6 (1-53) months in the AVF group, and there was a significant difference between the two groups with respect to the duration of ESRD (p=0.004). The median duration of HD was 4 (1-88) months in the CVC group and 5 (1-33) months in the AVF group, and the difference between the two groups was statistically significant (p=0.031). No significant difference was found between the two groups in terms of the weekly number of HD sessions (p=0.269) (Table 2).

Table 2: The number of hemodialysis sessions in the groups per week

Number of HD	CVC	AVF
1	4 (0.8%)	1 (0.4%)
2	64 (12.9%)	20 (8.6%)
3	427 (85.9%)	212 (91%)
4	2 (0.4%)	0 (0%)

HD: hemodialysis; CVC: central venous catheter; AVF: arteriovenous fistula

A comparison between the duration of normal functioning of CVC and AVF of the ESRD patients revealed a statistically significant difference ($p<0.001$). The median duration of normal functioning of the first CVC was 3 (1-240) months while the first AVF functioned normally for 48 (1-396) months. A comparison of the study groups with regard to the number of replacements of CVCs and AVFs revealed that the median number of CVC replacements in the CVC group was 1 (0-7) while the median number of AVF replacements in the AVF group was 0(0-5), with the difference being statistically significant ($p<0.001$).

Discussion

In our study, we determined that AVFs were more advantageous than CVCs with respect to both patency rate and the number of replacements, regardless of risk factors.

Although it is recommended to start HD therapy with AVF in ESRD patients, AVF maturation may take a period of 3-4 months, during which patients may have to begin HD therapy with a CVC. In elderly patients and women, on the other hand, the likelihood of AVF maturation is lower, and repeat interventions may be needed during the maturation period [8]. Lyu et al. failed to show any superiority of AVFs over CVCs in elderly patients and could not realize that AVFs were more beneficial in the long term [9]. It is not possible to draw any conclusion in our study due to an almost equal gender distribution. However, although the mean age of the AVF group was significantly higher compared with that of the CVC group, the AVFs functioned normally for a longer period and needed a lower number of reinterventions. We believe that this difference stemmed from the fact that the AVFs of our patients were created with a correct technique. Furthermore, using a correct technique for the cannulation of AVFs also contributes to lengthening of an AVF's life.

BMI is calculated as the ratio of body weight in kilograms to the square of height in meters. The World Health Organization categorizes obesity by the BMI value [10]. By this categorization, BMI <18.5 kg/m2 is categorized as underweight, 18.5-24.9 kg/m2 as normal healthy, 25.0-29.9 kg/m2 as overweight, 30.0-34.9 kg/m2 as class I obesity, 35.0-39.9 kg/m2 as class II obesity, and >40.0 kg/m2 as class III or extreme obesity [11,12]. Overweight and obesity are major risk factors for atherosclerotic cardiovascular diseases. Every 1 point above normal BMI causes a 10% increase in the risk of atherosclerotic cardiovascular disease [13]. CAD and PAD are among clinical consequences of atherosclerosis [14]. The latter is known to disrupt vascular anatomy by various mechanisms and to cause AVF stenosis and obstruction [15]. As an example of these mechanisms, DM, one of the causes of atherosclerosis, causes an increase in vascular intima-media thickness, which ultimately causes narrowing of vascular lumen [16]. In HF patients, AVFs cannot be effectively used, and their risk of thrombosis is higher than normal population due to a low cardiac output. Basile et al. showed a direct correlation between vascular access flow, cardiac output, and the effectiveness of HD [17]. In our study group, although BMI was equal in both groups, PAD and DM were more common in the AVF group, albeit to a statistically non-significant degree. The findings of our study indicating that AVF was more advantageous despite the existence of these risk factors suggest that the risk factors affecting cardiac output and vascular access flow (HF and CAD) may in fact be more influential on AVF patency than the risk factors affecting vascular wall (PAD and DM). A study on this subject may provide more accurate results.

Studies to date have shown that antiplatelet and anticoagulant drugs reduce the risk of vascular thrombosis and increase fistula patency. Studies have attributed this finding to the ability of antiplatelet and anticoagulant agents to prevent platelet adhesion to surgically treated vessels, and thereby, thrombus formation [18,19]. A metanalysis showed that antiplatelet therapy administered for the first 6 months reduced the risk of thrombosis by 50% [20]. Our study showed no significant difference between both groups regarding the rate of antiplatelet and anticoagulant agent use. In line with the studies performed on this subject, one can suggest that making early antiplatelet and anticoagulant use more widespread in AVF patients may improve AVF patency rates.

Calcium phosphate salts start to accumulate in vascular wall over time in ESRD patients. Furthermore, changes occur in vascular smooth muscle cells due to impaired mineral metabolism, which leads to arterial calcification [21]. This process causes a disruption in vascular structure as the duration of ESRD increases. As well as creating AVFs with a correct technique, their

correct cannulation also affects AVF patency. Three techniques are generally used for cannulation, and one should have a thorough knowledge of these techniques: area technique, rope ladder, and buttonhole technique [22]. When these techniques are not vigorously complied, several morbid complications may occur, and vascular access may be lost [23]. The risk of ESRD patients encountering these complications increases as the duration of HD lengthens. In accordance with the literature, our study showed that AVFs were more advantageous in terms of patency rate and the number of replacements despite significantly longer durations of ESRD and HD.

A limitation of our study may be that the groups were not evaluated in terms of complications. When the complications are determined, factors affecting patency of AVF, and CVC can be evaluated in a more detailed fashion. In addition, a more comprehensive study can be conducted by including AVGs in the study design.

Conclusion

Literature data suggest that AVFs are associated with a lower infection risk and are better tolerated by patients; thus, it is recommended that AVFs be preferred for HD. In addition to these advantages, our study also revealed that AVFs are superior in terms of patency rate and the number of replacements. HD in ESRD patients can be sustained with fewer complications and more cost-effectively as a result of the widespread use of AVF.

Declaration of conflict of interest

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