

ORIGINAL ARTICLE

Comparison of the Symmetric-Tip vs Split-Tip Tunneled Hemodialysis Catheter: A Retrospective Study

Simetrik Uçlu ve Ayrık Uçlu Tüneli Hemodiyaliz Kateterinin Karşılaştırılması: Retrospektif Bir Çalışma

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How to cite ?

Ozdemir M, Taydaş O, Durmuş MA. Comparison of the Symmetric-Tip vs Split-Tip Tunneled Hemodialysis Catheter: A Retrospective Study. Genel Tıp Derg. 2024;34(6):772-776

ABSTRACT

Background: Despite not being the primary choice for vascular access in hemodialysis patients, permanent tunneled catheters are commonly utilized, but exhibit elevated rates of complications and dysfunction. This study retrospectively compares the dysfunction durations of symmetric and asymmetric-tipped permanent hemodialysis catheters.

Materials and Methods: A total of 307 patients, undergoing the placement of either symmetric or asymmetric-tipped permanent tunneled catheters at our interventional radiology clinic between 2021 and 2023, were included. Therefore, the present study aimed to examine the dysfunction rates associated with each type of catheter.

Results: Among the included patients, 157 were male (51.1%), and 150 were female (48.9%), with an average age of 64.2±12.2 years. The catheters were predominantly placed in the right jugular in 242 patients (78.8%), followed by the left jugular in 59 patients (19.2%), and femoral placement in 6 patients (2%). Symmetric-tipped catheters were employed in 161 patients (52.4%), while asymmetric-tipped catheters were utilized in 146 patients (47.6%). During follow-up, the catheter dysfunction rate was significantly higher in split-tip catheters than in symmetrical-tip catheters ($p < 0.0001$).

Conclusion: The study revealed a statistically significant increase in catheter dysfunction for the asymmetric-tipped catheter type.

Keywords: Hemodialysis, Split tip, Symmetric tip, Tunneled catheter

ÖZ

Amaç: Hemodiyaliz hastalarının vasküler erişim yolu için kalıcı tüneli kateterler birinci seçenek olmamakla birlikte oldukça sık kullanılmaktadır. Bununla birlikte, komplikasyonları ve disfonksiyon oranları da oldukça yüksektir. Kalıcı hemodiyaliz kateterlerinin farklı tiplerine mevcuttur. Bu çalışmamızda simetrik ve ayrık uçlu kateterlerin disfonksiyone olma sürelerini retrospektif karşılaştırdık.

Gereç ve Yöntem: Girişimsel radyoloji kliniğimizde 2021-2023 yılları içerisinde, simetrik ve ayrık uçlu kalıcı tüneli kateter yerleştirilen toplam 307 hasta dahil edildi ve kateterlerin disfonksiyon oranlarına bakıldı.

Bulgular: Hastaların 157'si erkek (%51,1), 150'si (%48,9) kadındı. Hastaların yaş ortalaması 65,2±12,2 idi. Kateter 242 hastada (%78,8) sağ juguler, 59 hastada (%19,2) sol juguler, 6 hastada (%2) femoral yerleşimli idi. 161 hastada (%52,4) simetrik uçlu kateter, 146 hastada (%47,6) ayrık uçlu kateter yerleştirilmişti. Takiplerde kateter disfonksiyon oranı ayrık uçlu kateterde simetrik uçlu kateterlere göre anlamlı şekilde daha fazlaydı ($P < 0,0001$).

Sonuç: Kateter disfonksiyonu ayrık uçlu kateter tipinde anlamlı şekilde fazla bulundu.

Anahtar Kelimeler: Ayrık uç, Hemodiyaliz, Simetrik uç, Tüneli kateter

Introduction

Many patients needing dialysis rely on large-bore double-lumen permanent venous catheters as their vascular access route. Permanent dialysis catheters are placed into a central vein and tunneled subcutaneously. When arteriovenous fistulas or interposition grafts fail, permanent access routes are utilized in chronic hemodialysis (1). The ease of placement compared to fistula operations allows some patient groups to compete with fistulas (2). Additionally, permanent tunneled catheters are frequently preferred during the maturation process of fistulas (3). Furthermore, permanent tunneled catheters are preferred over AV fistulas in patients with comorbid

conditions such as heart disease or respiratory failure. If catheterization is required for more than three weeks, fistula formation is not feasible, and life expectancy is short, a permanent tunneled catheter is recommended (4).

Among the advantages of tunneled catheters are ease of placement, immediate readiness for use, avoidance of percutaneous cannulation in each treatment, and lower risk of re-circulation (5). Many early and late complications can cause catheter dysfunction. Thrombosis, infection, formation of fibrin sheath, and central venous stenosis are among the most prominent complications over time, encompassing both early and

late complications of the catheter (6-8). Development of fibrin sheath associated with hemodialysis catheters is widespread. Thrombus formation around the sheath is also frequent and among the most common causes of catheter malfunction. Therefore, due to early and late complications, the lifespan of permanent tunneled catheters is indicated to be within a wide range of 2-16 months in the literature (9,10). Mechanisms of fibrin sheath and thrombus formation are distinct. Fibrin sheath forms outside throughout the entire length of the catheter, leading to a flap valve effect. While fibrin sheath formation can occur within the first seven days, the formation mechanism is based on contact between fibrinogen and coagulation factors converting albumin to fibrin. Thrombus, on the other hand, can form both inside and outside the catheter tip, although the exact underlying mechanism of this formation is not yet precise; some contributing factors have been suggested, including recurrent vascular access, platelet and endothelial dysfunction, inflammation, and abnormalities in coagulation (8).

Numerous variables related to the catheter and the patient can be considered in catheter dysfunction. Regarding patient-related variables, age and gender, along with comorbidities such as hypertension (HT), diabetes mellitus (DM), high body mass index (BMI), anemia, and thrombotic genetic predispositions, can have an impact. Particularly, female gender and hypertension have been reported as prominent factors in the literature (10).

Various variables related to the catheter can contribute to dysfunction due to thrombosis and fibrin sheath formation. These include vascular calibration, secondary central venous stenosis, vascular access site traumas, catheter tip position, tunnel length, symmetry of catheter tips (symmetric, stepped, or split), angulation, straightness of the catheter, and the vessel into which the catheter is inserted (8,11).

Different approaches are available for revising catheters dysfunctional due to thrombosis or fibrin sheath. Treatment options for catheter dysfunction caused by fibrin sheaths or thrombi include catheter-directed thrombolysis, catheter replacement, balloon angioplasty, or stripping the fibrin sheath with a snare. Catheter-directed thrombolysis, where a thrombolytic agent is trapped within the catheter, is the simplest treatment method and provides a solution in two-thirds of cases. In the past, urokinase was used for this purpose, but nowadays, it has been replaced by alteplase. However, for underlying fibrin sheath-based

dysfunctions, balloon angioplasty is recommended to break down the fibrin sheath, thus resolving the issue (5, 12). Additionally, numerous lumen and tip designs have been developed to prevent dysfunction due to catheter-related factors. In our study, the dysfunction rates and reasons of patients presenting to our clinic with catheter dysfunction were compared retrospectively based on whether their catheters had symmetric or split tips.

Materials and Methods

The study was approved by the Ethics Committee. A total of 307 patients with permanent tunneled catheters placed in our interventional radiology clinic between 2021 and 2023 were included. Of these patients, 157 were male (51.1%), and 150 were female (48.9%). The mean age of the patients was 65.2 ± 12.2 years. Catheters were placed in the right jugular vein in 242 patients (78.8%), in the left jugular vein in 59 patients (19.2%), and in the femoral vein in 6 patients (2%). Symmetric-tip catheters were placed in 161 patients (52.4%), while split-tip catheters were placed in 146 patients (47.6%). Catheter dysfunction was accepted as the patient's inability to enter dialysis without any problems due to thrombosis or fibrin sheath. Causes of patient-related dysfunction, such as spontaneous extrusion of the catheter, were excluded. A total of 85 patients (27.6%) developed catheter dysfunction. The hospital system retrospectively evaluated the data of these patients by interventional radiologists.

Statistical Analysis

MedCalc (version 12, Ostend, Belgium) was used for statistical analysis. Descriptive statistics were presented as median (minimum-maximum) and mean \pm standard deviation. Categorical variables were expressed as frequencies and percentages. Fisher's exact test, Pearson chi-square test, and the corrected Yates version of Pearson chi-square test were used for comparing categorical variables. Independent sample t-test was used for comparing continuous variables with normal distribution, while Mann-Whitney U test was used for data that did not follow a normal distribution according to the Kolmogorov-Smirnov test. Kaplan-Meier analysis was used to evaluate catheter durability. A p-value < 0.05 was considered statistically significant.

Results

One hundred and fifty-seven patients were male (51.1%), and 150 patients were female (48.9%), with

an average age of 64.2 ± 12.2 years. The catheters were predominantly placed in the right jugular in 242 patients (78.8%), followed by the left jugular in 59 patients (19.2%), and femoral placement in 6 patients (2%). Symmetric-tipped catheters were employed in 161 patients (52.4%), while asymmetric-tipped catheters were utilized in 146 patients (47.6%). 51.5% of the patients had HT, and 33.7% had DM, and there was no statistical difference between the groups.

There was no significant difference observed between symmetric-tip and split-tip catheters in terms of age ($p=0.573$) and gender ($p=0.138$). However, the rate of catheter dysfunction was significantly higher in the split-tip catheter group ($p < 0.0001$) (Table 1).

Table 1. Patients' characteristics and comparison of the dysfunction of symmetrical-tip and split-tip catheters

	Symmetric Tip	Split Tip	<i>p</i>
Age (years) (mean)	64.1	64.3	0.573
Gender (M/F)	89/72	68/78	0.138
Hypertension (%)	52.3	50.8	0.813
Diabetes Mellitus (%)	34.9	32.5	0.698
Catheter Dysfunction (%)	9.3	47.9	<0.0001

DM: Diabetes mellitus, HT: Hypertension

The Kaplan-Meier analysis revealed a median patency duration of 10 months with a patency rate of 71.3%. The patency duration (11 months) and patency rate (89.7%) of the symmetric-tip catheter were significantly higher compared to the split-tip catheter, which had a patency duration of nine months and a patency rate of 71.3% ($p=0.0042$) (Figure 1).

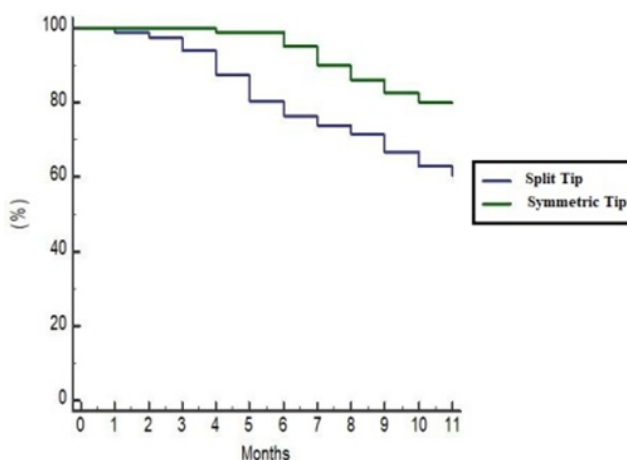


Figure 1. Survival curves obtained by the Kaplan-Meier analysis for symmetric-tipped and split-tipped catheter patency examined with a 95% confidence interval

Discussion

The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) recommends arteriovenous (AV) fistula as the preferred vascular access for dialysis patients. However, using permanent tunneled catheters is quite common in dialysis treatments (13). Dysfunction of permanent tunneled dialysis catheters leads to additional costs and interventions, prompting the development of various catheter types to prevent dysfunction. Some involve modifying the shape of the catheter tip, while others aim to extend functional durability by changing the material from which the catheter is made. In a study by Özdemir et al. (14), it was shown that dialysis catheters with symmetric tips made from heparin-coated materials exhibited less fibrin sheath formation compared to non-heparin-coated ones, and they had longer patency durations. Unfortunately, an ideal hemodialysis catheter has not yet been established. Each type of catheter has its advantages and disadvantages (15).

NKF-KDOQI defines dysfunction as the inability to sustain the necessary blood flow for adequate hemodialysis without prolonging the prescribed hemodialysis treatment. Effective blood flow, recirculation, and arterial-venous pressure data are determinants during dysfunction. However, reversing the bloodlines without intervention may significantly increase catheter recirculation (16). In a study by Tal on pigs, symmetric-tip catheters showed minimal recirculation compared to split-tip and stepped-tip catheters when the bloodlines were reversed without intervention (17).

The flow rate of the catheter is also a variable in the dysfunction process. In a study by O'Dwyer et al., they compared split-tip catheters with stepped-tip catheters. Split-tip catheters were found to allow increased flow rates during hemodialysis, but these increased flow rates were not statistically significant. However, they emphasized that split-tip catheters were more prone to minor complications, especially dislodgement and kinking (18).

One of the most critical variables in the dysfunction process is the recirculation rate. In a study conducted by Ash, it was found that split-tip catheters had a higher pullout force compared to symmetric-tip catheters, but the recirculation rate was lower (19). Hwang et al., in their study, reported that symmetric-tip and stepped-tip catheters provided adequate hemodialysis doses. However, they stated that symmetric-tip catheters

had advantages over stepped-tip catheters in terms of lower incidence of catheter dysfunction, maintenance of hemodialysis with reversed bloodlines without intervention, and higher short-term catheter survival rate (16).

In another similar study, Jean et al. compared the dysfunction rates of symmetric-tip and split-tip catheters in 87 hemodialysis patients. It was demonstrated that the symmetric-tip catheter had a lower dysfunction rate than the split-tip catheter, and fibrin sheath formation was also less common in the symmetric-tip catheter. Based on their experience, it was considered that the symmetric-tip catheter is a more suitable option for providing longer-term vascular access for chronic hemodialysis patients (20). In our study, the catheter patency durations of 307 patients were retrospectively evaluated, and similar results were obtained with a larger number of patients.

In the literature, these studies highlight symmetric-tip catheters associated with better dialysis adequacy and slower progression of the dysfunction process. Nadolski et al. compared symmetric-tip catheters from two brands and found their 90-day primary patency rates to be significantly similar (21).

As for the limitations of our study, it should be noted that besides age and gender, the relationship between patients' additional comorbidities and the vascular site where the catheter is placed was disregarded, and only the catheter type and dysfunction durations were evaluated. This might have influenced the results. Another limitation is the small and non-homogeneous sample size.

Conclusion

Our study demonstrated that symmetric-tip catheters can provide the expected blood flow for dialysis longer than split-tip catheters. These results are consistent with other studies in the literature comparing dysfunction durations of catheter types and show that symmetric-tip catheters have longer durations before dysfunction occurs.

Ethical Approval

The study was approved by the Ethics Committee of the Sakarya University Faculty of Medicine, (Number:330155_05 Date: 30.01.2024), and performed by Helsinki Declaration.

Conflict of Interest

The authors declare that they have no conflict of

interest.

Informed Consent

Informed consent was obtained from all patients before the procedure.

Funding

No funding was received from any source.

Presentation in a meeting (if any)

This manuscript has not been published or presented elsewhere in part or in entirety and is not under consideration by another journal.

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