



Single-center Surgical Outcomes of Arteriovenous Fistula Aneurysms in Patients with Chronic Renal Failure

Kronik Böbrek Yetmezliği Hastalarında Arteriyovenöz Fistül Anevrizmalarının Tek Merkezli Cerrahi Sonuçları

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ABSTRACT

Objective: To evaluate the surgical outcomes of arteriovenous fistula (AVF) aneurysm repair in patients with chronic renal failure (CRF) at a single center.

Methods: This retrospective study included 87 patients with CRF and AVF aneurysms treated between January 2012 and January 2023. Data on demographic characteristics, comorbid conditions, aneurysm characteristics, surgical procedures, and postoperative outcomes were collected. The primary endpoints were early (0-48 hours) and late (>48 h) complications, in-hospital mortality, and length of hospital stay.

Results: The mean age of the participants was 53.2±10.1 years, with 60.9% being male. The mean AVF flow rate was 897.6±328.9 ml/min. True aneurysms constituted 83.9% of the cases, with a mean diameter of 41.9±3.9 mm. The most common types of AVF aneurysm were radiocephalic (69.0%) and brachiocephalic (25.3%). Surgical indications included hand edema/skin laceration (41.4%), asymptomatic (26.1%), and extremely threatening ischemia (7.2%). No mortality was observed, and the average length of hospital stay was 2.4±0.9 days. Early complications included hematoma (2.3%) and bleeding (2.3%), whereas late complications included stenosis/thrombosis (4.6%), high-flow (2.3%), arterial steal syndrome (2.3%), and infection (3.4%).

Conclusion: Surgical treatment of AVF aneurysms in patients with CRF is effective and safe, with low complication rates and no in-hospital mortality. The most common types of AVF aneurysm were radiocephalic and brachiocephalic. Further multicenter prospective studies are needed to validate these findings and explore their long-term outcomes.

Keywords: AVF aneurysm, CRF, hemodialysis access, postoperative complications, surgical outcomes

ÖZ

Amaç: Bu çalışmanın amacı, kronik böbrek yetmezliği (KBY) olan hastalarda arteriyovenöz fistül (AVF) anevrizma onarımının cerrahi sonuçlarını değerlendirmektir.

Gereç ve Yöntem: Bu retrospektif çalışma, Ocak 2012 ile Ocak 2023 arasında AVF anevrizması tedavi edilen 87 KBY hastasını içermektedir. Demografik veriler, eşlik eden hastalıklar, anevrizma özellikleri, cerrahi işlemler ve postoperatif sonuçlar hakkında veriler toplanmıştır. Birincil sonuç ölçütleri erken (0-48 saat) ve geç (>48 saat) komplikasyonlar, hastane mortalitesi ve hastanede kalış süresiydi.

Bulgular: Katılımcıların yaş ortalaması 53,2±10,1 yıl olup, %60,9'u erkekti. Ortalama AVF akış hızı 897,6±328,9 ml/dak idi. Gerçek anevrizmalar olguların %83,9'unu oluşturmakta olup, ortalama çapları 41,9±3,9 mm idi. En yaygın AVF anevrizma tipleri radiosefalik (%69,0) ve brakiosefalik (%25,3) idi. Cerrahi endikasyonlar arasında el ödemi/cilt yaralanması (%41,4), asemptomatik (%26,1) ve ekstremiteyi tehdit eden iskemik (%7,2) durumlar bulunmaktaydı. Hastane mortalitesi gözlenmemiş olup, ortalama hastanede kalış süresi 2,4±0,9 gündü. Erken komplikasyonlar hematom (%2,3) ve kanama (%2,3) iken, geç komplikasyonlar stenoz/tromboz (%4,6), yüksek akım (%2,3), arteriyel çalma sendromu (%2,3) ve enfeksiyon (%3,4) olarak kaydedilmiştir.

Sonuç: KBY hastalarında AVF anevrizmalarının cerrahi tedavisi etkili ve güvenlidir, düşük komplikasyon oranları ve hastane mortalitesi yoktur. En yaygın AVF anevrizma tipleri radiosefalik ve brakiosefaliktir. Bu bulguları doğrulamak ve uzun dönem sonuçları araştırmak için daha fazla çok merkezli prospektif çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: AVF anevrizması, KBY, hemodiyaliz erişimi, ameliyat sonrası komplikasyonlar, cerrahi sonuçlar

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INTRODUCTION

An arteriovenous fistula (AVF) is the most commonly used vascular access site for hemodialysis in patients with chronic renal failure (CRF). Approximately 60-70% of CRF patients undergoing routine hemodialysis worldwide utilize AVFs because of their superior long-term patency and lower rates of complications compared with other vascular access options, such as central venous catheters and grafts (1). AVFs are preferred because they offer a reduced risk of infection and thrombosis over extended periods, which are critical factors in the management of patients requiring chronic hemodialysis (2).

Although AVFs are beneficial for long-term hemodialysis, they are associated with certain complications (3). A significant complication is aneurysm formation, which is characterized by localized vessel wall dilations that can lead to severe morbidity if not adequately managed (4). Aneurysm formation in AVFs is associated with high blood flow rates, repeated needle insertions, and pre-existing vascular pathology in patients with CRF (5). These aneurysms present risks, including rupture, thrombosis, and infection, which necessitate timely surgical intervention to preserve AVF patency and functionality. Studies have reported that aneurysms develop in up to 25% of patients with AVF, emphasizing the need for continuous monitoring and proactive management (6).

The Valenti and Balaz typing systems are used to categorize AVF aneurysms, with each providing a structured approach to assess aneurysms based on various clinical parameters. The Valenti typing system focuses on the morphological characteristics of the aneurysm, including the size, location, and extent of the arterial wall. In contrast, the Balaz typing system emphasizes hemodynamic aspects, such as blood flow dynamics within the aneurysm, and the potential risks of rupture or thrombosis (7). These typing systems are crucial for guiding the selection of appropriate surgical interventions and ensuring that the chosen technique is best suited to the specific characteristics of the aneurysm. Incorporating these classifications into clinical decision-making helps optimize patient outcomes by tailoring surgical strategies to individual needs of patients with AVF aneurysms.

Surgical repair of AVF aneurysms is a critical procedure to prevent life-threatening complications and ensure continued use of the fistula for hemodialysis (8). Various surgical techniques, such as aneurysmectomy and vascular reconstruction, have been used to address this issue. However, the outcomes of these interventions can vary significantly based on patient-specific factors, the size and

location of the aneurysm, and the presence of comorbid conditions (9). Standardized treatment protocols and comprehensive studies are required to evaluate the efficacy of different surgical approaches and optimize patient outcomes (10).

The primary objective of this study was to evaluate the surgical outcomes of AVF aneurysm repair in patients with CRF treated at our center. We aimed to identify factors associated with successful surgical outcomes and to analyze the incidence and types of postoperative complications. Additionally, we sought to establish guidelines for the optimal management of AVF aneurysms based on our findings to enhance the safety and efficacy of surgical interventions in this high-risk patient population.

METHOD

Study Location and Ethics Approval

This study was conducted at the Department of Cardiovascular Surgery, which is a tertiary center. This study was approved by the Bakirkoy Dr. Sadi Konuk Training & Research Hospital (decision no: 2023-24-19, date: 18.12.2023).

Study Design and Population

This retrospective study analyzed the medical records of patients with CRF and AVF aneurysms treated between January 2012 and January 2023. A total of 87 patients with CRF who developed AVF aneurysms were included in the study.

Patients were included if they had an AVF aneurysm with a diameter greater than 35 mm, had not previously undergone aneurysm surgery, did not have aneurysms in other arteries or veins, and were between the ages of 20 and 65 years. The exclusion criteria were AVF aneurysm diameter \leq 35 mm, history of aneurysm surgery, presence of aneurysms in other arteries or veins, and an age outside the 20 to 65-year range.

Data Collection

The retrospective data collection included demographic data (age, sex, body weight, and height), comorbid conditions (diabetes mellitus, chronic obstructive pulmonary disease, peripheral artery disease (PAD), coronary artery disease), laboratory values, and body mass index. AVF aneurysms were categorized as radiocephalic, brachiocephalic, brachio basilic, or snuff box. Indications for AVF aneurysm repair included a pulsatile mass, coldness, and numbness in the hand, hand edema, and skin laceration; heart failure; rupture; limb-threatening ischemia; embolism; and aneurysm infection.

Surgical Details

The documented surgical procedures included plication, arteriotomy constriction and plication, aneurysm excision (Figure 1) and new AVF creation, saphenous vein or graft interposition, and ligation with AVF creation. The location, method, technique, and duration of each surgical intervention were described in detail.

Patients who experienced late complications, such as stenosis or thrombosis, occurred, the patients underwent surgical revision. In cases where thrombosis was detected, embolectomy was performed, while stenosis was managed by reparation of the affected AVF site. These treatment approaches ensure successful management of vascular complications and preservation of AVF function. For patients undergoing AVF revision, temporary dialysis catheters were inserted to maintain dialysis access during the revision period. This approach ensured that patients were able to continue their necessary dialysis treatments without interruption until the revised AVF was fully functional.

The selection of surgical procedure was primarily guided by our extensive experience with aneurysm repair. The decision-making process involved evaluating whether the aneurysm was infected or not. An infection requires a more aggressive surgical approach, whereas non-infected aneurysms are managed with standard repair techniques.



Figure 1. Total aneurysm excision

Postoperative Data

Postoperative data collection focused on early complications (within the first 48 h), such as hematoma, thrombosis, and bleeding, and late complications (after 48 h), including stenosis and thrombosis, high flow, arterial steal syndrome, and infection. The Valenti and Balaz classifications were used to classify AVF aneurysms. Additionally, postoperative laboratory values, length of hospital stay, presence of wound infections, hematoma, neurological damage, and ischemia were recorded.

Ethical Considerations

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This comprehensive evaluation aimed to enhance the understanding of AVF aneurysm management in patients with CRF and improve clinical outcomes through evidence-based practices.

Statistical Analysis

Statistical analysis of the data was performed using the Statistical Package for the Social Sciences version 27.0. Continuous variables are expressed as mean±standard deviation, and categorical variables are presented as numbers and percentages (%). Demographic data, clinical characteristics, surgical procedures, and postoperative outcomes are summarized in tables, providing a statistical overview of data distribution. These analyses provided a comprehensive profile of surgical outcomes in patients with CRF undergoing AVF aneurysm repair.

RESULTS

Participants had a mean age of 53.2 ± 10.1 years. Of the participants, 53 were male, representing 60.9% of the study population. The majority of participants ($n=58$) reported smoking. Hypertension (4) was observed in 35 participants (40.2%), whereas 53 (60.9%) had diabetes mellitus (10). Chronic obstructive pulmonary disease (COPD) was present in 36 participants (41.4%), PAD in 43 (49.4%), and coronary artery disease (CAD) in 34 (39.1%). In addition, 46 participants (52.9%) had hypercholesterolemia (Table 1).

The mean flow rate of AVF aneurysms was 897.6 ± 328.9 ml/min. Among the aneurysms, 73 (83.9%) were classified as true and 14 (16.1%) as false. The mean diameter of the aneurysms was 41.9 ± 3.9 mm. The types of AVF aneurysms were radiocephalic (69.0%), brachiocephalic (25.3%), brachio basilic (3.4%), and snuffbox (2.3%). Regarding

indications for AVF aneurysm repair, 26.1% of the patients were asymptomatic, 5.4% had a pulsatile mass, 4.5% had hand coldness and numbness, and 41.4% had hand edema/skin laceration. Heart failure, extremity-threatening ischemia, embolism, and aneurysm infection were present in 4.5 %, 7.2%, 7.2%, and 3.6% (Table 2).

In the Valenti classification, Type 1a was observed in 3 patients (3.4%), Type 1b in 4 patients (4.6%), Type 2a in 41 patients (47.1%), Type 2b in 17 patients (19.5%), Type 3 in 8 patients (9.2%), and Type 4 in 14 patients (16.1%). According to the Balaz classification, type 1 aneurysms were the most

common (58 patients (66.7%). Type 2a was observed in six patients (6.9%), type 2b in seven patients (8.0%), type 2c in two patients (2.3%), type 2d in five patients (5.7%), and type 3 in nine patients (10.3%). No type 4 aneurysms were observed (Table 3).

Local anesthesia was used in 33 patients (37.9%), general anesthesia in 49 patients (56.3%), and upper extremity nerve block in 5 patients (5.7%). Regarding surgical procedures, plication was performed in 22 patients (25.3%), arteriotomy constriction and plication in six patients (6.9%), aneurysm excision with the creation of a new AVF in 52 patients (59.8%), saphenous vein/graft interposition in three patients (3.4%), and ligation with AVF creation in four patients (4.6%) (Table 4).

Hospital mortality was not observed in any of the patients, and all 87 patients (100.0%) survived. The mean length of hospital stay was 2.4±0.9 days. In terms of early complications (0-48 hours), 83 patients (95.4%) had no complications, whereas hematoma occurred in two patients (2.3%) and bleeding occurred in two patients (2.3%). Thrombosis was not observed in any patient during the study period. Seventy-six patients (87.4 %) experienced no late complications (after 48 h). Stenosis or thrombosis was noted in four patients (4.6%), high flow in two patients (2.3%), arterial steal syndrome in two patients (2.3%), and infection in three patients (3.4%) (Table 5).

Table 1. Baseline characteristics of the study population

	Mean±SD/N (%)
Age	53.2±10.1
Gender (male)	53 (60.9)
Smoke	58 (66.7)
HT	35 (40.2)
DM	53 (60.9)
COPD	36 (41.4)
PAD	43 (49.4)
CAD	34 (39.1)
Hypercholesterol	46 (52.9)

Values are expressed as mean±standard deviation and number (percentage). HT: Hypertension, DM: Diabetes mellitus, COPD: Chronic obstructive pulmonary disease, PAD: Peripheral artery disease, CAD: Coronary artery disease, SD: Standard deviation

Table 2. Characteristics and Indications for AVF aneurysm repair

	Mean±SD/N (%)	
Flow Rates (ml/min)	897.6±328.9	
Type Of Aneurysm	True	73 (83.9)
	False	14 (16.1)
Diameter of the aneurysm (9)	41.9±3.9	
AVF Aneurysm Types	Radiocephalic	60 (69.0)
	Brachiocephalic	22 (25.3)
	Brachiobasilic	3 (3.4)
	Snuffbox	2 (2.3)
AVF Aneurysm Repair Indications	Asymptomatic	29 (26.1)
	Pulsatile Mass	6 (5.4)
	Hand Coldness and Numbness	5 (4.5)
	Hend Eudema/Skin Laceration	46 (41.4)
	Heart Failure	5 (4.5)
	Rupture	0 (0)
AVF Aneurysm Repair Indications	Extremity-threatening ischemia	8 (7.2)
	Embolism	8 (7.2)
	Aneurysm Infection	4 (3.6)

Values are expressed as mean±standard deviation and number (percentage). AVF: Anterior venous fistula, SD: Standard deviation

Table 3. Classification of fistula aneurysms

		Count	Column N %
Valenti Classification of fistula aneurysms	Type 1a	3	3.4%
	Type 1b	4	4.6%
	Type 2a	41	47.1%
	Type 2b	17	19.5%
	Type 3	8	9.2%
	Type 4	14	16.1%
Balaz Classification of Fistula Aneurysms	Type 1	58	66.7%
	Type 2a	6	6.9%
	Type 2b	7	8.0%
	Type 2c	2	2.3%
	Type 2d	5	5.7%
	Type 3	9	10.3%
	Type 4	0	0.0%

Values are expressed as number (percentage). AVF: Anterior venous fistula

Table 4. Anesthesia types and surgical procedures

		Count	Column N %
The type of Anesthesia	Local	33	37.9%
	General	49	56.3%
	Upper extremity nerve bloc	5	5.7%
Surgical Procedure	Plication	22	25.3%
	Arteriotomy constriction and plication	6	6.9%
	Aneurysm excision and new AVF creation	52	59.8%
	Saphenous Vein/graft interposition	3	3.4%
	Ligation/AVF creation	4	4.6%

Values are expressed as number (percentage). AVF: Anterior venous fistula,

Table 5. Hospital mortality, hospitalization duration, and complications

		Mean±SD/N (%)	
Hospital Mortality	No	87	100.0%
	Yes	0	0.0%
Hospitalization (day)		2.4±0.9	
Early Complications (0-48 h)	No	83	95.4%
	Hematoma	2	2.3%
	Thrombosis	0	0.0%
	Bleeding	2	2.3%
Late Complications (>48 h)	No	76	87.4%
	Stenosis/thrombosis	4	4.6%
	High flow	2	2.3%
	Arterial stealing	2	2.3%
	Infection	3	3.4%

Values are expressed as mean±standard deviation and number (percentage). AVF: Anterior venous fistula, SD: Standard deviation

DISCUSSION

The creation of AVFs in patients with CRF is crucial for effective hemodialysis treatment. However, long-term use of AVFs can lead to serious complications, such as aneurysm. This study aimed to provide a detailed analysis of the repair and outcomes of AVF aneurysms conducted at a single center. Our findings offer significant insights into the early and late complications associated with the management of AVF aneurysms, hospital mortality rates, and length of hospital stay. In addition, the identification of AVF aneurysm types and repair indications contributes to the understanding of critical factors in patient management. These results expand the current knowledge regarding the surgical treatment of AVF aneurysms in patients with CRF and provide guidance for clinical practice.

In this study, significant findings were obtained regarding the surgical repair of AVF aneurysms in patients with CRF. Postoperative AVF aneurysm repair did not cause hospital mortality, and patients had an average hospital stay of 2.4 days. Early complications included hematoma and bleeding as the most common issues, whereas late complications were dominated by stenosis/thrombosis, high-flow arterial steal syndrome, and infection. The most frequent indications for AVF aneurysm repair were hand edema and skin laceration. However, serious indications, such as pulsatile mass and extremity-threatening ischemia, are also significant. Among the AVF types, radiocephalic aneurysms were the most common. These findings highlight critical points to be considered in the surgical management of AVF aneurysms and contribute to improving patient care.

In a study published by İnan et al. (11) in 2014, surgical treatment of AVF aneurysms in 24 patients with CRF was evaluated. Most patients had radiocephalic and brachiocephalic AVF aneurysms. Similarly, in our study, the most common AVF aneurysms were radiocephalic and brachiocephalic. In a study by İnan et al. (11), complications such as wound infection, hematoma, neurological damage, and ischemia were not observed postoperatively. Consistent with our findings, no in-hospital mortality was observed following surgical intervention, and early postoperative complications were minimal. In a 2023 study by Isik and Tanyeli. (12), six different surgical methods for AVF aneurysm repair were evaluated, with a focus on early outcomes. The most commonly used surgical methods include plication, arteriotomy constriction, and plication; aneurysm excision with new fistula creation; and saphenous vein or synthetic graft interpositioning. This study did not report postoperative fistula loss or minimal early complications.

Similarly, in our study, no in-hospital mortality was observed after AVF aneurysm repair, and early complications were reduced.

In a retrospective study by Yan et al. (13), open surgical interventions for AVF aneurysm repair were found to have high success rates, with lower early thrombosis rates in single-stage repair. Similarly, our study observed low early complication rates following surgical intervention, which supports the efficacy of these surgical methods.

In 2023, Corr et al. (14) discussed the management of AVF aneurysms in kidney transplant recipients. This study highlighted the importance of preserving AVFs in transplant recipients for potential future hemodialysis needs in cases of graft failure. Additionally, high-flow AVFs were associated with increased cardiac output and left ventricular remodeling. In our study, the mean flow rate following surgical repair of AVF aneurysms in patients with CRF was measured at 897.6 ± 328.9 ml/min, emphasizing the significance of managing high flow rates. Corr et al. (14) also evaluated various surgical options for treating AVF aneurysms, such as ligation and repair. Similarly, our study used different surgical techniques to achieve successful outcomes.

The findings of this study are in significant parallel with the existing literature. In a study by Płoński et al. (15) showed that classical, endovascular, and hybrid methods for the surgical treatment of AVF aneurysms were both safe and effective. Similarly, in our study, high success and low complication rates were observed following surgical intervention. In a study by Ecevit et al. (16), the mid-term outcomes of primary repair, saphenous vein interposition, and PTFE graft interposition in the surgical treatment of AVF aneurysms were examined. The patency rates were 80% and 60% at 12 and 24 months, respectively, in patients who underwent PTFE graft interposition. Consistent with these findings, our study also achieved high success and low complication rates using various surgical methods. Ecevit et al. (16) also reported short hospital stays and the absence of serious postoperative complications, which is consistent with our findings. Pasklinsky et al. (17) focused on the management of true aneurysms in hemodialysis access fistulas. Their study found that the various surgical techniques used for AVF aneurysm treatment were safe and effective. Similarly, our study observed low complication and high success rates following surgical intervention. Additionally, Pasklinsky et al. (17) reported that serious complications were rare during long-term follow-up, and most fistulas were successfully salvaged, which is consistent with our findings (17).

This study has several limitations. First, this was a retrospective study using data collected from patient records. This can lead to potential bias in data quality and accuracy. Additionally, our study was conducted at a single center, and the findings may not be generalizable to other centers. The sample size was also limited, and further validation of the findings is needed with larger patient groups in prospective studies. Furthermore, our study lacks long-term follow-up data, and more information on the long-term outcomes of surgical treatment of AVF aneurysms.

Surgical treatment of AVF aneurysms in patients with CRF is effective and safe, as demonstrated in our single-center study. The most common types of AVF aneurysms are radiocephalic and brachiocephalic. Our findings showed no in-hospital mortality and a short hospital stay (2.4 days). Early and late complications, including hematoma, bleeding, stenosis, and infection, were minimal. These results are consistent with those of the existing literature and highlight the importance of tailoring surgical techniques. Further multicenter prospective studies with larger cohorts are needed to validate and expand upon these findings.

ETHICS

Ethics Committee Approval: This study was conducted at the Department of Cardiovascular Surgery, which is a tertiary center. This study was approved by the Bakirkoy Dr. Sadi Konuk Training & Research Hospital (decision no: 2023-24-19, date: 18.12.2023).

Informed Consent: Since this study was retrospective, patient consent was not required.

FOOTNOTES

Authorship Contributions

Surgical and Medical Practices: H.T., Y.K., Concept: H.T., G.T., Design: H.T., A.A.Y., S.T., Data Collection or Processing: H.T., S.T., G.T., Analysis or Interpretation: H.T., G.T., H.B., Literature Search: H.T., G.T., H.B., Writing: H.T., A.A.Y.

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