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Original article

Surgical Management of Failing Arteriovenous Fistula as a hemodialysis Access

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Abstract

Background: Arteriovenous fistulas (AVFs) are the preferred vascular access for hemodialysis in patients with CKD. However, AVFs can encounter complications that lead to access failure, requiring surgical intervention. **This study aimed to** evaluate the effect and effort of surgical management of access failure after creation regarding to patency rate, and complication rate. **Methods:** This prospective study enrolled 20 patients with chronic kidney disease and AVF complications after creation. Inclusion criteria included age between 12-75 years, chronic renal failure with autogenous dialysis access, and confirmed AVF stenosis or other complications. Demographic data, comorbidities, clinical examinations, laboratory tests, imaging studies, and preoperative ultrasound assessments were collected. Detailed information on AVF specifics, surgical procedures performed, salvage interventions, patency measurements, and complications were documented. **Results**: The study included patients with a mean age of 55.5 ± 14.7 years, with a higher distribution in the age group of 41-60 years. Diabetes was the most prevalent comorbidity among the studied patients. Brachio-cephalic fistulas were the most common type of access, and thrombosis and infection were the primary complications observed. The primary patency rate was 2.3 ± 1.9 years, while secondary patency showed a decline over time. Complications such as hematoma, infection, and thrombosis were recorded, with varying rates of wound healing outcomes. **Conclusion:** Surgical management of failing AVFs in patients with chronic kidney disease can be effective in maintaining access patency. However, complications and decreasing secondary patency rates necessitate careful consideration and individualized approaches.

Keywords: Arteriovenous Fistula; Hemodialysis Access; Chronic Kidney Disease; Patency Rate; Complication Rate.

Introduction

As recommended in the 2006 Kidney Disease Outcome Quality Initiative Clinical Practice Guidelines arteriovenous fistula (AVF) is superior to both arteriovenous graft and central venous catheter in patients requiring long-term hemodialysis (1).

The principle in deciding the location for an AVF, in general, is to first attempt on the non-dominant hand before proceeding to the dominant hand; from distal to proximal; and from radio-cephalic (RC) to brachiocephalic (BC) to brachiobasilic transposition (BBT) (2).

The main preconditions to perform patent AVF are good inflow and outflow. The impact of the vessel diameter was researched in numerous studies. Artery and vein diameters below 2 mm were the predictors of high incidence of early thrombosis or failure to mature in some studies, and some authors recommended cut-off size of the artery and the vein (3). The most widely mentioned recommendation is artery diameter (AD) 2 mm and vein diameter (VD) 2.5 mm or VD 3 mm. Increasing the artery and the vein diameter is necessary for maturation (4).

There are some Factors Predicting Autogenous Access Outcome which are local factors or systemic factors. Local factors as Surgical technique, Arterial remodeling secondary to increased wall shear stress, increased arterial flow rate, establishment of laminar flow and venous compliance (5). Systemic Factors as Patient demographics including age, sex, ethnicity Pre-existing disease profile including atherosclerosis, cardiac performance and Thrombophilia (6).

From the time of its placement, autogenous AV access should be mature and ready for cannulation 12 weeks postoperatively. so proper starting time (Perfect mature AVF) "Rule of 6's" 6mm vein diameter or more, 2-6mm vein depth from the skin or less, 6wks from construction or more, 600 ml/min blood flow or more and 0.6mm thickness of the vein wall or more (7).

Successful maturation is characterized by sufficient blood flow to perform adequate dialysis and by enough size of the vein to allow repetitive puncturing (8). While AVF failure may be early Failure or late failure. Early Failure which is failure of maturation within 90 days of surgery which may be due to technical errors, early thrombosis, steal syndrome or a side branch affect the venous limb flow (9). Late Failure is following an extended period on dialysis with a normally functioning access due to Thrombosis, Hematoma, Infection, Pseudo-Aneurysm formation, Seroma and Venous Hypertension (10).

While surgical management depends on the cause of failure and can be revision of the surgery, surgical thrombectomy, aneurysmorraphy, surgical drainage of seroma, ligation of the fistula and distal revascularization and interval ligation (DRIL) (11).

The purpose of this study was to evaluate the effect and effort of surgical management

of access failure after creation regarding to patency rate, and complication rate.

Patients and methods

This study is a prospective nonrandomized trial that includes 20 patients suffering from chronic kidney disease and complications of AV fistulas after creation. Satisfying all the inclusion criteria mentioned below. They were selected from the vascular surgery department at Benha University Hospital, Nasr City Insurance Hospital and Egypt Air Hospital during the period from January 2022 to January 2023.

An informed written consent was obtained from the patients. Every patient received an explanation of the purpose of the study and had a secret code number. The study was done after being approved by the Research Ethics Committee, Faculty of Medicine, Benha University (**Ms.4.7.2022).**

Inclusion criteria were patients with age between 12 - 75 years, chronic renal failure with autogenous dialysis access, Duplex confirmed stenosis or other complications as stenosis, thrombosis, steel syndrome, venous hypertension or side branch and patients giving consent for either type of operations.

Exclusion criteria were working or functioning access and absence of consent to be involved in the study.

All patients were subjected to the following:

All patients participating in the study underwent various procedures and assessments. Firstly, demographic information such as age, gender, and relevant patient characteristics were collected, along with additional data like body mass index (BMI). Comorbidities and pre-existing medical conditions such as diabetes, hypertension, or cardiovascular disease were also noted.

For data collection, a detailed clinical examination was conducted for each patient, focusing on signs and symptoms related to AV fistula complications and overall health status. Patients underwent necessary investigations, including laboratory tests and imaging studies, to confirm the presence of complications such as stenosis, thrombosis, steal syndrome, venous hypertension, or side branch issues. A duplex ultrasound was performed to assess the AV fistula, proximal outflow, and central veins, providing crucial information on vessel caliber, flow rate, and the presence of stenosis or thrombosis. Additionally, a preoperative ultrasound assessment was conducted to evaluate the status of the failing arteriovenous fistula before surgical management.

Detailed data on the AV fistula specifics were collected, including the operation date, type of surgery performed (revision, thrombectomy, aneurysmorraphy, etc.), and any complications encountered during the procedure. The success or failure of a trial cannulation was documented to assess the patency and functionality of the AV fistula after surgical management. In case of AV fistula failure or complications following surgical management, salvage interventions such as thrombectomy, surgical ligation, or revision procedures were recorded, including the dates of these interventions. Patency measurements, including primary

patency, assisted primary patency, and secondary patency intervals, were used to determine the long-term success and durability of the AV fistula after surgical management. Any complications during or after surgical management, such as failure of thrombectomy, arterial thrombosis, acute reduction of blood flow to the limb, or surgical site infection, were also documented.

Outcome measures included primary patency, which represents the interval from AV fistula creation until any intervention to maintain or reestablish patency, AV fistula thrombosis, or the time of patency measurement. Assisted primary patency referred to the interval from AV fistula creation until AV fistula thrombosis or the time of patency measurement, including any intervening manipulations to maintain the functionality of the access. Secondary patency represented the interval from AV fistula creation until AV fistula abandonment or the time of patency measurement, including all intervening manipulations to maintain the functionality of the access and reestablish functionality of a thrombosed AV fistula. Complications of operations encompassed failure of thrombectomy, arterial thrombosis resulting in acute reduction of blood flow to the limb, and surgical site infection.

The surgical management approach depended on the cause of failure and included procedures such as revision of the previous surgery, surgical thrombectomy, aneurysmorraphy, surgical drainage of seroma, ligation of the fistula, or distal revascularization and interval ligation (DRIL).

Statistical analysis

The collected data was processed using the Statistical Package for Social Science (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). After revision, coding, and tabulation, the data were presented in a suitable format for analysis based on the type of data obtained for each parameter. To determine the normality of the data distribution, the Shapiro-Wilk test was conducted. Descriptive statistics, including the mean and standard deviation (± SD), were calculated for numerical data, while frequency and percentage were determined for non-numerical data. For analytical statistics, the Student T-test was employed to assess the statistical significance of the difference between two means of the study groups. The Chi-Square test was used to examine the relationship between two qualitative variables. The probability of the results was assessed using a significance level of $p<0.05$ at a 95% confidence interval. A p-value below this threshold was considered statistically significant.

Results

The current study was carried on 20 patients suffering from chronic kidney disease and complications of AV fistulas after creation. The mean age of the studied patients is 55.5 ± 14.7 years. A significant high distribution of patients (55%) fall in the age group (41-60 years) than the rest of age groups ($p=0.002$). In terms of gender, out of the 20

cases studied, 45% were female and 55% were male. According to comorbidities in the studied cases, 50% of patients had diabetes, 45% had hypertension, 10% had ischemic heart disease, 5% had heart failure and 5% had hyperparathyroidism. A significant higher distribution of diabetes was detected compared to other comorbidities in the studied patients (p<0.001) (**Table, 1).**

According to dialysis history in the studied patients, the mean duration of dialysis history was 3.7 ± 2.3years (**Table, 2).**

According to access details, 25% had brachio-basalic fistula, 65% had brachio-cephalic fistula, and 2 (10%) had radiocephalic fistula. A significant higher percentage of patients (65%) with BCF compared to BBF and RCF (p=0.008). The mean time since access applied in the studied patient was 2.3 ± 1.9 years (**Table, 3).**

According to problem with access, thrombosis and infection were the most common problems, each represented 25% of cases, followed by pseudoaneurysm affecting (20%), steal syndrome affecting (20%), and the remaining cases had other problems such as bleeding, hematoma, heart failure, neuropathy, aneurysm, and venous hypertension. The mean duration of access problem was 5.4 ± 13.7 months (**Table, 4).**

In terms of surgical interventions performed: ligation of the fistula and arranging for a permcath was the most common procedure, performed in 30% of cases, followed by thrombectomy (20%), aneurysmorraphy (15%), DRILL (10%), and the remaining cases had other surgical interventions such as ligation of the fistula and arranging for a new access, RUDI, surgical repair, and surgical evacuation and rest from dialysis for 15 days (**Figure, 1).**

According to outcome in the studied cases, the fate of the current access was as follows: 60% had a successful access, while 40% had a failed access. According to primary patency, the mean duration of primary patency in the studied patients was 2.3 ± 1.9 years.

According to secondary patency, after 3 months, 16.7% had non-functioning access, while 83.3% still had functioning access. After 6 months, 41.7% had non-functioning access, while 58.3% still had functioning access (**Table, 5).**

According to complication, 2 cases (33.3%) had hematoma 2 cases (33.3%) had infection and 2 cases (33.3%) had thrombosis as a complication. According to wound healing, 44.4% of the studied cases had primary wound healing, while 29.6% had secondary wound healing.

Table 1: Demographic data and Comorbidities in the studied cases

Variable		Total cases n=20	Test	*p*
Age (years)	M ± SD	55.5 ± 14.7	-	-
Age groups	<20.00	1(5%)	X^2=1.440	0.002*
	21.00 - 40.00	1(5%)		
	41.00 - 60.00	11(55%)		
	>60.00	7(35%)		
Gender, n (%)	Female	9(45%)	X^2=0.200	0.655
	Male	11(55%)		
	Diabetes	10(50%)	X^2= 1.675	<0.001*
	Heart failure	1(5%)		
	Hypertension	9(45%)		
	Hyperparathyroidism	1(5%)		
	Ischemic heart disease	2(10%)		

M: Mean; SD: Standard deviation; X2=Chi square test; *: Significant ≤0.05

Table 2: Past history of dialysis in the studied cases

Variable		Total cases n=20
Dialysis history (years)	M ± SD	3.7 ± 2.3
	Median (IQR)	3.0 (2.0-5.0)

M: Mean; SD: Standard deviation; IQR: Interquartile range

Table 3: Access details in the studied cases

Variable		Total cases n=20	Test	*p*
Present Access	BBF	5(25%)		0.008*
	BCF	13(65%)	X2=9.700	
	RCF	2(10%)		
History of the Access (years)	M ± SD	2.3 ± 1.9	-	-
	Median (IQR)	2.0 (2.0-4.0)		

BCF: Brachio-cephalic Fistula; BBF: Brachio-basilic Fistula; RCF: Radiocephalic Fistula; M: Mean; SD: Standard deviation; IQR: Interquartile range; X2=Chi square test; *: Significant ≤0.05.

Table 4: Main problem with access in the studied cases

Variable		Total cases n=20	Test	*p*
Problem with access, n (%)	Aneurysm	1(5%)	X^2=9.667	0.378
	Bleeding	2(10%)		
	Hematoma	3(15%)		
	Heart failure	1(5%)		
	Infection	5(25%)		
	Neuropathy	1(5%)		
	Pseudoaneurysm	4(20%)		
	Steal syndrome	4(20%)		
	Thrombosis	5(25%)		
	Venous hypertension	1(5%)		
Duration of access problem (months)	M ± SD	5.4 ± 13.7	-	-
	Median (IQR)	0.50 (0.3-2.0)		

M: Mean; SD: Standard deviation; IQR: Interquartile range; X2=Chi square test; *: Significant ≤0.05

Table 5: Secondary patency in the studied cases in follow up period

Variable		Successful cases n=12
Base secondary patency	Nonfunctioning	0(0%)
	Functioning	12(100%)
3 months secondary patency	Nonfunctioning	2(16.7%)
	Functioning	10(83.3%)
6 months secondary patency	Nonfunctioning	5(41.7%)
	Functioning	7(58.3%)

Cases:

Case 1: A 27-year-old female was diagnosed with steal syndrome 15 days ago and underwent a successful DRILL procedure **(Figure, 2).**

Case 2: A 59-year-old male presented with complaints of discharge and infection one week ago. The patient underwent ligation of the fistula and arrangements were made for the placement of a permicath (**Figure, 3).**

Case 3: A 66-year-old female patient experienced steal syndrome and subsequently underwent a successful radiocephalic ulnar deviation (RUDI) procedure, (**Figure, 4).**

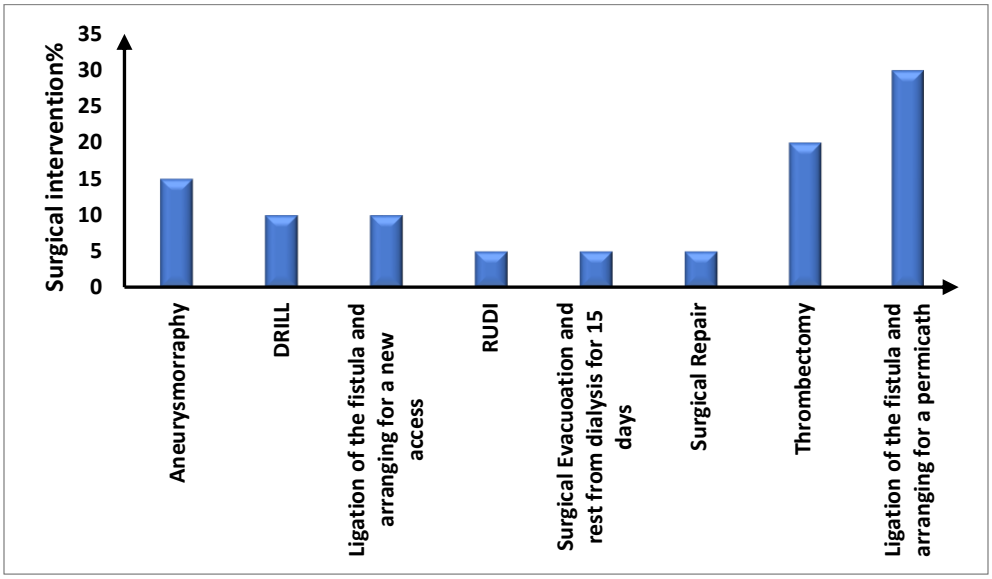

Figure 1: Distribution of surgical interventions in the studied cases

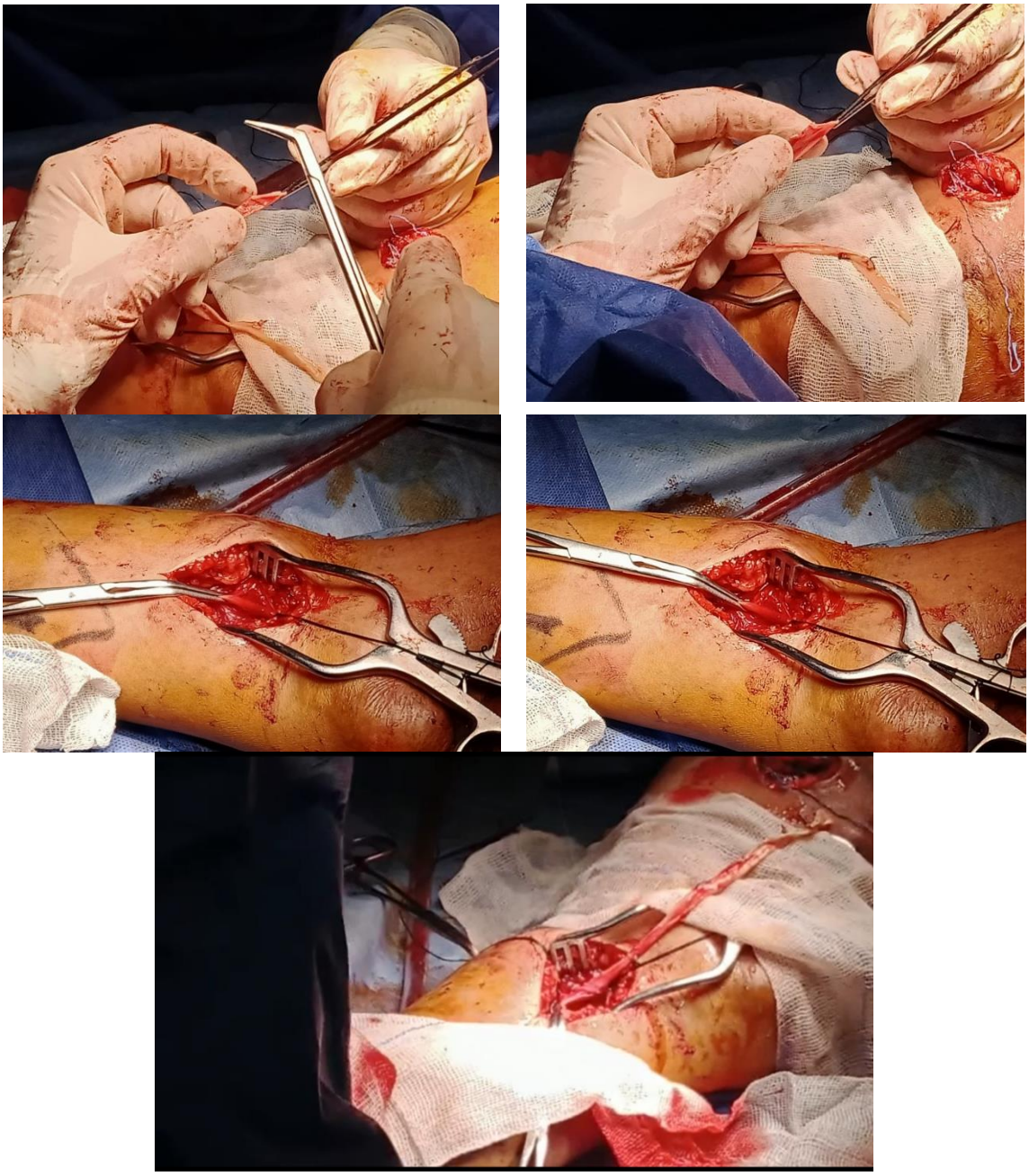

Figure 2: Case 1

Figure 3: Case 2

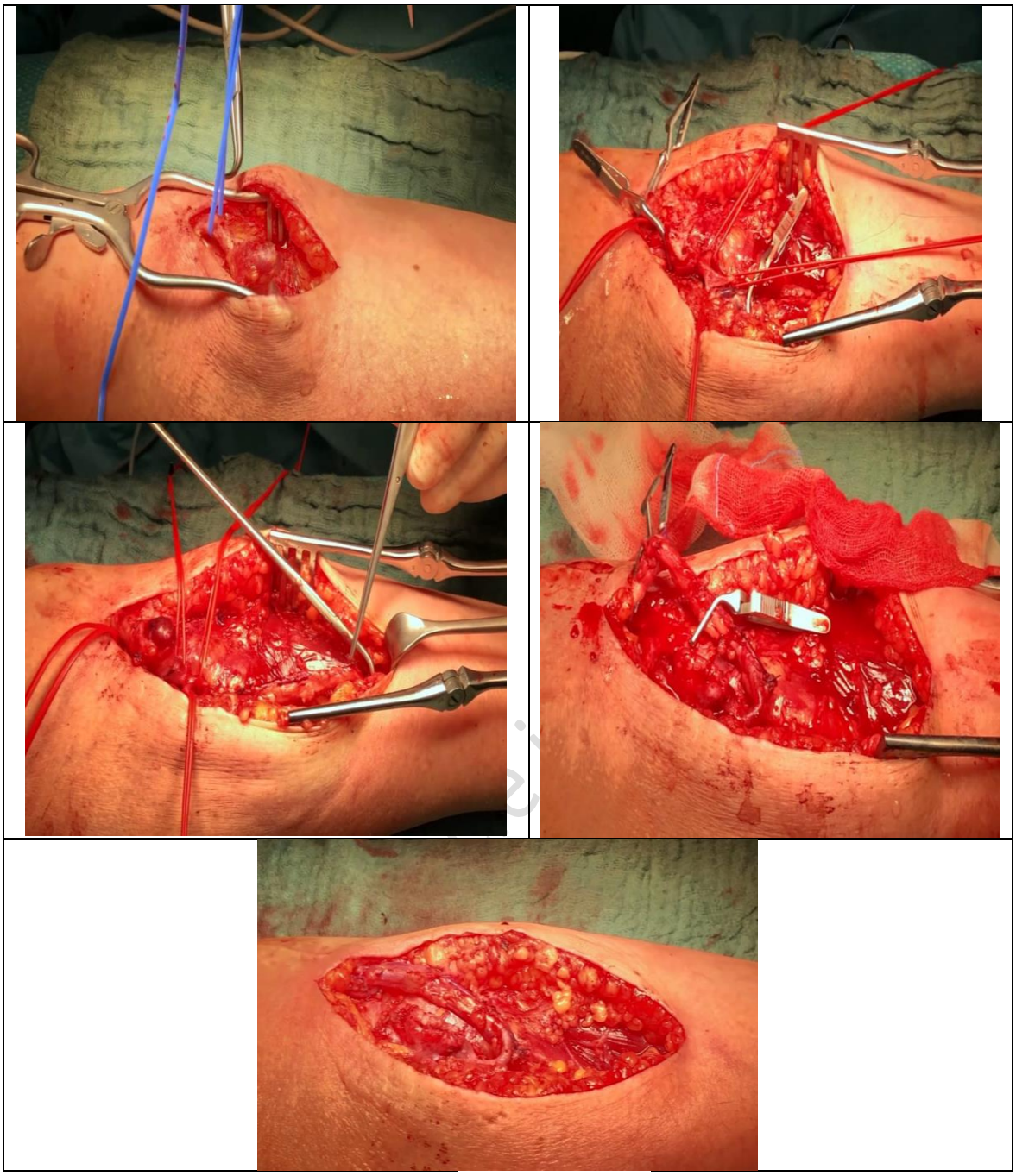

Figure 4: Case 3

Discussion

Regarding patients' demographic data in our study, the majority of the patients included in the study were between 41 and 60 years old. This age range is consistent with the typical population affected by chronic kidney disease and in need for hemodialysis access (12).

In agreement with our study, a study assessed the relationship between pre-existing, postoperative, and change in IH over time and AVF outcomes. Patients had a mean ± SD age of 55.5 ± 12.4 years. Out of the 97 patients, 37 were females and the rest were males (13).

Also, a study evaluated the prevalence, patency, and associated patient survival for pre-emptively placed autogenous fistulas and prosthetic grafts; for autogenous fistulas and prosthetic grafts placed after a temporizing catheter; and for hemodialysis catheters that remained in use. Patients had a mean age of 65 ± 15.1 years (14).

Another research found that the mean age of patients was 47.77 years (6 to 85 years). Considering gender, 148 (60.7%) were males and 96 (39.3%) were females (15).

In line with the current study, a study reported a man with a 2-stage brachiobasilic AVF that was complicated by failure 4 months after creation. His age was 64 years old (16).

Regarding the comorbidities in the studied cases, in consistent with our findings, a study reported that a significantly higher distribution of diabetes compared to other comorbidities in the studied patients (p<0.001) as 52 (54%) were diabetic, 92 (96%) were hypertensive, 20 (21%) had CAD, 7 (7%) had COPD and 6 (6%) had CHF (13).

Contrarily, a study declared that the underline diseases were hypertension (43.3%), hypertension and diabetes mellitus (21.2%) and diabetes mellitus (4.5%) (15).

These findings on comorbidities and dialysis history are consistent with existing literature in the field. Numerous studies have demonstrated the association between diabetes and hypertension with the development and outcomes of failing arteriovenous fistulas (17, 18). Additionally, the duration of dialysis history is an important factor to consider when assessing the success and outcomes of surgical management interventions.

According to access details, in harmony with our findings, a study found that 89 (93%) had Brachio-Basilic fistula, 2 (2%) had aberrant radiocephalic fistula, a significant higher percentage of 89 patients (93%) with BBF compared to the other types (13).

Additionally, a study documented that Cephalic vein was in 59.2% cases whereas antecubital vein and Basilic vein in 30.6% and 0.4% of cases respectively. Radial, Brachial and Ulnar arteries used in 53.1%, 35.9% and 1.2% of patients, respectively (15).

In our study, the most common problems encountered with access were thrombosis and infection, each representing 25% of the cases. Several studies have investigated the prevalence of access-related complications in hemodialysis patients (19, 20). A study examined AVF-related complications in a cohort of 155 patients and found that infection and thrombosis accounted for most complications (21).

The occurrence of pseudoaneurysm affecting 20% of cases in our study is noteworthy. Pseudoaneurysm formation is a known complication in AVFs and can result from repeated cannulation or trauma to the vessel. The incidence of pseudoaneurysms can vary across studies, with rates ranging from 6% to 31% (22, 23). While our study falls within this range, further exploration of the factors contributing to pseudoaneurysm formation would be valuable.

Another complication identified in our study was steal syndrome, affecting 20% of the cases. Steal syndrome occurs when blood flow is redirected away from the distal limb due to the creation of an AVF, leading to ischemic symptoms. The prevalence of steal syndrome has been reported to range from 4% to 18% in different studies (23, 24). The rate observed in our study aligns with these findings.

According to outcome in the studied cases, the fate of the current access was as follows: 60% had a successful access, while 40% had a failed access. According to primary patency, the mean duration of primary patency in the studied patients was 2.3 ± 1.9 years. According to secondary patency, after 3 months, 16.7% had non-functioning access, while 83.3% still had functioning access. After 6 months, 41.7% had non-functioning access, while 58.3% still had functioning access.

A study found a 70% success rate for AVFs, which is slightly higher than the success rate in outs (15).

Primary patency duration can vary widely depending on various factors. A study investigated vascular access (VA) outcomes and assessed if AVF non maturation outweighs long-term complications of AVGs. Fourty-one patients who received their first VA were included, of whom 863 had VAs that successfully matured. These patients were analyzed with a median follow-up of 25 months. The 1-year functional patency rates were 67%±2.0%. They reported a mean primary patency duration of 2.8 years for AVFs, which is in line with our findings (25).

According to complication, 2 cases (33.3%) had hematoma 2 cases (33.3%) had infection and 2 cases (33.3%) had thrombosis as a complication. According to wound healing, 44.4% of the studied cases had primary wound healing, while 29.6% had secondary wound healing.

A study reported in their study that the most frequent complication seen in our patients was aneurysm (51%), followed by venous hyper-tension (16.7%), infection (4.4%), thrombosis (3.3%) and arterial steal syndrome (1.1%) (21).

In their study, a study analyzed the patency rates and potential risk factors that affect functional patency and late arteriovenous fistula functionality. They reported that at the end of the follow-up period, 302 AVFs had been used for hemodialysis treatment in 285 patients. Thrombosis occurred 29 times (0.14 per patient-year). Eight patients received antibiotics for AVF infection. Two ischemic events required surgical intervention: One in a forearm AVF and one in an upper arm AVF. ischemia: f 49 PTA procedures (0.24 per patient-year) and 40 surgical revisions (including the two procedures for ischemia; 0.20 per patient-year) were performed to salvage fistulas (0.29 procedures per fistula) (26).

Conclusion

In conclusion, our study revealed that individualized surgical interventions, such as ligation of the fistula and arranging for a permcath, showed promising outcomes in

salvaging failing AVFs. However, access failure remained a significant challenge, highlighting the need for ongoing surveillance and interventions to maintain long-term access functionality. While the complication rate was relatively low, careful management of comorbidities, particularly diabetes, is crucial. These findings emphasize the complexity of managing failing AVFs and the importance of tailored approaches to optimize outcomes for hemodialysis patients.

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