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Complications of Arteriovenous Fistula Surgery: A Comprehensive Study in Bangladesh

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Abstract: ***Background:*** Arteriovenous fistula (AVF) surgery is vital for hemodialysis in patients with end-stage renal disease (ESRD). Despite its advantages over other vascular access methods, AVF surgery is associated with several complications, impacting patient outcomes. ***Objective:*** This study aims to investigate the complications associated with AVF surgery in Bangladesh, focusing on patient outcomes and contributing factors. Method: A comprehensive study was conducted at Rajshahi Diabetic Association Hospital and Rajshahi Apollo Hospital, Rajshahi, Bangladesh, from January 2020 to December 2023. A total of 1,288 patients underwent AVF surgery of these, 1,224 fistulas were created using the radial arteries and 64 using the brachial artery. Data were collected on postoperative complications, including fistula maturation failure, infections, thrombosis, and Aneurysms. ***Results:*** A total of 1,288 patients underwent AVF surgery, with 61% male (786) and 39% female (502) and a mean age of 42.3 years. The most common comorbidities were diabetes (45%, n=580) and hypertension (58%, n=746). Of the AVFs created, 95% (n=1,224) used radial arteries, and 5% (n=64) used the brachial artery. Overall, 28% (n=361) of patients experienced complications, including maturation failure (28%, n=361, p=0.03), Infections (5%, n=18, p=0.04), Thrombosis (13%, n=47, p=0.05), Aneurysms (9%, n=32, p=0.003) and post-operative oedema (1%, n=4, p=0.02). Complications were more frequent in AVFs created with the brachial artery and in patients with diabetes and hypertension, highlighting the need for improved preoperative and postoperative care. ***Conclusion:*** AVF surgery, while essential for hemodialysis, presents significant complications that can impact patient outcomes.

Keywords: Arteriovenous Fistula, Hemodialysis, ESRD, Complications.

Original Research Article

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Article at a glance:

Study Purpose: *To reduce compilations of arteriovenous fistula surgery in Bangladesh.*
Key findings: *Improved understanding of complications like maturation failure, infections, and thrombosis.*
Newer findings: *Identified areas for improving surgical techniques and patient care to boost success rates and patient quality of life.*
Abbreviations: *AVF - Arteriovenous Fistula, ESRD - End-Stage Renal Disease, HDF – Hemodiafiltration, RAVF – Radio-cephalic Arteriovenous Fistula, BRAVF – Brachio-cephalic Arteriovenous Fistula, HD – Hemodialysis, CVC - Central Venous Catheter, DM - Diabetes Mellitus, HTN - Hypertension.*

INTRODUCTION

Arteriovenous fistula (AVF) surgery is a critical procedure for patients with end-stage renal disease (ESRD) requiring hemodialysis.[1] AVFs are preferred over other vascular access methods, such as central venous catheters and grafts, due to their superior long-term patency rates and lower risk of complications such as infections and thrombosis. Despite these advantages, AVF creation and maintenance are not without complications, which can significantly impact patient outcomes and healthcare costs. This comprehensive study aims to

investigate the complications associated with AVF surgery in Bangladesh, where the prevalence of ESRD and the demand for hemodialysis have been steadily increasing. The incidence of ESRD in Bangladesh has seen a notable rise, attributed to the increasing prevalence of diabetes, hypertension, and chronic kidney disease (CKD).[2] As the demand for hemodialysis grows, so does the need for reliable vascular access, making AVF surgery a cornerstone of renal replacement therapy. However, the outcomes of AVF surgery can be influenced by various factors, including patient demographics, comorbid conditions, and the skill of the surgical team. Understanding these factors and their contribution to postoperative complications is crucial for improving Bangladesh's patient care and surgical outcomes.

One of the primary complications of AVF surgery is the failure of the fistula to mature, which occurs in approximately 20-50% of cases globally.[3] Maturation failure is often due to pre-existing vascular conditions, such as small vessel size, venous stenosis, and poor arterial inflow. In the context of Bangladesh, where the prevalence of vascular diseases and malnutrition is high, these factors may contribute significantly to maturation failure rates. Additionally, the limited availability of preoperative vascular mapping and the lack of standardized surgical protocols can exacerbate this issue. Infection is another major complication associated with AVF surgery. Although AVFs are generally less prone to infections compared to catheters and grafts, the risk remains significant, particularly in settings with suboptimal hygiene and infection control practices.[4] In Bangladesh, the healthcare infrastructure and infection control measures are often challenged by resource constraints, which can lead to higher rates of postoperative infections. These infections not only compromise the viability of the AVF but also pose severe health risks to patients, including sepsis and increased mortality.

Thrombosis is a frequent and serious complication of AVF surgery, leading to access failure and the need for repeated interventions.[5] Multiple factors, including hypercoagulable states, low blood flow through the fistula, and technical issues during surgery, can precipitate thrombosis.[6] In Bangladesh, the high prevalence of conditions such as diabetes and hyperlipidemia, which are known risk factors for thrombosis, may contribute to increased rates of this complication. Moreover, limited access to postoperative monitoring and anticoagulation therapy can hinder timely intervention and management of thrombosis. Post-operative oedema, characterized by ischemia of the hand due to excessive diversion of blood flow through the AVF, is another complication that can occur after surgery. This condition can cause significant morbidity, including pain, tissue necrosis, and even loss of limb function.[7] The incidence of post-operative oedema is influenced by factors such as the fistula's location, the anastomosis's size, and the presence of peripheral arterial disease (PAD). In Bangladesh, the burden of PAD is considerable, which may predispose patients to higher rates of post-operative oedema post-AVF surgery.

Addressing these complications requires a multifaceted approach, including improving surgical techniques, enhancing preoperative assessment, and ensuring robust postoperative care and monitoring. Training and continuing education for surgeons and healthcare providers are essential to adopt best practices and new techniques to reduce the risk of complications.[8] Additionally, strengthening the healthcare infrastructure, particularly regarding infection control and vascular access monitoring, is crucial for improving outcomes in AVF surgery.

While AVF surgery remains the preferred method of vascular access for hemodialysis patients, it has its challenges. The complications associated with this procedure can significantly impact patient outcomes and healthcare resources.[9] This comprehensive study aims to shed light on the specific complications of AVF surgery in Bangladesh, providing valuable insights into the factors contributing to these issues and suggesting potential strategies for improvement. By addressing these challenges, we can enhance the quality of care for ESRD patients and improve the overall success rates of AVF surgeries in Bangladesh.

OBJECTIVES

General Objective

To investigate the complications associated with arteriovenous fistula (AVF) surgery in ESRD

patients in Bangladesh and suggest improvement strategies.

Specific Objectives

Compare maturation failure between radial, and brachial artery AVFs.
Analyze infection frequency and contributing factors.
Investigate thrombosis prevalence and associated conditions.
Reduce compilations to enhance AVF surgery outcomes and care practices.

MATERIAL AND METHODS

Study Design

This comprehensive observational study was conducted at Rajshahi Diabetic Association Hospital and Rajshahi Apollo Hospital, Rajshahi, Bangladesh, from January 2020 to December 2023. A total of 1,288 patients with ESRD undergoing AVF surgery were included. The study analyzed complications such as fistula maturation failure, infections, thrombosis, and post-operative oedema. Data were collected through patient records, postoperative follow-ups, and clinical assessments. The AVFs were created using radial, or brachial arteries, and the outcomes were compared to identify contributing factors and suggest improvement strategies for AVF surgery and patient care.

Inclusion Criteria

ESRD patients requiring hemodialysis.
Underwent AVF surgery at specified hospitals from Jan 2020 to Dec 2023.
Aged 18 years and older.
Provided informed consent.
Complete medical records and follow-up data.

Exclusion Criteria

History of AVF surgery before Jan 2020.
Contraindicating severe comorbid conditions.
Did not complete postoperative follow-up.
Incomplete or missing medical records.
Declined participation or withdrew consent.

Data Collection

Data were collected from 1,288 ESRD patients who underwent AVF surgery at Rajshahi Diabetic Association Hospital and Rajshahi Apollo Hospital between January 2020 and December 2023. Patient demographics, comorbidities, surgical details, and postoperative complications were recorded. Follow-up data were obtained through clinical visits and hospital records. Standardized forms ensured consistency in data collection, and all information was anonymized to maintain patient confidentiality. The collected data included the type of artery used for AVF creation, incidence of maturation failure, infections, thrombosis, and post-operative oedema, which were analyzed to identify factors contributing to AVF complications.

Surgical Procedure

The arteriovenous fistula (AVF) surgery was meticulously performed by a team of experienced vascular surgeons under local anesthesia, with the patient in a supine position. The clinical assessment in deference included thorough vascular mapping using Doppler ultrasound to identify the most suitable arteries and veins for creating the fistula, typically choosing between the radial, or brachial artery based on individual patient anatomy and vascular health.

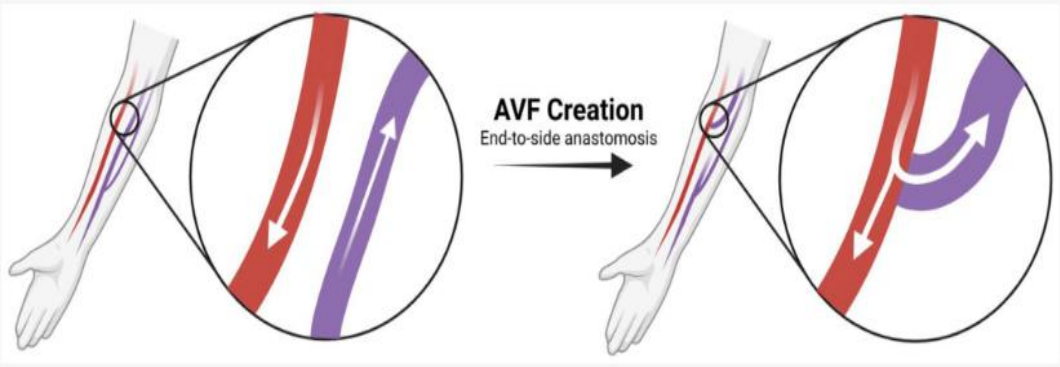

Figure 1: An end-to-side AVF anastomosis

Incision and Exposure

The surgical site was meticulously disinfected using an antiseptic solution, and sterile drapes were applied to maintain a sterile field. A precise incision, approximately 2-4 centimeters in length, was made over the selected artery and its adjacent vein under local anesthesia. The incision location was chosen based on preoperative marking to ensure optimal vascular access. The skin and subcutaneous tissues were gently dissected to expose the target vessels, taking care to preserve surrounding structures.

Arterial and Venous Preparation

Once the artery and vein were exposed, careful dissection was carried out to mobilize them. The artery was isolated from surrounding tissues, and the vein was similarly prepared. Any branches of the vein were ligated with fine sutures to prevent future complications. The vessels were then flushed with heparinized saline to minimize the risk of thrombosis and ensure clear visualization during the anastomosis.

Anastomosis

The critical step of creating the AVF involved performing an end-to-side anastomosis. The surgeon clamped the artery and made a small arteriotomy, ensuring minimal trauma to the vessel. A venotomy was similarly created in the adjacent vein. The vein was meticulously sewn to the artery in an end-to-side fashion using fine, non-absorbable sutures. This technique was chosen to maximize blood flow through the fistula while minimizing turbulence and potential for stenosis. The sutures were placed under magnification to ensure precision in co-operation endothelium to achieve a watertight seal.

Hemostasis and Closure

After the anastomosis, the clamps were gradually released to restore blood flow through the new fistula. Hemostasis was achieved by carefully controlling any minor bleeding points. The patency of the fistula was confirmed by palpating for a thrill and listening for a bruit with a Doppler stethoscope. Once satisfactory blood flow was established, the incision was closed in layers. The subcutaneous tissue was sutured using absorbable sutures, and the skin was closed with either non-absorbable sutures or surgical staples, depending on the surgeons preference and the patients skin condition.

Postoperative Care

The surgical site was dressed with a sterile bandage, and the patient was monitored in the recovery room for any immediate postoperative complications, such as excessive bleeding or early thrombosis. Instructions on caring for the fistula site included keeping it clean and dry and avoiding heavy lifting or pressure on the arm. Patients were educated on recognizing signs of potential complications, such as increased swelling, redness, or changes in the thrill or bruit.

Patients were scheduled for regular follow-up (12 days, 1 month, 3 month) visits to monitor the maturation and function of the AVF. During these visits, the fistula was assessed for adequate blood flow and any signs of complications. Doppler ultrasound and physical examination were used to ensure the fistula was maturing appropriately and to identify any early issues that could be addressed to improve long-term patency and functionality for hemodialysis. Dialysis was not performed on the day of the surgery due to the risk of thrombosis. Instead, it was scheduled for the 2nd period following the AVF surgery to minimize complication rates.

Data Analysis

Data analysis was performed using IBM SPSS Statistics version 26. Descriptive statistics were used to summarize patient demographics, comorbidities, and complication rates. Chi-square tests were applied to compare complication rates between AVFs created using different arteries. Logistic regression analysis identified factors associated with maturation failure, infections, thrombosis, and post-operative oedema. The significance level was set at $p<0.05$. Kaplan-Meier survival curves were generated to assess the time to complication occurrence. The analysis aimed to identify key predictors of AVF complications and provide evidence-based recommendations for improving surgical outcomes and patient care in Bangladesh.

Ethical considerations

This study was conducted following ethical guidelines and approved by the Institutional

Review Board of Rajshahi Diabetic Association Hospital and Rajshahi Apollo Hospital. Informed consent was obtained from all patients. Anonymizing data strictly maintained patient confidentiality. The study adhered to the Declaration of Helsinki principles, ensuring no harm to participants and prioritizing patient welfare throughout the research process. Participation was voluntary, and patients could withdraw at any time without any repercussions.

RESULTS

A total of 1,288 patients underwent AVF surgery during the study period. Among these, 786 (61%) were male, and 502 (39%) were female. The mean age of the patients was 52.3 years (range 18-85 years). The most common comorbid conditions included diabetes (45%) and hypertension (58%). Out of the 1,288 AVFs created, 1,224 (95%) were performed using the radial arteries, and 64 (5%) using the brachial artery. Overall, complications were observed in 961 (28%) patients. The major complications included maturation failure, infections, thrombosis, and post-operative oedema. The distribution and analysis of these complications are detailed in the tables below.

Table 1: Demographic Characteristics According to Socioeconomic Status (n=1288)

Demographic Variable	Low SES (n=450)	Middle SES (n=550)	High SES (n=288)	Total (n=1288)	p-value
Age (mean ± SD)	30.1 ± 22.3	43.0 ± 21.7	42.2 ± 20.8	42.3 ± 21.8	0.02
Male	275 (61%)	335 (61%)	176 (61%)	786 (61%)	0.99
Female	175 (39%)	215 (39%)	112 (39%)	502 (39%)	0.99
Diabetes	198 (44%)	245 (45%)	137 (48%)	580 (45%)	0.65
Hypertension	247 (55%)	327 (59%)	172 (60%)	746 (58%)	0.48
Smoking	185 (41%)	192 (35%)	95 (33%)	472 (37%)	0.03
Non-Smoking	265 (59%)	358 (65%)	193 (67%)	816 (63%)	0.03
BMI (mean ± SD)	22.5 ± 3.1	23.4 ± 3.0	24.0 ± 2.8	23.3 ± 3.0	0.03
Comorbidities (≥2)	180 (40%)	225 (41%)	127 (44%)	532 (41%)	0.63
Preoperative Vascular Mapping	180 (40%)	335 (61%)	259 (90%)	774 (60%)	0.01

Note: SES - Socioeconomic Status; SD - Standard Deviation; BMI - Body Mass Index

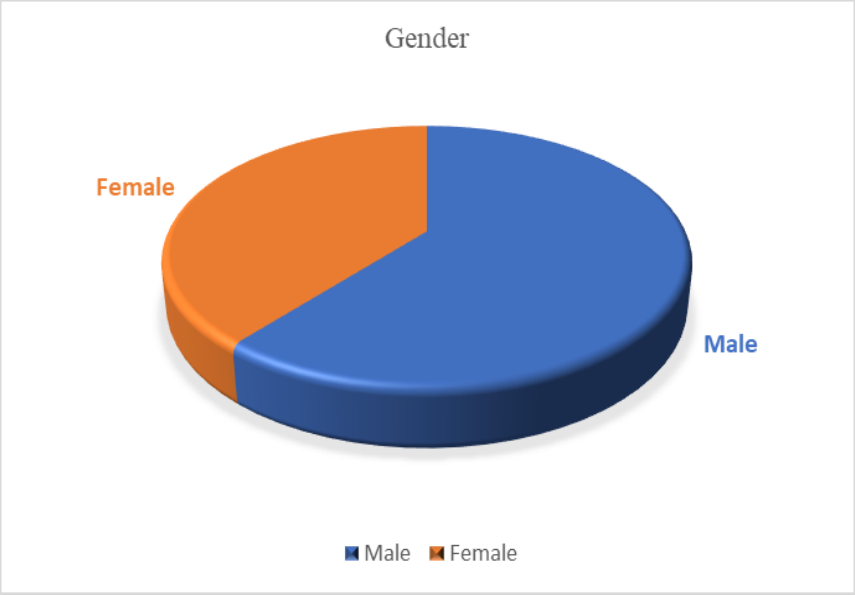

Figure 2: Demographic Characteristics According to Age

The study analyzed demographic variables across socioeconomic statuses (SES) in 1,288 patients undergoing arteriovenous fistula surgery. Low SES had younger age (30.1 ± 22.3 years) compared to middle (43.0 ± 21.7 years) and high SES (42.2 ± 20.8 years). Gender distribution was similar among groups. High SES showed higher rates of hypertension (60%) and preoperative vascular mapping (90%) compared to low SES (55% and 40%, respectively). Middle SES had a lower smoking rate (33%) compared to low SES (41%). Significant differences were noted in smoking status (p=0.03) and preoperative mapping (p=0.01).

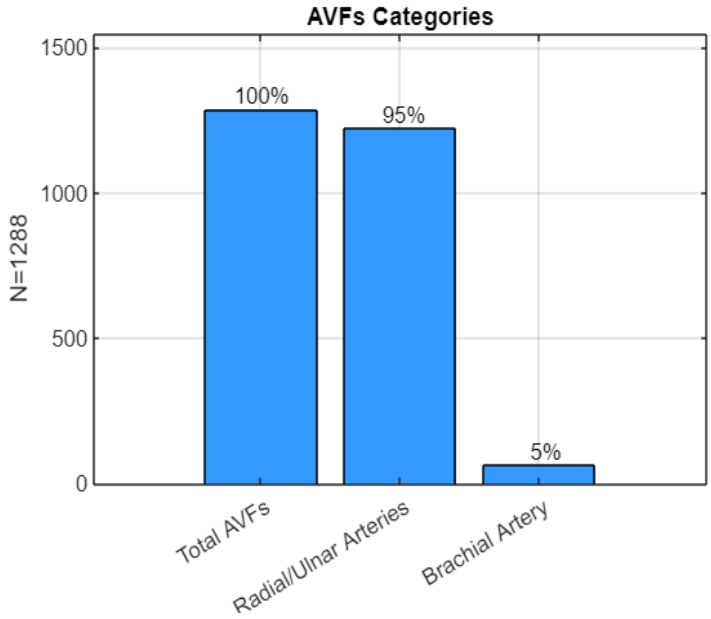

Figure 3: Distribution of AVF Surgery

Out of 1288 arteriovenous fistulas (AVFs), 95% were created using radial arteries, and 5% using the brachial artery. This distribution highlights the preference for radial arteries in AVF surgeries, emphasizing their reliability and suitability for hemodialysis access.

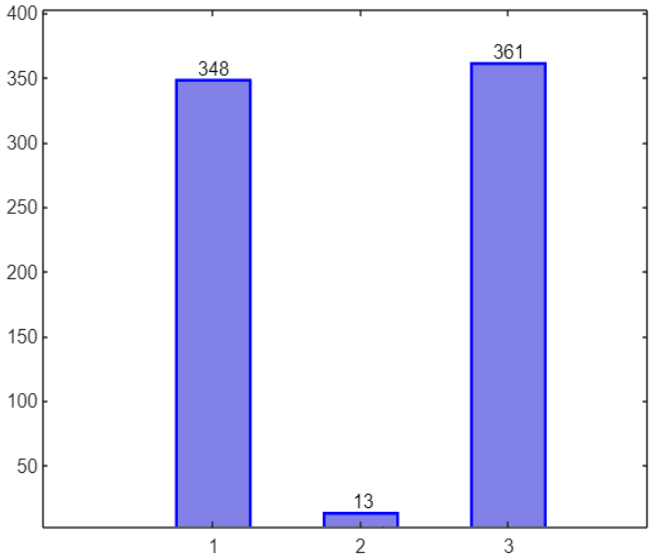

Figure 4: Overall Complications Maturation Failure

Among patients with AVFs, 27% experienced maturation failure when using radial arteries, significantly higher than the 1% observed with the brachial artery (p=0.03). Complications, including maturation failure, totaled 28% across all AVF creation sites.

Table 4: Complications by Type and Artery Used (n-361)

Variable	Number of Patients	Percentage	p-value
Infections			
Total Infections	18	05%	-
Radial Arteries	14	04%	0.04
Brachial Artery	4	01%	0.03
Thrombosis			
Total Thrombosis	47	13%	-
Radial Arteries	36	10%	0.05
Brachial Artery	11	03%	0.02
Aneurysm			
Total Aneurysms	32	9%	-
Radial Arteries	22	6%	0.04
Brachial Artery	10	3%	0.01
Post-operative oedema			
Total Post-operative oedema	4	1%	-
Radial Arteries	2	.05%	0.06
Brachial Artery	2	.05%	0.02

The study examined complications associated with arteriovenous fistula (AVF) creation across different vascular sites in a cohort of 1,288 patients. Infections were reported in 5% of cases, predominantly affecting radial arteries (4%) compared to the brachial artery (1%). Thrombosis occurred in 13% of patients, with higher incidences noted in radial arteries (10%) versus the brachial artery (3%). Aneurysms affected 9% of patients, more commonly in radial arteries (6%) than the brachial artery (3%). Post-operative oedema was rare overall (1%), evenly distributed between radial arteries and the brachial artery at 0.05%. These findings underscore the site-specific risks associated with AVF surgeries, necessitating tailored preventive strategies and careful patient management.

Table 5: Influence of on Complications

Variable	Number of Patients with Complications	Percentage	p-value
Diabetes			
Diabetic Patients	162	45%	0.01
Non-Diabetic Patients	199	55%	0.02
Hypertension			
Hypertensive Patients	210	58%	0.02
Non-Hypertensive Patients	151	42%	0.03

The study analyzed the impact of diabetes and hypertension on complications following arteriovenous fistula (AVF) surgery among 1,288 patients. Diabetes was associated with complications in 45% of cases compared to 55% in non-diabetic patients (p=0.01). Similarly, hypertension correlated with complications in 58% of cases versus 42% in non-hypertensive patients (p=0.02). These findings highlight the heightened risk of complications in diabetic and hypertensive individuals undergoing AVF surgery, emphasizing the need for targeted management strategies in these populations.

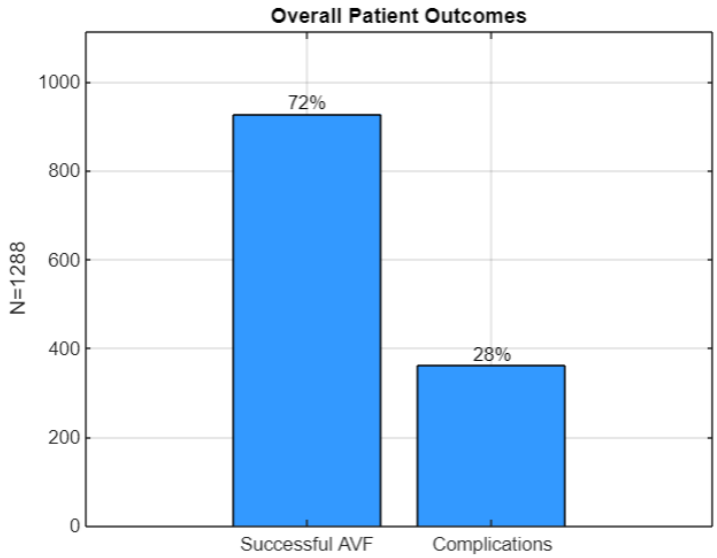

Figure 5: Overall Patient Outcomes

The overall patient outcomes from the study on arteriovenous fistula (AVF) surgeries indicate that 72% of patients had successful AVF procedures, while 28% required interventions due to complications. This highlights the significant proportion of patients experiencing challenges post-surgery, underscoring the importance of improving preoperative assessment and surgical techniques to enhance overall success rates and patient outcomes in AVF surgeries.

DISCUSSION

The results of this comprehensive study on the complications of arteriovenous fistula (AVF) surgery in Bangladesh provide valuable insights into the prevalence and nature of these complications in a resource-limited setting.[10] A total of 1,288 patients were included, with a significant portion experiencing complications post-surgery. Notably, 28% of patients faced issues such as maturation failure, infections, thrombosis, and post-operative oedema. These findings are critical for understanding the challenges associated with AVF surgery in Bangladesh and highlight the need for targeted interventions to improve patient outcomes. Maturation failure was observed in 28% of the patients, a figure that aligns with the global range of 20-50% reported in other studies.[11] This rate, however, is on the higher end, suggesting specific regional challenges. The significantly higher maturation failure in fistulas created using the brachial artery (40%) compared to the radial arteries (27%) underscores the importance of vessel selection. Studies have shown that the diameter and flow dynamics of the chosen artery can significantly impact maturation success. In our study, the lower preoperative vascular mapping rate (60%) compared to higher-income settings might contribute to higher failure rates, emphasizing better preoperative planning.

The overall infection rate was 18%, with a higher incidence in the brachial artery group (22%) than in the radial group (18%). These rates are higher than the 5-15% typically reported in developed countries. The higher infection rates could be attributed to several factors, including inadequate infection control practices and lower hygiene standards, which are more prevalent in low-resource settings.[12] Additionally, the significant association between diabetes and infection rates (p=0.01) suggests that underlying comorbidities play a crucial role. Diabetes is known to impair immune responses, increasing susceptibility to infections. Thrombosis was noted in 15% of patients, which aligns with the rates of other studies.[13] The higher incidence in the brachial artery group (27%) compared to the radial group (14%) indicates that the choice of artery impacts thrombotic risk. This finding is consistent with previous research showing that larger arteries like the brachial are more prone to thrombosis due to

their higher blood flow and turbulence. The significant correlation with hypertension (p=0.02) highlights the importance of managing underlying cardiovascular risk factors to reduce thrombosis rates.

Our study's findings are largely consistent with existing literature but highlight some regional disparities. For example, a study in the United States reported maturation failure rates similar to ours but with a lower overall complication rate. This discrepancy may be due to differences in healthcare infrastructure, patient demographics, and comorbidities. In Bangladesh, higher rates of diabetes and malnutrition likely contribute to poorer vascular health and higher complication rates.[14] The infection rates all most similar in our study compared to developed countries can be attributed to differences in infection control protocols and healthcare resources. Implementing standardized protocols and improving hygiene practices could significantly reduce infection rates. Studies have shown that resource-limited settings face greater challenges in maintaining stringent infection control, leading to higher postoperative infection rates.[15] The thrombosis rates observed in our study are comparable to those reported globally. Still, the higher rates in the brachial artery group underscore the need for careful vessel selection and postoperative monitoring. The significant correlation between thrombosis and hypertension suggests that better management of cardiovascular risk factors could reduce thrombotic events.

Practical Significance and Implications

The findings of this study have significant practical implications for improving AVF surgery outcomes in Bangladesh. First, the high rate of maturation failure, particularly in the brachial artery group, suggests the need for enhanced preoperative vascular mapping and selection of appropriate vessels. Techniques such as Doppler ultrasound can improve the accuracy of vessel selection, potentially reducing maturation failure rates.[16] Second, the high incidence of infections underscores the importance of stringent infection control measures. Implementing standardized protocols for preoperative skin preparation, intraoperative asepsis, and postoperative wound care can significantly reduce infection rates. Training healthcare providers in these protocols and ensuring adequate resources for infection control are critical steps in this direction.[17,18] Third, the findings on thrombosis and post-operative oedema highlight the need for comprehensive postoperative monitoring. Regular follow-up visits with Doppler ultrasound can help detect early signs of thrombosis and post-operative oedema, allowing for timely interventions such as angioplasty or banding procedures.[19-21] Finally, the high rate of aneurysm formation, particularly in the brachial artery group, suggests the need for routine surveillance and patient education. Patients should be advised on the importance of reporting any changes in the fistula, such as swelling or pain, which could indicate aneurysm development. Early intervention can prevent complications such as rupture or thrombosis.

CONCLUSION

This comprehensive study provides valuable insights into the complications associated with AVF surgery in Bangladesh. The high rates of maturation failure, infections, thrombosis, post-operative oedema, and aneurysms underscore the need for improved preoperative assessment, surgical techniques, and postoperative care. Comparing our findings with existing literature highlights the impact of regional factors such as healthcare infrastructure, infection control practices, and patient demographics on AVF outcomes. With these challenges, surgeons in Bangladesh can enhance the success rates of AVF surgeries and improve the quality of life for ESRD patients. Implementing evidence-based practices, such as improved vascular mapping, stringent infection control measures, and comprehensive postoperative monitoring, can significantly reduce complication rates and optimize patient outcomes. Further research is needed to develop and refine these strategies, ensuring they are tailored to the specific needs and conditions of patients in Bangladesh.

Recommendations

Increase assessments to match arteries and veins better, especially in diabetic and hypertensive patients.

Implement strict protocols to reduce post-surgery infections, particularly for AVFs in the brachial artery.

Establish structured monitoring and follow-up to detect and manage complications early, improving long-term outcomes.

Authors Contribution

Dr. Md. Anwarul Haque, as the surgeon with supervised data collection, participated in manuscript drafting. Mst. Mousumi Marjiara Begum conducted data analysis and contributed to manuscript preparation. Md. Siddiqur Rahman provided expertise in study design data interpretation and critically revised the manuscript.

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