DOI: https://doi.org/10.54393/pjhs.v4i11.1152

PAKISTAN JOURNAL OF HEALTH SCIENCES

https://thejas.com.pk/index.php/pjhs

Volume 4, Issue 11 (November 2023)

Original Article

Predictors of Outcome in Management of Ruptured Arteriovenous Fistula in Hemodialysis Patients: A Cross-Sectional Study at a Tertiary Care Hospital, Karachi

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ARTICLE INFO

Key Words:

Ruptured Arteriovenous Fistula, Predictors, Salvageability

How to Cite:

Basit, A., Masood, B., Memon, F., Habib, F. A., Zehra, D., & Keen, I. T. (2023). Predictors of Outcome in Management of Ruptured Arteriovenous Fistula in Hemodialysis Patients: A Cross-Sectional Study at a Tertiary Care Hospital, Karachi: Management of Ruptured Arteriovenous fistula. Pakistan Journal of Health Sciences, 4(11). https://doi.org/10.54393/pjhs.v4i11.1152

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Received Date: 26th October, 2023
Acceptance Date: 15th November, 2023
Published Date: 30th November, 2023

ABSTRACT

Bleeding from ruptured arteriovenous fistulae (AVF) is a distressing complication resulting from multiple factors and can lead to life-threatening hemorrhage. **Objective:** To analyze factors that contribute to the development of a bleeding ruptured AVF which could enable us to make decision regarding line of management for saving these AVFs. **Methods:** This cross-sectional study was conducted at Department of Vascular Surgery, Sindh Institute of Urology and Transplant (SIUT), including 52 patients presenting with burst arteriovenous fistula during the time period of six months. Data collection was carried out using a pretested questionnaire which comprised of detailed history regarding pre-operative and per-operative factors related to burst fistula. **Results:** The mean age of the patients was 35.7 ± 19.6 years with gender distribution identified as male (51.9%) and female (48.1%). The major outcome of the study was salvageability of AVF which was observed to be 36.5% among the study cohort. We also analyzed association of AVF salvageavility with pre-operative and intraoperative factors which showed its significant association with risk factors such as fistula age (<40 or > 40 days), area of surrounding inflammation, overlying skin, bleeding AVF before initiation of hemodialysis from fistula, type of cannulation, site of bleeding from AVF and ligation/repair status of fistula. **Conclusions:** Understanding these significantly associated factors could contribute to the early detection and allow measures aimed at averting adverse outcomes, which can span from the loss of vascular access to severe health problems and even, in some cases, prove fatal.

INTRODUCTION

Haemodialysis is recognized as a form of renal replacement therapy which is a measure to sustain acute kidney injury (AKI) or a prolonged, gradual loss in renal function, called chronic kidney disease (CKD), until a kidney transplant can be carried out, or for sustaining those ineligibles for it [1]. Many of the patients who failed to become candidate for renal transplantation remain dependent on HD for lifetime with ultimate long-term need for the development of dialysis access [2]. Haemodialysis patients with central venous catheters have larger mortality secondary to the development of infections while patients with native arteriovenous fistulas (AVFs) tend to experience extended patency and lesser complications. Therefore, AVFs is considered as the most preferred renal replacement methods [3]. National Kidney Foundation Kidney Disease Outcomes Quality Initiative vascular access guidelines correctly rank the arteriovenous fistula (AVF) as the best available access for providing haemodialysis [4]. AV fistula

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by definition is the autologous arteriovenous access surgically created communications between native artery and vein in an extremity where vein serves as the accessible conduit [5]. Most commonly suggested AVF include radiocephalic fistula, brachiocephalic fistula and basilic vein transposition. The access that is formed is usually used for HD 2-5 times per week [6]. Understanding the potential complications of AVFs may lead to their well-timed detection and enable actions to be taken that might avert damaging consequences that range from loss of vascular access to serious morbidity, and may ultimately be fatal [7]. The potential complications of fistulae for HD are lymphedema, infection, aneurysm, stenosis, congestive heart failure, steal syndrome, ischemic neuropathy and thrombosis. Such fistulas could also result in blood loss due to development of pseudo-aneurysm secondary to repeated punctures for vascular access, stenosis, infection trauma and use of anticoagulant which ultimately led these patients to present in surgical emergency [8]. To better preserve and manage bleeding ruptured arteriovenous fistulas (AVFs), understanding their early causes and associated outcomes is crucial for effective intervention and safeguarding these vital conduits in patients [9].

METHODS

This cross-sectional study was conducted at Department of Vascular Surgery, Sindh Institute of Urology and Transplant (SIUT), a tertiary care hospital after the approval of synopsis from ERC (Ethical review committee) of SIUT (SIUT-ERC-2023/A-437). We enrolled all the patients presenting with burst arteriovenous fistula either before or after initiation of haemodialysis over the time period of six months from March 15, 2023 to August 31, 2023. Data were collected using convenience sampling technique. Inclusion criteria were patients presenting with bleeding from AVF both before and after initiation of haemodialysis from the fistulae while patients undergoing HD presenting with bleeding arteriovenous grafts were excluded. The calculated sample size of the study calculated through OpenEpi, was 52 patients based on the frequency of bleeding/hematoma AVF observed as 16.7% [10] with a margin of error 7 % and 95 % confidence level. Data collection was carried out after taking patient's informed consent using a pretested questionnaire which included socio-demographic details, detailed history regarding pre-operative factors such as age of fistula, time duration since its construction, co-morbidity i.e, DM and HTN, site of fistula, pre-dialysis or post dialysis rupture of fistula and also information about the per-operative/intra-operative findings such as site of bleeding, presence of proximal stenosis, presence of pseudo aneurysm, need for ligation or repair and salvage of fistula for HD. Statistical analysis was done using SPSS version 23.0. Continuous data were shown as mean ± standard deviation (SD) while categorical variables were presented as frequency and percentages. For identification of risk factors associated with salvageability of AVF, a chi-square test was undertaken. A p-value of less than 0.05 was considered significant. Confidentiality of patient data were maintained throughout the study.

RESULTS

In this study, a total of 52 participants presented with burst fistula from March 15, 2023 to August 31, 2023. The gender distribution consisted of 27 participants identified as male (51.9%) and 25 as female (48.1%) with an average age of (35.7 ± 19.1) years. The prevalence of underlying co-morbidities included diabetes mellitus (DM) in 3.8%, hypertension (HTN), the most common co-morbidity accounted for 53.8%. Ischemic heart disease (IHD) constituted 1.9% of the sample. Notably, 9 individuals (17.3%) were found to have both DM and HTN, while only 1 participants (1.9%) presented with the combination of DM, HTN, and IHD. A considerable proportion of the participants, 11 individuals (21.2%), had no co-morbidities as presented in Table 1.

Table 1: Baseline Characteristics

Variable	Patients (N=52)
Age (Years)	35.7 ± 19.6
Gender	
Male	27 (51.9%)
Female	25 (48.1%)
Co-morbidity	
DM	2 (3.8%)
HTN	28 (53.8%)
IHD	1 (1.9%)
DM & HTN	9 (17.3%)
DM, HTN & IHD	1 (1.9%)
None	11 (21.2%)

(DM: Diabetes Mellitus, HTN: Hypertension, IHD: Ischemic Heart Disease)

In our setup, the underlying cause of renal failure in most of the patients was idiopathic (38.5%) followed by hypertension (17.3%), diabetic nephropathy (9.6%) and renal stone disease (7.7%). Some other causes of renal failure like obstetric complications, bladder obstruction and autoimmune disorders were also reported. The frequency of dialysis was also analyzed which showed that twice a week patients were most common (67.3%) followed by thrice weekly (28.8%) and once a week (3.8%) as shown in Table 2.

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Table 2: Hemodialysis patient characteristics

Variable	Patients (N=52)
Cause of Renal Failure	
Amyloidosis	1 (1.9%)
ARF secondary to obstetric complication	2 (3.8%)
Autoimmune disorder (SLE)	1 (1.9%)
Bilateral medullary nephrocalcinosis	1 (1.9%)
Bladder outflow obstruction	1 (1.9%)
CRF secondary to DM & HTN	1 (1.9%)
CRF secondary to HTN	9 (17.3%)
Diabetic nephropathy	5 (9.6%)
CRF secondary to obstetric complication	1 (1.9%)
CRF secondary to Pre-eclampsia	1 (1.9%)
Idiopathic	20 (38.5%)
Obstructive Uropathy	3 (5.8%)
Posterior urethral valve	1 (1.9%)
Postpartum hemorrhage	1 (1.9%)
Renal stone disease	4 (7.7%)
Frequency of Dialysis	
Once a week	2 (3.8%)
Twice weekly	35 (67.3%)
Thrice weekly	15 (28.8%)

(ARF: Acute Renal Failure, SLE: Systemic Lupus Erythematosus, CRF: Chronic Renal Failure, DM: Diabetes Mellitus, HTN: Hypertension)

During pre-operative assessment of the factors related to the AVF, it was noted that the most preferred side for AVF surgery was found to be the left brachiocephalic (42.3%) followed by left radiocephalic location (19.2%). The proportion of Left basilic vein transposition came out to be 17.3% which was nearly equal to left radiocephalic site. The frequency of age of fistula in less than 40 days AVF was (19.2%) while (80.8%) in more than 40 days AVF. There were total 47 (90.4%) patients who presented with bleeding AVF with surrounding inflammation. In the examined patient cohort, overlying skin induration was observed in 48.1% of cases, while necrosis of the overlying skin was documented in 42.3% of patients. The mean duration of symptoms was 7.6 ± 3.9 days whereas bleeding to intervention time period was spread over 7.8 ± 4.1 days. The predominant technique employed in our study was area technique (42.3%) followed by step ladder technique (32.7%). In 19.2% of the cases, the technique remain unidentified as shown in Table 3.

Table 3: Pre-Operative Characteristics

Variable	Patients (N=52)
Age of Fistula (< 40 or > 40 Days)	
(< 40 Days)	10 (19.2%)
(> 40 Days)	42 (80.8 %)
Site of Fistula	
Left Radiocephalic	10 (19.2%)
Right Brachiocephalic	5 (9.6%)
Left Brachiocephalic	22 (42.3%)
Right Basilic Vein Transposition	3 (5.8%)
Left Basilic Vein Transposition	9 (17.3%)
Left Brachiobasilic	3 (5.8%)
Inflamation area (cm)	
<2 cm	35 (45.5%)
2-4 cm	11 (14.3%)
>4 cm	25 (32.5%)
None	6 (7.8%)
Overlying Skin	
Intact	5 (9.6%)
Indurated	25 (48.1%)
Necrosed	22 (42.3%)
Bleeding AVF before initiation of Hemodialysis from Fistula	
Yes	13 (25%)
No	39 (75%)
Duration of Symptoms (Days)	7.6 ± 3.9
Duration from Bleeding to Intervention (Days)	7.8 ± 4.1
Duration from Admission to Procedure (Days)	1.9 ± 0.7
Type of Cannulation	
Button Hole	3 (5.8%)
Step Ladder	17 (32.7%)
Area Technique	22 (42.3%)
Unknown	10 (19.2%)
Previous Intervention on AVF	
Yes	12 (23.1%)
No	40 (76.9%)
Surgical procedures of previous intervention on AVF	
Outflow Refashioning	1 (1.9%)
Venoplasty	12 (23.1%)
None	39 (75%)

In this study, we observed a distribution of bleeding sites from AVF among the study population, with 19.2% of cases attributed to anastomotic site, 9.6% to side branch, and a majority, 71.2%, were categorized as needling site. AVF were subjected to ligation in 59.6% whereas 40.4% underwent repair of AVF. Clinical evidence of proximal stenosis was found in 55.8% of the cases while bleeding AVF with pseudoaneurysm was documented in 48.1% of the patients. The salvageability of AVF was observed to be 36.5% among the study cohort as presented in Table 4.

Table 4: Per-Operative Factors

Variable	Patients (N=52)
Site of Bleeding from AVF	
Anastomotic site	10 (19.2%)
Side branch	5 (9.6%)
Needling site	37 (71.2%)
AVF ligated/Repaired	
Ligated	31 (59.6%)
Repaired	21 (40.4%)

DOI: https://doi.org/10.54393/pjhs.v4i11.1152

Variable	Patients (N=52)
Clinical evidence of Proximal Stenosis	
Yes	29 (55.8%)
No	23 (44.2%)
Bleeding AVF accompanied with Pseudoaneurysm	
Yes	25 (48.1%)
No	27 (51.9%)
Surgical Treatment for Stenosis/Pseudoaneurysm	
Outflow Refashioning	1 (1.9%)
Outflow Venoplasty	4 (7.7%)
Outflow Refashioning with pseudoaneurysmectomy	3 (5.8%)
Outflow venoplasty with pseudoaneurysmectomy	6 (11.5%)
None	38 (73.1%)
Salvageability of Fistula	
Yes	19 (36.5%)
No	33 (63.5%)

We observed that salvageability of fistula was significantly associated with risk factors such as fistula age (< 40 or > 40 days), bleeding AVF with surrounding inflammation, area of surrounding inflammation, overlying skin, bleeding AVF before initiation of hemodialysis from Fistula, type of cannulation, site of bleeding from AVF and ligation/repair of fistula (Table 5). While factors such as gender, co-morbidity, site of Fistula, frequency of dialysis, previous intervention on AVF, clinical evidence of proximal stenosis and bleeding AVF accompanied with pseudoaneurysm didn't show any significant association with salvageability of fistula.

Table 5: Association of Salvageability of fistula with AVF ligated/Repaired

Parameter		AVF ligated/Repaired		Total	p-value
		Ligated	Repaired		
Salvageability of Fistula	No	31 (93.9%)	2 (6.1%)	33(100.0%)	0.0001
	Yes	0 (0.0%)	19(100.0%)	19(100.0%)	
Total		31 (59.6%)	21 (40.4%)	52(100.0%)	

DISCUSSION

Pakistan has a gross population of 144 million with majority of population (65%) living in rural areas. In Pakistan, chronic renal failure cases are endlessly increasing with an expected incidence of more than 100 new cases per million population annually of end-stage renal disease (ESRD). There is still very inadequate data existing on the gamut of renal diseases culminating in chronic renal failure in Pakistan. In one study conducted at Sindh Institute of Urology and Transplantation (SIUT), a tertiary care center situated in Karachi reported that out of total 874 enrolled patients the largest group of patients were those in whom the aetiology was unknown. Following that, diabetes mellitus (DM) and hypertension (HTN) emerged as the subsequent most prevalent underlying factors. Obstruction both secondary to stone disease and lower tract pathology came out as the fourth commonest cause [11]. Our results also showed alignment with this prior research as most of the patients were idiopathic (38.5%) followed by hypertension (17.3%), diabetic nephropathy (9.6%) and renal stone disease (7.7%). At present, Arteriovenous fistula (AVF) has established itself as the gold standard vascular access; and is reverberated in the renal disease outcomes and quality initiative (KDOQI) guidelines [12, 13]. Both patient related (co-mobidity, gender, age, cause of renal failure) and vascular related factors such as vascular anatomy, surgical procedure, AVF placement, previous complications, techniques employed for the correction of developed complications affect ultimately AVF maturity, patency and possibly result in burst fistulas. Certain other factors have also been identified that affect the AVF are daily care, the cannulation technique used, and the size and angle of the needle inserted [14]. Numerous researches have published the data on various aspects such as AVF patency and maturation but there is extremely limited data available on the incidence of burst AV fistula. At our setup, we encounter the cases of burst fistula frequently. In Pakistan, not a single study has been conducted on the patients presenting with ruptured AV fistula so our study is the first conducted research analyzing various pre-operative and per-operative factors associated with burst fistula. Although the recommendations are for the orderly placement of vascular access for dialysis such as radio-cephalic, brachio-cephalic, basilica-vein transposition followed by AV graft placement as a last resort, but it is evident from previous literature that patient factors majorly affects the preference of fistula sites. One study in this regard conducted in PNS Shifa Islamabad on 726 dialysis dependent patients, reported left brachio-cephalic as the most common site for fistula formation followed by left radio-cephalic site which is also consistent with our results where left brachio-cephalic is the most common site accounting for 42.3% of the cases followed by left radio-cephalic [15]. Proximal stenosis associated with AVF was reported intra-operatively in more than half of the patients in our study. Literature also document stenosis as the most common type of complication accompanied with fistula. One study in this regard reported some of the related findings in patients who developed stenosis such as use of button hole cannulation technique, however it also emphasized that stenosis is influenced by other factors also. On contrary, our study reports area technique as the most frequently employed technique [16]. In our center, we found 48.1% cases of bleeding AVF accompanied with pseudoaneurysm during the study period. Previous literature linked the development of pseudoaneurysms with the cannulation techniques. According to Van Loon *et al.*, the development of both aneurysm and

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pseudoaneurysms are associated with area puncture and rope ladder technique as compare to buttonhole technique [17]. Mudoni *et al.*, stated that pseudoaneurysms may arise from the anastomosis and reflect leaking of blood outside the lumen either during the perioperative period due to surgical techniques or later as a complication of infection which could even lead to massive hemorrhage [18]. In the case of vascular surgery, infection at the surgical site is thought to be a pronounced risk for massive bleeding due to loose stitches and open wounds which are in direct connection to the arteries [19]. With all of these characteristics, the overall rate of ligated fistulas (59.6%) exceeded that of repair cases [20]. In our study including a total of 31 cases subjected to AVF ligation procedures, 11 cases of brachial artery ligation and 2 cases of radial artery ligation were performed. Noteworthy among our findings is the remarkable absence of any reported occurrences of limb ischemia within our study cohort. This observation underscores the significance of employing precise surgical techniques and careful postoperative care in alleviating the risk of ischemic complications subsequent to AVF ligation procedures.

CONCLUSIONS

In conclusion, our results provide contemporary data on factors associated with salvageability of ruptured AV fistula. However further studies are needed in order to elaborate on these findings and provide a comprehensive understanding of causes and outcomes associated with burst fistulas so that they could be managed effectively.

Authors Contribution

Conceptualization: AB, BM
Methodology: AB, BM
Formal analysis: FAH, DZ, ITK
Writing-review and editing: AB, BM, FM

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Source of Funding

All authors have read and agreed to the published version of the manuscript.

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