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Endovascular management of failed arteriovenous fistula in dialysis patients

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Abstract

Aim: Our study aimed at evaluation of endovascular management of failed arteriovenous fistula in dialysis patients. **Material And Method:** This study was carried out in total of 24 patients referred to our department with complained of failed arteriovenous fistula for dialysis. These patients were evaluated with Duplex Doppler and DSA angiography. Patients were treated by endovascular treatment which included balloon plasty, stent and stent graft. Post procedure patients were followed up at 6 months. Follow up is done with duplex ultrasound. **Result:** In the study, majority of patients in the study were between 41-50 years (33%), followed by 31-40 years (29%). The mean age of patients in the study was 45.46+13.22 years (22-70). Males (58%) were more than females (42%) in the study. Majority of AVF were located at elbow (56%). Left sided (75%) vascular accesses presented more with complications compared to that with right side (25%).

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Introduction

End stage renal failure (ESRD) patient are dependent on maintenance dialysis. Arteriovenous fistula (AVF) is the first choice because of its feasibility followed by arteriovenous graft and then the central venous catheter.[1] But these arteriovenous fistulas are prone to failure and thus contributing to the increased morbidity and mortality as well the increased cost for the patient care in ESRD.

Primary reason for the failure of shunt function or its closure is the stenosis or occlusion of central venous system which leads to venous hypertension.[2] Various studies have reported theses complication around 11-50%.[3,4] The most common cause for stenosis or occlusion has been reported to be persistent acute or chronic trauma arising from repeated punctures or cannulations of the subclavian vein.[5,6] Prevalence of central vein stenosis or occlusions is as higher as 40%.[7]

We have option of percutaneous transluminal angioplasty (PTA), bare metal stents (BMS) and covered stents in treating these cases in endovascular management.[8]

Considering the constant updates in hardware utilised (balloon and/or stent) we need recent studies to help us established efficacy. Incidence of AVF failures in haemodialysis patients in India has been less commonly and constantly documented. Studies regarding endovascular

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 07, 2023

management of AVF complication are lacking in a rural hospital setting in India, wherein the efficacy may vary in comparison to studies conducted in developed nations as well metropolitan cities of India. Hence, this study was planned with an aim to evaluate the outcome of management of central vein stenosis or obstruction in arteriovenous fistula of patients with haemodialysis.

AIM: Endovascular management of failed arteriovenous fistula in dialysis patients.

Objective

1. To evaluate the clinical success rate in endovascular treatment of endovascular salvage of failed arteriovenous fistula in hemodialysis patients.
2. To evaluate the technical success rate in endovascular treatment of endovascular salvage of failed arteriovenous fistula in hemodialysis patients.

Review Of Literature

Related Anatomy

Vascular access in hemodialysis patients is established in such a way that the venous outflow along with arterial inflow in the arteriovenous vascular access is a complete flowing circuit. Components of vascular access for dialysis include the arterial vessel tree, arteriovenous anastomosis, peripheral veins and central veins. It is of utmost importance, that these, remain patent in order to provide consistent and adequate dialysis with comfort and devoid of complications. At the end of arterial anastomosis, the peripheral component of venous outflow of AV access begins which terminates at the intra-cavitary veins. This confluence is the demarcation or starting point of the "central veins".

In upper extremity, the central veins are comprised of major intra thoracic veins – subclavian vein, brachiocephalic/ innominate vein and superior vena cava.

Causes of failed AV fistula

- Primary surgical failure- inadequate/ unsuccessful communication/ Pseudoaneurysm formation
- Failure to mature
- Venous outflow obstruction.
- Central vein stenosis.

Symptoms

This condition may be asymptomatic as well as symptomatic.

The symptoms are features resulting from the venous hypertension at the point before the obstruction. The clinical observations in the ipsilateral extremity include,

- Edema
- Swelling
- Pain
- Tenderness
- Erythema

Endovascular intervention

Guidelines by National Kidney Foundation recommend following guideline. [11]

"Patients should be considered for construction of a primary fistula after failure of every hemodialysis access"

Percutaneous transluminal angioplasty (PTA) is the initial approach recommended in all cases of failure of hemodialysis access.12 PTA in addition with stent placement is recommended in those with significant residual stenosis after PTA or in lesions which occur within 3 months after angioplasty.[4] Different type of stents include stainless steel stents, Wallstent, bare metal stents and covered stents. Primary patency and secondary patency rates for each as observed from multiple studies.[12]

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 07, 2023

Mickley et al (1997) assessed the long term results of 15 Wallstent implantations in 14 hemodialysis patients with symptomatic central vein obstructions from November 1992 to July 1996. Distributions of occlusions were 10 subclavian and 2 brachiocephalic stenosis and 2 subclavian occlusions. Initial procedural success was 100%, with no occurrence of complications.

Hatzimpaloglou et al (2002) evaluated the efficacy of stenting of symptomatic central venous stenosis and obstruction to maintain hemodialysis in 10 patients in Greece. 8 self-expanding and 7 stainless steel stents were implanted. Distribution of lesions was 6 subclavian veins, 4 brachiocephalic and 3 re-stenosed vascular accesses. Stent insertion was successful in all cases. Death occurred in 4 patients within duration of 3 months to 4 years from unrelated causes to the procedure. 1 stenosis was encountered at each of 1, 3 and 4 months while occlusion was noted in a patient at 6 months. The cumulative primary 1 year and 2 year patency rates were 70%.

Bakken et al (2007) reviewed 73 patients of hemodialysis from 1995-2003 in New York state, who underwent endovascular treatment for central venous stenosis. They compared the outcomes between those with primary angioplasty, which was performed in 47 patients, and primary stenting, which was performed in 26 patients. Angioplasty primarily failed in 9 patients who were later on put on stents. At the end of follow up, it was observed that the cumulative access survival was similar between the primary angioplasty (PTA) and primary stenting (PTS) groups.

Anaya-Ayala et al (2011) evaluated the efficacy of covered stents as an option for hemodialysis related central vascular occlusive disease (CVOD) in 25 patients from April 2007- September 2010 in Houston, Texas. The mean age of patients in study was 57$\pm$29 years, with 56% males. Viabahn endoprosthesis was used in 24 patients and in 1 patient Fluency covered stent was deployed. Technical success was 100% and no residual stenosis was observed. 16 lesions were on right side, while 9 were on left side. Mean follow duration in the study was 12.4 months (2-29). 1 patient had thrombosis within 30 days and other had thrombosis had at 3 months, both presenting with severe upper extremity edema and access dysfunction which resolved after PTA. PTA was indicated in 3 patients due to occurrence of re-stenosis in the one of the ends of the covered stent. 4 patients died during follow up, which was not related to complications of the procedure. At 12 months, the primary patency rate of the covered stent was 56%, assisted primary patency was 86% and secondary patency was 100%.[13]

Materials And Methods

Materials

1. Colour duplex ultrasound scanner- Hitachi Aeriatta S60 with high frequency (7.5-10 MHz) linear array transducer
2. Cath lab machine

Type of study: Interventional study

Study area: Department of Interventional Radiology in Acharya Vinoba Bhave Rural Hospital, Sawangi (M), Wardha, a constituent unit of DMIMS, DU.

Duration of study: 6 Months

Sample size: 24.

Sample size calculation: In a study by Chemla et al[14], the prevalence of central venous stenosis among patients of hemodialysis was 10 in 640, i.e. 1.5625%. Using formula,

Sample size = $4pq/d^2$, where p = prevalence, q = 100-p, d = precision (5)

Sample size = $4 \times 1.5625 \times 98.438 / 5^2 = 24.1 = 24$ (round off)

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 07, 2023

Statistical analysis:

- The data was analyzed using SPSS version 21 software.
- Descriptive statistics were expressed in Mean±SD and percentages.
- The level of significance in the study desired at 0.05 ($p<0.05$).

Inclusion Criteria:

1. Patients of chronic renal failure with hemodialysis access consisting of arterio-venous fistulas.

Exclusion criteria:

1. Patient with coagulopathy and bleeding tendencies.
2. Patients with arterio-venous grafts or central venous catheters.
3. Patient with history of allergic reaction to previous contrast injection.
4. Terminally ill patients.

Definitions:

Primary patency: Interval between day of stent placement and the day of first repeat dilation, or the day when the patient was lost to follow-up due to renal transplantation or death.[9]

Successful stent placement: <30% residual stenosis, with no filling of venous collaterals.[9]

Risk factors:

1. Procedure related complications
2. Adverse effects following administration of contrast agents.

Research Methodology

Duplex ultrasound – Easy to demonstrate and repeatability is advantage.

Angiography –Digital subtraction central venography is the gold standard for the diagnosis of central venous obstruction, and is more sensitive than duplex ultrasound.

Percutaneous transluminal angioplasty (PTA) and stent placement:

Using the selective technique, the desired vein is catheterized using a 5-Fr cobra catheter. Check angiogram is performed to establish the site and extent of stenosis/thrombosis. The lesion is cross with Terumo guide wire. Balloon catheter is exchanged after crossing the lesion. Position of balloon is confirmed and then inflated to the recommended pressure. Check angiogram is performed post angioplasty. PTA in addition with stent placement is done in those with significant residual stenosis after PTA or in lesions which occur within 3 months after angioplasty. Significant residual stenosis here is defined as less than 50% diameter reduction.

Patients are evaluated at 3 months and 6 months interval with colour Doppler to demonstrate the patency across the treated lesion.

Results

Age

Table 1: Distribution of Age

Age range (in years)	Frequency	Percentage
21-30	3	13
31-40	7	29
41-50	8	33
51-60	4	17
61-70	2	8
Total	**24**	**100**

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 07, 2023

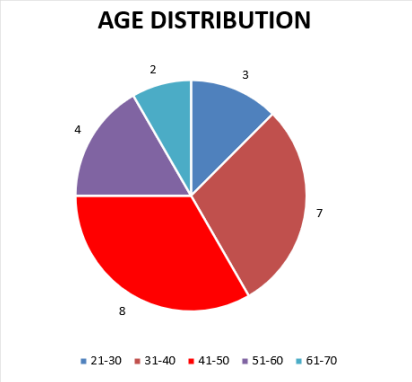

Figure: Distribution of age

In the study, majority of patients in the study were between 41-50 years (33%), followed by 31-40 years (29%). The mean age of patients in the study was 45.46±13.22 years (22-70).

Sex Distribution

Table 2: Sex Distribution

Sex	Frequency	Percentage
Female	10	42
Male	14	58
Total	**24**	**100**

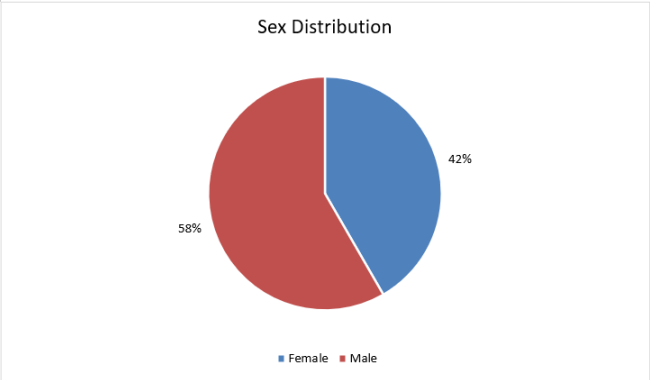

Figure: Sex Distribution

Males (58%) were more than females (42%) in the study.

Site of AVF

Table 3: Site of AVF

Site	Frequency	Percentage
Elbow	14	56
Wrist	10	44
Total	**24**	**100**

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 07, 2023

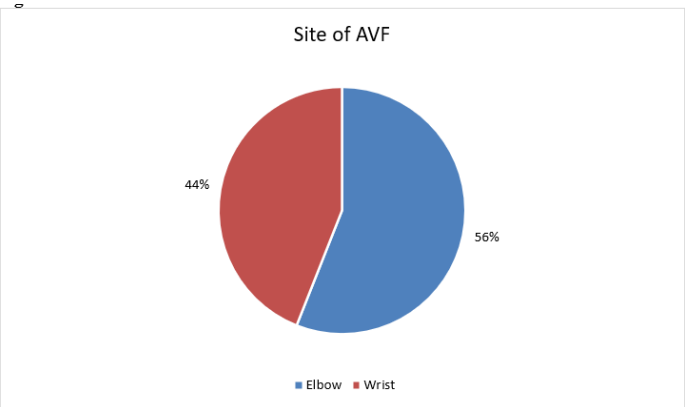

Figure: Site of AVF

Majority of AVF were located at elbow (56%).

Location of affected vascular access

Table 4: Location of affected vascular access

Side	Frequency	Percentage
Left side	18	75
Right side	6	25
Total	**24**	**100**

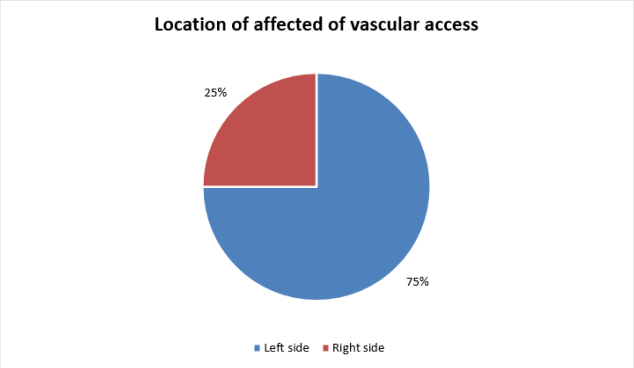

Figure: Location of affected of vascular access

Left sided (75%) vascular accesses presented more with complications compared to that with right side (25%).

Indication for intervention

Table 5: Indication for intervention

Indication	Frequency	Percentage
Bleeding/ pseudoaneurysm	8	34
Hand/ Arm swelling	14	58
Venous aneurysm	2	8
Total	**24**	**100**

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 07, 2023

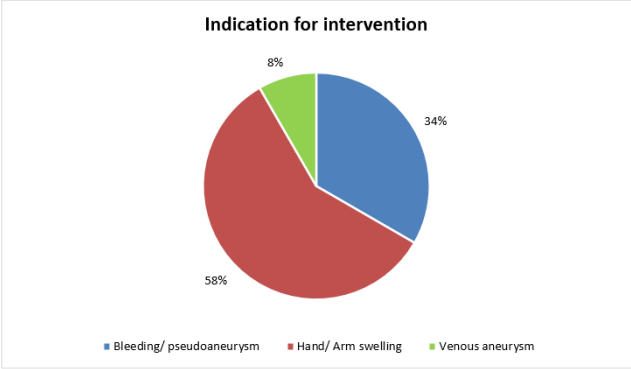

Figure: Indication for intervention

Table 6: Type of intervention used

Type of intervention/ stent used	Frequency	Percentage
Balloon plasty	10	42
Stent	6	24
Stent graft	6	24
Embolization of bleeder	2	10
Total	**24**	**100**

Procedural/ Technical success

Table 7: Procedural/ Technical success

Procedural/ Technical success	Frequency	Percentage
Yes	24	100
No	0	0
Total	**24**	**100**

Primary patency rates

Table 8: Primary patency rates for all interventions

	3 months (n=24)	6 months (n=24)
Primary patency	23 (95.8%)	21 (87%)

n= total number of patients on follow up

Discussion

Vascular access is the most crucial part in patients of end stage renal failure (ESRD) for providing adequate hemodialysis. However, maintaining the patency of the vascular access and preventing complications is a tedious task. Number of acute and chronic complications with arterio-venous fistulae (AVF) in patients of hemodialysis have been reported in past, including thrombosis in the vascular access (17-25%), stenosis (14.42%), infection (2-3%), steal syndrome (2-8%), aneurysm (5-6%), and congestive heart failure (12.2-17%).[15] Any complication occurring in the AVF has to be monitored and managed adequately in order to protect the patency of the vascular access. Hence, it is important to study the outcome of interventions, used to manage these complications. Currently, surgical approach is recommended only when the stenosis or obstruction is refractory to the endovascular management. [16] Ultimately, endovascular approach has risen to be the popular option. Endovascular approaches include percutaneous transluminal angioplasty (PTA) and

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 07, 2023

deployment of bare metal or covered stents. Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines from National Kidney Foundation have recommended PTA, with or without stenting, as the primary.[17] *Studies regarding endovascular management of complications of arterio-venous fistulae are lacking in India, which was revealed after extensive literature search*. The current study assessed the outcome of procedures used for management of complications encountered in AVF of patients of hemodialysis, in a hospital setting in India.

The mean age of patients in the current study was 45.46 ±13.22 years, with 60% study population within 31-50 years. It is, thus, observed that complications of AVF in hemodialysis patients are common in this age group. In the study by Maya et al, the mean age of the patients implanted with stents was 61±12 years and that with angioplasty group was 60±13 years.[18] In Rajan et al study, among the patients with AVF, the mean age was 65.7 years. In study by Kim et al, mean age of patients in the study was 55.1 years.[44] In the study by Jones et al, the mean age of patients was 60 years. *Compared to the other studies, age of patients presenting with complications of AVF was much younger in the current study.* Differences in epidemiology of patients of hemodialysis should be studied in detail in the local population.

Involvement of males (58%) was found to be higher than females in the current study (42%). This data, however, is insufficient to attribute increased incidence of complications in males, as data, regarding prevalence of hemodialysis depending on gender is lacking in the local population. In Maya et al study, 35% and 43% was the contribution males to those implanted with stents and angioplasty group, respectively.[43] In Rajan et al study, among the patients with AVF, 77.27% were males and 22.72% were females.[32] In Kim et al study, 45.45% were males and 54.54% were females.[17] Males were 53.33% and females were 46.67% in Jones et al study.[19] Lot of variation in the gender distribution of complications occurring in AVF in patients of hemodialysis can be observed from the various studies.

In the present study, it was observed that involvement of fistulae at the elbow (56%) was common than that at the wrist (44%). Location of fistula is, however, confounded by the nephrologists' preference for site selection for creation of AVF.

Technical success rate and primary patency of different interventions in patients of hemodialysis has been documented in number of studies and have been compared with the current study findings in the table below.

Table 9: Comparison with previous studies

Year	Author	Vascular access	Primary Intervention	Technical success	Primary Patency
2003	Buriankova et al	25 AV Shunts	PTA	96%	70%, 60% and 30% at 3, 6 and 12 months, respectively.
2007	Bakken et al	AV Shunts	PTA	82%	29% at 12 months
			Stents	96%	21% at 12 months
2007	Maya et al	AVF	23 Stents		83%, 56%, 33% and 19% at 1, 3, 6, and 12 months, respectively.
			32 Angioplasty		89%, 63%, 38% and 20% at 1, 3, 6, and 12 months, respectively.
2009	Kim et al	44 AVF	26 PTA	93.2% (for both	84.1%, 52.1%, 32.1% and 20% at 6, 12, 24 and 36 months,

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 07, 2023

				procedures)	respectively
			15 Stents		60%, 46.7%, 40% and 6.7% at 6, 12, 24 and 36 months, respectively
2013	Shi et al	AV Shunts	9 PTA		88.9%, 64.8% and 48.6% at 3, 6, and 12 months, respectively.
			11 Stents		90%, and 77.1% at 6, and 12 months, respectively.
2020	**Current study**	**50 AVF**	**6 Stent**	**100%**	**100%, 97.4% at 3 and 6 months, respectively**
			10 PTA	**83.30%**	**88.89%, 83.33% at 3 and 6 months, respectively**
			Stent graft- 6 Embolization-2		

From the above studies, it can be observed that extensive work in the field of endovascular management of AV fistula complications has been conducted with estimation of primary patency rates. However, studies conducted in Indian population cannot be found. Many of the above studies have documented the secondary patency rates of the procedures. Assessment of secondary patency rates was not possible in the current study due to limitation of the duration of the data collection period.

We have used ***stent- graft*** in 6 patient in case of pseudoaneurysm complicating the AV fistula. With 100% success in all the 6 cases pseudoaneurysm was excluded from the circulation avoiding possible catastrophic bleeding complications. However use of stent graft fistula can be used for haemodialysis as pseudoaneurysm were the result of primary surgical failure at the time of fistula creation.

Ours was a pilot study, which by definition has a small sample size, designed to be executed within our existing resources. We acknowledge these limitations. A larger sample size is likely to help improve the quality of evidence demonstrated by our study. We hope that the evidence presented through this study justifies acquiring the necessary resources and time for a larger and longer study that produces more robust evidence.

Section 8: Conclusion & Recommendations

- Stenting and balloon angioplasty are viable options for endovascular management of complications occurring in patients of hemodialysis with arteriovenous fistula, to maintain the patency of the vascular access.
- The primary patency rates, in stenting and balloon angioplasty, decrease over a period of 6 months.
- The primary patency rates of stenting are higher than balloon angioplasty at respective time points.
- Use of stent graft in case of pseudoaneurysm complicating the AV fistula excluding pseudoaneurysm sac from the circulation thus avoiding possible catastrophic bleeding complications.
- We recommend detail study with longer time horizon for follow up and need of secondary intervention as stent blockage due to stenosis or thrombus is known problem.

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