

## Research Article

### Interventional Radiology in Hemodialysis Access Management.

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**Abstract:** **Introduction:** Vascular access is crucial for patients undergoing hemodialysis for end-stage renal disease, but it is often plagued by stenosis, thrombosis and dysfunction. Interventional radiology offers minimally invasive procedures to maintain and restore access patency, obviating complications and surgical revision, thus improving dialysis efficiency and quality of life. **Objectives:** To assess the outcomes of interventional radiology treatments in preserving hemodialysis access patency and complications in patients treated for dysfunctional vascular access. **Methodology:** We enrolled 100 patients with arteriovenous fistula or graft dysfunction over six months in a prospective study at a tertiary care hospital. Percutaneous transluminal angioplasty, thrombectomy, and catheter-based interventions were performed under fluoroscopy. Patient demographic and clinical characteristics were recorded, and technical and clinical success were evaluated. We used the statistical software, SPSS version 25, to perform analysis and present results as mean ( $\pm$  standard deviation) and frequency. P-value  $<0.05$  was statistically significant. **Results:** Among 100 patients (58 males, 42 females), the mean age was  $52.4 \pm 13.6$  years. Arteriovenous fistula was present in 68% and grafts in 32%. Stenosis (60%) was the most common indication, followed by thrombosis (30%). Angioplasty was performed in 62%, thrombectomy in 28%, and catheter procedures in 10% of cases. Technical success was achieved in 91%, with primary patency of 85% at one month. Access flow improved significantly ( $280 \pm 95$  vs  $620 \pm 140$  mL/min;  $p < 0.001$ ). Complications were minor, including hematoma (6%) and infection (3%). **Conclusion:** Interventional radiology is a safe and effective approach to treat dysfunctional hemodialysis access with improved access patency and fewer complications, and should be used as a first-line treatment.

**Keywords:** Interventional Radiology, Hemodialysis, Vascular Access, Angioplasty

## INTRODUCTION

Hemodialysis is the most common form of renal replacement therapy for patients with chronic kidney disease and end-stage renal disease (ESRD). An adequate vascular access is critical for optimal dialysis, which affects patient survival and quality of life. Vascular access options broadly fall into three main categories: arteriovenous fistula (AVF), arteriovenous graft (AVG) and central venous catheters (CVC). AVF is preferred over other forms of access due to its durability and lower risk of complications. But, despite the improvements in surgical intervention, vascular access dysfunction continues to pose a major challenge [1,2]. Stenosis and thrombosis are the most frequent causes of access dysfunction due to neointimal hyperplasia and cannulation injury. This can result in poor blood flow, suboptimal dialysis and ultimately access failure. Historically, surgical correction was the mainstay of treatment for access dysfunction; however, this is more invasive, can lead to complications and prolonged recovery, and is costly [3]. Over the past few decades, interventional radiology (IR) has transformed

the approach to managing complications of hemodialysis access. Using minimally invasive image-guided techniques, IR allows for early detection and prompt treatment of vascular access issues. Techniques such as percutaneous transluminal angioplasty (PTA), thrombectomy, thrombolysis and stent insertion are now widely employed as primary therapies. These procedures not only re-establish access function but also improve the lifespan of the access and prevent multiple surgical interventions [4,5]. PTA is commonly employed to treat stenotic lesions and has shown excellent success rates. Likewise, thrombectomy and pharmacological thrombolysis are used to manage access thromboses and allow quick recovery. Stent grafts have also been used to treat recurrent stenosis and central venous occlusions. Interventional radiologists also contribute to the management of tunneled dialysis catheters [6,7]. Despite the improvements, vascular access dysfunction remains a major burden on health care, especially in resource-limited settings in developing countries. Timely diagnosis, monitoring and appropriate intervention are crucial for better outcomes. And a team approach, including nephrologists, vascular surgeons, and

interventional radiologists, is vital to patient care [8,9]. The objective of this study is to assess the impact of interventional radiology on the treatment of dysfunctional access in hemodialysis patients, including procedure success, complications and short-term success rates in patients treated with IR-assisted interventions [10].

### Study Objectives

To evaluate the role of interventional radiology interventions in re-establishing hemodialysis access, improving patency and reducing complications in patients with dysfunction of vascular access

## MATERIALS AND METHODS

### Study Design & Setting

This prospective study conducted at Peshawar Medical College Prime Teaching Hospital Peshawar from jan 2025 to june 2025. was undertaken at a tertiary care hospital with interventional radiology services for the management of hemodialysis vascular access dysfunction.

### Participants

The study included 100 patients with a dysfunctional hemodialysis access. The patients had clinical and or radiological signs of stenosis, thrombosis or catheter dysfunction. Arteriovenous fistula and graft access were both included. They were being referred from nephrology clinics for interventional radiology procedures to maintain or reopen access for adequate dialysis.

### Sample Size Calculation

A sample size of 100 patients was determined based on a confidence level of 95% with an expected success rate of 90% for interventional procedures, and a margin of

error of 6%. This was deemed adequate to evaluate the success of the intervention and statistical significance.

### Inclusion Criteria

- Patients aged  $\geq 18$  years
- Has CKD and is on hemodialysis
- AVF, AVG or CVC dysfunction
- Consent to participate

### Exclusion Criteria

- Active systemic infection or sepsis
- Severe coagulopathy
- Hemodynamic instability
- Refuses to give consent

### Diagnostic and Management Strategy

All patients had clinical and Doppler ultrasound assessment. Targeted interventional procedures, such as angioplasty, thrombectomy or catheter care, were undertaken under fluoroscopy guidance based on the underlying pathology, to re-establish patency of vascular access.

### Statistical Analysis

Data were analysed using SPSS version 25. Continuous variables were presented as mean  $\pm$  standard deviation, and categorical variables were reported as frequencies and percentages. Pre- and post-procedure comparisons were made using a paired t-test.  $P < 0.05$  was considered significant.

### Ethical Approval Statement

Ethical approval for this study was obtained from the Institutional Review Board/Ethics Committee prior to data collection. The study was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants, and confidentiality of personal information was strictly maintained throughout the research process.

## RESULTS

A total of 100 patients were included in the study, with 58 males and 42 females. The mean age was  $52.4 \pm 13.6$  years. Arteriovenous fistula was present in 68% of patients, while 32% had arteriovenous grafts. The most common indication for intervention was stenosis (60%), followed by thrombosis (30%) and catheter dysfunction (10%). Interventional procedures included percutaneous transluminal angioplasty in 62 patients, thrombectomy in 28 patients, and catheter-related interventions in 10 patients. Technical success was achieved in 91% of cases. Significant improvement in vascular access flow rates was observed following intervention ( $280 \pm 95$  mL/min pre-procedure vs  $620 \pm 140$  mL/min post-procedure;  $p < 0.001$ ). Primary patency at one month was maintained in 85% of patients. Minor complications were observed in a small proportion of cases, including hematoma (6%) and localized infection (3%). No major complications or mortality were reported. Patients who underwent early intervention demonstrated better outcomes compared to those with delayed presentation. Overall, interventional radiology procedures were effective in restoring access function and improving dialysis adequacy, with high success rates and minimal complications.

### Intervention Outcome

Interventional radiology procedures had a high technical success rate and restored vascular access. Adequate dialysis flow was achieved with low complication rates. Early treatment correlated with improved patency, which demonstrates the role of minimal invasive therapy in preserving long-term hemodialysis access.

**Table 1: Baseline Demographic and Clinical Characteristics**

Characteristic	Value (n = 100)
Age (years, Mean ± SD)	52.4 ± 13.6
Gender (Male/Female)	58 / 42
Hypertension (%)	64 (64%)
Diabetes Mellitus (%)	48 (48%)
Type of Access (AVF/AVG)	68 / 32

Table 1 shows the baseline demographic and clinical characteristics of the study population. The majority of patients were male, with a mean age of 52.4 years. Hypertension and diabetes were common comorbidities. Arteriovenous fistula was the predominant vascular access type.

**Table 2: Indications for Interventional Radiology Procedures**

Indication	Frequency (n)	Percentage (%)
Stenosis	60	60%
Thrombosis	30	30%
Catheter Dysfunction	10	10%

Table 2 summarizes the primary indications for interventional radiology procedures. Stenosis was the most common cause of access dysfunction, followed by thrombosis and catheter-related complications.

**Table 3: Types of Interventional Procedures Performed**

Procedure Type	Frequency (n)	Percentage (%)
Angioplasty (PTA)	62	62%
Thrombectomy	28	28%
Catheter-related Interventions	10	10%

Table 3 presents the distribution of interventional radiology procedures performed. Percutaneous transluminal angioplasty was the most frequently performed procedure, followed by thrombectomy and catheter-based interventions.

**Table 4: Procedural Outcomes and Complications**

Outcome/Complication	Value
Technical Success Rate	91%
Primary Patency (1 month)	85%
Pre-procedure Flow (Mean ± SD)	280 ± 95 mL/min
Post-procedure Flow (Mean ± SD)	620 ± 140 mL/min
p-value	< 0.001
Hematoma	6%
Infection	3%

Table 4 demonstrates procedural outcomes and complications. A significant improvement in vascular access flow rates was observed after intervention. High technical success and primary patency rates were achieved with minimal complications, indicating the effectiveness and safety of interventional radiology procedures.

## DISCUSSION

Our study shows that interventional radiology (IR) is critical for treating dysfunction of hemodialysis vascular access, with high technical success (91%) and acceptable short-term primary patency (85%). Our results are in accordance with recent studies that report IR is the primary treatment of access dysfunction in patients with chronic kidney disease [11-12]. Our finding that stenosis (60%) is the most common cause of access dysfunction is consistent with several recent studies in the past five years [13]. Neointimal hyperplasia continues to be the main cause of stenotic lesions, especially in arteriovenous fistulas (AVFs). A similar incidence of stenosis (55-65%) has been reported in studies by Smith et al. and Khan et al., further underlining the widespread prevalence of this complication [14,15]. In our study, a technical success rate of 91% is consistent with success

rates between 85% and 95% reported in recent multicenter studies assessing the efficacy of percutaneous transluminal angioplasty (PTA) and thrombectomy [16]. For example, a 2022 prospective study by Lee et al. noted a success rate of 93% after IR-guided intervention, similar to that in our study. This suggests the consistency and reproducibility of IR techniques across clinical settings [17]. Regarding patency rates, our 1-month primary patency rate of 85% is consistent with recent studies that have reported short-term patency rates ranging from 80-88% [18]. But primary patency rates over time are problematic, with a steady decline due to recurrent stenosis. Research has shown that long-term patency outcomes may be enhanced by the use of drug-coated balloons and stent grafts, though their economic viability in resource-poor settings is questionable [19]. We have seen a significant

increase in flow rates ( $p < 0.001$ ), as reported by recent randomised and observational studies [20]. Optimal flow rates translate to improved dialysis clearances and decreased morbidity. Ahmad et al. also showed similar improvement in flow rates following angioplasty, highlighting the flow benefits associated with timely IR intervention. Complications were rare in our study, with only minor hematoma (6%) and infection (3%), and no major events. Our results are in line with recent reports of complications less than 10%.

### Limitations

Our study has limitations, such as single-centre recruitment and a sample size of 100 patients, which may affect the applicability of the results. Limited follow-up time precluded analysis of long-term patency. Moreover, missing comparative data with surgery and novel techniques may influence the assessment of efficacy.

## CONCLUSION

Interventional radiology is a safe and effective means of treating dysfunction in hemodialysis vascular access. It enhances the patency and efficiency of dialysis with limited complications. Timely intervention and a multidisciplinary approach are crucial to improve treatment outcomes, making it an important first-line technique in current vascular access management for hemodialysis.

**Disclaimer:** Nil

**Conflict of Interest:** Nil

**Funding Disclosure:** Nil

### Authors Contributions

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