EAS Journal of Radiology and Imaging Technology
Abbreviated Key Title: EAS J Radiol Imaging Technol
ISSN: 2663-1008 (Print) & ISSN: 2663-7340 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-8 | Issue-6 | Nov-Dec-2026 | DOI: https://doi.org/10.36349/easjrit.2026.v08i06.009

Original Research Article

A Cross-Sectional Study to Assess the Role of Doppler Ultrasound in Evaluation of Arteriovenous Haemodialysis Fistula and the Complications of Arteriovenous Haemodialysis Fistula in a Tertiary Care Hospital

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Article History
Received: 12.09.2026
Accepted: 06.11.2026
Published: 09.11.2026

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: ***Background*:** Arteriovenous fistulas (AVFs) are important vascular access routes for patients undergoing maintenance haemodialysis. However, complications such as thrombosis, stenosis, infection and pseudoaneurysm may compromise fistula function. Doppler ultrasonography provides non-invasive anatomical and haemodynamic assessment of vascular access. ***Aim*:** To evaluate arteriovenous haemodialysis fistulas using Doppler ultrasonography, determine the prevalence and pattern of complications, and assess associations between Doppler parameters, clinical characteristics and fistula complications. ***Materials and Methods*:** This cross-sectional observational study was conducted at a tertiary care hospital from May 2024 to October 2025. Seventy adult patients with end-stage renal disease undergoing haemodialysis through an AVF were included. Doppler assessment evaluated blood flow, peak systolic velocity at the anastomosis, brachial artery resistive index, draining vein diameter and skin-to-fistula vein distance. Demographic and clinical variables were also recorded. Statistical analysis was performed using R software, with appropriate tests for continuous and categorical variables. ***Results*:** The mean age was 55 ± 13 years, and 64.3% of participants were male. Radiocephalic fistulas were the most common type (51.4%). Complications were identified in 14 patients (20%). Thrombosis was the most frequent complication (35.7%), followed by stenosis and perifistula haematoma (21.4% each). Mean fistula blood flow was significantly lower in patients with complications than in those without complications (688 ± 298 versus 831 ± 273 mL/min; $p = 0.049$). Diabetes mellitus was also associated with complications ($p = 0.028$). Other evaluated Doppler parameters did not demonstrate statistically significant differences between groups. ***Conclusion*:** Doppler ultrasonography identified fistula complications and provided useful haemodynamic information. Lower blood flow and diabetes mellitus were associated with complications. Larger prospective studies are needed to validate these findings.

Keywords: Arteriovenous Fistula, Doppler Ultrasonography, Haemodialysis, Thrombosis, Vascular Access Complications.

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INTRODUCTION

Arteriovenous haemodialysis fistula (AVF) is an important form of vascular access for patients with end-stage kidney disease (ESKD) who require maintenance haemodialysis. It provides a direct connection between an artery and a vein, allowing adequate blood flow for dialysis. Compared with other vascular access options, an autogenous AVF is generally preferred when feasible because of its long-term usability and lower complication burden. However, successful fistula creation does not guarantee adequate maturation or sustained function, and complications can lead to inadequate dialysis, repeated interventions and loss of vascular access [1, 2].

AVF complications include stenosis, thrombosis, aneurysm or pseudoaneurysm, infection,

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bleeding and haematoma. Among these, stenosis is particularly important because narrowing of the vascular lumen can impair access flow and contribute to thrombosis and access failure. Early recognition of these abnormalities is therefore essential for preserving fistula function and ensuring uninterrupted haemodialysis [3].

Clinical examination remains an important part of vascular access monitoring, but it may not adequately characterise the site, extent or haemodynamic significance of every abnormality. Duplex Doppler ultrasonography combines structural imaging with blood-flow assessment and offers a non-invasive, readily repeatable method for evaluating haemodialysis access. It can assess the feeding artery, anastomosis and draining vein; measure access blood flow, peak systolic velocity and vessel diameter; determine the depth of the draining vein; and identify stenosis, thrombosis, aneurysmal changes and surrounding collections [4, 5].

Doppler-derived measurements are relevant to both fistula maturation and the assessment of established access dysfunction. Evidence from the Hemodialysis Fistula Maturation Study demonstrated that blood flow, vein diameter and vein depth were associated with subsequent clinical maturation [6]. These parameters provide useful objective information, although their interpretation depends on the clinical setting and should not rely on a single measurement in isolation [7].

Guidelines emphasise appropriate vascular access planning and monitoring, while the role of routine imaging surveillance in asymptomatic patients should be distinguished from ultrasound evaluation prompted by clinical concerns. The Kidney Disease Outcomes Quality Initiative (KDOQI) guideline advocates an individualised approach to vascular access management, and the European Society for Vascular Surgery guidelines discuss duplex ultrasound in the surveillance and management of access dysfunction [1-8].

Evidence concerning ultrasound-based surveillance and its effect on clinical outcomes also requires careful interpretation. A systematic review found that access-flow or ultrasound-based screening reduced thrombosis risk in the subgroup of studies involving AVFs, but did not demonstrate a statistically significant reduction in fistula loss [9]. This distinction supports the need to evaluate both Doppler findings and clinically relevant complications rather than assuming that an abnormal ultrasound parameter necessarily predicts access failure.

Against this background, the present cross-sectional study evaluates AVFs in patients undergoing haemodialysis at a tertiary care hospital. It assesses the prevalence and pattern of fistula complications, describes Doppler parameters—including blood flow, anastomotic peak systolic velocity, resistive index, draining vein diameter and vein depth—and compares these measurements between patients with and without complications. It also examines associations between complications and selected demographic and clinical factors, particularly diabetes mellitus. The findings may help characterise AVF dysfunction in the study population and inform clinical assessment; however, the cross-sectional design is intended to identify associations rather than establish causation.

A large observational study involving 2,184 haemodialysis patients also found that lower access blood flow was associated with a higher frequency of vascular events requiring intervention, supporting the clinical relevance of Doppler-derived haemodynamic measurements [10].

OBJECTIVES

1. To evaluate arteriovenous haemodialysis fistulas using Doppler ultrasonography and determine the prevalence and distribution of associated complications.
2. To assess Doppler-derived parameters of arteriovenous haemodialysis fistulas, including blood flow, peak systolic velocity at the anastomosis, brachial artery resistive index, draining vein diameter and skin-to-fistula vein distance.

METHODOLOGY

A cross-sectional observational study was conducted at a tertiary care hospital from May 2024 to October 2025 to evaluate arteriovenous haemodialysis fistulas and their complications using Doppler ultrasonography. The study included 70 adult patients with end-stage renal disease receiving maintenance haemodialysis through an arteriovenous fistula. The sample size was calculated using an anticipated proportion of 22%, with a final sample of 70 participants. Patients were screened in the radiology department, and eligible participants were enrolled. Inclusion criteria comprised patients aged 18 years or older with end-stage renal disease undergoing haemodialysis through an arteriovenous fistula who provided informed consent. Patients younger than 18 years, those with vascular grafts instead of fistulas, those with an expected life expectancy below six months, and those participating in concurrent trials that could interfere with study outcomes were excluded.

Demographic and clinical variables included age, sex, duration of haemodialysis, fistula type and location, and underlying renal disease. Doppler assessment recorded access blood flow, peak systolic velocity at the anastomosis, brachial artery resistive index, draining vein diameter and skin-to-fistula vein distance. The primary outcome was the presence of arteriovenous fistula complications, including stenosis, thrombosis, infection, haematoma and pseudoaneurysm. Stenosis was defined as a diameter reduction of 50% or more. Secondary outcomes included blood-flow measurements, stenosis location and vascular

calcification. Data were entered into Microsoft Excel and analysed using R software. Categorical variables were expressed as frequencies and percentages, while continuous variables were summarised as mean with standard deviation or median with interquartile range, as appropriate. The Wilcoxon rank-sum test was used for continuous variables, and Pearson's chi-square test or Fisher's exact test was applied to categorical variables, depending on expected cell counts. Ethical approval was obtained before conducting the study, and informed consent was obtained from eligible participants.

RESULTS AND OBSERVATIONS

A total of 70 patients with end-stage renal disease undergoing haemodialysis through an arteriovenous fistula were evaluated using Doppler ultrasonography. The results are presented in three tables and two graphical representations, focusing on patient characteristics, fistula complications, and comparison of Doppler parameters.

Table 1: Demographic and Clinical Characteristics of the Study Population (N = 70)

Parameter	Number (n)	Percentage (%)
Age		
Mean age (years)	55 ± 13	—
Median age (IQR)	54 (46–61)	—
Sex		
Male	45	64.3
Female	25	35.7
Comorbidities		
Diabetes mellitus	42	60.0
Hypertension	50	71.4
Type of arteriovenous fistula		
Radiocephalic	36	51.4
Brachiocephalic	22	31.4
Brachiobasilic	12	17.1
Side of fistula		
Left	62	88.6
Right	8	11.4

The mean age of the study population was 55 ± 13 years, and males constituted 64.3% of participants. Hypertension was the most common reported comorbidity (71.4%), followed by diabetes mellitus (60%). Radiocephalic fistulas were the predominant type (51.4%), and most fistulas were located on the left side (88.6%).

Table 2: Prevalence and Types of Arteriovenous Fistula Complications

Complication status/type	Number (n)	Percentage (%)
Overall status (N = 70)		
Complications present	14	20.0
No complications	56	80.0
Type of complication among affected patients (n = 14)		
Thrombosis	5	35.7
Stenosis	3	21.4
Perifistula haematoma	3	21.4
Infection	2	14.3
Pseudoaneurysm	1	7.1
Total affected patients	14	100.0

Complications were identified in 20% of the study population. Thrombosis was the most frequent complication, accounting for 35.7% of affected patients. Stenosis and perifistula haematoma each accounted for 21.4%, followed by infection (14.3%) and pseudoaneurysm (7.1%).

Figure 1 Distribution of Patients According to Arteriovenous Fistula Complication Status.
AVF complication status (N = 70)
Proportion of patients with and without recorded fistula complications.
Complications present
No complications

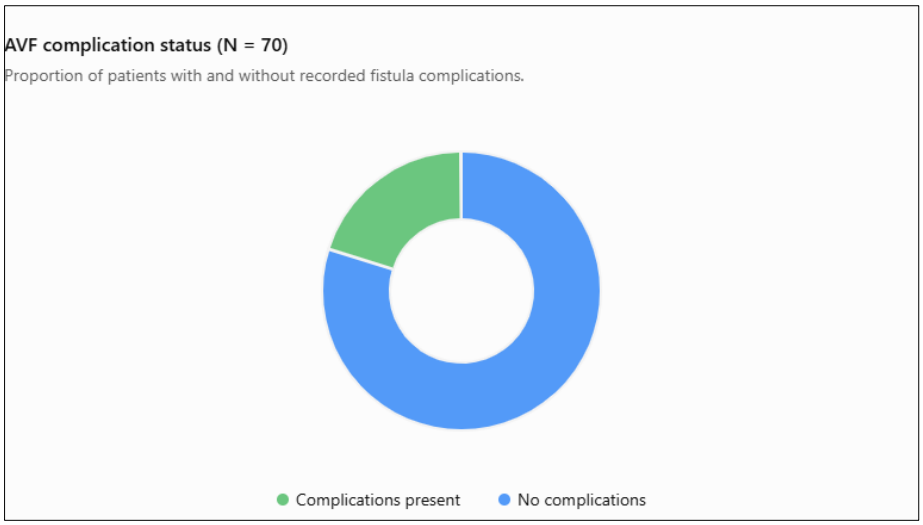


Figure 1: Twenty percent of patients had a documented complication, while 80% had no recorded complication

Figure 2. Distribution of Types of Arteriovenous Fistula Complications
Types of AVF complications (n = 14)
Distribution of complications among affected patients only.
Infection
Perifistula haematoma
Pseudoaneurysm
Stenosis
Thrombosis

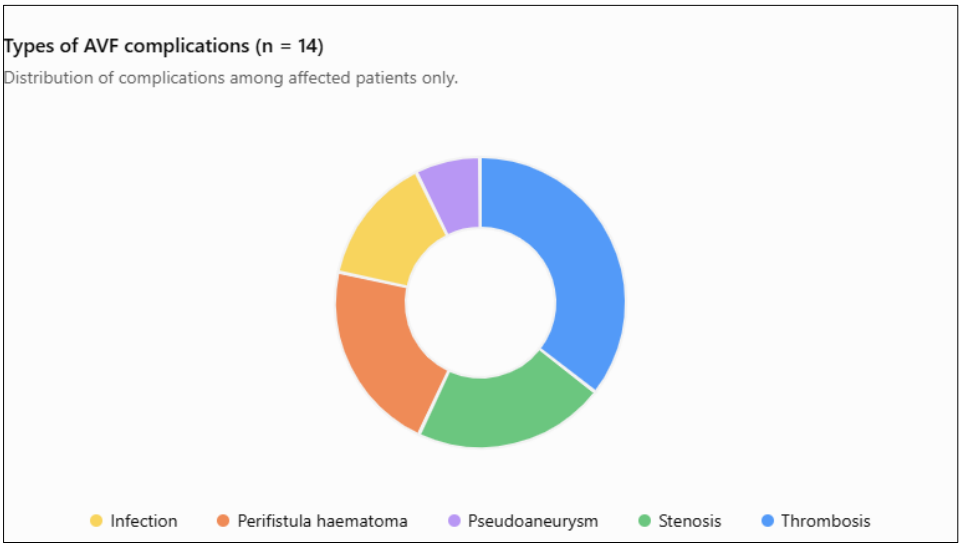


Figure 2: Thrombosis was the most frequent complication, followed by stenosis and perifistula haematoma

Table 3: Comparison of Doppler Ultrasound Parameters between Patients with and Without Complications

Doppler parameter	Complications present (n = 14), Mean ± SD	No complications (n = 56), Mean ± SD	p-value
Blood flow (mL/min)	688 ± 298	831 ± 273	0.049
Peak systolic velocity at anastomosis (cm/s)	303 ± 118	304 ± 81	>0.9
Brachial artery resistive index	0.60 ± 0.09	0.57 ± 0.09	0.2
Draining vein diameter (mm)	6.56 ± 1.42	5.98 ± 1.46	0.2
Skin-to-fistula vein distance (mm)	5.95 ± 2.19	5.91 ± 2.39	>0.9

The mean blood flow was lower in patients with complications than in those without complications (688 versus 831 mL/min), with a reported statistically significant difference (p = 0.049). The other Doppler parameters did not show statistically significant differences between the groups.

DISCUSSION

In the present study, 70 patients undergoing haemodialysis through arteriovenous fistulas were evaluated using Doppler ultrasonography. Complications were identified in 20% of patients, with thrombosis being the most frequent, followed by stenosis

and perifistula haematoma. These findings highlight the clinical importance of identifying vascular access abnormalities, as stenosis and thrombosis can compromise fistula function and the continuity of haemodialysis [11, 12]. Early recognition of these complications may help clinicians plan appropriate management and preserve vascular access for future dialysis sessions.

The mean fistula blood flow was significantly lower in patients with complications than in those without complications (688 ± 298 versus 831 ± 273 mL/min; $p = 0.049$). This finding is consistent with the study by Ishii *et al.,* which reported an association between lower access blood flow and vascular events, including thrombosis and stenosis, in haemodialysis patients [13]. Reduced blood flow may reflect underlying vascular narrowing, impaired access function or other haemodynamic abnormalities. Nevertheless, the borderline statistical significance in the present study and the relatively small complication subgroup warrant cautious interpretation. Further studies with larger sample sizes are required to establish the consistency and clinical relevance of this association.

Other Doppler parameters, including peak systolic velocity at the anastomosis, brachial artery resistive index, draining vein diameter and skin-to-fistula vein distance, did not demonstrate statistically significant differences between the groups [13, 14]. Although these measurements provide valuable anatomical and haemodynamic information, their individual ability to distinguish complicated from uncomplicated fistulas may vary according to the underlying lesion, fistula characteristics and clinical setting. Therefore, Doppler findings should be interpreted alongside clinical examination and other relevant patient information rather than relying on a single parameter.

Diabetes mellitus was also associated with fistula complications in the present study ($p = 0.028$). Diabetic vascular disease may contribute to arterial and venous abnormalities; however, the present cross-sectional findings cannot establish a causal relationship. The association should be interpreted in view of the sample size and possible confounding factors. No statistically significant associations were observed for hypertension, age, fistula type or fistula side. These non-significant findings do not necessarily exclude clinically relevant relationships, particularly given the limited number of patients with complications.

Overall, the study supports the usefulness of Doppler ultrasonography in evaluating fistula blood flow and detecting vascular access complications. Lower mean blood flow and diabetes mellitus were the principal findings associated with complications. Larger prospective studies are needed to validate these observations and determine the predictive value of Doppler parameters for future fistula dysfunction.

CONCLUSION

Doppler ultrasonography provided useful anatomical and haemodynamic information about arteriovenous fistulas. Lower blood flow and diabetes mellitus were the principal factors associated with complications in this study. Larger prospective studies are required to validate these associations and clarify the predictive value of individual Doppler parameters.

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Cite This Article: Kumavat, S. P., Lamdhade, P., & Pawar, S. S. (2026). A Cross-Sectional Study to Assess the Role of Doppler Ultrasound in Evaluation of Arteriovenous Haemodialysis Fistula and the Complications of Arteriovenous Haemodialysis Fistula in a Tertiary Care Hospital. *EAS J Radiol Imaging Technol, 8*(6), 207-212. https://doi.org/10.36349/easjrit.2026.v08i06.009