Original Article

Diagnostic Accuracy of Physical Examination for Detecting Arteriovenous Fistula Stenosis in Haemodialysis Patients

Rana Umar[1], Mateen Akram[1*], Haris Naeem[2], Faisal Rehman[3], Nauman Ali[4], Sehar Aslam[5], Waqar Ahmed[6]

ABSTRACT

OBJECTIVE: This study was conducted to determine the accuracy of physical examination in detecting arteriovenous fistula stenosis in patients receiving maintenance hemodialysis.

METHODOLOGY: A cross-sectional study was undertaken from October 2021 to March 2022, encompassing both outpatient and inpatient units of Nephrology and Cardiothoracic Surgery at Shaikh Zayed Hospital (SKZ), Lahore. This study evaluated 162 maintenance hemodialysis (MHD) patients selected through convenience sampling for the Presence of arteriovenous fistula (AVF) stenosis. The data were collected after the MHD session. After collecting demographics, patients underwent physical examinations performed by a trained nephrology resident, followed by colour Doppler sonography (CDS) performed by a radiologist blinded to the results of the physical examination (PE) for AVF stenosis. Cohen's Kappa (κ), positive predictive values (PPV), negative predictive values (NPV), sensitivity, and specificity were used to calculate the accuracy of PE for AVF stenosis.

RESULTS: There was a strong agreement between PE and CDS regarding the diagnosis of AVF stenosis. The overall diagnostic accuracy of physical examination to detect AVF stenosis was 89.50% with PPV= 88.5%, NPV=90.7%, sensitivity= 91.7%, specificity=87.2%, and κ= 0.790. The diagnostic accuracy of physical examination to detect AVF inflow stenosis was 89.473% with PPV= 87.2%, NPV=90.7%, sensitivity= 82.9%, specificity=93.2%, and κ= 0.769. The diagnostic accuracy of physical examination to detect AVF outflow stenosis was 90.243% with PPV= 89.6%, NPV=90.7%, sensitivity= 86.0%, specificity=93.2%, and κ= 0.797.

CONCLUSION: The findings of this study demonstrate that PE examination is a reliable method for regularly monitoring AVF patency.

KEYWORDS: Chronic Kidney disease (CKD), End Stage Renal Disease (ESRD), Arterio-Venous Fistula (AVF), Physical Examination (PE), Colour Doppler Sonography (CDS), Stenosis.

INTRODUCTION

Chronic kidney disease (CKD) is becoming prevalent around the globe and has become a significant public health issue. Despite the extensive use of therapies to reduce the progression of CKD, the burden of end-stage renal disease (ESRD) continues to be significant[1]. One of the most essential treatments for people with ESRD is haemodialysis (HD). ESRD patients on haemodialysis (HD) require reliable arteriovenous access. Arteriovenous fistulae (AVFs) are indeed the gold standard for HD vascular access (VA). When compared to other types of VA, a functioning AVF is linked to lower mortality, infection, and morbidity[2,3].

When compared to an arteriovenous graft (AVG) or a central venous catheter (CVC), an arteriovenous fistula (AVF) is the best haemodialysis vascular access, as it has a lower infection rate and related morbidity and mortality[4]. Long-term AVF patency, on the other hand, is a substantial issue; recent research has reported a 1-year AVF survival rate of 40-90%[5,6]. The most prevalent cause of AVF stenosis is neointimal hyperplasia, which leads to thrombosis in any section of the fistula. AVF dysfunction, on the other hand, can result in insufficient dialysis, fluid overload, and hyperkalaemia, as well as the requirement for temporary access and hospitalization, all of which result in patient discomfort and a bad treatment experience with expensive repercussions[3,7]. The great difficulty is the maintenance of the VA in the management of patients of maintenance haemodialysis (MHD), which is a significant factor in hospitalization of these patients[8,9]. Though the recommended VA for MHD is AVF, it is also prone to many complications, particularly stenosis[10,11]. Colour Doppler ultrasonography (CDS) can assess the access flow through stenosis sites in the AVF. PE of

[1]*Department of Nephrology, Shaikh Zayed Post Graduate Institute, Lahore, Pakistan*
[2]*Department of Nephrology, Avicenna Teaching Hospital, Lahore, Pakistan*
[3]*Department of Medicine, University College of Medicine and Dentistry, Lahore, Pakistan*
[4]*Department of Urology, King's College NHS Foundation, London, United Kingdom*
[5]*Department of Bioinformatics & Biotechnology, Government College University, Faisalabad, Pakistan*
[6]*Department of Nephrology, Lahore General Hospital, Lahore, Pakistan*
Correspondence: *mateenephrologist@gmail.com*
doi: 10.22442/jlumhs.2025.01282
Received: 17-03-2025 Revised: 20-05-2025
Accepted: 18-06-2025 Published Online: 18-07-2025

AVF is being evaluated as an essential surveillance tool for detecting Stenosis. Prospective observational studies have elaborated that physical examination, if practised by physicians with expertise, can be a valid diagnostic tool for Stenosis of fistula[12,13]. However, these studies, along with others on PE, have certain limitations due to their small sample sizes, static angiographic images, retrospective design, and biasing issues[3,14]. This study aimed to assess the diagnostic accuracy of physical examination (PE) for detecting arteriovenous fistula (AVF) stenosis in hemodialysis patients, as an alternative to color Doppler sonography (CDS), providing a more straightforward, cost-effective, and accessible method for routine AVF monitoring.

METHODOLOGY

This cross-sectional study was conducted from October 2021 to March 2022 and involved both the outpatient and inpatient departments of Nephrology and Cardiothoracic Surgery at Shaikh Zayed Hospital (SKZ), Lahore. Ethical approval for this research was obtained from the Institutional Review Board (SZMC/IRB/Internal/00102/2021) at Shaikh Zayed (SKZ) Medical Complex, Lahore. Probable purposive sampling was employed, and the sample size was estimated at the 95% confidence level with a 5% margin of error. The inclusion criteria were male and female patients aged 18 years or older who had been on maintenance haemodialysis via AVF for more than 3 months. After informed consent, the researcher performed the PE according to the scheme illustrated by Beathard, followed by CDS on the same day[15]. After that, a consultant radiologist at SKZ Hospital performed the CDS using the LOGIQ S7 Expert machine. During CDS, the patient was in a supine position with their arms at rest. The radiologist was kept blind to the findings of PE. The CDS was used to calculate the sensitivity, specificity, PPV, NPV, and diagnostic accuracy of physical examinations. The operational definitions are:

Non-Significant PE: On inspection, the AVF is of normal appearance and collapses on arm elevation. On palpation, the pulse is soft and easily compressible while the thrill is continuous. On auscultation, the bruit is low-pitched and continuous. Pulse augmentation is positive.

Non-significant CDS: AVF has smooth walls, a patent lumen, and complete filling on colour flow signals. The range of velocities will be 100-400 cm/sec during systole and 60-200 cm/sec during diastole. Typically, a negative CDS for AVF stenosis is characterized by a reduction in internal diameter of less than fifty percent, and a peak systolic velocity that is less than twice that of the normal adjacent segment.

Significant PE: For inflow stenosis, there is a hypopulsatile pulse, poor pulse augmentation, and decreased or discontinuous thrill. For outflow stenosis, there is a distended segment that does not collapse on arm elevation, and the pulse is hyperpulsatile. Moreover, thrill and bruit are discontinuous and accentuated at the site of the lesion.

Significant CDS: There will be a decline in the internal diameter of more than 50% compared to the adjacent segment, and the peak systolic velocity is more than 100% compared to the normal segment.

RESULTS

After collection, the data were analyzed using SPSS version 25. The mean age of the participants was 41.15 ± 8.15 years, and the mean duration of MHD was 36.30 ± 10.30 years. Most patients (89.5%) underwent dialysis three times a week, while the remaining patients (10.5%) received dialysis twice a week. Diabetes was the leading cause of ESRD with 40.1%, followed by hypertension with 17.9% and bilateral SSK with 17.3%. Radio-cephalic (55.6%) was the most common type of AVF, followed by brachio-cephalic (38.3%) and brachio-basilic (6.2%). The majority of patients had been on MHD for more than 24 months, indicating a chronic ESRD status. Among the diabetic ESRD patients (40.1%), nearly all had coexisting hypertension, while patients with bilateral small-sized kidneys (17.3%) were typically younger and had a longer dialysis vintage.

The overall diagnostic accuracy of physical examination to detect AVF stenosis is 89.50% with PPV = 88.5%, NPV = 90.7%, sensitivity = 91.7%, specificity = 87.2%, and Kappa (κ) = 0.790 (**Table I**). The diagnostic accuracy of physical examination to detect AVF inflow stenosis is 89.473% with PPV = 87.2%, NPV = 90.7%, sensitivity = 82.9%, specificity = 93.2%, and Kappa (κ) = 0.769 (**Table II**). The physical examination's diagnostic accuracy in detecting AVF outflow stenosis is 90.243% with PPV = 89.6%, NPV = 90.7%, sensitivity = 86.0%, specificity = 93.2%, and Kappa (κ) = 0.797 (**Table III**).

Table I: Sensitivity, Specificity, PPV, NPV of PE to predict AVF Stenosis

Presence of Stenosis * Presence of Stenosis using CDS Cross-tabulation

			Presence of Stenosis using CDS		Total
			Yes	No	
Presence of Stenosis	Yes	Count	77(True positive)	10(False positive)	87
		% within Presence of Stenosis	88.5%(PPV)	11.5%	100.0%
		% within Presence of Stenosis using CDS	91.7% (Sensitivity)	12.8%	53.7%
	No	Count	7(False negative)	68(True negative)	75
		% within Presence of Stenosis	9.3%	90.7%(NPV)	100.0%
		% within Presence of Stenosis using CDS	8.3%	87.2% (Specificity)	46.3%
Total		Count	84	78	162
		% within Presence of Stenosis	51.9% (Prevalence)	48.1%	100.0%
		% within Presence of Stenosis using CDS	100.0%	100.0%	100.0%

Table II: Sensitivity, Specificity, PPV, NPV of PE to predict AVF Inflow Stenosis

Presence of inflow Stenosis * Presence of Stenosis using CDS Cross-tabulation

			Presence of Stenosis using CDS		Total
			Yes	No	
Presence of In-flow Stenosis	Yes	Count	34	5	39
		% within Presence of Stenosis	87.2%(PPV)	12.8%	100.0%
		% within Presence of Stenosis using CDS	82.9%(Sensitivity)	6.8%	34.2%
	No	Count	07	68	75
		% within Presence of Stenosis	9.3%	90.7%(NPV)	100.0%
		% within Presence of Stenosis using CDS	17.1%	93.2%(Specificity)	65.8%
Total		Count	41	73	114
		% within Presence of Stenosis	36.0%	64.0%	100.0%
		% within Presence of Stenosis using CDS	100.0%	100.0%	100.0%

Table III: Sensitivity, Specificity, PPV, NPV of PE to predict AVF Outflow Stenosis

Presence of Outflow Stenosis * Presence of Stenosis using CDS Cross-tabulation

			Presence of Stenosis using CDS		Total
			Yes	No	
Presence of Out-flow Stenosis	Yes	Count	43	5	48
		% within Presence of Stenosis	89.6%(PPV)	10.4%	100.0%
		% within Presence of Stenosis using CDS	86.0%(Sensitivity)	6.8%	39.0%
	No	Count	7	68	75
		% within Presence of Stenosis	9.3%	90.7%(NPV)	100.0%
		% within Presence of Stenosis using CDS	14.0%	93.2%(Specificity)	61.0%
Total	Count		50	73	123
	% within Presence of Stenosis		40.7%	59.3%	100.0%
	% within Presence of Stenosis using CDS		100.0%	100.0%	100.0%

DISCUSSION

The goal of arteriovenous fistula (AVF) vigilance is to prevent vascular access (VA) thrombosis by detecting high-risk Stenosis early and performing pre-emptive dilation. The preliminary results of these studies shed light on the value of diagnosing PE compared to CDS. The findings of this study demonstrate that monitoring PE in the VA is convenient, straightforward, and cost-effective, as the overall performance of the full PE in identifying Stenosis was satisfactory[16,17]. The sensitivity index was greater than 80%. As a result, PE may be a sufficient diagnostic technique for detecting Stenosis in MHD patients[9,18].

PE findings should be evaluated by gold-standard techniques, such as angiography and Doppler ultrasonography, to establish that PE of the AVF can identify Stenosis. PE findings in diagnosing Stenosis had similar sensitivity (>80%) and positive predictive value (>80%) as continuous-wave Doppler ultrasonography in 23 individuals, according to Migliacci R et al[19]. The determination of Stenosis by PE of the AVF was compared with the non-invasive gold standard, Doppler ultrasonography, in three observational studies[12,20-22]. The findings of our study align with those of previous studies, with a sensitivity of 82.9% and a specificity of 93.2%.

The sensitivity and specificity of inflow stenosis in this study was 82.9% and 93.2%, which is higher than the sensitivity(70%) and specificity(76%) of inflow stenosis by Coentrão L 2012[20] and Hwang SD et al.[20,23] , but very similar to the 82% sensitivity of Maldonado-Cárceles AB 2017[14]. Another essential factor is in this study; PE was performed in all of the cases by a resident nephrologist. Leon C 2008[24] demonstrated that a nephrology fellow may perform as well as an interventionist nephrologist after just a month of training in AVF evaluation[25]. Although the length of time spent caring for HD patients did not appear to increase these skills, experienced HD nurses may be able to detect AVF immaturity and dysfunction with PE of the vascular access. If a positive quantitative PE marker is found, the VA is sent for treatment. Alternatively, if there is a suspicion of high-risk Stenosis, an ultrasound examination is undertaken to confirm the existence of high-risk Stenosis before therapy[26].

The physical examination remains a valuable, non-invasive, and cost-effective tool in the initial assessment of arteriovenous fistula (AVF) stenosis, particularly in resource-constrained settings or when immediate access to advanced imaging is limited[27]. Clinical manoeuvres such as inspection for arm swelling, palpation for thrill abnormalities, and auscultation for changes in bruit characteristics provide meaningful cues that may indicate underlying hemodynamic alterations[28]. Several studies have reported moderate to high sensitivity and specificity of physical examination in detecting clinically significant AVF stenosis, primarily when performed by experienced clinicians. However, its diagnostic accuracy is operator-dependent and subject to interobserver variability, which can affect the consistency of findings across different clinical settings[29].

Despite these limitations, physical examination should not be undervalued. When integrated with patient history and clinical context, it can guide timely referrals for confirmatory imaging such as duplex ultrasound or fistulography[30]. Moreover, serial examinations can help monitor fistula function longitudinally and identify subtle changes suggestive of progressive stenosis[31]. While advanced imaging remains the gold standard for anatomical and functional assessment, the utility of physical examination lies in its ability to serve as a frontline screening tool, enabling early detection and potentially reducing the risk of access failure through prompt intervention[32].

Several limitations may apply to this study. Firstly, this was a cross-sectional study conducted at a single centre. A single resident did all of the PEs, so inter-rater reliability could not be assessed. Because a nephrology resident performed the PE, concerns may arise regarding its application by other healthcare providers[34].

CONCLUSION

PE shows moderate to high accuracy in detecting AVF stenosis in patients with MHD. PE of the vascular access (VA) is a practical, straightforward, and cost-effective method for identifying dysfunction. PE is a reliable and accurate method for detecting Stenosis. With its reliability and accuracy, PE can serve as a valuable tool in routine clinical assessment. These examination skills can be taught to physicians and nurses involved in the care of hemodialysis (HD) patients. Furthermore, educating patients themselves may empower them to recognize early signs of AVF malfunction.

ACKNOWLEGDMENT

We extend our sincere gratitude to all the participants who contributed to this study. We also extend our appreciation to the paramedical staff of the Nephrology department at Shaikh Zayed (SKZ) Medical Complex, Lahore, for their invaluable support and assistance.

Ethical Permission: Shaikh Zayad Medical Complex, Lahore, IRB letter No. SZMC/IRB/ 00113/2021.

Conflict of interest: There is no conflict of interest between the authors.

Financial Disclosure / Grant Approval: No funding agency was involved in this research.

Data Sharing Statement: The corresponding author can provide the data proving the findings of this study on request. Privacy or ethical restrictions bound us from sharing the data publicly.

AUTHOR CONTRIBUTION

Umar R: Main contributor, first author

Akram M: Conceived the study, supervised the process

Naeem H: Contributed substantially to the acquisition and analysis of data

Rehman F: Assisted in drafting the manuscript and reviewing it critically for important intellectual content

Ali N: Provided technical assistance and contributed to the interpretation of data

Aslam S: Assisted in data collection and provided critical revisions to the manuscript

Ahmed W: Contributed to data collection and analysis, and assisted in manuscript preparation

REFERENCES

1. Wu S, Shen L, Gong W. Evaluation value of Portable Color Doppler Ultrasound for Arteriovenous Fistula Stenosis in Patients with Maintenance Hemodialysis. Am J Intern Med. 2020; 8(4): 143-7.
2. Lok CE, Huber TS, Lee T, Shenoy S, Yevzlin AS, Abreo K et al. KDOQI Clinical Practice Guideline for Vascular Access: 2019 Update. Am J Kidney Dis. 2020; 75(4 Suppl 2): S1-s164.
3. Jackson VE, Hurst H, Mitra S. Structured physical assessment of arteriovenous fistulae in haemodialysis access surveillance: A missed opportunity? J VascAccess. 2018; 19(3): 221-9.
4. Lok CE, Huber TS, Lee T, Shenoy S, Yevzlin AS, Abreo K et al. KDOQI clinical practice guideline for vascular access: 2019 update. Am J Kidney Dis. 2020; 75(4): S1-S164.
5. Raksasuk S, Rojwatcharapibarn S, Srithongkul T. Comparing Non-invasive Diagnostic Methods for Arteriovenous Fistula Stenosis: A Prospective Study. 2020.
6. AIUM Practice Parameter for the Performance of Vascular Ultrasound Examinations for Postoperative Assessment of Hemodialysis Access. J Ultrasound Med. 2020; 39(5): E39-e48.

7. Richards J, Hossain M, Summers D, Slater M, Bartlett M, Kosmoliaptsis V et al. Surveillance arteriovenous fistulas using ultrasound (SONAR) trial in haemodialysis patients: a study protocol for a multicentre observational study. BMJ Open. 2019; 9(7): e031210.
8. Lakshminarayana G, Sheetal L, Mathew A, Rajesh R, Kurian G, Unni V. Hemodialysis outcomes and practice patterns in end-stage renal disease: Experience from a Tertiary Care Hospital in Kerala. Indian J Nephrology. 2017; 27(1): 51.
9. Chen MC, Weng MJ, Chang BC, Lai HC, Wu MY, Fu CY et al. Quantification of the severity of outflow stenosis of hemodialysis fistulas with a pulse- and thrill-based scoring system. BMC Nephrology. 2020; 21(1): 304.
10. Nagalakshmi T, Mahesh C, Parvathi KS, Nagaraj R, Sunnesh A, Sameera NS et al. Lower limb vascular access for maintenance hemodialysis patients–A case series. J Dr NTR University of Health Sciences. 2020; 9(1): 60.
11. Schoch ML, Currey J, Orellana L, Bennett PN, Smith V, Hutchinson AM. Point-of-care ultrasound -guided cannulation versus standard cannulation in haemodialysis vascular access: protocol for a controlled random order crossover pilot and feasibility study. Pilot and Feasibility studies. 2018; 4: 176.
12. Abreo K, Amin BM, Abreo AP. Physical examination of the hemodialysis arteriovenous fistula to detect early dysfunction. J Vvasc Access. 2019; 20(1): 7-11.
13. Jarosciakova J, Utikal P, Malik J, Janeckova J. Using ultrasound in preoperative mapping and surveillance of arteriovenous grafts for haemodialysis improves patency rates: Single-centre experience. J Vasc Access. 2024: 11297298241308377.
14. Maldonado-Cárceles AB, García-Medina J, Torres -Cantero AM. Performance of physical examination versus ultrasonography to detect Stenosis in haemodialysis arteriovenous fistula. J Vasc Access. 2017; 18(1): 30-4.
15. Beathard G. Physical examination: The forgotten tool. A multidisciplinary approach for hemodialysis access. 2002; 111-8.
16. Wu CK, Lin CH. Integrating vascular access surveillance with clinical monitoring for stenosis prediction. J Nephrology. 2024; 37(2): 461-70.
17. Zamboli P, Punzi M, Calabria M, Capasso M, Granata A, Lomonte C. Color Doppler ultrasound evaluation of arteriovenous grafts for hemodialysis. J Vasc Access. 2024; 25(6): 1721-40.
18. Lee CY, Gao YC, Ciou WS, Wu MJ, Du YC. Combining RGB-D Sensing with Adaptive Force Control in a Robotic Ultrasound System for Automated Real-Time Fistula Stenosis Evaluation. IEEE Sensors J. 2025; 25(3): 5446-56.
19. Migliacci R, Selli ML, Falcinelli F, Vandelli L, Lusvarghi E, Santucci A et al. Assessment of occlusion of the vascular access in patients on chronic hemodialysis: comparison of physical examination with continuous-wave Doppler ultrasound. Nephron. 1999; 82(1): 7-11.
20. Coentrão L, Faria B, Pestana M. Physical examination of dysfunctional arteriovenous fistulae by non-interventionalists: a skill worth teaching. Nephrology Dialysis Transplantation. 2012; 27(5): 1993-6.
21. Campos RP, Chula DC, Perreto S, Riella MC, Do Nascimento MM, editors. Accuracy of physical examination and intra-access pressure in the detection of Stenosis in hemodialysis arteriovenous fistula. Seminars in dialysis; 2008: Wiley Online Library.
22. Thurlow JS, Joshi M, Yan G, Norris KC, Agodoa LY, Yuan CM et al. Global Epidemiology of End-Stage Kidney Disease and Disparities in Kidney Replacement Therapy. Am J Nephrology. 2021; 52(2): 98-107.
23. Hwang SD, Lee JH, Lee SW, Kim JK, Kim MJ, Song JH. Comparison of ultrasound scan blood flow measurement versus other forms of surveillance in the thrombosis rate of hemodialysis access: A systemic review and meta -analysis. Medicine. 2018; 97(30): e11194.
24. Leon C, Asif A, editors. Physical examination of arteriovenous fistulae by a renal fellow: does it compare favorably to an experienced interventionalist? Seminars in dialysis; 2008: Wiley Online Library.
25. Ali H, Mohamed MM, Baharani J. Effects of hemodialysis access surveillance on reducing risk of hemodialysis access thrombosis: A meta-analysis of randomized studies. Hemodialysis Int. 2021; 25(3): 309-21.
26. Salman L, Rizvi A, Contreras G, Manning C, Feustel PJ, Machado I, et al. A Multicenter Randomized Clinical Trial of Hemodialysis Access Blood Flow Surveillance Compared to Standard of Care: The Hemodialysis Access Surveillance Evaluation (HASE) Study. Kidney Int Reports. 2020; 5(11): 1937-44.
27. Wu CK, Tarng DC, Yang CY, Leu JG, Lin CH. Factors affecting arteriovenous access patency after percutaneous transluminal angioplasty in chronic haemodialysis patients under vascular access monitoring and surveillance: a single-centre observational study. BMJ Open. 2022; 12 (1): e055763.
28. Yang CY, Wu BS, Wang YF, Wu Lee YH, Tarng DC. Weight-Based Assessment of Access Flow Threshold to Predict Arteriovenous Fistula

Functional Patency. Kidney Int Reports. 2022; 7 (3): 507-15.
29. Kim DH, Park HC, Cho A, Kim J, Yun KS, Kwon YE et al. Nurse Caseload and Patient Survival in Hemodialysis Units: A Korean Nationwide Cohort Study. Am J Nephrology. 2022; 53(5): 407-15.
30. Lee HS, Kim SG. A Korean perspective on the 2019 Kidney Disease Outcomes Quality Initiative guidelines for vascular access: what has changed and what should be changed in practice? Kidney Res Clin Pract. 2021; 40(1): 29-39.
31. Lok CE, Rajan DK. KDOQI 2019 Vascular Access Guidelines: What Is New. Seminars in Interventional Radiology. 2022; 39(1): 3-8.
32. Peralta R, Garbelli M, Bellocchio F, Ponce P, Stuard S, Lodigiani M et al. Development and Validation of a Machine Learning Model Predicting Arteriovenous Fistula Failure in a Large Network of Dialysis Clinics. Int J Environ Res Public Health. 2021; 18(23).
33. Saati A, Puffenberger D, Kirksey L, Fendrikova-Mahlay N. The role of hemodialysis access duplex ultrasound for evaluation of patency and access surveillance. Cardiovasc Diagn Therapy. 2023; 13 (1): 190-5.
34. Alnahhal KI, Rowse J, Kirksey L. The challenging surgical vascular access creation. Cardiovasc Diagn Therapy. 2023; 13(1): 162-72.