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

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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 found a one-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 and locate the stenosis sites in the AVF. PE of 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 because of their small sample size, static angiographic images, retrospective approach, and biasing issues[3,14]. This study aimed to assess the diagnostic accuracy of physical examination (PE) in 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, involving both outpatient and inpatient departments of Nephrology and Cardiothoracic Surgery at Shaikh Zayed Hospital (SKZ), Lahore.

The ethical approval for this research work 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 with a 95% confidence level and a 5% margin of error. The inclusion criteria were male and female patients above 18 years who were on maintenance haemodialysis via AVF for more than three 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 hypo-pulsatile pulse, poor pulse augmentation with decreased and discontinuous thrill. For outflow stenosis, there is a distended segment that does not collapse on arm elevation, and the pulse is hyper-pulsatile. Moreover, thrill and bruit are discontinuous and accentuated at the site of the lesion.

Significant CDS: There will be a decline in 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 Crosstabulation					
			Presence of Stenosis using CDS		Total
			Yes	No	
Presence of Inflow 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 Crosstabulation					
			Presence of Stenosis using CDS		Total
			Yes	No	
Presence of Outflow 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 et al**[19]. The determination of Stenosis by PE of the AVF was compared to the non-invasive gold standard technique, 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 et al.**[20,23] but very similar to the 82% sensitivity of **Maldonado-Cárceles et al**.[14]. Another essential factor is in this study; PE was performed in all of the cases by a resident nephrologist. **Leon and Asif**[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.

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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

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