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Research Paper

Role of Color Doppler Ultrasonography in the Assessment of Suspected Complicated Brachiocephalic Fistulas in Hemodialysis Patients

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ABSTRACT:

BACKGROUND:

Arteriovenous fistula (AVF) has been the preferred vascular access in hemodialysis. Doppler ultrasonography is the main imaging modality of hemodialysis arterio-venous (AV fistula).

OBJECTIVE:

To study the role of Color Doppler Ultrasonography (CDUS) in assessment of suspected complication of brachiocephalic fistulas in hemodialysis patients.

PATIENTS AND METHODS:

Prospective cross-sectional study carried out in the Radiology Department at Al-Imamain Al-Kadhimain Medical city, between November 2021 and November 2022. The study included 50 patients with end stage kidney disease and had suspected non-functioning brachiocephalic fistula. All patients were examined by using linear probe and occasionally curvilinear probe. Color Doppler was done for assessment of associated brachiocephalic arteriovenous fistula (BCAVF) complications. Doppler parameters in the arterial and venous side, blood volume through the fistula, and the type of complication.

RESULTS:

The mean age of the patients was 43.8±12.2 with an age range of (27-68) The fistula was functioning among 12 (24%) patients, functioning with complication among 11 (22%) patients, and not functioning among 27 (54%) patients. Regarding patients with adequate flow and associated complications 5 (45.5%) had stenosis, and 6 (54.5%) had aneurysm in comparison of those with fistula dysfunction where thrombosis is shown in 12 (44.44%), stenosis in 10 (37.04%), aneurysm in 2 (7.41%) and steal syndrome in 3 (11.11%).

CONCLUSION:

CDUS is a good modality for evaluation of quantity and quality of the AVF and detection of early and late complications. Stenosis and thrombosis were the most common complications.

KEY WORDS: Ultrasonography, Brachiocephalic Fistulas, Hemodialysis.

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INTRODUCTION:

The incidence of end-stage renal disease (ESRD) has substantially increased in the elderly population. Diabetes is the most common cause of ESRD, and accounts for up to 50 % of all cases [(1)]. Hemodialysis (HD) is one of the treatment modalities that could choose among the three commonly used therapies including peritoneal dialysis and kidney transplantation[(2)]. Arteriovenous fistula (AVF) has been the preferred vascular access in hemodialysis as it is shown to be associated with lowest risk of death, infection, cardiovascular event and hospitalization, as compared to the use of arteriovenous graft (AVG) and hemodialysis catheters [(3-5)]. In AVF, the anastomosis is surgically formed between artery and vein [(6)]. The term maturation refers to the development of those physical characteristics that render an AVF suitable for venipuncture with large-gage needles [(7)]. Dysfunction or related vascular access complications account for 20% to 30% of hospital admissions in patients undergoing renal replacement therapy with HD [(8)] resulting in additional high morbidity, high mortality, and high economic burden [(9, 10)].

The role of color Doppler ultrasound (CDUS) has been progressively established as a complement to preoperative assessment and follow-up [11-15]. CDUS enables early evaluation after access creation [1]. DUS is also an excellent modality for hemodialysis access evaluation and can help to identify nonmatured AVFs and other complications associated with grafts and AVFs, including thrombosis, hematoma, pseudoaneurysm and infections [16, 17].

AIM OF THE STUDY:

To study the role of color Doppler Ultrasonography in the assessment of suspected complications of brachiocephalic fistulas in hemodialysis patients.

PATIENTS AND METHODS:

Study design and setting: a prospective study was done at Ultrasound unit in the Radiology of Al-Imamain Al-Kadhimain Medical city.

Study population: All patient with end stage kidney disease and had suspected non-functioning brachio-cephalic fistula

Study period: the study was carried out from November 2021 to November 2022.

Sample size: a sample of 50 patients.

Inclusion criteria: adult patients with suspected complications or non-functioning brachiocephalic fistula (persistent high renal indices after hemodialysis session).

Exclusion criteria: patients with newly established brachiocephalic fistula and patients with end stage kidney disease with other types of fistula (radio-cephalic and brachio-basilic fistulas) and central venous line (double lumen).

Ethical consideration: was approved by the scientific committee of the Iraqi Board of diagnostic radiology. Verbal informed consent was obtained from all patients included in the study.

Doppler ultrasound examination: all patients were examined using U/S machine (Affinity 30, Philips medical system, Netherland). Each patient was examined by using linear probe (frequency 4-12MHz) and occasionally curvilinear probe (frequencyC2-6 MHz). The examination of the patients were done in the sitting or semi-recumbent position, the forearm is extended and resting on a pillow putted below the patient‘s upper limb. The examination time for every patient was ranging from 15-20minutes started by using Gray scale. The site of fistula and diameter were determined both arterial and venous sides were examined for any gross mural thrombosis or visible plaques as well as assessing the arterial and venous diameters, any stenosis or aneurysms was also assessed and recorded. Examination was followed by using color doppler technique and adjusting the doppler parameters using appropriate setting, appropriate steering angle making as parallel as possible and should not exceed 60 degree. The device was set on arterial Doppler setting and the velocity scale was adjusted to maximum. Spectral waveform was examined by a spectral mode evaluating the peripheral resistance (mono-phasic mean low resistance while triphasic mean high resistance).

A normally functioning fistula should demonstrate a mono-phasic high velocity flow while abnormally functioning BCAVF will return a triphasic pattern. Flow volume was measured at the arterial side pre-fistula and at the venous side post-fistula; however, the latter was not always possible or accurate due to high incidence of venous irregularity (aneurysm, stenosis or thrombosis) resulting in flow turbulence and subsequent inaccurate measurements, so we highly depend on the readings in the arterial flow in this study.

The size of the sampling volume was set so that it covers the whole arterial lumen from wall to wall and mean systolic velocity was taken (determined by device software settings), mean flow volume was also calculated by the device taking into account both the mean systolic velocity and the vessel diameter at the same point where the velocity taken. Three measurements were taken and the mean value was taken for statistical analysis, the flow rate was considered adequate if between 500- 1500ml/min, reduced flow if <500ml/min and high flow if >1500ml/min.

For assessment of complications the examination should include: The afferent (brachial) artery, Site of AVF, The draining vein (cephalic vein) and Distal arterial tree (away from the AVF site).

Statistical analysis: Data obtained was entered, processed and analyzed using Statistical Package for Social Sciences (SPSS) version 25, and excel program. Descriptive analysis was used to summarize data. Categorical data were summarized in percentages. Continuous variables were summarized by use of mean with their respective measures of dispersion. P value of < 0.05 was taken as cut off level of statistical significance.

RESULTS:

The study included 50 patients with suspected BCAVF dysfunction, mean age of the patients was 43.8±12.2 with an age range of (27-68).

The male patients were 28 (56%), and females were 22 (44 %), the male to female ratio was 1.27:1. History of diabetes mellitus (DM) found among 14 (28%) patients, history of hypertension (HT) found among 8 (16%) patients, polycystic kidney 6 (12%) patients, DM+HT found among 18 (36%) patients. The age of the fistula (range of duration after operation in months) was 3-15 months.

Flow rate: the flow rate was adequate (500-1500ml/min) among 23 (46%) patients, decreased (<500 ml/min) in 12 (24%) patients, increased (>1500 ml/min) in 5 (10%) patients, and no flow 10 (20%) of the patients.

The fistula was functioning among 12 (24%) patients, functioning with complication among 11 (22%) patients, and failed among 27 (54%) patients.

The complicated fistula found among 38 (76%) patients, and uncomplicated found among 12(24%) patients.

The distribution of the complicated AVF according to the type of complication show that stenosis found among 15 (39.5%) patients, followed by thrombosis in 12 (31.6%) patients, aneurysm in 8 (21.1%) patients, and steal syndrome in 3 (7.9%) patients.

Mild stenosis and adequate flow was seen in 5 patients while moderate to severe stenosis and decreased blood flow was seen in 10 patients, this relation was statistically significant P value < 0.05. Partial thrombosis and decreased blood flow was in 2 patients while total thrombosis and no flow was seen in 10 patients, this relation was statistically significant P value <0.05. Small aneurysm and adequate flow was seen in 5 patients while large aneurysm and increased flow was seen in 7 patients, this relation was statistically significant P value <0.05. Increased flow and steal syndrome found among 3 patients, this relation was statistically significant P value < 0.05. All these findings were shown in (table 1).

Table 1: The reported complications among study patients according to level of complications and blood flow volume (BFV) across fistula (ml/min).

Complications		BFV across fistula (ml/min)				**P value**
		Adequate	decrease	Increased	No flow	
Stenosis	mild	5	0			<0.05*
	Moderate-sever	0	10			
Thrombosis	Partial		2		0	<0.05*
	Total		0		10	
Aneurysm	Small	6		0		<0.05*
	Large	0		2		
Steal syndrome				3		

**Fisher's Exact Test*

Regarding patients with adequate flow and associated complications: 5 (45.5%) patients had stenosis and 6 (54.5%) patients had aneurysm while those with fistula dysfunction thrombosis is shown in 12 (44.44%) patients, stenosis in 10 (37.04%) patients, aneurysm in 2 (7.41%) patients and steal syndrome in 3 (11.11%) patients this relation was statistically significant (p value < 0.05) as shown in (2).

Table 2: The relation between flow in AVF and complications.

	Adequate		Dysfunctional		P value
	No.	%	No.	%	
Stenosis	5	45.5%	10	37.04%	< 0.05
Thrombosis	0	0%	12	44.44%	
Aneurysm	6	54.5%	2	7.41%	
Steal syndrome	0	0%	3	11.11%	
Total	11	100%	27	100%	

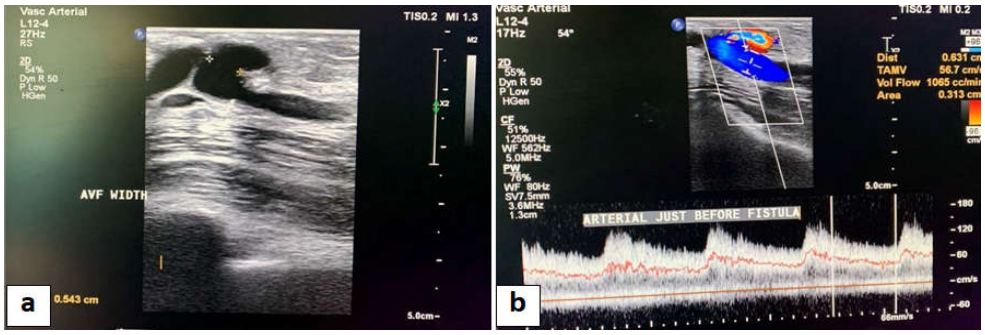

Figure 1: A 70-year-old male with BCAVF on hemodialysis for the last 3 months. (a) Gray scale US shows normal diameter of the fistula (5mm), (b) CDUS shows mono-phasic arterial waveform with low resistance. BFV the arterial side just proximal to the fistula (1065ml/min).

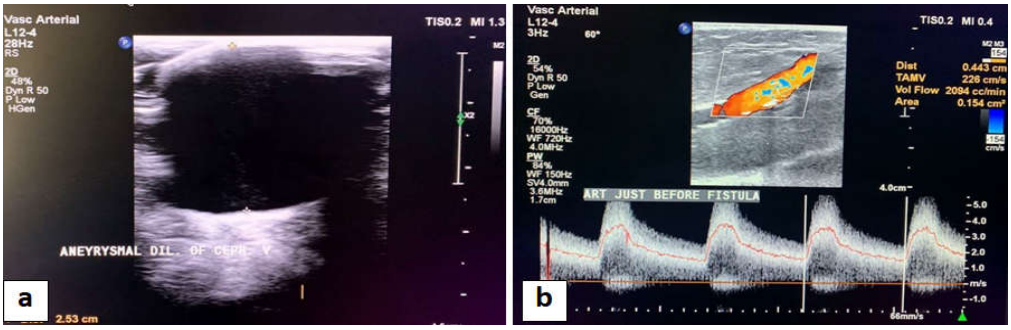

Figure 2: A 60-year-old female patient with BCAVF on hemodialysis for the last 10 months complaining of swelling at site of fistula. (a) gray scale US shows large aneurysmal dilatation of cephalic vein (20mm in diameter), (b) CDUS shows mono-phasic arterial waveform with low resistance. BFV (2384ml/min) at arterial side.

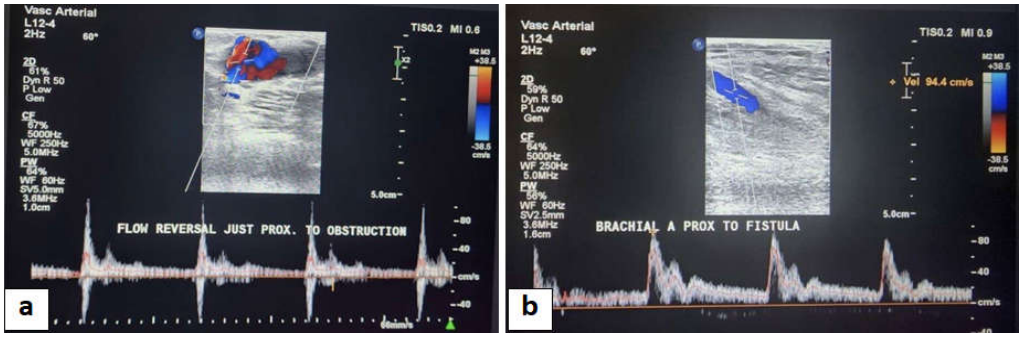

Figure 3: A 28-year-old female patient with BCAVF on hemodialysis for the last 8 months presented with high renal indices after HD sessions. (a) CDUS show total thrombosis of the cephalic vein, (b) brachial artery shows high resistant and reverse arterial flow (94.4 cm/sec).

DISCUSSION:

Arteriovenous fistula (vascular access) has become the most widely used mean for end-stage renal disease patients on regular hemodialysis [18]. Many types of hemodialysis AVF are known, but the most widely used one is that created with autogenous material, because they have very good primary and secondary patency than those fistulas created with synthetic graft [19]. Catheters or grafts are liable for many complications that lead to early failure and these include higher incidence of

thrombosis, infection, ischemia, and occlusion secondary to intimal hyperplasia, providing higher morbidity and mortality rates for the patients when compared with an autogenous AVF [20].

The current study included 50 patients consists of 28 Males and 22 females with the male to female ratio was 1.27: 1, their ages range from 27 to 68 years, mean age of the patients was 43.8± 12.2. Similar demographic characteristics were observed in Hazem et al [21] study.

Abd-Elmageed M. et al [22] study in 2020 found that (36%) of patients in their study had diabetics which are comparable with current study.

This present study showed that (76%) of cases had complicated fistula while (24%) had no complications. The most common complication was stenosis, followed by thrombosis while steal syndrome was the least. Moghazy et al [23] study showed similar results. Another study by Hassan et al [24] show different results in which the most common complication was thrombosis with lowers percentage of stenosis. This difference may be attributed to lower number of high risk patients included in their study and the short term follow up exam from the time of AV fistula creation.

In the current study, thrombosis was detected at the venous side of the fistula in most cases; these findings agree with Hassan et al [24] study.

All patients with mild stenoses in this study (5 patients) showed adequate flow with no effect on fistula function; while all the cases with moderate to severe stenoses (10 in number) had fistula dysfunction (inadequate BFV). These results were in agreement with Moghazy et al [23] study.

The present study showed 8 patients (21.1%) with aneurysmal dilatation at the venous side (vein diameter more than 6mm), 6 of them with small aneurysm and adequate BFV while 2 patients had large diameter and increased BFV. These results were in agreement with Pietura et al [25] study.

CONCLUSION:

CDUS is a good modality for evaluation of quantity and quality of the AVF and detection of early and late complications. Stenosis and thrombosis were the most common complications.

REFERENCES:

1. Chytilova E, Jemcov T, Malik J, Pajek J, Fila B, Kavan J. Role of Doppler ultrasonography in the evaluation of hemodialysis arteriovenous access maturation and influencing factors. J Vasc Access. 2021 Nov;22(1_suppl):42-55. doi: 10.1177/1129729820965064. Epub 2021.
2. Arasu R, Jegatheesan D, Sivakumaran Y. Overview of hemodialysis access and assessment. Can Fam Physician. 2022; 68:577-82.
3. National Kidney Foundation Kidney Disease Outcomes Quality Initiative (DOQI): Clinical practice guidelines for vascular access. Am J Kidney Dis 2006; 48:S176-247.
4. Ethier J, Mendelssohn DC, Elder SJ et al. Vascular access use and outcome: an international perspective from the dialysis outcomes and practice pattern study. Nephrol Dial Transplant 2008;23:3219-26.
5. Ravani P, Palmer SC, Oliver MJ et al. Associations between hemodialysis access type and clinical outcomes: a systematic review. J Am Soc Nephrol 2013; 24:465-73.
6. Steinke, T., Rieck, J. & Nuth, L. Endovascular arteriovenous fistula for hemodialysis access. Gefässchirurgie 2019; 24 (Suppl 1):25–31.
7. Yun SS, Mok S, Park SC, Park YJ, Kim JY. Efficacy of blood flow measurement using intraoperative color flow Doppler ultrasound as a predictor of autologous arteriovenous fistula maturation. Therapeutic Apheresis and Dialysis. 2023;27:50-58.
8. Gomes AP, Germano A, Sousa M, Martins R, Coelho C, Ferreira MJ, Rocha E, Nunes V. Preoperative color Doppler ultrasound parameters for surgical decision-making in upper arm arteriovenous fistula maturation. J Vasc Surg. 2021;73:1022-30. doi: 10.1016/j.jvs.2020.07.063. Epub 2020 Jul 22.
9. Ocak G, Rotmans JI, Vossen CY, Rosendaal FR, Krediet RT, Boeschoten EW, et al. Type of arteriovenous vascular access and association with patency and mortality. BMC Nephrol 2013;14:79.
10. Roy-Chaudhury P, Sukhatme VP, Cheung AK. Hemodialysis vascular access dysfunction: a cellular and molecular view-point. J Am Soc Nephrol 2006;17:1112-27.
11. Lomonte C, Basile C. Preoperative assessment and planning of haemodialysis vascular access. Clin Kidney J 2015;8:278-81.
12. Smith GE, Barnes R, Chetter IC. Randomized clinical trial of selective versus routine preoperative duplex ultrasound imaging before arteriovenous fistula surgery. Br J Surg 2014;101:469-74.
13. Kukita K, Ohira S, Amano I, Naito H, Azuma N, Ikeda K, et al. 2011 update Japanese Society for Dialysis Therapy guidelines of vascular

access construction and repair for chronic hemodialysis. Ther Apher Dial 2015;19(Suppl 1):1-39.

14. Zamboli P, Fiorini F, D'Amelio A, Fatuzzo P, Granata A. Color Doppler ultrasound and arteriovenous fistulas for hemodialysis. J Ultrasound 2014;17:253-63.

15. Wong CS, McNicholas N, Healy D, Clarke-Moloney M, Coffey JC, Grace PA, et al. A systematic review of preoperative duplex ultrasonography and arteriovenous fistula formation. J Vasc Surg 2013;57:1129-33.

16. Dujim LEM, Caris R. Imaging techniques of vascular access. Update on pre-operative assessment. In: Tordoir J, ed. Best practice in vascular access. Turin: Edizioni Minerva Medica, 2010;29-37.

17. Malik J, Tuka V, Tesar V. Local hemodynamics of the vascular access for hemodialysis. Kidney Blood Press Res. 2009; 32:59-66.

18. Thomas M, Nesbitt C, Ghouri M and Hansrani M. Maintenance of hemodialysis vascular access and prevention of access dysfunction: a review. Ann Vasc Surg 2017; 43:318–27.

19. Jeferson F.; Claudio J.; Antonio S. et al. Evaluation of hemodialysis arteriovenous fistula maturation by colorflow Doppler ultrasound. J. vasc. bras. 2008; 7.

20. Duval L.: Proximal radial artery arteriovenous fistulae (PRA- AVF). Nephrol Nurs J. 2007;34:217-18.

21. Mohammed Hazem. Efficiency of color doppler ultrasonography for assessment of maturation and post-operative.dysfunction of hemodialysis arteriovenous fistula. MedPulse International Journal of Medicine 2019; 11:73-80.

22. Abd-Elmageed, M., Elsayed, B.F. & Elkholy, M.R. Role of early postoperative ultrasonography in prediction of AV fistula failure in hemodialysis patients. Egypt J Radiol Nucl Med 2020; 51:1-2.

23. Khaled M. Moghazy. Value of Color Doppler Sonography in the Assessment of Hemodialysis Access Dysfunction. Saudi J Kidney Dis Transplant 2009;20:35-43.

24. Hassan, M.H., Abdelrazek, G.M. & Hashim, A.A. The clinical importance of color Doppler ultrasonography in puncture related complications of hemodialysis vascular access. Egypt J Radiol Nucl Med 2019; 50:1-7.

25. Pietura R, Janczarek M, Zaluska W, Szymanska A, Janicka L, Skublewska-Bednarek A, Szczerbo-Trojanowska M. Colour Doppler ultrasound assessment of well-functioning mature arteriovenous fistulas for haemodialysis access. European journal of radiology. 2005; 55:113-19.