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Original Research

DISCRIMINATIVE ROLE OF BRACHIAL ARTERY DOPPLER PARAMETERS IN CORRELATION WITH HEMODIALYSIS ARTERIOVENOUS FISTULA

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Abstract

Purpose. *The aim of this study was to evaluate the flow volume and resistive index parameters of the brachial artery in the functioning and dysfunctioning radiocephalic and brachiocephalic hemodialysis arteriovenous fistula (AVF).*

Methods. *82 patients were distributed into three groups according to their hemodialysis function - as normal function, decreased pump flow and increased venous pressure. Flow volumes and resistive indexes (RI) of the brachial artery of radiocephalic and brachiocephalic AVFs were measured by Doppler ultrasound. Flow parameters of the groups were compared.*

Results. *A statistically significant difference was found between the normal and decreased pump flow groups in terms of flow volume and resistive index values. 770 ml/min flow volume of the brachial artery has a 94% sensitivity and 84% specificity and 0.52 value of RI has an 89% sensitivity and 88% specificity in the the differentiation of normal and decreased pump flow groups.*

Conclusion. *Doppler parameters of the brachial artery such as flow volume and RI can provide valuable information about AVF function.*

Keywords: arteriovenous fistula, brachial artery, Doppler ultrasonography.

Introduction

The increase in the prevalence of patients with chronic renal failure on hemodialysis has made the maintenance of long-term patency of hemodialysis vascular access essential. Vascular access failure is a crucial problem in chronic hemodialysis patients. Vascular access primary patency is 79.5%/year and 48% every 4 years [1,2]. Stenosis and thrombosis are the most common complications in each access type. Early diagnosis and treatment are important in terms of access salvage [3]. Periodic monitoring is recommended, since early detection of access dysfunction and subsequent intervention may help reduce the rate of access failure. Being both non-invasive and inexpensive, Duplex Doppler Ultrasonography (DDU) is one of the most commonly chosen methods. Although angiography has been considered as the gold standard for imaging of vascular access abnormalities, DDU may be superior in some aspects for providing information about the morphology and function of vascular access [4]. In the literature, several studies on functional Doppler parameters such as flow volume of the drainage vein have been described [5-8]; but functional parameters of the feeding artery such as brachial artery of native AVF have rarely been studied [9-11]. The aim of this study was to evaluate the differences between brachial artery flow volume and resistive index (RI) according to clinically functional and dysfunctional AVFs.

Materials and methods

Between January 2014 and March 2015, 82 patients with native AVFs were retrospectively assessed. All patients were assessed clinically according to their AVF function during a dialysis session. Clinically dysfunctional AVFs were defined if there was reduced pump flow (< 200 ml/min) or increased venous pressure (200 mm/Hg>, pump flow >250 ml/min) [10]. Only those patients whose pump flow had been recorded in the dialysis session and who had

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undergone routine ultra sonographic control were included in the study.

All patients were classified into three groups:group 1 - AVF with normal function (33 of 82 patients; 40%), group 2 - AVF with reduced pump flow (36 of 82 patients; 44%), and group 3 - AVF with increased venous pressure (13 of 82 patients; 16%).

All patients were first evaluated by ultrasound in order to identify the anatomy and morphologic changes of their AVFs. Flow volume and RI values of the feeding artery were calculated in the brachial artery of AVF. DDU evaluation of access of the brachial artery was determined by B-mode ultrasonography in a transverse plane from inner to inner edge. The cross-sectional area was calculated by software equipment (Aplio 80, Toshiba, Tokyo, Japan). At the same site, Doppler calculation of time averaged velocity (TAV) was obtained in a longitudinal plane with an angle of insonation maintained below 60 degrees. The sample volume size was large enough to include the entire vessel lumen. Access flow was calculated with software equipment using the formula: flow volume (ml/min) = TAV x cross-sectional area x 60. The following resistive index formula was used RI = (A-B)/A, (A = Peak Systolic Velocity, B = End Diastolic Velocity) (figures 1 and 2). All measurements were performed on the same portion of the brachial artery, which is proximal to AVF.

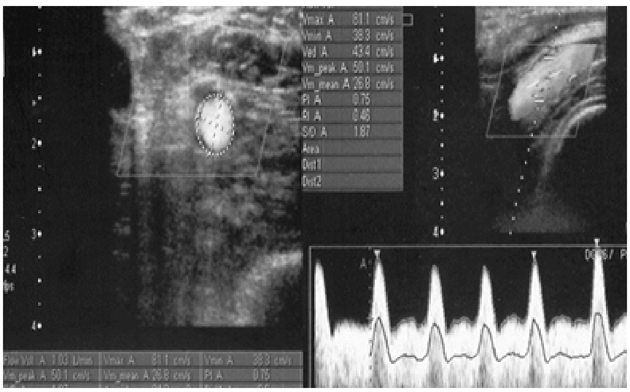


Figure 1. Flow parameters of feeding artery in a patient with normal functioning AVF (volume flow: 1030 ml/m, RI: 0.46).

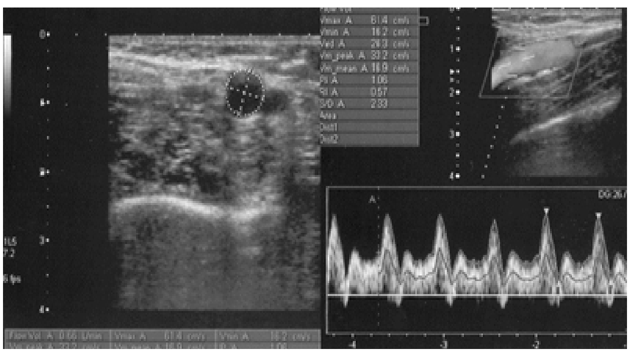


Figure 2. Flow parameters of feeding artery in a patient with decreased pump volume at hemodialysis session (volume flow: 660 ml/m, RI: 0.57).

As a second step of the evaluation, the upper extremity venous system was scanned with B-mode and color mode ultrasound. Any morphologic changes such as aneurysm, stenosis or thrombosis in the vascular bed were noted. All these measurements were made on a non-dialysis day with a high frequency transducer (7.5 mHz) of ultrasound machine by an experienced radiologist. A fistulography was performed on all patients with abnormal AVF function (group 2 and 3) except patients who had total thrombosed AVF.

Statistical analysis

Medcalc software (Belgium) was used for statistical analysis of the results. The measurements of flow volume and RI were compared between the functioning and dysfunctioning AVFs using One-Way ANOVA test. Differences with values of p less than 0.05 were considered to be significant. A receiver operator characteristic (ROC) curve analysis was performed to identify the sensitivity and specificity of flow volume and RI cut-off value in prediction of AVF functioning.

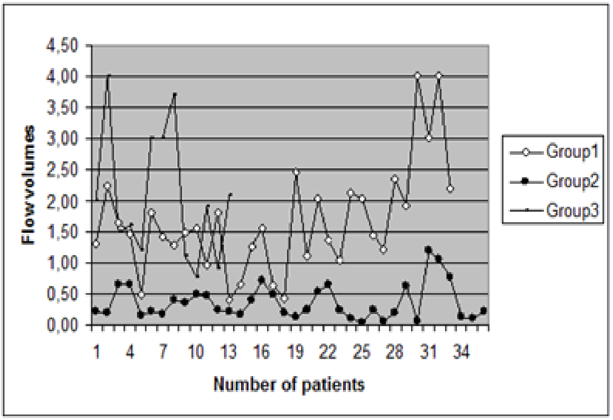
Results

A total of 82 patients comprising 50 males and 32 females were included in the study, with a mean age of 42.84±27.75. The type of AVFs were 35 (42.6%) radiocephalic and 47 (57.3%) brachiocephalic. All AVFs were matured with average dialytic age of 29±28 months (range 2 to 156 months). Mean flow volume and RI values are shown in table I. Decreased flow volume and increased RI values were detected in group 2.

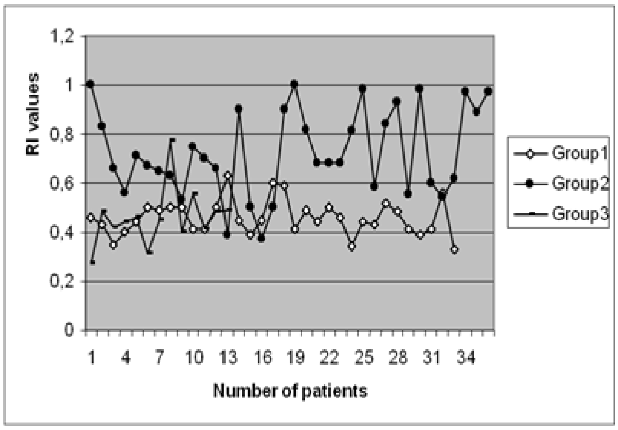
Table I. Groups mean flow parameters.

Groups	Patients	Function	Flow Volume (ml/min)	RI
1	33	Normal	1658 ± 860	0.45 ± 0.07
2	36	Decreased pump flow	368 ± 278	0.72 ± 0.17
3	13	Increased venous pressure	2560 ± 1058	0.45 ± 0.11

There was a statistically significant difference between group 1 and group 2 in terms of flow volume and RI ($p<0.001$). There was no statistically significant difference of flow volume and RI between group 1 and 3 ($p = 0.1935$). Diagrams 1 and 2 show flow volume and RI values for each group. Different cut-off points were obtained for each value in group 1 and 2. These findings showed that a value of 770 ml/min of flow volume of the feeding artery had a 94% sensitivity and 84% specificity in differentiating a normal AVF from a dysfunctioning one. Similarly, 0.52 value of RI had an 89% sensitivity and 88% specificity in differentiation of normal and dysfunctioning AVFs.



Graph 1. Flow volumes of feeding arteries according to the groups.



Graph 2. RI values in the feeding arteries according to the groups.

DDU revealed a broad spectrum of morphologic changes such as stenosis or thrombosis in all patients of group 2 (36/36), 3 patients of group 1 (3/33), and 5 patients of group 3 (5/13). Fistulography revealed vascular complications as fistula vein and central vein stenosis in all patients of group 2 and 3 (Table II).

Table II. Distribution of vascular complications in decreased pump flow and increased venous pressure groups' arteriovenous fistulas (AVF) detected with fistulography.

AVF function	Morphologic Complications
AVFs with decreased pump flow	1 arterial failure (decreased calibration)
	18 stenosis in the draining vein
	3 partial thrombosis
AVFs with increased venous pressure	5 proximal drainage vein stenosis
	8 subclavian vein stenosis

Discussion

In this study a statistically significant difference was found between normal and reduced pump flow groups in terms of flow volume and resistive index values. By using DDU, 770 ml/min flow volume of the brachial artery has 94% sensitivity and 84% specificity and 0.52 value of RI has 89% sensitivity and 88% specificity about differentiation of normal function AVF from dysfunctioning AVF.

In routine clinical examination, changes in dialysis-related parameters such as pump flow rate and venous pressure ratio have an important role in AVF functional assessment. Today, DDU is used as a common imaging modality both in pre and postoperative periods. It has been reported that DDU has high sensitivity to detect morphologic changes and vascular complications of AVF [8,12,13]. Also, DDU could be useful in the assessment of functional parameters such as flow volume and RI. Many studies investigating the flow volume changes in AVF or PTFE grafts showed that there was flow reduction in dysfunctioning ones [6,14]. However, it is more difficult to examine the native AVFs than grafts due to multiple outflow veins and the intrinsic tortuosity. Using the brachial artery for flow volume measurement has advantages such as its deeper location, so there is a remote probability of compression and this facilitates the diameter measurement, obtaining an easily maintained 60-degree angle of insonation and laminar flow. Because of this, the brachial artery is the preferred site for measuring the flow volume of AVFs [15]. In the literature, feeding artery flow parameters have been studied, which may help in identifying dysfunctioning AVFs [9-11]. One of them showed 500 ml/min flow volume with 40% sensitivity and 100% specificity [10]. A limited number of studies have evaluated the feeding artery RI value. One study evaluating the AVFs in early period using radial artery showed that RI values higher than 0.52 RI had an increased risk for thrombosis in the future [16]. A variable portion of the fistula flow may come from the ulnar artery via the palmar arch, so measuring flow volume from the radial artery can lead to underestimation. In terms of RI values from the brachial artery site, we found 89% sensitivity and 88% specificity for 0.52 RI value to detect AVF dysfunction. Sánchez et al. [17] showed that flow reductions together with RI elevations were associated with AVF dysfunction. But that study did not establish cut-off values of flow volume or resistive index because there were a small number of normal function AVFs in the study. We found 770 ml/min of flow volume of the feeding artery had a 94% sensitivity and 84% specificity in differentiating between a normal and reduced pump flow group. Our results showed that functional parameters of the feeding artery were not a predictor in cases of increased venous pressure. Flow parameters of the brachial artery in the increased venous pressure group were not statistically different from the normal pump flow group.

Vascular complications of AVF can also be detected by fistulography. We detected various vascular complications in all patients with dysfunctioning AVF. Also, we detected significant stenosis in three patients in the normal functioning group by DDU and fistulography. It is well known that significant stenosis in the drainage vein can be associated with normal functioning native AVF especially in the presence of collateral veins [5].

The limitations of this study include the fact that it is retrospective; and the number of patients, especially the increased venous pressure group, was small. Therefore, further randomized studies are required to verify our results.

In **conclusion**, DDU can give us functional information about AVF. Also, according to this study, flow volume and RI measurements of the brachial artery by DDU could discriminate the patients with normal and reduced pump flow in hemodialysis session. However, these parameters of the brachial artery are insufficient in patients with increased venous pressure.

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