Global Journal of Medical Research: F
Diseases
Volume 16 Issue 3 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4618 & Print ISSN: 0975-5888

The Sensitivity and Specificity of Clinical Examination of the Hemodialysis Arterial-Venous Fistula (AVF) as Compared to Angiography

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Abstract- *Background and Objectives:* Physical examination of the hemodialysis arterial-venous fistula (AVF) is convenient and inexpensive, and can often detect common problems associated with hemodialysis access. Routine systematic physical examination of the fistula by the dialysis staff with each treatment may allow early detection of problems that are commonly associated with mature fistula. This avoiding missed treatments and emergent situations. Dialysis access stenosis is the most common cause of access dysfunction. Physical examination is an important method in the assessment of stenotic lesions. The purpose of this study is to evaluate the two simple maneuvers in physical examination of the AVF (pulse augmentation and pressure assessment inside the fistula and collapsibility of the fistula on arm elevation) and compare them with the gold standard angiography.

Keywords: *AVF (arteriovenous fistula), angiography, augmentation of the AVF, collapsibility of the AVF, interventional nephrologist, stenosis of the outflow tract of the fistula.*

GJMR-F Classification : *NLMC Code: WL141.5.C4*

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The Sensitivity and Specificity of Clinical Examination of the Hemodialysis Arterial-Venous Fistula (AVF) as Compared to Angiography

Awad Magbri [α], Ji-Yank Sophie Lee [σ], Eussera El-Magbri [ρ], Mariam El-Magbri [ω] & Taha El-Magbri [¥]

Abstract- ***Background and Objectives:*** Physical examination of the hemodialysis arterial-venous fistula (AVF) is convenient and inexpensive, and can often detect common problems associated with hemodialysis access. Routine systematic physical examination of the fistula by the dialysis staff with each treatment may allow early detection of problems that are commonly associated with mature fistula. This avoiding missed treatments and emergent situations. Dialysis access stenosis is the most common cause of access dysfunction. Physical examination is an important method in the assessment of stenotic lesions. The purpose of this study is to evaluate the two simple maneuvers in physical examination of the AVF (pulse augmentation and pressure assessment inside the fistula and collapsibility of the fistula on arm elevation) and compare them with the gold standard angiography.

Design, setting, participants, & measurements: This is a prospective cohort study of 118 consecutive hemodialysis patients who were referred to dialysis access center of Pittsburgh, PA because of dysfunctional AVF. We compared the accuracy of the clinical examination in diagnosing outflow stenosis in AVF with the gold standard (angiography). Two separate experienced interventional nephrologists (IN) were involved in the study. The IN who carried out the angiography of the fistula was blinded to the results of the physical examination findings. Cohen's k was used as a measurement of the level of agreement beyond chance between the physical examination and the angiography.

Results: There was good agreement between physical examination and angiography in the diagnosis of outflow stenosis (k value = 0.74). The sensitivity, specificity, positive and negative predicted values of the 2 maneuvers used in physical examination (augmentation, collapsibility of the fistula) were 94.3%, 79.1%, 86.4%, 90.3% and 93.3%, 79.5%, 88.5%, and 87.5%, respectively.

Conclusion: This study confirmed that physical examination of hemodialysis AVF can accurately diagnose outflow stenoses in mature fistula and correlated well with angiographic findings.

Keywords: AVF (arteriovenous fistula), angiography, augmentation of the AVF, collapsibility of the AVF, interventional nephrologist, stenosis of the outflow tract of the fistula.

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I. Background and Objectives

Physical examination of the hemodialysis arterial-venous fistula (AVF) is convenient and inexpensive, and can often detect common problems associated with hemodialysis access (1-5).

Routine physical examination of the fistula by the dialysis staff with each treatment may allow early detection of problems that are commonly associated with mature fistula, thus avoiding missed treatments and emergent situations. Dialysis access stenosis is the most common cause of access dysfunction. Therefore, physical examination is an important method in the assessment of stenotic lesion (1,6-9).

The 2006 National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF-K/ DOQI) guidelines recommend that physical examination (monitoring) be performed on all mature AVFs on a weekly basis (10,11). Such monitoring is also recommended by the 2008 Society for Vascular Surgery practice guidelines (12). We strongly agree that hemodialysis AVF should be examined at every hemodialysis treatment. This requires that all clinical staff who are directly involved in the care of hemodialysis patients be familiar with the basic techniques used to examine the fistula.

The purpose of this study is to evaluate the two simple maneuvers in physical examination of the AVF (pulse augmentation and pressure assessment inside the fistula and collapsibility of the fistula on arm elevation) compared to the gold standard (angiography).

II. Subjects and Methods

A total of 118 patients dialyzed via a mature AVF were included. The patients were referred to the dialysis access center of Pittsburgh because of dysfunctional AVF. There were 27 right arm fistulas (3 radial-cephalic and 24 upper arms AVF), and 91 left arms AVF (15 radial-cephalic AVF, and 76 upper arms AVF), Table-1. The age range of the patients is 22 yrs to 92 yrs, with a mean of 63.2 yrs. 55% of the patients were males and 53% were diabetics. 91% of patients were hypertensive, and 4.3% have peripheral arterial disease.

Clinical examination of the dialysis AVF includes;

1. Pulse augmentation and pressure assessment in the fistula is graded into 1,2
2. Good augmentation of the pulse pressure and AVF is soft by palpation.
3. No augmentation and high pulse pressure in the AVF
4. Collapsibility of the fistula on arm elevation is also graded to;
5. The AVF is completely collapsed on arm elevation
6. The AVF is hyperpulsatile and not collapsed on arm elevation.

Pulse augmentation is assessed by complete occlusion of the access several centimeters away from the arterial anastomosis and evaluation of the stenght of the pulse as well as palpating the fistula without obstructing the outflow tract and assesses the pressure inside the fistula. The fistula is considered normal when there is good augmentation of the pulse upstream from the occluded finger (7). The pulse pressure as assessed by palpation is not increased in this case.

Collapsibility of the AVF is assessed by elevating the arm of the fistula above the heart and examination of the normal collapsing of the fistula. These two simple maneuvers are correlated with the angiogram findings of the AVF (7). The test was considered abnormal when the fistula remained pump after arm elevation. Then angiography is used to assess the fistula. Both retrograde and antegrade angiography were done to evaluate the access from the feeding artery to the right atrium (C-arm 9900 vascular package; General Electric, Milwaukee WI).

Two interventional nephrologists (IN) were involved, separately, in physical examination and angiographic examination and interpretation. To offset the bias, the IN who is carrying out the angiographic studies does not know about the results of the physical examination. The findings of the physical examination and angiography were then analyzed at the end of the study.

a) Statistical Analyses

Chi-square with Fisher's exact test for the two-tailed p value was used to analysis the dichotomous data from the physical examination and angiographic findings. A p value of $<.05$ was considered as significant. The Cohen's k value was used to measure the level of agreement beyond chance between the diagnoses made by physical examination and angiography (13,14,15). It is a robust statistic tool useful for either interrater or intrarater reliability testing. It can range from -1 to +1, where 0 represents the amount of agreement that can be expected from random chance, and 1 represents perfect agreement between the raters. Kappa value of <0 as indicating no agreement and 0.01-0.20 as none to slight, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial, and 0.81-1.00 as most perfect agreement. The kappa was designed to take account of the possibility of guessing.

III. Results

In this study only the outflow stenosis was assessed and compared to the finding on angiography. 74 patients were found to have significant out flow stenoses by angiography (>50% stenosis). Physical examination using collapsibility of the AVF detected 69/74 stenoses (93.3%), and augmentation and pulse pressure assessment detected 66/70 patients (94.3%), (Tables -2, 3). The specificity of the augmentation and collapsibility were 79.1% and 79.5%, respectively. Collapsing of the fistula missed 5 patients who had side branches to divert blood away from the main fistula.

Analysis of forearm and upper arm fistulas revealed no significant difference in the diagnostic accuracy of these two physical examination maneuvers in detecting stenosis. Sensitivity and specificity of forearm and upper arm fistula were identical. Therefore, no breakdown of the results by fistula type was done.

The sensitivity, specificity, positive and negative predictive value of the 2 maneuvers was calculated and is shown in Tables-2, 3.

The overall sensitivity of the augmentation and pulse pressure palpation when compared to angiography is 94.3%, with specificity of 79.1%, positive predictive value of the test of 86.4%, and negative predictive value of 90.3%, Table-2. The p value of the two-tailed fisher's test was highly significant <0.0001. There was a good agreement beyond chance between the physical examination and the angiography in the diagnosis of outflow stenosis (Cohen's k value for agreement $k=0.749$).

When collapsibility of the fistula is compared with angiography, the overall sensitivity of the maneuver is 93.3%, with specificity of 79.5%, positive and negative predictive values of 88.5% and 87.5% respectively, Table-3. The p value of the two-tailed fisher's test was highly significant <0.0001. There was a good agreement beyond chance between the physical examination and the angiography in the diagnosis of outflow stenosis (Cohen's k value for agreement $k=0.742$).

IV. Discussion

Physical examination is a good and convenient tool in the assessment of vascular access dysfunction. A few reports have studied and evaluated its usefulness in the detection of access stenosis when compared to the gold standard, angiography, (9,15). The results of this study agreed with the work of Choi et al (8), and Mishler et al (16). These investigators found that physical examination reliably diagnosed significant outflow stenosis of the AVF when compared to angiography. While, these workers showed the strength

of physical examination, their work was limited by co-founders; like study design, the sample size, lack of independent assessment of the angiographic images, and bias, since the same physician who performed the physical examination read the angiography images. Also, they did not report on the sensitivity, specificity of the physical examination, nor the agreement between the physical examination and angiography.

Both this study and that of Asif et al, avoided all these cofounders (8). Our study and that of Asif have clearly shown that physical examination has high sensitivity, specificity, and can be a useful tool for detecting stenosis in the dialysis access. We used Cohen's k values to ascertain the agreement between the physical examination and angiography. We found a robust correlation between physical examination and angiographic findings.

We undoubtedly, demonstrated high sensitivity and specificity (93 to 94% and 79%, respectively) of the physical examination to detect significant outflow stenosis in the dialysis access (AVF). The high sensitivity and specificity make physical examination a valuable tool to screen for the presence of out flow stenosis in mature AVF. This makes physical examination a valuable tool for streamline patients with dysfunctional fistula to vascular access center by the staff in a timely manner. Because physical examination of the vascular access is inexpensive and available, it should be adopted, universally, by all staff members who care for hemodialysis patient.

Performing physical examination during angioplasty of the stenosis can assist in the success of balloon angioplasty. It can also help the interventionalist as to the site of cannulation, thus, potentially save time, minimize morbidity, and reduce cost.

The limitations of this study are that physical examinations are carried out by well versed interventionalist who has long experience on vascular access evaluation. This may not be applied for the general nephrologists who often see the patients on the dialysis machine. The study also investigated only outflow obstruction in mature fistula as related to physical examination. Since the study has a small sample size, and was carried out in one facility may limit its applicability to all other dialysis facilities.

V. Conclusion

Dialysis access stenosis is the most common cause of access dysfunction. Physical examination of the hemodialysis vascular access is inexpensive and valuable tool in the diagnosis and localization of stenosis. Referring patients with dysfunctional access can avoid missed treatments, emergent situations, and can impact cost and inconvenience.

Table 1 : Location of arterial-venous fistulas

	RCAVF	Upper arm AVF
Right arm	3	24
Left arm	15	76

RCAVF- radial-cephalic arterial-venous fistula

Table 2 : Augmentation of fistula and pulse pressure Vs Angiography

	Angiography positive	Angiography negative	
No Augmentation & high pressure	66	10	PPV = 86.4%
Good augmentation & fistula soft	4	38	NPV = 90.3%
	Sensitivity = 94.3%	Specificity = 79.1%	Prevalence = 59.3%

PPV = Positive predictive value
NPV = Negative predicative value
Two-tailed Fisher's exact test (p value <0.0001)
(Cohen's k value for agreement k=0.749).

Table 3 : Collapsibility of AVF Vs Angiography

	Angiography positive	Angiography negative	
AVF not collapsible	69	9	PPV = 88.5%
AVF collapsible	5	35	NPV = 87.5%
	Sensitivity = 93.3%	Specificity = 79.5%	Prevalence = 62.7%

PPV = Positive predictive value
NPV = Negative predictive value
Two-tailed Fisher's exact test (p value <0.0001)
(Cohen's k value for agreement k=0.742).

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