Original Article

Evaluation of Diagnostic Values of Clinical Assessment in Determining the Maturation of Arteriovenous Fistulas for Satisfactory Hemodialysis

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Abstract

Background: Fistulas are the preferred permanent hemodialysis vascular access, but a significant obstacle to increasing their prevalence is the fistula's high "failure to mature" (FTM) rate. This study aimed to identify postoperative clinical characteristics that are predictive of fistula FTM. **Materials and Methods:** This descriptive cross-sectional study was performed on 80 end-stage renal disease patients who referred to Al Zahra Hospital, Isfahan, for brachiocephalic fistula placement. After 4 weeks, the clinical criteria (trill, firmness, vein length, and venous engorgement) examined and the fistulas situation divided to favorable or unfavorable by each criterion, and the results comprised with dialysis possibility. Data were analyzed with SPSS version 21. Diagnostic index for CLINICAL examination was calculated. **Results:** Among the 80 cases, 25 (31.2%) female and 55 (68.8%) male were studied with the mean age of 51.9 (standard deviation = 17) year ranged between 18 and 86 years old. Sixty-two (77.5%) cases had successful hemodialysis. All four clinical assessments were significantly more acceptable in patients with successful dialysis ($P < 0.001$). According to the results of our study, the accuracy of all physical assessments was above 70% and except vein length other criteria had a sensitivity and negative predictive value of 100%. In this study, firmness of vein has highest specificity and positive predictive value (83.9% and 64.3%, respectively). **Conclusion:** Results of our study showed that high sensitivity and relatively low specificity of the clinical criterion. It means that unfavorable results of each clinical criterion predict unfavorable dialysis. Clinical evaluation of a newly created fistula 4–6 weeks after surgery should be considered mandatory.

Keywords: *Arteriovenous fistulas, clinical examination, hemodialysis, maturation*

Introduction

The incidence of end-stage renal disease (ESRD) has been increased 43% based on age, gender, and race around the world since 1991.[1] The patient physical state and other factors determine choice treatment. Although, the creation of vascular access is a necessary maneuver for hemodialysis, creation and maintenance of a well-functioning vascular access are remained the most challenging problems for hemodialysis.[2] The first access method was Brescia-Cimino fistula which was introduced in 1966. In the 1st years, only young and healthy patients were candidates for AVF creation.[3] Nowadays, the creation of arteriovenous fistula (AVF) is feasible in most cases including diabetics and old patients. In patients undergoing hemodialysis Autogenous AVFs are considered as the most reliable long-term vascular access that compared with prosthetic arteriovenous grafts and tunneled catheters, require fewer interventions, are less susceptible to failure due to infection and thrombosis, and have been shown to improve patient survival. Although, thrombosis and/or lack of maturation are the reasons of primary failure,[4] but the risk factor for primary failures is not limited to these like the site and diameter of vessels are thought to fulfill an important trole.[5] A recent meta-analysis has demonstrated 15.3% primary failure rate for native AVF.[6,7] Fistula maturation depends on several changes involving the vein such as increased blood flow, increased vein diameter, and increased visibility of the vein. Traditionally, one-quarter to one-third of all autogenous hemodialysis AVF created never mature.[8,9] Nephrologists and surgeons often wait for up to 6 months and even longer with the hope of AVF will eventually grow to support dialysis before declaring that the AVF has failed. In the

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interim, if dialysis is needed, then a tunneled catheter is inserted, exposing the patient to the morbidity and mortality associated with the use of this device. In general, a blood flow of 500 ml/min and a diameter of at least 4 mm are needed for an AVF to be adequate to support dialysis therapy. In most successful fistulae, these parameters are met within 4–6 weeks.[10-14] Most important, commonly encountered problems (stenosis and accessory veins) that result in early AVF failure can be diagnosed easily with the skillful physical examination. Recent studies have indicated that a great majority of fistulae that have failed to mature adequately can be salvaged by percutaneous interventions and become available for dialysis. Early intervention regarding identification and salvage of a nonmaturing AVF is critical for several reasons. First, an AVF is the best available type of access regarding complications, costs, morbidity, and mortality. Second, this approach minimizes catheter use and its associated complications. Finally, access stenosis is a progressive process and eventually culminates in complete occlusion, leading to access thrombosis.[14-16]

Fistulas are the preferred permanent hemodialysis vascular access, but a significant obstacle to increasing their prevalence is the fistula's high "failure to mature" (FTM) rate. This study aimed to (1) identify postoperative clinical characteristics that are predictive of fistula FTM and (2) use these predictive factors to develop and validate a scoring system to stratify the patient's risk for FTM.

Materials and Methods

Study design

This study is a descriptive-analytic single-center prospective study based on referral patients to vascular surgery clinic of a university hospital, who underwent primary AVF creation.

Patient's selection

All patients with ESRD requiring hemodialysis and candidate for creating AVFs who referred to Al Zahra Hospital (affiliated to Isfahan University of Medical Sciences) between 2011 and 2013 enrolled to this cross-sectional study. This study performed on patients with side to end brachiocephalic AVF. Patient with distal or brachiobasilic fistula, side-to-side anastomosis, very obese patients (body mass index >35) and patients under 14 years old excluded from our study. This study was approved by the ethics committee of our institution, and each patient who participated provided informed, written consent.

Methods

Demographic and clinical data were collected for all patients including: Age, sex, etc. In addition, 6 weeks after fistula placement the clinical criteria of maturation including: Thrill, firmness, vein length, and venous engorgement examined and recorded. The AVFs situation divided to favorable or unfavorable by each criterion, and the results comprised with dialysis possibility.

All examinations were performed by a single blind general surgery resident before hemodialysis.

On the same day, all patients were referred for hemodialysis in the dialysis unit. In patients with a minimum of 4 h with 300 ml/min flow were undergoing hemodialysis,[17] hemodialysis was deemed satisfactory. Patients based on whether they have been satisfactory hemodialysis or not divided into two groups, and scores were compared between the two groups.

Physical assessment

Palpation is the key assessment process to determine access development. The thrill should feel like a vibration or purring that is soft and easy to compress.

With a loosely applied tourniquet (inflating the cuff blood pressure with a pressure approximately 5 mmHg above the diastolic pressure by cuff blood pressure) to the axilla area of the upper arm, document the baseline width of the fistula by either taking a photo, marking the fistula margins with an indelible pen or by measuring the width with a tape measure. If the access is arterializing appropriately, there will be a noticeable increase of the size of the vessel. Using your fingertips, palpate the entire length of the fistula. Not only should the vessel increase in size, it needs to thicken in order to withstand repeated needle punctures, increased pressure created by the arterial blood flow and eventually by the blood pump. Take a minute and feel the vein in your wrist and see how soft and pliable an immature "fistula" is. A clinical sign that a patient's fistula wall is thickening is when you compress and release the fistula, and the vein wall rebounds under your fingers with a springy, firm feel.

In our study, the score for clinical evaluation to determine AVF maturation was defined: Vein length visible during light tourniquet pressure: Up to 6 cm and more than 6 cm. Vein stiffness and hardness (firmness) with light tourniquet pressure: Feel firm or not.

Vein expansion (engorgement): Dilated and engorged without tourniquet pressure or not engorged with tourniquet pressure. Thrill palpable on fistula and the vein: Machinery thrill on fistula or vein as a desirable or systolic thrill as undesirable criteria.

Statistical analysis

Data were analyzed with SPSS version 21 (233 South Wacker Drive, 11th Floor, Chicago, IL 60606-6412.). All data are expressed as mean ± standard deviation (SD). The distribution of nominal variables was compared using the Chi-squared test. In order to compare the mean values of quantitative variables the independent *t*-test. Furthermore, diagnostic indices including sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV), and accuracy of physical assessment in determining the maturity of new AVF for satisfactory hemodialysis were calculated.

A two-sided $P < 0.05$ was considered to be statistically significant.

Results

Among the 80 cases, 25 (31.2%) female and 55 (68.8%) male were studied with the mean age of 51.9 (SD = 17) year ranged between 18 and 86 years old. Sixty-two (77.5%) cases had successful hemodialysis. Independent *t*-test analysis demonstrated that the mean age difference was not statistically significant in patient with successful and unsuccessful dialysis ($P = 0.852$). Evaluating gender status qualitatively with Chi-square analysis, it showed that the gender difference was not statistically significant in patient with successful and unsuccessful dialysis ($P = 0.348$).

Vein visible length during light tourniquet pressure was more than 6 cm in 43 (53.8%).

Vein feel firm with light tourniquet pressure, vein engorgement, and machinery thrill palpable on fistula was in 52 (65%), 43 (53.8) and 51 (63.8) respectively. Qualitative evaluation of clinical assessment status in two groups of study (successful and unsuccessful dialysis) is illustrated in Table 1. As it is shown, all four clinical assessments were significantly more suitable in patients with successful dialysis ($P < 0.001$).

A sensitivity of 88.9%, specificity of 66.1%, accuracy of 71.25%, PPV of 43.2%, and NPV of 95.3% were found in determining satisfactory dialysis for vein length visible during light tourniquet pressure. It means that if vein visible length during light tourniquet pressure was less than 6 cm hemodialysis was not successful in 88.9% of cases and we can rely on negative result of our test (vein visible length during light tourniquet pressure was less than 6 cm) in 95.3% to cases. On the other hand, if vein visible length during light tourniquet pressure was more than 6 cm, hemodialysis was successful in 66.1% of cases and we can rely on positive result of our test (vein visible length during light tourniquet pressure was more than 6 cm) in 43.2% to cases. Overall the results of vein visible length have 71.25% accuracy in determining dialysis status.

Diagnostic values of all clinical examination are summarized in Table 2.

Table 1: Clinical assessment status in two groups of study (successful and unsuccessful dialysis)

Dialysis status	Successful (%)	Unsuccessful (%)	Total (%)	*P*
Length (cm)				
<6	16 (88/9)	21 (33/9)	37 (46/3)	0.001
≥6	2 (11/1)	41 (66/9)	43 (53/8)	
Firmness				
Firm	18 (100)	10 (16/1)	28 (35)	0.001
Not firm	0	52 (83/9)	52 (65)	
Engorgement				
Engorged	18 (100)	19 (30/6)	37 (46/3)	0.001
Not engorged	0	43 (69/4)	43 (53/8)	
Thrill				
Machinery thrill	18 (100)	11 (17/7)	29 (36/3)	0.001
Systolic thrill	0	51 (82/3)	51 (63/8)	

Table 2: Diagnostic values of clinical examination

Diagnostic value Clinical examination	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Firmness	100	83.9	64.3	100	87.5
Vein length	88.9	66.1	43.2	95.3	71.25
Engorgement	100	69.4	48.6	100	76.25
Thrill	100	82.3	62	100	86.25

PPV: Positive predictive value, NPV: Negative predictive value

Discussion

According to the results of our study, the accuracy of all physical assessment was above 70% and except vein length other criteria had sensitivity and NPV of 100%. Which means that hemodialysis is low probability of success in the case of the four clinical assessment were undesirable, in other words, maturation of AV fistula for successful hemodialysis was diagnosed by physical examination and if clinical assessment was not desirable the practical success of dialysis and maturation of fistula is low.

These results manifest that clinical examination is a useful and noninvasive method in determining the maturation of AVFs for suitable hemodialysis. In this study firmness of vein has highest specificity and PPV (83.9% and 64.3%, respectively).

Specificity and PPV indicate that desirable clinical examination (even desirable for all the clinical criteria) cannot be completely sure about the success of the hemodialysis. Results of this study showed that among four criteria firmness with an accuracy of 87.5% had greatest accuracy and followed by trill, engorgement, and vein length respectively.

To date, to the best of our knowledge, our study is one of the first to evaluate postoperative clinical assessment in determining the maturation of AVFs for suitable hemodialysis.[18]

In another recent study, Wayne *et al.*[19] showed a significant association of the absence of peripheral vascular disease, aspirin use, and absence of previous permanent dialysis access with higher primary patency rates. They concluded that higher blood pressure during the maturation period relative to preoperative blood pressure was associated with lower patency rates. In a similar study, the clinical predictors that were associated with FTM were aged ≥65 years, peripheral vascular disease, coronary artery disease, and white race.[20]

In 2008, Berman *et al*.[21] observed during the 12-month period in 70 autologous AVFs intraoperative blood flow measurements at the time of autologous AVF construction can identify fistulas that are unlikely to mature; and therefore, that require immediate revision or abandonment which will ultimately expedite the establishment of a useful access in the HD patient.

Feldman *et al*.[22] found maturation was associated with greater intraoperative doses of heparin, use of large-diameter veins, and mean arterial pressure of 85 mm Hg or greater. Using the optimal surgical technique, the probability of successful AVF maturation would have been as high as 84%.

In a study conducted by Patel *et al*.,[11] preoperative duplex ultrasonography scanning was performed in 68% of patients and venography in 32% of patients. Autogenous fistula creation rate increased from 61% to 73% in all patients with hemodialysis access. Functional maturation rate decreased from 73% to 57% after implementation of preoperative imaging and more aggressive vein use.

They concluded the implementation of preoperative duplex US scanning and venography as a component of a more aggressive protocol to create native fistulas was pivotal in exceeding Dialysis Outcome Quality Initiative (DOQI) guidelines for hemodialysis access.

Recently, in one study pattern of blood flow was evaluated as a predictor of maturation of AVF for hemodialysis. Doppler ultrasound was used immediately postoperatively and at follow-up (6 weeks). They concluded spiral laminar flow was strongly supportive of successful fistula maturation. A "thrill" was characteristic of spiral rather than turbulence.[23]

In obese subjects, for example, even veins that are well developed can be difficult to visualize or palpate because of their depth; in these cases, duplex ultrasonography (DUS) can reveal whether the fistula is mature, and US mapping of the outflow veins can facilitate the first cannulation and simplify subsequent punctures.[24] In this regard, it is important to recall the proposal of Rayner *et al*.,[25] which was incorporated in the K-DOQI guidelines[26] as "the rule of 6." It identifies the ultrasound characteristics that confirm that a fistula is mature and therefore, ready for use: A flow volume of 600 ml/min, an outflow vein diameter of 6 mm, and an outflow vein depth of 6 mm below the skin surface. Clearly show that maturation should be sonographically monitored until the fistula is used, especially when maturation seems to be proceeding slowly and in patients whose veins cannot be easily assessed with physical examination alone (e.g., due to obesity). DUS measurement of AVF flow volumes is perhaps the only imaging tool that can be used to monitor the fistula even during its maturation.[27,28]

As mentioned above, various studies about different factors affecting and predicting AVFs maturation have been done, while our approach was identifying postoperative noninvasive clinical characteristics that are predictive of fistula FTM. Also in many centers, Doppler ultrasound and expert operator were not accessible.

This is the first study to establish the clinical examination needed for determining AVFs maturation to a functional access. Results of our study showed that the high sensitivity and relatively low specificity of clinical criteria mean that unfavorable results of each clinical criterion predict unfavorable dialysis. Evaluation of a newly created fistula 4–6 weeks after surgery should be considered mandatory. If the fistula is going to become adequate for dialysis, it will be apparent at this time. This evaluation can be accomplished by physical examination. However, it must be performed by someone who is knowledgeable. Using a systematic approach facilitates the evaluation and ensures that a problem is not overlooked. Once it is determined that the fistula is dysfunctional, the case should be immediately referred for management to an interventionalist who is experienced in dealing with early fistula failure. The majority of these cases can be salvaged.

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Conflicts of interest

There are no conflicts of interest.

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