Determination of reliability of some tests in evaluating AV fistula flow rate in hemodialysis patients:

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Introduction and aim:

Vascular access blood flow is the best modality to monitor function of arteriovenous fistula (AVF). Vascular access blood flow can be quantified using various techniques. Techniques directly quantifying vascular access flow rate are Doppler ultrasound and Magnetic Resonance angiography, while indirect quantification is made dilution techniques, which include ultrasound dilution technique, Crit-Line III, Crit Line III direct transcutaneous technique, glucose pump infusion technique, urea dilution technique, differential conductivity and in-line dialysance method.

Our aim is to compare glucose pump infusion test with Doppler ultrasound with respect to quantifying vascular access blood flow of patients with arteriovenous fistula who undergo dialysis and to determine reliability of the test and ultimately to assess the method in conjunction with static pressure measurements.

Materials and methods:

Ninety three patients were enrolled who undergo hemodialysis due to arteriovenous fistula in 3 different dialysis centers. Mean age of patients was 50.8±17.1 years. Demographic data of patients was obtained from medical files.

Location of fistula was determined. Physical examination was made and arterial blood pressure (TA) and mean arterial pressure (MAP) were estimated using conventional formulas below:

MAP: Diastolic blood pressure + (pulse pressure/3),

Pulse pressure: Systolic blood pressure – diastolic blood pressure

Counter-streamwise arterial catheterization and streamwise venous catheterization were performed by experienced nurses of dialysis center. The distance between two lines (arterial and venous) was minimum 10 cm. An infusion map was used (Plussep 12 S, infusion rate of 16 ml per minute, ability to fit 50 ml syringe). Syringe was filled with 10% glucose solution and infusion rate was adjusted to 16 ml per minute. Totally, 2.93 ml of 10% glucose solution was infused via arterial line at 11 seconds. However, a blood sample (0.2 ml) was drawn from arterial line immediately before infusion and glucose level was measured in all patients using same glucometer (Accu-check) and glucose measurement strips. Infusion of 10% glucose solution was started and a blood sample was drawn from venous line after 11 seconds. Totally, 8 ml of blood sample was aspirated, including 2 cc of air in the syringe, at 2 seconds and glucose level was measured (5).

Based on the glycemic values, flow rate of fistula was calculated with the equation below;

$Qa=Qi\ (Ci-C2)/(C2-C1)$.

Where, Qa is the flow rate of fistula (ml/min), Qi is infusion rate (ml/min), Ci is concentration of glucose infused (mg/dl), C1 is pre-infusion glycemic value (mg/dl) and C2 is post-infusion glycemic value (mg/dl).

Fistula flow was assessed with Doppler ultrasound at the day between two dialysis sessions and later, mean of three GPTs was calculated.

Static pressure measurement was performed in one of hemodialysis session where GPT was performed. Therefore, pressure sensors of hemodialysis device were set after arterial and venous catheters were placed and hemodialysis was started (0±5 mmHg). TA was measured from non-vascular access arm.

Blood pump and ultrafiltration were discontinued in order to measure vascular access arterial and venous pressures; proximal end of venous drip chamber was clamped. Arterial line was not clamped since the roller pump of arterial drip chamber functions as clamp. Approximately thirty seconds elapsed until venous pressure stabilized. Intra-access pressure (IAP) of vascular line was read by dialysis device and the value was recorded; the height from non-access arm to venous and arterial drip chambers was measured using same measuring tape. Clamp was released on venous line and hemodialysis was resumed. Arterial and venous rates were calculated for evaluating function of vascular access, as recommmended by the guideline (NKF K/DOQI Guidelines 2006 Updates):

Arterial rate: (intra-access pressure of arterial line + height measured from non-access arm to drip chamber)/ MAP

Venous rate: (intra-access pressure of venous line + height measured from non-access arm to drip chamber)/ MAP.

Data was entered to SPSS 13.0 software pack. Results were expressed as mean, mean ± standard deviation and percent (%). Data was analyzed whether data was compatible with normal distribution. Data with normal distribution was analyzed with Student's t test. Data without normal distribution was analyzed with Mann-Whitney U test. Chi-square test was used for comparing categorical variables. Inter-data relations were examined with Pearson's correlation analysis. Confidence interval (CI), odds ratio, sensitivity and specificity were estimated. A p value <0.05 was considered significant.

Results:

Of all patients, 45 were male and 48 were female. Mean age was 50.8±17.1. Hemodialysis period was 50.1± 49 months. Vascular access site was brachial region in 70.3% of patients and radial region in 29.7 percent. Fistula was associated with aneurysm in 36.6% of patients. Kt/V was above 1.2 in 87.1 percent of all patients.

Paired t test was used in repeated measurements to determine internal consistency of GPT since GPT was measured for three times. No difference was observed, or in other words, GPT measurement had internal consistency (p> 0,05).

Vascular access blood flow rates were compared between Doppler Ultrasound and GPT modalities. Mean flow rate was 809.8±444.3 ml/min with Ultrasound, while corresponding figure was 826.2±435.2 ml/min with GPT. There was no statistically significant difference between two mean values (p> 0.05, t: - 0,257). Mean flow rates are given in Table 1.

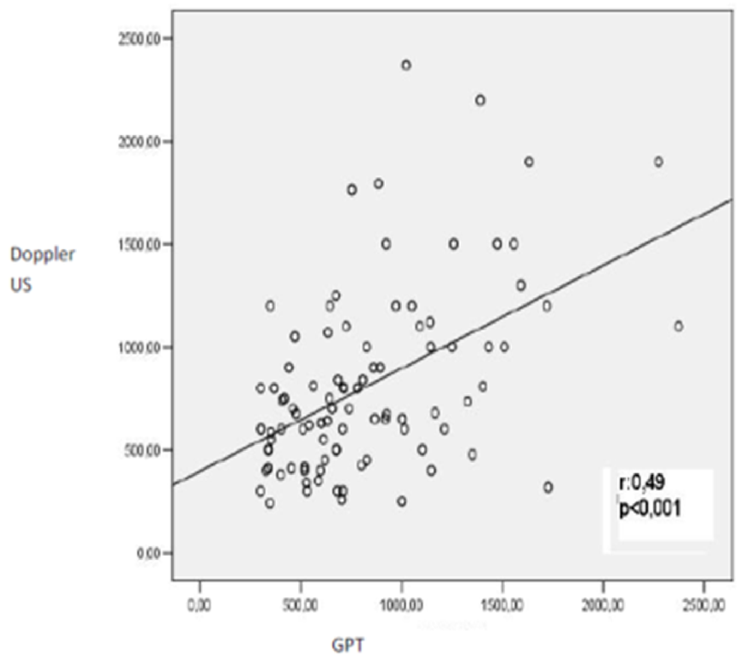
Table 1: Mean vascular flow rates measured with Doppler ultrasound and GPT:

	Mean flow rate (ml/min)	Standard deviation
Doppler Ultrasound	809.8	444.3
GPT	826.2	435.2

Confidence interval (CI) of GPT was 0.80- 4.45. Odds ratio was 1.89. Positive predictive valu was 69%, while negative predictive value was 45 percent

Correlation graphic of mean flow rates measured with GPT and Doppler ultrasound was plotted. There was significantly positive correlation between two methods (r: 0,49; p value <0,001). Correlation graphic is given in Figure 1:

Figure 1: Correlation graphic of mean of GPT measurements and Doppler ultrasound:



With the assumption that normal range of AV fistula flow rate is 400-1000 ml/min, sensitivity and specificity of glucose pump infusion technique were calculated. Sensitivity and specificity were 62% and 53 %, respectively. This finding indicates that the test can be used.

Mean arterial and venous pressure rates of all patients were calculated. In the light of the calculation, arterial rate was 0.66± 0.54, while venous rate was 0.74± 0.58. When the data is assessed in the light of NKF DOQI Guideline, stenosis should be considered in a substantial part of patients (78%); however, physicial examination and Doppler ultrasound did not indicate stenosis of AV fistula in any patient. Kt/V was within normal ranges in most patients and this fact makes us consider that pressure value is not sensitive enough to determine stenosis.

The relation of arterial and venous pressure with mean access flow rates measured with GPT and Doppler Ultrasound was examined. It was observed that the correlation was poor between arterial rate and access blood flow. The relation is shown in Figures 2 and 3. The relation between Doppler ultrasound flow rate measurements and arterial pressure rates was insignificant (p: 0.5, r: 0.07)

The relation between flow rate measured with GPT and arterial pressure rates was insignificant (p: 0.2, r: 0.11 **)**

The relation between static pressure calculated using venous pressure rates and vascular access blood flow rates, which were measured with GPT or Doppler ultrasound, was investigated. No significant correlation was found between venous pressure and vascular access blood flow.

The relation between blood flow rate, which was measured with Doppler Ultrasound, and venous pressure rates was insignificant (p: 0.07, r: 0.18).

Venous pressure rate

The relation between blood flow rate, which was measured with GPT, and venous pressure rates was insignificant (p: 0.42, r: 0.08). According to NKF-DOQI guideline, patients with arterial and venous pressure rates indicating >50% stenosis were divided into 3 groups including patients with arterial flow, intra-vascular access and venous access stenoses. Stenosis was present in 73 of 93 patients as indicated by pressure measurements. Nevertheless, physical examination and Doppler ultrasound did not indicate stenosis in any patient; Kt/V was within normal ranges. There were 13 patients with arterial flow stenosis, 43 patients with interior stenosis of vascular access and 18 patients with venous access stenosis. Vascular access blood flow rates were calculated in those 3 groups of patients. With GPT, mean flow rate was 680 ml/min in patients with arterial flow stenosis, 912.8 ml/min in patients with interior stenosis of vascular access and 690.6 ml/min in patients with venous access stenosis. With Doppler ultrasound, mean flow rate was 716.3 ml/min in patients with arterial flow stenosis, 885.8 ml/min in patients with interior stenosis of vascular access and 608.6 ml/min in patients with venous access stenosis. Flow rate was higher in patients with arterial flow stenosis in comparison with the patients with interior stenosis of vascular access and venous access stenosis. However, the difference was not statistically significant (p>0.05).

Conclusion:

It is concluded that a cheap, easy and non-operator dependent glucose pump infusion technique can be used in stead of AV fistula flow rate measurement for monitoring function of AV fistula in patients who are undergoing hemodialysis, but static pressure rates cannot be successfully used for monitoring function of AV fistula [1 2 3 4]

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