SEARCHING FOR THE IDEAL TEST IN DETECTING ARTERIOVENOUS FISTULA STENOSIS : A PILOT STUDY.

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Current guidelines recommend the systematic monitoring and surveillance program of both fistulae (AVFs) and graft for hemodinamically significant stenosis because, combined with prompt referral for access imaging and correction of the stenosis, it may reduce the incidence of thrombosis and improve patency rates [1,2]. Several methods have been proposed as “preferred or acceptable” in AVFs, including measuring access blood flow (Qa), clinical examination (monitoring), Duplex Ultrasound (DU), access recirculation (R) and static dialysis pressure measurements, direct or derived [1]. Unfortunately, very few studies have compared the diagnostic accuracy of the different techniques in detecting stenosis in AVFs [3,4] and none have comprehensively evaluated all the options. The authors of the guidelines consequently believe there is insufficient evidence to recommend one technique rather than another [1] and suggest that each dialysis unit establish its own program [2].

To identify the optimal AVF monitoring/surveillance program for our units, we conducted a pilot study on hemodialysis patients (pts) with native AVFs to compare the utility of several techniques in diagnosing angiographycally-proven significant (>50 %) stenosis - including clinical examination, dynamic and derived static dialysis venous pressures, dialysis negative arterial pre-pump pressure (NAP), R and Qa measurements - and also to identify the most suitable thresholds for continuous variables.

Patients and Methods

This study was performed in a randomly selected population of 54 (of 147) pts with native mature AVFs attending the two hemodialysis units in Verona between May 2006 and February 2007.

The arteriovenous anastomosis was located in the distal third of the forearm for 20 AVFs, between the radial artery and the cephalic vein, and these were identified as distal AVFs (dAVF). In the remaining 34 AVFs the anastomosis was constructed in the midforearm (16 radiocephalic AVFs) or elbow region (6 radio-cephalic, 9 brachiocephalic, 3 brachiobasilic with vein transposition) and these accesses were identified as proximal AVFs (pAVF). All AVFs were cannulated with 15-G needles.

Study design. All AVFs were tested as follows: 1) clinical examination, to seek any physical signs of inflow stenosis (inability to achieve the prescribed dialysis blood pump flow rate (Qb), abnormal thrill, pulse or bruit characteristics in the anastomotic area) or outflow stenosis (arm swelling, no partial vein collapse with arm elevation, prolonged post-dialysis bleeding, abnormal thrill, pulse or bruit in the outflow region); 2) dynamic venous pressure measurement at Qb 200 ml/min in the first 5 minutes of dialysis (VP_{200}); 3) derived static venous pressure measurement according to Frinak et al [5] (VAPR); 4) NAP measured at Qb 400 ml/min and expressed as the Qb/NAP ratio; 5) ultrasound dilution (UD) R measurement and 6) UD Qa measurement, as described elsewhere [3]. Biplanar fistulography was performed in all AVFs as previously described [3], to detect any significant stenosis (> 50% reduction in the vessel diameter compared with the adjacent segment). Stenosis was defined as inflow stenosis (ST_{in}) when located upstream from the arterial needle, or outflow stenosis (ST_{out}) when located downstream from the venous needle. Stenoses between needles were included in the ST_{in} group.

Statistical Analyses. Data are reported as percentage, mean $\pm$ sd or se. Receiver operating characteristics (ROC) curve analysis was used to identify optimal test and threshold values for predicting stenosis, plotting the sensitivity (SE) *vs* specificity (SP) of the predictor being tested. SE indicates the percentage of stenotic AVFs with a positive test result, and SP the percentage of non-stenotic AVFs with a negative test result. Diagnostic accuracy is defined as the percentage of AVFs for which the test results and diagnoses coincide and computed as (SE + SP) / 2. Significance is set at a 2-sided $p < 0.05$.

Results

Patient and AVF characteristics are reported in Table 1.

Table 1

	STENOSIS	No STENOSIS	*p*
Number of AVFs	29	25	
Gender (male / female)	19 / 10	18 / 7	ns
Patients age (years)	66.8 $\pm$ 13.8	57.2 $\pm$ 15.9	0.026
Proportion of diabetes (%)	21 %	16 %	ns
AVF age (months)	38 $\pm$ 6	43 $\pm$ 9	ns
Anastomosis site (dAVF / pAVF)	9 / 20	11 / 14	ns

Stenosis was located upstream from the arterial needle in 20 AVFs (8 dAVFs and 12 pAVFs), downstream from the venous needle in 6 pAVFs, in both locations in 2 pAVFs and between the needles in 1 dAVF. The distribution of ST_{in} did not depend on anastomotic site (45 % in dAVF and 39 % in pAVF, *p* ns), while an ST_{out} was only documented in pAVF (23 % *vs* 0 % in dAVF, *p* 0.068).

Table 2 shows the results of the ROC curve analysis for ST_{in}, expressed as area under curve.

Table 2 : Area under curve (AUC) for ST_{in}

	Clinical examination	VP_{200}	VAPR	Qb/NAP	R	Qa
AUC $\pm$ se	0.71 $\pm$ 0.08	0.48 $\pm$ 0.09	0.58 $\pm$ 0.10	0.49 $\pm$ 0.10	0.44 $\pm$ 0.08	0.84 $\pm$ 0.06
p	0.015	ns	ns	ns	ns	< 0.001

The only tests with discriminative ability for ST_{in} were Qa and monitoring and no statistically significant difference was observed between the two.

Table 3 lists the optimal tests and thresholds for ST_{in} in order of diagnostic accuracy.

Table 3 : Accuracy, Sensitivity and Specificity values for ST_{in} of the different tests

	Qa < 900 ml/min	Clinical examination	R > 0	VAPR > 0.40	Qb/NAP < 2.50	VP_{200} > 80 mmHg
Accuracy	84 %	71 %	62 %	56 %	54 %	52 %
SE	87 %	62 %	43 %	47 %	83 %	41 %
SP	80 %	80 %	82 %	65 %	26 %	63 %

Table 4 shows the results of the ROC curve analysis for ST_{out}, expressed as AUC.

Table 4 : Area under curve (AUC) for ST_{out}

	Clinical examination	VP_{200}	VAPR	Qb/NAP	R	Qa
AUC $\pm$ se	0.79 $\pm$ 0.12	0.80 $\pm$ 0.09	0.93 $\pm$ 0.05	0.65 $\pm$ 0.13	0.61 $\pm$ 0.12	0.71 $\pm$ 0.09
p	0.028	0.015	< 0.001	ns	ns	ns

The only tests with discriminatory ability for ST_{out} were measurements of static and dynamic venous pressures and clinical examination, the diagnostic power of VAPR being significantly higher than the others (p <0.007).

Table 5 lists the optimal tests and thresholds for ST_{out} in order of diagnostic accuracy.

Table 5 : Accuracy, Sensitivity and Specificity values for ST_{out} of the different tests

	VAPR > 0.50	Positive monitoring	VP_{200} > 80 mmHg	Qa <1200 ml/min	Qb/NAP < 2.50	R > 0
Accuracy	88 %	79 %	74 %	70 %	64 %	61 %
SE	87 %	67 %	75 %	87 %	75 %	37 %
SP	89 %	92 %	74 %	53 %	53 %	85 %

Discussion

Our study confirms that stenosis is a highly prevalent complication in AVFs, located more often in the inflow region (23/54, equating to a prevalence of 42 %) and less often found in the outflow region (8/54, equating to a prevalence of 15 %) [1]. Inflow stenosis was evenly distributed among all types of AVFs, whereas outflow stenosis could only be found in the proximally located AVFs (with the arteriovenous anastomosis at or above the midforearm). This difference in location approached but did not reach statistical significance, however, probably because our study is underpowered.

The results of our study also confirm that many of the currently used monitoring/surveillance techniques (with the exception of recirculation and dialysis pre-pump arterial pressure monitoring after correction for Qb) have a discriminatory power for stenosis in AVFs, though the diagnostic performance of each test is strongly influenced by the location of the stenosis in the inflow or outflow region.

Qa measurement was the best predictor of inflow stenosis, the most accurate value being obtained for Qa < 900 ml/min and showing an excellent combination of sensitivity and specificity (87 % and 89 %, respectively). This threshold is higher than the one proposed by the K/DOQI guidelines for access imaging (Qa < 400-500 ml/min) [1], a difference probably due to the object of our study, which was to detect a significant stenosis rather than to identify fistulae at risk of incipient failure.

Clinical examination was the only other method with a discriminatory power for inflow stenosis showing a lower sensitivity than Qa (62 % *vs* 87 %) and comparable specificity, but the difference in accuracy between the two tests was not statistically significant.

Dialysis venous pressure measrement was the best predictor of outflow stenosis and we confirmed that measuring derived static venous pressure is more useful than dynamic venous pressure (p 0.007) [1]. The optimal VAPR threshold observed in our study was also similar to the one reported by others for grafts [5]. After VAPR, the next best tool for detecting stenosis was clinical examination, which showed a similar specificity (92 % *vs* 89 %) but was less sensitive (67 *vs* 87 %). The diagnostic accuracy of Qa measurement for ST_{out} neared, but failed to reach statistical significance (p 0.068).

In conclusion, despite its limitations (small sample-size, single-center), our pilot study suggests that the accuracy of currently-available surveillance techniques in detecting AVF stenosis depends largely on its location, Qa measurement being the most accurate tool for inflow and VAPR for outflow stenoses. We also found that clinical examination is the only tool with a good discriminatory power for stenosis irrespective of location, though a number of stenotic AVFs escape its notice. Another advantage of clinical examination, however, lies in its usefulness for all AVFs, including cases unsuitable for study using other surveillance techniques because of their anatomy. Finally, our results suggest that, in clinical practice, the choice of the surveillance procedure(s) should be tailored to the location of the arteriovenous anastomosis, Qa measurement and clinical examination being preferable for distal forearm AVFs and derived static venous pressure and clinical examination for more proximally located accesses.

References

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