Prospective follow-up of vascular access in hemodialysis by a multidisciplinary team

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SUMMARY

Porpuse: *Now a day the expert guide line recommend the monitoring programs of the vascular access (VA) by a multidisciplinary team.*

Material and method: *We present the experience over the last five years, of a prospective VA surveillance by a multidisciplinary team. The quality indicators reached are described as the associated factors for survival of the new VA.*

Results: *Three hundred seventeen VA have been studied, 73% were arteriovenous fistulas (AVF) and the rest were polytetrafluoroethylene (PTFE) grafts at 282 patients. The main causes of dysfunctions were elevated dynamic venous presion (42,5%) and the decreased blood flow (36.4%) with a 88% of positive predictive value. Over the 5 years there was 88 thrombosis (24 AVF and 64 PTFE grafts), that means a hazard thrombosis global rate of 0,15 access/year, which were distributed in 0.06 for AVF and 0,38 in PTFE grafts. Two hundred and one repair of the VA were done: 66.6% were elective repair after a proper review by the multidisciplinary team and the rest of them were done after the AV thrombosis happened. Urgent rescue surgery were done in 76% of the thrombosis. The 62,5% of the patients do not needed a catheter after vascular access thrombosis. The complication relation with AVF and PTFE were 11,4% of the total patientes hemodialysis hospitalizations.*

The 65,2% of the VA were new access. The 57% of patients were properly review in the pre-dialysis unit at least once and 80% of them start haemodialysis with a mature access. The average survival (Kaplan Meier) of the new AVF was 1,575 ± 55 days vs *1,087 ± 102 of the PTFE grafts ($p < 0.008$). The survival after 1, 2 and 3 years for the AVF was 89%, 85% and 83% and for the PTFE graft 3% 67% and 51% respectively. The Cox regression have proved that the type of vascular access is the strongest factor associated to VA survival. The survival added of VA repaired due to dysfunction was 1,062 ± 97 days* vs *707 ± 132 due to thrombosis, log rank 5,17 ($p < 0,02$). The increasing risk of those repaired after a thrombosis* vs *dysfunction is 4,2 $p < 0,01$.*

Conclusions: *The monitoring of the vascular access by a multidisciplinary team has reached: low rate of thrombosis, high elective number of repairs of the VA, high urgent rescue surgery after a thrombosis and a few number catheter needed and hospitalizations. The AVF are associated a greater survival that PTFE. The VA repair due to dysfunction vs thrombosis had a greater survival as well.*

Key words: ***Vascular access. Hemodialysis. Multidisciplinar team. Surveillance. Thrombosis. Survival.***

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SEGUIMIENTO PROSPECTIVO DEL ACCESO VASCULAR EN HEMODIÁLISIS MEDIANTE UN EQUIPO MULTIDISCIPLINAR

RESUMEN

Introducción: *Las guías de expertos recomiendan programas de monitorización del acceso vascular (AV) en hemodiálisis mediante equipos multidisciplinares.*

Material y métodos: *Presentamos la experiencia, de 5 años de seguimiento prospectivo del AV mediante un equipo multidisciplinar. Describimos los indicadores de calidad alcanzados y los factores asociados a supervivencia en AV incidentes.*

Resultados: *Se estudiaron 317 AV, 73% fístulas arteriovenosas autólogas (FAV) y el resto PTFE, en 282 pacientes. Se produjeron 88 trombosis: tasa de trombosis/acceso año de 0,06 para FAV y 0,38 en PTFE. El 66,6% de reparaciones del AV fueron electivas, realizándose cirugía urgente en el 76% de las trombosis. No precisaron catéter el 62,5% de los pacientes. Los ingresos relacionados con las complicaciones de FAV y PTFE fueron el 11,4% del total.*

El 80% de pacientes valorados previamente en la consulta de prediálisis comenzó hemodiálisis con un AV desarrollado. La supervivencia media de las FAV incidentes fue de 1.575 ± 55 días vs *1.087 ± 102 de los PTFE (p < 0,008). La supervivencia al año, 2 años y 3 años de las FAV fue del 89%, 85% y 83% y en los PTFE de 83, 67 y 51% respectivamente. La regresión de Cox demostró que el tipo de AV es el factor más importante asociado a supervivencia, OR 0,4 [0,2-0,8] para las FAV (p < 0,01). La supervivencia añadida de todos los AV incidentes reparados tras disfunción fue de 1.062 ± 97 días* vs *707 ± 132 en los reparados por trombosis; log rank 5,17, p < 0,02. El aumento de riesgo en los AV reparados tras trombosis frente a disfunción fue de 4,2 p <: 0,01.*

Conclusiones: *El seguimiento del AV de forma multidisciplinar ha conseguido: tasa baja de trombosis, elevado número de reparaciones tanto electivas como después de una trombosis, poca necesidad de catéteres y pocos ingresos. Las FAV se asociaron a una mejor supervivencia. Los AV reparados por disfunción* vs *trombosis presentaron mayor supervivencia.*

Palabras clave: ***Acceso vascular. Hemodiálisis. Equipo multidisciplinar. Monitorización. Trombosis. Supervivencia.***

INTRODUCTION

Maintenance of functional vascular access (VA) is a challenge in hemodialysis (HD) patients. The type of VA determines its own survival, and today the autologous arterial-venous fistula (AVF) has been recognized as the best option. PTFE prosthetic VA and venous catheters are related with increased number of infections, such as thrombosis and infections, and thus, with shorter survival[1-4]. These complications account for 15-36% of all hospitalizations in the USA and Europe, with a financial burden higher than $700 million in the USA[5,6]. Therefore, expert committees have proposed guidelines, such as K/DOQI, achieving the goal of reducing annual thrombosis rate to 0.5 with PTFEs and to 0.25 episodes with AVF. Besides, the goal for PTFEs survival rate should be 70% within the first year, 60% within 2 years, and 50% within 3 years. Moreover, the annual infection rate should be lower than 1% for AVF and 10% for PTFEs[7]. To reach these goals, experts recommend the creation of multidisciplinary teams with prospective protocols monitoring VA, and computer-based collection of VA follow-up data. Recent Hemodialysis Vascular Access Guidelines of the Spanish Society of Nephrology (SEN) recommend as well «… *to develop surveillance and VA monitoring protocoled, programs with multidisciplinary participation…*» and it propose objectives in health care quality within the process of VA. Besides thrombosis rates, similar to those recommended by the K/DOQI guidelines, these objectives include that 75% of patients starting on hemodialysis have a VA created, and that 80% of prevalent patients have an autologous AVF[8].

To date, we have not found any prospective study on integral VA management by a multidisciplinary team. Our group presented a preliminary study showing that the recommendations within the K/DOQI guidelines were achievable[9].

The goals of the present study were: 1) To know quality indicators achieved within 5 years of prospective follow-up of VA by a multidisciplinary participation; 2) To analyze which were the factors conditioning the survival of incident VAs.

MATERIAL AND METHODS

Study general characteristics and methodology

Our health care area comprises 420,000 inhabitants and includes one hospital-based HD unit and one extra-hospital HD unit, with a point-prevalence at the end of the year 2004 of 416 HD patients per million population. A prospective follow-up study of all VA in dialyzed patients within

our health care area has been carried out between January 1st of 2000 and January 1st of 2005.

On January of 2000, the nephrology (nephrologists, nursing staff from the hospital and the extra-hospital center), general surgery, and interventional radiology departments created a multidisciplinary team for vascular access management (VAMT). The main goals for the VAMT have been: 1) Having a VA created, preferably an autologous VA, in most of the patients at the beginning of HD. When the clinical condition does not allow creating a native fistula or a PTFE, having elective placement of a funneled venous catheter; 2) Maintaining as long as possible VA permeability and trying to detect as soon as possible VA malfunctioning; 3) Finally, in thrombosis cases, performing an emergency salvage surgery on the VA within a maximum period of 48 hours and avoiding as much as possible the placement of a catheter. In these cases, the commonest surgical technique is proximal anastomosis of PTFE inter-positioning within the AVF. For PTFEs, simple thrombectomy and post-thrombosis fistulography when stenosis is suspected.

Time periods during which patients were dialyzed with catheters have been excluded from the follow-up study.

For survival analysis and assessment of survival conditioning factors we have only considered incident VA, thus avoiding the selection bias from surviving VA at the study beginning.

Risk factors studied associated with VA survival have been: type of VA, gender, patient's age, use of anti-aggregation and/or anti-coagulation, dialysis start with a catheter, referral from the pre-dialysis clinic, hemoglobin level, presence of diabetes mellitus, and time of VA maturation until use.

All related data were prospectively gathered and entered into the a single database for the whole health care area, and coordinated by nephrologist from the hospital and linked to the electronic patient's nephrology clinical chart[10].

Monitoring and intervention protocol

1. Physical examination performed by the nursing staff. Stenosis was suspected when the pulse took over the thrill, a brief and coarse murmur or a squeak were heard, there was an aneurysm or pseudoaneurysm and there was edema formation and/or development of a collateral venous network. Also assessed were any sign of suspected infection. All abnormalities detected by the nursing staff were communicated to the nephrologist who checked them and further referred the patient to surgery or asked for a fistulogram.
2. Measurement of dynamic venous pressure (DVP): DVP was monitored hourly by the dialysis device and registered on the nursing chart. At the end of the dialysis session, mean DVP was registered. Indication for fistulography was set on the basis of one of the following clinical conditions: 1) DVP increase above 150 mmHg with pump flows of 300 mL/min and G15 needle for AVF, and DVP greater than 200 mmHg with pump flow of 300 mL/min for PTFEs. In any case, whenever there was a progressive increase of DVP during dialysis sessions.
3. Pump flow measurement: indication for fistulography has been set whenever there was a progressive decrease in prescribed pump flows or whenever there was a progressive decline in pump flows below 300 mL/min, after incorrect needle placement or other causes, such as patient's hypotension, had been ruled out.
4. Dialysis efficacy: A fistulogram was ordered when it was not possible to attain the desired Daurgidas Kt/V (> 1.3) once any other cause for lack of efficacy had been excluded.
5. Assessment in regular ground sessions with nephrologists, radiologists, and surgeons on the type of repair to be undertaken for each pathological fistulogram. In case of critical stenosis, and whenever indicated, stenosis dilation was done within the same radiological procedure. Stent placement was done in central vein and peripheral vessels when there was an elastic stenosis (recurrence of an stenosis greater than 30% when dislodging the balloon) or in those cases having previously received several percutaneous angioplasties.

Definitions and indicators

Event: we considered «event» any problem related with VA: stenosis, thrombosis, haematoma, aneurysm/pseudoaneurysm, or infection.

VA infection: diagnosis of infection was based on the presence of clear signs of infection and/or positive culture and/or need for antibiotic therapy.

Annual thrombosis rate for AVF: number of thrombosis episodes in AVF within the study year divided by the total number of AVF at risk per year.

Annual thrombosis rate for PTFE: number of thrombosis episodes in PTFE within the study year divided by the total number of PTFEs at risk per year.

Annual rate of radiological procedures: number of radiological procedures performed within one year per each functioning VA for a whole year.

VA survival: time period from the first use until end of follow-up after necessary surgical and/or radiological repairs had been to maintain VA permeability. Follow-up date has been the date of VA end due to thrombosis or clamping; or the date of end of the study due to loss to follow-up with functioning VA because of patient's death, moving to another area, or transplantation.

Maturation time: time from VA creation to first use for dialysis.

Statistical analysis

The statistical analysis has been done with the SPSS (V 11.0) software package. Quantitative variables are expressed as percentages and numerical variables as means ± standard deviations. Survival analysis has been done by log-rank test and Kaplan-Meier curves. Survival estimates are indicated in days as mean ± deviation and 95% confi-

dence intervals. A Cox regression model adjusted for the remaining significant variables has also been used. A minimal significance level of $p < 0.05$ has been considered for all tests, although also indicated are those with a p value < 0.09.

RESULTS

General results and quality indicators:

The number of prevalent VA within the 5 study years has been 482 implanted VA to 307 patients, 47.9% were AVF, 17.9% PTFEs, and 34.2% catheters. These figures represent 657 VA at complete risk within the 5 years of follow-up, being distributed by type of VA as 66% AVF, 25% PTFE, and 9% catheters. Follow-up study was only performed on AVF and PTFE, thus we have finally included 317 VA implanted to 282 patients, of which 231 were AVF (73%) and the remaining PTFE, accounting for 594 functioning VA at complete risk within the 5 study years: 427 AVF and 167 PTFE. Table I shows the patients characteristics.

During the 5 years of VA monitoring, 295 events have been diagnosed representing an incidence rate of 0.50 per VA and year at risk, distributed as follows: 163 stenosis cases (54.8%), 88 thrombosis cases (29.6%), 9 infection cases (3.7%), 8 steal syndrome cases (2.7%), and other causes (23 cases). In 57% (181/317) of the VA diagnostic fistulographies have been performed, excluding those ordered after a thrombosis episode, which accounts for an annual rate of 0.30 diagnostic radiological procedures per VA and year at risk. Table II shows the reasons for ordering fistulographies. The mean of the positive predictive value of fistulographies ordered due to high DVP or to low pump flow was 88% versus 60% ordered due to difficult puncturing.

Twenty-four out of 88 thrombosis episodes that developed within the 5 years occurred in AVF and 64 in PTFE, which accounts for and annual global thrombosis rate per VA and year at risk of 0.15 (88/594), being distributed as 0.06 (24/427) for AVF and 0.38 (64/167) for PTFE. Sixteen percent of thrombosis episodes occurred in AVF with previously dysfunction and repair pending. The nine VA infection cases corresponded to 2 AVF (0.86% of total AVF) and 7 PTFE (8,13%).

Two hundred and one VA repairs have been performed, 66.6% (134) being elective repairs after evaluation by the VAMT and the remaining after thrombosis occurred. Of elective thrombosis, 71 (53%) were surgical repairs, 81.6% done on AVF, and the remaining required radiological percutaneous angioplasty (30.1% with stent placement), of which 69.4 % were done on PTFEs.

Emergency salvage surgery was done in 76% (67/88) of thrombosed VA without needing catheter placement in 62.5% (55/88) of the patients. Post-thrombosis fistulography was done in 25 PTFEs, with further angioplasty in 92% of them.

Thirty-six point two percent (115/317) of the whole VA required at least one surgical or radiological repair. In the 115 VA, a mean of 2.44 ± 1.9 repairs have been necessary to maintain VA permeability for PTFEs versus 1.28 ± 0.68) for AVF ($p < 0.000$).

Complications related with PTFEs or AVF accounted for 11.4% (74/649) of all hospitalizations in HD patients, accounting for a mean hospitalization rate of 0.10 per patient-year.

Survival and prognostic factors in incident VAs

The number of incident VAs during the study period was 207 (65.2% of the whole VA), in 180 patients. Seventy-five point eight percent (157) of incident VAs were AVF and the remaining (50) were PTFEs. Fifty-seven percent of the patients were assessed at least once at the pre-dialysis clinic. Of them, 80% started on HD with an already created VA. The characteristics of incident patients and the differences between types of VA are shown in Tables III and IV.

Mean survival assessed by the Kaplan-Meyer curves for AVF was 1575 ± 55 days, CI [1467-1683] and for PTFE 1087 ± 102 days; CI [887-1286] ($p < 0.006$) (fig. 1).

Table II. Dysfunction causes

	Number	PPV	Tipe of VA
High venous pressure	77	85.7	70% PTFE
Low pump flow	66	90.9	99% AVF
Low Kt/V	14	78.5	
Difficult puncturing	10	60	
Other causes	14		

PPV: Positive predictive value.

Table I. Patients characteristics

Patients	282
Mean age (years)	64 ± (21-86)
Younger than 65 years	123 (43.6%)
65-74 years	74 (27.7%)
75 years and older	81 (28.7%)
Gender (males)	173 (61.3%)
Diabetics	70 (24.8%)

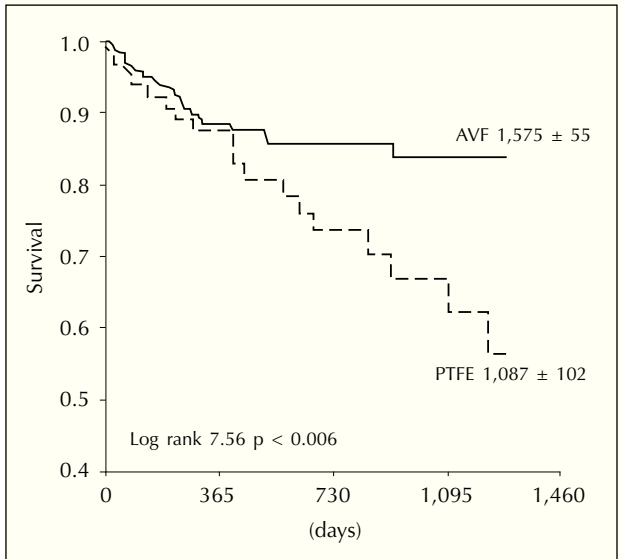
Table III. Characteristics of incident patients

Patients	187
Mean age (years)	64 ± 15 (22-86)
Younger than 65 years	78 (41.7%)
65 years and older	109 (27.7%)
Gender (males)	113 (60.4%)
Diabetics	42 (22.5%)
Referred from pre-dialysis	107 (57%)
With already created VA	86
Patients on anti-aggregation or anti-coagulation 187	82 (44%)

Table IV. Differences between the different types of incident vascular accesses

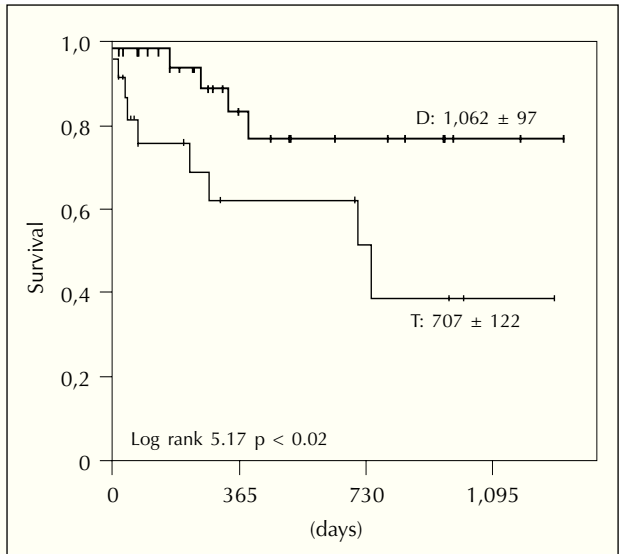
AVF	(n = 157)	PTFE (n = 50)	p value
Diabetes	26 (16.56%)	18 (36%)	P < 0.003
Males	106 (67.5%)	20 (40%)	P < 0.0005
Age	62.8 ± -16 (22-84)	69 ± 12.3 (33-86)	P < 0.07

Global one-year, two-years, and three-years survival rates for AVF were 89%, 85%, and 83%, and for PTFE 83%, 67%, and 51%, respectively. Univariate analysis of incident VA showed that PTFE type of VA ($p < 0.006$), maturation time < 30 days ($p < 0.01$), and Hb < 12 g/dL ($p < 0.08$) were all associated with shorter survival. Sex, age, diabetic condition, start on HD with a catheter, use of anti-aggregation and/or anti-coagulation, and previous assessment at the pre-dialysis clinic were not associated to VA survival. In the stratified analysis by type of VA, being male ($p < 0.04$) and maturation time < 30 days ($p < 0.06$) were associated with shorter survival for both VA types. Hb < 12 g/dL ($p < 0.09$) was associated with shorter survival only with PTFEs. Cox regression model only includes the type of VA, with an OR of 0.4 [0.2-0.8] for native AVF ($p < 0.01$), which does not change by adding other not significant variables.



	1 year	2 years	3 years
Global VA	0.87 ± 0.02	0.81 ± 0.03	0.73 ± 0.04
AVF	0.93 ± 0.04	0.85 ± 0.04	0.83 ± 0.04
PTFE	0.83 ± 0.06	0.67 ± 0.08	0.51 ± 0.10

Fig. 1.—Survival comparison by using K-M curves for AVF vs. PTFE in incident vascular accesses. Table shows the survival likelihood (mean ± SD) within one, two, and three years for all accesses and by type of VA.



	Disfunction	Thrombosis	Long rank	Sig
Added VA	1,062 ± 97	707 ± 132	5.17	0.02
Global VA	1,417 ± 89	909 ± 127	6.47	0.01
AVF native	1,425 ± 96	849 ± 241	4.90	0.02
VA PTFE	1,144 ± 177	915 ± 125		

Fig. 2.—Survival analysis by K-M of added time after repair due to dysfunction (D) vs. thrombosis (T), for all incident VA (pooled AVF and PTFE). The corresponding table shows survival added and secondary survival (Global) for repaired VA ((T vs D), as well as in dialysis stratified by type of access (Native and PTFE).

Mean added survival of all incident VA repaired after dysfunction was 1,062 ± 97 days *vs* 707 ± 132 in those repaired due to thrombosis; log rank 5.17, $p < 0.02$. In the stratified analysis by type of VA survival is still higher for VA repaired due to dysfunction, for both AVF and PTFE. The risk increase for those repaired due to dysfunction is 4.2 fold [1.3-13.6], $p = 0.01$ calculated by means of Cox' regression, and adding other not significant variables does not improve the model (fig. 2).

DISCUSSION

K/DOQI guidelines warn about the high cost of creating and maintaining VA and recommend the creation of multidisciplinary teams for integral VA follow-up[7]. Nephrologists are generally concerned with the problem that VA-related complications represent to HD patients. However, it is unusual to come across radiologists and specially surgeons interested on this issue. So far, and to our knowledge, there are no publications showing VA follow-up by a VAMT. We believe that our experience comprising the

creation of a VAMT and further protocoled follow-up of VA has globally shown satisfactory results within 5 years. Considering the time elapsed on HD with each VA within the five study years, only 9% of the patients are dialyzed through a catheter, 66% have received dialysis through an AVF, and the remaining 25% have done so through a PTFE. The percentage of AVF is lower than that recommended by SEN vascular access guidelines (80%)[8] and the DOPPS study[11], maybe due to the advanced age of our patients (almost 30% were older than 75 years). However and spite a relatively high ratio of PTFE in our population, we achieved a global thrombosis rate of 0.15, which we believe is low as compared to that reported in other series published in our Country (annual thrombosis rate of 0.1 with only 8.4% of VA being PTFEs)[12]. If we analyze the rate by type of VA, AVF account for a thrombosis rate of 0.06 VA-year and PTFE of 0.38, both exceeding the goals set by the K/DOQI guidelines. A recent study only including autologous AVF reports a thrombosis rate similar to ours, although with a less restrictive definition of thrombosis rate. By applying that definition we would obtain a thrombosis rate of 0.02 per VA-year for AVF in our series[13]. We believe that the reasons for this low thrombosis rate may be explained by: 1) it has been demonstrated that 50-80% of thrombosed AVF occur on a previous stenosis and thus most of them will end up in thrombosis is no action is taken[14]. Therefore, VA monitoring would allow us early diagnosing dysfunction before thrombosis occurs. Systematic application of dysfunction testing in our case accounts for a high rate of diagnosed events: for each year at risk of a VA, in half of them an event is diagnosed, most of these events being stenosis (55%). Increase in dynamic venous pressure and decrease in pump flow, assessment tools available at any dialysis unit, show in our series positive predictive values close to 90%. However, and according to the data from Rodriguez et al.[15] only 47% of dialysis units in Spain use dynamic VA monitoring. Other groups have also achieved to reduce thrombosis rate by VA monitoring with "classical" and readily available methods[13,16-19]. Systematic application of dysfunction testing is similarly reflected in the high number of ordered diagnostic fistulographies, since in 57% of VA a fistulography has been done due to dysfunction (rate: 0.30 per VA-year), data that are higher to those from other published studies showing a percentage of ordered fistulographies ranging 50-25%[13,20]. 2) Another factor we believe is determining for the low thrombosis rate is that of the whole number of repairs done, 67% are electively performed indicated by the VAMT, before thrombosis might occur. Usually the indication of the type of repair is based upon the best availability of surgeons or interventional radiologists, unbalancing the numbers towards ones or the others. Collaboration of both teams in our case allows better estimating the real indication for surgical or radiological repair; according to our experience, 53% of the repairs are surgical, predominating in AVF, whereas most of radiological repairs are done on PTFEs. However, and spite of our follow-up program, 16% of thrombosis episodes occur after having detected the dysfunction and before programming the repair, whereas the remaining are thrombosis episodes not previously detected. Therefore, it is necessary to try to improve thrombosis rate by doing earlier repair and by applying early VA dysfunction detection methods. Recently, VA flow measurement has improved early detection of dysfunctional VA. Among the different existing methods, ultrasound dilution with normal saline is the most extended one[21]. Although there are studies failing to prove a greater efficacy of this technique as compared to DVP for PTFEs[22], other studies do show greater screening capability[23]. In our series, thrombosis rate for PTFEs is 6 fold higher for PTFEs than for AVF, and although it is within the proposed objectives, and even lower to rates reported by others[20.24], we believe that early detection of stenosis could be best improved with this type of VA.

Many times VA thrombosis involves patient hospitalization, catheter placement, and delayed creation of a new access, with the resulting risk for complications and high health care cost. In our study, the high level of implication of the surgical team in maintaining VA permeability resulted in the fact that almost 75% of thrombosis episodes regained permeability within 48 hours leading, on the other hand, to the need of catheter placement after thrombosis in only one in three patients. We have not found comparable data in the literature.

We believe that the low thrombosis rate, together with the high percentage of elective repairs, the high rate of salvage surgery for thrombosed AVF, and the low VA infection rate contribute to reduce VA-related hospitalization episodes. The DOPPS study points out that 24.8% of HD hospitalizations are VA-related, with a hospitalization rate of 0.20 patient/year[6]. Our study shows 11.4% hospitalizations for AVF and PTFE, accounting for a hospitalization rate of 0.10 patient/year. Although we do not have available a detailed cost analysis for our country, the annual cost per patient/year for VA-related hospitalizations is about 1000 euros[15]. Therefore, we may suppose considerable cost savings by this way of approaching VA management and make profitable the costs that this new work structure may represent.

In our series, the most important factor related to global survival of incident VA was the type of VA, with a mean survival for AVF of 1575 days versus 1087 for PTFE. This fact has already been described in the literature[25] and is likely related to endothelial hypertrophy and shorter durability of the prosthetic material, which favor PTFE occlusion. However, the survival obtained with PTFE reaches the goals proposed by the K/DOQI guidelines[7] at the first (89 *vs* 70%), second (85 *vs* 60%), and third year (51 *vs* 50%), although achieving this goal involves an average of 2 repairs of the PTFEs versus only one for AVF. We should remember that there is an important colinearity between the type of VA and patient's characteristics since generally patients carrying a PTFE tend to be women, older, and with greater diabetes prevalence. Thus, we believe that the type of VA itself explains most of the differences and does not leave room to other factors. However, considering each type of VA separately, we find a trend to worse survival in men when maturation time is shorter than 30 days and for PTFE when Hb is < 12 g/dL. The association of these factors with VA survival is controversial. Although there are studies relating female gender with worse VA survival[25], others do not find this relationship[20]. About maturation time of the VA, we observed worse survival

when maturation time is shorter than 30 days, both for AVF and PTFE, similarly to what has been described in other studies[26,27] but not found in more recent works[28]. Our study, however, is not randomized and they may exist confounding factors. Another factor debated in the literature is the excessive control of anemia, and the EBPG guidelines[29] already warn about the risk that increased pre-dialysis Hb entails in patients submitted to high ultrafiltration rates. The combination of hemoconcentration and post-HD hypotension may favor thrombosis. We have not found a greater thrombosis rate among patients with Hb > 12 g/dl, and the latest Hb determination done before the thrombosis event does not allow predicting it. Further more, we found an association between low HB and later thrombosis onset in PTFEs. We can only explain this considering the role as comorbidity and poor general prognosis marker that anemia refractory to adequate treatment has.

We believe it is particularly relevant that permeability of AVF repaired due to dysfunction was greater than that of AVF repaired due to thrombosis, for both VA as a whole and taken separately. This supports the need for adequate follow-up and early detection and repair of VA dysfunction in order to maintain VA permeability before it gets thrombosed.

In conclusion, we may state that protocoled management of VA by a VAMT involving nurses, nephrologists, radiologists, and surgeons, even using classical methods, may lead to positive outcomes: low thrombosis rate, increased number of elective repairs, reduced use of catheters, and decrease in the number of VA-related hospital admissions. Preventive repair of dysfunctional VA prolongs the its useful life. It is likely that other more sensitive monitoring measures may improve early detection of dysfunctional VA.

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