Changes in vascular access in a dialysis unit in recent years: planning problems, change in preferences, or demographic change?

T. Malek, F. Álvarez-Ude, M. T. Gil, A. Moledous, M. López-Collado, C. Núñez and M. D. Arenas

Hospital Perpetuo Socorro. Alicante.

Nefrología 2008; 28 **(5)** 531-538

SUMMARY

Background*: Evidence on the reasons for the general and discouraging overutilization of catheters in DOPPS countries is lacking. Methods: We analysed the changes in distribution of the different types of vascular access in all 398 patients ongoing hemodialysis at our unit, from january 2000 until december 2005, as well as patients' characteristics. Secondly, risk factors associated with the use of permanent catheters were evaluated in all 95 patients who used that kind of vascular access from january 1997 until april 2006.*

Results: *The percentage of fistulas in prevalent patients diminished from year 2000 until year 2005 (from 95% to 77.9%); concurrently there was an increase in the use of permanent catheters (from 4.2% to 21.5%). The percentage of incident patients having a usable fistula or graft at the beginning of hemodialysis diminished progressively (83.4% in 2000; 69.3% in 2005), and there was a significant increase in the percentage of incident patients using a permanent catheter (from 0 to 23%). Coincidentally, there was a change in patients characteristics: increasing age (71.3* vs *60.5 years); greater diabetes percentage (7.1%* vs *18.5%) and less time on dialysis (93.2* vs *37 months; p < 0.03). Causes of permanent catheter insertion varied, exhaustion of all other arteriovenous options being the most frequent in the first period of the study and the presence of an unsuitable vascular anatomy in the second.*

Conclusions: *Despite our policy favoring arteriovenous angioaccess, our results with regards to vascular access worsened in both prevalent and incident patients, coinciding with a change in patients' characteristics. We believe that reversing this trend may become more complicated as the population on dialysis grows older and becomes more prone to diabetes.*

Key words: *Arteriovenous fistula. Dialysis Outcomes and Practice Patterns Study (DOPPS). KIDOQI guidelines. Hemodialysis. Permanent catheter. Vascular access.*

Correspondence: *María Dolores Arenas Jiménez*
Hospital Perpetuo Socorro
Plaza Dr. Gómez Ulla, 15
03013 Alicante. España.
lola@olemiswebs.com

RESUMEN

Introducción: **El incremento en el uso de catéteres permanentes (CP) en los pacientes en hemodiálisis, tanto en España como en los países analizados en el Dialysis Outcomes and Practice Patterns Study (DOPSS), es una realidad, pero se desconoce cuales son las razones subyacentes que lo justifican.**

Métodos: **Analizamos los cambios en la distribución de los diversos tipos de acceso vascular en 398 pacientes de nuestra unidad de hemodiálisis, desde enero de 2000 hasta diciembre de 2005, así como las causas que pudieron influir en estos cambios. Al mismo tiempo se estudiaron, de manera retrospectiva, los factores de riesgo asociados al uso de CP en los 95 pacientes que utilizaron ese tipo de acceso vascular entre enero de 1997 y abril de 2006.**

Resultados: **El porcentaje de fístulas arteriovenosas en pacientes prevalentes disminuyó progresivamente a lo largo del periodo estudiado (de 95% a 77,9%); y el uso de CP se incrementó (de 4,2% a 21,5%). El porcentaje de pacientes incidentes que tenía un acceso vascular utilizable (fístula o injerto) al inicio de la diálisis disminuyó (83,4% en 2000; 69,3% en 2005), al tiempo que hubo un aumento significativo en el porcentaje de pacientes que utilizaban CP (de 0 a 23%) (p < 0,0001), y un descenso en el uso de catéteres temporales (de 16% a 7%) (p < 0,01) Coincidentemente, se observó un cambio en las características demográficas de los pacientes: mayor edad (71,3 *vs* 60,5 años), y mayor porcentaje de pacientes diabéticos (7,1% *vs* 18,5%) aunque las diferencias no fueron estadísticamente significativas; y menor tiempo en diálisis (93,2 *vs* 37 meses, p < 0,03). Las causas de colocación de CP variaron en el tiempo: en el primer periodo (hasta 2003) la causa más frecuente fue el agotamiento de otros accesos vasculares, en tanto que en el segundo periodo (de 2003 a 2007) lo fue la presencia de un mal lecho vascular.**

Conclusiones: **A pesar de la política de favorecer la realización de fístulas arteriovenosas en nuestra unidad, nuestros resultados empeoraron, tanto en los pacientes prevalentes como en los incidentes, y ello coincidiendo con un cambio en las características de los pacientes, lo que parece haber influido en el cambio de tendencia observado. Se necesitan nuevos estudios con programas de mejora para evaluar si es posible un cambio de tendencia, a pesar de las peores condiciones de los nuevos pacientes incidentes en diálisis.**

Palabras clave: Fístula arteriovenosa. Dialysis Outcomes and Practice Patterns Study (DOPPS). Guías DOQI. Hemodiálisis. Catéter permanente. Acceso vascular.

IINTRODUCTION

Availability of an adequate vascular access (VA) for hemodialysis (HD) is essential to ensure a good clinical result and adequate patient quality of life[1] and survival.[2] Use of catheters as vascular access in patients on hemodialysis has been related to an increased morbidity and mortality,[3,4] and the desired objective is therefore that most of them are dialyzed through an arteriovenous fistula rather than a catheter.

Adequate VA planning during the predialysis phases,[5] as well as adequate care and maintenance in the hemodialysis phase,[6,7] are vital aspects. Priority should be given to creation of multidisciplinary teams involving nephrologists, vascular surgeons, interventional radiologists, and nursing staff having as a common objective[8] achievement of adequate results in the vascular access of patients on hemodialysis.

The growing trend to use indwelling catheters (ICs) as vascular access seen in most DOPPS countries is discouraging,[9] but the true reason for this change in trend has not been elucidated yet.[10]

On the other hand, a change has been seen in recent years in the characteristics of patients undergoing hemodialysis (HD), who show an increased age and comorbidity.[11] The purpose of this study was to analyze the changes seen in the type of vascular access used at our dialysis unit, and the potential influence of different factors on this change.

METHODS

Study design

A descriptive, observational study.

Study population

A total of 398 patients undergoing dialysis at our hemodialysis unit from January 2000 to December 2005 were studied. Incident patients were defined as those starting dialysis within the year studied, and prevalent patients were defined as all those receiving hemodialysis at our center on December 31 of each year of the study period. Patients transiently attending our unit during holidays were excluded from the study. No other exclusion criterion was applied.

Risk factors associated to use of ICs and the reasons for their insertion were analyzed in 95 patients who had ICs inserted at some time between January 1997 and December 2005.

Unit characteristics

No changes occurred in the characteristics of the hemodialysis unit during the study period. Our unit has an agreement with the national social security. Patients come from the reference public hospital, but the agreement provides for the possibility of autonomously performing and repairing vascular accesses in our patients using vascular surgery or radiology at our hospital. The same vascular surgeon was available throughout the study period, with a response time of approximately one week. The prevailing criteria for creating VA were as follows: 1) The preferred VA in all patients, irrespective of age, was an autologous AVF (1st radiocephalic, 2nd brachiocephalic, 3rd brachiobasilic); 2) basilic vein surfacing is routinely performed in patients who develop towards the basilic or in those in whom this vein has to be used due to loss of the cephalic vein; 3) the goretex prosthesis was only used if a convenient artery was available and there were no veins that could be surfaced; 4) an IC was inserted if an AVF could not be created because of absence of distal pulse or arterial flow, a severe steal syndrome, multiple prior thrombosed VAs with lack of vascular bed and, in some selected cases, in patients with advanced neoplasms and/or a poor baseline clinical condition and a short life expectation (less than 6 months). Patients arriving at the unit from the reference hospital with an inserted IC were re-evaluated for attempting to create an AVF.

Temporal femoral catheters were used for a mean of 21 days, similar to our mean time of AVF cannulation, and a maximum of 31 days.

Our unit has a quality management system since 2000, and a VA monitoring and follow-up program has been developed for early detection of VA dysfunction, consisting of monthly measurements of Kv/T, peak VA flow, and venous pressure, and a physical examination for detecting steal, arm edema, prolonged bleeding after puncture, and altered pulse or thrill. Fistulography is requested if Kt/V is < 1.3 after taking all measures to increase dialyzer diameter, time, and arterial flow; recirculation > 20% (measured by the urea-based method); venous pressure greater than 200 with a blood flow of 300 mL/min; prolonged bleeding after puncture; presence of collateral circulation, arm edema, or excessive flow to the hand. If stenosis was detected, patients were referred to vascular radiology for repermeabilization.

Study variables

The database for patients on hemodialysis (Nefrosoft®) was used. This database includes:

1. Demographic information.
2. Cause of ESRD and comorbidities.
3. Date of first contact with nephrologist.
4. Date of first hemodialysis of the patient.
5. VA type and location at entry into hemodialysis and at December 31 of each year of the study period, as well as the dates of creation and start and end of use of the VA. VA data were updated whenever an event related to it occurred, including the dates and reasons for complications (thrombosis, infections) and procedures used.
6. Reasons for IC placement.

The following variables were calculated and recorded:

1. Mean age of the prevalent population at December 31 of each year.

Table I. Demographic characteristics of the study population

Year	Mean age of prevalent patients	Mean age of prevalent patients	% patients with diabetes mellitus	% males
2000	60.6 ± 16.0	61.8 ± 13.0	20.0	63.0
2001	60.9 ± 13.4	60.5 ± 12.2	19.8	63.5
2002	61.7 ± 13.2	61.1 ± 14.2	20.0	64.0
2003	62.9 ± 14.3	65.9 ± 10.3	25.3	63.8
2004	63.1 ± 14.5	64.7 ± 11.3	25.0	63.4
2005	64.2 ± 10.2	65.2 ± 10.5	28.4	64.0

2. Mean age of the incident population at HD start.
3. Proportion of patients diagnosed of diabetes mellitus (DM).
4. Proportion of males
5. Proportion of prevalent patients using AVF, goretex prosthesis, or IC at December 31 of each year.
6. Proportion of usable vascular accesses at the start of HD treatment in incident patients (AVF, prosthesis, IC, or temporal catheter).
7. Mean age and time on hemodialysis of patients at the time of IC insertion.
8. Follow-up time by the nephrologist before IC insertion.
9. Reasons for IC placement.
10. AVF and prosthesis (considered together because of the low prevalence of prosthesis at our unit) thrombosis rate per patient-year at risk.

Indwelling catheters

The observed difference in the trend to use IC over the years was also analyzed. The reasons and factors potentially related to IC insertion (age, time on hemodialysis, diabetes mellitus, and referral time to nephrologist) were analyzed in all 95 patients who used an IC as VA from January 1997 to April 2006. Two periods were defined and compared: from 1997 to 2000 and from 2001 to 2006.

Statistical analysis

The SPSS 12.1 software package was used for statistical analysis. The percentages of the different types of VA in the different years were compared using a McNemar's test. A Mann-Whitney's U test was used to compare mean ages, and a Student's *t* test to compare mean time on hemodialysis. Non-quantitative variables were compared using a Chi-square test. Normal distribution of the sample was analyzed using a Kolmogorov-Smirnov test. A value of $p < 0.05$ was considered statistically significant.

RESULTS

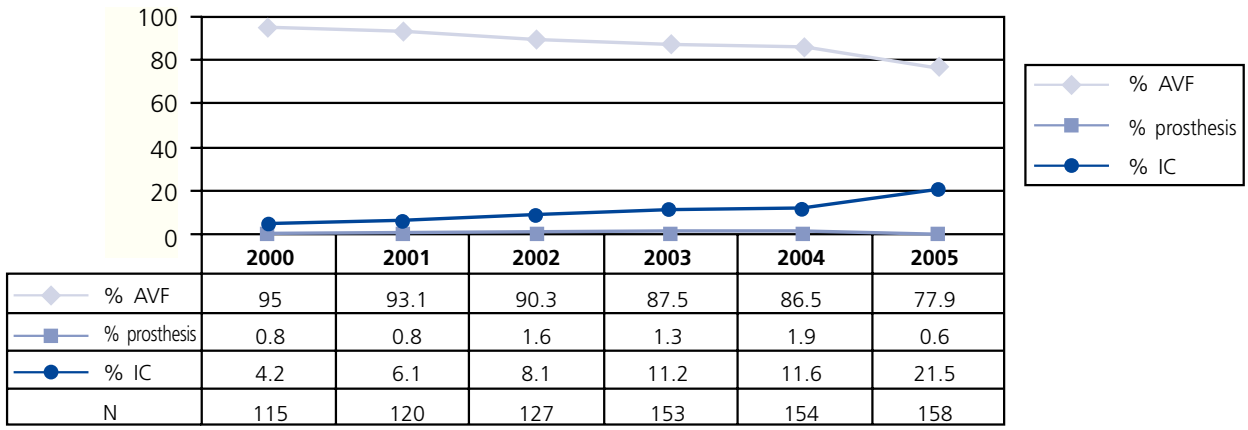
Baseline clinical and demographic information

Table I shows the clinical and demographic characteristics of the study population. Mean age of incident patients and DM percentage increased during the study period. There were no changes in sex distribution between both periods.

Vascular access

AVF percentage decreased in prevalent patients from 2000 to 2005, with a concurrent increase being seen in use of IC. The proportion of patients using a goretex prosthesis continued to be low, with small changes over the years (fig. 1). The proportion of incident patients having a usable AVF or goretex prosthesis at HD gradually decreased (83.4% in 2000, 69.3% in 2005), and a significant increase was seen in the proportion of incident patients using an IC (fig. 2). Use of non-tunneled temporal catheters decreased from 2000 (16.6%) to 2005 (7.0%) ($p < 0.01$). The AVF/goretex thrombosis rate remained stable throughout the study period (between 0.06 and 0.07 thrombotic episodes per patient/year at risk) ($p = NS$) and was lower than the goals suggested by DOQI guidelines (< 0.25 for AVF).

Vein surfacing was performed in 27 patients in the period from January 2000 to December 2005. The reason was total or partial thrombosis of the cephalic vein in 16 patients, and development to basilic in 11 patients. An autologous VA was created using this procedure in 5 patients with ICs.



	2000	2001	2002	2003	2004	2005
% AVF	95	93.1	90.3	87.5	86.5	77.9
% prosthesis	0.8	0.8	1.6	1.3	1.9	0.6
% IC	4.2	6.1	8.1	11.2	11.6	21.5
N	115	120	127	153	154	158

Figure 1. Proportions of prevalent patients as of December 31 by type of vascular access.

Indwelling catheters

Use of ICs at the unit significantly increased in the last five years of the study period, coinciding with a change in the characteristics of unit patients: older age, higher DM rate, and less time on HD (table II). Both the referral time to the nephrologist of patients with ICs before the start of hemodialysis (table II) and the proportion of patients with ICs who had been seen by a nephrologist at least one year before the start of HD were similar in both periods: 35.7% in 1997-2001 and 30.9% in 2002-2006; Chi-square test 0.13; p = 0.76. On the other hand, reasons for IC insertion changed in the final years: the most common reason for IC insertion was vascular bed depletion and the impossibility of creating more AVFs due to their repeated thrombosis in the first period, and the existence of an inadequate vascular bed in the second period (table III).

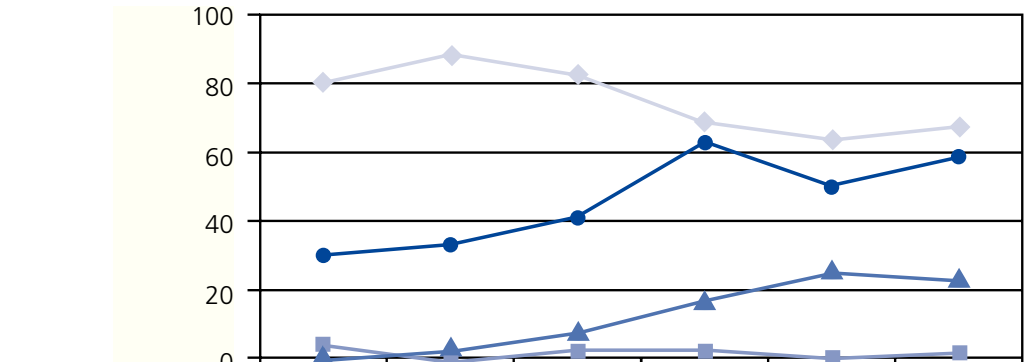
DISCUSSION

The main findings of this study included: 1) A significant decrease in the proportion of autologous AVFs and an increase in the proportion of ICs in both incident and prevalent patients, parallel to a change in age and comorbidity of the incident population (older age and a higher DM percentage). 2) A change in the reason for IC placement in the past 5 years; before 2000, the most common reason was depletion of vascular accesses, but after that date was the absence of an adequate vascular bed due to calcified arteries. 3) A decrease in the percentage of usable vascular accesses (VA and grafts) with an increase in the proportion of ICs in the incident population. 4) A decreased use of temporal catheters in incident patients. 5) The VA thrombosis rate remained stable and was lower than the goals proposed by the K/DOQI guidelines (< 0.25 in AVF and < 0.50 in prosthesis).

Table II. Indwelling catheters (ICs): between-period differences

Years	IC number	Age (years)*	Time on HD (months)**	% DM***	Follow-up time by nephrologist before HD (years)
1997-2001	14	60.5 (52.0-77.6)	93.2 ± 94.9	7.1	4.2 ± 4.0
2002-2006	81	71.3 (58.0-76.9)	37.0 ± 91.8	18.5	3.9 ± 3.7
P		0.20	0.03	0.29	0.78

*Median (p25-p75) (Mann Whitney's U).
**Mean ± SD (Student's t).
***Chi-square.
HD: Hemodialysis; DM: Diabetes mellitus.



	2000	2001	2002	2003	2004	2005
% AVF	80.1	87.9	82.9	68.4	64	67.7
% prosthesis	3.3	0	2.4	1.6	0	1.6
% IC	0	3	7.3	17.4	26	23.7
N	30	33	41	63	50	59

Figure 2. Type of usable vascular access in incident patients.

The recently published vascular access guidelines of the SEN promote use of AVF as first choice VA, and recommend use of this type of vascular access in 80% of prevalent patients on hemodialysis.[12] This recommendation is based on publications showing that use of ICs is independently associated to mortality,[3] and that change from an IC to an AVF is associated to a substantial decrease in mortality risk.[13] In addition, use of central ICs in upper venous trunks has been associated to an increased risk of AVF failure in that arm.[3]

Until 2004, use of AVFs in prevalent patients was still above the 80% recommended by the guidelines.[13] However, an alarming decrease in this proportion was seen throughout the observation period. The proportion of prevalent patients with AVFs changed from 95% in 2000 to 77.9% in 2005, while the corresponding figures for incident patients were 80.1% and 67.7% (both lower than the goals recommended by the SEN guidelines). This decrease in AFV number was at the expense of an increased use of ICs. No increase was seen in the number of thromboses at the unit.

The increased use of ICs seen in the incident population was particularly striking. No incident patient had an IC inserted in 2000, while 23.7% had ICs in 2005. By contrast, a decreased use of temporal catheters (from 16.6% to 7%) was also noted in these patients, and also a greater trend to use the IC as a «bridging» catheter until VA maturation in patients coming from the reference hospital. At our unit, all patients with ICs were re-evaluated by the surgeon for the possibility of creating another type of VA, and in the event of AVF throm-

Table III. Reasons for IC insertion: differences between both periods

Years	VA depletion (> 4 prior VAs)	As firs VA due to lack of vascular bed and/or arterial calcification	As first VA in patients with a short life expectation	AVF closure due to severe steal syndrome
1997-2001	71.4%	21.4%	7.14%	0%
2002-2006	30.8%	59.2%	3.70%	6.1%
P	0.004	0.01	0.55	0.34

VA: Vascular access. AVF: Arteriovenous fistula. Chi-square test.

bosis, our first option continued to be use of a non-tunneled temporal catheter, preferably femoral. ICs were only inserted in patients evaluated by the vascular surgeon in whom no other vascular access was considered to be feasible.

SEN guidelines recommend insertion of a tunneled indwelling catheter if the AVF cannulation time is expected to be longer than 3 weeks,[13] but the trend to use an IC may possibly have been generalized as first choice in all incident patients not having a developed VA, regardless of the expected time for fistula cannulation. In our experience, as in other studies,[14] femoral catheters in ambulatory hemodialysis patients have a similar duration to jugular or subclavian catheters, and their complications are similar to those from catheters placed in other locations, allowing for preservation of upper venous trunks. Although US guidelines 8 and 9 for vascular accesses (K/DOQI) recommend that AVF should mature for at least one month, and ideally for 3 to 4 months before puncture, early AVF puncture (2-3 weeks after it is created) has been shown not to affect AVF survival.[15] In fact, fistula survival in the US, despite longer periods prior to puncture, is clearly lower as compared to Europe.[16] Increased use of IC as a «bridge» may possibly result in an involuntary delay in fistula creation and puncture because a relatively safe and convenient VA is not available, thus unnecessarily prolonging the time at risk for the complications associated to IC use.

A comparison of periods before and after 2000 reveals a change in the profile of patients placed ICs. In the first period (1997-2000), patients with ICs had been on hemodialysis for a long time and had four or more thrombosed AVFs or prostheses (71.4%), while in the second period (2001-2006), the main reason for IC placement was a poor vascular anatomy, mainly because of calcification of the arterial vascular tree (59%), and unlike in previous years, patients especially affected were those who had been less time on HD. These reasons for IC placement in the Spanish population differ from those argued in the US,[17] where the most important reason is the lack of surgery planning or AVF immaturity; IC placement was attributed to the impossibility of creating a VA due to a poor vascular bed in only 11%-14% of cases.

The proportion of prevalent patients using grafts remained stable at very low levels (0.6%-1.6%). Low graft use at our unit was due to the surgeon choosing basilic surfacing instead of prosthesis placement.[18] In our experience, this procedure was an acceptable alternative method in patients in whom a functioning VA was available but could not be punctured due to vein depth. It also represents an alternative method to implantation of vascular prostheses of catheters in patients with cephalic vein thrombosis but a permeable basilic vein.

This change in trend noted cannot be explained by modifications in the internal working strategy, as the surgical team was not changed, and the AVF continued to be preferred both by us and the surgeon.

Predialysis nephrological care and, thus, entry into dialysis using a functioning AVF has been associated to a longer survival in incident patients.[4] In this study, delayed arrival to the nephrologist does not appear to explain the increased use of ICs in the second period, since no difference was found between both periods in the follow-up time at the nephrology clinic. The only differential factor was the change seen in patient characteristics: older age, greater prevalence of DM, and poorer vascular bed due to arterial calcification. This suggests that the change noted in use of AVF and IC at our unit may be related, at least partly, to the abovementioned clinical and demographic differences. However, the following question arises: Is use of ICs «unacceptably» or «inevitably» high at our unit, considering the population where they are placed? Factors reported to be associated to AVF maturation failure include age > 65 years and the presence of peripheral vascular disease and/or coronary disease,[19] which could explain our need to use tunneled catheters as permanent vascular access in this type of incident patients. While a change in this trend to a greater chance of success in AVF creation may be conceived and attempted if the nephrologist considers VA creation earlier, the possibility exists that IC tends to be used as the first choice VA in patients having greater comorbidity and older age and in whom long-term prognosis is difficult to establish.

It should be noted that while use of native fistula increased in the US and Canada,[8] at our unit, as in other European countries,[9] the opposite trend was seen. The change seen in the US mainly resulted from implementation of the K/DOQI guidelines and decreased use of vascular grafts, but use of IC followed the same increasing trend as seen in our unit (from 14% in 2000 to 21% in 2004). However, despite the different trends noted, our results are still far away from the US situation.[17] The proportion of AVFs in prevalent patients in the US was 26.5% in 2003, as compared to 77.9% in our study in 2005. It should be noted that we started from an ideal situation in which 95% of our patients had AVFs in 2000. On the other hand, these results are similar to those reported in an observational, cross-sectional study conducted in Spain in 1999 on 5,472 patients.[20]

Medical preferences have been shown to be one of the reasons for the variability found between centers from different countries, irrespective of the demographic characteristics of the study population.[9,16] A study conducted to assess this aspect showed that managers of US dialysis centers commonly prefer grafts, while most European and Japanese managers prefer fistulas.[9,16] The preference at our unit, both by nephrologists and vascular surgeon, has always been and continues to be the creation of an AVF as first choice for VA, despite which a change in trend was seen. In Spain, the unavailability of a motivated surgical team, with the resultant delay in vascular surgery, and easy accessibility to catheters due to the little technical difficulty involved in their insertion and the fact that they may be immediately used, may account for the increased IC use at some units. In our case, mean time from surgeon referral to VA creation was 7 days, shorter than in other countries

(Europe: 29.4 days; US: 16 days),[21] and no changes were seen over time. The short response time of our vascular surgeon allowed for temporal use of femoral catheters as the VA of choice while waiting for AVF creation and maturation.

The main limitation of this study resulted from the fact that it was a retrospective analysis conducted in a single hemodialysis unit, which prevented generalization of the results (center factor). However, we think that its interest mainly lies in the description of changes in VAs over a long time period in a unit with a homogeneous operation where the same criteria were used and the same vascular surgeon was available. Both these factors may initially be ruled out as an explanation for the findings made. Results found open the way to future studies to investigate in more depth the comorbidities related to the type of VA, as well as to develop improvement programs to change this trend as much as possible.

Differences between countries as regards objectives are also remarkable. The K/DOQI guidelines establish at ≥ 40% the goal of prevalent patients with AVFs,[22] while the corresponding figure in Canada is > 60%.[23] Both objectives clearly differ from those established in our country (> 80%). The gradual increase in the number of elderly patients with greater vascular comorbidity among the population of hemodialysis patients will undoubtedly increase the difficulties for AVF creation, even despite adequate planning and care of the vascular access, but the mentioned difficulties in this type of patients may also deter us from attempting to create another vascular access, all the more so when the catheter used as «bridge» is an IC. The objectives proposed in the Spanish guidelines should perhaps be reconsidered taking into account the current type of incident population. Action guidelines should be under permanent review and be adapted to the different realities. The question should be: must objectives be reasonable or ideal?

The worsening seen over time in results obtained with VA contrasts with the improved evolution seen in dialysis suitability, anemia, or bone metabolism. VA continues to be one of the «Achilles heels» in hemodialysis.[24] Much as the US and Canada have been able to modify their trends to AVF creation by successful implementation of the K/DOQI guidelines, and based on data suggesting an increased mortality and morbidity and a decreased quality of life in patients with ICs,[25] our effort should be focused to reduce use of this type of vascular access in our patients.

REFERENCES

1. Wasse H, Kutner N, Zhang R, Huang Y. Association of initial hemodialysis vascular access with patient-reported health status and quality of life. *Clin J Am Soc Nephrol* 2007; 2 (4): 708-714.
2. Astor BC, Eustace JA, Powe NR, Klag MJ, Fink NE, Coresh J. CHOICE Study. Type of vascular access and survival among incident hemodialysis patients: the Choices for Healthy Outcomes in Caring for ESRD (CHOICE) Study. *J Am Soc Nephrol* 2005; 16 (5): 1449-1455.
3. Pastan S, Soucie JM, McClellan WM. Vascular access and increased risk of death among hemodialysis patients. *Kidney Int* 2002; 62 (2): 620-626.
4. Bradbury BD, Fissell RB, Albert JM, Anthony MS, Critchlow CW, Pisoni RL, Port FK, Gillespie BW. Predictors of early mortality among incident US hemodialysis patients in the Dialysis Outcomes and Practice Patterns Study (DOPPS). *Clin J Am Soc Nephrol* 2007; 2 (1): 89-99.
5. Lorenzo V, Martín M, Rufino M, Hernández D, Torres A, Ayus JC. Predialysis nephrologic care and a functioning arteriovenous fistula at entry are associated with better survival in incident hemodialysis patients: an observational cohort study. *Am J Kidney Dis* 2004; 43 (6): 999-1007.
6. Danese MD, Liu Z, Griffiths RI et al. Catheter use is high even among hemodialysis patients with a fistula or graft. *Kidney Int* 2006; 70 (8): 1482-1485.
7. Wijnen E, Planken N, Keuter X et al. Impact of a quality improvement programme based on vascular access flow monitoring on costs, access occlusion and access failure. *Nephrol Dial Transplant* 2006; 21: 3514-3519.
8. Ackad A, Simonian GT, Steel K et al. A journey in reversing practice patterns: a multidisciplinary experience in implementing DOQI guidelines for vascular access. *Nephrol Dial Transplant* 2005; 20: 1450-1455.
9. Rayner HC, Besarab A, Brown WW, Disney A, Saito A, Pisoni RL. Vascular access results from the Dialysis Outcomes and Practice Patterns Study (DOPPS): performance against Kidney Disease Outcomes Quality Initiative (K/DOQI) Clinical Practice Guidelines. *Am Kidney Dis* 2004; 44 (5 Supl. 2): 22-26.
10. Ceballos M, López-Revuelta K, Saracho R et al. Informe de diálisis y trasplante correspondiente al año 2002 de la Sociedad Española de Nefrología y Registros Autonómicos. *Nefrología* 2005; 25: 121-129.
11. Rodríguez Hernández JA, González Parra E, Julián Gutiérrez JM et al. Vascular access guidelines for hemodialysis. *Nefrología* 2005; 25 (Supl. 1): 3-97.
12. Allon M, Daugirdas J, Depner TA, Greene T, Ornt D, Schwab SJ. Effect of change in vascular access on patient mortality in hemodialysis patients. *Am J Kidney Dis* 2006; 47 (3): 469-477.
13. Borrego-Utiel FJ, Pérez del Barrio P, Pérez Bañasco V et al. Femoral catheters as vascular access in ambulatory patients on chronic haemodialysis. *Nefrología* 1996; 16: 432-438.
14. Saran R, Dykstra DM, Pisoni R et al. Timing of first cannulation and vascular access failure in haemodialysis: an analysis of practice patterns at dialysis facilities in the DOPPS. *Nephrol Dial Transplant* 2004; 19 (9): 2334-2340.
15. Pisoni RL, Young EW, Dykstra DM et al. Vascular access use in Europe and the United States: results from the DOPPS. *Kidney Int* 2002; 61 (1): 305-316.
16. Centers for Medicare & Medicaid Services. 2005 Annual Report, End Stage Renal Disease Clinical Performance Measures Project. Department of Health and Human Services, Centers for Medicare & Medicaid Services, Centers for beneficiary Choices, Baltimore, Maryland, 27-33.
17. Rivers SP, Scher LA, Sheehan E, Lynn R, Veith FJ. Basilic vein transposition: an underused autologous alternative to prosthetic dialysis angioaccess. *J Vasc Surg* 1993; 18: 391-397.
18. Lok CE, Allon M, Moist L, Oliver MJ, Shah H, Zimmerman D. Risk equation determining unsuccessful cannulation events and failure to maturation in arteriovenous fistulas (REDUCE FTM I). *J Am Soc Nephrol* 2006; 17 (11): 3204-3212.
19. Rodríguez Hernández JA, López Pedret J, Piera L. Vascular access in Spain: analysis of its distribution, morbidity, and monitoring systems. *Nefrología* 2001; 21 (1): 45-51.
20. Mendelssohn DC, Ethier J, Elder SJ, Saran R, Port FK, Pisoni RL. Haemodialysis vascular access problems in Canada: results from the Dialysis Outcomes and Practice Patterns Study (DOPPS II). *Nephrol Dial Transplant* 2006; 21 (3): 721-728.
21. National Kidney Foundation. Available at http://www.kidney.org/professionals/kdoqi/index.cfm. Accessed december 28, 2006.

22. Jindal K, Chan CT, Deziel C et al. Hemodialysis clinical practice guidelines for the Canadian Society of Nephrology. *J Am Soc Nephrol* 2006; 17 (3 Supl. 1): S1-27.
23. Schwab SJ. Hemodialysis vascular access: the Achilles' heel remains. *Kidney Int* 2007; 72 (6): 665-6.
24. Portolés J, López-Gómez JM, Gruss E, Aljama P; MAR Study Group. Course of vascular access and relationship with treatment of anemia. *Clin J Am Soc Nephrol* 2007; 2 (6): 1163-9.