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Incident hemodialysis patients: the vascular access and clinical outcomes

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Dissertação de candidatura ao grau de Mestre em Medicina, submetida ao Instituto de Ciências Biomédicas Abel Salazar – Universidade do Porto

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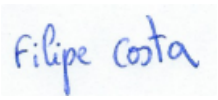

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Resumo

Introdução: Portugal tem uma das maiores incidências e prevalências de doença renal terminal (ESKD) na Europa, de acordo com a *European Renal Association*. O acesso vascular (AV) é fundamental para os doentes em hemodiálise (HD), tal como a HD eficiente depende do bom funcionamento do AV. Além disso, o AV é um dos elementos considerados como podendo determinar a morbidade e a mortalidade nestes doentes. O objetivo deste estudo foi a avaliação de doentes em HD seguidos num único centro (Centro Hospitalar Universitário do Porto) e o curso do acesso vascular.

Métodos: Foram estudados doentes incidentes que iniciaram HD de manutenção entre 1 de janeiro de 2018 e 31 de agosto de 2018. Os dados incluíram caraterísticas clínicas basais, o tipo de acesso escolhido, sua evolução e viabilidade com o curso de vida do paciente. Ao longo de um período de três anos, os internamentos, as complicações e os desfechos/*outcomes* foram revistos. Três desfechos principais foram estudados: mortalidade e intervenções no acesso, consequências da angioplastia e trombose do AV.

Resultados: Dos 82 pacientes, 50 (61%) iniciaram a hemodiálise com fístula arteriovenosa (FAV), enquanto 32 pacientes (39%) iniciaram com cateter venoso central. Durante o seguimento, 39% dos doentes alteraram o tipo de AV. Nesta população, a causa mais frequente de ESKD foi diabetes mellitus (28%), seguida de glomerulonefrite crónica (13,4%). A nefropatia diabética, a fragilidade, a doença arterial periférica, a doença maligna e a hipoalbuminemia estiveram significativamente associadas a maior mortalidade. A construção precoce de AV e um acesso permanente foram associados a uma maior taxa de sobrevida. A indução de hemodiálise no internamento foi significativamente associada à mortalidade, quando comparada ao procedimento em ambulatório. O tipo de AV não se associou a variações significativas na mortalidade. Os doentes submetidos a angioplastia (10 doentes) apresentaram menor falência de acesso; a trombose (em 8 doentes) não se apresentou nem se associou significativamente com as caraterísticas clínicas, prévias ou posteriores ao início de HD.

Conclusões: Este estudo de coorte, num centro com procedimentos padronizados, mostrou que o tipo de AV não se correlacionou com a mortalidade. As condições basais dos doentes tiveram um forte impacto na sobrevida a longo prazo. Os desfechos/outcomes foram influenciados pela fragilidade, diabetes, comorbilidades, hipoalbuminemia e início da diálise hospitalar. Definir as características da população de doentes de cada centro e implementar uma política homogénea em relação à construção e opções de AV poderão contribuir para melhorar a prática clínica.

Palavras-chave: Hemodiálise, acesso vascular, patência do acesso, fístula arterio-venosa, cateter, morbilidade, mortalidade, complicações

Abstract

Background: Portugal has one of the highest incidences and prevalence of end-stage kidney disease (ESKD) in Europe, according the European Renal Association. Vascular access (VA) is the lifeline for hemodialysis (HD) patients, and efficient HD is dependent on well-functioning VA. Moreover, VA is one of the most important elements that determine superimposed morbidity and mortality in HD patients. The main focus of this study was the evaluation of patients and its vascular access course, followed at a single centre (Centro Hospitalar Universitário do Porto).

Methods: Incident patients who initiated maintenance HD between January 1, 2018 and August 31, 2018 were studied. Data included baseline clinical characteristics, which access was chosen, its evolution and feasibility with the patient's life course. Along a three years period, hospitalizations, complications and outcomes were reviewed. Three main outcomes were studied: patients' mortality and access interventions, angioplasty and VA thrombosis.

Results: Of 82 patients, 50 (61%) started hemodialysis with an AVF, while 32 patients (39%) initiated with a catheter. During the follow-up, 39% of patients registered an alteration in vascular access type. The most frequent cause of ESKD was diabetes (28%), followed by chronic glomerulonephritis (134%). Diabetic nephropathy, frailty, peripheral arterial disease, malignancy and hypoalbuminemia were strongly associate with higher mortality. Early VA creation and a permanent access were associated with a better survival rate. Inpatient first hemodialysis was significantly associated with mortality, when compared with outpatient procedure. The type of VA was not associated with significant variations in mortality. Patients submitted to angioplasty (10 patients) had a lower access failure; thrombosis (in 8 patients) did not showed any significant association to clinical characteristics, previously or far ahead HD.

Conclusion: This cohort study, in a centre with standard procedures, showed that VA type was not correlated with patient mortality. Patients' baseline conditions had a strong impact in patient long-term survival. The outcome was influenced by frailty, diabetes, comorbidities, hypoalbuminemia and inpatient dialysis initiation. Defining characteristics of patient's population from each centre and implementing a homogeneous policy concerning VA, may help to ameliorate clinical practice.

Keywords: Hemodialysis, vascular access, patency of access, arteriovenous fistula, catheter, morbidity, mortality, complications.

List of abbreviations

ADPKD: Autosomal dominant polycystic kidney disease

AVF: Arteriovenous fistula

AVG: Arteriovenous graft

CFS: Clinical frailty scale

CVC: Central venous catheter

ESKD: End-stage kidney disease

ERA-EDTA: European Renal Association-European Dialysis and Transplantation Association

RRT: Renal replacement therapy

ICU: Intensive care unit

Index of Contents

Tables Index

Introduction

Portugal has one of the highest incidences and prevalence of end-stage kidney disease (ESKD) in Europe, according to the latest annual 2019 report from European Renal Association - European Dialysis and Transplant Association (ERA-EDTA).[1]. In 2018, Portugal recorded 20730 patients treated by dialysis or with functioning kidney transplants.[2] From that sample, 2634 represented the number of new cases starting any kind of renal replacement therapy (RRT)[2]. Several reasons had been identified as causes of this rising tendency, such as the increase in the elderly population, poor control of risk factors, a delayed referral to a nephrologist, or a lack of description of genetic disorders leading to chronic renal disease.[3] Of those patients starting RRT in 2018, approximately 90% were receiving hemodialysis, 9% corresponded to peritoneal dialysis and the remaining 1% received a kidney transplant.[2]

Chronic hemodialysis has become an increasingly safe and well-tolerated therapy for patients with ESKD.[4] Although life-sustaining, hemodialysis is marked by persistently high mortality, mostly due to cardiovascular and infectious diseases.[5] Part of this high mortality rate is ascribed to vascular access-related complications.[6] Vascular access is one of the most important elements that determine morbidity and mortality in hemodialysis patients.[7] General recommendations for vascular access have been fistula first strategy.[8] A fistula is an autologous arteriovenous access created by a connection between a vein and an artery.[9] Initiating hemodialysis with an arteriovenous fistula (AVF) is associated with improved outcomes, ranging from reduced infection complications, hospitalization, health care costs, and above all, improved vascular access and patient survival.[10] These efforts have resulted in an improvement in prevalent vascular access, over the last two decades, but when compared with the incidence rates this improvement has been modest.[10] Portugal even registered a decline in its use, going from 44% incident hemodialysis patients with an AVF in 2008 to 39.1% in 2018.[1]

Each form of hemodialysis vascular access has distinct advantages and disadvantages, with specific access types potentially better for certain individuals.[11] Central venous catheters (CVC) are the dominant form of vascular access at hemodialysis initiation (51.6% of incident hemodialysis patients in 2018)[1]. Most of their use comes as temporary vascular access in patients awaiting placement or maturation of permanent vascular access, in some cases being also required as a long-term access.[4] Temporary or non-tunnelled catheters are intended for short use, less than 2 weeks.[9] Although studies have shown that AVF has better survival rates than CVC, patient factors, under certain conditions may play a significant role in mortality outcomes.[8] Arteriovenous grafts (AVG), a third type of vascular access, are neither recommended nor discouraged.[11] They are created by

connecting an artery and a vein with an artificial prosthetic segment.[9] Despite higher initial successful function rates compared with AVF and lower infection rates compared with CVC, AVG tend to require more interventions and are more likely to fail after successful use compared with AVF.[11]

Nephrology departments across hospitals, are responsible for the patient's chronic renal disease follow-up, vascular access creation, and hemodialysis induction, but a large part of the vascular access path is lost due to dissociation between the staff pre-hemodialysis and those at the hemodialysis unit, so the main goal of this study is to add the patient's follow-up in-hospital to the follow-up out-of-hospital, focusing the vascular access and the respective outcomes.

The main focus of this study is the evaluation of the vascular access course, namely which access was chosen, its evolution and feasibility with the patient's course, complications and outcome. This study will be able to bring, for the first time in CHUPorto, an evaluation of the path of the patient in hemodialysis, joining the hospital clinic to the extra-hospital clinic.

Methods

Design and Setting

We conducted a retrospective population-based cohort study using the registries of the Department of Nephrology of Centro Hospitalar Universitário do Porto (CHUPorto), Portugal, a University Hospital that provides renal replacement therapy including hemodialysis, peritoneal dialysis and kidney transplantation. The Hospital is responsible, at least, for the creation of the first vascular access for hemodialysis in a team setting including Nephrology and Vascular Surgery.

Data sources

All patients that start dialysis have administrative records coupled with the Portuguese Ministry of Health database. We support our review in healthcare electronic records and direct contacts with CHUPorto and outpatient's hemodialysis clinics nephrologists. All the patients included had previous observation at CHUPorto.

Ethical statement

The use of data in this project was approved by the Responsible for Personal Health Information of CHUPorto, reviewed and approved by the Ethics Committee of CHUPorto-Instituto de Ciências Biomédicas Abel Salazar, University of Porto; reference study number 2021-314(259-DEFI/267-CE).

Study population

We included the incident patients that experienced hemodialysis as RRT considered in a context of CKD stage 5 and who started maintenance dialysis between January 1, 2018 and August 31, 2018, older than 18 years at first hemodialysis.

Incident hemodialysis patients were defined by receipt hemodialysis in-hospital or out-hospital (in-center/dialysis clinic) for the first time during the defined interval.

We evaluated the patients that fulfilled the inclusion criteria – consecutive incident hemodialysis patients that maintained this treatment for more than six weeks. Patients treated by kidney transplant and who needed to start hemodialysis during the period mentioned were added too. The period of registry and follow-up ended at December 31, 2021.

Inclusion criteria for transplant patients were that both the kidney transplant and graft failure occurred during this time frame; a 6-month time frame was selected to ensure we were not

including recipients who had primary non-function patients was performed on all patients who started chronic hemodialysis treatment at CHUPorto.

The definition of hospital level at start dialysis therapy was Level 1 - patients at risk of their condition deteriorating, or those recently relocated from higher levels of care, whose needs can be met on an acute ward with additional advice and support from the Critical Care team; Level 2 - patients requiring more detailed observation or intervention including support for a single failing organ system or post-operative care and those 'stepping down' from higher levels of care.

The Clinical Frailty Scale (CFS) used was reported Rockwood K et al, based on the Canadian Study of Health and Aging, by ranges from 1 (robust health) to 7 (complete functional dependence on others).

Data collection

All data including date of birth, gender, clinical fragility, biopsy, type of kidney disease, comorbidities at initiation of dialysis, biochemical parameters, vascular access, and cause of death were collected by electronic health records review.

Baseline biochemical markers were extracted from the moment prior to the decision of starting hemodialysis, these included creatinine, albumin, hemoglobin and cystatin C. Information on kidney biopsy were noted too.

Three vascular access are used at the current practice.[12] AVF is an autologous AV access created by a connection of a vein to an artery.[9] AVG consist in an arterial prosthetic segment used to connect an artery and vein.[9] Central venous catheter is established by inserting a catheter into a central vein.[12] The strategy adopted was according to general recommendations on establishing an arteriovenous procedure in patients that are soon expected to undergo a stage 5 chronic kidney disease.[8] Hemodialysis via catheter was performed in all patients undergoing emergency conditions like hyperkalaemia or severe fluid overload, as a mean to obtain an emergent hemodialysis, then an AV procedure creation when clinical conditions was acceptable to do that.[12]

We assessed the first and the last vascular access reports for each patient. The last one, being the permanent access, which was defined as the definitive one, not foreseeing construction of another. Hemodialysis local was added too, meaning if the patient-initiated dialysis in-hospital or out-hospital (dialysis clinic). Every change in vascular access type during the study period was registered, as well as every procedure submitted (angioplasty, thrombectomy or surgical revision) and hospitalizations, focusing complications related to the vascular access.

Outcome

All-cause mortality was the outcome of interest, to avoid time bias, due to the variation between the vascular access creation and hemodialysis initiation. The outcomes at the end included still on hemodialysis, death, transplanted, transferred to peritoneal dialysis, lost for follow-up, decision to stop because of gaining in renal function or comorbidities.

Statistical analysis

Categorical variables are expressed as number and proportion; Continuous variables are expressed as mean and standard deviation if normally distributed and as median and interquartile range if non-normally distributed. Univariate logistic regression was employed to analyse the relation between the outcomes and patients baseline characteristics. All statistical analysis were performed using IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, N.Y., USA).

Results

Studied population

Overall, 82 patients were included in the study, with a mean age at initiation of hemodialysis of 65.2 ± 14.6 years; 52.4% of patients were male. The clinical features of the sample are displayed in Table 1. Most of the patients studied (76.8%) were managing well, according to the clinical frailty scale, while almost 5% were living with severe frailty.[13] There were 11% of patients with a kidney transplantation. Of those 82 who started dialysis in 2018, 61% initiated with an AV access (being all fistulas): 29.3% were wrist fistulas and 31.7% were upper arm fistulas. The remaining 39% initiated with a catheter: 2.4% were temporary catheter, 36.6% tunnelled cuffed catheter. When comparing the local where hemodialysis was started, 54.9 % initiated at hospitalization, while 42.7% did it at outpatient clinic, leaving 2.4% at intensive care unit (ICU).

During the follow-up, 61% of the vascular access were permanent access, and so retained the same type. Adding those 39% who changed their vascular access, we end up with 96% of patients being under an AV access: 84% were with a fistula (56% upper arm and 28% wrist fistulas) and 12% were with a graft. Only a few amount of patients stayed with a catheter (4%). Note that a large part of patient had constructed their AV access prior to the dialysis induction (65.4%). Some patients have undergone some procedures during the follow-up, 12% were submitted to angioplasty, while 9.8% reported thrombosis of the vascular access. Of note among the patient's vascular access, only 3.7% reported complete access failure.

The most frequent causes of ESKD were diabetes (28%), chronic glomerulonephritis (13.4%), autosomal dominant polycystic kidney disease (ADPKD) (9.8%), obstructive/urological (8.5%) and vascular (6.1%). Systemic and hereditary disease were responsible for 4.9% and 3.7% of ESRD, respectively. 18-3% of patients' ESKD cause was unknown. A biopsy was taken in 31.7% patients. Comorbidities were found in 58 (69.9%) patients. Diabetes was the most common among the sample, being present in 45.1%, the following being: heart failure in 30.5%, coronary heart disease in 23.2%, peripheral arterial disease in 19,5%, malignancy in 14,6% and cerebrovascular disease in 12,2%.

Biochemical markers, at initiation of dialysis, mean creatinine was 7.1 ± 27 mg/dL, mean cystatin C was 4.6 ± 0.8 mg/dL, mean hemoglobin was 10.0 ± 1.5 g/dL and mean albumin was 3.6 ± 0.6 g/dL. During the observation period, there were evidence of three outcomes. Most of patients were still under hemodialysis at the end of the study (48.7%), followed by death, representing 38.5% and lastly those who were transplanted, with 12.8%.

Outcomes

Mortality

There were recorded 30 deaths (36.6%) in our study population. Looking at the patient survival there was no difference between each vascular access type at the initiation of hemodialysis. On the other hand, we verified that a vascular access created before dialysis induction was strongly associated with a better survival rate (OR 0.27, 95% CI: 0.10-0.71, p=0.008). Permanent access established was also a protective factor on mortality outcome (OR 0.31, 95% CI: 0.12-0.79, p=0.014). A higher score in CFS was a strong predictor of mortality (OR 3.96, 95% CI: 1.62-9.69, p=0.003), additionally those with diabetic nephropathy as a cause of ESkD had an increased risk of dying. When we look at biochemical markers, in particular albumin, patients with higher levels were more likely to have a better survival (OR 0.308, 95% CI: 0.118-0.807, p=0.017). Comorbities strongly associated with mortality in this analysis were diabetes, peripheral arterial disease, and malignancy. When also compared the local at initiation of hemodialysis with mortality, starting at the hospital signalled an increased risk of dying (OR 4.181, 95% CI: 1.517-11.524, p=0.006) when compared to those in dialysis unit.

Angioplasty

There were 10 patients submitted to angioplasty, during the follow-up period. Patients that undergone angioplasty were associated to a lower risk of access failure (OR 0.056, 95% CI: 0.005-0.693, p=0.025). Despite this, that was the only statistically significant association.

Thrombosis

There were 8 patients reporting thrombosis of the access. Overall, looking at those patients, we did not find any significant association.

The overall results are detailed in table I, II, II and IV for a wider evaluation and appreciation.

Discussion

Our study identified a cohort of 82 patients that initiated hemodialysis in 2018, then we evaluated every detailed information on the vascular access during the follow-up regarding three main outcomes: mortality, angioplasty, and thrombosis. Overall, our study showed that patients with diabetic nephropathy as cause of ESKD and higher score in CFS were associated with higher mortality. Diabetes, peripheral arterial disease, and malignancy were comorbidities also strongly associated with this outcome. Some important features concerning the vascular access were obtained and demonstrated, as a higher mortality in inpatient dialysis induction. On the other hand, patients with an early vascular access and permanent access established, were associated with a better survival rate. As expected, hypoalbuminemia represented a higher risk of death. Of note, vascular access submitted to angioplasty was associated with a lower rate of failure during the follow-up.

Vascular access is the hallmark for an appropriate hemodialysis in patients with ESRD.[14] Over these last few years, a lot of studies have been discussing the relation between the hemodialysis vascular access type and mortality. Although, almost every study, showed a decrease mortality experienced by patients initiating dialysis with a AVF compared with a catheter[8], it is also true that after correction for several variables, the correlation between the vascular access type and mortality is no longer significant[6], which raise some questions regarding the differences in patients factors.

It seems to have been made an effort to the implementation of studies that focus the definition of characteristics of patient populations.[5] These kinds of studies allow to a better understanding about how some patient's factors influence the vascular access type and other outcomes.

This study, concerning the Portuguese reality, had a particular interest in the mortality outcome for three main reasons: (1) it was by far the one who gave us more data statistically significant; (2) compare its influence with our patient population's features; and clarify the relation between vascular access type and its outcome.

Diabetes is an important risk factor for hemodialysis patient's survival.[12] In our cohort, the only cause of ESKD strongly associated with mortality was diabetic nephropathy, but this finding can be misleading and should be interpreted carefully. Some studies are consistent with diabetes being an important predictor of mortality[12,15] but there a few ones where the association wasn't statistically significant.[6,16] This can be explained by some of macro- and microvascular complications

from diabetes, that leads to others comorbidities, which can diminish the significant association of diabetes with this outcome.

In line with the hypothesis, patient that initiated dialysis with higher frailty were at higher risk of death. The comorbidities define patient's life quality and dependency, so, it becomes easier to understand the relation with this outcome. In contrast, a variable that surprisingly didn't show any association was patient's age. Age as a variable, had been described as an important mortality predictor in other studies[6,8,12], like Lijie and Sumei's study that recently showed some risk factors for mortality in patients undergoing hemodialysis, with age having a significant harmful impact.[17] Due to aging being associated with disease development, it seems reasonable that elder patients would have a worse prognosis, however, studies suggest that other patient factor can be influencing age's impact, like Ko at al, that identified patients over 80 years-old with a comparable survival in those initiating dialysis with AVF and those with a catheter first then switched to an AVF.

Serum albumin reflects the nutritional status and chronic inflammation of dialysis patients, it also represents a predictor of prognosis.[18] The association between mortality and hypoalbuminemia was significant in our cohort, confirming the key role that it holds in improving survival after dialysis initiation.

Beside the risk factors previously identified, our study was designed to collect every data regarding the vascular access during the follow-up and in that field, we found some interesting findings. When comparing the vascular access types at starting of hemodialysis or any change during the follow-up, there was no association with high mortality risk in our patient population. This finding can be explained by 2 hypotheses: (1) the centre in study has high percentage of AVF (61% at initiation of dialysis), which may be responsible for diminish the significance of the vascular access type; (2) the vascular access type not being independent correlation with mortality, like shown some studies in these recent years.[6,8,19] In this study, we remarked that patient with a vascular access created before hemodialysis induction was associated with a better survival rate. Early creation of an AVF when patients has stage 4 CKD, has both risk and potential benefits reported in Swapnill and colleague's study.[20] However, in our cohort, an early creation allows appropriate time for the AVF to mature, and also an adequate time to perform another access if necessary; if the first effort fails, it was showed some positive impact in mortality. Currently policy, recommends the use of AVF first, catheter last.[21] Comparing that strategy with our findings, a permanent access was associated with non-deleterious impact in mortality rate, which is consistent with some of the current literature. Of note, studies seems to be increasingly agreeing with the

patient mortality may be explained by different patient factors, so catheter involvement by itself may be less than previously considered.[8]

Starting haemodialysis is an important life changing event with huge impact in patient survival[22], and in our study it appeared to have great significance for patient prognosis. We have shown that inpatients starting hemodialysis was associated with higher mortality risk, which can be explained by patient's comorbidities burden allied with less dialysis preparation by the Nephrology and Vascular Surgery team.

Two more outcomes were evaluated, angioplasty and thrombosis. Our findings, with no significance between these groups can be due to the low number of events recorded in our cohort. However, it is of worth to mention that access failure rate was lower when an angioplasty procedure was performed, as explored in other studies that showed a longer patency in accesses that requiring angioplasty with stent grafts.[23]

This study adds some interesting elements to the already vast literature.[24,25] First, it was important for patient characterization from the centre in study, helping for future reflections in the centre clinical practice; second, we add some interesting variables around the vascular access, including what occurs subsequently commencing hemodialysis.

There are some limitations of our study. It is a single-centre retrospective study, and some bias may be introduced by treatment selection, including patient with severe comorbidities receiving a catheter. Finally, the sample size, that certainly play a role on missing statistical differences. Nonetheless, previous studies in the same centre bring important issues for clinical practice.[26,27]

In conclusion, this study showed a no independent correlation between the type of vascular access and mortality. This outcome was influenced by patient's risk factors (frailty, diabetic nephropathy, comorbidities, hypoalbuminemia), early access construction and inpatient dialysis initiation. This study stands as a representative group of our centre, so may be worthwhile an extended Portuguese work to define the characteristics of patient's population, given the distinct sociodemographic, clinical characteristic and access options from other centres.

Appendix

Table I. Clinical characteristics of the studied population.

Characteristics [82 patients]	Number of patients (SD or %)*
Mean age (years)	65.2 (14.6)[1]
Male gender	43 (52.4)[0]
Clinical fragility scale (%)	
3	63 (76.8)[0]
4	10 (12.2)[0]
5	5 (6.1)[0]
7	4 (4.9)[0]
Causes of ESKD (%)	
Diabetes	23 (28)[0]
Glomerulonephritis	11 (13.4)[0]
Obstructive/urological	7 (8.5)[0]
Vascular	5 (6.1)[0]
ADPKD	8 (9.8)[0]
Hereditary non-ADPKD	3 (3.7)[0]
Systemic disease	4 (4.9)[0]
Multifactorial	6 (7.3)[0]
Unknown	15 (18.3)[0]
After graft lost	9 (11)[0]
Diagnosis based on kidney biopsy	26 (31.7)[0]
Comorbidities	
Diabetes	37 (45.1)[0]
Heart failure	25 (30.5)[0]
Coronary artery disease	19 (23.2)[0]
Cerebrovascular disease	10 (12.2)[0]
Peripheral arterial disease	16 (19.5)[0]
Malignancy	12 (14.6)[0]
HD starting	
Inpatient Hospital – level 1	45 (54.9)[0]
Inpatient Hospital – level 2	2 (2.4)[0]
Outpatient HD unit	35 (42.7)[0]
First HD access (%)	
Proximal fistula	26 (31.7)[0]
Distal fistula	24 (29.3)[0]
Tunnelled catheter	30 (36.6)[0]
Non-tunnelled catheter	2 (2.4)[0]
Permanent vascular access	50 (61)[0]
Early vascular access	53 (65.4)[0]
Permanent access - distinct from 1st HD	
Proximal fistula	14 (56)[0]
Distal fistula	7 (28)[0]
AV Graft	3 (12)[0]
Tunnelled catheter	1 (4)[0]
Vascular access details	
Angioplasty	10 (12.2)[0]
Thrombosis	8 (9.8)[0]
Definitive failure	3 (3.7)[0]
Transplant list	16 (19.8)[0]

Table I (continued)

Overall mortality	30 (36.6) [0]
Outcome	
Still on HD	38 (48.7) [0]
Death	30 (38.5) [0]
Transplantation	10 (12.8) [0]
Serum biochemical markers values	
Creatinine (mg/dL)	7.100 (2.715) [1]
Cystatin C (mg/dL)	4.621 (0.805) [1]
Hemoglobin (g/dL)	10.032 (1.482) [1]
Albumin (g/dL)	3.617 (0.569) [1]
Hospitalizations	
Number	1 (3)[2]
Nonvascular access-related	0 (1)[2]
Vascular access-related	0 (0)[2]

Abbreviations: ESKD, end-stage renal disease; HD, hemodialysis. *Number presentation: 0, Categorical variables are expressed as number of patients (percentage); 1, Continuous variables are expressed as mean (standard deviation); 2, Hospitalizations are expressed as median (inter-quartile range).

Table II. Odds ratio for mortality outcome and patient's characteristics.

	Mortality	
Characteristics [30 patients]	OR (95% CI)	P-value
Age	1.024 (0.000-0.000)	0.169
Gender	2.015 (0.802-5.063)	0.136
Clinical Frailty Scale	**3.960 (1.619-9.690)**	**0.003**
Causes of ESKD		
Diabetes	**6.222 (1.365-28.369)**	**0.018**
Glomerulonephritis	0.889 (0.122-6.483)	0.908
Obstructive/urological	5.333 (0.751-37.862)	0.094
Vascular	1.000 (0.080-12.557)	1.000
ADPKD	0.571 (0.049-6.606)	0.654
Hereditary non-ADPKD	0.000 (0.000-0.000)	0.999
Systemic	4.000 (0.388-41.228)	0.244
Multifactorial	4.000 (0.520-30.762)	0.183
Comorbidities		
Diabetes	**4.118 (1.585-10.700)**	**0.004**
Heart failure	0.964 (0.363-2.564)	0.942
Coronary artery disease	1.800 (0.635-5.102)	0.269
Cerebrovascular disease	3.000 (0.773-11.650)	0.112
Peripheral arterial disease	**8.000 (2,282-28.050)**	**0.001**
Malignancy	**4.364 (1.187-16.043)**	**0.027**
Serum biochemical markers		
Creatinine	0.840 (0.695-1.014)	0.070
Cystatin C	0.805 (0.398-1.626)	0.545
Hemoglobin	0.909 (0.666-1.241)	0.550
Albumin	**0.308 (0.118-0.807)**	**0.017**
HD starting		
Inpatient	**4.181 (1.517-11.524)**	**0.006**
Vascular access details		
Permanent access	**0.310 (0.121-0.793)**	**0.014**
Early vascular access	**0.269 (0.102-0.707)**	**0.008**
Angioplasty	1.400 (0.334-5.875)	0.646
Thrombosis	1.826 (0.345-9.680)	0.479
Access failure	0.275 (0.024-3.163)	0.300
Hospitalization		
Number	1.099 (0.901-1.339)	0.352
Nonvascular access-related	1.176 (0.827-1.671)	0.367
Vascular access-related	2.237 (0.765-6.543)	0.142

Abbreviations: ESKD, end-stage renal disease; HD, hemodialysis.

Table III. Odds ratio for angioplasty outcome and patient's characteristics.

	Angioplasty	
Characteristics [10 patients]	OR (95% CI)	P-value
Age	0.960 (0.920-1.001)	0.054
Gender	0.343 (0.082-1.433)	0.142
Clinical Frailty Scale	1.180 (0.655-2.127)	0.582
Causes of ESKD		
Diabetes	0.000 (0.000-0.000)	0.999
Glomerulonephritis	0.000 (0.000-0.000)	0.999
Obstructive/urological	3.167 (0.392-25.576)	0.279
Vascular	0.679 (0.064-7.161)	0.747
ADPKD	0.000 (0.000-0.000)	0.999
Hereditary non-ADPKD	1.583 (0.129-19.422)	0.719
Systemic	0.000 (0.000-0.000)	0.999
Multifactorial	0,731 (0.116-4.593)	0.738
Comorbidities		
Diabetes	0.504 (0.131-1.941)	0.319
Heart failure	0.385 (0.100-1.473)	0.163
Coronary artery disease	1.236 (0.239-6.388)	0.800
Cerebrovascular disease	0.000 (0.000-0.000	1.000
Peripheral arterial disease	0.966 (0.184-5.056)	0,967
Malignancy	0.000 (0.000-0.000	1.000
Serum biochemical markers		
Creatinine	1.223 (0.975-1.534)	0.082
Cystatin C	1.232 (0.508-2.99)	0.645
Hemoglobin	0.947 (0.598-1.499)	0.816
Albumin	0.861 (0.266-2.787)	0.802
HD starting		
Inpatient	0.585 (0.145-2.366)	0.452
Vascular access details		
Permanent access	0.377 (0.097-1.459)	0.158
Prior vascular access	0.479 (0.126-1.822)	0.280
Angioplasty	-	-
Thrombosis	0.364 (0.063-2.115)	0.260
Access failure	**0.056 (0.005-0.693)**	**0.025**
Hospitalization		
Number	1.101 (0.843-1.438)	0.480
Nonvascular access-related	0.000 (0.000-0.000)	1.000
Vascular access-related	0.000 (0.000-0.000)	1.000

Abbreviations: ESKD, end-stage renal disease; HD, hemodialysis.

Table IV. Odds ratio for thrombosis outcome and patient's characteristics.

	Thrombosis	
Characteristics [8 patients]	OR (95% CI)	P-value
Age	1.028 (0.969-1.091)	0.359
Gender	1.579 (0.352-7,092)	0.551
Clinical Frailty Scale	0.484 (0.095-2.464)	0.382
Causes of ESKD		
Diabetes	2.100 (0.197-22.330)	0.538
Glomerulonephritis	0.000 (0.000-0.000)	0.999
Obstructive/urological	0.000 (0.000-0.000)	0.999
Vascular	3.500 (0.177-69.339)	0.411
ADPKD	8.400 (0.701-100.595)	0.093
Hereditary non-ADPKD	0.000 (0.000-0.000)	0.999
Systemic	0.000 (0.000-0.000)	0.999
Multifactorial	0.000 (0.000-0.000)	0.999
Comorbidities		
Diabetes	0.457 (0.102-2.056)	0.308
Heart failure	1.353 (0.254-7.218)	0.723
Coronary artery disease	2.250 (0.259-19.540)	0.462
Cerebrovascular disease	0.969 (0.107-8.819)	0.978
Peripheral arterial disease	0.355 (0.075-1.676)	0,191
Malignancy	0.000 (0.000-0.000)	1.000
Serum biochemical values		
Creatinine	1.134 (0.885-1.454)	0.321
Cystatin C	1.094 (0.418-2.864)	0.854
Hemoglobin	1.126 (0.700-1,812)	0.624
Albumin	3.385 (0.732-15.660)	0.119
HD starting		
Inpatient	0.429 (0.095-1.932)	0.270
Vascular access details		
Permanent access	1.074 (0.238-4.840)	1.074
Prior vascular access	4.109 (0.479-35.219)	0.197
Angioplasty	0.364 (0.061-2.115)	0.260
Thrombosis	0.000 (0.000-0.000)	1.000
Access failure	0.000 (0.000-0.000)	1.000
Hospitalization		
Number	0.000 (0.000-0.000)	1.000
Nonvascular access-related	0.000 (0.000-0.000	1.000
Access-related	0.000 (0.000-0.000)	1.000

Abbreviations: ESKD, end-stage renal disease; HD, hemodialysis.

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