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Pre-dialysis care trajectory and post-dialysis survival and transplantation access in patients with end-stage kidney disease

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Authors' Contribution

The project administrator is Sahar Bayat. The data was prepared by Maxime Raffray. The methodology was discussed with Juliette Piveteau, Maxime Raffray, Cécile Couchoud, Cécile Vigneau and Sahar Bayat.

Juliette Piveteau did the analyses and wrote the main text of the manuscript. All authors reviewed the manuscript.

Abstract

Background: The pre-dialysis care trajectory impact on post-dialysis outcomes is poorly known. This study assessed survival, access to kidney transplant waiting list and to transplantation after dialysis initiation by taking into account the patients' pre-dialysis care consumption (inpatient and outpatient) and the conditions of dialysis start: initiation context (emergency or planned) and vascular access type (catheter or fistula).

Methods: Adults who started dialysis in France in 2015 were included. Clinical data came from the French REIN registry and data on the care trajectory from the French National Health Data system (SNDS). The Cox model was used to assess survival and access to kidney transplantation.

Results: 8856 patients were included with a mean age of 68 years. Survival was shorter in patients with emergency or planned dialysis initiation with a catheter compared with patients with planned dialysis with a fistula. The risk of death was lower in patients who visited the nephrologist more than once in the 6 months before dialysis than in those who visited only once. The rate of kidney transplant receipt at year 1 post-dialysis was lower for patients with emergency or planned dialysis initiation with a catheter (respectively HR=0.5 [0.4 ; 0.8] and HR=0.7 [0.5 ; 0.9]) compared with patients with planned dialysis start with a fistula. Patients who visited the nephrologist more than three times between 0 and 6 months before dialysis start were more likely to access to the waiting list 1 and 3 years after dialysis start (respectively HR=1.3 [1.1 ; 1.5] and HR=1.2 [1.1 ; 1.4]).

Conclusions: Nephrological follow-up in the year before dialysis initiation is associated with better survival and higher probability of access to kidney transplantation. These results emphasize the importance of early patient's referral to nephrologists by general practitioners.

Keywords: care trajectory, dialysis, end-stage renal disease, kidney transplantation, survival

Introduction

Chronic kidney disease (CKD) is defined as "*the presence of markers of kidney damage or a decrease in estimated glomerular filtration rate (eGFR) below 60ml/min/1.73m² for more than 3 months, regardless of its cause*"(1,2). The last of the five CKD stages is end-stage kidney disease (ESKD). CKD is a silent disease that slowly progresses over months or years, and signs/symptoms often appear only at the last stage. Patients with ESKD can be managed with kidney replacement therapy (KRT): hemodialysis, peritoneal dialysis, or kidney transplantation. Some patients do not receive KRT, but only conservative or palliative treatments.

In the United States of America (USA), ESKD incidence started to decrease between 2006 and 2019 (3) and in Europe between 2008 and 2011 (4). However, in France, the overall age- and sex-standardized incidence has been steadily increasing between 2012 and 2017 (1% of increase per year) (5). According the French National Renal Epidemiology and Information Network (REIN) registry, which collects data on patients with ESKD starting KRT, 11,437 new patients started KRT in 2019, and at the end of that year, 50,501 patients were on dialysis and 41,374 had a functioning graft (5).

As patients with CKD often have associated pathologies, their management is complex (6) and implicates different healthcare professionals. The transition period to dialysis (i.e. the pre-dialysis care trajectory) requires significant preparation and therapeutic education of the patient. Collaboration among the involved health professionals, particularly between nephrologist and general practitioner (GP), is essential to start dialysis in optimal conditions and to reduce the recourse to emergency dialysis. The REIN registry defines emergency dialysis initiation as "*dialysis started within 24 hours after the nephrologist's assessment because of a vital risk for the patient*" (7). Recommendations on CKD management have been published internationally and also in France (1,8). However, between 20% and 60% of patients start dialysis in an unplanned manner (5,9,10). In France, in 2019, 25% of patients in the REIN registry started dialysis in emergency (5). Yet, starting dialysis in emergency increases the risk of morbidity and mortality, decreases the quality of life, and increases the dialysis-related hospitalization length (11–16). Nevertheless, most studies on the post-dialysis outcomes (survival and/or access to

transplantation) did not take into account the pre-dialysis care trajectory or included only few elements of the care trajectory and the access type (fistula or catheter) (17–19). Few studies carried out in the USA, Australia, Japan, Canada, South Korea and the Netherlands assessed the association between late or early pre-dialysis referral to a nephrologist and patient survival. Their definition of late referral differed: first consultation with a nephrologist at 3 months (20,21), 4 months (22,23), 6 months (24–26), or 1 year (27) before dialysis initiation. They all found that the risk of death was higher in patients with late referral (independently of its definition) than in those who saw a nephrologist early before dialysis initiation. Moreover, an USA study on veterans showed that frequent pre-dialysis monitoring of laboratory parameters is associated with better survival at 1 year after dialysis initiation (28). Few studies investigated starting dialysis with a central venous catheter (CVC), and all found that it is associated with higher complication (17) and mortality rates compared with starting dialysis with a fistula (18,19,29).

Therefore, the objectives of this study were identify the determinants of (i) the survival of patients at 6 months, 1 year, and 3 years after dialysis initiation by taking into account the pre-dialysis care trajectory and the conditions of dialysis start; (ii) the access to the kidney transplant waiting list (from living or deceased donors) and to transplantation at 1 year and 3 years after dialysis initiation again by taking into account the pre-dialysis care trajectory and the conditions of dialysis start.

Materials and methods

Study population

For this retrospective study, all ≥ 18 -year-old patients with ESKD who initiated dialysis in France in from 01/01/2015 to 12/31/2015, followed through 01/31/2018, were extracted from the French national REIN registry that collects the data of all patients starting KRT in France (30).

Data studied

Three categories of data were included in this study: patients' characteristics (socio-demographic, bioclinical), dialysis initiation data (conditions and vascular approach) and pre-dialysis care consumption.

The data came from two databases:

i) The REIN registry that collects socio-demographic and clinical data, comorbidities, and KRT type. The following data at dialysis initiation were extracted: sex, age, employment status (inactive : student, retired, at home; active: unemployed, full-time and part-time employed), clinical and laboratory data [body mass index (BMI), albuminemia, hemoglobin, eGFR, nephropathy type (acute, chronic, unknown) , mobility (total incapacity, need of help, autonomous), cirrhosis, active cancer, diabetes, chronic respiratory disease, behavioral disorders, number of cardiovascular diseases], dialysis modality (hemodialysis, peritoneal dialysis), use of stand-alone dialysis (home and out-center hemodialysis, nonassisted peritoneal dialysis), conditions of dialysis initiation (emergency or planned), and vascular approach (catheter or fistula). A four-modality variable that summarizes the dialysis initiation condition was created by combining access type (catheter or fistula) and emergency or planned initiation.

ii) the French National Health Data System (SNDS) database that contains reimbursement data for ambulatory care consumption and hospital activity of 99% of the French population. As the REIN registry does not contain pre-dialysis information, the SNDS data were used to determine the pre-dialysis care trajectory (i.e. the healthcare consumption) of each patient. Using a previously described deterministic matching method (31), data from the SNDS database were matched with the data extracted from the REIN registry for patients who started dialysis in 2015. Based on previously published work on pre-dialysis care trajectories (32) the following variables were extracted from the SNDS database to define the pre-dialysis care trajectory : number of consultations with the GP, nephrologist, other specialists; number of blood creatinine measurements; number of hospital stays of more than 24 hours for kidney or other problems; hospital stays to prepare for dialysis (based on International Classification of Diseases codes) and ambulatory stays (<24 hours, all diagnoses) during the year before dialysis initiation. The number of consultations with a nephrologist in the penultimate (between 6 and 12 months before dialysis start) and final pre-dialysis semester (between 0 and 6 months before dialysis start) was specified.

Patients were excluded from the study if matching with the SNDS database was not possible, and in the absence of data on dialysis initiation (emergency or planned) or on the pre-dialysis care trajectory.

Statistical analysis

The patients' sociodemographic, clinical and laboratory characteristics at dialysis initiation, the context of dialysis initiation, and the pre-dialysis care consumption were described using categorical variables (numbers and percentages). The characteristics of patients with emergency and planned dialysis initiation were compared using the χ^2 test.

Missing data were processed using the multiple imputation by chained equations procedure with ten iterations repeated five times to obtain five imputed datasets (33). The events of interest, extracted from the REIN registry, were (i) survival at 6 months, 1 year, and 3 years after dialysis initiation, (ii) access to the kidney transplant waiting list at 1 year and 3 years after dialysis initiation, and (iii) access to kidney transplantation (receipt of a transplant) at 1 year and 3 years after dialysis initiation. Kaplan-Meier survival curves were plotted. In this study, we had an etiological approach to identify the determinants of the events of interest. The use of Cox models is recommended in etiological studies and using Fine & Gray in predictive studies (34–36). Univariate and multivariate Cox models were used to assess the association between patient characteristics, pre-dialysis care trajectory, dialysis initiation conditions, and events of interest. Patients registered on the waiting list before the initiation of dialysis will be considered waitlisted at dialysis start. Kidney transplantation was censored in the survival model, and death was censored in the transplantation models. Variables with a p-value < 0.20 in univariate models were included in the multivariable models. We used stepwise process to obtain our multivariable models. As sensitivity analysis, we performed also the Fine & Gray competing risk models. Statistical analyses were performed with the R 4.0.2 software, and tests were considered significant when the p-value was lower than 5%. This study was approved (agreement number DR-2017-119) by the CNIL (Commission Nationale de l'Information et des Libertés).

Results

Description of the study population

In 2015, 10,667 ≥ 18 -year-old patients started dialysis in France, and 8,856 patients were included in the

study after exclusion of patients without match in the SNDS database (90% of patients were matched in the SNDS database) or without data on dialysis initiation and pre-dialysis care consumption (Figure 1).

Among the included patients, 39.7% (N=3514) started dialysis in a planned manner with fistula, 24.9% (N=2206) in a planned manner with catheter, 4.3% (N=378) in emergency with fistula and 25.4% (N=2255) in emergency with catheter. Comparison of their socio-demographic characteristics (Supplemental Table 1), clinical and laboratory characteristics (Supplemental Table 2), comorbidities (Supplemental Table 3), first dialysis characteristics (Supplemental Table 4), and pre-dialysis care consumption (Supplemental Table 5) showed that patients who started dialysis in emergency with catheter had fewer consultations with a GP and nephrologist, fewer creatinine measurements, and more hospital stays for other cause (for a least 24 hours). Conversely, patients who started dialysis in a planned manner with fistula had more hospital stays for dialysis preparation, more ambulatory stays, more stand-alone dialysis, and more peritoneal dialysis.

Patient survival

The overall survival was 92% (95% CI=[91%-92%]) at 6 months, 85% (95% CI=[85%-86%]) at 1 year, and 63% (95% CI=[62%-64%]) at 3 years after dialysis initiation. Compared with patients with planned first dialysis and fistula, the risk of death at 6 months, 1 year and 3 years after dialysis initiation was higher in all the other patients (emergency first dialysis with fistula or catheter and planned first dialysis with catheter) (Figure 2).

The multivariate Cox models (Table 1) showed that for the whole population, the risk of death was higher for patients with than without comorbidities. Conversely, the risk of death was lower for patients who saw a nephrologist more than once in the 6 months before dialysis than for patients who saw a nephrologist only once. Other factors associated with higher risk of death at 1 year were >12 blood creatinine measurements and >1 all-cause hospital stays (inpatient/ambulatory) in the year before dialysis (Table 1). The results of the Fine & Gray analyses were similar to those of Cox models.

Registration on the kidney transplant waiting list

One year after dialysis initiation, 20% of patients were on the kidney transplant waiting list, and 28% at 3 years. The multivariate Cox models (Table 2) showed that compared with patients with planned first

dialysis with a fistula, patients with catheter-based dialysis (emergency and planned) were less likely to be on the waiting list at 1 year after dialysis initiation. For the whole population, patients with comorbidities were less likely to be waitlisted. Patients who saw a nephrologist more than twice in the pre-dialysis year (HR=1.3 95% CI=[1.1-1.5] for the penultimate semester and HR=1.3 95% CI %=[1.1-1.5] for the final semester before dialysis) and who had at least one ambulatory stay (HR=1.6 95% CI=[1.4-1.8]) were more likely to be on the transplant waiting list at 1 year after dialysis initiation. Conversely, the probability of being on the waiting list at 1 year after dialysis initiation was lower for patients with >7 visits to the GP (HR=0.7 95% CI=[0.6-0.8]), who did not see a nephrologist (HR=0.8 95% CI=[0.7-0.9] for the penultimate semester and HR=0.8 95% CI=[0.6-0.9] for the final semester pre-dialysis), with at least one hospital stay for kidney problems (HR=0.8 95% [CI=0.7-0.9]), or for other causes (HR=0.8 95% CI=[0.6-0.9]) in the year before dialysis. The results of the Fine & Gray analyses were similar to those of Cox models.

Access to kidney transplantation

One year after dialysis start, 4% of patients had a kidney transplant, and 14% at 3 years. The multivariate Cox models (Table 3) showed that patients who started dialysis with a catheter (emergency or planned) were less likely to undergo kidney transplant at 1 year after dialysis initiation than those with planned dialysis and a fistula. Overall, the probability to undergo transplantation 1 year after dialysis initiation was lower for patients with comorbidities, and higher for patients who saw a nephrologist more than twice in the last 6 months before dialysis initiation (HR=1.8 95% CI=[1.2-2.6]). Conversely, patients who, in the year before starting dialysis, saw their GP >7 times (HR=0.6 95% CI=[0.5-0.8]) and who had >1 hospital stay for other causes (HR=0.2 95% CI=[0.1-0.5]) had a lower probability of receiving a kidney transplant at 1 year after dialysis initiation. Three years after dialysis start, the probability of accessing to transplantation was still lower for patients with emergency first dialysis with a catheter than for those with planned first dialysis with fistula. The results of the Fine & Gray analyses were similar to those of Cox models.

Discussion

In this study, we investigated the impact of pre-dialysis care trajectory including preparation of patients by nephrological team, on the post-dialysis outcomes (survival, registration on the kidney transplant waiting list, access to kidney transplantation) in France, by taking into account the conditions of dialysis initiation (in emergency or planned) combined with the vascular approach (fistula, catheter). We found that the risk of death (at 6 months, 1 year and 3 years) was higher in patients who started dialysis in emergency and in those who had a planned initiation with a catheter compared with patients with planned start and a fistula. Patients with planned dialysis with a catheter had a lower probability to be registered on the kidney transplant waiting list 1 year and 3 years after dialysis start and to be transplanted 1 year after dialysis initiation compared to patients who started with planned dialysis with a fistula. Patients who started dialysis in emergency with catheter had also a lower probability to be registered on the waiting list in the year after dialysis start and to be transplanted 1 year and 3 years after dialysis. In addition, consultations with a nephrologist were associated with a lower risk of death and higher access to the kidney transplant waiting list and transplantation, whatever the dialysis initiation conditions.

The definition of emergency dialysis initiation is still debated and there is no international consensus. Indeed, there are several approaches to define emergency initiation. The first focuses on the notion of "planned" dialysis (11,37,38). The second focuses on the access routes at dialysis start: CVC (defined as suboptimal) and arteriovenous fistula (synonymous of planned dialysis). (39–46). The third definition, used in Canada and the United States, concerns the place of dialysis initiation: inpatient or outpatient settings (15,47–51). Moreover, despite the presence of a long pre-dialysis follow-up dialysis may start in emergency because of an acute decompensation specially for old patients having several comorbidities. To refine the context of dialysis initiation, we combined the vascular access with the dialysis initiation mode. This allowed us to highlight that starting dialysis in emergency or with a catheter leads to poorer post-dialysis outcomes (survival and access to kidney transplantation) compared with planned start with a fistula.

The literature, particularly previous studies by our group, showed that patients starting dialysis in

emergency are at higher risk of death than patients with planned first dialysis (9,14,52). Other authors also showed that CVC use is independently associated with poorer 3-year survival (14). However, this previous study focused only on the vascular access and did not consider the dialysis initiation modality. A recent work showed that starting dialysis with a CVC is an independent predictor of mortality, whereas starting dialysis in the emergency department had only a marginal effect (53). This fact could be due to an increased risk of infections and bleeding in patients using CVC. Our results confirmed that starting with a CVC increases mortality. Conversely, we found that survival (6-months, 1-year and 3-years post-dialysis start) was worse in patients who started dialysis in emergency with fistula than in patients with planned first dialysis with a fistula. This suggests that the emergency or unplanned start, probably due to an acute precipitating factor, influences survival. The few studies on pre-dialysis care consumption showed that the risk of death is higher for patients who consulted a nephrologist late compared with patients who consulted early (20–27). These studies were mainly interested in the interval between the first specialist consultation and dialysis start. An American study showed that frequent creatinine, potassium, and hemoglobin testing before the transition to ESRD is associated with better 1-year survival post-dialysis (28). However, the patients included in this study were American men veterans and therefore, the results cannot be generalized. Here, we studied the number of visits to a nephrologist and GP, and hospitalizations in the last pre-dialysis year and found several factors (e.g. consulting a nephrologist, hospital stays) that influenced survival. Indeed, consulting a nephrologist is associated with a better survival, this result confirms the importance of the collaboration between GPs and nephrologists and the early referral.

At 1-year post-dialysis initiation, access to the waiting list was lower for patients who started dialysis with a catheter. This primarily reflects a delay in the waiting list registration. However, access to the kidney transplant waiting list at 1-year and, also at 3-years post-dialysis start was lower for patients with planned first dialysis with a catheter compared with patients with emergency first dialysis with a fistula. We hypothesize that patients in the first group were seen very late by a nephrologist and therefore, a fistula could not be done. These patients could also have needed a catheter due to poor vascular access.

Therefore, preparation for replacement therapy (consulting a nephrologist, having a fistula and starting dialysis in a planned manner) improves patient access to waiting list regardless of the patient's comorbidities. These findings show that an effective collaboration between GPs and nephrologists and an early referral to nephrologist are crucial for improving the quality of ESKD patients care. Moreover, the access to transplantation at 1-year post-dialysis initiation was lower for patients with first dialysis with a catheter and at 3-years for patients with emergency first dialysis with a catheter compared with patients with emergency first dialysis with a fistula. Frequent consultations with GP were associated with lower access to the waiting list and to the kidney transplantation. However, it was shown that socio-economic status is associated with use of health care services (54). Moreover, several studies showed that individual socioeconomic factors or neighborhood deprivation level are associated with the access to the waiting list or transplantation (55–57). Indeed, a recent French study showed an association between social deprivation, estimated by the European Deprivation Index, and early registration on the kidney transplant waiting list (before dialysis and six months after dialysis initiation) (58). The level of health literacy can also influence the possibility to be on the waiting list and to be transplant as soon as possible (59,60). In this study, we did not have data on individual or neighborhood social deprivation level. These factors could explain partly our results. More analyses including socio-economic variables will allow identifying patients' subgroups or geographical areas with less survival or access to transplantation. The specific public health interventions could be implemented in these areas or for these subgroups in order to improve patients' survival and access to transplantation.

One of the strengths of this study is the combination of data from the SNDS and the REIN registry. These data allowed us to have information on the patients' clinical and biological characteristics at dialysis initiation and also on the pre-dialysis care consumption, particularly on hospital stays (causes and duration) and nephrologists consultations. Another strength of this study was to analyze the context of dialysis initiation by combining the vascular approach and emergency versus planned start.

The first limitation of our study is the difficulty to compare our results on dialysis initiation, especially because there is no international consensus on the definition. Second, we did not study drug

consumption. Third, we did not have information on the patients' socio-economic status, such as socio-professional category or neighborhood social deprivation level, well-known to be associated with access to health care and survival. Fourth, we used data from incident patients in 2015, because we needed to know their access to kidney transplantation in the next 3 years after dialysis initiation. However, the REIN reports (5) show that the patient characteristics of the 2015 cohort are not different from those of more recent incident cohorts. Finally, our results may not be generalizable to the countries where there is no universal healthcare.

Conclusion

This study allowed us to obtain insights into the patients' pre-dialysis care consumption and to show that consultations with a nephrologist/GP and pre-dialysis hospital stays are associated with the post-dialysis initiation outcomes (survival and access to kidney transplantation). The association of frequent follow-up by GPs and less access to transplantation points out the effectiveness of collaboration between GP and nephrologists. Therefore, this collaboration should be promoted to better monitor patients with CKD and to better prepare them for KRT. This might reduce the number of patients who will start dialysis in emergency or with a catheter and improve their survival and access to kidney transplantation.

Disclosure and conflicts of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest. The results presented in this paper have not been published previously in whole or part, except in abstract format.

Ethics approval and consent to participate

The restrictions due to French Personal data protection regulation (CNIL) prohibit the authors from making the minimal data set publicly available. The French REIN registry that received the agreement by the CNIL (Commission Nationale de l'Information et des Libertés) in 2010 (agreement number: 903188 Version 3). All involved subjects received an information leaflet before giving their verbal consent to participate. This procedure was approved by the ethics committee.

Data Availability Statement

The access to the data of the REIN implies the approval by the REIN scientific board which analyses each request. Information about the data of the REIN registry can be requested by mail to Dr. Cécile Couchoud who manages the REIN registry at the French Biomedicine Agency (cecile.couchoud@biomedecine.fr).

Supplemental Material

Supplemental Table 1: Socio-demographic characteristics (data before imputation) of patients who started dialysis in France in 2015 in function of the dialysis initiation (planned or in emergency) and vascular access (with fistula or catheter).

Supplemental Table 2: Clinical and biological characteristics (data before imputation) of patients who started dialysis in France in 2015 in function of the dialysis initiation (planned or in emergency) and vascular access (with fistula or catheter).

Supplemental Table 3: Comorbidities (data before imputation) of patients who started dialysis in France in 2015 in function of the dialysis initiation (planned or in emergency) and vascular access (with fistula or catheter).

Supplemental Table 4: Dialysis characteristics (data before imputation) of patients who started dialysis in France in 2015 in function of the dialysis initiation (planned or in emergency) and vascular access (with fistula or catheter).

Supplemental Table 5: Healthcare consumption (data before imputation) of patients who started dialysis in France in 2015 in function of the dialysis initiation (planned or in emergency) and vascular access (with fistula or catheter).

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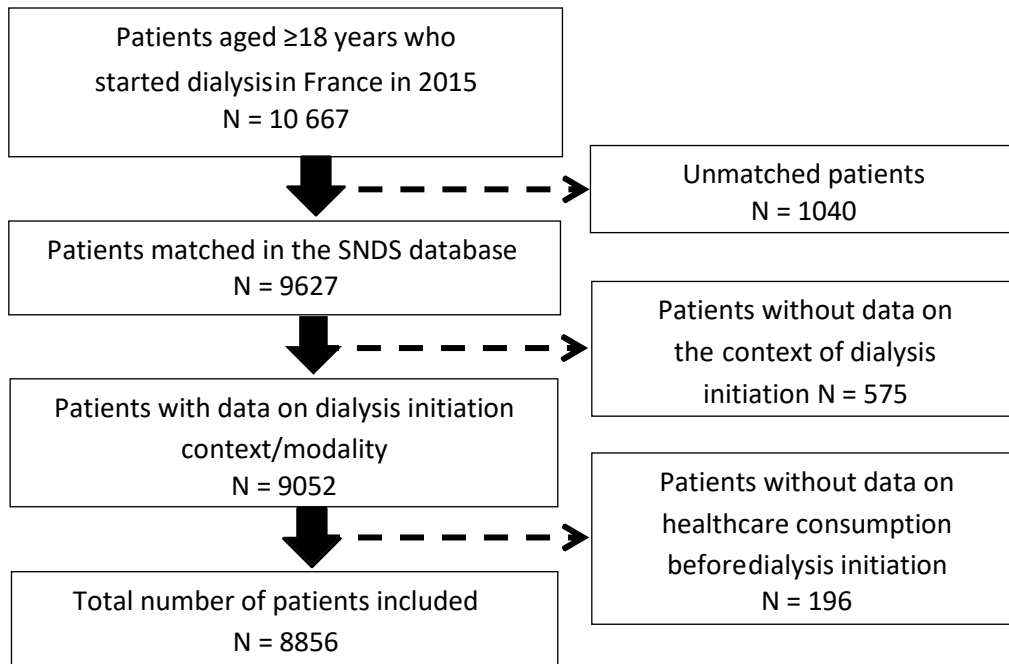


Figure 1. Flowchart of patient selection; SNDS, French National Health Data System

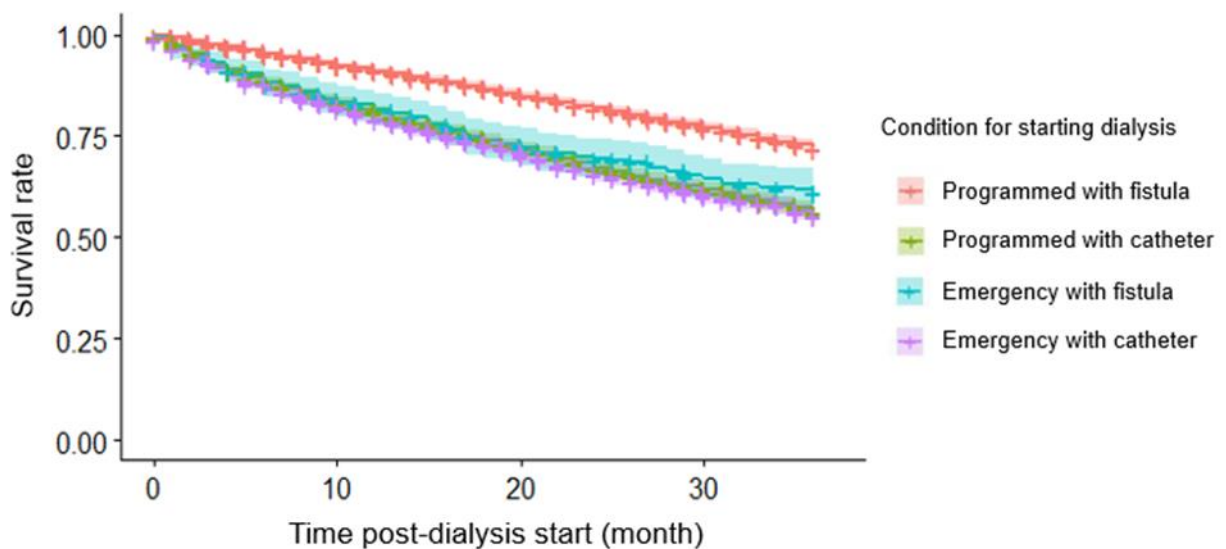


Figure 2. Unadjusted crude Kaplan-Meier survival curves at year 3 after dialysis initiation in function of the dialysis initiation conditions (planned or in emergency) and of the vascular access (fistula or catheter).

Table 1. Association of patient-related variables and care consumption variables with risk of death at 6 months, 1 year, and 3 years after dialysis initiation (multivariate Cox model adjusted on patient characteristics, pre-dialysis care trajectory, dialysis initiation conditions; N=8856; 2636 patients were dead at year 3 post-dialysis initiation)

| Variable | Risk of death at 6 months HR [95% CI] ¹ | Risk of death at 1 year HR [95% CI] ¹ | Risk of death at 3 years HR [95% CI] ¹ |
|--|---|---|--|
| Dialysis initiation and vascular access | | | |
| Planned dialysis with fistula | - | - | - |
| Planned dialysis with catheter | 1.7 [1.3 ; 2.1] | 1.4 [1.2 ; 1.7] | 1.4 [1.2 ; 1.5] |
| Emergency dialysis with fistula | 1.7 [1.2 ; 2.4] | 1.4 [1.1 ; 1.8] | 1.2 [1.1 ; 1.5] |
| Emergency dialysis with catheter | 1.7 [1.4 ; 2.1] | 1.4 [1.2 ; 1.7] | 1.4 [1.3 ; 1.6] |
| Sex | | | |
| Women | - | - | - |
| Men | 1.1 [0.9 ; 1.3] | 1.0 [0.9 ; 1.1] | 1.1 [1.0 ; 1.2] |
| Age | | | |
| 18 - 45 years | - | - | - |
| 45 - 60 years | 4.6 [1.7 ; 13.0] | 3.3 [1.7 ; 6.1] | 4.3 [2.8 ; 6.7] |
| 60 - 75 years | 6.3 [2.3 ; 17.6] | 4.5 [2.4 ; 8.4] | 5.7 [3.7 ; 8.8] |
| ≥ 75 years | 9.5 [3.4 ; 26.4] | 6.9 [3.7 ; 12.8] | 9.4 [6.1 ; 14.5] |
| BMI² | | | |
| 23 - 24 | - | - | - |
| ≤ 18.5 | - | 1.5 [1.1 ; 2.0] | 1.5 [1.2 ; 1.9] |
| 18,5 - 22 | - | 1.0 [0.8 ; 1.2] | 1.0 [0.9 ; 1.2] |
| 25 - 29 | - | 0.9 [0.7 ; 1.1] | 0.9 [0.8 ; 1.0] |
| ≥ 30 | - | 0.8 [0.6 ; 1.0] | 0.9 [0.8 ; 0.9] |
| Employment | | | |
| Not active | - | - | - |
| Active | 0.4 [0.2 ; 0.9] | 0.5 [0.3 ; 0.8] | 0.7 [0.5 ; 0.9] |
| Albuminemia | | | |
| ≤ 30 g/L | - | - | - |
| ≥ 30 g/L | 0.5 [0.4 ; 0.7] | 0.6 [0.5 ; 0.7] | 0.7 [0.7 ; 0.8] |
| eGFR | | | |
| 5 – 9 ml/min/1.73m ² | - | - | - |
| ≤ 5 ml/min/1.73m ² | - | 1.1 [0.9 ; 1.3] | 1.0 [0.9 ; 1.1] |
| 10 – 14 ml/min/1.73m ² | - | 1.1 [1.0 ; 1.3] | 1.2 [1.1 ; 1.3] |
| 15 – 19 ml/min/1.73m ² | - | 1.4 [1.0 ; 1.8] | 1.3 [1.1 ; 1.6] |
| ≥ 20 ml/min/1.73m ² | - | 1.2 [1.0 ; 1.5] | 1.2 [1.1 ; 1.4] |
| Mobility | | | |
| Total incapacity | - | - | - |
| Needs help | 0.5 [0.4 ; 0.6] | 0.6 [0.5 ; 0.7] | 0.7 [0.6 ; 0.8] |
| Autonomous walking | 0.2 [0.2 ; 0.3] | 0.3 [0.3 ; 0.4] | 0.5 [0.4 ; 0.5] |

| | | | |
|---|------------------------|------------------------|------------------------|
| Nephropathy type | | | |
| Acute | - | - | - |
| Chronic | - | - | 0.9 [0.8 ; 0.9] |
| Unknown | - | - | 0.9 [0.8 ; 1.1] |
| Dialysis modality | | | |
| Peritoneal Dialysis | - | - | - |
| Hemodialysis | - | - | 0.6 [0.5 ; 0.7] |
| Stand-alone dialysis | | | |
| No | - | - | - |
| Yes | - | 0.7 [0.6 ; 1.0] | 0.7 [0.6 ; 0.8] |
| Cirrhosis | | | |
| No | - | - | - |
| Yes | 2.0 [1.5 ; 2.8] | 2.3 [1.8 ; 2.9] | 2.0 [1.7 ; 2.4] |
| Cancer | | | |
| No | - | - | - |
| Yes | 1.9 [1.6 ; 2.3] | 2.0 [1.8 ; 2.3] | 1.8 [1.6 ; 2.0] |
| Chronic respiratory disease | | | |
| No | - | - | - |
| Yes | - | 1.2 [1.1 ; 1.4] | 1.2 [1.1 ; 1.3] |
| Number of cardiovascular diseases | | | |
| 0 | - | - | - |
| 1 | 1.3 [1.1 ; 1.6] | 1.3 [1.1 ; 1.5] | 1.3 [1.2 ; 1.5] |
| 2 | 1.4 [1.1 ; 1.7] | 1.4 [1.2 ; 1.7] | 1.6 [1.4 ; 1.7] |
| ≥ 3 | 1.7 [1.4 ; 2.2] | 1.7 [1.5 ; 2.1] | 1.8 [1.6 ; 2.0] |
| Behavioral disorder | | | |
| No | - | - | - |
| Yes | - | - | 1.4 [1.1 ; 1.7] |
| Number of visits to a general practitioner in the year before dialysis | | | |
| [1-7] | - | - | - |
| 0 | - | - | 0.9 [0.7 ; 1.1] |
| ≥ 8 | - | - | 1.1 [1.1 ; 1.2] |
| Number of visits to a nephrologist in the 6 months before dialysis | | | |
| 1 | - | - | - |
| 0 | 0.8 [0.7 ; 1.0] | 0.9 [0.8 ; 1.1] | 0.9 [0.8 ; 1.0] |
| 2 | 0.6 [0.5 ; 0.8] | 0.7 [0.6 ; 0.9] | 0.9 [0.8 ; 0.9] |
| ≥ 3 | 0.6 [0.4 ; 0.7] | 0.6 [0.5 ; 0.8] | 0.8 [0.7 ; 0.9] |
| Number of creatinine measurements in the year before dialysis | | | |
| [1-12] | - | - | - |
| 0 | - | 1.1 [0.9 ; 1.4] | 1.0 [0.9 ; 1.2] |
| ≥ 13 | - | 1.2 [1.1 ; 1.4] | 1.2 [1.1 ; 1.3] |
| Hospital stays for kidney problems in the year | | | |

| | | | |
|--|-----------------|-----------------|-----------------|
| before dialysis | | | |
| 0 | - | - | - |
| 1 | - | 1.1 [1.0 ; 1.4] | 1.1 [0.9 ; 1.2] |
| ≥ 2 | - | 1.2 [1.1 ; 1.4] | 1.1 [1.1 ; 1.2] |
| Hospital stays for other problems in the year before dialysis | | | |
| 0 | - | - | - |
| 1 | 1.1 [0.9 ; 1.4] | 1.1 [0.9 ; 1.3] | 1.1 [1.0 ; 1.2] |
| ≥ 2 | 1.4 [1.2 ; 1.8] | 1.3 [1.1 ; 1.5] | 1.3 [1.1 ; 1.4] |
| Ambulatory stays in the year before dialysis | | | |
| 0 | - | - | - |
| 1 | 1.0 [0.9 ; 1.3] | 1.0 [0.9 ; 1.2] | - |
| ≥ 2 | 1.3 [1.1 ; 1.6] | 1.2 [1.1 ; 1.4] | - |

¹HR, Hazard Ratio; 95% CI, 95% Confidence Interval; ²BMI, Body Mass Index

Table 2. Association of patient variables and care consumption variables with placement on the kidney transplant waiting list at 1 and 3 years after dialysis initiation (multivariate Cox model adjusted on patient characteristics, pre-dialysis care trajectory, dialysis initiation conditions; N=8856; 2524 patients were registered at year 3).

| Variable | On the list at 1 year after dialysis initiation HR [95% CI]¹ | On the list at 3 years after dialysis initiation HR [95% CI]¹ |
|--|--|---|
| Dialysis initiation and vascular access | | |
| Planned dialysis with fistula | - | - |
| Planned dialysis with catheter | 0.8 [0.7 ; 0.9] | 0.9 [0.8 ; 0.9] |
| Emergency dialysis with fistula | 1.0 [0.7 ; 1.2] | 0.9 [0.8 ; 1.2] |
| Emergency dialysis with catheter | 0.7 [0.6 ; 0.8] | 0.8 [0.7 ; 1.0] |
| Sex | | |
| Women | - | - |
| Men | 1.1 [1.0 ; 1.2] | 1.1 [1.1 ; 1.2] |
| Age | | |
| 18 - 45 years | - | - |
| 45 - 60 years | 0.7 [0.6 ; 0.8] | 0.7 [0.6 ; 0.8] |
| 60 - 75 years | 0.4 [0.4 ; 0.5] | 0.4 [0.4 ; 0.5] |
| ≥75 years | 0.03 [0.02 ; 0.04] | 0.03 [0.02 ; 0.04] |
| BMI² | | |
| 23 - 24 | - | - |
| <18.5 | 1.0 [0.7 ; 1.3] | 0.9 [0.7 ; 1.2] |
| 18.5 - 22 | 1.0 [0.8 ; 1.1] | 1.0 [0.8 ; 1.1] |
| 25 - 29 | 1.0 [0.9 ; 1.2] | 1.0 [0.9 ; 1.2] |

| | | |
|---|------------------|-----------------|
| >30 | 0.7 [0.6 ; 0.9] | 0.8 [0.7 ; 0.9] |
| Employment | | |
| Not active | - | - |
| Active | 1.4 [1.2 ; 1.6] | 1.3 [1.2 ; 1.5] |
| Albuminemia | | |
| <30 g/L | - | - |
| ≥30 g/L | 1.3 [1.1 ; 1.6] | 1.2 [1.1 ; 1.4] |
| Hemoglobin | | |
| <10 g/dL | - | - |
| 10 – 11 g/dL | 1.1 [1.0 ; 1.3] | 1.1 [1.1 ; 1.3] |
| ≥12 g/dL | 1.3 [1.1 ; 1.5] | 1.3 [1.2 ; 1.5] |
| Mobility | | |
| Total incapacity | - | - |
| Needs help | 2.2 [0.8 ; 5.8] | 1.4 [0.8 ; 2.3] |
| Autonomous walking | 4.7 [1.9 ; 12.0] | 2.8 [1.8 ; 4.3] |
| Nephropathy type | | |
| Acute | - | - |
| Chronic | - | 1.3 [1.1 ; 1.5] |
| Unknown | - | 1.2 [1.1 ; 1.4] |
| Stand-alone dialysis | | |
| No | - | - |
| Yes | 1.3 [1.1 ; 1.4] | 1.3 [1.1 ; 1.4] |
| Cirrhosis | | |
| No | - | - |
| Yes | 0.6 [0.4 ; 0.9] | - |
| Cancer | | |
| No | - | - |
| Yes | 0.3 [0.3 ; 0.5] | 0.4 [0.3 ; 0.5] |
| Diabetes | | |
| No | - | - |
| Yes | 0.6 [0.6 ; 0.7] | 0.7 [0.6 ; 0.7] |
| Chronic respiratory disease | | |
| No | - | - |
| Yes | 0.8 [0.7 ; 0.9] | 0.8 [0.7 ; 0.9] |
| Number of cardiovascular diseases | | |
| 0 | - | - |
| 1 | 0.7 [0.6 ; 0.8] | 0.8 [0.7 ; 0.8] |
| 2 | 0.6 [0.5 ; 0.7] | 0.6 [0.5 ; 0.7] |
| ≥3 | 0.3 [0.2 ; 0.4] | 0.4 [0.3 ; 0.4] |
| Behavioral disorder | | |
| No | - | - |
| Yes | 0.4 [0.2 ; 0.6] | 0.3 [0.3 ; 0.6] |
| Number of visits to a general practitioner in the year before dialysis | | |

| | | |
|---|------------------------|------------------------|
| [1-7] | - | - |
| 0 | 1.1 [0.9 ; 1.3] | 0.9 [0.8 ; 1.1] |
| ≥8 | 0.7 [0.6 ; 0.8] | 0.7 [0.6 ; 0.8] |
| Number of visits to a nephrologist in the penultimate semester before dialysis | | |
| 1 | - | - |
| 0 | 0.8 [0.7 ; 0.9] | 0.9 [0.8 ; 1.0] |
| 2 | 1.2 [1.1 ; 1.4] | 1.1 [1.0 ; 1.3] |
| ≥3 | 1.3 [1.1 ; 1.5] | 1.2 [1.1 ; 1.4] |
| Number of visits to a nephrologist in the final semester before dialysis | | |
| 1 | - | - |
| 0 | 0.8 [0.6 ; 0.9] | 0.9 [0.7 ; 1.0] |
| 2 | 1.0 [0.8 ; 1.2] | 0.9 [0.8 ; 1.1] |
| ≥3 | 1.3 [1.1 ; 1.5] | 1.2 [1.1 ; 1.4] |
| Hospital stays for kidney problems in the year before dialysis | | |
| 0 | - | - |
| 1 | 1.0 [0.9 ; 1.1] | 1.0 [0.9 ; 1.1] |
| ≥2 | 0.8 [0.7 ; 0.9] | 0.8 [0.8 ; 0.9] |
| Hospital stays for other problems in the year before dialysis | | |
| 0 | - | - |
| 1 | 0.8 [0.7 ; 0.9] | 0.8 [0.7 ; 0.9] |
| ≥2 | 0.8 [0.6 ; 0.9] | 0.8 [0.7 ; 1.0] |
| Ambulatory stays in the year before dialysis | | |
| 0 | - | - |
| 1 | 1.4 [1.2 ; 1.5] | 1.3 [1.2 ; 1.4] |
| ≥2 | 1.6 [1.4 ; 1.8] | 1.4 [1.3 ; 1.6] |

¹HR, Hazard Ratio; 95% CI, 95% Confidence Interval; ²BMI, Body Mass Index

Table 3. Association of patient variables and care consumption variables with access to kidney transplantation, 1 and 3 years after dialysis initiation (multivariate Cox model adjusted on patient characteristics, pre-dialysis care trajectory, dialysis initiation conditions; N=8856; 1281 patients had a kidney transplant at 3 years)

| Variable | Access to transplant 1 year after dialysis start HR [95% CI] ¹ | Access to transplant 3 years after dialysis start HR [95% CI] ¹ |
|--|--|---|
| Dialysis initiation and vascular access | | |
| Planned dialysis with fistula | - | - |

| | | |
|--|--------------------------|---------------------------|
| Planned dialysis with catheter | 0.7 [0.5 ; 0.9] | 1.0 [0.9 ; 1.2] |
| Emergency dialysis with fistula | 0.9 [0.5 ; 1.5] | 0.9 [0.6 ; 1.2] |
| Emergency dialysis with catheter | 0.5 [0.4 ; 0.8] | 0.8 [0.7 ; 0.9] |
| Sex | | |
| Women | - | - |
| Men | 1.2 [0.9 ; 1.4] | 1.2 [1.0 ; 1.3] |
| Age | | |
| 18 - 45 years | - | - |
| 45 - 60 years | 0.5 [0.4 ; 0.6] | 0.6 [0.5 ; 0.7] |
| 60 - 75 years | 0.3 [0.2 ; 0.4] | 0.4 [0.3 ; 0.5] |
| >75 years | 0.06 [0.04 ; 0.1] | 0.06 [0.05 ; 0.08] |
| BMI² | | |
| 23 - 24 | - | - |
| <18.5 | - | 0.9 [0.6 ; 1.3] |
| 18.5 - 22 | - | 1.1 [0.9 ; 1.3] |
| 25 - 29 | - | 1.0 [0.9 ; 1.2] |
| ≥30 | - | 0.7 [0.6 ; 0.9] |
| Employment | | |
| Not active | - | - |
| Active | - | 1.3 [1.1 ; 1.5] |
| Albuminemia | | |
| <30 g/L | - | - |
| ≥30 g/L | - | 1.3 [1.1 ; 1.6] |
| Hemoglobin | | |
| <10 g/dL | - | - |
| 10 – 11 g/dL | - | 1.1 [0.9 ; 1.2] |
| ≥12 g/dL | - | 1.3 [1.1 ; 1.6] |
| Mobility | | |
| Total incapacity | - | - |
| Needs help | - | 1.8 [0.5 ; 5.7] |
| Autonomous walking | - | 4.6 [1.5 ; 13.9] |
| Stand-alone dialysis | | |
| No | - | - |
| Yes | 1.5 [1.2 ; 1.9] | 1.5 [1.3 ; 1.7] |
| Cancer | | |
| No | - | - |
| Yes | 0.3 [0.1 ; 0.6] | 0.3 [0.2 ; 0.5] |
| Diabetes | | |
| No | - | - |
| Yes | 0.4 [0.3 ; 0.5] | 0.6 [0.5 ; 0.7] |
| Chronic respiratory disease | | |
| No | - | - |
| Yes | 0.5 [0.3 ; 0.9] | 0.8 [0.6 ; 0.9] |
| Number of cardiovascular diseases | | |

| | | |
|---|------------------------|------------------------|
| 0 | - | - |
| 1 | 0.8 [0.6 ; 1.1] | 0.8 [0.6 ; 0.9] |
| 2 | 0.7 [0.4 ; 1.1] | 0.6 [0.5 ; 0.8] |
| ≥3 | 0.5 [0.3 ; 0.9] | 0.5 [0.3 ; 0.6] |
| Behavioral disorder | | |
| No | - | - |
| Yes | - | 0.4 [0.2 ; 0.7] |
| Number of visits to a general practitioner in the year before dialysis | | |
| [1-7] | - | - |
| 0 | 0.9 [0.7 ; 1.4] | 0.8 [0.7 ; 1.0] |
| ≥8 | 0.6 [0.5 ; 0.8] | 0.8 [0.7 ; 0.9] |
| Number of visits to a nephrologist in the penultimate semester before dialysis | | |
| 1 | - | - |
| 0 | - | 0.8 [0.7 ; 0.9] |
| 2 | - | 1.2 [1.1 ; 1.5] |
| ≥3 | - | 1.3 [1.1 ; 1.5] |
| Number of visits to a nephrologist in the final semester before dialysis | | |
| 1 | - | - |
| 0 | 0.8 [0.5 ; 1.2] | - |
| 2 | 1.2 [0.8 ; 1.9] | - |
| ≥3 | 1.8 [1.2 ; 2.6] | - |
| Hospital stays for kidney problems in the year before dialysis | | |
| 0 | - | - |
| 1 | - | 0.9 [0.8 ; 1.1] |
| ≥2 | - | 0.8 [0.7 ; 0.9] |
| Hospital stays for other problems in the year before dialysis | | |
| 0 | - | - |
| 1 | 0.9 [0.7 ; 1.4] | 0.9 [0.7 ; 1.1] |
| ≥2 | 0.2 [0.1 ; 0.5] | 0.7 [0.5 ; 0.9] |
| Ambulatory stays in the year before dialysis | | |
| 0 | - | - |
| 1 | 1.6 [1.3 ; 2.1] | 1.3 [1.1 ; 1.4] |
| ≥2 | 1.5 [1.2 ; 2.0] | 1.4 [1.2 ; 1.6] |

¹ HR, Hazard Ratio; 95% CI, 95% Confidence Interval; ² BMI, Body Mass Index