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Original Article

ORIGINAL ARTICLE

Transfers from home to facility-based dialysis: comparisons of HHD, assisted PD and autonomous PD

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ABSTRACT

Background. Home dialysis therapies such as peritoneal dialysis (PD) and home hemodialysis (HHD) are beneficial for quality of life and patient empowerment. The short technique survival time partly explains their low prevalence. We aimed to assess the risk of transfer to facility-based hemodialysis in patients treated with autonomous PD, assisted PD and HHD.

Methods. This was a retrospective study using data from the REIN registry of patients starting home dialysis in France from 2002 to 2019. The risks of transfer to facility-based hemodialysis (HD) were compared between three modalities of home dialysis (HHD, nurse-assisted PD, autonomous PD) using survival models with a propensity score (PS)-matched and unmatched cohort of patients.

Results. The study included 17 909 patients: 628 in the HHD group, 10 214 in the autonomous PD group, and 7067 in the assisted PD group. During the follow-up period, there were 5347 transfers to facility-based HD. The observed number of transfers was 2458 (13.7%) at 1 year and 5069 (28.3) at 5 years after the start of home dialysis, including 3272 (32%) on autonomous PD, 1648 (23.3%) on assisted PD, and 149 (23.7) on HHD. Owing to clinical characteristics differences, only 38% of HHD patients could be matched to patients from the others group. In the PS-matched cohort, the adjusted Cox model showed no difference in the risk of transfer for assisted PD (cs-HR 1.04, 95% CI 0.75–1.44) or HHD (cs-HR 1.07, 95% CI 0.77–1.48) compared with autonomous PD.

Conclusions. Unlike results from other countries, where nurse assistance is not fully available for PD-associated care, there was no difference in technique survival between autonomous PD, nurse-assisted PD, and HHD in France. This discrepancy may be attributed to our inclusion of a broader spectrum of patients who derive significant benefits from assisted PD.

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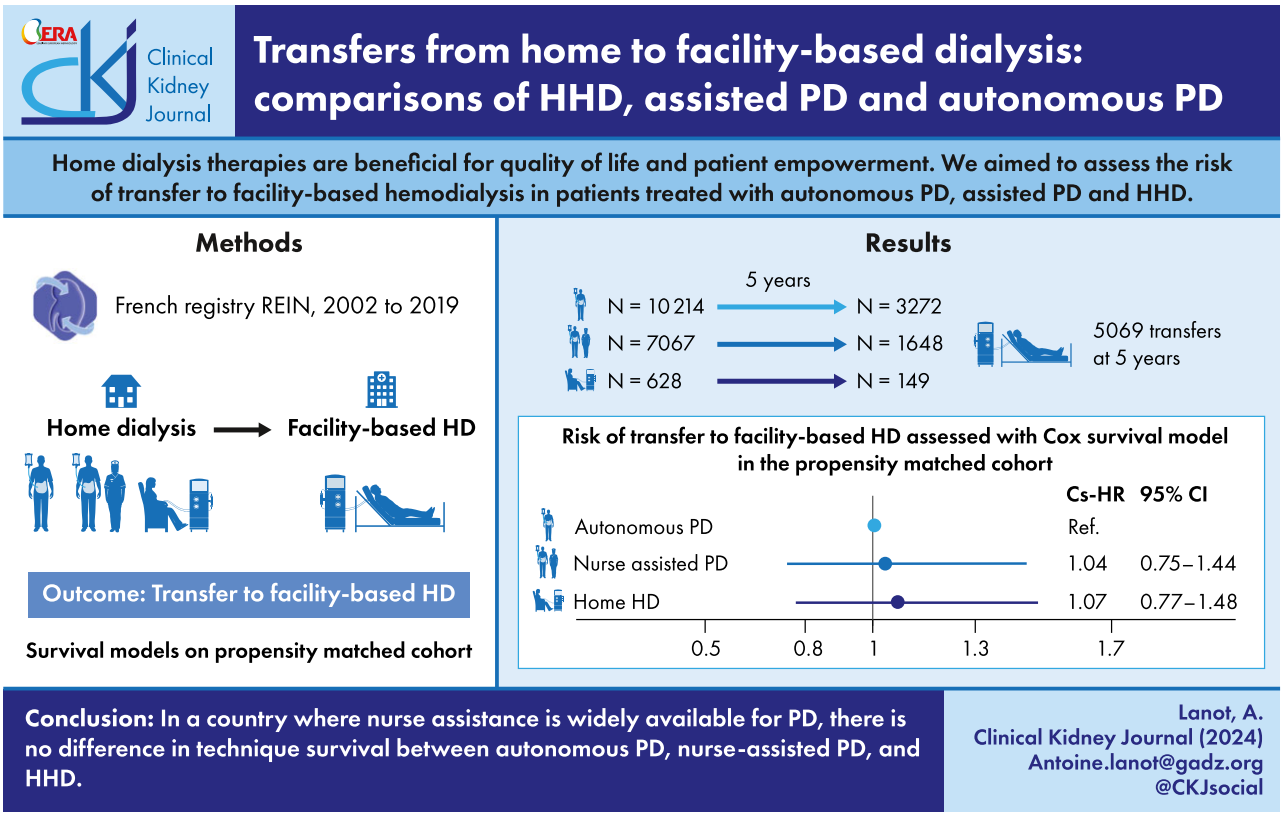
GRAPHICAL ABSTRACT



Keywords: home dialysis, home hemodialysis, nurse assistance, peritoneal dialysis, technique survival

KEY LEARNING POINTS

What was known:

- Home dialysis offers many advantages to patients with end-stage kidney disease in terms of quality of life, patient empowerment, and flexibility.
- These methods remain underutilized worldwide.
- Difference in the risk of transfer to in-facility hemodialysis for peritoneal dialysis and home hemodialysis is not well established.

This study adds:

- The utilization of nurse assistance may facilitate the adoption of home dialysis techniques by a wider range of patients, ultimately leading to improved technique survival.

Potential impact:

- These data support the need to promote reimbursement of nursing assistance for peritoneal dialysis and suggest that the effect of such assistance in home hemodialysis should be investigated in further studies.

INTRODUCTION

Treatments for end-stage kidney disease (ESKD) impose significant constraints on patients [1]. For a patient with ESKD who is willing to be transplanted and who does not have any contraindication, it is widely accepted that renal transplantation is the best treatment [2]. Unfortunately, numerous patients cannot benefit from kidney transplantation, whether because of organ shortages or because of contraindications to transplantation [3]

Therefore, there is a real need to offer a free choice from among the whole panel of dialysis modalities to patients with ESKD. Home dialysis, which encompasses peritoneal dialysis (PD) and home hemodialysis (HHD), affords autonomy, allows more flexibility, and decreases the disease burden in patients treated with dialysis [4–6]. Several studies show an improvement in quality of life associated with home dialysis compared to facility-based hemodialysis [7, 8] Nevertheless, HHD and PD remain underused since only 13% of ESKD patients being treated with home

dialysis worldwide, according to the available data compiled in the USRDS report [9].

Unexpected transfer to facility-based dialysis may affect negatively the quality of life of patient who made the choice to be treated at home. Moreover, the transition period from home dialysis to facility-based hemodialysis is associated with higher mortality and morbidity [10, 11]. Home dialysis technique survival, which can be defined as the time spent on therapy until a transfer to facility-based HD is a major concern for patients on home therapy. Improving technique survival on HHD and PD is one of the top priorities of the nephrologists in charge of home dialysis patients.

Recent studies have suggested that patients on home HD had a longer technique survival than patients on PD [12, 13]. The French health care system provides reimbursement for nurse assistance for PD and coverage for home dialysis expenses. It has been demonstrated that nurse-assisted PD is associated with a lower risk of transfer to facility-based hemodialysis (HD) than self-care PD [14]. By contrast, there is no reimbursement of nurse assistance for HHD care in France. Consequently, one may expect that nurse-assisted PD could decrease or abolish the technique survival difference between PD and HHD.

The first aim of this study was to compare the risk of transfer to facility-based HD between patients treated with autonomous PD (self-care or family assisted), nurse-assisted PD and HHD. The second aim was to evaluate patient survival in these three groups of treatment.

MATERIALS AND METHODS

Data source and study population

This was a retrospective study of prospectively collected data from the Renal Epidemiology and Information Network (REIN) Registry. The REIN is the French national registry of clinical, demographic, and laboratory data of all patients receiving chronic renal replacement therapy [15, 16]. Patients older than 18 years starting home dialysis in France between 1 January 2002 and 31 December 2018 were included in the study. Home dialysis was not necessarily the first renal replacement therapy received. The end of the study period was 31 December 2019.

Definition of variables

The individual characteristics of the population were determined at the time of starting home dialysis. These characteristics were sex, age, body mass index (BMI), presence of diabetes mellitus, primary renal disease, smoking history, peripheral artery disease, heart failure, cirrhosis, cancer, respiratory insufficiency, history of arrhythmia, history of stroke, urgent start of dialysis (defined as the need to start dialysis within 24 hours due to a life-threatening situation), inscription on waiting list for kidney transplantation, and modality of home dialysis separated into autonomous PD (self-care or family assisted), nurse-assisted PD, and HHD. Complementary analyses were performed with home dialysis modality considered as a binary covariate: PD or HHD.

Events of interest and study outcomes

Once a patient has started home dialysis, four outcomes of interest can be observed over time: renal recovery, kidney transplantation, transfer to facility-based HD, and death. The primary outcome was the transfer to facility-based HD for a period of >60 days. The participation time for patients experiencing this event was the time between home dialysis initiation and transfer to facility-based HD. Transfers between HHD and PD were not counted because in those cases, the patients remain on home therapy. Death, kidney transplantation and renal recovery were competing outcomes, and death was specifically studied as a secondary outcome. Outcomes during the first year on home dialysis were also modeled in another analysis, in which the observations were restricted to the first year after home dialysis initiation.

Statistical analysis

This was a retrospective study with an intent to treat analysis. Characteristics of the patients are described as absolute number and percentage. The Kaplan–Meier method was used to draw survival curves and to assess survival times without transfer according to the modality of treatment.

Multivariable analysis

We used Cox models to estimate the cause-specific hazard ratio (cs-HR) of the event of interest, and Fine–Gray models to estimate the subdistribution hazard ratio (sd-HR) to consider the role of competing events in survival analysis [17]. The Cox model provides cause-specific hazard ratio (cs-HR), and thus is used for etiological analyses. In the Fine–Gray model, the hazard function is the probability of the event of interest given that an individual has survived up to time t without any event or has had a competing event before time t. The subdistribution hazard ratio (sd-HR) assessed by the Fine–Gray models is used to estimate the prognostic [17]. It is recommended to report both results [18].

Bivariate regression models were carried out, and covariates associated with the considered outcome with $P < 0.2$ were included in the multivariate models. The threshold for statistical significance in multivariate analysis was set to $P < 0.05$. The proportional hazards assumption was tested graphically and by using Schoenfeld residuals.

Propensity score analysis

The choice of the home dialysis modality is influenced by the patient's characteristics; therefore, we used a propensity score (PS) matching method to reduce the effects of confounding. PS methods aim to unbiasedly estimate the effect of an exposure in presence of confounding. The inspection of the PS distribution between the groups of patients allows to identify areas of non-overlap, whereas in these cases, outcome regression involves extrapolation that may be inappropriate without any means of control [19]. PS matching allows to check the balance of covariates between groups, and like in a randomized experiment, covariate balance is assessed without any access to the outcome [20]. PS methods do not require accurate modeling of the relationship between confounders and outcome; therefore, PS methods are more robust to model misspecification than outcome regression models [21]. However, PS methods have limitations, especially it cannot eliminate residual unmeasured confounding. Furthermore, a reduction in the total sample size of the cohort is expected with PS matching. The external validity of a matched cohort can be limited due to the exclusion of patients with extreme propensity scores with no match. PSs were calculated for each treatment modality. The covariates included in the PS calculation were selected a priori as being those more

Table 1: Characteristics of patients according to the home dialysis modality.

	Autonomous PD (N = 10 214)	Assisted PD (N = 7067)	HDD (N = 628)	Overall (N = 17 909)	P value
Sex					
Male	6392 (62.6%)	3930 (55.6%)	445 (70.9%)	10 767 (60.1%)	<.001
Female	3822 (37.4%)	3137 (44.4%)	183 (29.1%)	7142 (39.9%)	
Age (years)					
18–55	3399 (33.3%)	690 (9.8%)	395 (62.9%)	4484 (25.0%)	<.001
56–70	3067 (30.0%)	1251 (17.7%)	181 (28.8%)	4499 (25.1%)	
71–80	2262 (22.1%)	2144 (30.3%)	44 (7.0%)	4450 (24.8%)	
≥81	1486 (14.5%)	2982 (42.2%)	8 (1.3%)	4476 (25.0%)	
BMI (kg/m^2)					
<20	854 (8.4%)	517 (7.3%)	53 (8.4%)	1424 (8.0%)	.00 157
20–25	3165 (31.0%)	2187 (30.9%)	189 (30.1%)	5541 (30.9%)	
25–30	2717 (26.6%)	1999 (28.3%)	137 (21.8%)	4853 (27.1%)	
30–35	1002 (9.8%)	746 (10.6%)	87 (13.9%)	1835 (10.2%)	
Missing	2476 (24.2%)	1618 (22.9%)	162 (25.8%)	4256 (23.8%)	
Diabetes					
No	6737 (66.0%)	3999 (56.6%)	499 (79.5%)	11 235 (62.7%)	<.001
Yes	3181 (31.1%)	2968 (42.0%)	104 (16.6%)	6253 (34.9%)	
Missing	296 (2.9%)	100 (1.4%)	25 (4.0%)	421 (2.4%)	
Primary renal disease					
PKD	835 (8.2%)	254 (3.6%)	97 (15.4%)	1186 (6.6%)	<.001
Diabetic	1753 (17.2%)	1542 (21.8%)	54 (8.6%)	3349 (18.7%)	
GN	1960 (19.2%)	611 (8.6%)	185 (29.5%)	2756 (15.4%)	
Other	359 (3.5%)	178 (2.5%)	19 (3.0%)	556 (3.1%)	
Systemic	505 (4.9%)	177 (2.5%)	45 (7.2%)	727 (4.1%)	
TIN	482 (4.7%)	289 (4.1%)	44 (7.0%)	815 (4.6%)	
Unknown	1541 (15.1%)	1346 (19.0%)	54 (8.6%)	2941 (16.4%)	
Urologic	407 (4.0%)	195 (2.8%)	43 (6.8%)	645 (3.6%)	
Vascular	2372 (23.2%)	2475 (35.0%)	87 (13.9%)	4934 (27.6%)	
Tobacco					
No	4956 (48.5%)	3482 (49.3%)	303 (48.2%)	8741 (48.8%)	.0606
Yes	3433 (33.6%)	2243 (31.7%)	238 (37.9%)	5914 (33.0%)	
Missing	1825 (17.9%)	1342 (19.0%)	87 (13.9%)	3254 (18.2%)	
PAD					
No	8294 (81.2%)	5206 (73.7%)	557 (88.7%)	14 057 (78.5%)	<.001
Yes	1490 (14.6%)	1596 (22.6%)	45 (7.2%)	3131 (17.5%)	
Missing	430 (4.2%)	265 (3.7%)	26 (4.1%)	721 (4.0%)	
Heart failure					
No	7603 (74.4%)	4284 (60.6%)	550 (87.6%)	12 437 (69.4%)	<.001
Yes	2267 (22.2%)	2619 (37.1%)	55 (8.8%)	4941 (27.6%)	
Missing	344 (3.4%)	164 (2.3%)	23 (3.7%)	531 (3.0%)	
Arrythmia					
No	8167 (80.0%)	4706 (66.6%)	564 (89.8%)	13 437 (75.0%)	<.001
Yes	1644 (16.1%)	2188 (31.0%)	42 (6.7%)	3874 (21.6%)	
Missing	403 (3.9%)	173 (2.4%)	22 (3.5%)	598 (3.3%)	
Stroke					
No	8959 (87.7%)	5883 (83.2%)	560 (89.2%)	15 402 (86.0%)	<.001
Yes	814 (8.0%)	980 (13.9%)	21 (3.3%)	1815 (10.1%)	
Missing	441 (4.3%)	204 (2.9%)	47 (7.5%)	692 (3.9%)	
Cancer					
No	9212 (90.2%)	6367 (90.1%)	532 (84.7%)	16 111 (90.0%)	<.001
Yes	600 (5.9%)	531 (7.5%)	67 (10.7%)	1198 (6.7%)	
Missing	402 (3.9%)	169 (2.4%)	29 (4.6%)	600 (3.4%)	
Respiratory insufficiency					
No	9032 (88.4%)	6074 (85.9%)	560 (89.2%)	15 666 (87.5%)	<.001
Yes	786 (7.7%)	806 (11.4%)	42 (6.7%)	1634 (9.1%)	
Missing	396 (3.9%)	187 (2.6%)	26 (4.1%)	609 (3.4%)	

Table 1: Continued.

	Autonomous PD (N = 10 214)	Assisted PD (N = 7067)	HDD (N = 628)	Overall (N = 17 909)	P value
Cirrhosis					
No	9672 (94.7%)	6695 (94.7%)	594 (94.6%)	16 961 (94.7%)	<.001
Yes	169 (1.7%)	198 (2.8%)	7 (1.1%)	374 (2.1%)	
Missing	373 (3.7%)	174 (2.5%)	27 (4.3%)	574 (3.2%)	
Urgent start					
No	6817 (66.7%)	5766 (81.6%)	442 (70.4%)	13 025 (72.7%)	<.001
Yes	1798 (17.6%)	391 (5.5%)	138 (22.0%)	2327 (13.0%)	
Missing	1599 (15.7%)	910 (12.9%)	48 (7.6%)	2557 (14.3%)	
Waiting list					
No	5133 (50.3%)	5707 (80.8%)	237 (37.7%)	11 077 (61.9%)	<.001
Yes	2025 (19.8%)	458 (6.5%)	148 (23.6%)	2631 (14.7%)	
Missing	3056 (29.9%)	902 (12.8%)	243 (38.7%)	4201 (23.5%)	

BMI: body mass index, PKD: polycystic kidney disease, GN: glomerulonephritis, TIN: tubulo-interstitial nephritis, PAD: peripheral artery disease

Table 2: characteristics of patients matched according to the propensity scores.

	Autonomous PD (N = 233)	Assisted PD (N = 241)	HHD (N = 241)	Overall (N = 715)	P value
Sex					1
Male	154 (66.1%)	160 (66.4%)	160 (66.4%)	474 (66.3%)	
Female	79 (33.9%)	81 (33.6%)	81 (33.6%)	241 (33.7%)	
Age (years)					1
18 to 55	101 (43.3%)	106 (44.0%)	106 (44.0%)	313 (43.8%)	
56 to 70	91 (39.1%)	93 (38.6%)	93 (38.6%)	277 (38.7%)	
71 to 80	35 (15.0%)	36 (14.9%)	36 (14.9%)	107 (15.0%)	
≥ 81	6 (2.6%)	6 (2.5%)	6 (2.5%)	18 (2.5%)	
BMI					1
< 20	85 (36.5%)	85 (35.3%)	88 (36.5%)	258 (36.1%)	
20 to 25	31 (13.3%)	34 (14.1%)	32 (13.3%)	97 (13.6%)	
25 to 30	75 (32.2%)	72 (29.9%)	77 (32.0%)	224 (31.3%)	
30 to 35	42 (18.0%)	50 (20.7%)	44 (18.3%)	136 (19.0%)	
Diabetes					
No	165 (70.8%)	172 (71.4%)	172 (71.4%)	509 (71.2%)	.999
Yes	68 (29.2%)	69 (28.6%)	69 (28.6%)	206 (28.8%)	
Primary renal disease					
PKD	22 (9.4%)	28 (11.6%)	25 (10.4%)	75 (10.5%)	
Diabetic	37 (15.9%)	37 (15.4%)	37 (15.4%)	111 (15.5%)	1
GN	33 (14.2%)	40 (16.6%)	41 (17.0%)	114 (15.9%)	
Other	9 (3.9%)	11 (4.6%)	12 (5.0%)	32 (4.5%)	
Systemic	20 (8.6%)	13 (5.4%)	15 (6.2%)	48 (6.7%)	
TIN	20 (8.6%)	24 (10.0%)	25 (10.4%)	69 (9.7%)	
Unknown	26 (11.2%)	28 (11.6%)	24 (10.0%)	78 (10.9%)	
Urologic	22 (9.4%)	19 (7.9%)	20 (8.3%)	61 (8.5%)	
Vascular	44 (18.9%)	41 (17.0%)	42 (17.4%)	127 (17.8%)	
Heart failure					.862
No	198 (85.0%)	203 (84.2%)	198 (82.2%)	599 (83.8%)	
Yes	35 (15.0%)	38 (15.8%)	43 (17.8%)	116 (16.2%)	
Arrythmia					.991
No	205 (88.0%)	212 (88.0%)	210 (87.1%)	627 (87.7%)	
Yes	28 (12.0%)	29 (12.0%)	31 (12.9%)	88 (12.3%)	
Stroke					.687
No	221 (94.8%)	222 (92.1%)	224 (92.9%)	667 (93.3%)	
Yes	12 (5.2%)	19 (7.9%)	17 (7.1%)	48 (6.7%)	
Cirrhosis					.593
No	231 (99.1%)	235 (97.5%)	236 (97.9%)	702 (98.2%)	
Yes	2 (0.9%)	6 (2.5%)	5 (2.1%)	13 (1.8%)	
Urgent start					.986
No	186 (79.8%)	191 (79.3%)	189 (78.4%)	566 (79.2%)	
Yes	47 (20.2%)	50 (20.7%)	52 (21.6%)	149 (20.8%)	

PKD: polycystic kidney disease, GN: glomerulonephritis, TIN: tubulo-interstitial nephritis

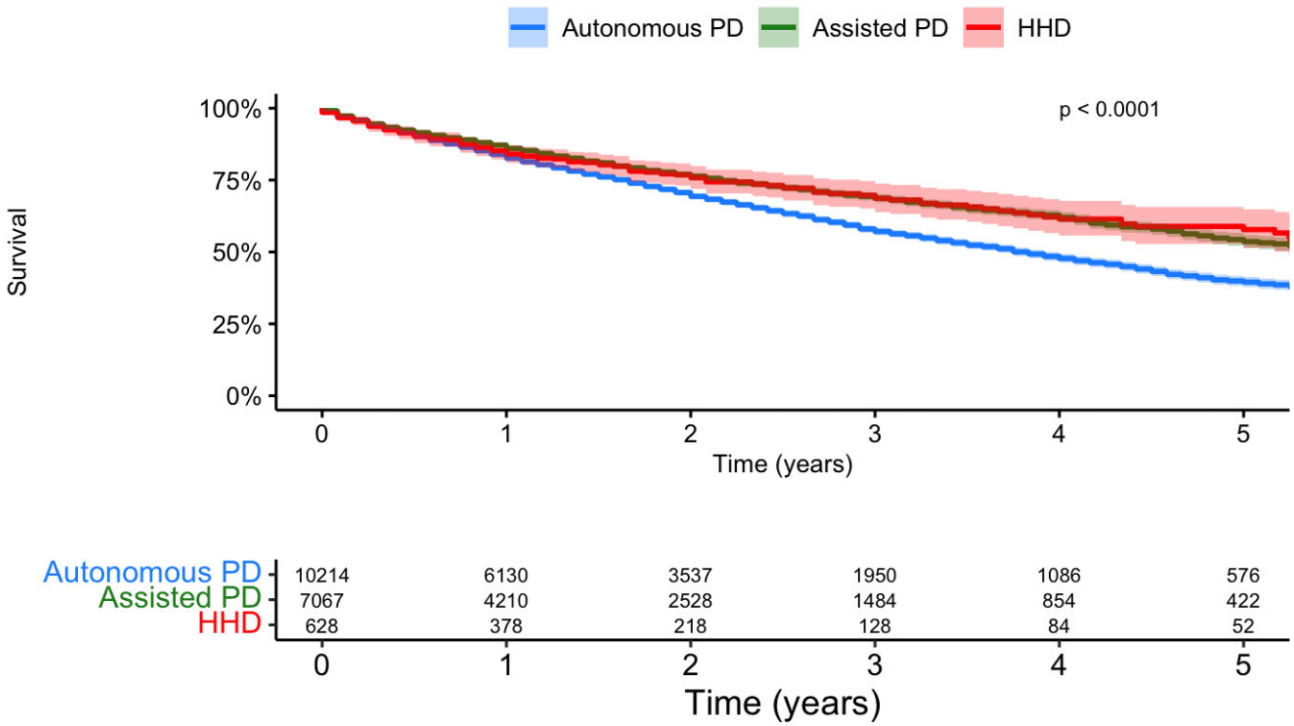


Figure 1: Survival free of transfer to facility-based HD.

strongly associated with the choice of a dialysis modality than with the outcome of interest. These covariates included in the PS for assessment of the risk of transfer to facility-based HD and for the risk of death were sex, age, BMI, diabetes, primary renal disease, heart failure, arrhythmia, stroke, cirrhosis, and urgent start (Supplemental Fig. 1). Standardized mean differences for the covariates included in the PS were calculated to evaluate the balance before and after matching (Supplemental Fig. 2). Subsequently, triplets of patients were constituted using a nearest-neighbor matching method with a caliper of 0.25 standard deviation and a 1:1:1 ratio of participants, with exact matching imposed on sex, age, and diabetes status. Cox and Fine–Gray models were performed on the matched dataset.

Subgroup analyses were performed within prespecified groups: sex, age, and home dialysis vintage.

There were fewer than 6% missing data, which we assumed to be missing at random. We used the multiple imputation by chained equation method, with five imputed datasets and a maximum of 10 iterations, to impute missing values and achieve convergence of the models.

We performed sensitivity analysis by computing the different survival models on a complete case dataset.

Statistical analyses were performed with R 4.2.0 (R Foundation for Statistical Computing, Vienna, Austria).

This study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [22].

The REIN registry has the approval of the French National Ethics Committee. This study took place within the framework of this authorization.

RESULTS

During the 17 years of the study period, 17 909 patients who began a treatment with home dialysis were included. The median follow-up time after starting home dialysis was 18 months (IQR 8–33.9). Patient characteristics according to their dialysis modality are detailed in Table 1 (Table 1).

The first home dialysis treatment was HHD in 628 patients, autonomous PD in 10 214 patients, and nurse-assisted PD in 7067 patients. During the follow-up period, there were 6499 deaths, 3307 kidney transplantations, 696 renal function recoveries, and 5347 transfers to facility-based HD. Patients characteristics after PS matching are shown in Table 2.

Primary outcome: transfer to facility-based HD

The observed number of transfers to facility-based HD was 2458 (13.7%) at 1 year and 5069 (28.3) at 5 years after the start of home dialysis, including 3272 (32%) in the autonomous PD group, 1648 (23.3%) in the assisted PD group, and 149 (23.7) in the HHD group (Fig. 1). The cumulative incidence curves of all events are illustrated in Fig. 2.

In the PS-matched patient cohort, the Cox model showed no significant difference in the risk of transfer to facility-based HD while on nurse-assisted PD (cs-HR 1.04, 95% CI 0.75–1.44) or HHD (cs-HR 1.07, 95% CI 0.77–1.48) compared with autonomous PD as the reference group. Similar results were obtained using the Fine–Gray model (sd-HR 1.18, 95% CI 0.85–1.62 and sd-HR 1.16, 95% CI 0.84–1.60) for nurse-assisted PD and HHD, respectively, with autonomous PD as the reference group (Fig. 3a).

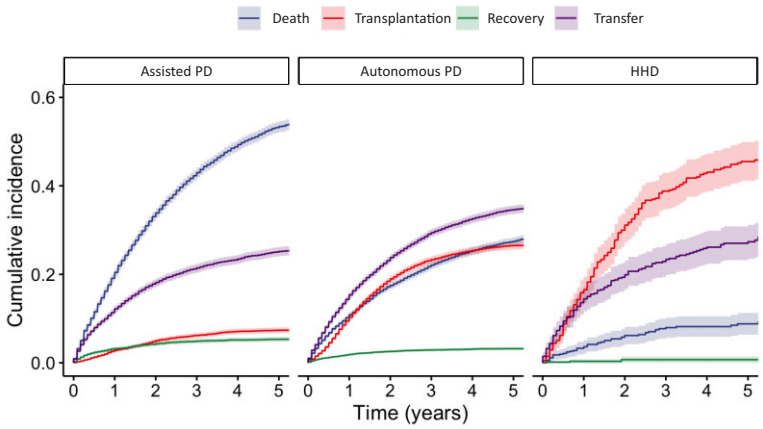


Figure 2: Cumulative incidence function for the four causes of home dialysis discontinuation.

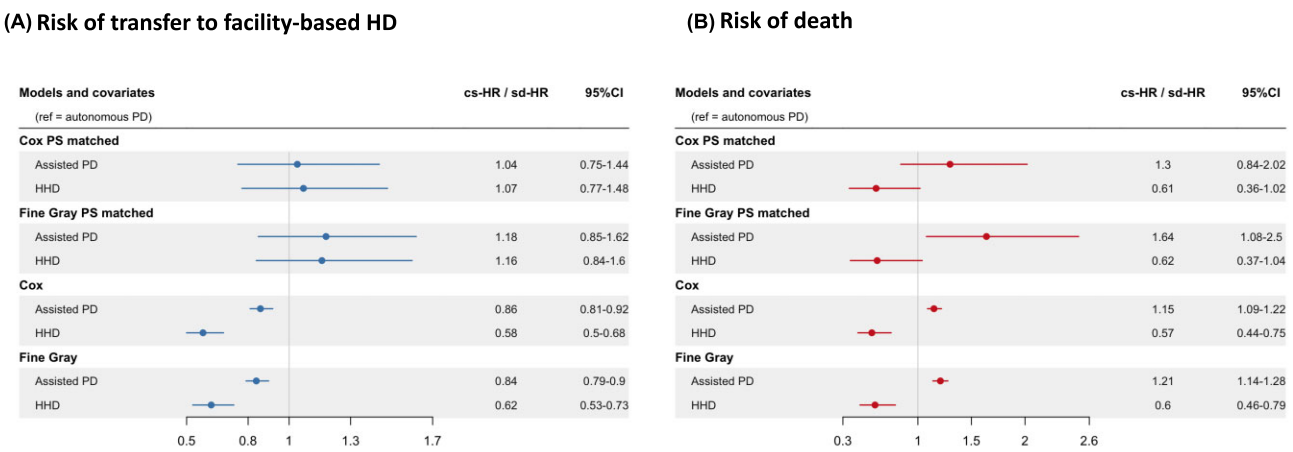


Figure 3: Hazard ratios for the risks associated with autonomous PD, assisted PD, and HHD. (a) Risk of transfer to facility-based HD. (b) Risk of death. Survival models on unmatched datasets are adjusted for sex, age, BMI, presence of diabetes mellitus, primary renal disease, smoking history, presence of peripheral artery disease, heart failure, cirrhosis, cancer, respiratory insufficiency, history of arrhythmia, history of stroke, urgent start of dialysis, and being put on a waiting list for kidney transplantation.

These findings differed significantly from those observed in the unmatched cohort. Compared to autonomous PD nurse-assisted PD and HHD were associated with a significantly lower risk of transfer to facility-based HD with the Cox models (cs-HR 0.86, 95% CI 0.81–0.92 and cs-HR 0.58, 95% CI 0.50–0.68, respectively). Similarly, the Fine–Gray models showed that patients treated by nurse-assisted PD or HHD had a lower likelihood of transfer to facility-based HD compared to patients treated with autonomous PD (sd-HR 0.84, 95% CI 0.79–0.90 and sd-HR 0.62, 95% CI 0.53–0.73, respectively) (Fig. 3a).

Secondary outcome: patient survival

The number of deaths at 5 years was 2567 (25.1%) in the autonomous PD group, 3439 (48.7%) in nurse-assisted PD, and 47 (7.5%) in HHD.

In the PS-matched cohort, the Cox model showed no significant association between the risk of death and nurse-assisted PD (cs-HR 1.3, 95% CI 0.84–2.02) or HHD (cs-HR 0.61, 95% CI 0.36–1.02) compared with autonomous PD. With the Fine–Gray model, HHD was not associated with the risk of death (sd-HR 0.62, 95% CI 0.37–1.04), but nurse-assisted PD patients had a higher risk of mortality (sd-HR 1.64, 95% CI 1.08–2.5) (Fig. 3B).

Using the Cox model applied to the unmatched cohort, nurse-assisted PD was associated with a higher risk of death (cs-HR 1.15, 95% CI 1.09–1.22), whereas patients on HHD had a lower chance of mortality than patients on autonomous PD (cs-HR 0.57, 95% CI 0.44–0.75). In the Fine–Gray model, the risk of death was higher in nurse-assisted PD (sd-HR 1.21, 95% CI 1.14–1.28) and lower in HHD patients (sd-HR 0.6, 95% CI 0.46–0.79) than it was for patients treated with autonomous PD (Fig. 3B).

Subgroup analysis

In the PS-matched cohort, no significant difference was observed in the risk of transfer to facility-based HD in the male subgroups (cs-HR 1.26, 95% CI 0.84–1.89 for assisted PD and cs-HR 1.15, 95% CI 0.76–1.73 for HHD) or in the female subgroup (cs-HR 0.77, 95% CI 0.44–1.36 for assisted PD and cs-HR 0.97, 95% CI 0.56–1.68 for HHD).

The risk of transfer associated with HHD was higher in the subgroup of patients aged 71 years and more (cs-HR 2.45, 95% CI

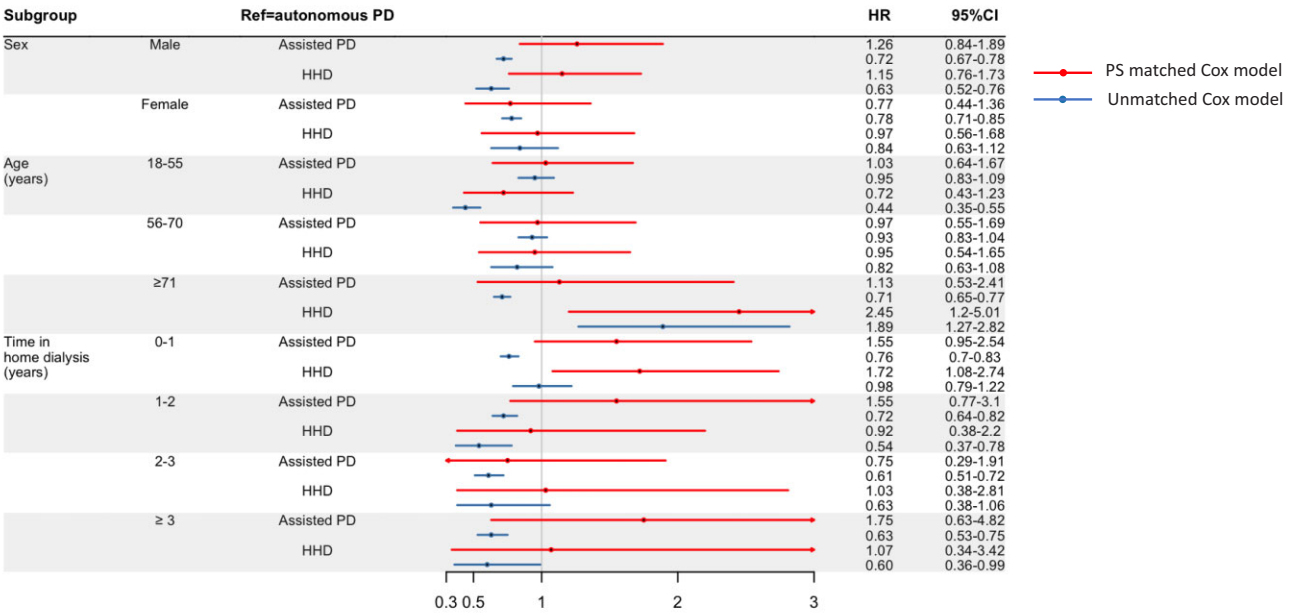


Figure 4: Risk of transfer to facility-based HD. Subgroup analysis. Survival models on unmatched datasets are adjusted for sex, age, BMI, presence of diabetes mellitus, primary renal disease, smoking history, presence of peripheral artery disease, heart failure, cirrhosis, cancer, respiratory insufficiency, history of arrhythmia, history of stroke, urgent start of dialysis, and going on a waiting list for kidney transplantation. Ref: reference.

1.20–5.01). No association was significant in the other subgroups, regardless of the dialysis modality (Fig. 4).

Risk of transfer over the first year at home

HHD was associated with a higher risk of transfer in the first year of home dialysis (cs-HR 1.72, 95% CI 1.08–2.74). There was no significant difference between the three modalities after the first year of home dialysis (Fig. 3).

Comparison of PD vs HHD

Complementary analyses were performed to study the effect of home dialysis modalities classified binarily as PD and HHD on the outcomes.

Compared to PD, HHD had no protective effect on the risk of transfer to facility-based HD, according to the Cox model run on the PS-matched cohort (cs-HR 1.04, 95% CI 0.79–1.38). In the unmatched cohort, HHD was associated with a lower risk of transfer to facility-based HD in the Cox multivariate model (cs-HR 0.58, 95% CI 0.50–0.68).

The results of the competing events analysis with Fine–Gray models showed no significant effect of the dialysis modality on the risk of transfer to facility-based HD in the PS-matched dataset (sd-HR 1.07, 95% CI 0.81–1.40), although again HHD patients had a lower risk of transfer to facility-based HD in the unmatched cohort (sd-HR 0.62, 95% CI 0.53–0.73) (Supplemental Fig. 3A).

For the secondary outcome, patient survival, HHD was associated with a lower risk of death than PD in the Cox model computed on the PS-matched cohort (cs-HR 0.53, 95% CI 0.34–0.83) and on the unmatched cohort (cs-HR 0.57, 95% CI 0.44–0.75). This result was consistent in the Fine–Gray model run on the PS-matched cohort (sd-HR 0.48, 95% CI 0.31–0.75) and on the unmatched cohort (sd-HR 0.60, 95% CI 0.46–0.79) (Supplemental Fig. 3).

DISCUSSION

Using a nationwide registry in a country where nurse assistance for PD is covered by the health care system, our study shows that assisted PD and HHD were associated with a lower risk of transfer to facility-based HD than autonomous PD but that these differences were no longer significant when matching the patients by PS to reduce indication bias. These findings were consistent with the results of the multivariable analysis performed with the Cox and Fine–Gray models and when considering home dialysis modality as a binary variable (PD or HHD).

We studied the risk of transfer to facility-based HD. The SONG PD surveys highlighted that this outcome was highly consequential and relevant [14]. It has been pointed out that nephrology teams should focus on patient-centered goals [23]. Transfer to facility-based HD may negatively affect quality of life of patients treated with home dialysis, especially when dialysis switch is unexpected. Maintaining the viability of the chosen modality is therefore a matter of concern. Furthermore, the risk of transfer to facility-based HD must be estimated if one wants to provide information about dialysis choice to ESKD patients in the shared decision-making process.

A limited number of studies have compared technique survival between PD and HHD, with results in favor of HHD over PD in three studies and no significant difference in one study [12, 24–26]. Technique survival was compared between 853 HHD and 14 461 PD patients in Canada. The risk of home dialysis cessation was lower for patients treated with HHD than for those treated with PD using a Fine–Gray competing risk model (sd-HR 0.79, 95% CI 0.69–0.90). In this study, the protective effect of HHD became significant only after the first year on dialysis. Similar results were found in the sensitivity analysis

in a PS-matched cohort [12]. In the USA, 4201 incident HHD and 4201 PD patients from the USRDS database were PS-matched to compare the risks of mortality, hospitalization, and transfer to facility-based HD. The risk of transfer was lower for patients treated with HHD than for PD patients (cs-HR 0.63, 95% CI 0.58–0.68) [24]. In a study that aimed to compare technique survival between HHD and PD using the ANZDATA registry, Nadeau-Fredette *et al*. demonstrated that HHD was associated with a lower risk of home dialysis cessation (cs-HR 0.34, 95% CI 0.28–0.41) [25]. In another observational study from the USA in which HHD patients and PD patients were PS-matched, the crude rates (95% CI) of transfer to facility-based HD were similar between the HHD and the PD groups (17%, 95% CI 15.4–18.7 and 17.2%, 95% CI 15.7–18.8, respectively) [26].

Our study adds information to the literature as it compares the risk of home dialysis cessation between HHD and two PD modalities: nurse-assisted and autonomous PD. The wide use of nurse assistance for PD care in France is made possible by the reimbursement by the health care system (whether in APD or CAPD). This provision authorizes the prescription of home dialysis for a wide range of patients who would not otherwise be able to perform dialysis by their own means. This causes indication bias and could explains the older age and the greater number of comorbidities of the assisted PD patients. Furthermore, it is well known that even in countries where assisted PD is not available, there is a systematic difference between PD and HHD patients' characteristics at baseline [27]. PS was used in all these studies to compare the effect of PD and HHD on technique survival, but the ability of PS matching to reduce the effects of confounding is strongly dependent on the inclusion of covariates affecting treatment assignment and outcome [28]. In this work, we used nationwide granular data and numerous comorbidity covariates were included in the calculation of the PS, resulting in a good balance of the covariates among the three matched patient groups. No significant difference was observed in the risk of transfer to facility-based HD between the three dialysis modalities using the PS-matched Cox model, whereas the risk of home dialysis cessation was lower for HHD patients than for patients treated by PD using the multivariate Cox model on the full cohort. This supports the hypothesis that the differences observed between HHD, assisted PD and autonomous PD are the result of differences in the patients' baseline characteristics and not on the type of home dialysis modality. Nevertheless, the sample size reduction due to the matching process may have affected the statistical power to detect differences.

We can also hypothesize from our results that the availability of full nurse assistance for PD may have been the source of improvement in PD technique survival in our population compared to other countries, where there is no such wide use of nurse-assisted PD [12, 24–27]. It has also been shown that patients with CKD who were expected to require dialysis within 12 months preferred home dialysis over facility-based dialysis when increased nursing support was available [29]. This should encourage stakeholders to introduce financial measures to implement nurse assistance for PD.

Several limitations of our work must be considered. This is an observational study with its caveats, and no conclusions should be drawn about causality. The cause of transfer was not available. Relevant covariates were not available in the registry and could not be included in the analyses, such as center-specific covariates, socioeconomic factors, and the causes of transfer to facility-based HD. The inability to perform home dialysis after a training period was not considered, which could have led to some survivor bias. We performed an intention to treat analysis, meaning that the switch from a home modality to another one during the follow-up period was not considered. During the follow-up period, 131 patients experimented a switch between HHD and PD. We stress that the estimates obtained from PS-matched models are evaluated on the population of patients who could actually be matched. Results should not be extrapolated to patients not eligible to one of the three home dialysis modalities. One of the strengths of this study is that it is a large-scale cohort study using exhaustive national data with numerous relevant patient characteristics. Robust statistical methods were used to overcome indication bias, and to our knowledge, this is the first study to compare the technique survival between HHD and PD while considering the specificity of assisted PD.

In this large nationwide study, we found no difference in technique survival between autonomous PD, assisted PD, and HHD in a PS-matched cohort. These results differ with those of other countries where nurse assistance is not as widely available for full PD-associated care, in which favorable outcomes were found in HHD patients over PD patients. This difference may be explained by the inclusion of a wider range of patients who benefit from the protective effect of nurse-assisted PD on the risk of transfer to HD. In our opinion, the findings of our study confirm that nurse-assisted PD should be funded by the health care system to improve home dialysis technique survival. Further research should aim to confirm these results, considering the causes of the transfers to facility-based HD, the center-specific and socioeconomic factors.

SUPPLEMENTARY DATA

Supplementary data is available at *Clinical Kidney Journal* online.

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AUTHORS' CONTRIBUTIONS

A.L. conceived and designed the study, analyzed, and interpreted the data and drafted the manuscript. C.B., M.F., and A.B. made critical revisions for important intellectual content to the manuscript. C.C. made critical revisions for important intellectual content to the manuscript and contributed to the data acquisition. M.L., F.C., and A.S. contributed to the data acquisition. T.L. made critical revisions for important intellectual content to the manuscript and supervised the drafting. All authors provided important intellectual content and read and approved the manuscript.

DATA AVAILABILITY STATEMENT

All data used for this study were extracted from the French ESKR REIN registry. The data cannot be made publicly available due to legal restrictions. Aggregated data are available upon request following some procedures. The contact

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

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