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ORIGINAL ARTICLE

Home Hemodialysis

Characteristics, practices, and outcomes in a Belgian cohort of incident home hemodialysis patients: A 6-year experience

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Abstract

Background: Home hemodialysis (HHD) remains underused in patients with kidney failure. Current literature on HHD mostly originates from non-European countries, making generalization difficult. The present study describes patients' profile and practice patterns from a Belgian HHD center, and assesses patient and technique survival and complications associated with HHD.

Methods: We analyzed data from all our incident patients during a 6-year period. The patient's characteristics were summarized using descriptive statistics. Transition to another therapeutic modality, estimated using a risk model with death and transplantation as competing events, episodes of respite cares and hospitalizations, and access complications were analyzed.

Results: Eighty patients (mean age: 47 years; male: 64%) met the inclusion criteria. Fifty-one percent of patients initiated dialysis with a central venous catheter (CVC) and 96% were not assisted. Arterio-venous fistula (AVF) cannulation was performed using buttonhole technique. Standard-frequent HD (47%) and short-frequent low-flow dialysate HD (34%) were mostly used at HHD initiation. Cumulative incidences of technique failure and death were 15%, 24%, and 32% at 1, 2, and 5 years. Incidence rates for respite dialysis and hospitalizations were 2.39 and 0.54 per patient-year of HHD. In comparison with AVF, incidence rate ratios of overall access complications and access-related infections for CVC were 4.3 (95% CI: 3.1–6, $p < 0.01$) and 4.4 (95% CI: 2.1–10, $p < 0.01$), respectively. Buttonhole cannulation was complicated by 0.26 (95% CI: 0.15–0.46) infections per 1000 AVF-days.

Conclusions: This present study provides important information about patient's profile and practice patterns and safety in a cohort of 80 incident Belgian HHD patients, with encouraging techniques and patient survival.

KEYWORDS
arterio-venous fistula, buttonhole cannulation, central venous catheter, home hemodialysis, technique failure, technique survival

Bernard Vô and Blaise Anthonissen contributed equally to this work.

INTRODUCTION

The management of kidney failure (KF) is a worldwide medical and economical challenge.[1–4] Promoting the expansion of home therapies, especially home hemodialysis (HHD), is associated with potential social, medical, and economic benefits.[5] Data on feasibility, safety, and outcome of HHD largely originate from North America and Australia/New Zealand.[6–10] Nonetheless, patient characteristics and technical procedures significantly differ worldwide.[11]

Frequent and/or longer dialysis sessions associated with HHD have demonstrated improvement of some parameters such as quality of life, blood pressure control, left ventricular mass, and clearance of small- and middle-sized molecules.[12–16] Although HHD is recognized as an effective and less expensive therapy,[17,18] concerns are pervasive regarding HHD feasibility and safety, especially for nocturnal HHD. Data are also conflicting regarding the occurrence of complications, mainly those related to vascular access.[19]

On January 1, 2019, 8333 patients were on dialysis in Belgium,[20] with only 1.2%–2.6% of them on HHD.[21,22] For more than 50 years our nephrology unit has proposed both peritoneal dialysis (PD) and HHD to our KF patients. Here, we describe patients' profiles, practices patterns, technique survival, and complications in 80 consecutive incident patients started on HHD in our unit, to support HHD as a safe and flexible modality for the treatment of KF.

METHODS

Study design and population

This is a monocentric retrospective observational cohort study using the French Language Peritoneal Dialysis Registry (RDPLF) in which information regarding all our HHD patients has been regularly recorded.

All incident patients older than 18-year-old starting HHD at Cliniques universitaires Saint-Luc, Brussels, Belgium, between January 1, 2013 and December 31, 2018 were included. Exclusion criteria were as follows: inability to complete the educational program or installation at home after December 31, 2018, primary failure subjectively defined as HHD duration inferior to 2 weeks, and previous HHD treatment episode without in-between transplant period. Patients were followed until June 30, 2019. The study was approved by the CUSL/UCLouvain Biomedical Ethics Committee (reference 2019/28AOU/368).

Patient characteristics

Characteristics and comorbidities of each patient at HHD training onset were collected from the RDPLF database. Demographic variables included age, sex, race, primary kidney disease, and presence of residual diuresis (defined as urinary output >500 ml of urine/day[23]). The following comorbidities were recorded: current smoking status, Charlson comorbidity index, presence of diabetes, hypertension, and history of cardiovascular disease (CVD), defined by prior ischemic heart disease, cerebrovascular event and/or peripheral obliterating arteriopathy. Duration of KF and treatment modality, if any, prior to HHD [in-center HD, PD, or kidney transplantation (KT)], and current transplant status (on list, not transplantable, not listed) were recorded.

HHD prescription variables including access type [arterio-venous fistula (AVF), graft (AVG), or tunneled central venous catheter (CVC)], mode of home dialysis surveillance (non-assisted or assisted dialysis), and dialysis regimen (type of monitor, number of weekly dialysis sessions and duration of dialysis session) were registered at the first home dialysis session and subsequently, at every modification.

Distance between patient's home and dialysis center, patient's housing (house, apartment, other), and location for HHD therapy (dedicated-, living-, sleeping-room…) were also recorded.

Home hemodialysis regimen

HHD regimens were classified according to the intensive HD taxonomy proposed by Marshal,[24] based on the frequency and duration of HD sessions, and adding low-flow dialysate systems[25] (Figure 1, *panel A*). Because of the small number of patients in some subcategories, a total of six different regimens were considered (Figure 1, *panel B*). Prescriptions using either GAMBRO AK95 or GAMBRO AK96 (Gambro Lundia AB, Lund, Sweden) monitors were classified as standard HD (Std HD; 3–6 h, 3 sessions/week), standard-frequent HD (Std-fqt HD; 3–6 h, 3.5+ sessions/week), short-frequent HD (S-fqt HD; <3 h, 5+ sessions/week) or nocturnal HD (>6 h, 3.5+ sessions/week). We added two subclasses for patients using the low-flow dialysate NxStage System One (NxStage Medical Inc.): short-frequent low-flow dialysate HD (S-fqt LFD HD; <3.5 h, 5+ sessions/week) and nocturnal low-flow dialysate HD (Nocturnal LFD HD; >6 h, 3.5+ sessions/week). The choice of the dialysis regimen was made by the patient, under medical supervision, according to personal lifestyle preferences.

AVF was the first choice for vascular access. However, AVG and CVC were also considered depending on patient's preference or inability to create an AVF. All

(a)

Duration \ Frequency	Standard 3/week	Alternate 3.5-4/week	Frequent > 4/week	NxStage ® Low-flow HD
Short *< 3 hrs*	Short-standard HD (0)	Short-alternate HD (0)	Short-frequent HD (5)	Short-frequent Low-flow HD (27)
Standard *3-6 hrs*	Standard HD (7)	Standard-alternate HD (34)	Standard-frequent HD (4)	-
Prolonged/nocturnal *> 6 hrs*	Nocturnal-standard HD (0)	Nocturnal-alternate HD (3)	Nocturnal-frequent HD (0)	Nocturnal Low-flow HD (0)

(b)

Standard HD (7)
Standard-Frequent HD (38)
Short-Frequent HD (5)
Nocturnal HD (3)
Short-Frequent Low-Flow Dialysate HD (27)
Nocturnal Low-Flow Dialysate HD (0)

FIGURE 1 Home hemodialysis regimen classification. Panel a shows the initial HHD classification adapted from the intensive hemodialysis taxonomy proposed by Marshal, with two additional subclasses for low-flow dialysate systems. Panel B shows the final classification adjusted for repartition of our cohort patients. (number of patients)

AVF were cannulated using the buttonhole technique (local protocol described in Table S1).

Aims of the study

The primary aim of the study was to provide an extensive clinical description of the whole HHD cohort and of their dialysis regimens, respectively. The secondary aim was to analyze patient and technique survivals, determine incidence and causes of respite care and hospitalization, and incidence and causes of access complications.

Statistical analyses

Baseline characteristics are presented as means ± standard deviations (SD) or medians and interquartile ranges (IQR) for continuous variables. Comparisons between HHD regimens were performed using the Kruskal–Wallis test or the one-way analysis of variance, as appropriate. Categorical variables were reported using numbers and proportions and compared by a Chi-square test.

HHD failure was defined as a transfer to either in-center HD, self-care HD facility, or peritoneal dialysis for more than 90 days. Survival analyses were performed using a competing risk cumulative incidence analysis method considering death of any cause and kidney transplantation as competing events.[26–28] Censoring at the end of the period of observation was performed if the patient had not experienced any of the three events. Patients lost to follow-up were censored at the time of the last available information date. Incidence rates were calculated by intention-to-treat for the entire population and for each HHD subgroups separately. Gray's test was used to compare cumulative incidence rates between subgroups.[29] We finally performed a Fine and Gray competing risk regression analysis to estimate subdistribution hazard ratios (sd-HR) of HHD failure and its 95% confidence intervals (95% CI) using baseline characteristics as covariates.[30]

Number of episodes of respite cares and hospitalizations were reported as crude numbers and as incidence rates (per patient-year of HHD delivered) for the entire cohort and by HHD regimen, in intention-to-treat (ITT) and as-treated (AT) analysis. In the AT analysis, events occurring within 60 days after a switch of regimen were attributed to the previous one. Incidence rate ratios (IRR) with 95% CI were calculated for direct comparison between various HHD modalities. Description of vascular access complications included crude numbers and incidence rates (per access-year) for the entire population and for each access type in an as-treated analysis. Vascular access types were compared with IRR and 95% CI. All analyses were performed using R v4.0.3 (R Foundation for Statistical Computing). A *p*-value inferior to 0.05 was considered statistically significant.

RESULTS

Study cohort

Eighty incident patients older than 18-year-old starting HHD at Cliniques universitaires Saint-Luc, Brussels, Belgium, between January 1, 2013 and December 31, 2018 were included (median follow-up: 19 [IQR: 8–35] months for a total of 159 patients-years) (Figure S1).

TABLE 1 Baseline characteristics for the HHD overall cohort and stratified by HHD regimen

Characteristics	Overall ($n = 80$)	HHD regimen: Std HD ($n = 7$)	Std-fqt HD ($n = 38$)	S-fqt HD ($n = 5$)	Nocturnal HD ($n = 3$)	S-fqt LFD HD ($n = 27$)	p
Age, yrs.	47 ± 14	43 ± 14	50 ± 14	43 ± 17	37 ± 2	46 ± 15	0.44
Male	51 (64)	5 (71)	29 (76)	3 (60)	2 (67)	12 (44)	0.13
Race							0.23
Caucasian	59 (74)	4 (57)	31 (82)	3 (60)	2 (67)	19 (74)	
North African	7 (9)	1 (14)	1 (3)	2 (40)	0	3 (11)	
Black African	6 (7)	0	3 (8)	0	0	3 (11)	
Others	8 (10)	2 (29)	3 (8)	0	1 (33)	2 (7)	
Primary Kidney disease							0.99
Diabetes	6 (7)	1 (14)	2 (5)	1 (20)	0	2 (7)	
HTA/renovascular	2 (2)	0	1 (3)	0	0	1 (4)	
GN/autoimmune	23 (29)	3 (43)	12 (32)	1 (20)	1 (33)	7 (26)	
PKD	15 (19)	2 (29)	7 (18)	1 (20)	0	5 (18)	
Others	34 (42)	1 (14)	16 (42)	2 (40)	2 (67)	12 (44)	
Comorbidities							
Diabetes	12 (15)	1 (14)	6 (16)	1 (20)	1 (33)	3 (11)	0.87
HTA	63 (79)	5 (71)	30 (79)	3 (60)	1 (33)	24 (89)	0.16
Cardiovascular disease	14 (17)	2 (29)	5 (13)	1 (20)	0	6 (22)	0.70
Current smoking	11 (14)	3 (43)	3 (8)	0	1 (33)	4 (7)	0.09
Charlson comorbidity score	3 [2-5]	3 [2-5]	4 [2-4]	5 [2-5]	2 [2-2]	3 [2-4]	0.21
Residual diuresis	48 (70)	4 (80)	22 (71)	2 (50)	1 (33)	19 (70)	0.55
None	16 (23)	1 (20)	5 (16)	2 (50)	2 (67)	6 (22)	
[0;500], ml/d	5 (7)	0	4 (13)	0	0	1 (4)	
[500;1000], ml/d	11 (16)	2 (40)	4 (13)	0	0	5 (18)	
≥1000, ml/d	37 (54)	2 (40)	18 (58)	2 (50)	1 (33)	14 (52)	
History of ESKD, mos.	9 [0-79]	8 [0-29]	0 [0-58]	90 [10-144]	70 [40-136]	17 [0-137]	0.24
Modality before HHD							0.73
Incident	28 (35)	3 (43)	17 (45)	1 (20)	0	7 (26)	
HD	30 (38)	3 (43)	12 (32)	3 (60)	2 (67)	10 (37)	
PD	8 (10)	1 (14)	3 (8)	0	0	4 (15)	
KT	14 (17)	0	6 (16)	1 (20)	1 (33)	6 (22)	
History of kidney transplant							0.30
None	59 (74)	7 (100)	30 (79)	3 (60)	2 (67)	18 (67)	
1	15 (19)	0	6 (16)	2 (40)	0	7 (26)	
≥2	6 (7)	0	2 (5)	0	1 (33)	2 (7)	
Distance home-center, km	21 [9-57]	25 [11-56]	26 [9-63]	9 [7-67]	22 [16-71]	15 [9-42]	0.80
On-list for KT	44 (55)	3 (43)	20 (53)	3 (60)	1 (33)	17 (63)	0.77
Non-transplantable	12 (15)	2 (29)	4 (10)	1 (20)	0	5 (18)	0.64

(Continues)

TABLE 1 (Continued)

Characteristics	Overall ($n = 80$)	HHD regimen Std HD ($n = 7$)	Std-fqt HD ($n = 38$)	S-fqt HD ($n = 5$)	Nocturnal HD ($n = 3$)	S-fqt LFD HD ($n = 27$)	p
Access type							0.39
AVF	38 (47)	3 (43)	23 (60)	3 (60)	2 (67)	8 (30)	
CVC	41 (52)	4 (57)	14 (37)	2 (40)	1 (33)	19 (70)	
AVG	1 (1)	0	1 (3)	0	0	0	
HD Surveillance							0.94
None	77 (96)	7 (100)	36 (95)	5 (100)	3 (100)	25 (93)	
Family	2 (2)	0	2 (5)	0	0	1 (4)	
Nurse	1 (1)	0	0	0	0	1 (4)	
Residency							0.34
Home	53 (66)	3 (43)	28 (74)	2 (40)	2 (67)	18 (67)	
Apartment	23 (29)	3 (43)	9 (24)	3 (60)	1 (33)	7 (26)	
Others[a]/NR	4 (5)	1 (14)	1 (3)	0	0	2 (7)	
Dialysis room							0.24
Dedicated room	29 (36)	1 (14)	21 (55)	1 (20)	1 (33)	5 (18)	
Bedroom	25 (31)	3 (43)	7 (18)	2 (40)	1 (33)	12 (44)	
Living room	21 (26)	3 (43)	8 (21)	2 (40)	1 (33)	7 (26)	
Others[b]/NR	5 (6)	0	2 (5)	0	0	3 (11)	
HD session/w, No.	4 [3.5-5]	3	4 [3.5-4]	6	4 [3.7-4]	5	0.05
Duration of HD session, hrs.	3 [2.5-4]	4 [3.7-4]	3.5 [3-4]	2	7 [7-7.5]	2.5 [2-2.7]	<0.01
Training duration, d.	40 [30-58]	51 [29-62]	47 [31-62]	51 [48-86]	28 [24-29]	37 [23-47]	<0.01

Notes: Values for categorial variables are given as crude number (percentage); values for continuous variables, as mean ± standard deviation or median [interquartile range].

Abbreviations: AVF, arteriovenous fistula; AVG, arteriovenous graft; CVC, central venous catheter; d, day; ESKD, end-stage kidney disease; GN, glomerulonephritis; HD, hemodialysis; HHD, home-hemodialysis; hrs, hours; HTA, hypertension; KT, kidney transplant; ml/d, milliliter per day; mos, months; NR, not recorded; PD, peritoneal dialysis; PKD, polycystic kidney disease; Std HD, standard HD; Std-fqt HD, standard-frequent HD; S-fqt HD, short frequent HD, S-fqt LFD HD, short-frequent low-flow dialysate HD.

[a]Prison.

[b]Large bathroom, office.

Baseline patient characteristics

Baseline patient characteristics are presented as a whole group and stratified by HHD regimen in Table 1. Mean (± SD) age was 47 (± 14) years, 64% were male and 74%, Caucasian. Hypertension was present in 79% of the patients; 15% and 17% of the patients had diabetes and CVD, respectively. Eleven patients (14%) were current smoker at HHD initiation. Median (IQR) Charlson comorbidity score was 3 (2–5). Primary kidney diseases were diabetes, hypertension/vascular disease, chronic glomerulonephritis, and polycystic kidney disease in 7%, 2%, 29%, and 19% of the patients, respectively. Seventy percent of the patients still had significant residual diuresis. The absence of previous kidney replacement therapy (KRT) was reported in 35% ("true incident") of the patients. Thirty-seven percent, 10%, and 17% of patients were previously treated with HD, PD, and KT. Fifty-five percent were listed for transplantation at HHD onset, while 15% were considered unfit for KT. More than half of the patients (51%) initiated HHD with a tunneled CVC and 96% were doing non-assisted HHD. No difference in the type of vascular access was observed between the incident and previous KRT patients (Table S2).

HHD regimens were as follows: Std HD: 9% ($n = 7$), Std-fqt HD: 47% ($n = 38$), S-fqt HD: 6% ($n = 5$), nocturnal HHD: 4% ($n = 3$), and S-fqt LFD HD: 34% ($n = 27$).

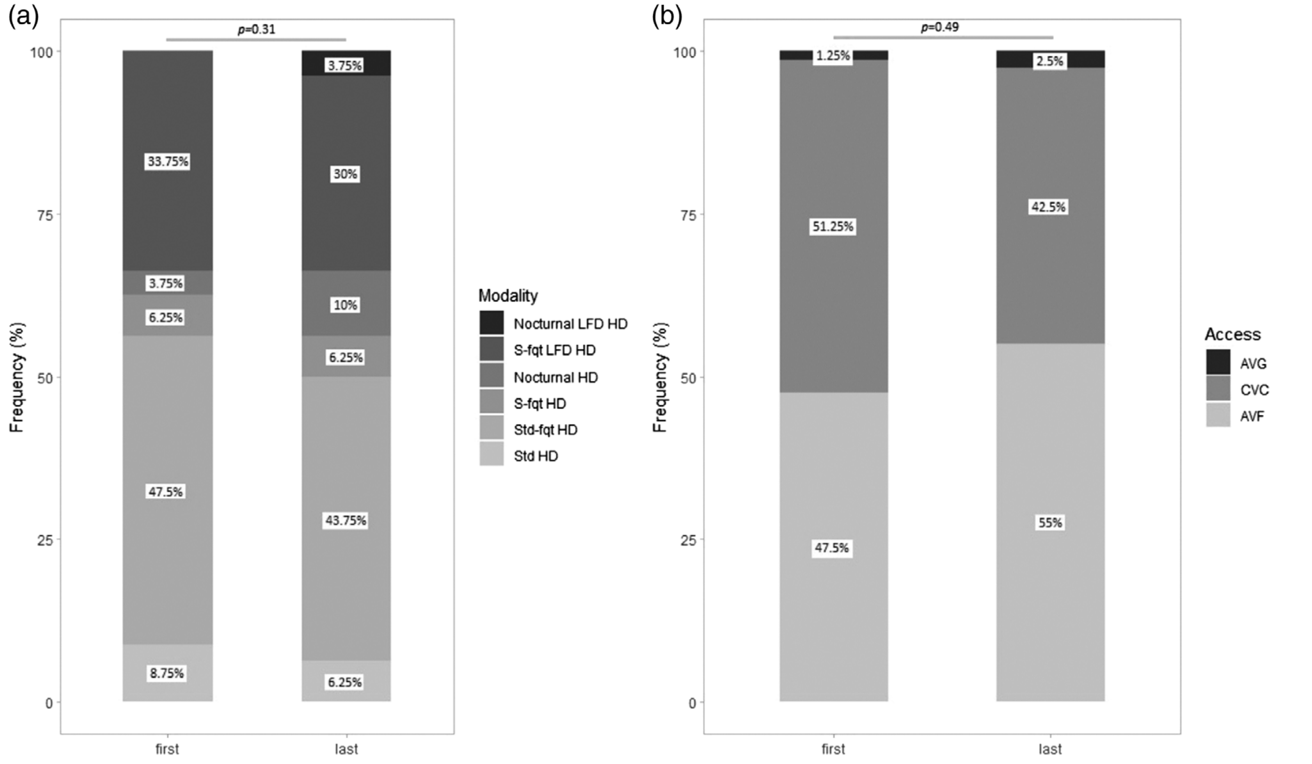

FIGURE 2 Repartition of HHD regimens (panel a) and vascular access types (panel B) at HHD initiation and last follow-up

Baseline characteristics were not different between subgroups. Training duration was significantly shorter for patients on NxStage System One or nocturnal dialysis.

Repartition between HHD regimens at HHD initiation and at last follow-up is illustrated in Figure 2, *panel A*: proportion of nocturnal techniques, both nocturnal HD and nocturnal LFD HD, tended to increase at the expense of Std-, Std-fqt, and S-fqt LFD HD ($p = 0.31$). The proportion of patients dialyzed with tunneled CVC decreased from dialysis initiation to last follow-up (51% and 42%, respectively, $p = 0.49$) (Figure 2, *panel B*).

Technique survival

During the study period, 15 (19%) patients were transferred to collective HD (11 to in-center and 4 to self-care HD, respectively), 7 (9%) died, and 29 (36%) were transplanted. The reasons for transfer were either medical ($n = 6$), patient's personal choice ($n = 5$), psychological intolerance ($n = 3$), or unspecified ($n = 1$). Among the medical reasons, only two were directly associated with dialysis itself, one because of dialysis inadequacy and non-compliance, the other due to vascular access difficulties. Other medical causes of HHD withdrawal were oncologic ($n = 2$), severe acute heart failure ($n = 1$), and post-operative ($n = 1$). Deaths were attributed to CVD in two patients, complications of infective endocarditis in two, cancer in one, sudden death in one, and trauma in one.

The stacked cumulative incidence curves for each event of interest are shown in Figure 3. Incidences of HHD failure were 10 (95% CI: 3–17), 14 (95% CI: 6–22), and 23 (95% CI: 11–34) % at 1, 2, and 5 years, respectively. KT incidences were 14 (95% CI: 6–22), 27 (95% CI: 17–37), and 49 (95% CI: 35–63) % at 1, 2, and 5 years, respectively. Death incidence was 9 (95% CI: 3–16) % at 2 years. There was no difference between different dialysis regimens concerning cumulative incidences of HHD failure (Gray's test: p-value $= 0.50$), death ($p = 0.87$), and KT ($p = 0.61$).

Results from the competing risk regression analysis are detailed in Figure 4 *and* Table S3. The sd-HR of HHD failure was 0.3 (95% CI: 0.1–0.9) for patients listed for KT at HHD initiation compared to those not yet listed or recused for KT ($p = 0.03$).

Episodes of respite care and hospitalization

Table 2 describes the needs for respite dialysis care for the whole group and for each HHD regimen (as-treated analysis). During follow-up, 64 patients (80%) required at least one respite dialysis. The median (IQR) number of respite dialysis sessions was 4 (2–8) per patient; the median duration was one (1–4) day. Access dysfunction

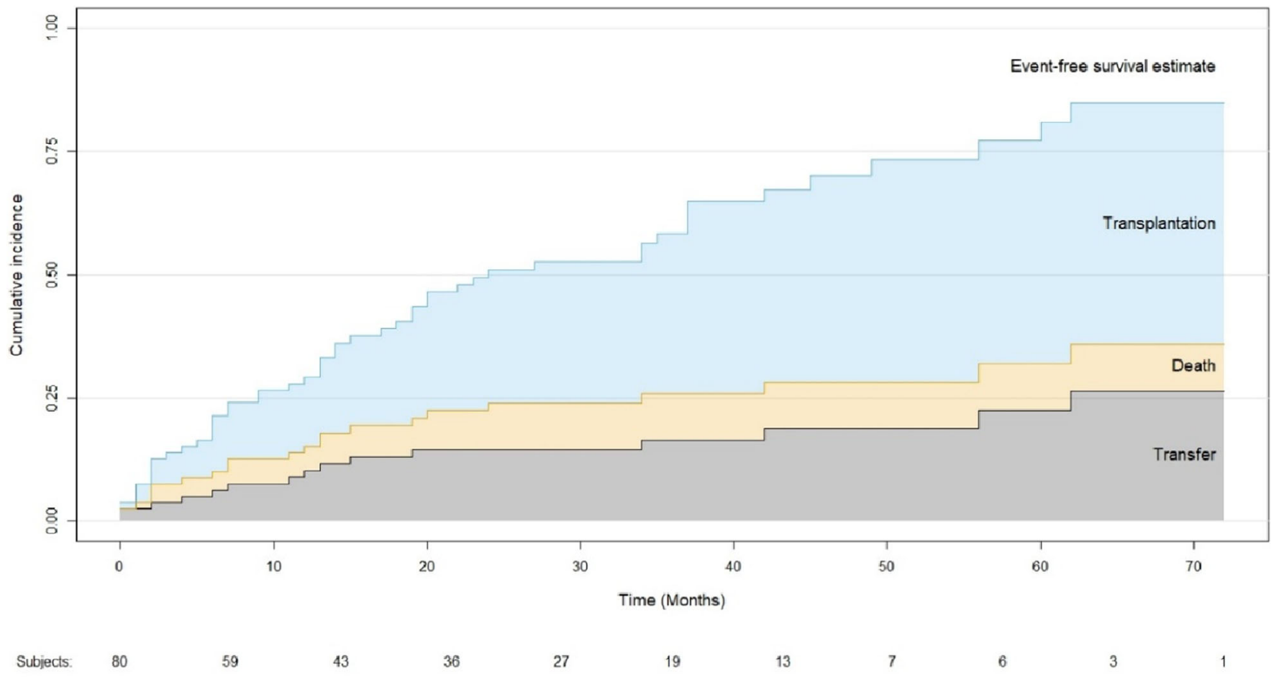

FIGURE 3 Stacked cumulative incidence curves of home hemodialysis failures, deaths, and transplantations amongst incident home hemodialysis patients [Color figure can be viewed at wileyonlinelibrary.com]

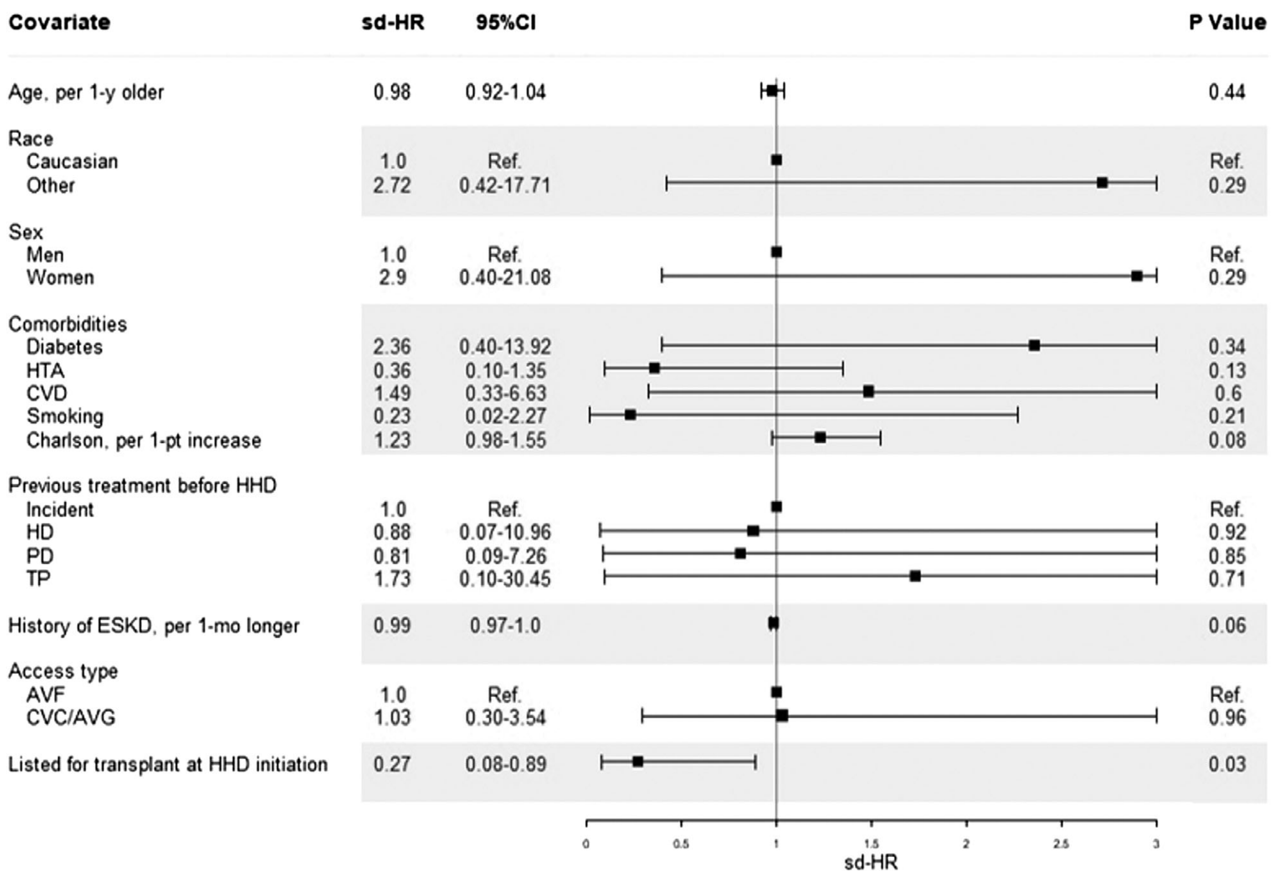

FIGURE 4 Predictors of HHD failure. Subdistribution hazard ratios of HHD failure with use of age, sex, race, comorbidities, previous treatment before HHD, duration of kidney failure, access type, and transplant status, as predictors and factors for the multivariate model

TABLE 2 Respite cares

As-treated analysis	Overall ($n = 80$)	Std HD ($n = 7$)	Std-fqt HD ($n = 40$)	S-fqt HD ($n = 5$)	Nocturnal HD ($n = 9$)	S-fqt LFD HD ($n = 27$)	Nocturnal LFD HD ($n = 3$)	p
Patients	64 (80)	7 (100)	29 (72)	5 (100)	7 (78)	21 (78)	3 (100)	0.41
Total events, No.	381	41	147	35	22	120	16	—
Events/patient concerned, No.	4 [2–8]	3 [2–6]	4 [1–8]	4 [3–4]	2 [1–4]	4 [2–7]	4 [4–6]	0.86
Duration, d.	1 [1–4]	1 [1–7]	1 [1–6]	1 [1–2]	1 [1–1]	1 [1–3]	1 [1–3]	0.08
Reason, No (%)								
Access dysfunction	89 (23)	3 (7)	33 (22)	4 (11)	4 (18)	44 (37)	1 (6)	<0.01
Puncture difficulties	84 (22)	6 (15)	35 (24)	21 (60)	2 (9)	19 (16)	1 (6)	<0.01
AVF infection	5 (1)	2 (5)	3 (2)	0	0	0	0	0.21
Infection, other	14 (4)	1 (2)	7 (5)	0	0	5 (4)	1 (6)	0.66
Retraining	36 (9)	6 (15)	21 (14)	0	0	8 (7)	1 (6)	0.03
Complementary work-up	35 (9)	2 (5)	14 (10)	4 (11)	0	12 (10)	3 (19)	0.39
Training for Vacation[a]	27 (7)	5 (12)	8 (5)	0	11 (50)	3 (2)	0	<0.01
Machine problem[b]	40 (10)	6 (15)	17 (12)	5 (14)	2 (9)	8 (7)	2 (12)	0.63
Other	51 (13)	10 (24)	9 (6)	1 (3)	3 (14)	21 (17)	7 (44)	<0.01

Note: Values for categorial variables are given as crude number (percentage); values for continuous variables, as mean ± standard deviation or median [interquartile range].

Abbreviations: d, day; HD, hemodialysis; No, number; Nocturnal LFD HD, nocturnal low-flow dialysate HD; Std HD, standard HD; Std-fqt HD, standard-frequent HD; S-fqt HD, short frequent HD, S-fqt LFD HD, short-frequent low-flow dialysate HD.

[a]Training for vacation using NxStage.

[b]Technical problem at home with the dialysis monitor or the water treatment system.

accounted for 23% of respite episodes and was statistically more frequent with more intensive HHD regimens. Nine percent of respite dialysis were dedicated to retraining sessions, a more frequent event with Std- and Std-fqt HD. Respite dialysis also concerned HHD patients on a conventional monitor to be trained on NxStage System One to allow autonomous holidays (7% of cases). Forty-nine percent of the patients ($n = 39$) required at least one episode of hospitalization (Table S4). The median number of hospitalizations for patients with at least one admission was 2 ([IQR: 1–3], median duration: 5 [IQR: 1–9] days). Surgery (access-related [$n = 9$], kidney graft nephrectomy [$n = 6$], cancer-related [$n = 5$], other [$n = 15$]) was the main cause for hospitalization (41%, $n = 35$). Six percent of hospitalizations were due to access-related infection, all in patients on NxStage System One ($p = 0.03$).Incidence rates for respite dialysis and hospitalization were 2.4 and 0.5 per patients-years of HHD, respectively (Table 3 *and* Table S5). There were 2- (IRR = 0.5, 95% CI: 0.3–0.7) and 3-fold (IRR = 0.3, 95% CI: 0.2–0.5) lower incidence rates of respite dialysis with Std-fqt HD and nocturnal HD, respectively, compared with Std HD. Differences in the incidence rate of hospitalizations were not statistically significant.

Access complications

Access complications in the whole cohort and according to access type are presented in Table 4. Fifty-nine percent of patients ($n = 49$) experienced at least one access complication (median number of 3 [IQR: 1–5] events). Patients with AVF experienced a significantly lower incidence of access complications. Catheter dysfunctions accounted for 46% of all access complications. Localized infections, either of AVF or CVC, and access-related bloodstream infections represented 14 and 6% of all access complications, respectively. Of the 11 access-related systemic infections, two caused by Staphylococcus aureus originated from a CVC

TABLE 3 Comparison of incidence rates of respite care between HHD regimens

Regimen	Intention-to-treat No. respite care episodes	Rate per PY of HD	IRR	95% CI	*p*	As-treated No. respite care	Rate per PY of HD	IRR	95% CI	*p*
Overall	381	2.4	—	—	—	381	2.4	—	—	—
Std HD	42	3.7	1.0	Ref.	Ref.	41	4.0	1.0	Ref.	Ref.
Std-fqt HD	151	1.8	0.5	0.3–0.7	<0.01	147	1.9	0.5	0.3–0.7	<0.01
S-fqt HD	35	3	0.8	0.5–1.2	0.32	35	3.0	0.7	0.5–1.2	0.18
Nocturnal HD	12	1.1	0.3	0.1–0.5	<0.01	33	1.1	0.3	0.2–0.5	<0.01
S-fqt LFD HD	141	3.6	1.0	0.7–1.4	0.86	120	3.4	0.8	0.6–1.2	0.38
Nocturnal LFD HD	—	—	—	—	—	16	2.7	0.7	0.4–1.2	0.18

Abbreviations: CI, confidence interval; HD, hemodialysis; IRR, incidence rate ratio; Nocturnal LFD HD, nocturnal low-flow dialysate HD; PY, person year; -+56+31Std HD, standard HD; Std-fqt HD, standard-frequent HD; S-fqt HD, short frequent HD; S-fqt LFD HD, short-frequent low-flow dialysate HD.

TABLE 4 Comparison of incidence rates of respite care between HHD regimens

As-treated analysis	Overall (*n* = 80)	AVF (*n* = 49)	CVC (*n* = 45)	AVG (*n* = 3)	*p*
Patients	47 (59)	22 (45)	31 (69)	3 (100)	0.02
Number of events, No.	181	47	121	13	
Events/patient, No.	3 [1–5]	1 [1–2]	3 [1–5]	4 [3–5]	0.02
Reason, No (%)					
Thrombosis	9 (5)	6 (13)	2 (2)	1 (8)	0.01
Infection, localized	25 (14)	7 (15)	15 (12)	3 (23)	0.55
Infection, systemic	11 (6)	2 (4)	9 (7)	0	0.47
Catheter dysfunction	84 (46)	—	84 (69)	—	—
Post-puncture hematoma	4 (2)	4 (8)	—	0	0.28
Difficult cannulation	21 (12)	13 (28)	—	8 (61)	0.02
Stenosis	10 (5)	9 (19)	—	1 (8)	0.33
Vascular steal	1 (0)	1 (2)	—	0	0.60
Symptomatic hyper-flow	1 (0)	1 (2)	—	0	0.60
Other/NR	15 (8)	4 (8)	11 (9)	0	0.53

Note: Values for categorial variables are given as crude number (percentage); values for continuous variables, as mean ± standard deviation or median [interquartile range].
Abbreviations: AVF, arteriovenous fistula; AVG, arteriovenous graft; CVC, central venous catheter; No, number; NR, not recorded.

and were complicated by fatal infective endocarditis in immunosuppressed patients. AVF thrombosis occurred in six of 49 (13%) of the patients.

Overall incidence rate for access complications was 1.14 per access-year (Figure 5 *and* Table S6). In comparison with AVF, incidence rate ratios for tunneled CVC and AVG were 4 (95% CI: 3–6) and 3 (95% CI: 1.7–6), respectively ($p < 0.01$). Incidence rate ratios of access-related infections for CVC and AVG, compared to AVF, were 4 (95% CI: 2-10, $p < 0.01$) and 4 (95% CI: 1-14, $p = 0.07$), respectively.

DISCUSSION

The present study provides important information about patient's profile and practice patterns in a cohort of 80 incident Belgian HHD patients. The population mainly consisted of young and non-comorbid patients, explaining the excellent retention rate of the technique and the low incidence of technique failure and death. We document that HHD patients often practice more intensive therapies (more frequent and/or longer dialysis sessions), very frequently perform non-assisted HHD and that >50% of them

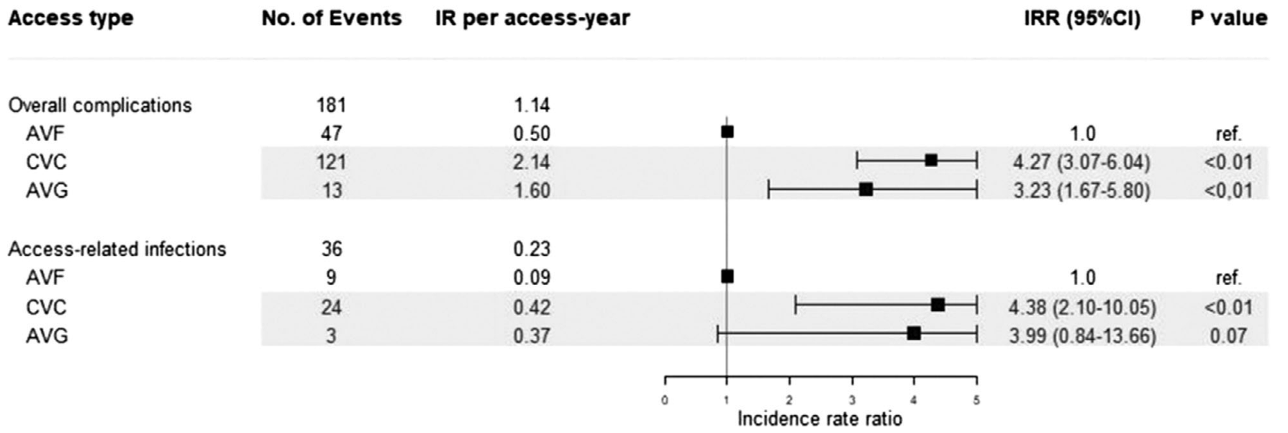

FIGURE 5 Number of events, incidence rates, and incidence rate ratios for access complications (all-cause) and access-related infections depending on type of HHD vascular access (as-treated)

use a CVC at dialysis initiation. Not surprisingly, incidence rate ratios of overall access complications and access-related infections were significantly higher for CVC as compared to AVF. Access-related problems and surgery were the main reasons for respite dialysis and hospitalizations, respectively.

Despite many advantages, HHD remains an uncommon dialysis modality for KF management in Europe.[21,31,32] The highest rates of HHD patients were found in Finland (7.6%), Denmark (6.7%), the United Kingdom (4.7%), the Netherlands (4.1%), and Sweden (3.4%).[21] Belgium lags behind these "top countries" (1.2%–2.6%). Barriers responsible for this HHD underuse result from factors related to patients, health care professionals, and governing agencies.[33–36] In this context, extensive data from our unit, which has a unique 50-year expertise with home dialysis therapies, are of interest.

Our HHD patients generally have low comorbidities, similarly to other European studies.[23,31,37] The mean age was below 50 years, that is, 10–15 years less than of incident patients in most European countries,[21] but also, sensibly less than that described in non-European studies.[6,8–10] Importantly, diabetes and hypertension/vascular nephropathies were reported as primary kidney diseases in less than 10% of the patients, a lower proportion than that expected from the overall European KF population,[21] but consistent with previous HHD observations.[23,31,37] Likewise, the median Charlson comorbidity score was only 3. Training for HHD constituted the initial KRT in 35% of our patients, as part of our strategy after patients had attended the pre-dialysis education program.[38] This high percentage of incident patients probably contributes to the proportion of patients with a significantly higher residual diuresis than previously reported.[23] Interestingly, 10% and 17% of the patients were originating from the PD or the transplant clinic respectively, an observation previously reported elsewhere,[39] and in concordance with optimized dialysis modality transition programs.[40] However, summarizing our cohort to a young, Caucasian population, with few comorbidities would be simplistic as age ranged from 18 to 76 years, Charlson comorbidity score from 2 to 12, and 65% of the patients had already been treated by PD, HD, or KT. This recruitment does not prevent more than 90% of our patients to perform non-assisted dialysis, that is, without the help, even the presence, of a partner.

A great proportion of our population is doing more intensive dialysis as 47% and 33.7% of the patients were started on HHD with Std-fqt and S-fqt LFD HD, respectively. Unlike some previous reports[6,7,10] nocturnal HHD modality was used after a short period on a day regimen.

Another characteristic of our cohort is the high rate of tunneled CVC at dialysis initiation and very few subsequent AVF creations, in contrast with the current European "fistula first" policy.[23,31] This can be accounted for by a specific demand of the patients and/or the inability to create an AVF in some of them. AVF was exclusively cannulated with the buttonhole technique.[41,42] Training duration comprised cannulation formation and learning of all dialysis requirements: it was significantly shorter for S-fqt LFD HD possibly explained by the relative simplicity of the NxStage System One. Previous studies reported even shorter training durations of 9.6 sessions and 2.5 weeks, for Nocturnal LFD HD[43] and S-fqt LFD HD,[31] respectively, but in some centers, HHD training is initiated only when patients are able to perform their AVF cannulation. Furthermore, most of our S-fqt LFD HD patients were dialyzed with a tunneled CVC (70.4%) making the connecting manipulation simpler, hence reducing overall training duration.

We observed good technique retention and few deaths and technique failures within the 5 years of follow-up, and a high rate of kidney transplantations. Cumulative incidence of technique failure and death was 15%, 24%, and 32% at 1, 2, and 5 years, respectively. The median time to technique failure was 12 (IQR: 5–26.5) months, an observation similar to that reported by Trinh's et al.[7] Better event-free and technique survivals were reported in a Canadian nocturnal HHD study,[44] but not in a Northern American study with the NxStage One system.[8] We were unable to document any difference between HHD regimens in terms of patient and technique survival, similar to a previous intention-to-treat observation.[10] This might be due to both the low death (4.4 /100 patients-year) and treatment failure (9.4/100 patients-year) rates observed here, the moderate number of patients included and a short follow-up. Also, the high transplant rate (18.2/100 patients-year) probably reflects the good general condition and young age of our cohort. Although most of our patients were already on a KT waiting list at HHD initiation, the median time to transplantation was 17 (IQR: 6–34) months. Being on KT list was associated with a lower risk of HHD failure. However, conversely to some previous studies, there was no association between diabetes, smoking habit, KF duration prior to HHD initiation, and cardiac failure, with technique failure.[8,45,46] This has, however, to be read with caution because of the low prevalence of co-morbid conditions in our cohort.

In an AT analysis, we experienced fewer episodes of respite care than previously reported,[6] with a similar rate of hospitalization.[6,47] Still, the proportion of respite dialysis for vascular access reasons is higher with intensive HD, except for nocturnal regimens. A selection bias might explain this latter observation, as patients with a difficult-to-manage access are less likely to be addressed for nocturnal HD.

Analysis of vascular access complications is of particular interest as we do not have a "fistula first" policy, resulting in a high proportion of CVC at HHD initiation and at last follow-up. Moreover, AVF cannulation is exclusively performed with a buttonhole technique. Unsurprisingly significantly higher proportions and higher total incidence rates of access complications were found in patients with tunneled CVC as compared to those with AVF. In the overall population, nearly half of the complications were due to catheter dysfunction. The incidence rate of access-related infections, either localized or systemic, was significantly 4-fold higher with CVC, compared with AVF, as already reported.[48,49] Buttonhole cannulation (BHC) was complicated by 0.26 (95% CI: 0.15–0.46) infections per 1000 AVF-days, that is, 0.09/AVF-year, a rate similar to that of 0.13 (95% CI: 0.08–0.23) and 0.34 (95% CI: 0.19–0.55) previously reported in our self-care facility[42] and in-center HD[41] populations, respectively, with the same cannulation technique. A higher incidence rate of 0.39 infectious events per 1000 AVF-days associated with BHC in Australian HHD patients had already been reported.[50] The use of BHC has been fully discussed elsewhere and is still debatable, mainly because of insufficient quality studies.[51–54] In the particular setting of HHD, one major advantage of BHC is its relative ease for the self-cannulating patient. In this study, we have no control group using rope-ladder cannulation to compare overall AVF-related infection rate; still, it is much lower than that associated with CVC. Ultimately, we acknowledge that BHC requires a well-defined protocol and regular reevaluation of patients and staff to avoid increasing infection rates.[41]

Access-related bloodstream infections were uncommon (0.19 per 1000 access-days) but severe, as two of 11 (18%) episodes were complicated with fatal S. aureus-associated infective endocarditis, both in immunocompromised patients. Both infections originated from a CVC. A similarly high rate (33%) of infective endocarditis was found in a retrospective cohort analyzing BHC-associated bacteremia.[55]

Apart from the observational design and the absence of a comparative group, the limitations of our study are its small sample size, short follow-up, and disparities in different HHD regimens. For the same reason, a small number of variables were included in the regression analysis. Also, 65% of our incident HHD patients had a history of KRT, which might indicate a bias of selected survivors and overall results reflect a center effect. Furthermore, no information on HHD selection criteria was available because the pre-dialysis information program is rather informal and clinicians might have subjectively pre-selected options they considered suitable for their patients. Finally, information on truly delivered dialysis dose, dialysis adequacy, and biochemical data was not recorded.

Despite these limitations, our study also has strengths. We provide an extensive baseline description of our cohort and capture outcomes for every patient, including episodes of respite care, hospitalization, and access complications.

In conclusion, we report data from a Belgian cohort of patients benefiting from diverse HHD techniques and characterized by relatively young age, few comorbidities, and short history of KF. The apparent good healthy state of patients, that is, being listed for transplant, is associated with better technique survival, while more intensive HHD techniques are not grieved with more complications. This study brings additional information about HHD in Europe and confirms worldwide current data concerning the applicability of HHD with encouraging techniques and patient survival.

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CONFLICT OF INTEREST

Each author confirms that he has no conflict of interest regarding the present work.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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