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Original Article

Improvement in Quality of Life via Catheter Ablation for Atrial Fibrillation in Patients Undergoing Hemodialysis Therapy

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ABSTRACT

Background: Atrial fibrillation (AF) is the most common arrhythmia in patients undergoing hemodialysis (HD); AF lowers quality of life (QoL) and increases the risk of dialysis-related complications. The present study aimed to evaluate the effectiveness of AF ablation on the QoL in patients undergoing HD.

Methods: Nineteen patients undergoing HD (14 men, age 68 ± 8 years; 15 with paroxysmal AF) who underwent catheter ablation (CA) of AF were enrolled in the study. The Kidney Disease Quality of Life Short Form (KDQOL-SF) was assessed to evaluate the QoL of the HD patients at baseline and 6 months after the ablation. Ablation outcomes and procedural complications were evaluated and compared to those of 1053 consecutive non-HD patients who underwent AF ablation.

Results: The KDQOL-SF of the HD patients 6 months after the ablation showed an improvement in physical functioning (54 ± 23 to 68 ± 28, $P < 0.01$), general health perceptions (38 ± 17 to 48 ± 15, $P < 0.01$),

RÉSUMÉ

Contexte : La fibrillation auriculaire (FA), la forme d'arythmie la plus fréquente chez les patients sous hémodialyse (HD), entraîne une diminution de la qualité de vie (QdV) et une augmentation des risques de complications liées à la dialyse. La présente étude visait à évaluer l'effet de l'ablation de la FA sur la QdV des patients sous HD.

Méthodologie : Dix-neuf patients sous HD (âgés de 68 ± 8 ans, dont 14 étaient des hommes et 15 étaient atteints de FA paroxystique) ayant subi une ablation par cathéter de la FA ont été admis dans l'étude. Le questionnaire KDQOL-SF (*Kidney Disease Quality of Life Short Form*) a été utilisé pour évaluer la QdV des patients sous HD avant l'intervention et six mois après l'ablation. L'issue de l'ablation et les complications liées à l'intervention ont été évaluées et comparées à celles de 1 053 patients consécutifs n'étant pas hémodialysés et ayant subi une ablation de la FA.

Résultats : La comparaison des résultats initiaux au KDQOL-SF des patients hémodialysés avec les résultats obtenus six mois après

The increasing epidemic of chronic kidney disease and end-stage renal disease is a serious problem, and the number of patients who need to receive maintenance hemodialysis (HD) therapy is rising worldwide.[1] Patients undergoing HD therapy have a lower quality of life (QoL) than the general healthy population, due to the intrusiveness of the required treatment.[2] Improving the QoL in patients receiving HD therapy is an essential issue, as a low QoL is a risk factor for all-cause and cardiovascular mortality,[3] and an improved QoL is associated with positive effects in terms of laboratory values, mortality, and adherence to the therapy.[4]

Atrial fibrillation (AF) is frequently observed in patients undergoing HD, with a prevalence of 8%-28%.[5] The presence of AF is associated with a high level of all-cause and cardiovascular-related mortality.[6,7] in patients receiving HD therapy. The development of AF with a rapid ventricular

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Ethics Statement: The study protocol conformed to the Declaration of Helsinki, and the present study was conducted with the prior approval of the Ethics Committee of Nippon Medical School Hospital. All the patients gave written informed consent for the catheter ablation.

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and symptoms/problems (75 ± 21 to 84 ± 13, $P = 0.02$), compared to baseline. For intradialytic symptoms, dyspnea during HD significantly improved after the CA in the HD patients without AF recurrence (43% to 7%, $P = 0.04$), whereas the atrial tachyarrhythmias and hypotension during HD remained unchanged. During the follow-up period of 17 ± 13 months after the last procedure, the incidence of being arrhythmia-free was similar (HD patients, 79% vs non-HD patients, 86%, log-rank $P = 0.82$). No life-threatening complications occurred in any of the patients.

Conclusions: CA of AF improves QoL in patients undergoing chronic HD therapy.

l'ablation a montré des améliorations de la fonction physique (de 54 ± 23 à 68 ± 28, $p < 0,01$), de la perception de l'état de santé global (de 38 ± 17 à 48 ± 15, $p < 0,01$), et des symptômes/problèmes de santé (de 75 ± 21 à 84 ± 13, $p = 0,02$). En ce qui concerne les symptômes survenant lors des séances d'HD, une amélioration significative de la dyspnée a été observée après l'ablation par cathéter chez les patients sous HD sans récurrence de la FA (de 43 % à 7 %, $p = 0,04$), alors qu'aucun changement n'a été constaté pour les tachyarythmies auriculaires et l'hypotension. Durant la période de suivi de 17 ± 13 mois après la dernière intervention, le nombre de patients sans arythmie était comparable dans les deux groupes (79 % chez les patients hémodialysés et 86 % chez les patients non hémodialysés, test du log-rank = 0,82). Aucun patient n'a subi de complication menaçant le pronostic vital.

Conclusions : L'ablation par cathéter de la FA permet d'améliorer la QdV des patients qui subissent un traitement par HD de longue durée.

response during HD can result in intradialytic complications, including palpitations, dyspnea, and chest pain.[8] Moreover, AF during HD causes hemodynamic compromise, leading to an interruption in the HD. The negative impact of AF on the QoL in patients undergoing HD therapy is assumed to be a more serious clinical problem than AF in patients who are not receiving maintenance HD therapy.

Recently, catheter ablation (CA) has become a first-line therapy for AF,[9,10] and previous reports have examined CA of AF in patients undergoing HD therapy.[11,12] Although those studies showed that CA may be a reasonable initial procedure in HD patients as a rhythm-control therapy, little is known about its effect on QoL, especially during HD. The purpose of the current study was to examine whether the elimination of AF by CA improves QoL in patients undergoing HD therapy.

Methods

Study population

From January 2017 to December 2020, a total of 19 consecutive patients on ongoing HD who underwent their first CA of AF at Nippon Medical School Hospital were retrospectively enrolled in the current study. All the HD patients underwent an assessment of their QoL, at baseline and after the ablation. The ablation outcomes were also examined and compared with those in the 1053 consecutive patients who were not receiving HD therapy, who underwent their initial CA of AF during the same period. The patients were excluded if they had a history of CA or surgery for AF, or were unable to receive follow-up evaluation at the study site. The CA of AF was performed based on current guidelines.[13] The study protocol conformed to the Declaration of Helsinki, and the study was conducted with the prior approval of the Ethics Committee of Nippon Medical School Hospital. All the patients provided written informed consent for CA.

Electrophysiologic study and catheter ablation

All antiarrhythmic drugs were discontinued for at least 5 half-lives before the CA was performed. Amiodarone was discontinued more than 1 month before the CA. All the HD patients received appropriate oral anticoagulation therapy with warfarin (international normalized ratio 2.0-3.0) for at least 3 weeks, and warfarin was continued throughout the periprocedural period. In the non-HD patients, administration of oral anticoagulants was skipped only on the day of the CA and was restarted on the morning of the first postoperative day. After written consent was obtained, CA was performed with patients under deep sedation using midazolam and dexmedetomidine. The intracardiac electrograms and surface electrocardiograms were continuously monitored and recorded using the EP Workmate (St. Jude Medical, Minneapolis, MN). A 20-polar catheter with 2−2−2 mm interelectrode spacing (BeeAT, Japan Lifeline Co., Ltd, Tokyo, Japan) was introduced from the right internal jugular vein and advanced into the coronary sinus. A transseptal puncture was performed using the RF needle (Baylis Medical, Montreal, Quebec, Canada) inserted through a long sheath (SL 0 and/or SL 8.5, St. Jude Medical). Heparin was initiated before the transseptal puncture, and an activated clotting time of 300-350 seconds was maintained with continuous administration of heparin during catheter manipulation and the ablation procedure in the left atrium (LA). After transseptal access, one or two 7-F duo-decapolar circular mapping catheters (Lasso, Biosense Webster, Diamond Bar, CA, or Optima, Abbott, Abbot Park, IL) and an irrigated ablation catheter (SmartTouch, Biosense Webster Inc. or FlexAbility, Abbott) were inserted into the LA. A steerable sheath (Agilis, St. Jude Medical) was used for the ablation catheter in all procedures. The procedures were guided with an electroanatomic mapping system: CARTO system (Biosense Webster Inc.) or Ensite Velocity system (Velocity, Abbott) in which the 3-dimensional reconstructed computerized tomography images of the LA and pulmonary veins (PVs) were merged with real-time anatomic maps. The radiofrequency power was delivered at 30-40W to the LA, and was reduced to 20W inside the coronary sinus. The upper limit of the esophageal temperature was set as 39.5℃ to prevent esophageal thermal damage. The endpoint of the ablation was the complete isolation of all 4 pulmonary veins (PVs). Decisions about whether to create linear lesions—that is, a roof line, an inferior-posterior line, a mitral isthmus line, a cavotricuspid isthmus line, and isolation of the superior vena

cava—and whether to perform ablation of complex fractionated atrial electrograms (CFAEs) and non-PV triggers were left up to the discretion of each operator.

Follow-up

After discharge from the hospital, the patients were seen in the outpatient clinic every month for the first 3 months, and every 2 or 3 months thereafter. The antiarrhythmic drug therapy used during the follow-up period was determined by the individual physician. In the case of an AF recurrence, which was confirmed by electrocardiograms after the 3-month blanking period, we offered to perform a second CA procedure in which a re-isolation was made if reconnections of the PVs and linear lesions were documented. The oral anticoagulants were discontinued when AF had not recurred after the 3-month blanking period in all the HD patients and in the non-HD patients with a **C**ongestive Heart Failure, **H**ypertension, **A**ge $\geq$ 75, **D**iabetes, and Prior **S**troke/Transient Ischemic Attack (doubled) ($CHADS_2$) score of < 2.

Assessment of QoL and intradialytic complications

Among the HD patients, QoL was evaluated using the Japanese version of Kidney Disease Quality of Life Short Form version 1.3 (KDQOL-SF 1.3), which is designed for studies of patients undergoing HD therapy and has been used worldwide for the assessment of QoL in these patients. The Japanese version has been validated for use in Japanese populations, and internal consistency and reliability tests were carried out.[14] The KDQOL-SF 1.3 consists of 36 comprehensive questions about general physical and mental state of health (short form 36 [SF-36] Japanese version 1.2), and 43 questions related specifically to renal failure.[15] Those 43 questions focused on the following issues that patients receiving dialysis therapy experience: symptoms, effects of kidney disease on daily life, renal failure weight, dialysis staff encouragement, and patient satisfaction. The KDQOL-SF 1.3 was evaluated prior to and 6 months after the first ablation. If AF recurred or post-ablation atrial tachycardia occurred, the post-ablation KDQOL-SF 1.3 assessment was performed at least 3 months after the last ablation procedure.

In the present study, the incidence of intradialytic complications, defined as any symptoms that occurred during the HD session, was evaluated at baseline and after the CA. Interruption of HD caused by tachycardic AF or intradialytic complications also was examined before and after the ablation.

Statistical analysis

The data are expressed as mean $\pm$ standard deviation, or median (interquartile range), for continuous variables, and as absolute frequencies and percentages for categorical variables. The differences between the HD and non-HD patients were compared, using a Student *t*-test or Mann-Whitney *U* test, for continuous variables and for categorical variables, the Fisher exact test. The results of the answers to the KDQOL-SF 1.3 assessment were converted from the original scores into corresponding scores ranging from 0 to 100 using directions in the manual specialized for this purpose,[16] and the mean values of the scores belonging to each subscale were calculated. The differences between the QoL score before and after the ablation were compared using a paired-samples *t*-test. All tests were 2-sided, and a P value of < 0.05 was considered statistically significant. A Kaplan-Meier analysis and log-rank test were performed in order to present and compare the primary outcome of the HD and non-HD patients. All statistical analyses were conducted using SPSS 25.0 software (IBM Inc., Armonk, NY).

Table 1. Changes in the Kidney Disease Quality of Life Short Form version 1.3 (KDQOL-SF 1.3) before and after catheter ablation (CA) in the hemodialysis patients

Scale (no. of items)	Before CA (n = 18)	After CA (n = 18)	*P*
SF-36			
Physical functioning (10)	54.4 ± 22.9	68.4 ± 28.3	**0.009**
Physical role functioning (4)	48.6 ± 48.1	52.7 ± 43.6	0.653
Bodily pain (2)	75.8 ± 29.0	81.2 ± 26.5	0.285
General health perceptions (5)	38.3 ± 16.9	48.0 ± 15.1	**0.001**
Vitality (4)	52.7 ± 24.2	59.5 ± 22.5	0.236
Social functioning (2)	77.7 ± 25.2	80.5 ± 23.5	0.607
Emotional role functioning (3)	50.0 ± 46.0	70.3 ± 41.0	0.052
Mental health (5)	60.8 ± 21.6	69.1 ± 21.0	0.112
Kidney-disease-targeted			
Symptoms/Problems (12)	74.7 ± 20.8	83.5 ± 12.5	**0.022**
Effect of kidney disease (8)	55.7 ± 36.2	64.4 ± 31.3	0.148
Burden of kidney disease (4)	28.4 ± 19.9	28.8 ± 21.2	0.905
Work status (2)	52.9 ± 41.3	58.8 ± 44.1	0.163
Cognitive function (3)	78.5 ± 18.0	84.4 ± 18.1	0.111
Quality of social interactions (3)	81.8 ± 18.5	82.9 ± 21.1	0.823
Sexual function (2)	13.8 ± 32.3	17.3 ± 31.8	0.399
Sleep (4)	66.2 ± 13.1	64.8 ± 14.4	0.733
Social support (2)	72.2 ± 32.3	75.9 ± 25.7	0.361
Dialysis staff encouragement (2)	72.2 ± 30.4	73.6 ± 30.5	0.798
Patient satisfaction (1)	69.4 ± 37.1	69.4 ± 34.8	1.0

Values are mean ± standard deviation, unless otherwised indicated. Boldface indicates significance.

SF-36, short form 36.

Results

The comparison of the QoL score before and after the ablation

Among the 19 HD patients, questionnaire results after the ablation were not available for 1 patient who died 19 months after the last ablation. The KDQOL-SF 1.3 evaluation was made in the remaining 18 patients, at baseline and 6 months after the ablation procedure (Table 1). Among the SF-36 components, physical functioning ($P = 0.009$) and general health perceptions ($P = 0.001$) significantly improved after the ablation. Regarding the kidney-disease-targeted scales, the measure of symptoms/problems showed statistical improvement after the ablation ($P = 0.022$). No difference occurred in the other scales, including the mental health, social interaction, and patient satisfaction measures.

Complications during HD

Among the 18 HD patients who completed the questionnaire, intradialytic complications were documented in 17 patients (94%). The most common complication that occurred during HD before the CA was palpitations (n = 12), a finding that did not change after the ablation (67% vs 56%, $P = 0.494$; Supplemental Table S1). However, among the patients who remained free from AF recurrence after the last

Table 2. Incidence of atrial fibrillation-related symptoms and complications during hemodialysis in patients without atrial fibrillation recurrence after the last catheter ablation (n = 14)

Symptom/complication	Before ablation	After ablation	*P*
Palpitations	9 (64)	8 (57)	0.699
Vertigo	4 (29)	2 (14)	0.324
Lightheadedness	6 (43)	4 (29)	0.430
Chest pain	3 (21)	2 (14)	0.500
Dyspnea	6 (43)	1 (7)	**0.038**
Interruption of hemodialysis	3 (21)	3 (21)	0.676

Values are n (%), unless otherwise indicated. Boldface indicates significance.

CA (n = 14), the dyspnea during HD significantly improved after the ablation (43% vs 7%, $P = 0.038$; Table 2). Among the 17 patients, an interruption of HD was observed in 4 patients, and the reasons for interruption were hypotension (n = 2), palpitation (n = 1), and chest pain (n = 1). Although those 4 patients remained free from an arrhythmia recurrence after the last ablation, interruption of HD still occurred.

CA outcomes

The ablation outcomes of the HD patients were compared with those of the non-HD patients who underwent initial CA for AF at the same time. The baseline characteristics of the study population are summarized in Table 3. The HD patients had a significantly lower body mass index ($P = 0.048$), a higher **C**ongestive Heart Failure, **H**ypertension, **A**ge (≥ 75 Years) (doubled), **D**iabetes Mellitus, **S**troke (doubled), **V**ascular Disease, **A**ge (65-74) Years, **S**ex **C**ategory (Female) (CHA_2DS_2-VASc) score ($P = 0.001$), and a higher prevalence of vascular disease ($P < 0.001$), hypertension ($P < 0.001$), and diabetes mellitus ($P < 0.001$) than the non-HD patients. The hemoglobin level was lower ($P < 0.001$) in the HD patients, and echocardiography indicated a larger left atrial diameter ($P = 0.004$) and lower left ventricular ejection fraction ($P = 0.046$) in the HD patients than in the non-HD patients. Of the 19 HD patients, 5 developed AF before the introduction of HD, and 14 developed AF 6.9 ± 8.9 years after the introduction of HD. An antiarrhythmic drug was given before ablation to 3 patients in the HD group (16%), including 2 who were given amiodarone.

The ablation procedural characteristics, including procedure-related complications, did not differ between HD patients and non-HD patients (Table 4). The details of the pre-procedural complications are shown in Table 5. A vascular access complication with a hematoma that required a blood transfusion occurred in 1 HD patient. No life-threatening complications were observed in the HD patients, and the incidence of complications did not differ statistically between the HD patients and the non-HD patients. During a mean follow-up of 20 ± 14 months after the initial CA, 12 of the HD patients (63%) and 686 of the non-HD patients (65%) remained free from atrial tachyarrhythmia recurrences (log-rank $P = 0.86$). The number of patients who underwent the repeated procedure is shown in Figure 1. Eventually, during a mean follow-up period of 17 ± 13 months after the last CA, sinus rhythm was maintained in 15 HD patients (79%) and

Table 3. Comparison of patient characteristics in the hemodialysis (HD) vs non-HD patients

Variable	HD patients (n = 19)	Non-HD patients (n = 1053)	*P*
Age, y	68 ± 8	66 ± 11	0.510
Male gender	14 (74)	738 (70)	0.734
Body mass index, kg/m^2	23 ± 4	25 ± 4	**0.048**
Paroxysmal AF	15 (79)	608 (58)	0.063
Number of failed AADs	0.2 ± 0.4	0.2 ± 0.4	0.617
AADs before CA	3 (16)	214 (20)	0.443
Class I AADs	0 (0)	70 (7)	0.274
Amiodarone	2 (11)	36 (3)	0.143
Bepridil	1 (5)	102 (10)	0.441
d-Sotalol	0 (0)	7 (1)	0.882
Oral anticoagulants			
Warfarin	19 (100)	40 (4)	**< 0.001**
Edoxaban	0 (0)	373 (35)	**< 0.001**
Apixaban	0 (0)	213 (20)	**0.014**
Dabigatran	0 (0)	299 (28)	**0.006**
Rivaroxaban	0 (0)	128 (12)	0.087
Congestive heart failure	5 (26)	193 (18)	0.264
Hypertension	18 (95)	590 (56)	**< 0.001**
Diabetes mellitus	9 (47)	159 (15)	**< 0.001**
History of a stroke	2 (11)	112 (11)	0.671
Vascular disease	6 (32)	51 (5)	**< 0.001**
$CHADS_2$ score	2.0 ± 1.2	1.2 ± 1.1	**0.002**
CHA_2DS_2-VASc score	3.3 ± 1.5	2.1 ± 1.5	**0.001**
Underlying heart disease			
Valvular	4 (21)	119 (11)	0.165
Ischemic	4 (21)	44 (4)	**0.008**
Non-ischemic cardiomyopathy	1 (5)	45 (4)	0.569
Smoking; Brinkman index	480.4 ± 642.9	297.5 ± 546.7	0.150
Alcohol habit	9 (47)	543 (52)	0.717
Echocardiography			
Left atrial diameter, mm	44 ± 7	39 ± 7	**0.004**
LV ejection fraction, %	57 ± 15	64 ± 11	**0.046**
LV end-diastolic diameter, mm	51 ± 7	47 ± 6	**0.004**
LV end-systolic diameter, mm	35 ± 9	30 ± 7	**0.023**
TR max PG, mm Hg	26.6 ± 9.6	22.1 ± 5.9	0.053
NT-pro BNP, pg/mL	14622 ± 1617	719 ± 2450	**0.001**
Hemoglobin, g/dL	12 ± 1	14 ± 2	**< 0.001**
Serum creatinine, mg/dL	5.9 ± 2.7	0.9 ± 0.4	**< 0.001**
eGFR, mL/min per 1.73 m^2	11 ± 11	63 ± 16	**< 0.001**
Creatinine clearance, mL/min	14 ± 13	77 ± 29	**< 0.001**
Cause of kidney disease			
Diabetic nephropathy	8 (42)	—	
Nephrosclerosis	4 (21)	—	
Chronic glomerulonephritis	4 (21)	—	
Polycystic kidney disease	1 (5)	—	
IgA nephropathy	1 (5)	—	
Crescentic glomerulonephritis	1 (5)	—	
Duration of HD, y	6.7 ± 8.4	—	
Free of AADs after the last ablation	14 (74)	826 (78)	0.395
Follow-up period after 1st CA, mo	28.8 ± 30.2	20.3 ± 13.1	0.238
Follow-up period after last CA, mo	24.1 ± 27.7	17.0 ± 12.5	0.279

Values are mean ± standard deviation, or number (%), unless otherwised indicated. Boldface indicates significance.

AAD, antiarrhythmic drug; AF, atrial fibrillation; CA, catheter ablation; $CHADS_2$ score, **C**ongestive Heart Failure, **H**ypertension, **A**ge ≥ 75, **D**iabetes, and Prior **S**troke/Transient Ischemic Attack (doubled); CHA_2DS_2-VASc score, **C**ongestive Heart Failure, **H**ypertension, **A**ge (≥ 75 Years) (doubled), **D**iabetes Mellitus, **S**troke (doubled), **V**ascular Disease, **A**ge (65-74) Years, **S**ex **C**ategory (Female); eGFR, estimated glomerular filtration rate; LV, left ventricular; NT-pro BNP, N-terminal pro brain natriuretic peptide; TR max PG, tricuspid regurgitation maximum pressure gradient.

Table 4. Ablation procedural characteristics in hemodialysis (HD) and non-HD patients

Characteristic	HD patients (n = 19)	Non-HD patients (n = 1053)	*P*
Completion of the PVI	19 (100)	1050 (99.7)	0.948
Additional ablation line			
Roof line	10 (53)	539 (51)	0.901
Inferior line	10 (53)	534 (51)	0.868
Posterior wall isolation	9 (47)	507 (48)	0.946
CTI line	7 (37)	215 (20)	0.077
Mitral isthmus line	1 (5)	85 (8)	0.541
Number of left atrial linear lesions	2.5 ± 1.3	2.4 ± 1.4	0.715
SVC isolation	1 (5)	35 (3)	0.480
CFAE ablation	0 (0)	22 (2)	0.672
Procedure time, min	135 ± 49	128 ± 45	0.479
Fluoroscopic time, min	27 ± 13	28 ± 16	0.776
Number of CA procedures	1.3 ± 0.5	1.3 ± 0.5	0.767
Procedure-related complications	1 (5)	43 (4)	0.552

Values are mean ± standard deviation or n (%), unless otherwise indicated.

CA, catheter ablation; CFAE, complex fractionated atrial electrogram; CS, coronary sinus; CTI, cavo tricuspid isthmus; PVI, pulmonary vein isolation; SVC, superior vena cava.

903 non-HD patients (86%), respectively (log-rank $P = 0.82$; Fig. 2). Among the HD patients, 14 (93%) without an arrhythmia recurrence discontinued warfarin therapy, whereas 3 of 4 patients with arrhythmia recurrences continued warfarin therapy due to a previous history of cerebral infarction. During the follow-up period, 1 HD patient (5.3%) and 15 non-HD patients (1.4%) died (Fig. 3). No deaths were associated with the ablation procedure.

Discussion

The main findings were as follows: (i) the CA of AF significantly improved QoL in the patients undergoing chronic HD therapy; (ii) the CA for AF significantly decreased the incidence of dyspnea during HD in patients without a recurrence of AF; and (iii) the ablation outcome and procedure-related complications in patients undergoing HD therapy were similar to those in non-HD patients.

Table 5. Incidence of pre-procedural complications in hemodialysis (HD) and non-HD patients

Complication	HD patients (n = 19)	Non-HD patients (n = 1053)	*P*
Cardiac tamponade/effusion	0 (0)	13 (1.2)	0.792
Cerebral infarction	0 (0)	5 (0.5)	0.914
Phrenic nerve injury	0 (0)	5 (0.5)	0.914
Periesophageal vagal nerve injury	0 (0)	2 (0.2)	0.965
Pneumothorax	0 (0)	1 (0.1)	0.982
Arteriovenous fistula	1 (5.3)	5 (0.5)	0.102
Coronary artery spasms	0 (0)	4 (0.4)	0.931
Pericarditis	0 (0)	1 (0.1)	0.982
Cerebral hemorrhage	0 (0)	2 (0.2)	0.965
Takotsubo cardiomyopathy	0 (0)	1 (0.1)	0.982
Retroperitoneal hematoma	0 (0)	1 (0.1)	0.982
Mediastinal hematoma	0 (0)	1 (0.1)	0.982
Minor bleeding	0 (0)	4 (0.4)	0.931
Major bleeding	1 (5.3)	17 (1.6)	0.277

Values are n (%), unless otherwise indicated.

Effect of AF ablation on the QoL in HD patients

AF causes impairment of QoL due to the unpredictable onset of palpitations, requirement for medications, and heart failure-associated symptoms. Previous studies have revealed that maintenance of sinus rhythm by CA improves QoL in patients with symptomatic AF.[17-19] Although improvement of QoL by CA for AF has been reported, no previous study has evaluated the effect of AF ablation on QoL in AF patients undergoing maintenance HD therapy. The QoL in patients undergoing HD therapy is reported to be worse than that in age-matched subjects from the general population, due to the high burden of comorbidity and complications associated with HD.[20] Seica et al.[21] reported that older age, female gender, lower socioeconomic status, and higher educational level were associated with lower QoL scores in patients receiving ongoing HD therapy. Impaired QoL in patients receiving HD therpay is an important issue, as lower QoL is associated with a higher incidence of death and hospitalization.[15]

In the present study, QoL significantly improved after CA, as measured by physical functioning, general health perceptions, and symptoms/problems related to kidney disease. QoL has been reported to improve after CA, owing to maintenance of sinus rhythm, reduction of symptoms of AF, or transition to asymptomatic disease states as a result of direct CA effects and improved pharmacologic efficacy.[17-19] The improvement in QoL that occurred in the HD patients after CA in the present study might have been achieved by a similar mechanism. Previous studies have reported that adequate medical interventions improve QoL in patients undergoing maintenance HD therapy. Lacson et al.[22] reported that achieving an adequate hemoglobin level and albumin level resulted in a significant improvement in the QoL of HD patients. Salhab et al.[23] repoted that intradialytic exercise improved QoL in HD patients. AF is one of the most common arrhythmias in patients undergoing HD therapy,[7] and AF onset is frequently observed on the day of the HD and specifically during the dialysis procedure itself.[8] As most of the antiarrhythmic drugs are difficult to use due to their renal excretion, CA of AF can be an optimal therapeutic option for improving the QoL in patients receiving ongoing HD therapy who are suffering from AF.

Complications during HD

Although HD technologies have developed in the past few decades, patients who undergo HD still suffer from various intradialytic complications. The most common complications are hypotension and cardiac arrhythmias followed by muscle cramps, dyspnea, palpitation, chest pain, nausea, and vomiting.[24] In the present study, the interruption of the HD was mostly due to hypotension, which was still observed even after successful ablation that suppressed AF. The mechanism of hypotension during HD is not fully understood; it is believed to be due to multiple factors, such as rapid fluid removal, cardiovascular system impairment, and failure of compensatory mechanisms for a reduction in venous volume. The present study results indicate that the presence of AF does not always explain the complicated physical response associated with HD in AF patients.

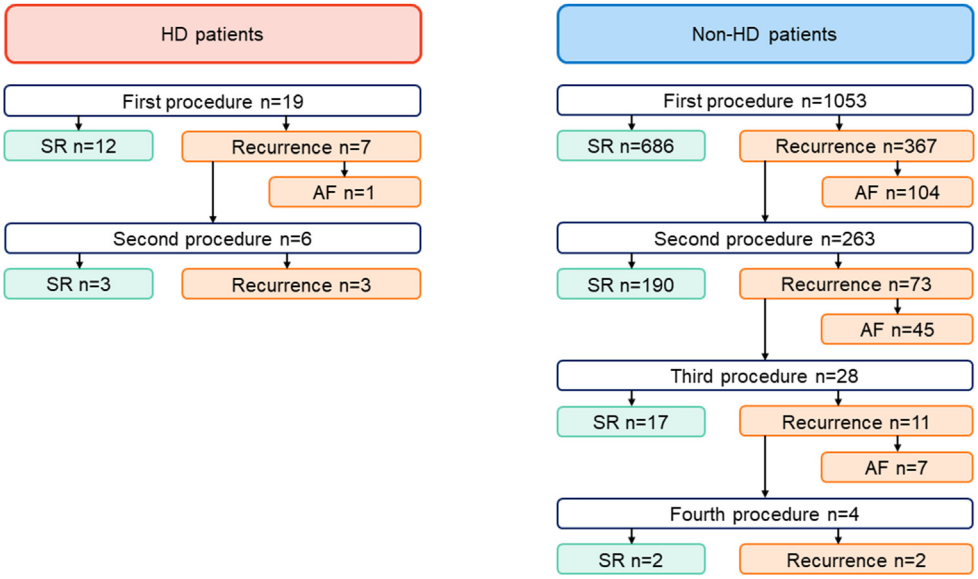

Figure 1. Flowchart of the ablation outcomes after each procedure in the hemodialysis (HD) and non-HD patients. AF, atrial fibrillation; SR, sinus rhythm.

AF-related symptoms in patients undergoing HD therapy

In the present study, dyspnea during HD significantly improved in the patients who did not have AF recurrence, whereas dyspnea did not improve in the patients with AF recurrence after CA. AF causes various symptoms, and AF during HD is the main cause of intradialytic dyspnea, which can be suppressed by successful CA. Palpitation was unchanged before vs after ablation in the present study. Palpitation, one of the main symptoms associated with AF, may be caused by a reactive increase in the heart rate due to fluid removal from the intravascular compartment and other cardiac arrhythmias in patients undergoing HD. Previous studies[25,26] using Holter monitoring and an implantable cardiac monitor for arrhythmia screening in patients undergoing HD, reported frequent atrial and ventricular premature contractions and nonsustained ventricular tachycardia during HD. Given that palpitations in patients undergoing HD are caused by a variety of factors other than AF, palpitation in the HD patients likely did not improve after CA in the present study.

Four of the 19 HD patients in our study did not have sinus rhythm restoration, even with multiple CA procedures. These patients had a history of long-lasting AF with an extensively enlarged LA, which might limit the efficacy of the CA. Early intervention by CA in HD patients would increase the rate of successful CA leading to an improvement in AF-related symptoms, as recently shown in the general AF population.[27]

Ablation outcomes in patients undergoing HD

Previous studies have evaluated ablation outcomes for AF in patients receiving ongoing HD therapy.[11,12] These

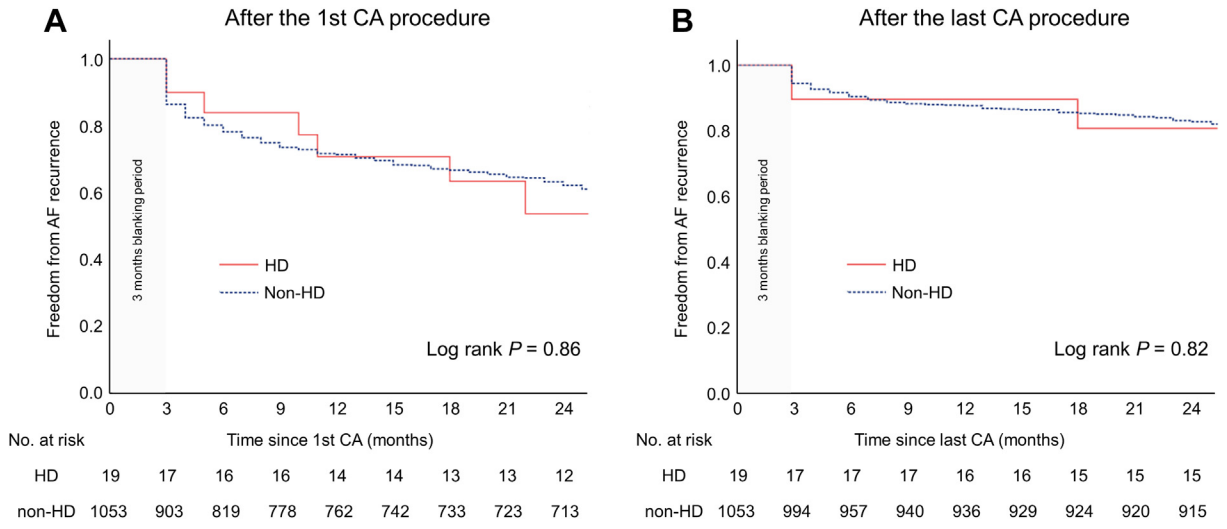

Figure 2. Kaplan-Meier analysis of the long-term freedom from recurrent atrial fibrillation (AF) after (**A**) the first catheter ablation (CA) and (**B**) the last CA in hemodialysis (HD) and non-HD patients.

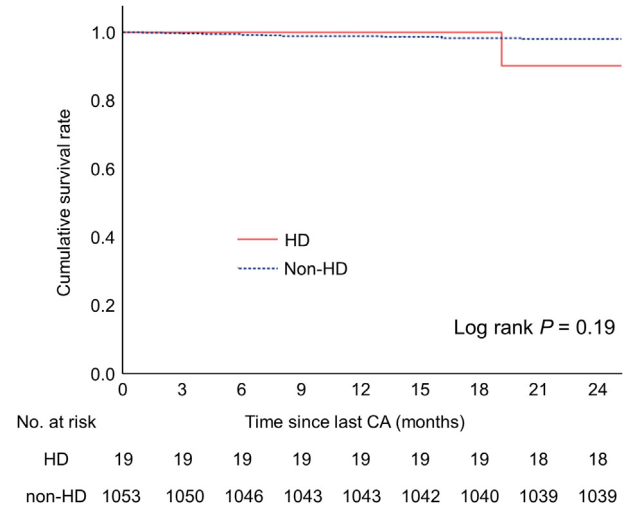

Figure 3. Accumulated survival rates after the last catheter ablation (CA) procedure in the hemodialysis (HD) and non-HD patients.

studies[11,12] showed that patients on HD therapy had a significantly higher AF recurrence rate than patients not on HD therapy, and HD was associated with AF recurrence. The dilated LA, an excessively activated renin-angiotensin-aldosterone system, and an electrolyte shift after dialysis may cause advanced atrial remodeling, eventually resulting in development of AF.

In the present study, the arrhythmia-free rate after a single ablation and the last CA in the HD patients was similar to that in the non-HD patients, in spite of the fact that the HD patients had a larger LA volume with a lower left ventricular ejection fraction. The discrepancy in results between previous studies and the present study can be explained by the fact that the non-irrigated ablation catheter without contact force sensing was used for CA in previous studies. Since the introduction of the irrigated catheter with contact force-sensing technology, outcomes of AF ablation have dramatically improved,[28] which might have raised the success rate in HD patients. Supporting this speculation, a recent report evaluating AF ablation outcomes in HD patients was favorable, indicating that the arrhythmia-free rate after multiple procedures was similar to that in non-HD patients.[29] Another probable explanation is the difference in the ablation strategy. In the present study, a posterior wall isolation (PWI) was performed in 53% of the HD patients. An adjunctive PWI was associated with decreased recurrence of AF and atrial arrhythmias, compared to PV isolation alone in patients with persistent AF.[30] As renal dysfunction has been reported to be significantly associated with the presence of low-voltage zones in the LA, and recurrence after AF ablation,[31] the additional PWI might have improved the ablation outcome in the present study.

The incidence of procedure-related complications in the present study was 5.3%, which is consistent with the incidence reported in previous studies.[11,12,32]. According to these previous studies[11,12,32] and present data, vascular injury and bleeding were the most common complications associated with AF ablation in HD patients. The anticoagulation administered at the time of dialysis to prevent clotting, continuation of warfarin therapy during ablation, and vascular vulnerability due to hypertensive vascular disease or diabetes may be related to the vascular complications and bleeding seen in the HD patients. Therefore, attention should be paid to the vascular access site for the catheter and bleeding at the puncture site after the CA procedure is performed in HD patients. No complications occurred with long-term sequelae in any of the reported studies,[11,12,32] and the incidence of complications did not differ statistically between the patients with vs without HD, which indicates that AF ablation in HD patients is safe.

Study limitations

The present study has several limitations. First, the design of the study was retrospective in nature, with data from a single centre. Although the present study showed the benefit of AF ablation in terms of QoL related to renal failure, the sample size was smaller compared to that in previous studies evaluating the efficacy of AF ablation in patients receiving ongoing HD therapy. Due to the higher rate of AF recurrence and risk of complication, including bleeding, in HD patients, compared to that of non-HD patients, physicians may have tended to recommend pharmacotherapy rather than CA, resulting in a small sample size. Second, in order to assess the factors associated with QoL that are specific to HD patients , we used the KDQOL-SF 1.3, which was specifically designed to assess QoL in HD patients. Therefore, we did not assess QoL in non-HD patients, and a comparison of the QoL between HD patients and non-HD patients could not be made. Further prospective analyses with a larger population comparing HD patients and non-HD patients are warranted.

Third, most of the patients underwent CA without receiving an antiarrhythmic drug before the ablation, which might have been an unusual practice pattern. Although the current guideline recommends a trial of antiarrhythmic drugs before ablation,[33] accumulating evidence suggests that a strategy of early rhythm control using CA is associated with better AF-free survival, fewer rehospitalizations, and a decrease in the incidence of progression to persistent AF. In addition, as antiarrhythmic drugs contain a risk of proarrhythmic effect and hemodynamic intolerance when metabolism of the drugs is impaired, CA tended to be chosen as a first-line therapy, especially for HD patients. Finally, not all the patients underwent continuous prolonged electrocardiogram (ECG) recording, such as Holter ECGs, hand-held single-lead ECGs, or implantable loop recorders; therefore, asymptomatic AF recurrence might not have been evaluated adequately.

Conclusions

CA for AF significantly improved QoL for HD patients. As the ablation outcome was favorable and was similar to that for non-HD patients, CA of AF is the optimal therapeutic option for improving QoL in patients undergoing HD.

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Disclosures

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Supplementary Material

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