Increased risk of atrial fibrillation in end-stage renal disease patients on dialysis

A nationwide, population-based study in Taiwan

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Abstract

End-stage renal disease (ESRD) patients commonly have a higher risk of developing cardiovascular diseases than general population. Chronic kidney disease is an independent risk factor for atrial fibrillation (AF); however, little is known about the AF risk among ESRD patients with various modalities of renal replacement therapy. We used the Taiwan National Health Insurance Research Database to determine the incident AF among peritoneal dialysis (PD) and hemodialysis (HD) patients in Taiwan.

Our ESRD cohort include Taiwan National Health Insurance Research Database, we identified 15,947 patients, who started renal replacement therapy between January 1, 2002 and December 31, 2003. From the same data source, 47,841 controls without ESRD (3 subjects for each patient) were identified randomly and frequency matched by gender, age (±1 year), and the year of the study patient’s index date for ESRD between January 1, 2002 and December 31, 2003.

During the follow-up period (mean duration: 8–10 years), 3428 individuals developed the new-onset AF. The incidence rate ratios for AF were 2.07 (95% confidence interval [CI] = 1.93–2.23) and 1.78 (95% CI = 1.30–2.44) in HD and PD groups, respectively. After we adjusted for age, gender, and comorbidities, the hazard ratios for the AF risk were 1.46 (95% CI = 1.32–1.61) and 1.32 (95% CI = 1.00–1.83) in HD and PD groups, respectively. ESRD patients with a history of certain comorbidities including hypertension, diabetes mellitus, hyperlipidemia, coronary artery disease, heart failure, valvular heart disease, and chronic obstructive pulmonary disease (COPD) have significantly increased risks of AF.

This nationwide, population-based study suggests that incidence of AF is increased among dialysis ESRD patients. Furthermore, we have to pay more attention in clinical practice and long-term care for those ESRD patients with a history of certain comorbidities.

Abbreviations: AF = atrial fibrillation, CI = confidence interval, COPD = chronic obstructive pulmonary disease, ESRD = end-stage renal disease, HD = hemodialysis, HR = hazard ratio, ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification, LHID = Longitudinal Health Insurance Database, LVH = left ventricular hypertrophy, PD = peritoneal dialysis.

Keywords: atrial fibrillation, end-stage renal disease, hemodialysis, peritoneal dialysis

1. Introduction

With the progressive renal function impairment, chronic kidney disease patients usually experienced several comorbid conditions including cardiovascular disorders and at final end-stage renal disease (ESRD) stage, cardiovascular mortality accounts for about 50% of total mortality.[1,2] Medical costs associated with these cardiovascular diseases are also increasing annually. Apart from coronary atherosclerosis, left ventricular hypertrophy (LVH), and dilation, congestive heart failure and cardiac...
Atrial fibrillation (AF) is the most common arrhythmia and increasing prevalence is noted among dialysis patients (11%–27%) than age-matched general population (approximately 1%). Risk factors for AF have been investigated and renal function deterioration has been documented as independent risk factors for AF among many studies. Renal dysfunction also predicts AF-related stroke and related systemic thromboembolism.

In general, ESRD patients undergo 1 of 3 modalities, hemodialysis (HD), peritoneal dialysis (PD), and renal transplantation. ESRD patients comprise 0.3% of the general population in Taiwan, and National Health Insurance (NHI) program covers NT$23 billion (occupy 6.18% of total medical expenditures) for dialysis treatment every year. Due to the shortage of donor kidneys, renal transplantation is less frequently performed. Therefore, more than 65,000 people receive a long-term renal replacement therapy in Taiwan; with approximately 91.5% undergo HD and 8.5% undergo PD. Incidence of new-onset AF in ESRD dialysis patients and risk factors associated with this has been studied by Liao et al. Recently, however, impact of dialysis on the incidence of AF in dialysis patients has not been determined. Thus, we conducted a nationwide, population-based study to evaluate the incidence and risks factors related with AF among Taiwanese HD and PD patients.

2. Methods

2.1. Data sources

The NHI program was implemented in March 1995 by the National Health program in Taiwan and National Health Insurance (NHI) program covers NT$23 billion (occupy 6.18% of total medical expenditures) for dialysis treatment every year. Due to the shortage of donor kidneys, renal transplantation is less frequently performed. Therefore, more than 65,000 people receive a long-term renal replacement therapy in Taiwan; with approximately 91.5% undergo HD and 8.5% undergo PD. Incidence of new-onset AF in ESRD dialysis patients and risk factors associated with this has been studied by Liao et al. Recently, however, impact of dialysis on the incidence of AF in dialysis patients has not been determined. Thus, we conducted a nationwide, population-based study to evaluate the incidence and risks factors related with AF among Taiwanese HD and PD patients.

2.2. Study population

This study has a retrospective population-based cohort design. ESRD patients on a dialysis modality were selected from patients who were diagnosed with ESRD (ICD-9-CM 585) and started renal replacement therapy (HD or PD). All these ESRD patients had catastrophic illness registration cards. In Taiwan, ESRD patients who require a long-term dialysis modality are eligible to apply for a catastrophic illness registration card. The index date for ESRD patients was the date of their 1st diagnosis of new-onset ESRD. We excluded patients aged younger than 18 years or those aged older than 85 years. In addition, we excluded patients with a history of malignancy (ICD-9-CM 140–208) before the index date, patients with incomplete information on age and gender, and patients who did not receive a dialysis modality. Finally, a total of 17,213 patients, who started the renal replacement therapy between January 1, 2002 and December 31, 2011 and were considered as eligible controls. For the controls, their 1st use of health care in this year served as their index date and were served as their index date regardless of inpatient or ambulatory setting. We excluded patients with a history of malignancy before the index date, patients with incomplete information on age and gender, and patients aged younger than 18 years or older than 85 years. Finally, 47,841 eligible controls (at least 3 subjects for each ESRD patient) were identified randomly and frequency matched by gender, age (±1 year), and the year of the study patient’s index date for ESRD. Both ESRD patients and controls were followed up from the index date to the onset of AF or until December 31, 2011.

2.3. Variable measurement

The age of participants was classified into 4 subgroups: <50, 50–60, 60–70, and ≥70 years. Geographic area was divided into Northern, Central, Southern, and Eastern Taiwan. AF patients were patients with 3 outpatient AF (ICD-9-CM 427.31) claims. In this study, atrial flutter (ICD-9-CM: 427.32) claims were excluded because, in general, the prevalence and mechanisms of atrial flutter differ from those of AF. Comorbidity was defined as a certain disease with at least 3 outpatient claims before the index date. These selected comorbidities included hypertension (ICD-9-CM 401–405), diabetes mellitus (ICD-9-CM 250), hyperlipidemia (ICD-9-CM 272), coronary artery disease (ICD-9-CM 410–414), hyperthyroidism (ICD-9-CM 242), heart failure (ICD-9-CM 428), valvular heart disease (ICD-9-CM 394, 396, 424, 746), LVH (ICD-9-CM 429.3), venous thromboembolic disease (ICD-9-CM 453), and chronic obstructive pulmonary disease (COPD) (ICD-9-CM 490–492, 494, 496). The duration from the implementation of dialysis to the newly onset AF was determined by estimating the time elapsed since the start of dialysis therapy and the onset of AF.

2.4. Statistical analysis

The chi-square test was used to compare the categorical variables among control, HD, and PD groups. The person-years of follow-up were calculated for each participant from the date of the index (acute or chronic, HD or PD) to the diagnosis date of AF and to the end of the study. The incidence rate was calculated for each participant from the date of the index date to the end of the study. The incidence rate (per 1000 person-years) was calculated by dividing the number of incident AF by the person-years of follow-up as the denominator under the Poisson assumption. The Kaplan–Meier method and log-rank test were used to compare the risk of AF among the control, HD, and PD groups. The Cox proportional hazards model was used to estimate the hazard ratio (HR) and 95% confidence interval (CI). The adjusted HR was adjusted for age, gender, geographic area, and comorbidities, including hypertension, diabetes mellitus, hyperlipidemia, coronary artery disease, hyperthyroidism, heart failure, valvular heart disease, LVH, venous thromboembolic disease, or COPD. The SAS statistical package Version 9.3 (SAS Institute Inc., Cary, NC) was used for all statistical tests. Results with P < 0.05 were considered statistically significant.

2.5. Ethical approval

This study was reviewed and approved by the Taipei Medical University-Joint Institutional Review Board. As personal identification information was transformed and encrypted to protect the privacy of study participants, this study was exempted from full review by the Taipei Medical University-Joint Institutional Review Board (Approval No. 201211011).
3. Results

3.1. Patient demographics

We included 15,947 ESRD patients with dialysis who met our inclusion criteria, between January 1, 2002 and December 31, 2003, in the study group. Baseline characteristics of control and study groups are shown in Table 1. The mean ages were 60.8 ± 13.6, 61.3 ± 13.3, and 53.7 ± 15.0 years old in the control, HD, and PD groups, respectively. Regarding the duration from the implementation of dialysis to the newly onset AF, the mean ± standard deviation showed no significant difference between the HD group (2.89 ± 2.8) and the PD group (3.16 ± 2.9). Most ESRD patients also had the following comorbidities including hypertension, diabetes mellitus, hyperlipidemia, coronary artery disease, hyperthyroidism, heart failure, valvular heart disease, LVH, venous thromboembolic disease, and COPD (model 2, Table 2).

3.2. Incident AF among PD, HD, and control groups

To estimate the incidence rate, we excluded patients who had a history of AF before the index date. During the mean follow-up period of 8 to 10 years, 3428 ESRD patients developed the new-onset AF (1318, 64, and 2046 subjects in the HD, PD, and control groups, respectively). The incidence rates of AF were 9.91, 6.42, and 4.86 per 1000 person-years in the HD, PD, and control groups, respectively. The incidence rates of AF were 9.91, 6.42, and 4.86 per 1000 person-years in the HD, PD, and control groups, respectively. Compared with the controls, the risk of AF were 1.46 (95% CI = 1.32–1.61) and 1.32 (95% CI = 1.00–1.83) in HD and PD groups, respectively, after adjusting for age, gender, and comorbidities, including hypertension, diabetes mellitus, hyperlipidemia, coronary artery disease, hyperthyroidism, heart failure, valvular heart disease, LVH, venous thromboembolic disease, and COPD (model 2, Table 2).

3.3. Risks factors of new-onset AF in ESRD patients on different dialysis modalities

The adjusted HRs of AF (model 2) stratified by potential comorbidities for ESRD patients on different dialysis modalities are shown in Table 3. Compared with the control group, the significant HRs of 1.41 (95% CI = 1.22–1.62) and 1.51 (95% CI = 1.32–1.74) were found in the HD group for female and male ESRD patients, respectively. Among ESRD patients in different age subgroups, the significantly increased HRs of 6.36 (95% CI = 3.54–11.41), 2.65 (95% CI = 1.98–3.56), and 1.49 (95% CI = 1.33–1.68) were found in the HD group than those in the control group for <50 years, 50 to 59 years, and ≥60 years subgroups, respectively. Compared with the control group, those patients aged <50 years had a significantly increased risk of AF (HR = 5.18, 95% CI = 1.85–14.50) in the PD group.

The presence of certain comorbidities also significantly increased the risk of new-onset AF for the HD and PD groups, respectively. Those ESRD patients with hypertension had significantly higher risks of AF from the HR of 2.08 (95% CI = 1.64–2.63) in the HD group and from the HR of 2.59 (95% CI = 1.15–5.84) in the PD group. For ESRD patients with

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### Table 1

Basic characteristics and comorbidities of ESRD patients with dialysis modality.

| Variable                        | Controls (N = 47,841) | HD (N = 14,854) | PD (N = 1093) | P-value |
|---------------------------------|-----------------------|-----------------|--------------|---------|
| **Age (years)**                 |                       |                 |              |         |
| <50                             | 10305 (21.5)          | 2991 (20.1)     | 444 (40.6)   | 0.1938  |
| 50–59                           | 10221 (21.4)          | 3155 (21.3)     | 252 (23.1)   |         |
| 60–69                           | 12649 (26.4)          | 4001 (26.9)     | 214 (19.6)   |         |
| ≥70                             | 14670 (30.7)          | 4707 (31.7)     | 183 (16.7)   |         |
| **mean ± SD**                   | 60.8 ± 13.6           | 61.3 ± 13.3     | 53.7 ± 15.0  |         |
| **Gender**                      |                       |                 |              |         |
| Male                            | 22890 (47.8)          | 7201 (48.5)     | 429 (39.2)   | 0.6681  |
| Female                          | 24951 (52.2)          | 7653 (51.5)     | 664 (60.8)   |         |
| **Geographic area**             |                       |                 |              |         |
| Northern                        | 19503 (40.8)          | 5964 (40.2)     | 537 (49.1)   | 0.394   |
| Central                         | 11316 (23.7)          | 3475 (23.4)     | 297 (27.2)   |         |
| Southern                        | 15753 (32.9)          | 5013 (33.7)     | 238 (21.8)   |         |
| Eastern                         | 1269 (2.6)            | 402 (2.7)       | 21 (1.9)     |         |
| **Duration of AF onset**        |                       |                 |              |         |
| mean ± SD                       | 2.89 ± 2.8            | 3.16 ± 2.9      | <.0001       |
| **Comorbidities**               |                       |                 |              |         |
| Hypertension                    | 14657 (30.6)          | 10952 (73.7)    | 722 (66.1)   | <.0001  |
| Diabetes mellitus               | 7088 (14.8)           | 7485 (50.4)     | 359 (32.9)   | <.0001  |
| Hyperlipidemia                  | 7056 (14.8)           | 3896 (26.2)     | 239 (21.9)   | <.0001  |
| Ischemic heart disease          | 6147 (12.9)           | 3925 (26.4)     | 217 (19.9)   | <.0001  |
| Hypothyroidism                  | 336 (0.7)             | 197 (1.3)       | 20 (1.8)     | <.0001  |
| Heart failure                   | 655 (1.4)             | 4884 (32.0)     | 187 (17.1)   | <.0001  |
| Valvular heart disease          | 765 (1.6)             | 1250 (8.4)      | 69 (6.3)     | <.0001  |
| Left ventricular hypertrophy    | 131 (0.2)             | 286 (1.9)       | 16 (1.5)     | <.0001  |
| Venous thromboembolic disease   | 64 (0.1)              | 1299 (8.8)      | 25 (2.3)     | <.0001  |
| COPD                            | 3701 (7.7)            | 2493 (16.8)     | 117 (10.7)   | <.0001  |

AF = atrial fibrillation, COPD = chronic obstructive pulmonary disease, ESRD = end-stage renal disease, HD = hemodialysis, PD = peritoneal dialysis, SD = standard deviation.

* The time elapsed since the start of dialysis therapy and the onset of AF.

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diabetes mellitus, significantly higher risks of AF were observed from the HR of 1.52 (95% CI = 1.33–1.75) in the HD group and from the HR of 1.76 (95% CI = 1.13–2.75) in the PD group. ESRD patients with dyslipidemia had a significantly higher risk of AF from the HR of 1.50 (95% CI = 1.33–1.69) in the HD group. ESRD patients with coronary artery disease in the HD group had an adjusted HR of 1.82 (95% CI = 1.60–2.07). Those ESRD patients with heart failure had significantly higher risks of AF from the HR of 1.61 (95% CI = 1.44–1.80) in the HD group and from the HR of 1.48 (95% CI = 1.01–1.89) in the PD group. In addition, ESRD patients with valvular heart disease had a significantly higher risk of AF (HR = 1.51, 95% CI = 1.36–1.67) in the HD group. Regarding those ESRD patients with COPD, a significantly higher risk of AF (HR = 1.61, 95% CI = 1.44–1.81) was identified for the HD group.

### 4. Discussion

We investigated the risk of new-onset AF among ESRD patients receiving dialysis using National Health Insurance Research

### Table 3

Risks of AF stratified by covariates for ESRD patients with dialysis modality.

| Covariates                      | Model 1          | Model 2          | Model 1          | Model 2          |
|---------------------------------|------------------|------------------|------------------|------------------|
|                                 | HR (95% CI)      | HR (95% CI)      | HR (95% CI)      | HR (95% CI)      |
| Gender                          |                  |                  |                  |                  |
| Female                          | 2.02 (1.82–2.24) | 1.41 (1.22–1.62) | 1.56 (1.01–2.14) | 1.13 (0.72–1.78) |
| Male                            | 2.13 (1.93–2.36) | 1.51 (1.32–1.74) | 2.09 (1.33–3.29) | 1.59 (0.99–2.54) |
| Age (years)                     |                  |                  |                  |                  |
| <50                             | 8.72 (6.03–12.61)| 6.36 (3.54–11.41)| 5.14 (2.03–13.06)| 5.18 (1.85–14.50)|
| 50–59                           | 4.55 (2.69–5.60) | 2.65 (1.76–3.96) | 3.59 (1.70–7.48) | 2.04 (0.92–4.52) |
| ≥60                             | 1.71 (1.53–1.90) | 1.49 (1.33–1.68) | 1.31 (1.01–1.66) | 1.14 (0.81–1.63) |
| Hypertension                    |                  |                  |                  |                  |
| No                              | 1.44 (1.29–1.59) | 1.17 (1.02–1.34) | 1.27 (0.78–2.08) | 1.11 (0.67–1.83) |
| Yes                             | 2.39 (1.96–2.92) | 2.08 (1.64–2.63) | 2.55 (1.15–5.88) | 2.59 (1.15–5.84) |
| Diabetes mellitus               |                  |                  |                  |                  |
| No                              | 1.80 (1.49–2.18) | 1.47 (1.12–1.92) | 1.32 (0.65–2.72) | 1.21 (0.59–2.43) |
| Yes                             | 2.23 (1.99–2.49) | 1.52 (1.33–1.75) | 2.34 (1.53–3.50) | 1.76 (1.13–2.75) |
| Hyperlipidemia                  |                  |                  |                  |                  |
| No                              | 1.94 (1.46–2.58) | 1.32 (0.89–1.98) | 0.95 (0.33–2.78) | 0.80 (0.26–2.47) |
| Yes                             | 2.15 (1.97–2.35) | 1.50 (1.33–1.69) | 1.89 (1.28–2.80) | 1.46 (0.97–2.20) |
| Ischemic heart disease          |                  |                  |                  |                  |
| No                              | 1.06 (0.86–1.31) | 0.79 (0.59–1.09) | 1.86 (0.68–7.59) | 1.45 (0.95–2.21) |
| Yes                             | 2.44 (2.22–2.69) | 1.82 (1.60–2.07) | 2.27 (1.23–2.80) | 1.87 (1.04–3.49) |
| Heart failure                   |                  |                  |                  |                  |
| No                              | 0.67 (0.41–1.09) | 0.55 (0.26–1.16) | 1.00 (0.14–5.24) | 0.75 (0.64–2.70) |
| Yes                             | 1.94 (1.76–2.14) | 1.61 (1.44–1.80) | 1.76 (1.23–2.09) | 1.48 (1.01–1.93) |
| Vascular heart disease          |                  |                  |                  |                  |
| No                              | 0.68 (0.28–1.69) | 0.57 (0.95–1.84) | 1.00 (0.68–4.22) | 0.88 (0.71–4.54) |
| Yes                             | 2.01 (1.86–2.18) | 1.51 (1.36–1.67) | 1.83 (1.31–2.59) | 1.39 (0.98–1.91) |
| Chronic obstructive pulmonary disease | 1.56 (1.14–2.16) | 1.31 (0.84–2.05) | 1.00 (0.84–3.41) | 0.92 (0.57–2.23) |
| Yes                             | 2.26 (2.07–2.45) | 1.61 (1.44–1.81) | 1.62 (1.14–2.31) | 1.23 (0.89–1.82) |

Model 1: Adjustment for age and gender; Model 2: Adjustment for age, gender, geographic area and comorbidities including hypertension, diabetes mellitus, hyperlipidemia, ischemic heart disease, hyperthyroidism, Heart failure, Vascular heart disease, LVH = left ventricular hypertrophy, HD = hemodialysis, HR = hazard ratio, PD = peritoneal dialysis.
increased the risk of new-onset AF for the HD and PD groups. Valvular calcification is a common complication of dialysis patients and occurs as a result of dysregulation of calcium and phosphate metabolism. Calcification of the cardiac valve leaflets can change the mechanical properties of the cardiac tissue and results in development of AF. With loss of residual renal function, most of these patients experienced chronic volume overload, LVH, and repeated heart failure, all of which are found to increased incident AF in our patients. Respiratory and renal diseases are frequently coexisting, and most dialysis patients experienced intradialytic hypoxemia. Abnormal pulmonary functions, dialytic, and pulmonary hypertension related hemodynamic changes can lead to the development of AF. Medications used for COPD prevention and exacerbation, for example, beta-adrenergic agonist and theophylline might associated with development of AF. Some studies also point out the importance of these risk factors in chronic dialysis patients. Similarly to the general population, a high incidence of stroke in AF might lead to high mortality in this population.

This study has several limitations. First, we did not include individual behaviors that related with AF including smoking habits, alcohol intake, and physical activity, etc. and clinical data including body mass index, severity of comorbidities, residual renal function, and actual blood pressure values were lacking. Second, we relied on the ICD-9-CM diagnosis codes of AF and comorbidities associated with AF; and echocardiographic parameters such as left atrial dimension, LVH, and valvular status were also lacking. However, recent clinical diagnosis of AF is largely based on electrocardiogram, we believed most of our study could represent most of the AF population. Finally, our study lacked specific data on dialysis vintage, fluid management during dialysis sessions, and intradialytic hemodynamic change, and we did not analyzed specific medications which might influence AF in this population.

In conclusion, increased risk of AF is noted among ESRD patients on dialysis especially with certain comorbidities. Although we can only show a relationship, not causality, between dialysis and incident AF, this relationship is clinically crucial since it can help physicians to pay more attention on AF related morbidity and mortality among dialysis patients.

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References

[1] Shik J, Parfrey PS. The clinical epidemiology of cardiovascular disease in chronic kidney disease. Curr Opin Nephrol Hypertens 2005;14:350–7.
[2] Remppis A, Retz E. Cardiac problems in the dialysis patient: beyond coronary disease. Semin Dial 2008;21:319–22.
[3] January CT, Wann LS, Alpert JS, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol 2014;64:e1–76.
[4] Genovesi S, Pogliani D, Fami A, et al. Prevalence of atrial fibrillation and associated factors in a population of long-term hemodialysis patients. Am J Kidney Dis 2005;46:897–902.
[5] Konarztopoulos P, Kokkoris S, Liu T, et al. Atrial fibrillation in end-stage renal disease. Pacing Clin Electrophysiol 2007;30:1391–7.
[6] Reinecke H, Brand E, Mesters R, et al. Dilemmas in the management of atrial fibrillation in chronic kidney disease. J Am Soc Nephrol 2009; 20:705–11.
[7] Genovesi S, Vincenti A, Rossi E, et al. Atrial fibrillation and morbidity and mortality in a cohort of long-term hemodialysis patients. Am J Kidney Dis 2008;51:255–62.

[8] Iuchi Y, Kimura K, Kobayashi K, et al. Relation of atrial fibrillation to glomerular filtration rate. Am J Cardiol 2008;102:1056–9.

[9] Soliman EZ, Princea RJ, Go AS, et al. Chronic kidney disease and prevalent atrial fibrillation: the Chronic Renal Insufficiency Cohort (CRIC). Am Heart J 2010;159:1102–7.

[10] Baber U, Howard VJ, Halperin JL, et al. Association of chronic kidney disease with atrial fibrillation among adults in the United States: REasons for Geographic and Racial Differences in Stroke (REGARDS) Study. Circ Arrhythm Electrophysiol 2011;4:26–32.

[11] Chao TF, Tsao HM, Ambrose K, et al. Renal dysfunction and the risk of atrial fibrillation: the Chronic Renal Insufficiency Cohort (CRIC). Am Heart J 2010;159:1102–7.

[12] Vazquez E, Sanchez-Perales C, Lozano-Cabezas C, et al. Atrial fibrillation and morbidity and mortality in a cohort of long-term hemodialysis patients. Kidney Blood Pressure Res 2012;35:431–40.

[13] Wu M, Rementer C, Giachelli CM. Vascular calcification: an update on atherogenesis and left ventricular hypertrophy and geometry in peritoneal dialysis patients. Kidney Blood Pressure Res 2012;35:431–40.

[14] Takeda K, Nakamoto M, Hirakata H, et al. Disadvantage of long-term haemodialysis patients: clinical features and associations with anticoagulant therapy. Kidney Int 2010;77:1098–106.

[15] Goldstein BA, Arce CM, Hlatky MA, et al. Trends in the incidence of atrial fibrillation in older patients initiating dialysis in the United States. Circulation 2012;126:293–301.

[16] Mesler DE, McCarthy EP, Byrne-Logan S, et al. Does the survival advantage of nonwhite dialysis patients persist after case mix adjustment? Am J Med 1999;106:300–6.