Peripheral artery disease at the time of dialysis initiation and mortality: a prospective observational multicenter study

Hikaru Morooka 1, Akihito Tanaka 1, 1, Daijo Inaguma 1, 2, Shoichi Maruyama 3

ABSTRACT

Objectives Patients with peripheral artery disease (PAD) are reported to have a poorer prognosis than those without PAD. PAD is sometimes found at dialysis initiation, but its influence on the prognosis in these patients has not been investigated. We aimed to compare the mortality rate between patients with PAD at the time of dialysis initiation and those without PAD.

Design We undertook an observational prospective multicenter study of patients starting dialysis treatment. Data were collected on patients’ sex, age, presence of PAD, medication, medical history and clinical and laboratory data.

Setting Seventeen centers participated in the Aichi Cohort Study of Prognosis in Patients Newly Initiated into Dialysis.

Participants A total of 1524 patients with chronic kidney disease started dialysis from October 2011 to September 2013. The patients were followed-up until March 2015. During this time, there were two patients who lost the follow-up.

Primary and secondary outcome measures The primary outcome was defined as all-cause mortality. The secondary outcomes were defined as each cause of mortality.

Results This study included 1030 men and 492 women with a mean age of 67.50±13.10 years. Of these, 71 had PAD and 1451 did not have PAD. After a median follow-up of 814.5 days, 33.80% of the former group and 17.00% of the latter group had died in March 2015 (p=0.001). After adjusting for confounding factors, PAD at dialysis initiation remained an independent risk factor for mortality (p<0.01).

Conclusions Patients with PAD at the time of dialysis initiation had a poorer prognosis than patients without PAD. Therefore, the presence of PAD in patients starting dialysis should be considered for their monitoring and follow-up.

INTRODUCTION

The number of patients receiving dialysis treatment is increasing every year, and these patients have a high mortality risk from various causes, particularly cardiovascular diseases (CVDs). 1 2 End-stage kidney disease (ESKD) represents a considerable risk of atherosclerosis, and patients on dialysis tend to have further risk factors contributing to the rapid deterioration of CVD. 3 While CVD, including stroke, and coronary artery disease have been reported in more detail in patients on dialysis, 4–6 the problem of peripheral artery disease (PAD) in patients undergoing dialysis treatment has been less frequently addressed. With both ageing and a growing number of patients with diabetes on dialysis, the prevalence of PAD among these patients is likely to increase every year. 7 PAD with distal lesions is more common in patients with ESKD, making the transarterial approach to the stenosis sometimes difficult. 8 9 Furthermore, a vascular stenosis can promote peripheral ischemic skin ulcers or gangrene, leading to an intractable pathology. Thus, patients with PAD on dialysis treatment have a worse prognosis than those without PAD. 10 Consequently, there is an urgent need to clarify the relationships between PAD and mortality in patients on dialysis. Furthermore, to improve the prognosis of dialysis patients, it is crucial to understand the characteristics of those with high mortality risk.

The classic atherosclerosis risk factors, such as age, smoking, diabetes, hypertension and hyperlipidemia, are common in patients with...
ESKD, but their chronic kidney disease (CKD) condition adds unique risk factors that promote PAD (eg, chronic inflammation, hypoalbuminemia and a pro-calcific state). PAD in patients with ESKD markedly increases the possibility of myocardial ischemia and stroke, and is the main cause of limb loss and mortality, the rates of which are much higher than those in the general population.\textsuperscript{10,11} Moreover, it has been pointed out that if patients with PAD develop critical limb ischemia, their overall survival is worse than those of patients with malignant tumours.\textsuperscript{12} Hence, when considering the prognosis of patients receiving dialysis, the presence of PAD is important.

There are few recent reports on PAD in patients with ESKD at the time of dialysis initiation. Several studies have investigated patients receiving maintenance dialysis. In these studies, descriptive data included the prognosis of ‘only maintenance dialysis’ patients.\textsuperscript{10,13-15} According to them, PAD had an overall prevalence of 18.2%, and the patient survival rate was 28.6% during 8.8 years in the PAD group. Moreover, since these studies focused on patients on maintenance dialysis, they mainly addressed PAD that occurred during dialysis. However, renal function in patients with CKD may decrease during the treatment of PAD. At other times, PAD is found when investigating the cause of renal function deterioration or when screening patients for their eligibility of a renal transplant. PATD at the time of dialysis initiation is a complex and clinically relevant problem.

In this study, we compared PAD and non-PAD patients who had started dialysis treatment in the Aichi prefecture to identify the mortality associated with PAD in patients with ESKD at the time of initiation of dialysis treatment.

**PATIENTS AND METHODS**

**Patient registration and data collection**

Data from the Aichi Cohort Study of Prognosis in Patients Newly Initiated into Dialysis\textsuperscript{14,16} were used in this prospective multicenter study. Patients who started dialysis between October 2011 and September 2013 at 17 Japanese institutions were eligible for participation.

First, we screened all patients with ESKD for whom dialysis was initiated. Only patients who became stable and discharged or transferred from the hospital were included. Patients who were not discharged and died in the hospital were excluded (figure 1). Data regarding patients’ demographics, medical history, comorbidities, medications and laboratory data during the period of dialysis initiation were collected. PAD was clinically diagnosed based on symptoms, physical findings and various examinations, but not all patients received angiography for diagnosis. After physician’s careful evaluation of patients, we used the Fontaine classification for grading the severity.\textsuperscript{17} The presence of PAD was defined as a Fontaine stage II or higher. Laboratory data were obtained immediately prior to the first dialysis session. Patients followed by survey slips were sent to the dialysis facilities until the end of March 2015.

**Mortality**

Patients were divided into one group with PAD and other group without PAD. The primary endpoint was all-cause mortality. Causes of death were recorded to a possible extent. The occurrence of death was investigated via survey slips sent to the dialysis facilities at the end of March 2015.
Table 1  Baseline and clinical characteristics and outcomes of patients starting dialysis (n=1522) and propensity score-matched patients starting dialysis (n=284)

|                        | Without propensity-score matched (n=1522) | With propensity-score matched (n=284) |
|------------------------|-------------------------------------------|--------------------------------------|
|                        | Patients without PAD (n=1451) | Patients with PAD (n=71) | P value | Patients without PAD (n=213) | Patients with PAD (n=71) | P value |
| Female (%)             | 33.10 | 16.90 | 0.007 | 15.00 | 16.90 | 0.850 |
| Age (years) [mean (SD)]| 67.40 (13.10) | 69.90 (12.10) | 0.106 | 69.10 (12.20) | 69.90 (12.10) | 0.607 |
| History                |                                            |                                      |                                    |                                            |                                      |        |
| Diabetes (%)           | 50.20 | 67.60 | 0.006 | 67.10 | 67.60 | 1.000 |
| CAD (%)                | 15.90 | 36.60 | <0.001 | 40.40 | 36.60 | 0.674 |
| PCI (%)                | 9.60  | 21.10 | 0.003 | 26.80 | 21.10 | 0.431 |
| CABG (%)               | 3.80  | 14.10 | <0.001 | 9.90  | 14.10 | 0.442 |
| Aortic dissection (%)  | 5.00  | 15.50 | <0.001 | 7.00  | 15.50 | 0.057 |
| Admission of HF (%)    | 19.40 | 42.30 | <0.001 | 29.10 | 42.30 | 0.057 |
| Stroke (%)             | 9.10  | 7.00  | 0.704 | 14.10 | 7.00  | 0.175 |
| Cause of CKD           |                                            |                                      |                                    |                                            |                                      |        |
| Diabetes (%)           | 42.50 | 59.20 | 0.010 | 58.70 | 59.20 | 0.781 |
| Nephrosclerosis (%)    | 25.30 | 25.40 | 0.999 | 25.40 | 25.40 | 0.999 |
| CGN (%)                | 15.60 | 4.20  | 0.001 | 8.50  | 4.20  | 0.001 |
| Others, unknown (%)    | 4.30  | 4.20  | 0.100 | 2.30  | 4.20  | 0.100 |
| Vital data             |                                            |                                      |                                    |                                            |                                      |        |
| Pre-dialysis SBP (mmHg) [mean (SD)] | 151.10 (25.90) | 151.70 (29.50) | 0.843 | 151.80 (28.30) | 151.70 (29.50) | 0.977 |
| Cardiac ultrasonography|                                            |                                      |                                    |                                            |                                      |        |
| EF (%) (mean (SD))     | 60.90 (12.20) | 55.80 (13.70) | 0.001 | 59.80 (13.80) | 55.80 (13.70) | 0.049 |
| Chest X-ray            |                                            |                                      |                                    |                                            |                                      |        |
| CTR (%) (mean (SD))    | 55.20 (7.20) | 55.20 (7.10) | 0.973 | 55.30 (6.80) | 55.20 (7.10) | 0.885 |
| Administration         |                                            |                                      |                                    |                                            |                                      |        |
| ARB or ACEI (%)        | 60.60 | 56.30 | 0.554 | 59.20 | 56.30 | 0.781 |
| BB (%)                 | 34.00 | 47.90 | 0.024 | 49.30 | 47.90 | 0.945 |
| Statin (%)             | 39.40 | 53.50 | 0.024 | 58.70 | 53.50 | 0.533 |
| VDRA (%)               | 26.90 | 29.60 | 0.726 | 27.20 | 29.60 | 0.819 |
| Antiplatelets (%)      | 28.90 | 56.30 | <0.001 | 58.20 | 56.30 | 0.890 |
| ESA (%)                | 85.80 | 87.30 | 0.861 | 89.70 | 87.30 | 0.742 |
| Laboratory data        |                                            |                                      |                                    |                                            |                                      |        |
| WBC (×10^9/L) (mean (SD)) | 6.73 (3.13) | 7.21 (3.58) | 0.214 | 6.70 (2.72) | 7.21 (3.58) | 0.217 |
| Hb (g/L) (mean (SD))   | 93.70 (15.50) | 94.00 (14.50) | 0.887 | 96.20 (14.30) | 94.00 (14.50) | 0.275 |
| Pt (×10^9/L) (mean (SD)) | 182.40 (76.20) | 181.70 (81.90) | 0.943 | 179.00 (73.90) | 181.70 (81.90) | 0.796 |
| Alb (g/dL) (mean (SD)) | 3.21 (0.59)  | 3.02 (0.62) | 0.010 | 3.20 (0.60)  | 3.02 (0.62) | 0.032 |
| BUN (mg/dL) (mean (SD)) | 92.02 (30.69) | 86.68 (24.84) | 0.149 | 87.14 (27.58) | 86.68 (24.84) | 0.901 |
| Cr (mg/dL) (mean (SD)) | 9.03 (3.24)  | 7.74 (2.22) | 0.001 | 8.47 (2.82)  | 7.74 (2.22) | 0.049 |
| eGFR (mL/min/1.73 m^2) (mean (SD)) | 5.40 (2.23) | 6.34 (1.83) | 0.001 | 6.05 (2.47) | 6.34 (1.83) | 0.368 |
| Na (mEq/L) (mean (SD)) | 137.88 (4.41) | 137.93 (3.91) | 0.933 | 138.36 (4.56) | 137.93 (3.91) | 0.475 |
| K (mEq/L) (mean (SD)) | 4.56 (0.84)  | 4.43 (0.81) | 0.194 | 4.51 (0.83)  | 4.43 (0.81) | 0.492 |
| Adjusted Ca (mg/dL) (mean (SD)) | 8.59 (1.06) | 9.06 (0.93) | <0.001 | 8.71 (0.96) | 9.06 (0.93) | 0.007 |
| P (mg/dL) (mean (SD)) | 6.40 (1.89)  | 5.76 (1.56) | 0.005 | 5.96 (1.63)  | 5.76 (1.56) | 0.372 |
| Mg (mg/dL) (mean (SD)) | 2.15 (0.49)  | 2.17 (0.44) | 0.826 | 2.22 (0.46)  | 2.17 (0.44) | 0.497 |
| UA (mg/dL) (mean (SD)) | 8.80 (2.44)  | 8.64 (2.27) | 0.582 | 8.75 (2.49)  | 8.64 (2.27) | 0.731 |
| LDL C (mg/dL) (mean (SD)) | 89.97 (34.25) | 87.08 (37.14) | 0.525 | 87.07 (32.01) | 87.08 (37.14) | 0.999 |

Continued
We compared the outcomes, HRs and logistic regression model between the two groups.

Statistics
Baseline characteristics were presented descriptively and compared between the two groups using the Student’s \( t \)-test or \( \chi^2 \)-test. Survival was presented graphically using the Kaplan-Meier method and analysed using univariate and multivariate Cox regression and univariate and multivariate logistic regression model. ORs were calculated and presented graphically using forest plots. HRs were calculated and presented on a table. We used propensity score matching to account for differences in baseline characteristics between the two groups. The propensity score was calculated based on age, sex, presence of diabetes, medication (use of statins, ACE inhibitors, angiotensin-receptor blockers, beta blockers and antiplatelets), laboratory data (levels of phosphorus, haemoglobin and estimated glomerular filtration rate) and history of coronary artery disease.

\[ P \text{ values of } <0.05 \text{ were considered to be statistically significant. We used the R software (V.4.0.0, R Foundation for Statistical Computing, Vienna, Austria, http://www.R-project.org/) for all statistical analysis. For the propensity score matching, the R-package MatchIt (1:3 matching with the nearest neighbour) was used.} \]

We compared the outcomes, HRs and logistic regression model between the two groups.

**RESULTS**

**Baseline characteristics**

Patients’ baseline characteristics are shown in Table 1.

The initial population included 1524 participants, of which 1032 were men and 492 were women. Two patients were untraceable and lost to follow-up. The mean age was 67.50±13.10 years. Of the remaining 1522 patients, 71 (4.70 %) had PAD and 1451 did not have PAD. There were significant differences between patients with and without PAD with regard to comorbidities and drug use. Antiplatelet administration was significantly more frequent in those with PAD than in those without PAD. This may be because the treatment for PAD includes antiplatelets. However, since other causes, such as myocardial infarction, can be the reason why these patients were on the antiplatelet therapy. The prevalence of diabetes mellitus, coronary artery disease and aortic dissection was significantly higher in those with PAD than in those without PAD. Patients with PAD had significantly lower ejection fractions than patients without PAD. The use of both beta-blockers and statins was significantly higher in patients with PAD than in those without PAD (beta-blockers: 34.00 % and 53.50 %, respectively, \( p=0.024 \); statins: 39.40 % and 53.50 %, respectively, \( p=0.024 \)). The estimated glomerular filtration rate was significantly higher in patients with PAD than in those without PAD (\( 6.34±1.83 \) mL/min/\( 1.7 \) m\(^2\) and \( 5.40±2.23 \) mL/min/\( 1.7 \) m\(^2\), respectively, \( p=0.001 \)). The median follow-up was 814.5 days (IQR 645–1037).

**Mortality**

During the follow-up period, 271 patients died from various causes, including cardiovascular events (102 patients, 37.6 %), infectious disease (56 patients, 20.7 %), cancer (45 patients, 16.6 %) and other causes.

| Outcome | Without propensity-score matched \( n=1522 \) | With propensity-score matched \( n=284 \) |
|---------|---------------------------------------------|---------------------------------------------|
| CRP (mg/dL) (mean (SD)) | 1.82 (4.14) | 2.39 (4.68) | 0.271 |
| \( \beta \text{2MG} \) (ng/dL) (mean (SD)) | 19.32 (5.78) | 17.33 (5.05) | 0.027 |
| TSAT (%) (mean (SD)) | 27.16 (16.60) | 25.44 (17.95) | 0.438 |
| Ferritin (ng/dL) (mean (SD)) | 222.28 (1009.80) | 226.65 (395.74) | 0.972 |

| Outcome | Without propensity-score matched \( n=213 \) | With propensity-score matched \( n=71 \) |
|---------|---------------------------------------------|---------------------------------------------|
| CRP (mg/dL) (mean (SD)) | 1.61 (3.30) | 2.39 (4.68) | 0.137 |
| \( \beta \text{2MG} \) (ng/dL) (mean (SD)) | 19.32 (5.78) | 17.33 (5.05) | 0.497 |
| TSAT (%) (mean (SD)) | 27.16 (16.60) | 25.44 (17.95) | 0.992 |
| Ferritin (ng/dL) (mean (SD)) | 222.28 (1009.80) | 226.65 (395.74) | 0.153 |

ACEI, ACE inhibitor; Adjusted Ca, adjusted calcium; Alb, albumin; ARB, angiotensin receptor blocker; BB, beta blocker; BUN, blood urea nitrogen; Ca, calcium; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CGN, chronic glomerulonephritis; CKD, chronic kidney disease; Cr, creatinine; CRP, C reactive protein; CTR, cardiothoracic ratio; CVD, cardiovascular disease; EF, ejection fraction; eGFR, estimated glomerular filtration rate; ESA, erythropoetin stimulating agent; hb, haemoglobin; HF, heart failure; K, potassium; LDL-C, low-density lipoprotein cholesterol; \( \beta \text{2MG} \), beta-2 microglobulin; Mg, magnesium; Na, sodium; P, phosphate; PAD, peripheral arterial disease; PCI, percutaneous coronary intervention; Plt, platelet; SBP, systolic blood pressure; TSAT, transferrin saturation; UA, uric acid; VDRA, vitamin D receptor agonist; WBC, white blood cells.
PAD group had a significantly higher mortality rate of 33.80% than the group without PAD with 17.00% (p=0.001; table 1). Figure 2A shows the Kaplan-Meier plot for all-cause mortality in patients with and without PAD. Figure 2B shows the Kaplan-Meier plot for CVD-related mortality in patients with and without PAD. The former group had a significantly higher mortality rate than the latter group (p=0.048). Figure 2C shows the Kaplan-Meier plot for infection-related mortality in patients with and without PAD. The former group had a significantly higher mortality rate than the latter group (p=0.011). Figure 3 shows the forest plot for the HRs of PAD for all-cause death with adjustment for confounding factors. PAD was an independent risk factor for death (HR, 1.76; 95% CI, 1.15–2.69; p=0.009). As sensitivity analyses, we conducted the same analyses on patients, who survived longer than 3 months after the observation beginning. The results resembled the former ones (online supplemental figure S1–S3), except the Kaplan-Meier plot for CVD-related mortality in patients with and without PAD with no significant differences between the groups (p=0.300, p=0.069). In logistic regression analysis including propensity score into multivariable factors, patients with PAD had significantly worse prognosis than patients without PAD (table 2). Online supplemental table S1 shows results of the marginal structural Cox model. In all models, PAD was an independent risk factor even after propensity score matching (HRs>2.20, p<0.01).

**DISCUSSION**

Our study showed that patients with PAD at the time of dialysis initiation had a significantly higher mortality rate than patients without PAD. This higher risk should be considered in the treatment and monitoring of these patients.
A previous study suggested that the prevalence of PAD in patients with ESKD reached almost 20%. In our cohort, the prevalence of PAD was much lower, most likely because our patients started dialysis, whereas the patients in the literature were on maintenance dialysis. This might reflect a deterioration of peripheral atherosclerosis with longer duration of dialysis. Another study suggested that the chronic uremic state is associated with systemic inflammation in dialysis patients, leading to hypoalbuminemia and an increased risk of PAD. Hence, our results are remarkable because we showed the prevalence of PAD at the time of dialysis initiation, while previous studies reported on PAD during maintenance dialysis. Furthermore, patients with PAD in our study more frequently had a decreased ejection fraction and decreased albumin and increased adjusted calcium levels than those without PAD, even after propensity score matching. We cannot exclude the possibility of other factors associated with PAD that were not corrected even after our propensity score matching. This implies that PAD is one symptom of a systemic atherosclerotic disease that affects not only the peripheral but also coronary arteries. When seeing patients with myocardial infarction or low cardiac systolic function, it is recommended to suspect that they have PAD.

In this study, patients with PAD at the time of dialysis initiation had a worse prognosis than patients without PAD. Patients with PAD suffered more frequently from CVD and infectious diseases. After propensity score matching, all-cause mortality still indicated a similar result. As our propensity score included a history of coronary artery disease, we could not show a significant difference between patients with and without PAD regarding this aspect. We assume that the number of patients with PAD was too small to demonstrate a significant difference in infection-related deaths between patients with and without PAD. However, these results support that atherosclerosis is likely to occur not only in the coronary but also in the peripheral arteries in patients with ESKD. PAD is a systemic disease, which can negatively affect patients’ prognosis. Based on our findings, it is critical to detect patients with PAD at the time of dialysis initiation.

Our results should be interpreted within the limitations of our study. First, as this was an observational study, there is an inevitable selection bias in our patients with ESKD and PAD. Second, the number of patients with PAD was small, and the number of patients who received Ankle Brachial Index (ABI) is not available. As we did not examine ABI for all patients, we were not able to diagnose PAD.

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**Table 2** ORs of the mortality of the patients (n=1522)

| Model       | OR    | 95% CI        | P value |
|-------------|-------|---------------|---------|
| Model 1     | 2.49  | 1.49 to 4.15  | <0.001  |
| Model 2     | 2.00  | 1.18 to 3.38  | 0.010   |
| Model 3     | 2.12  | 1.24 to 3.61  | 0.006   |
| Model 4     | 1.93  | 1.12 to 3.30  | 0.017   |

Model 1: PAD.
Model 2: PAD + propensity score.
Model 3: PAD + propensity score + pre SBP.
Model 4: PAD + propensity score + pre SBP + adjusted calcium.
PAD, peripheral artery disease; SBP, systolic blood pressure.
asymptomatic patients or those who did not describe their symptoms seen in PAD. ABI is a frequently used examination for PAD diagnosis and the lack of this result is important. Furthermore, how many patients underwent other diagnostic tests, such as contrast-enhanced CT, magnetic resonance angiography and peripheral angiography, and the results of these tests were unavailable. Hence, the statistical power of our results may be low. Furthermore, we did not include patients with Fontaine stage I into the PAD group. However, our study included a well-defined population as a strength.

CONCLUSION
Patients with PAD at the time of dialysis initiation showed higher rates of mortality than patients without PAD. Therefore, the presence of PAD in patients starting dialysis should be considered for their monitoring and follow-up.

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REFERENCES
1. Sato T, Sakurai H, Okubo K, et al. Current state of dialysis treatment and vascular access management in Japan. J Vasc Access 2019;20:10–14.
2. Masakane I, Nakai S, Ogata S, et al. An overview of regular dialysis treatment in Japan (as of 31 December 2013). Ther Apher Dial 2015;19:540–74.
3. Cozzolino M, Galassi A, Pivari F, et al. The cardiovascular burden in end-stage renal disease. Contrib Nephrol 2017;191:44–57.
4. Cozzolino M, Mangano M, Stucchi A, et al. Cardiovascular disease in dialysis patients. Nephrol Dial Transplant 2018;33:iii28–34.
5. US, System RD. Atlas of chronic kidney disease and end-stage renal disease in the United States. Bethesda, MD: National Institute of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2009.
6. Seliger SL, Gillen DL, Longstreth WT, et al. Elevated risk of stroke among patients with end-stage renal disease. Kidney Int 2003;64:603–9.
7. Garimella PS, Hirsch AT. Peripheral artery disease and chronic kidney disease: clinical synergy to improve outcomes. Adv Chronic Kidney Dis 2014;21:480–7.
8. Murakata Y, Aoyama T, Iishi H, et al. Long-term outcome of percutaneous transluminal angioplasty in chronic haemodialysis patients with peripheral arterial disease. Nephrol Dial Transplant 2007;22:3996–4001.
9. Graziani L, Silvestrini M, Bertone V, et al. Percutaneous transluminal angioplasty is feasible and effective in patients on chronic dialysis with severe peripheral artery disease. Nephrol Dial Transplant 2007;22:1144–9.
10. Otsubo S, Kitamura M, Wakaume T, et al. Association of peripheral arterial disease and long-term mortality in hemodialysis patients. Int Urol Nephrol 2012;44:569–73.
11. Liew YP, Bartholomew JR, Demirjian S, et al. Combined effect of chronic kidney disease and peripheral arterial disease on all-cause mortality in a high-risk population. Clin J Am Soc Nephrol 2008;3:1084–9.
12. O’Hare AM, Feinglass J, Sidawy AN, et al. Impact of renal insufficiency on short-term morbidity and mortality after lower extremity revascularization: data from the Department of Veterans Affairs’ national surgical quality improvement program. J Am Soc Nephrol 2005;16:1287–95.
13. Liu J-H, Chen J-Y, Lin S-Y, et al. Comparing survival between peritoneal dialysis and hemodialysis patients with subclinical peripheral artery disease: a 6-year follow-up. Int J Med Sci 2013;10:434–40.
14. Hishida M, Tamai H, Morinaga T, et al. Aichi cohort study of the prognosis in patients newly initiated into dialysis (AICOPP): baseline characteristics and trends observed in diabetic nephropathy. Clin Exp Nephrol 2016;20:795–807.
15. Lee C-G, Wu C-J, Chou L-H, et al. Peripheral artery disease in peritoneal dialysis and hemodialysis patients: single-center retrospective study in Taiwan. BMC Nephrol 2012;13:100.
16. Tanaka A, Inaguma D, Shinjo H, et al. Presence of atrial fibrillation at the time of dialysis initiation is associated with mortality and cardiovascular events. Nephron 2016;123:86–92.
17. Fontaine R, Kim M, Kiyeni R. [Surgical treatment of peripheral circulation disorders]. Hélv Chir Acta 1954;21:499–533.
18. DE H, Imai K, King G. MatchIt: nonparametric preprocessing for parametric causal inference. J Stat Soft 2011;42:1–28.
19. Matsuo S, Imai E, Horio M, et al. Revised equations for estimated GFR from serum creatinine in Japan. Am J Kidney Dis 2009;53:982–92.
20. Cooper BA, Perre EL, Bartlett LH, et al. Protein malnutrition and hypoalbuminemia as predictors of vascular events and mortality in ESRD. Am J Kidney Dis 2004;43:81–6.