Association of Young versus Elderly Maintenance Hemodialysis Patients with Mortality: A Multicenter Retrospective Cohort Study in China

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Research Article

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Abstract

Background End-stage renal disease patients with maintenance hemodialysis have high-mortality risk. The association of different age of hemodialysis patients with mortality remains uncertain in China. This study aimed to assess the survival outcomes and risk factors affecting mortality between young and elderly patients with maintenance hemodialysis.

Methods The multicenter retrospective cohort study enrolled adult patients undergoing maintenance hemodialysis from 24 hemodialysis centers in China between January 1, 2008, and September 30, 2015. The patients were assigned to young and elderly group according to age on the initiation of the hemodialysis. The primary outcome was all-cause mortality of patients. Survival outcomes of patients was performed using a Kaplan-Meier survival analysis. Multivariate cox proportional hazards regression models were implemented to identify risk factors affecting all-cause mortality of patients with maintenance hemodialysis.

Results A total of enrolled 1601 patients undergoing maintenance hemodialysis, including 642 young patients and 959 elderly patients. The mean follow-up duration was 48.17 ± 25.59 months, the all-cause mortality was 64 (9.97%) in young group and 255 (26.59%) in elderly group, the hazard ratio [HR] of elderly patients relative to young patients, 1.699 (95% confidence interval [95% CI], 1.482 to 1.949, $P < 0.001$). The Kaplan-Meier survival curve showed that overall cumulative survival was lower in elderly group than young group (Log Rank tests = 63.31, $P < 0.001$). Multivariate cox regression analysis revealed that the cardiovascular disease (HR, 1.544; 95% CI, 1.103 to 2.161; P = 0.011), cerebrovascular disease (HR, 2.158; 95% CI, 1.309 to 3.557; P = 0.003), lower serum albumin (HR, 1.404; 95% CI, 1.001 to 1.968; P = 0.049), Charlson comorbidity index (CCI) scores with 4-5 (HR, 4.910; 95% CI, 2.327 to 10.357; $P < 0.001$), CCI scores with ≥6 (HR, 9.596; 95% CI, 4.807 to 19.158; $P < 0.001$) were the risk factors associated all-cause mortality of patients.

Conclusions The elderly patients undergoing maintenance hemodialysis showed lower survival and higher mortality than young patients in China. Cardiovascular disease, cerebrovascular disease, serum albumin, CCI scores were the risk factors for all-cause mortality of young and elderly patients with maintenance hemodialysis.

Background

End-stage renal disease (ESRD) has become a global public health problem with a high prevalence and mortality in worldwide[1, 2]. Hemodialysis is the major modality of renal replacement therapy for patients with ESRD[2–4], accounting for 91.0% of all patients receiving dialysis in China[2], and 86.9% of in United States[5]. The numbers of ESRD patients with receiving hemodialysis in China with an annual increasing rate of 52.9%[6], approximately 553,000 in China[2]. The number of elderly patients has been increasing in recent years, Epidemiological surveys showed that the number of starting dialysis patients between 65 and 74 years old increased by 47%, while the number of elderly patients more than 75 years old increased by 300% from 1980 to 2012[7]. Meanwhile, young patients also account for significant proportion in receiving hemodialysis patients[4, 5, 8, 9].

ESRD patients undergoing maintenance hemodialysis were associated with much higher mortality than the general population, and the mortality were not consistent among different ages of patients with maintenance hemodialysis, especially elderly hemodialysis patients were associated with highest mortality[10]. The association of young verus elderly Hemodialysis patients with mortality remains uncertain in China, and few studies have evaluated the risk factors affecting mortality in different ages of hemodialysis population. Therefore, the aim of this retrospective study was to evaluate the clinical characteristics, survival outcomes and various risk factors affecting mortality in young and elderly maintenance hemodialysis patients in China. The study will provide the evidence-based clinical data for making appropriate strategies to improve the survival prognosis of ESRD population.

Methods

Participants

A total of 1680 patients with ESRD undergoing maintenance hemodialysis were screened from 24 hemodialysis centers from China (including the Northeast, North, East, Central south, Southwest, and Southeast) between January 1, 2008, and September 30, 2015, the cohort from the DIFE study[11]. All patients met the following inclusion criteria: (1) 18–44 or more than 60 years old; (2) diagnosed with chronic kidney disease with 2 consecutive estimated glomerular filtration rate (eGFR) measurements of < 30 mL/min/1.73 m^2 within 3 months before hemodialysis; and (3) duration of maintenance hemodialysis more than 3 months. The exclusion conditions were (1) patients with acute kidney injury; (2) patients who have undergone peritoneal dialysis or kidney transplantation before or after hemodialysis; (3) patients with the presence of cancer, chronic infection, liver cirrhosis, or other diseases that can affect survival time at the initiation of hemodialysis; (4) patients who died from non disease-related causes, such as traffic accidents and suicide; and (5) patients who underwent emergency hemodialysis because of acute pulmonary edema, hypokalemia, or acidosis. The patients were assigned to either an young (18–44 years old) or elderly (≥ 60 years old) group according to age on the initiation of the dialysis. Patients were followed from the initiation of dialysis until December 30, 2016. Patients were censored on the date of peritoneal dialysis or renal transplantation, loss to follow-up or death during the follow-up period. The survival time of the patients was measured in months and was calculated from the date of dialysis initiation to the date of their death or to the final follow-up date.

Outcomes

The primary outcome was all-cause mortality of patients with maintenance hemodialysis. Mortality information was obtained from the medical record in 24 hemodialysis centers. Information on a patient’s death was extracted from the patient's medical records, and the cause of their death was diagnosed by internal medicine physicians.

Clinical and laboratory data collection

All medical records of patients at the initiation of hemodialysis were reviewed retrospectively, the demographics data included age, gender, height, weight, Body Mass Index. Clinical data included date of hemodialysis initiation, type of hemodialysis associated vascular access (including AVF: Arteriovenous Fistula; NTC: Non-Tunneled Catheter, TCC: Tunneled Cuffed Catheter),causes of ESRD. Comorbid conditions were assessed using the charlson comorbidity index (CCI)[12]. The laboratory tests were performed within 3 months before hemodialysis initiation, and the tested factors included hemoglobin, blood urea nitrogen, creatinine, uric acid, serum sodium, potassium, calcium, phosphorus, carbon dioxide combining power, serum albumin, cholesterol, parathyroid hormone. The eGFR was calculated based on serum creatinine at the time of hemodialysis initiation using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation[13]. Data for all the patients were from electronic outpatient and inpatient medical records provided by the hemodialysis centers. All researchers involved in this study were internal medical physicians and postgraduate students majoring in nephrology, who have received unified training. Such data, which were checked by the data entry clerk when they were extracted[11].

Data analysis

Continuous variables with normal distribution were expressed as means and standard deviations, whereas variables with non-normal distribution were expressed as medians and interquartile ranges, and categorical variables were presented as frequencies with percentages. A student independent t-test or a Mann-Whitney U test was used for analysis in the case of normally or non-normally distributed continuous variables. Categorical variables data was compared using Chi-square tests or Fisher's exact test. A multiple imputation approach was applied to process missing data. Follow-up time was calculated for each subject from the initial hemodialysis until death or the end of the study. The survival prognosis was compared using the Kaplan-Meier survival curves and log-rank test. The hazard ratios (HR) of mortality of elderly patients relative to young patients was assessed using univariate cox proportional hazards regression models. The association between the demographics or clinical characteristics of the patients and all-cause mortality was assessed using multivariable cox proportional hazards regression models, adjusting for age, sex, eGFR, hypertension, diabetes, serum albumin, heart failure, cardiovascular disease, cerebrovascular disease, CCI scores. All hypothesis tests were evaluated using two-sided with 95% confidence intervals (CIs), $P < 0.05$ indicated statistical significance, All analyses were performed with SPSS software (version 19.0, IBM Corp., Armonk, NY, USA) .

Results

There were 1680 young and elderly ESRD patients undergoing maintenance hemodialysis were screened in the 24 hemodialysis centers between January 1, 2008 and September 30, 2015. Among these patients, 79 patients were excluded as lacking of important demographic, laboratory and survival data. Finally, a total of 1601 patients were included in the study. The research flow chart was shown in Fig. 1.

Baseline Patient Characteristics

The baseline demographics and clinical characteristics of the young and elderly patients at the initiation of hemodialysis were described in Table 1. A total of 1601 patients with maintenance hemodialysis, including 642 young patients and 959 elderly patients were enrolled in this study. The young and elderly patients had different sex and BMI distribution, 417 males (64.95%) in young group compared with 535 males (55.79%) in elderly group respectively (X^2 = 13.404, P < 0.001). The young patients had a higher average BMI than the elderly patients (P = 0.014). There were obviously differences in causes of ESRD, lower prevalence of diabetes (7.32%), higher glomerulonephritis (44.39%) in young group compared to the higher prevalence of diabetes (29.82%), lower glomerulonephritis (15.53%) in the elderly group (X^2 = 2333.6, P < 0.001). At the start of hemodialysis, the elderly patients had a higher mean eGFR levels than the young patients (6.37 ± 3.30 mL/min/1.73 vs. 5.25 ± 3.02 ml/min/1.73 m^2, p < 0.001). The young patients showed significantly higher levels of diastolic pressure (92.94 ± 16.28mmHg vs. 81.64 ± 13.15 mmHg, P < 0.001), serum creatinine (12.44 ± 5.39 mg/dL vs. 8.33 ± 3.24 mg/dL, P < 0.001), Phosphorus (2.23 ± 0.79 mg/dL vs. 1.84 ± 0.59 mg/dL, P < 0.001), ALB (3.51 ± 0.65 g/dL vs. 3.43 ± 0.61 g/L, P = 0.014), and parathyroid hormone (352.86 ± 324.60 pg/mL vs. 281.88 ± 263.90 pg/mL, P = 0.002). However, the elderly patients showed higher levels of CCI scores (5.57 ± 0.75 vs. 2.36 ± 0.57 g/dL, P < 0.001), serum calcium (2.01 ± 0.36 mmol/L vs. 1.99 ± 0.40 mmol/L, P = 0.001), hemoglobin (8.52 ± 1.95 g/dL vs. 8.16 ± 2.25 g/dL, P = 0.001), and serum sodium (139.07 ± 4.71 mmol/L vs. 138.65 ± 4.01mmol/L, P = 0.007).

Table 1
Baseline demographics and clinical characteristics of the patients at the initiation of hemodialysis.

Variables	Young group n = 642	Elderly group n = 959	P-value
Age at entry (year)	34.31 ± 6.80	68.55 ± 6.53	< 0.001
Male(%)	417(64.95%)	535(55.79%)	< 0.001
Body mass index (kg/m2)	25.34 ± 3.32	24.45 ± 3.82	0.014
Systolic pressure (mmHg)	152.61 ± 24.66	153.38 ± 23.05	0.093
Diastolic pressure (mmHg)	92.94 ± 16.28	81.64 ± 13.15	< 0.001
Cause of ESRD (%)			
Diabetic nephropathy	47(7.32%)	286(29.82%)	< 0.001
Hypertensive nephropathy	56(8.72%)	168(17.51%)	
Glomerulonephritis	285 (44.39%)	149(15.53%)	
Others	254(39.56%)	356(37.12%)	
Comorbidity (%)			
Diabetes	84(13.08%)	446(46.51%)	< 0.001
Hypertension	255(39.72%)	688(71.74%)	< 0.001
Coronary artery disease	66(10.28%)	303(31.59%)	< 0.001
Congestive heart failure	183(28.50%)	378(39.42%)	< 0.001
Cerebrovascular disease	15(2.33%)	68(7.09%)	< 0.001
CCI Scores, median (IQR)	2.36 ± 0.57	5.57 ± 0.75	< 0.001
Types of vascular accesses			
AVF	136(21.18%)	244(25.44%)	0.055
TCC	59(9.19%)	103(10.74%)	
NTC	447(69.63%)	612(63.82%)	
Laboratory tests			
Hemoglobin (g/dL)	8.16 ± 2.25	8.52 ± 1.95	0.001
Blood urea nitrogen (mg/dL)	98.30 ± 40.97	81.44 ± 32.66	< 0.001
Serum creatinine (mg/dL)	12.44 ± 5.39	8.33 ± 3.24	< 0.001
eGFR (mL/min/1.73m2)	5.25 ± 3.02	6.37 ± 3.30	< 0.001

Variables	Young group n = 642	Elderly group n = 959	P-value
Albumin(g/dL)	3.51 ± 0.65	3.43 ± 0.61	0.014
Sodium(mmol/L)	138.65 ± 4.01	139.07 ± 4.71	0.007
Potassium(mmol/L)	4.79 ± 0.92	4.77 ± 0.96	0.336
Phosphorus(mmol/L)	2.23 ± 0.79	1.84 ± 0.59	< 0.001
Calcium(mmol/L)	1.99 ± 0.40	2.01 ± 0.36	0.001
Parathyroid hormone(pg/mL)	352.86 ± 324.60	281.88 ± 263.90	0.002

ESRD:end-stage renal disease; eGFR:estimated glomerular filtration rate; AVF: arteriovenous fistula; NTC: non-tunneled catheter; TCC: tunneled cuffed catheter.

Outcomes

Mortality

Of the 1601 subjects, the mean follow-up duration was 48.17 ± 25.59 months for overall cohort. During follow-up, 319 (19.92%) patients death, 64 (9.97%) in young group and 255 (26.59%) in elderly group, the hazard ratio [HR] of elderly patients relative to young patients, 1.699 (95% confidence interval [95% CI], 1.482 to 1.949, P < 0.001). The 1-year mortality rate of young and elderly patients was 2.65% and 5.53%, respectively, the HR of elderly patients relative to young patients, 1.454 (95% CI, 1.107 to 1.911, P = 0.007). The 3-year mortality rates of young and elderly patients were 10.50% and 20.84%, respectively, the HR of elderly patients relative to young patients, 1.446 (95% CI, 1.229 to 1.701, P < 0.001). The comparison of mortality between young and elderly patients with maintenance hemodialysis was summarized in Table 2.

Table 2
The comparison of mortality between young and elderly patients with maintenance hemodialysis.

Variables	Young group			Elderly group			Univariate analysis		
	Event	Total	Rate	Event	Total	Rate	HR	95% CI	p-value
Overall mortality	64	642	9.97%	255	959	26.59%	1.699	1.482–1.949	<0.001
1-years mortality	17	642	2.65%	53	959	5.53%	1.454	1.107–1.911	0.007
3-years mortality	48	457	10.50%	149	715	20.84%	1.446	1.229–1.701	<0.001

Rate: per 100 persons; HR: hazard ratio.

Survival Prognosis

The Kaplan-Meier survival curve plots of the time course of all-cause mortality of young and elderly patients with maintenance hemodialysis were shown in Fig. 2, which displayed the overall cumulative survival was lower in elderly group than young group (Log Rank tests = 63.31, P< 0.001), the median survival time of young and old patients was 93.59 and 78.63 months, respectively. The HR of elderly patients relative to young patients, 2.884 (95% confidence interval [95% CI], 2.309 to 3.602, P< 0.001). To assess the effects of the timing of hemodialysis initiation on survival of young and elderly patients, patients were divided into the early dialysis starting subgroup (eGFR >5 mL/min.1.73 m^2) and the late dialysis starting subgroup (eGFR $\leq$ 5mL/min.1.73 m^2) according to eGFR at the initiation of hemodialysis. The Kaplan-Meier survival curve showed overall cumulative survival was lower in the elderly group than the young group no matter whether in the early dialysis starting subgroup (Log Rank tests = 36.06, P< 0.001), or in the late dialysis starting subgroup (Log Rank tests = 23.16, P< 0.001), which were shown in Fig. 3A and Fig. 3B, respectively. In the early dialysis starting subgroup, Log-rank analysis showed that HR of elderly patients relative to young patients, 3.428, (95% CI, 2.525 to 4.653, P< 0.001), In the late dialysis starting subgroup, Log-rank analysis showed that HR of elderly patients relative to young patients, 2.399, (95% CI, 1.714 to 3.358, P< 0.001).

Risk Factors Of All-cause Mortality

The multivariable cox regression analysis assessed that the risk factors affecting all-cause mortality of young and elderly patients with maintenance hemodialysis using a forward stepwise regression method (Forward LR), the results were shown in Table 3, cardiovascular disease (HR, 1.544; 95% CI, 1.103 to 2.161; P = 0.011), cerebrovascular disease (HR, 2.158; 95% CI, 1.309 to 3.557; P = 0.003), serum albumin (HR, 1.404; 95% CI, 1.001 to 1.968; P = 0.049), CCI scores with 4–5 (HR, 4.910; 95% CI, 2.327 to 10.357; P <

0.001), CCI scores with ≥ 6 (HR, 9.596; 95% CI, 4.807 to 19.158; P < 0.001), were the risk factors of all-cause mortality in young and elderly patients with maintenance hemodialysis.

Table 3
Multivariable cox proportional hazards regression models of variables associated with all-cause mortality of young and elderly patients.

Variables	B	SE	HR	Lower 95%CI	Upper 95% CI	P value
Cardiovascular disease	0.435	0.172	1.544	1.103	2.161	0.011
Cerebrovascular disease	0.769	0.255	2.158	1.309	3.557	0.003
Serum albumin						
ALB ≥ 3.5g/dL	Reference					
ALB<3.5g/dL	0.339	0.172	1.404	1.001	1.968	0.049
CCI scores						
CCI (1–3)	Reference					
CCI (4–5)	1.591	0.381	4.910	2.327	10.357	<0.001
CCI(≥6)	2.261	0.353	9.596	4.807	19.158	<0.001

Cox regression was used to calculate hazard ratios, adjustment for age, sex, eGFR, hypertension, diabetes, serum albumin, heart failure, cardiovascular disease, cerebrovascular disease, CCI scores.

Discussion

Our study was the first report of nationwide retrospective cohort research comparing the clinical characteristics, survival outcomes and risk factors affecting all-cause mortality between young and elderly patients with maintenance hemodialysis in China. We found that the overall mortality of elderly patients was higher than that of young patients, and the overall survival rate of elderly patients was lower than that of young group.

Our study showed that the 1-year mortality rate of young and elderly patients was 2.65% and 5.53%, and the 3-year mortality rates of young and elderly patients were 10.50% and 20.84%, respectively. Our findings were consistent with previous studies in this field, the elderly patients undergoing hemodialysis had a higher mortality risk[14, 15]. Based on the United States Renal Data System (USRDS) registry, the 1-year mortality rate after dialysis initiation for these older adults, was currently approximately 30%[16]. A recent study showed that the mortality rate among patients 65 years and older was 54.5% at the 1st year[17]. The 1-year mortality rate of the elderly with 65–74 years old was 28%, more than 75 years old was 41%[18]. Obviously, the 1-year mortality of dialysis patients in China was significantly lower than that in United States, it may be associated with the fact that the majority of enrolled patients were from higher quality dialysis centers in this study. Meanwhile, the timing of dialysis initiation of ESRD patients in our study was significantly later than that in Taiwan, Japan, and the United States. It may be associated with tolerance to uremic symptoms, economic status and family factors of patients, and national medical insurance policies.

Our study showed the eGFR of initiation of hemodialysis was 5.25 ± 3.02 ml/min/1.73 m^2 in the young group compared with 6.37 ± 3.30 mL/min/1.73 m^2 in the elderly group, which indicated that the timing of hemodialysis initiation of elderly patients was earlier than young patients in China. Our findings were consistent with previous studies with timing of hemodialysis initiation of elderly patients was earlier than young patients[19]. The possible reasons may be associated with the elderly ESRD patients may be more likely to start earlier hemodialysis due to more complications, poor nutritional status and worsen tolerance to uremia symptoms than young ESRD patients[8, 20–22]. Our study showed that the timing of hemodialysis initiation of elderly patients was earlier than young patients, however, the overall mortality was higher in elderly patients compared to young patients. Our findings was similar to previous studies that early initiation of dialysis principle was not associated with an improvement in survival or clinical outcomes[14, 23–25].

The timing of hemodialysis initiation is one of the important factors influencing patient survival prognosis[26, 27]. Previous studies did not compare the impaction of timing of dialysis on survival prognosis in different age patients especially between young and elderly patients together. The Kaplan-Meier survival curve showed that overall survival was lower in elderly than young patients no matter whether in the early dialysis starting subgroup (eGFR $>$5 mL/min.1.73 m^2) or in the late dialysis starting subgroup (eGFR ≤ 5mL/min.1.73 m^2). Multivariate cox regression indicated that the eGFR was not the risk factor affecting mortality in hemodialysis patients. The study results suggest that timing of dialysis initiation based on eGFR does not affect survival outcomes in older and younger patients.

A multivariate cox regression model of 2920 patients with uremia showed that the risk of death increased 1.25 times for each additional 10 years of age of dialysis patients[28]. The poor prognosis of elderly patients may be associated with primary diseases, higher prevalence of cardiovascular disease, diabetes, frailty, cognition disorder, higher levels of CCI scores, lower levels of albumin, serious dialysis complications, and reduced life expectancy together, which maybe leadings to increased risk of all-cause mortality compared with younger patients. To assess the risk factors affecting all-cause mortality in young and elderly patients with maintenance hemodialysis, we calculated hazard ratios using multivariable cox proportional hazards regression models, adjusting of the demographics and clinical characteristics of the patients at the initiation of hemodialysis, including age, sex, eGFR, hypertension, diabetes, serum albumin, heart failure, cardiovascular disease, cerebrovascular disease, CCI scores. Our study indicated that cardiovascular disease, cerebrovascular disease, lower serum albumin, higher CCI scores were associated with the higher mortality of young and elderly patients with maintenance hemodialysis. As we know, cardiovascular disease was a leading cause of death among ESRD patients, accounting for nearly 50% of deaths in hemodialysis population[29, 30], and nearly 40% of deaths in young adults with incident ESRD based on the United States Renal Data System (USRDS) [31]. A systematic review and meta-analysis showed that lower albumin is the risk of mortality and cardiac death in patients undergoing hemodialysis[32]. A prospective cohort study of dialysis patients, a 1-g/dL decrease in serum albumin was associated with an increased mortality risk of 47% in HD patients, association between serum albumin and mortality in dialysis patients is partly explained by inflammation[33]. Comorbid conditions were highly prevalent among ESRD patients and CCI scores was a predictor of mortality in dialysis patients, our study showed that the significantly increased risk of death in dialysis patients with the higher CCI scores than lower CCI scores. A 6-year cohort study of 893 hemodialysis patients showed that CCI was a strong predictor of mortality in hemodialysis patients, CCI independent of age was a robust and linear predictor of mortality in hemodialysis patients[34]. Identified above risk factors may assist clinicians to inform development of appropriate strategies to improve the survival prognosis of ESRD population and make decisions when patients need long-term dialysis.

Our study has the following several aspects limitation, firstly, The main limitation of this study was that the selection bias may exist for retrospective study, the included patients were from relatively high-quality of the hemodialysis centers in economically developed areas mainland China, and there was no coverage of community hemodialysis units with poor medical and economical conditions. Secondly, the other limitation was limited sample size. In the future, we will conduct a multicenter, large-sample prospective randomized controlled study covering different regions of hemodialysis centers with different medical and economic levels.

Conclusion

In conclusion, the elderly patients undergoing maintenance hemodialysis showed lower survival and higher mortality than young patients in China. Cardiovascular disease, cerebrovascular disease, serum albumin, CCI scores were the risk factors for all-cause mortality of young and elderly patients with maintenance hemodialysis. Based on our study, it maybe develop appropriate hemodialysis strategies for ESRD patients of different ages for improving their survival prognosis.

Abbreviations

AVF
Arteriovenous Fistula
CCI
Charlson comorbidity index
CKD-EPI
Chronic Kidney Disease Epidemiology Collaboration
eGFR
estimated glomerular filtration rate
ESRD
End-stage renal disease
HR
Hazard ratio
NTC

Non-Tunneled Catheter
TCC
Tunneled Cuffed Catheter.

Declarations

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Authors‘ contributions

HL, JC, and YL conceived and designed the study. JC, JW, YL, FG, and WW were in charge of management of screened, collected, reviewed, and recorded the data. JC, JW, YL, and MH performed statistical analyses. JC, JW, and YL drafted the main manuscript text. HL had full access to all the data of the study and took responsibility for the integrity of the data and the accuracy of the data analysis. All authors reviewed the manuscript and approved the final version.

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Availability of data and materials

The datasets analysed during the current study are not publicly available due to the potential use in further researches but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study was carried out in accordance with Declaration of Helsinki. The study protocol was reviewed and approved by the Ethics Committee of the First Affiliated Hospital of Dalian Medical University China, approval number (LUCK 2014–25) and Ethical Committees of all the participating institutions. We obtained written informed consent from all patients, the information of all patients was anonymized and de-identified prior to analysis.

Consent for publication

Not applicable.

Competing interestsNo competing interests are declared.

The authors declare that they have no competing interests.

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Figures

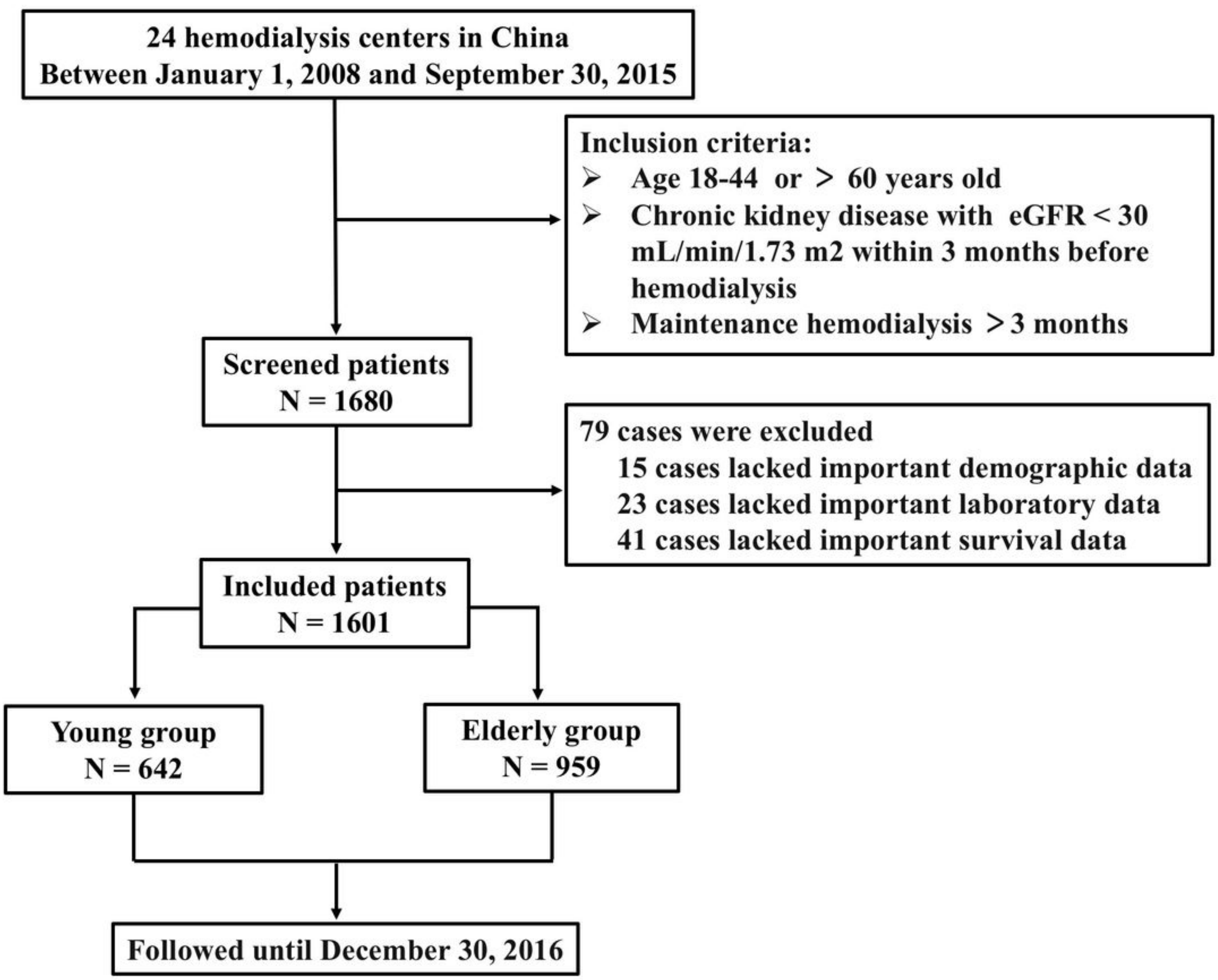

Figure 1

Flow chart of the study. eGFR, estimated glomerular filtration rate.

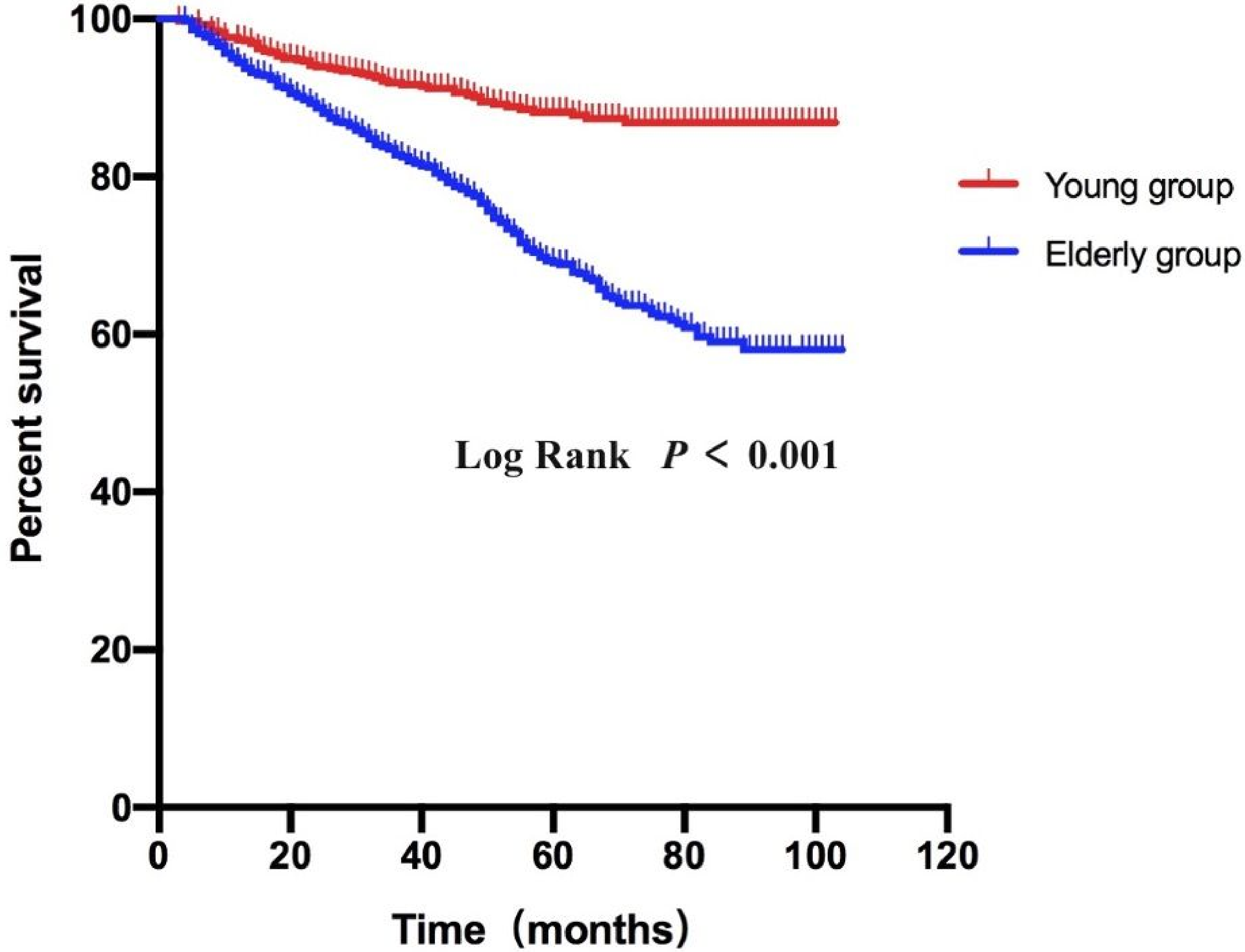

Figure 2

Kaplan-Meier survival curve between the young and elderly groups. The elderly group survival was significantly lower than young group (Log Rank tests = 63.31, P< 0.001).

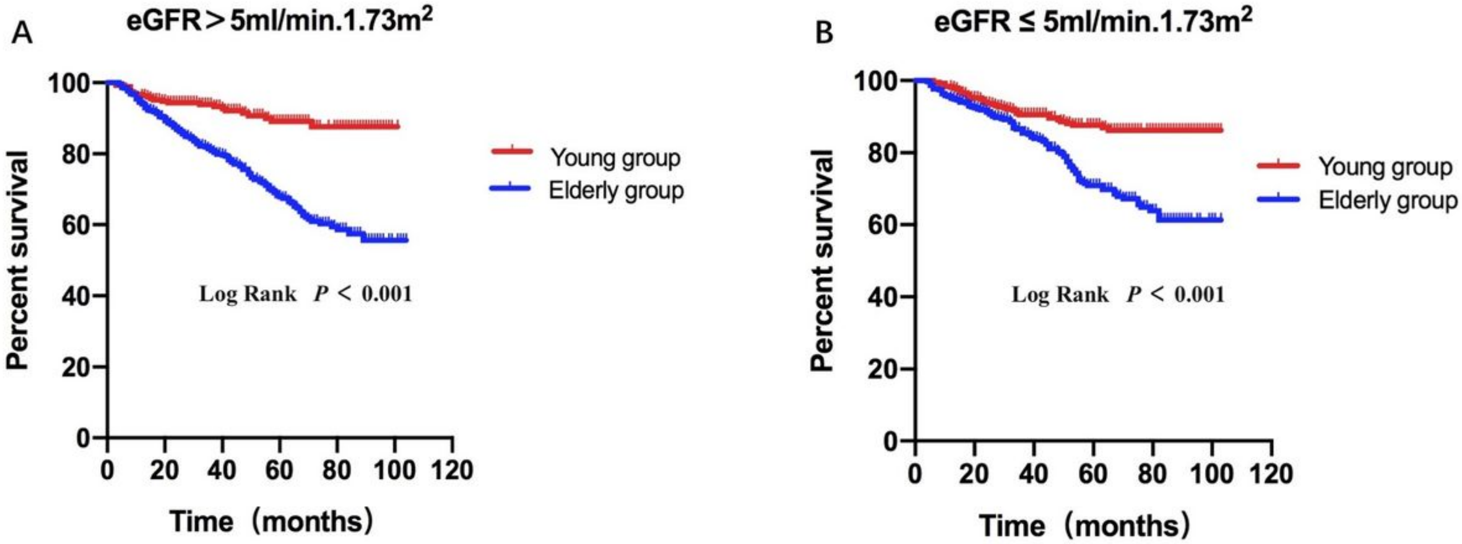

Figure 3

Kaplan-Meier survival curve between young and elderly patients in the early and late dialysis starting subgroups.

A. The elderly patients survival was significantly lower than young patients in early dialysis starting subgroup with eGFR ＞5.0 mL/min.1.73 m^2. (Log Rank tests = 36.06, P＜ 0.001).

B. The elderly group survival was significantly lower than young group in late dialysis starting subgroup with eGFR ≤ 5.0 mL/min.1.73 m^2. (Log Rank tests = 23.16, P＜ 0.001) .