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Trends in clinical outcomes of older hemodialysis patients: data from the 2023 Korean Renal Data System (KORDS)

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With an increasing aging population, the mean age of patients with end-stage kidney disease (ESKD) is globally increasing. However, the current clinical status of elderly patients undergoing hemodialysis (HD) is rarely reported in Korea. The current study analyzed the clinical features and trends of older patients undergoing HD from the Korean Renal Data System (KORDS) database. The patients were divided into three groups according to age: <65 years (the young group), n = 50,591 (35.9%); 65–74 years (the younger-old group), n = 37,525 (26.6%); and ≥75 years (the older-old group), n = 52,856 (37.5%). The proportion of older-old group undergoing HD significantly increased in incidence and decreased in prevalence from 2013 to 2022. The median levels of hemoglobin, serum creatinine, albumin, calcium, phosphorus, and intact parathyroid hormone significantly decreased in the older-old group. The proportions of arteriovenous fistula creation and left forearm placement showed decreased trends with age. Although the utilization of low surface area dialyzers increased with age, the dialysis adequacy, including urea reduction ratio and Kt/V was within acceptable range in the older-old group on HD. Over the past 20 years, the mortality rate in the older-old group has increased, with cardiovascular diseases decreasing and infectious diseases increasing. The incidence of elderly patients undergoing HD has increased over time, but the high mortality of the older-old group needs to be solved. Therefore, it is imperative to develop holistic strategies based on age and individual needs for patients with ESKD.

Keywords: Elderly, End-stage kidney disease, Geriatrics, Hemodialysis, Mortality

Introduction

As the global population of older individuals continues to grow, the prevalence and incidence of end-stage kidney disease (ESKD) among elderly patients are on the rise [1–4]. According to data from the United States Renal Data System (USRDS), patients aged ≥65 years occupied the highest incidence of ESKD. Other studies have shown that

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the increase in ESKD incidence has been predominantly driven by patients aged ≥75 years [4]. In addition, the prevalence of ESKD is significantly higher in individuals aged 65 to 74 and those aged 75 years and older when compared to those aged <65 years [4]. According to the annual report of the Korean Renal Data System (KORDS), the number of patients aged ≥65 years exceeded 50% for the first time in 2018 and has been steadily increasing to date in Korea [2].

The elderly population with ESKD often contends with comorbidities, limited life expectancy, frailty, and reduced functional capacity, all of which significantly increase the burden of dialysis and present challenges to delivering optimal care [1,5]. Hence, a precise understanding of the current characteristics of elderly patients with ESKD is crucial for providing rationale for policy and planning of dialysis. However, previous studies focusing on dialysis prescriptions and clinical features among this demographic are limited. An extensive analysis comparing hemodialysis (HD) practices and clinical outcomes between elderly and young patients across 12 countries during the period of 2005–2007 was documented in the Dialysis Outcomes and Practice Patterns Study [6]. In Korea, the registry committee of the Korean Society of Nephrology (KSN) presented the clinical features of elderly patients aged ≥65 years receiving maintenance HD using data from 2015 KORDS [3]. Then, there has not been any updated information on the clinical characteristics of elderly patients undergoing HD.

The term "elderly" has traditionally encompassed individuals aged ≥65 years [7]. However, functional vulnerability is different by age even within the same category of "elderly" and this difference leads to an increase in mortality and complications with increased age [1]. Therefore, recent studies suggest that elderly patients were divided into a "younger-old" and an "older-old" group [8–12]. This study aims to explore the demographic traits, vascular access patterns, dialysis adequacy, and clinical outcomes of elderly patients with ESKD depending on age in Korea.

Methods

We retrospectively analyzed the data from patients undergoing HD using the KORDS data [13], a nationwide Korean ESKD patient registry updated on an annual basis, to investigate the demographic characteristics and clinical outcomes of elderly patients undergoing HD. A total of 140,972 patients from 2001 to 2022 were classified according to age into the following three groups: <65 years (the young group), n = 50,591 (35.9%); 65–74 years (the younger-old group), n = 37,525 (26.6%); and ≥75 years (the older-old group), n = 52,856 (37.5%). A flow diagram for patient selection is shown in Supplementary Fig. 1 (available online).

The trends in incidence and prevalence of elderly patients undergoing HD were analyzed from 2013 to 2022 due to the lack of information for the enrollment date in this study. Variables including demographic factors, laboratory data, vascular access, dialyzer surface area, dialysis adequacy, complications, and cause of death were obtained from the data collected in 2022. Blood samples were obtained in the fasting state. Body mass index (BMI, kg/m^2) was divided into four groups according to the Asia-Pacific obesity classification: underweight, <18.5 kg/m^2; normal, 18.5–22.9 kg/m^2; overweight, 23.0–24.9 kg/m^2; obese, ≥25.0 kg/m^2 [14]. The definitions of complications and the cause of death are followed by those in the KORDS data. Vascular diseases as complications included cerebrovascular accident, hypertension, and other vascular disease, and cardiac diseases included coronary artery disease, heart failure, pericardial effusion, and arrhythmia. On the other hand, vascular diseases as the cause of death included cerebrovascular accident, pulmonary embolism, gastrointestinal bleeding, gastrointestinal embolism, and other vascular diseases, and cardiac diseases included coronary artery disease, heart failure, pericardial effusion, and arrhythmia. The Kruskal-Wallis test was used to compare the differences between the three groups because data were not normally distributed, while the chi-square test was used for categorical variables.

Annual mortality rates and survival curves were analyzed for patients undergoing HD enrolled in KORDS from 2001 to 2022. Trends in mortality rates are presented for patients treated each year according to the number of patient-years at risk. Unadjusted survival rates were calculated using the Kaplan-Meier method, and absolute mortality rates are expressed per 1,000 person-years of follow-up. The log-rank test was used to compare the survival distributions across each group. All survival data were analyzed using R programming (version 4.2.1; R Foundation for Statistical Computing).

Results

Trends in the incidence and prevalence of end-stage kidney disease according to age

The age-related rates for the ESKD incidence were 40.2% for the young group, 26.0% for the younger-old group, and 33.8% for the older-old group in 2022. From 2013 to 2022, the proportion of older-old group in the incidence exhibited a gradual increase from 29.4% to 33.8%, but the proportion of the young group showed a decrease from 44.2% to 40.2% ($p < 0.001$) (Fig. 1A).

On the other hand, the prevalence showed a distinct aspect. The proportion of the older-old group in the prevalence decreased from 47.7% to 34.1%. Meanwhile, the prevalence in the young group increased from 29.3% to 39.3%, and that in the younger-old group exhibited a slight rise from 23.0% to 26.6% ($p < 0.001$) (Fig. 1B).

Distribution of sex, cause of end-stage kidney disease, and body mass index according to age

The prevalence of male patients undergoing HD displayed an age-related decline of 64.1% in the young group, 63.2% in the younger-old group, and 55.3% in the older-old group with a statistically significant difference ($p < 0.001$) (Fig. 1C). The major cause of ESKD were diabetes mellitus (DM), hypertension, and chronic glomerulonephritis. The proportion of patients with DM is higher in the older-old group (64.0%) and in the younger-old group (70.8%), compared with the young group (59.4%) ($p < 0.001$). Hypertension was most prevalent in the older-old group at 28.6%, followed by the young group at 23.6%, and the younger-old group at 20.6% ($p < 0.001$). In contrast, the proportion of patients with chronic glomerulonephritis is the lowest rate in the older-old group (7.4%), compared with the younger-old group (8.6%) and the young group (17.0%) ($p < 0.001$) (Fig. 1D). The percentage of underweight patients undergoing HD significantly higher in the older-old group (17.5%), compared to the younger-old group (12.7%) and the young group (14.0%). In contrast, the proportion of obese patients was 13.9% in the older-old group, which was lower than the younger-old group (17.1%) and the young group (20.0%). These results suggest that BMI in patients undergoing HD had lower trends over age ($p < 0.001$) (Fig. 1E).

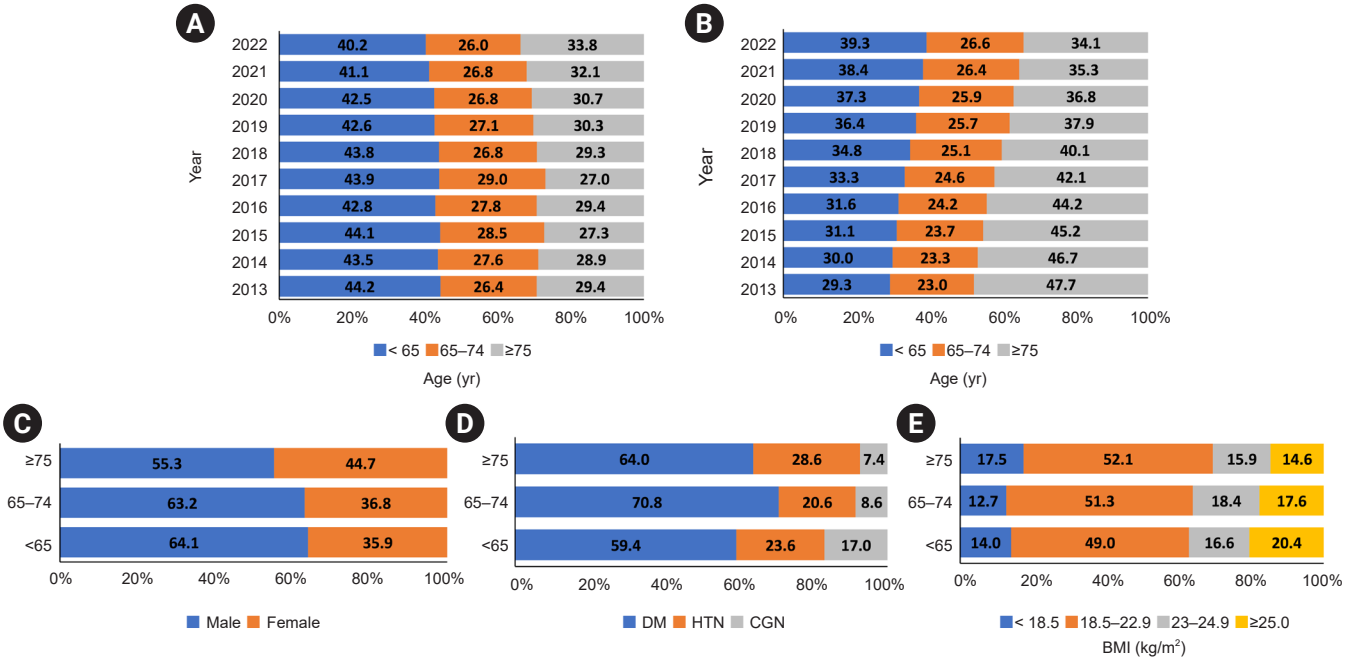

Figure 1. Trends in incidence and prevalence, sex distribution, primary renal disease, and BMI according to age. (A) Incidence trends of end-stage kidney disease (ESKD) according to age. (B) Prevalence trends of ESKD according to age. (C) Sex distribution according to age. (D) Distribution of primary renal disease according to age. (E) Distribution of BMI according to age.
BMI, body mass index; CGN, chronic glomerulonephritis; DM, diabetes mellitus; HTN, hypertension.

Distribution of the findings based on laboratory test according to age

The median value of various parameters, including hemoglobin, serum creatinine, albumin, calcium, phosphorus, and intact parathyroid hormone (PTH) levels exhibited a significant decrease over age ($p < 0.001$ for each parameter) (Fig. 2A). The percentage of patients with the lowest value among hemoglobin, serum creatinine, albumin, calcium, phosphorus, and intact PTH was significantly highest in older-old group, followed by the younger-old group and the young group ($p < 0.001$ for each parameter) (Fig. 2B).

Types of vascular access and dialysis adequacy according to age

In all age groups, the major type for vascular access in HD was the arteriovenous fistula (AVF), followed by arteriovenous graft (AVG), tunneled cuffed catheters, and temporary catheters ($p < 0.001$) (Fig. 3A). AVFs were predominantly located in the left forearm across all age groups, followed by the left upper arm, right forearm, and right upper arm ($p < 0.001$) (Fig. 3B). The proportion of patients using AVFs in the vascular access type decreased with increasing age ($p < 0.001$) (Fig. 3A). In contrast, the older-old group showed a significantly higher proportion of AVG (20.3%) compared to the younger-old (15.1%) and young (10.4%) groups ($p < 0.001$) (Fig. 3A). Furthermore, the highest proportion of tunneled catheter placements was observed in the older-old group (13.3%), compared to the younger-old group (8.6%) and the young group (9.8%) ($p < 0.001$) (Fig. 3A).

Dialyzers with a surface area of 1.5–2.0 m^2 were more frequently used in the young male group (53.3%), followed by the younger-old male group (49.8%) and the older-old group (42.4%). In contrast to the other male groups, the older-old male group showed a higher proportion of 1.0–1.5 m^2 dialyzers (52.8%) than 1.5–2.0 m^2 dialyzers (42.4%). Across all age groups, female used more low surface area dialyzers (1.0–1.5 m^2) compared to male ($p < 0.001$) (Fig. 3C). The urea reduction ratio (URR) and the single pooled Kt/V (spKt/V) exhibited an upward trajectory with advancing age ($p < 0.001$ for both), ultimately meeting the dialysis adequa-

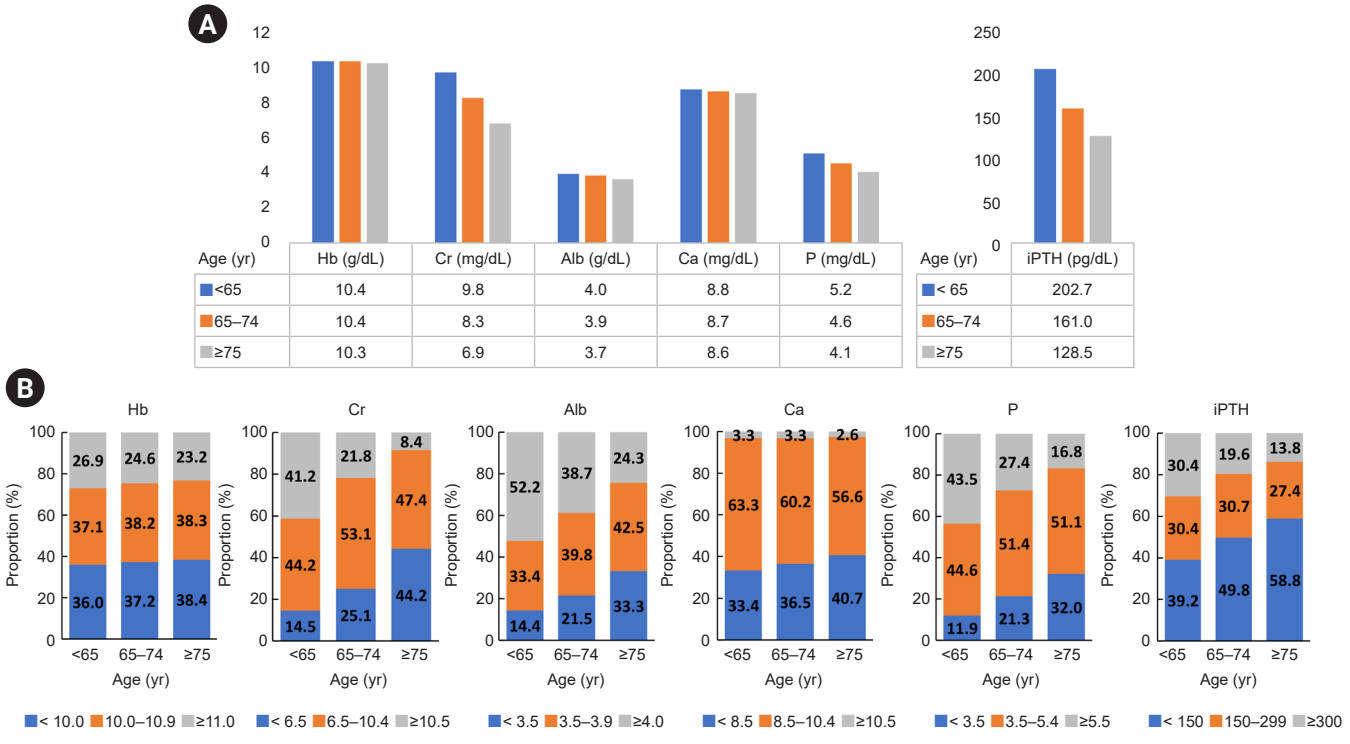

Figure 2. Laboratory values according to age. (A) Median values of hemoglobin (Hb), serum creatinine (Cr), albumin (Alb), calcium (Ca), phosphorus (P), and intact PTH (iPTH) according to age. (B) Proportional chart representing the distribution of laboratory values within the reference range according to age.

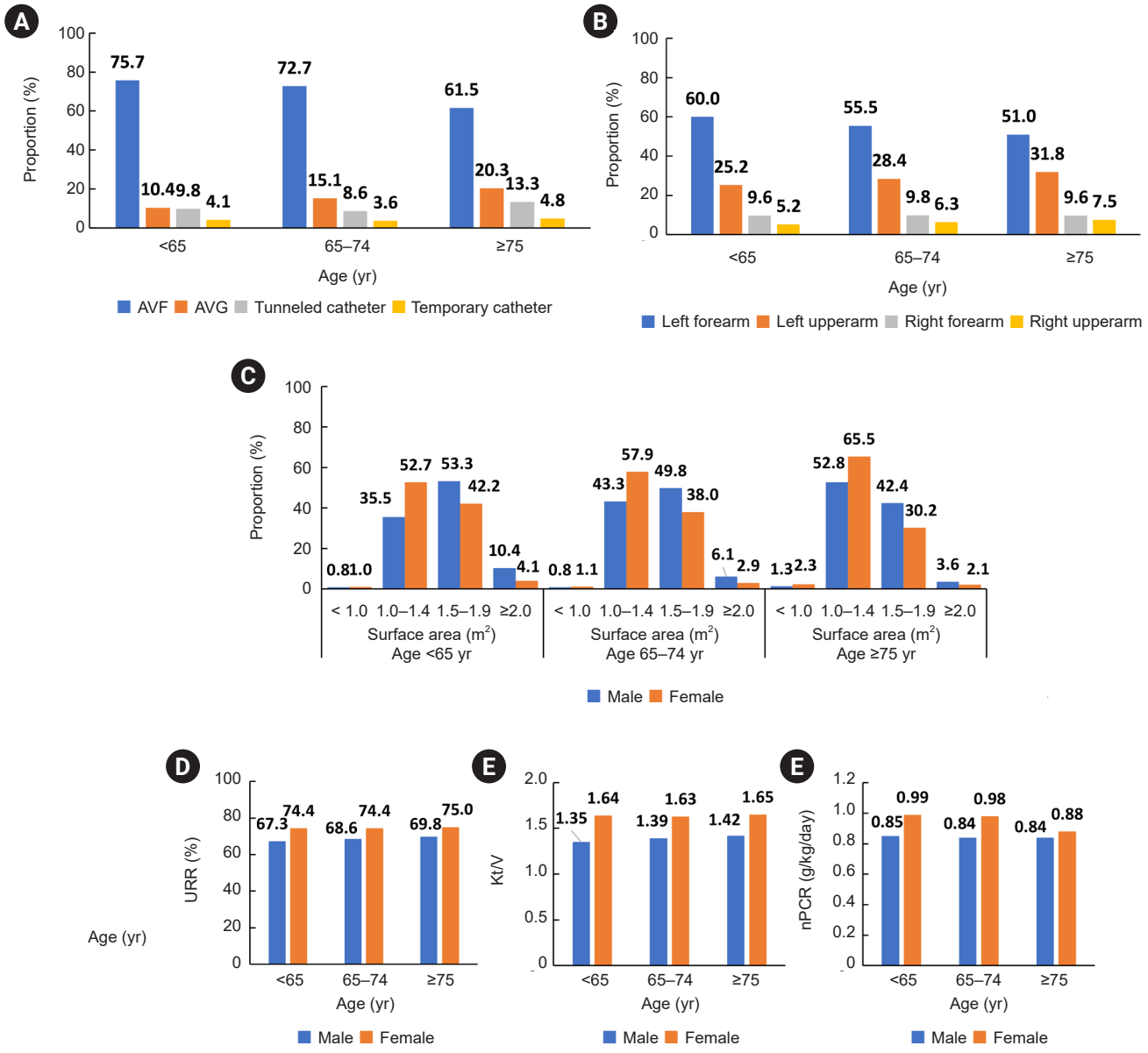

Figure 3. Types and locations of vascular access, dialysis adequacy, and nPCR according to age and sex. (A) Distribution of types of vascular access according to age. (B) Location of arteriovenous fistula (AVF) according to age. (C) Distribution of dialyzer surface area according to age and sex. (D) Distribution of Kt/V according to age and sex. (E) Distribution of urea reduction ratio (URR) according to age and sex. (F) Distribution of nPCR according to age and sex.
AVG, arteriovenous graft; nPCR, normalized protein catabolic rate.

cy target in all the groups (Fig. 3D, E). Notably, female consistently showed higher URR and spKt/V levels compared to male across all age groups ($p < 0.001$) (Fig. 3D, E). On the other hand, the normalized protein catabolic rate (nPCR) showed a declining trend over age, with higher nPCR values in female compared to male ($p < 0.001$) (Fig. 3F).

Complications and cause of death according to age

Vascular diseases were the most prevalent complication across all age groups. However, their occurrence demonstrated a declining trend with age, with 57.3% in the young group, 53.2% in the younger-old group, and 49.0% in the older-old group, respectively ($p < 0.001$) (Fig. 4A). In con-

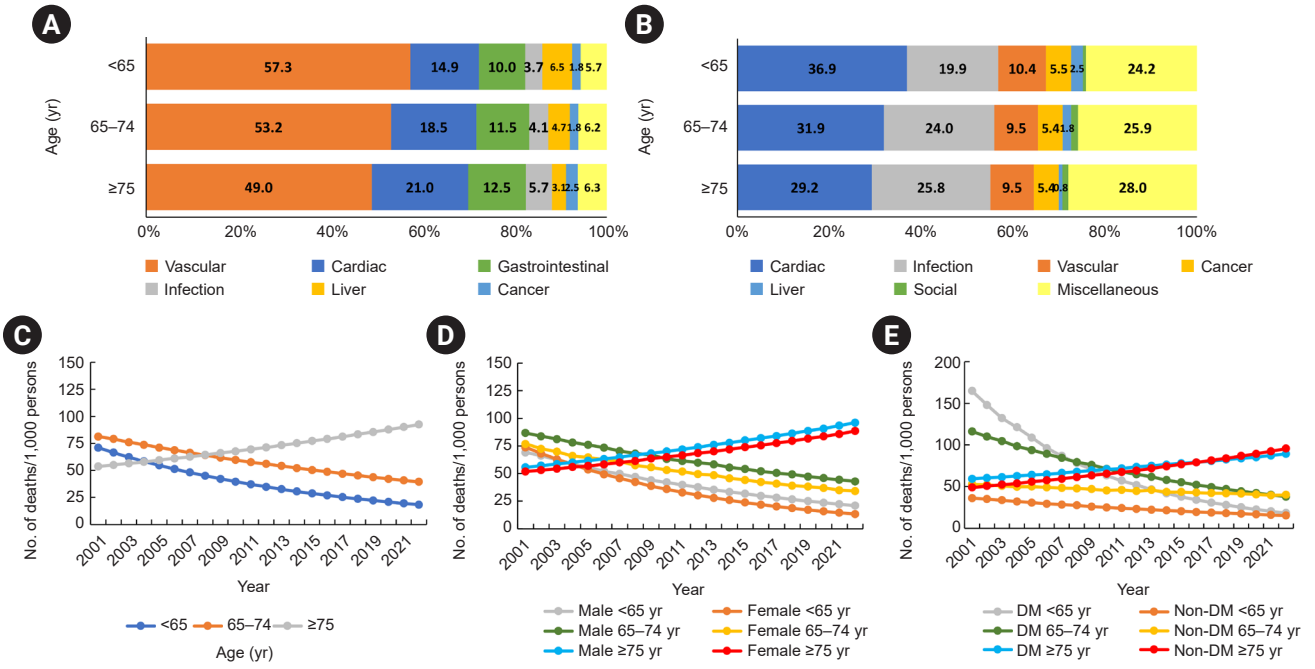

Figure 4. Complications, cause of death, and trends in mortality rates according to age stratified by sex and diabetes. (A) Proportion of complications according to age. (B) Proportion of cause of death according to age. (C) Trends in mortality rates according to age. (D) Trends in mortality rates according to age stratified by sex. (E) Trends in mortality rates according to age stratified by diabetes. DM, diabetes mellitus.

trast, cardiac diseases as complications showed an upward trend with increasing age, affecting 14.9% of the young group, 18.5% of the younger-old group, and 21.0% of the older-old group ($p < 0.001$). A similar tendency was observed for infectious diseases, with prevalence rates of 3.7%, 4.1%, and 5.7% in the young group, younger-old group, and older-old group, respectively ($p < 0.001$) (Fig. 4A).

While the incidence of cardiac diseases increased with age, the rates of death caused by cardiac diseases decreased, accounting for 36.9% in the young group, 31.9% in the younger-old group, and 29.2% in the older-old group ($p = 0.002$) (Fig. 4B). In contrast, the rates of death attributed to infectious diseases exhibited an increasing trend with age: 19.9% in the young group, 24.0% in the younger-old group, and 25.8% in the older-old group. The overall proportion of cause-specific death was significantly different among the three groups ($p = 0.025$) (Fig. 4B).

Trends in mortality rates stratified by sex and diabetic status

From 2001 to 2022, a consistent increase in mortality rates among patients undergoing HD was noted in the older-old group, surpassing other age groups starting in 2009. In contrast, the mortality rates in the younger-old group and the young group steadily decreased over the past two decades (Fig. 4C). Mortality rates of female patients undergoing HD were lower compared to their male counterparts across all age groups (Fig. 4D).

Mortality rates, defined as the number of deaths per 1,000 person-years, were consistently higher in patients with than in patients without DM across all age groups until 2017. However, the difference in mortality rates between patients with and without DM decreased over time, eventually becoming comparable in the younger-old group and the young group in 2022. Since 2017, the mortality rate of patients without DM was slightly higher than that of patients with DM in the older-old group (Fig. 4E).

Comparison of survival rates according to age stratified by sex and diabetic status

Over the past 20 years, the survival rate has consistently been the lowest in the older-old group, followed by the

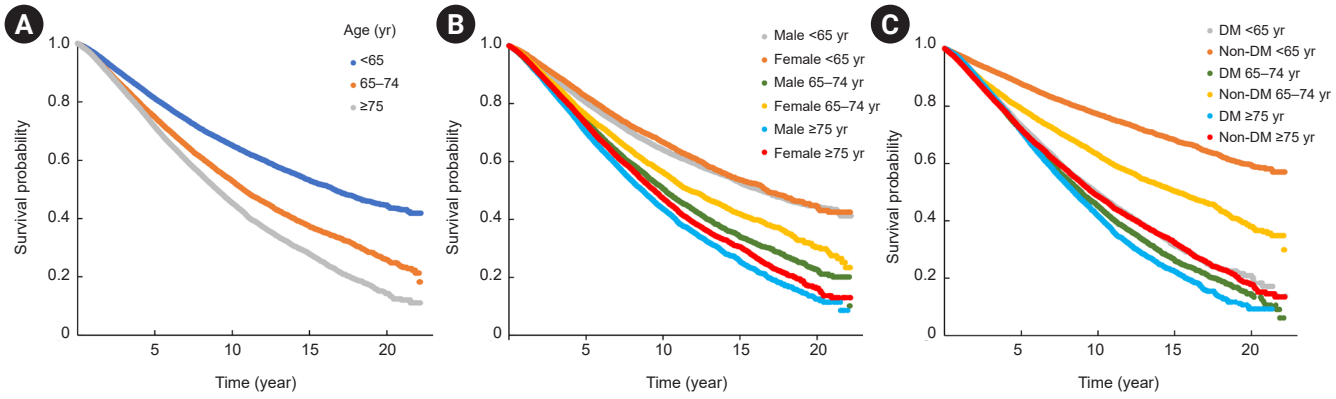

Figure 5. Comparison of survival rates according to age stratified by sex and diabetes. (A) Survival rates according to age. (B) Survival rate according to age stratified by sex. (C) Survival rates according to age stratified by diabetes.
DM, diabetes mellitus.

younger-old group and the young group ($p < 0.001$) (Fig. 5A). Female patients undergoing HD consistently showed a superior survival rate compared to male across all age groups ($p < 0.001$ for all age groups) (Fig. 5B).

The survival rate was the highest in the young group without DM, followed by the younger-old group without DM. The older-old group with DM showed the lowest survival rate, followed by the younger-old group with DM. The young group with DM had a similar survival rate to the older-old group without DM. The groups without DM consistently showed a superior survival rate compared to the groups with DM across all age groups ($p < 0.001$ for all age groups) (Fig. 5C).

Discussion

This study investigated demographic characteristics, vascular access, dialysis adequacy, and clinical outcomes in elderly patients undergoing HD from recent KORDS data. The proportion of older-old group was increased in incidence, while was declined in prevalence over the past decade. In contrast, the young group has exhibited an opposite trend, with a decline in incidence and an increase in prevalence. DM is the most important cause of ESKD in both the older-old group and the younger-old group. Hemoglobin, serum creatinine, albumin, phosphorus, intact PTH, and nPCR levels were notably lower in the older-old group compared to other groups. Although AVF was the major vascular access type, the proportion of AVF gradually decreased with age. Despite the higher use of low surface area dialyzers, dialysis adequacy of the elderly patients undergoing HD was achieved within a target range. Mortality rates were significantly higher in the older-old group, with infection-related deaths increasing and cardiac-related deaths declining with age.

According to the 2022 USRDS report, ESKD has the highest incidence globally in patients aged 75 years and older, with a higher prevalence in both patients aged 75 years and older and those aged 65 to 74 years than in those younger than 65 years [4]. Recent studies from Europe and Japan also reported that the increase in ESKD prevalence was primarily owing to an increase in the number of patients over 70 years old [15,16]. In contrast, our study revealed a decreasing prevalence rate among patients in the older-old group, despite the high incidence rate observed in this age group. A possible explanation is that the elevated incidence of ESKD in the older-old group may be mitigated by a high mortality rate during early period after initiating dialysis. Currently, there are no previous studies presenting accurate early mortality rates for Korean elderly patients and comparing mortality between Korea and other countries. Therefore, additional research may be helpful to investigate the status and risk factors associated with early mortality following dialysis in elderly patients with ESKD.

The KORDS data showed a decrease in nutritional parameters, including BMI, hemoglobin, serum albumin, phosphorus, and nPCR, with increasing age. This trend is consistent with the USRDS 2022 Annual Report, which

demonstrated lower levels of nutritional parameters in the older-old group compared to the younger-old group and the [4]. The poor nutritional status among the elderly patients undergoing HD has been also observed in several studies [17–19] and is considered one of the critical risk factors contributing to mortality. Consequently, our results suggest the importance of comprehensive strategies for ameliorating malnutrition among Korean elderly patients undergoing HD.

To date, there have been some reports regarding the trends and outcomes of vascular access based on age group in Korea [20–23]. The recent KORDS data revealed comparable outcomes with significantly lower primary success and patency rates for AVF, increased proportions of AVG and tunneled cuffed catheters, and decreased use of AVF in elderly patients from previous studies. Kim et al. [23] found a diminished survival rate in patients with a central venous catheter in both patients aged 65 to 74 years and 75 years and older, while there was no noticeable decrease in patients younger than 65 years. In addition, the rate of conversion from central venous catheter to AVF declined with increasing age, reaching its lowest point in patients aged ≥75 years [23]. Trends in the type and location of vascular access in KORDS data seem to be in line with tailored strategies according to the life plan outlined in the 2019 KDOQI clinical practice guideline for vascular access.

This study also revealed that Korean elderly patients with ESKD achieved dialysis adequacy targets as outlined in clinical practice guidelines [24], despite the more frequent use of lower-surface-area dialyzers. Consistent with our study, the 2022 USRDS report showed that a higher percentage of elderly patients achieved the Kt/V target compared to younger patients, and the percentage of female achieving the dialysis adequacy target was greater than that of male [4]. Except for the USRDS annual analysis, detailed analysis on dialyzer type or dialysis adequacy in elderly patients is scarce. Although the guidelines from the KSN and European Renal Best Practice recommend high-flux dialysis membranes for adult patients [24,25], the actual use of dialyzer in elderly patients undergoing HD was different from the current guidelines. A recent study from the Japanese Society for Dialysis Therapy Renal Data Registry including elderly patients revealed that the use of a low-flux dialyzer was associated with a significantly higher all-cause mortality compared to that of a high-flux dialyzer after adjusting Kt/V [26]. The higher use of low-flux-area dialyzer may be one of the risk factors for increasing mortality in Korean elderly patients. Therefore, the use of high-flux dialyzer in elderly patients undergoing HD needs to be recommended in the real world.

Finally, the present study showed the older-old group displayed a constant increase in mortality rates since 2001. In contrast, the USRDS 2022 and European Renal Association–European Dialysis and Transplant Association registry indicated a decreasing trend in mortality rates for all age groups, with the most significant decline in patients aged ≥75 years [4,27]. In the present study, the increase in mortality may consequently lead to an increase in incidence but a decrease in prevalence in the older-old group. Although we cannot fully explain the differences in mortality between KORDS data and the registry data of other countries, high mortality rates among elderly patients undergoing HD may be associated with several factors, including low BMI, reduced serum albumin and phosphorus levels, as well as clinical conditions such as sarcopenia and frailty [28–33]. In particular, malnutrition and sarcopenia in elderly patients undergoing HD are associated with advanced age and low BMI, leading to an almost three-fold increase in mortality compared to those without these conditions [34]. Therefore, the assessment and management of malnutrition and sarcopenia should be emphasized to prevent the increase in mortality in Korean elderly patients with ESKD.

This study has some limitations. The KORDS data includes missing data because it is created through the voluntary participation of KSN members. This limitation can make it difficult to interpret some variables correctly. The KORDS data does not provide information on variables that can directly assess sarcopenia and malnutrition, which affect mortality in elderly patients. In addition, the KORDS data did not include the etiology of infectious diseases including coronavirus disease 2019 (COVID-19), which contributed to mortality during the COVID-19 pandemic. Future nationwide epidemiologic research needs to include additional information associated with age-specific risk factors in Korean elderly patients with ESKD.

In conclusion, the 2023 KORDS data reveal an increasing incidence coupled with declining prevalence within the older-old group. To mitigate the increasing mortality rate in the older-old group, it is crucial to prioritize a comprehen-

sive understanding of clinical features specific to this age group. Tailored strategies to provide optimal care to elderly patients with ESKD hold promise for improving survival rates, minimizing complications, and preserving their quality of life throughout dialysis treatment.

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Conflicts of interest

Tae Hyun Ban is the Deputy Editor of *Kidney Research and Clinical Practice* and was not involved in the review process of this article. All authors have no other conflicts of interest to declare.

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Data sharing statement

The data presented in this study are available from the corresponding author upon reasonable request.

Authors' contributions

Conceptualization: SHA, YKK, THB, YAH
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Formal analysis: HK, YAH, SAJ
Investigation: KMK, SDH, SRC, HL, JHK, SHK, THK, HSK, CYY, KK, SHA, HEY
Methodology: SHK, HSK, HEY, YAH
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