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고령 혈액투석 환자의 암 상태와 사망률 : 후향적 코호트 연구

Cancer Status and Mortality in Older Hemodialysis Patients : A Retrospective Cohort Study

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지도교수 박종하

이 논문을 의학석사 학위 논문으로 제출함

2024 년 2 월

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2024 년 2 월

ABSTRACT

Background: It is difficult to decide treatment plan an older end-stage kidney disease (ESKD) patients, especially when they active cancer or previous cancer history. On this issue, whether older hemodialysis (HD) patients with current cancer or a history of cancer have the same mortality risk as those without the disease is unclear. Thus, we compared the prognosis of older HD patients with current or previous cancer versus without cancer.

Methods: The study was undertaken using The Korean Society of Geriatric Nephrology retrospective cohort. It consisted of 2,087 patients older than 70 years who started HD between 2010 and 2017 and had information on comorbid cancer status. The Kaplan-Meier survival estimator and Cox proportional hazards regression analysis were used to examine all-cause mortality in the three groups.

Results: At recruitment, 259 (12.4%) patients had previous cancer history, and 54 (2.6%) had ongoing cancer. During a median follow-up of 3.2 years, 1360 (65.2%) HD patients died. All-cause mortality was significantly higher in the active cancer group than in the previous cancer group and no cancer group (85.2% vs. 68.7% vs. 64.0%, $p = 0.003$). Kaplan-Meier analysis showed that all-cause mortality differed across the three groups ($p < 0.001$, log-rank test). After adjusting for clinical variables, multivariate Cox regression analysis indicated a significant association between active cancer and all-cause death (hazard ratio [HR]:2.077; 95% confidence interval [CI]:1.481-2.913; $p<0.001$). Previous cancer was also associated with the overall mortality (HR: 1.228; 95%CI: 1.030-1.463; $p = 0.022$), but the relationship was weaker than active cancer.

Conclusion: Older HD patients with active cancer had a higher mortality rate than those with previous or no cancer. However, those with previous cancer had a mortality risk comparable to those with no cancer. Our findings suggest that the decision for starting maintenance HD should not be delayed or not be ruled out from treatment options even in older ESRD patient who had previous cancer history.

차 례

그림 목차

표 목차

Introduction

End-stage kidney disease (ESKD) has emerged as a pressing global health concern, with a marked increase in both its incidence and prevalence. This surge has propelled the need for more aggressive interventions, primarily dialysis or kidney transplantation, as evidenced by various international studies [1,2]. Notably, South Korea observed this trend with 18,642 patients starting renal replacement therapy (RRT) for ESKD by the end of 2019 [3].

Traditionally, cardiovascular disease have been the predominant cause of mortality in patients with ESKD. However, recent advancements in dialysis techniques, which have extended patient lifespans, have suggested a paradigm shift. Now, increased mortality in this segment is related to cancer [4]. This revelation intersects with another critical juncture in medical progress. The last decade has marked significant advances in cancer diagnostics and therapeutics. Consequently, a growing number of patients now have coexisting cancer, thanks to early detection and progressive treatment modalities. Epidemiological studies have demonstrated a rising incidence of cancer among patients with ESKD, particularly among those on dialysis [5]. As the boundaries of medicine continue to expand, offering a longer life expectancy, punctuated by a spectrum of chronic diseases, the intersection between ESKD and oncology is becoming more obvious, calling for in-depth exploration.

In South Korea, comprehensive data on the interface between cancer and ESKD, particularly among dialysis-dependent patients, remain scarce [8,9]. We here addressed this gap in knowledge by investigating whether older hemodialysis (HD) patients, either with current cancer or with a history of cancer, have similar mortality rates as those without current or previous cancer.

Methods

Study population

The dataset utilized in this study was sourced from the Korean Society of Geriatric Nephrology (KSGN) and encompassed a cohort of 2,736 older patients with ESKD (aged > 70 years) for whom HD was initiated. The patients were registered at 16 university hospitals in Korea between 2010 and 2017. Inclusion in the study required complete patient records; therefore, individuals who received emergency HD or peritoneal dialysis and those without recorded death information were excluded.

Ethical approval and consent to participate

Patients' clinical data were collected after receiving approval from the Institutional Review Board (IRB) for each study period. The study was conducted in accordance with the principles of the Declaration of Helsinki. The need to obtain informed patient consent was waived by the relevant IRBs and all personal identifiable information was adequately protected.

Data collected

The factors considered in this study included the patient's age, sex, and comorbidities, such as diabetes mellitus (DM), cardiovascular disease, cerebrovascular accidents (CVA), hypertension, dementia, severe behavioral disorders other than dementia, liver cirrhosis, and cancer, along with medication history and history of hospitalization, cause of ESKD, and type of vascular access at dialysis initiation. In this study, dementia was defined as the use of dementia medication under the Korean government's health insurance service policy. Additionally, serum albumin, white blood cell count, hemoglobin, glucose, blood urea nitrogen, creatinine, total bilirubin, and total cholesterol levels were measured at dialysis initiation.

Outcome measurement

The main objective of this study was to compare the mortality risk between cancer and non-cancer groups of CKD patients receiving HD. Mortality data were obtained from the Korean National Statistical Office and from medical chart reviews (Microdata Integrated Service, On-demand, 20,180,619; https://mdis.kostat.go.kr).

Statistical analyses

Continuous and nominal variables were expressed as means with standard

deviations. Normally distributed variables were analyzed using Student's t-tests, independent two-sample t-tests, and analyses of variance. Data with non-normal distribution were analyzed using the Wilcoxon rank-sum test. Categorical variables were expressed as frequencies and percentages and were analyzed using the chi-squared or Fisher's exact test.

Differences in survival rates between the groups were compared using Kaplan-Meier survival curves and log-rank tests. Cox proportional hazards models were used to examine mortality based on risk factors. Furthermore, the variance influence factor was used to confirm multicollinearity.

For sensitivity analysis, propensity-score matching (PSM) and standardized differences were employed to compare the baseline traits of the two study groups. Certain variations in the initial characteristics were observed between the groups, which could potentially have skewed the estimation of the effect on mortality. Characteristics exhibiting these variations included sex, age at HD initiation, DM, hypertension, CVA, and severe behavioral disorders. Kaplan-Meier survival curves and life tables were generated for both the dementia and non-dementia groups. Statistical significance was set at $P < 0.05$. All statistical analyses were performed using SPSS software (version 26; IBM Corp, Chicago, IL, USA) and R programming language (version 4.2.2; R Foundation for Statistical Computing, Vienna, Austria).

Results

Baseline characteristics

A cohort of 2,736 patients with CKD undergoing HD was assembled from 16 medical institutions across South Korea (Figure 1). Following the exclusion of subjects with incomplete datasets, the final study population comprised 2,087 patients. Of these, 313 (15.0%) had been diagnosed with cancer, 259 (12.4%) had a history of cancer, and 54 (2.6%) were undergoing active cancer treatment at the time of the study. The baseline characteristics of the three distinct groups—those without a cancer diagnosis, those with a cancer history, and those with active cancer—are shown in Table 1. No significant age differences were observed among the three groups. The proportion of female patients was higher in the non-cancer cohort. The primary etiology of ESKD in all three groups was DM. Albumin and hemoglobin levels were lower in the active cancer group than in the other groups.

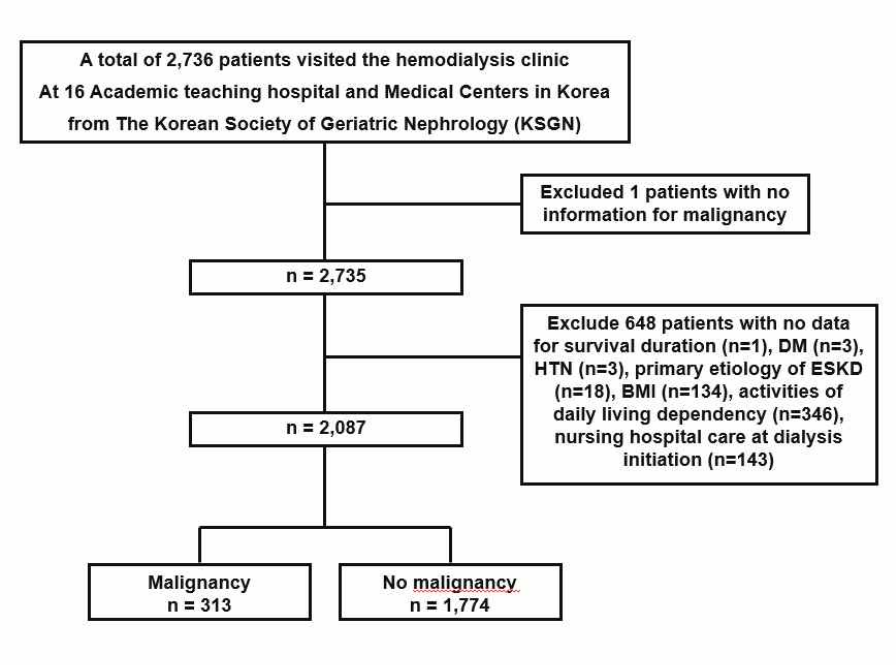

Figure 1. Study flow chart

Missing data for the variables pertaining to malignancy (n =1), survival duration (n=1), diabetes mellitus (DM) (n=3), hypertension (HTN) (n=3), primary etiology of ESKD (n=18), body mass index (BMI) (n=134), activities of daily living dependency (n=346), and nursing hospital care at dialysis initiation (n=143).

Table 1. Baseline characteristics of the study patients

Variable	No cancer (N = 1774)	Previous cancer (N = 259)	Active cancer (N = 54)	p-values
Age at the hemodialysis initiation	77 (73–81)	77 (74–81)	78 (75–81)	0.111
Sex				0.006
Men	966 (54.5%)	168 (64.9%)	32 (59.3%)	
Women	808 (45.5%)	91 (35.1%)	22 (40.7%)	
Body mass index				0.313
Normal	756 (42.6%)	114 (44.0%)	20 (37.0%)	
Underweight	166 (9.4%)	25 (9.7%)	6 (11.1%)	
Overweight	387 (21.8%)	40 (15.4%)	12 (22.2%)	
Obesity	465 (26.2%)	80 (30.9%)	16 (29.6%)	
Primary etiology of ESKD				0.010
GN	109 (6.1%)	17 (6.6%)	1 (1.9%)	
DKD	885 (49.9%)	120 (46.3%)	23 (42.6%)	
Renovascular	441 (24.9%)	49 (18.9%)	15 (27.8%)	
Others	339 (19.1%)	73 (28.2%)	15 (27.8%)	
IHD				0.605
No	1379 (77.8%)	200 (77.2%)	45 (83.3%)	
Yes	394 (22.2%)	59 (22.8%)	9 (16.7%)	
PAD				0.912
No	1668 (94.1%)	242 (93.4%)	51 (94.4%)	
Yes	105 (5.9%)	17 (6.6%)	3 (5.6%)	

CVA				0.045
No	1428 (80.5%)	220 (84.9%)	49 (90.7%)	
Yes	346 (19.5%)	39 (15.1%)	5 (9.3%)	
CHF				0.227
No	1446 (81.6%)	221 (85.3%)	47 (87.0%)	
Yes	325 (18.4%)	38 (14.7%)	7 (13.0%)	
Atrial fibrillation				0.660
No	1600 (90.2%)	231 (89.2%)	47 (87.0%)	
Yes	173 (9.8%)	28 (10.8%)	7 (13.0%)	
DM				0.172
No	727 (41.0%)	106 (40.9%)	29 (53.7%)	
Yes	1047 (59.0%)	153 (59.1%)	25 (46.3%)	
HTN				0.025
No	164 (9.2%)	35 (13.5%)	9 (16.7%)	
Yes	1610 (90.8%)	224 (86.5%)	45 (83.3%)	
Liver cirrhosis				0.000
No	1729 (97.5%)	248 (95.8%)	46 (85.2%)	
Yes	45 (2.5%)	11 (4.2%)	8 (14.8%)	
Rheumatic disease				0.021
No	1602 (90.5%)	242 (93.4%)	44 (81.5%)	
Yes	169 (9.5%)	17 (6.6%)	10 (18.5%)	
Vascular access at dialysis initiation				0.314
Catheter	1463 (82.5%)	208 (80.3%)	49 (90.7%)	

AVF	234 (13.2%)	42 (16.2%)	4 (7.4%)	
AVG	77 (4.3%)	9 (3.5%)	1 (1.9%)	
Vascular access on maintenance dialysis				0.000
Catheter	335 (19.1%)	62 (23.9%)	24 (44.4%)	
AVF	1091 (62.1%)	162 (62.5%)	21 (38.9%)	
AVG	330 (18.8%)	35 (13.5%)	9 (16.7%)	
Activities of daily living dependency				0.030
None	999 (56.3%)	160 (61.8%)	22 (40.7%)	
Partial	474 (26.7%)	67 (25.9%)	22 (40.7%)	
Total	301 (17.0%)	32 (12.4%)	10 (18.5%)	
Severe behavior disorder				0.459
No	1678 (94.6%)	249 (96.1%)	50 (92.6%)	
Yes	95 (5.4%)	10 (3.9%)	4 (7.4%)	
Hospitalization history prior to HD initiation within 6 months				0.093
None	1150 (64.9%)	159 (61.4%)	26 (48.1%)	
Less than 1 month	534 (30.1%)	88 (34.0%)	25 (46.3%)	
More than 1 month	89 (5.0%)	12 (4.6%)	3 (5.6%)	
Nursing hospital care at dialysis initiation				0.037
None	1593 (89.8%)	241 (93.1%)	53 (98.1%)	
Nursing hospital	181 (10.2%)	18 (6.9%)	1 (1.9%)	
Fracture history prior to HD initiation				0.079
None	1638 (92.3%)	246 (95.0%)	48 (88.9%)	

Femur fracture	74 (4.2%)	9 (3.5%)	6 (11.1%)	
Vertebra fracture	26 (1.5%)	1 (0.4%)	0 (0.0%)	
Other fracture	36 (2.0%)	3 (1.2%)	0 (0.0%)	
White blood count (/mm^3)	7580 (5805–10470)	7450 (5880–9840)	7900 (5500–9700)	0.541
Hemoglobin (g/dL)	9.2 (8.2–10.2)	9.2 (8.3–10.2)	8.4 (7.5–9.8)	0.015
Albumin (g/dL)	3.4 (3.0–3.8)	3.3 (2.8–3.7)	3.1 (2.7–3.7)	0.004
Total cholesterol	139 (112–168)	129 (108–164)	133 (97–159)	0.109

ESKD, end-stage kidney disease; GN, glomerulonephritis; DKD, Diabetic kidney disease; IHD, ischemic heart disease; PAD, Peripheral artery disease; CVA, cerebrovascular accident; CHF, congestive heart failure; DM, diabetes mellitus; HTN, hypertension; AVF, arteriovenous fistula; AVG, arteriovenous graft; HD, hemodialysis

All-cause mortality

The all-cause mortality rate was significantly higher in the active cancer group than in the previous cancer and non-cancer groups (85.2%, 68.7%, and 64.0%, respectively; p = 0.003) (Table 2). Kaplan-Meier survival analysis indicated significant disparities in survival rates across the three groups (p < 0.001, log-rank test), with the active cancer group demonstrating a substantially reduced survival rate as compared to the other two groups (Figure 2). Furthermore, multivariate Cox regression analyses revealed a robust association between active cancer status and all-cause mortality, with an adjusted hazard ratio (HR) of 2.077 (95% confidence interval [CI[]: 1.481-2.913; p < 0.001) (Table 3). Similarly, the previous cancer group exhibited a statistically significant increase in overall mortality as compared to the non-cancer group, with an adjusted HR of 1.228 (95%CI : 1.030-1.463 ; p = 0.022).

Table 2. All–cause mortality in the no cancer group, previous cancer group, and active cancer group

	No cancer (N = 1774)	Previous cancer (N = 259)	Active cancer (N = 54)	p–values
Death				0.003
– Death	1136 (64.0%)	178 (68.7%)	46 (85.2%)	
– Survival	638 (36.0%)	81 (31.3%)	8 (14.8%)	
Death within 6 months				<0.001
– Death	285 (16.1%)	60 (23.2%)	21 (38.9%)	
– Survival	1489 (83.9%)	199 (76.8%)	33 (61.1%)	

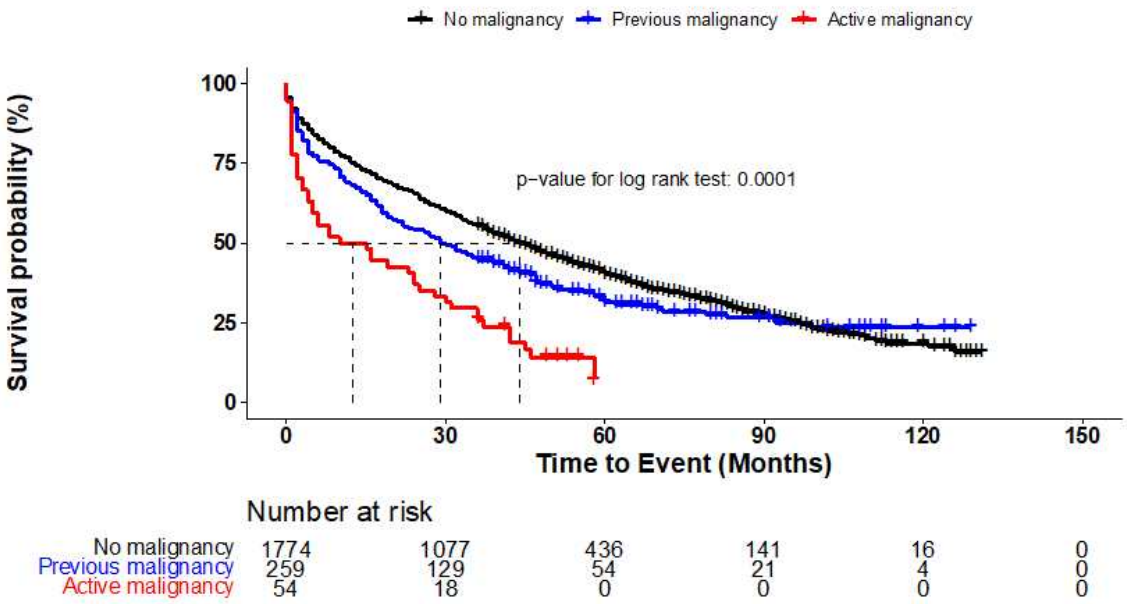

Figure 2. Kaplan-Meier survival curve

Survival rates of patients without malignancy (no malignancy group), patients with previous malignancy (previous malignancy group) and patients with active malignancy (active malignancy group) are presented using Kaplan-Meier survival curves, and the difference in survival rate between groups was compared using the log-rank test (Mantel-Cox). $P < 0.0001$

Table 3. Cox regression analysis of patient survival

Variable	Cancer status	HR (95% CI)	p–values
Unadjusted	Previous versus None	1.198 (1.023–1.403)	0.025
	Active versus None	2.410 (1.793–3.240)	<0.001
Model 1	Previous versus None	1.150 (0.981–1.348)	0.085
	Active versus None	2.433 (1.809–3.272)	<0.001
Model 2	Previous versus None	1.168 (0.993–1.375)	0.06
	Active versus None	2.251 (1.659–3.053)	<0.001
Model 3	Previous versus None	1.228 (1.030–1.463)	0.022
	Active versus None	2.077 (1.481–2.913)	<0.001

Model 1 was adjusted for sex, age, and BMI at dialysis initiation; Model 2 was adjusted for sex, age, and BMI at dialysis initiation, primary etiology of ESKD, comorbidity (such as DM, HTN, IHD, CVA, CHF, AF, LC and severe behavior disorder [other than dementia]), hospitalization history within 6 months prior to HD initiation, dependency in activities of daily living, nursing hospital care at dialysis initiation, fracture history prior to HD initiation, and vascular access on maintenance dialysis; Model 3 was adjusted for sex, age, and BMI at dialysis initiation, primary etiology of ESKD, comorbidity (such as DM, HTN, IHD, CVA, CHF, AF, LC and severe behavior disorder [other than dementia]), hospitalization history within 6 months prior to HD initiation, dependency in activities of daily living, nursing hospital care at dialysis initiation, fracture history prior to HD initiation, vascular access on maintenance dialysis, WBC, albumin, and total cholesterol

BMI, body mass index; ESKD, end-stage kidney disease; DM, diabetes mellitus; HTN, hypertension; IHD, ischemic heart disease; CVA, cerebrovascular accident; CHF, congestive heart failure; AF, atrial fibrillation; LC, liver cirrhosis; HD, hemodialysis; WBC, white blood cell; HR, hazard ratio; CI, confidence interval

Subgroup analysis

The adjusted HRs and their 95%CIs for all-cause mortality across the selected subgroups are illustrated in Figure 3. Statistically significantly higher all-cause mortality rates were found in the following patient subgroups: those with a cancer diagnosis, CVA, congestive heart failure (CHF), total dependency in activities of daily living, hospitalization exceeding 1 month within the 6 months prior to initiating HD, residence in a nursing facility at the time of HD initiation, and a history of femur fractures prior to HD initiation. Conversely, patients undergoing HD with vascular access and those with elevated albumin levels demonstrated a decreased risk of mortality.

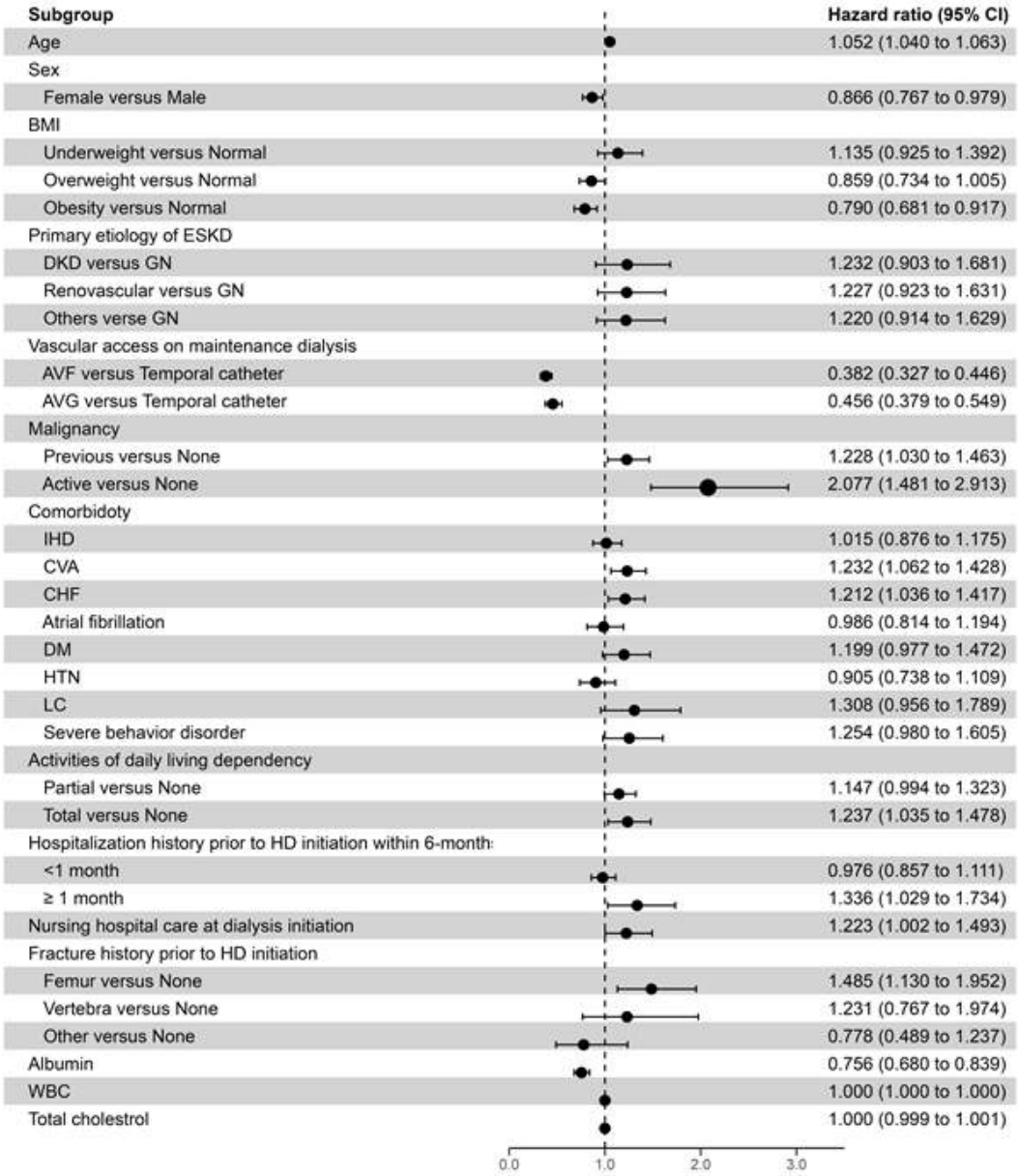

Figure 3. Subgroup analysis

Adjusted HRs (95% CIs) for all-cause mortality across the selected subgroups.

CI, confidence interval; BMI, body mass index; ESKD, end stage kidney disease; DKD, diabetic kidney disease; GN, glomerulonephritis; AVF, arteriovenous fistula; AVG, arteriovenous graft; IHD, ischemic heart disease; CVA, cerebrovascular accidents; CHF, chronic heart failure; DM, diabetes mellitus; HTN, hypertension; LC, liver cirrhosis; HD, hemodialysis; WBC, white blood cells; HR, hazard ratio

Discussion

We conducted a study using the retrospective cohort data managed by the Korean Society of Geriatric Nephrology to examine the association between cancer status and mortality rates in older patients undergoing hemodialysis. We found that fifteen percent of older patients undergoing HD in our study in South Korea had a preexisting cancer diagnosis. In individuals with active cancer, the rate of all-cause mortality was more than twice as high as that in individuals without cancer, establishing active cancer as an independent prognostic factor for mortality. After adjusting for clinical variables, multivariate Cox regression analysis indicated a significant association between active cancer and all-cause death. In subgroup analysis, patients with a history of cancer exhibited a 23% increase in mortality as compared to the non-cancer group. This elevated risk was similar to the mortality risk observed in patients with CVA or CHF.

Although there are some reports about the association between ESKD and cancer among Western European HD patients [10-12] , data from Korea are lacking. So, this is the study for investigating cancer prevalence and prognosis among HD patients of the Korean Society of Geriatric Nephrology. In individuals with active cancer, the rate of all-cause mortality was more than twice as high as that in individuals without cancer, establishing active cancer as an independent prognostic factor for mortality. Contemporary estimates of cancer mortality in people on dialysis for kidney failure are 2 to 3 times that of the general population [13-16]. Also, a registry-based studies where the relative risk of cancer mortality was twice for patients on dialysis for kidney failure than in the general population [17]. This implies that there may be unidentified risk factors for cancer death or an unexplored systemic bias in the delivery of cancer treatments. When tailoring anticancer treatments for individuals on dialysis, it is crucial to take into account not only the interplay between efficacy and nephrotoxicity but also the optimization of therapies in this population who have multiple comorbidities [18-20].

The increased risk of cancer in patients with predialytic CKD is still debated. The Atherosclerosis Risk in Communities (ARIC) cohort in the USA [21] and the 2016 meta-analysis by Wong et al. failed to demonstrate an increased risk of cancer in predialytic CKD patients [22]. However, some population-based studies suggest that predialytic CKD patients are at a higher risk of developing cancer than the general population [23,24]. It seems that in the elderly, for every 10 mL/min/1.73m^2 decline in eGFR, the risk of cancer increases by 29% [23]. In a large-sample and multicenter study, the prevalence of cancer was significantly higher as compared to the general population from Romania for cancers before HD initiation [25]. In our study, Fifteen percent of older patients undergoing HD in our study in South Korea had a preexisting cancer diagnosis. CKD in cancer patients can attribute to

the nephrotoxicity of anti-cancer drug. It can also be due to episodes of acute kidney injury [26], for example in case of sepsis and shock that may occur with treatment. It has been demonstrated that, even in patients having a complete recovery of renal function after the episode, acute kidney injury was related with a risk of stage 3 chronic kidney disease [27]. Moreover, chronic kidney disease can be attributed to certain comorbid conditions associated with cancer, such as cardiac failure and hypertension [28].

We found that previous cancer in older CKD patients undergoing HD increased the overall mortality rate as compared to the non-cancer group, but had similar overall mortality to patients with comorbidities such as CVA, CHF through subgroup analysis. Similarly, in the study by Béchade et al. [11], survival in dialysis was not different among patients with a history of cancer compared to matched patients without malignancy.

Determining whether dialysis should be initiated in patients with ESKD, particularly the older population, is a crucial and challenging clinical decision. The decision-making process is even more complex for older patients with a history of cancer prior to dialysis initiation. Physicians are increasingly confronted with treatment choices for elderly cancer patients with advanced kidney disease. A decision about initiating versus forgoing dialysis for these can be emotionally burdensome for nephrologists for a number of reasons including clinical uncertainty about prognosis on dialysis and discomfort with death [7]. Ben Sprangers provided guidance in this complicated situation, mentioned that decisions in this context are particularly complex and multifaceted and underlined that close collaboration like multidisciplinary discussion between oncologists, nephrologists, and geriatricians is crucial to making optimal treatment decisions, and several tools are available for estimating cancer prognosis, prognosis of renal disease, and general age-related prognosis [6]. Our study can give helpful clues to decide whether older cancer patients with ESKD initiate dialysis. Based on our study, it is recommended that older ESKD patient with active cancer treat with conservative therapy, but those with previous cancer initiate HD.

Our study had several limitations. First, we were unable to capture specific data concerning the type, treatment, or stage of cancer at the time of patient inclusion. In the previous cancer group, the cancer might have been a less fatal type or at an earlier stage comparatively. Second, the cohort comprised patients with ESKD from diverse geographical regions in South Korea, limiting the generalizability of our findings. Finally, given the retrospective observational nature of our study design, the potential for residual confounding factors cannot be entirely ruled out.

Despite these limitations, our study had notable strengths. Primarily, this represents one of the largest domestic cohorts of older patients with ESKD, thereby enhancing the robustness of our findings. Furthermore, the study design

incorporated multiple potential confounders into the analysis, thereby mitigating the effect of extraneous variables on the observed outcomes.

Conclusions

Based on our study, older ESKD patient with active cancer should carefully consider initiating HD, taking into account factors such as cancer type, comorbidities and overall health condition due to the elevated risk of mortality. It is recommended that those with a history of previous cancer initiate HD, as their mortality risk are similar to those with CVA and CHF.

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국문 요약

연구 배경 및 목적 : 고령의 말기 신장병 환자에서, 특히 활동성 암 또는 이전 암 병력이 있는 경우 치료 계획을 세우는 것은 어렵다. 이러한 점에서, 현재 암이 있거나 과거에 암 병력이 있는 고령의 투석 환자가 그렇지 않은 환자들과 비교했을 때 사망 위험이 동일한 지 여부는 불분명하다. 따라서, 우리는 암이 없는 환자들에 비해 현재 암이 있거나 이전에 암 병력이 있는 고령의 투석 환자의 예후를 비교하고자 한다.

연구 방법 : 이 연구는 The Korean Society of Geriatric Nephrology retrospective cohort를 사용하여 수행되었다. 이것은 2010년에서 2017년 사이에 혈액투석을 시작하고 동반한 암 상태의 정보를 가진 70세 이상의 2,087명의 환자로 구성되었다. Kaplan-Meier 생존 추정법과 Cox 비례 위험 회귀 분석을 사용하여 세 그룹 간의 모든 원인에 의한 사망률을 조사하였다.

연구 결과 : 연구 모집 당시, 259명(12.4%)의 환자가 이전에 암 병력이 있었고, 54명(2.6%)의 환자가 진행하는 암이 있었다. 중앙값 3.2년의 추적 관찰 기간 동안 1360명(65.2%)의 혈액투석 환자가 사망하였다. 모든 원인에 의한 사망률은 이전의 암 병력 그룹과 암이 없는 그룹보다 진행성 암 그룹에서 유의하게 더 높았다(85.2% vs. 68.7% vs. 64.0%, $p = 0.003$). Kaplan-Meier 분석을 통해 모든 원인에 의한 사망률이 세 그룹 간에 차이가 있는 것으로 나타났다($p < 0.001$, log-rank test). 임상 변수들을 보정한 후에도, 다변량 Cox 회귀 분석에서 진행성 암 그룹과 모든 원인에 의한 사망 사이에 유의미한 상관관계를 보였다(hazard ratio [HR] : 2.077; 95% confidence interval [CI] : 1.481 – 2.913 ; $p < 0.001$). 이전의 암 병력 그룹은 전체 사망률과 상관관계가 있었지만, 그 연관성은 활동성 암 그룹에 비해 약했다. (HR: 1.228; 95%CI: 1.030–1.463; $p = 0.022$)

결론 : 활동성 암을 가진 고령의 혈액투석 환자는 이전의 암 병력이 있거나 암이 없는 환자들보다 더 높은 사망률을 보였다. 그러나, 이전의 암 병력이 있는 환자들은 암이 없는 환자들과 사망 위험이 비슷했다. 우리의 연구 결과는 이전의 암 병력이 있는 고령의 말기 신장병 환자에서 유지 혈액투석 시작 결정을 미루거나 치료 옵션에서 배제해서는 안 된다는 것을 시사한다.