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Effect of renal dialysis on mortality and complications following hip fracture surgery in elderly patients

A population based retrospective cohort study

Eun-Jin Ahn, MD, PhD[a], Si Ra Bang, MD, PhD[b,*]

Abstract

Hip fractures in older patients requiring dialysis are associated with high mortality. The primary aim of this study was to evaluate the specific burden of dialysis on 30-day mortality following hip fracture surgery. The secondary aim was to determine the burden of dialysis on overall survival as well as several postoperative complications.

A retrospective cohort study was conducted using data from the Korean National Health Insurance Research Database. Patients were aged ≥65 years and underwent hip fracture surgery during the period from 2009 to 2015. To construct a matched cohort, each dialysis patient was matched to 4 non-dialysis patients based on age, sex, hospital type, anesthesia type, and comorbidities. Survival status was determined 30 days after surgery and at the end of the study period.

In total, 96,289 patients were identified. Among them, 1614 dialysis patients were included and matched to 6198 non-dialysis patients. During the 30-day postoperative period, there were 102 mortality events in the dialysis group and 127 in the non-dialysis group, for an adjusted hazard ratio of 3.12 (95% confidence interval, 2.42–4.09). Overall, by the end of the study period, there were 1120 mortality events in the dialysis group and 2731 in the non-dialysis group, for an adjusted hazard ratio of 1.97 (95% confidence interval, 1.83–2.1). These findings may be limited by the characteristics of the administrative database.

The 30-day mortality rate was 3-fold higher in the dialysis group than in the non-dialysis group, while the overall mortality rate was approximately 2-fold higher in the dialysis group than in the non-dialysis group. These findings suggest that caution in the perioperative period is required in dialysis patients undergoing hip fracture surgery. The results of our study represent only an association between dialysis and mortality. Further studies are necessary to investigate the possible causal effect of dialysis on mortality and complications after hip fracture surgery.

Abbreviations: CI = confidence interval, CKD = chronic kidney disease, HR = hazard ratio, ICU = intensive care unit, NHID = National Health Information Database, NHIS = National Health Insurance Service, PTE = pulmonary thromboembolism.

Keywords: anesthesia, dialysis, hip fracture, mortality, surgery

1. Introduction

In an aging society, the incidence of hip fracture is rapidly increasing. Similarly, the incidence of chronic kidney disease (CKD) and use of dialysis is also steadily increasing. With the prolongation of average lifespan, dialysis patients are more likely to undergo surgical procedures.[1] CKD is associated with mineral and bone disorders, and consequently it is associated with increased risk of hip fracture.[2]

The mortality rate in adults with CKD is approximately 10% to 15% worldwide, and it is 2- to 4-fold higher than the rate in

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The authors have no conflicts of interest to disclose.

The data that support the findings of this study are available from a third party, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are available from the authors upon reasonable request and with permission of the third party.

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those without CKD.[3] In a recent study by Lo et al, end-stage renal failure requiring dialysis was an independent risk factor for 1-year mortality after hip fracture surgery.[4] Indeed, osteoporotic hip fractures related to CKD were associated with high mortality and morbidity, with rates up to 30% in elderly patients,[5–8] while mineral and bone disorders were associated with an increased risk of cardiovascular and valvular calcification, arterial stiffness, hypertension, and sudden death.[9]

Not only hip fracture patients are major issues in clinicians,[10–12] but hip fractures in patients with CKD are also a nationwide health problem. Nevertheless, there are few population-based studies that determine the relationship between dialysis and mortality in such patients. Thirty-day mortality has long been accepted as a valuable quality indicator for healthcare systems.[13] However, there are few reports of 30-day mortality and complications following hip fracture surgery in elderly patients requiring hemodialysis. Therefore, in this study, we used a nationwide database to determine the burden of dialysis on postoperative outcomes in elderly patients who underwent hip fracture surgery. The primary aim was to determine the effect of dialysis on 30-day mortality, and the secondary aim was to estimate its effect on postoperative complications as well as overall mortality.

2. Methods

This study was reviewed and approved by the institutional review board of Seoul Paik Hospital (IRB No. 2018-07-007) and the need to obtain informed consent was waived because we used deidentified administrative data. This retrospective cohort study population comprised all patients aged ≥65 years who underwent hip fracture surgery covered by the Korean National Health Insurance Service (NHIS) between January 1, 2009, and December 31, 2015.

The NHIS is a single health insurer managed by the Korean government, which covers approximately 97% of Koreans. The remaining 3% of Koreans who cannot afford national insurance are covered by the Medical Aid Program (MAP). Claims submitted for reimbursement to the NHIS and MAP are reviewed by the Health Insurance Review and Assessment service, a central office in the Korean Ministry of Health. The NHIS records have garnered academic interest because of the effectiveness of the system and its relevance to public health and medical research. To meet this interest, a population database was developed, called the "National Health Information Database" (NHID) that contains personal information, demographics, and medical treatment data for Korean citizens, all of whom were categorized as insured employees, insured self-employed individuals, or medical aid beneficiaries. The NHID was generated using participants' medical bill expenses claimed by medical service providers.[14] NHID is a public database on health care utilization, health screening, sociodemographic variables, and mortality for the whole population of South Korea, formed by the National Health Insurance Service.[15] Our data were obtained from the National Health Information Database (NHID), created by the NHIS. The NHID offers information on both costs and operation and procedure codes to researchers. The NHID is open to all researchers whose study protocols are approved by the official review committee.

2.1. Study population

We included all patients aged ≥65 years who underwent hip fracture surgery between January 1, 2009, and December 31, 2015, based on admission date. Hip surgery was limited to the following procedure codes: open reduction of fractured extremity (femur), total arthroplasty (hip), or hemiarthroplasty (hip), with a principal diagnosis of femoral neck fracture (S720) or trochanteric fracture (S721) based on the International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) code. We included patients who received general, spinal, or epidural anesthesia. Patients with a diagnosis of multiple trauma or fracture (S00-S70, S73-99, T07, T14) were excluded, as were those with >2 such operations during the same period of admission.

Among these patients, we selected those with a history of hemodialysis or peritoneal dialysis, which was identified by procedural codes. These selected patients were defined as the dialysis group. We excluded patients with acute renal failure requiring emergency dialysis after hip surgery. The remaining patients were defined as the non-dialysis group. Each dialysis patient was matched to 4 randomly selected non-dialysis patients based on age, sex, hospital type, anesthesia type, and comorbidities according to the Elixhauser method.

2.2. Independent variables

Patient characteristics included age, sex, hospital type, anesthesia type, and comorbidities, all of which were estimated using the Elixhauser comorbidity method. The Elixhauser comorbidity method has been shown to outperform the Charlson comorbidity index in predicting mortality after orthopedic surgery.[16] It uses the sum of weighted points based on the presence or absence of 31 different medical conditions, including congestive heart failure, cardiac arrhythmias, valvular disease, pulmonary circulation disorders, peripheral vascular disorders, uncomplicated hypertension, complicated hypertension, paralysis, other neurologic disorders, chronic pulmonary disease, uncomplicated diabetes mellitus, complicated diabetes mellitus, hypothyroidism, renal failure, liver disease, peptic ulcer disease, AIDS/HIV infection, lymphoma, metastatic cancer, solid tumor without metastasis, rheumatoid arthritis, coagulopathy, obesity, weight loss, fluid and electrolyte disorders, blood loss anemia, deficiency anemia, alcohol abuse, drug abuse, psychoses, and depression. Hospital type was classified according to the number of beds as medical center (hospital type1), general hospital (hospital type2), and clinic (hospital type3). Stay in the intensive care unit (ICU) and ventilator care were also recorded.

The primary outcome was 30-day mortality (defined as death from any cause within 30 days of the index date, in or out of hospital). The secondary outcome was overall mortality monitored from 2009 through 2015. We also recorded other complications, including myocardial infarction, pulmonary embolism, cerebral hemorrhage, acute respiratory distress syndrome, pulmonary edema, hepatic failure, and sepsis.

2.3. Statistical analysis

To improve study efficiency and precision, propensity score matching was performed using the caliper-matching method to match patients from the 2 groups in a 1:4 ratio. The propensity score was calculated by logistic regression analysis using age, sex, hospital type, anesthesia type, and comorbidities as covariates in order to examine the influence of renal dialysis on 30-day mortality and other complications after hip fracture surgery. Anesthesia type was classified as general or regional anesthesia.

Prior to propensity score matching, patient characteristics were summarized using descriptive statistics. For continuous variables, data were presented as median (range), and groups were compared using the Mann–Whitney *U* test. Descriptive variables were analyzed using Chi-squared analysis or the Fisher exact test, as appropriate. Post-matching continuous variables were presented as median (range) and were compared using the Wilcoxon signed rank test. Categorical variables were presented as absolute number (percentage), and statistical differences between groups were analyzed using the McNemar test. A P value < .05 was considered statistically significant. SAS version 9.3 (SAS Institute, Cary, NC) was used for analysis. All statistical testing was 2-sided with a significance level of .05.

Survival analyses, including the Cox proportional hazards model and Kaplan–Meier estimations, were performed for the matched cohort. The Cox proportional hazards model was constructed to calculate the hazard ratio (HR) and associated 95% confidence interval (CI) in order to evaluate the increased risk of mortality associated with dialysis.

3. Results

We identified 118,012 patients aged ≥65 years who underwent hip fracture surgery during the period from 2009 through 2015. Of these, 21,723 who had missing data were excluded. Among 96,289 patients, 2291 had a history of dialysis. However, 639 patients received dialysis in only the postoperative period and 38 patients had missing data. Finally, 1614 dialysis patients were included (Fig. 1).

Propensity score matching was performed to reduce potentially confounding variables. After performing 1:4 matching, 6198 patients were selected for the non-dialysis group, with no significant differences between groups in terms of covariates, including age, sex, hospital type, anesthesia type, or comorbidities (Table 1).

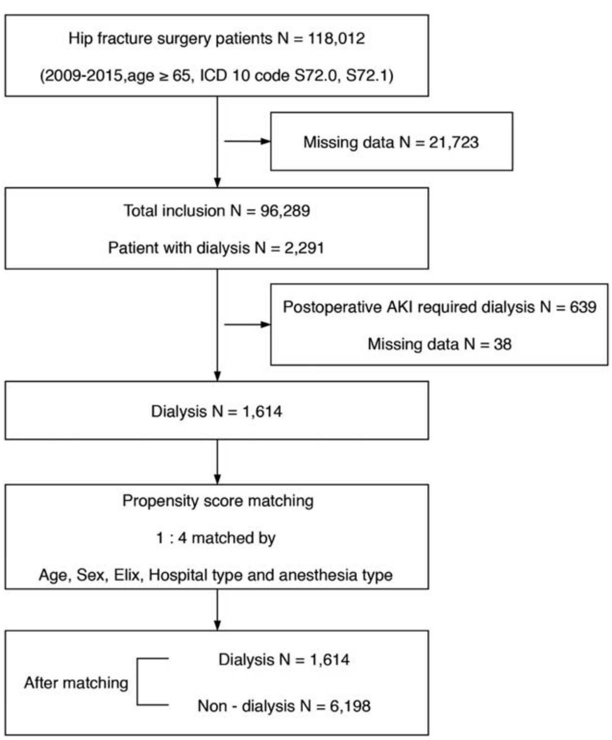

Figure 1. Flow diagram of patient enrollment.

Table 1

Patient characteristics.

	Total (n = 7810)	Dialysis (n = 1612)	Non-dialysis (n = 6198)	*P* value
Age (65–70 yr)	1456	326	1130	.47
Age (70–75 yr)	2232	459	1773	
Age (75–80 yr)	2251	452	1799	
Age (80–85 yr)	1316	264	1052	
Age (≥85 yr)	555	111	444	
Elixhauser 1	45	9	36	.40
Elixhauser 2	795	159	636	
Elixhauser 3	3950	790	3160	
Elixhauser 4	3020	654	2366	
Hospital type 1	7270	1503	5767	.96
Hospital type 2	530	107	423	
Hospital type 3	10	2	8	

Hospital type 1, medical center; hospital type 2, general hospital; hospital type 3, clinic. Elixhauser 1, Elixhauser < 5; Elixhauser 2, Elixhauser 5–9; Elixhauser 3, Elixhauser 10–14, Elixhauser 4, Elixhauser ≥ 15. Values are expressed as absolute number.

Among all 7810 patients, 229 (2.93%) died in the 30-day postoperative period. However, during the overall observation period (2009–2015), 3851 patients (49.3%) died. During the 30 days after surgery, there were 102 mortality events in the dialysis group (6.32%) and 127 in the non-dialysis group (2.05%), for an adjusted HR of 3.12 (95% CI, 2.42–4.09) (Fig. 2). Overall, by the end of the study period, there were 1120 mortality events in the dialysis group (69.39%) and 2731 in the non-dialysis group (44.06%), with an adjusted HR of 1.97 (95% CI, 1.83–2.1) (Fig. 3).

Postoperative complications, including cerebral hemorrhage, myocardial infarction, pulmonary edema, hepatic failure, and acute respiratory distress syndrome, showed no significant difference between groups. Other complications, including sepsis, stay in the ICU, and ventilator care, showed higher incidences in the dialysis group than in the non-dialysis group (P = .003, < .001, and < .001, respectively) (Table 2). However, pulmonary

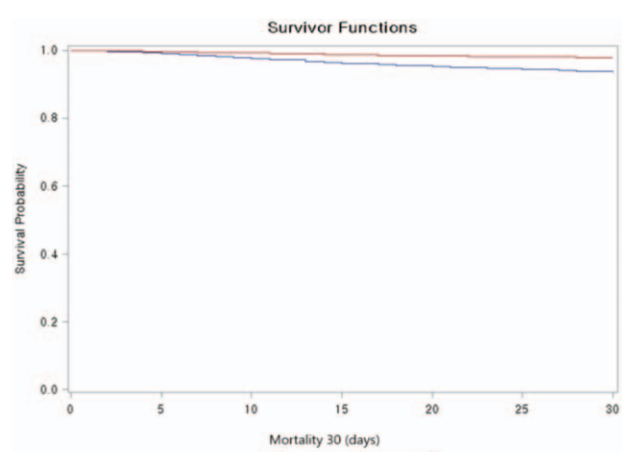

Figure 2. Kaplan–Meier estimate of cumulative 30-day mortality in the dialysis and non-dialysis groups. There were 102 (6.32%) survivors vs 127 (2.05%) survivors in the dialysis vs non-dialysis groups, respectively, with an adjusted hazard ratio of 3.12 (95% confidence interval, 2.42–4.09).

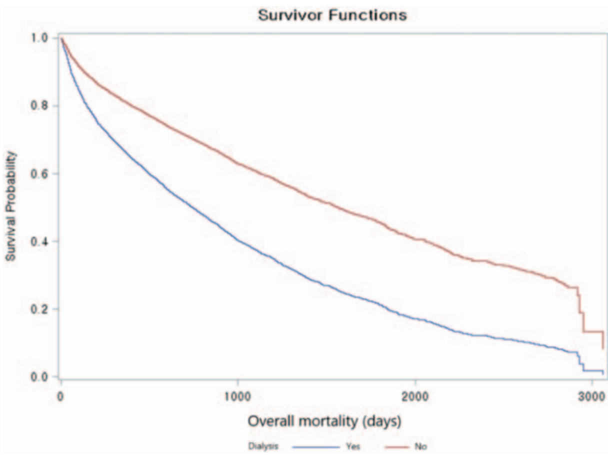

Figure 3. Kaplan–Meier estimate of overall mortality in the dialysis and non-dialysis groups. There were 1120 (69.39%) survivors vs 2731 (44.06%) survivors in the dialysis vs non-dialysis groups, respectively, with an adjusted hazard ratio of 1.97 (95% confidence interval, 1.83–2.1).

embolism showed a lower incidence in the dialysis group than in the non-dialysis group ($P=.007$) (Table 2).

4. Discussion

Hip fractures in patients with CKD usually arise because of low-energy trauma due to malnutrition, decreased muscle strength, lower bone mineral density, abnormal vitamin D metabolism, and/or abnormal parathyroid hormone level.[17] In our study, among 118,012 patients who underwent hip fracture surgery, the 30-day mortality rate was >3-fold higher in the dialysis group in the non-dialysis group, while the overall mortality rate was approximately 2-fold higher in the dialysis group than in the non-dialysis group. With adjustment for age, sex, hospital type, anesthesia type, and comorbidities, incidence of sepsis, stay in the ICU, and ventilator care were higher in the dialysis group than in the non-dialysis group.

Few studies have evaluated the role of CKD in perioperative outcomes. In a study by Warth et al,[18] CKD was shown to be an independent risk factor for early 90-day mortality and 30-day morbidity after total joint arthroplasty. In our study, short-term mortality, reflecting the postoperative period, had a higher incidence in hip fracture patients than did overall mortality. The HR of 30-day mortality in our study was 3.12, which is comparable to that of a previous study that reported an odds ratio 3.13 of in-hospital mortality.[19]

Table 2

Complications.

	Total (n=7810)	Dialysis (n=1612)	Non-dialysis (n=6198)	*P* value
Pulmonary embolism	298 (3.8)	43 (2.7)	255 (4.1)	.007*
Cerebral hemorrhage	67 (0.9)	11 (0.7)	56 (0.9)	.39
Myocardial infarction	126 (1.6)	28 (1.7)	98 (1.6)	.66
Sepsis	109 (1.4)	35 (2.2)	74 (1.2)	.003*
Pulmonary edema	143 (1.8)	38 (2.4)	105 (1.7)	.08
ARDS	57 (0.73)	9 (0.6)	48 (0.8)	.36
Hepatic failure	63 (0.81)	13 (0.81)	50 (8.01)	>.99
ICU admission	2218 (28.4)	530 (32.8)	1688 (27.2)	<.001*
Ventilator	309 (3.9)	94 (5.8)	215 (3.5)	<.001*

ARDS=acute respiratory distress syndrome, ICU=intensive care unit. Values are expressed as absolute number (percentage) or absolute number.
* $P<.05$ between-group comparison.

On the other hand, incidence of pulmonary embolism was significantly lower in the dialysis group than in the non-dialysis group. This result is controversial in previous studies.[19–21] In a study by Molnar et al,[20] venous thromboembolism, including pulmonary thromboembolism (PTE) and deep vein thrombosis, showed higher incidence in dialysis patients (8.4%) than in non-dialysis patients (2.3%). Moreover, in a study by Wang et al,[21] risk of PTE in dialysis patients was increased by >2-fold. Although the difference was statistically insignificant in the study of Hickson, the incidence of PTE and deep vein thrombosis were lower in the dialysis group than in the non-dialysis group.[19] Our study evaluated a short-term follow-up period, which is different from those of previous studies that evaluated long-term follow-up periods. Nevertheless, there are no studies evaluating influence of dialysis on PTE during the perioperative period. Therefore, we are limited in our ability to explain the mechanism by which PTE occurred less often in dialysis patients than in non-dialysis patients. Further studies would be needed to determine the cause and mechanism of this result.

The incidence of sepsis was significantly higher in the dialysis group than in the non-dialysis group. This result was also shown in the study of Hickson, who found a higher incidence of sepsis in the dialysis group than in the non-dialysis group in patients with hip fractures (5.3% vs 2.2%, $P=.001$).[19] Hemodialysis patients are vulnerable to infections.[22] In another study, sepsis-related mortality was 100 to 300-times higher in dialysis patients than in the general population.[23] Investigators hypothesized that the higher mortality was due to susceptibility to infection, the presence of comorbidities such as diabetes, and repetitive exposure to pathogens during hemodialysis.[24] Based on these results, we believe clinicians should pay more attention when treating hip fracture patients who are on hemodialysis.

In a previous meta-analysis, the risk factors for overall mortality were older age, male sex, nursing home or facility residence, poor preoperative walking capacity, poor daily activities, poor mental state, and multiple comorbidities, including chronic renal disease.[25] However, this study only showed risk factors for overall mortality rather than short-term mortality; 30-day mortality (13.3%) was different from that of our study (2.93%), despite the fact that the mean ages were similar in both studies. Nevertheless, 30-day mortality rates varied in previous studies from 1.2% to 13.3%.[25,26] Considering that all of our included patients underwent surgery and were matched based on a history of CKD, the mortality in our study appears to be lower than that of the meta-analysis. In a study by Lin et al,[27] the 30-day mortality rate was also higher in the dialysis group than in the non-dialysis group (6.9% vs 2.1%), which is very similar to our results (6.32% vs 2.05%).

There are some limitations in this study. First, because the national claims database was not established for the purpose of research, but rather was designed for medical services claims and reimbursements, the database is limited in that it might contain coding errors. Second, the risks are higher with hemodialysis than with peritoneal dialysis.[28] However, in our study, the dialysis group included patients requiring either hemodialysis or peritoneal dialysis. Third, in previous studies, the severity of renal disease was associated with higher rates of postoperative complications.[29] However, there was a lack of data regarding the severity of renal disease in this study. Finally, various risk factors affect mortality rate after hip fracture surgery, including co-medications, dialysis time before and after surgery, perioperative abnormal laboratory values, optimal time for surgery, and intraoperative management, none of which we able to evaluate. Finally, the fracture healing process is associated with factors such as platelet counts.[30] However, we did not have access to these laboratory values.

Despite these limitations, there are some strengths of our study compared with previous studies. The comorbidities of the included patients were evaluated, including 31 diagnoses in the Elixhauser method. This adjustment is the major strength of our study because the comorbidities include most of confounding factors that affect mortality and complications. Furthermore, we collected data from 2009 through 2015, which might reflect the outcomes derived from the most recent trends in medical treatment, including surgery and anesthesia. Finally, this database contains a large number of patients, covering nearly the entire population of the country. For this reason, there was no selection bias in our investigation.

In conclusion, the 30-day mortality rate was 3-fold higher in the dialysis group than in the non-dialysis group, while the overall mortality rate was approximately 2-fold higher in the dialysis group than in the non-dialysis group. These findings suggest that caution is required during the perioperative period for dialysis patients undergoing hip fracture surgery.

Author contributions

Conceptualization: EunJin Ahn, Si Ra Bang.
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Funding acquisition: Si Ra Bang.
Investigation: Si Ra Bang.
Methodology: EunJin Ahn, Si Ra Bang.
Project administration: Si Ra Bang.
Resources: Si Ra Bang.
Software: Si Ra Bang.
Supervision: Si Ra Bang.
Validation: Si Ra Bang.
Visualization: Si Ra Bang.
Writing – original draft: EunJin Ahn, Si Ra Bang.
Writing – review & editing: EunJin Ahn, Si Ra Bang.

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