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Risk of Major Nonemergent Inpatient General Surgical Procedures in Patients on Long-term Dialysis

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Hypothesis: Patients on long-term dialysis undergoing major nonemergent general surgical procedures are thought to have high rates of postoperative complications and death.

Design: Retrospective cohort study.

Setting: Academic and private hospitals.

Patients: The American College of Surgeons National Surgical Quality Improvement Program database was used to select dialysis and nondialysis patients who had undergone nonemergent major general surgical procedures between 2005 and 2008. Multivariable logistic regression analysis was used to examine the effect of dialysis on 30-day surgical outcomes adjusted for age, race, sex, work relative value units, American Society of Anesthesiologists class, and recent operations (within the past 30 days).

Main Outcome Measures: Patient morbidity, mortality, and failure-to-rescue rates.

Results: Dialysis patients undergoing major nonemergent general surgical procedures were significantly more likely to develop pneumonia, unplanned intubation, ventilator dependence, and need for a reoperation within 30 days from the index procedure. Dialysis patients also had a higher risk of vascular complications and postoperative death. Older dialysis patients (aged ≥65 years) had a significantly higher postoperative mortality rate compared with their younger counterparts. Dialysis patients were significantly more likely to die after any complication occurred, and mortality rates were especially high following stroke, myocardial infarction, and reintubation. Abnormalities in potentially modifiable preoperative variables (blood urea nitrogen level, albumin level, and hematocrit) did not increase the risk of postoperative complications or death in dialysis patients compared with nondialysis patients.

Conclusions: Dialysis patients undergoing nonemergent general surgery have significantly elevated risks of postoperative complications and death, particularly if they are aged 65 years or older.

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More than half a million individuals in the United States undergo dialysis,[1] a number that has been forecasted to increase by 7% annually.[2] End-stage renal disease requiring dialysis is associated with poor health care outcomes, including a 10-fold increase in risk of hospitalization[3] and an expected lifespan between one-fourth and one-sixth of that of the general population.[4] Despite the well-described outcomes of the effect of end-stage renal disease on community-dwelling individuals, little is known about the contribution of long-term dialysis to the risks of postoperative complications and death.

Most of the currently existing surgical literature examining the postoperative outcomes of dialysis patients is limited to small retrospective reviews of single-institution experiences.[5-9] While complication and mortality rates of dialysis patients have been a subject of several articles in cardiac surgery,[10,11] there is a relative paucity of data on the complication and mortality rates of dialysis patients undergoing general surgery. As a result, the optimal perioperative medical and surgical management of these patients is poorly understood.

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The purposes of our study were to better characterize the risk of major general surgery in long-term dialysis patients and to identify potentially modifiable preoperative risk factors that could be moderated to improve surgical outcomes. Using

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the large American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, we examined the postoperative morbidity and mortality in patients undergoing major nonemergent general surgery with and without dialysis.

METHODS

DATA SOURCE

Data for this study were obtained from the ACS-NSQIP database, which assesses preoperative risk factors, operative data, and 30-day postoperative outcomes for sampled patients undergoing major surgery at participating hospitals. A trained surgical clinical nurse collects the data from the patient's medical records. All data contained within the data set are deidentified. On the 30th postoperative day, the nurse obtains outcome information through record review, reports from morbidity and mortality conferences, and communication with each patient or the patient's family by letter or telephone.[12]

PATIENTS

The ACS-NSQIP database was used to select patients who had undergone major nonemergent general surgical operations between 2005 and 2008. Because emergent surgical operations are known to have further elevated risks of complications and death, all cases coded as emergent in the data set were excluded. Other exclusions included operations aimed at creating or revising hemodialysis access. *Current Procedural Terminology* codes were used to select patients whose procedure warranted more than overnight stay as we were interested in complication rates following major general surgical procedures (mean postoperative length of stay for all patients, 5.9 days). Additionally, patients with missing information for sex, race, wound classification, age, work relative value units, and whether the patient had undergone a prior operation within the past 30 days were excluded. Patients with missing values for albumin level (n=51 461 [31.1%]), blood urea nitrogen (BUN) level (n=18 280 [11.0%]), and hematocrit (n=10 061 [6.1%]) were retained and missing values were imputed. The eTable (http://www.jamasurg.com) lists all *Current Procedural Terminology* codes used to select patients for this study.

The "currently on dialysis" variable was used to categorize patients into dialysis and nondialysis groups. This variable was defined as yes if the patient had renal failure requiring treatment with peritoneal dialysis, hemodialysis, hemofiltration, hemodiafiltration, or ultrafiltration within 2 weeks prior to surgery according to the ACS-NSQIP data user guide. As all operations collected were nonemergent, the assumption is that few of the patients in the analysis had acute renal failure. Finally, patients were also grouped according to age, 65 years or older vs younger than 65 years (where <65 years is the reference group) as this is a threshold age at which reported mean survival is less than 5 years according to the US Renal Data Service.[13]

DEFINITIONS OF OUTCOMES OF INTEREST

Postoperative outcomes of interest were complications occurring within 30 days of the index operation, return to the operating room within 30 days, postsurgical length of stay, and 30-day mortality. Postoperative complications included the following: surgical site infection (SSI) (including superficial and deep wound infections as well as wound disruptions); cardiovascular, pulmonary, urinary tract, and central nervous system complications; return to the operating room; and postoperative hospital length of stay. In addition, we also grouped complications to form a composite pulmonary outcome (pneumonia, failure to wean from ventilator >48 hours, or reintubation for cardiorespiratory failure) and a composite vascular outcome (stroke/cerebrovascular accident or myocardial infarction [MI]). An overall composite outcome was created by combining SSI, pulmonary complications, and vascular complications.

STATISTICAL ANALYSIS

Baseline patient characteristics were compared among the dialysis and nondialysis groups using χ^2 test of association for categorical variables and unpaired *t* test for continuous variables. Unadjusted postoperative outcome rates were compared by dialysis status using Pearson χ^2 test of association.

For each of the dichotomous postoperative outcomes, the adjusted odds ratio (OR) was determined for the dialysis group vs the nondialysis group using multivariable logistic regression analysis. Analyses were adjusted for age, sex, race/ethnicity, work relative value units,[14] American Society of Anesthesiologists classification, and prior operation within the past 30 days. The SSI outcome was additionally adjusted for wound classification. A second model of multivariable logistic regression was also done with additional adjustment performed for 6 different procedure types, using groupings outlined in **Table 1**.

While several preoperative comorbid conditions were more frequently present in dialysis patients, multivariable models were not additionally adjusted for all of these comorbidities individually as their presence resulted in an upgrade in the American Society of Anesthesiologists classification already.

Failure-to-rescue (FTR) rates were computed for the dialysis and nondialysis patients by computing the 30-day mortality rates for those patients who developed each type of postoperative complication. For example, the FTR rate for SSI was calculated as the number of patients who had a postoperative SSI and died within 30 days following the operation divided by the total number of patients who developed a postoperative SSI. These FTR rates were compared between the dialysis and nondialysis patients using relative risk and a 95% CI computed by the Cochran-Mantel-Haenszel method. The 95% CIs greater than 1 indicate FTR rates higher in the dialysis patients compared with the nondialysis patients.

Additional multivariable logistic regression analyses were performed to examine the relative importance of potentially modifiable preoperative risk factors (serum albumin level, BUN level, and hematocrit) in predicting 30-day postoperative morbidity and mortality between the dialysis and nondialysis patients. These models also included age, sex, race, diabetes, functional status, American Society of Anesthesiologists class, and prior operation as adjustment variables. A random normal imputation method was used to populate missing values for albumin level, BUN level, and hematocrit. These random variables were generated to approximate a range of values typically seen in healthy individuals because it was assumed that these values tend to be missing more often for healthy patients than unhealthy patients. All analyses were performed using SAS version 9.3 statistical software (SAS Institute, Inc).

RESULTS

A total of 165 600 patients who underwent elective major general surgery between 2005 and 2008 were included from the ACS-NSQIP data set. The subgroup with dialysis included 1506 patients (0.9%). Patient demographic characteristics for dialysis and nondialysis patients are shown

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Table 1. Patient Characteristics by Dialysis Status

Characteristic	No. (%)			*P* Value
	Total (N = 165 600)	Not on Dialysis (n = 164 094)	On Dialysis (n = 1506)	
Demographic				
Race/ethnicity				<.001
American Indian or Alaska native	1084 (0.7)	1071 (0.7)	13 (0.9)	
Asian or Pacific Islander	3207 (1.9)	3173 (1.9)	34 (2.3)	
Non-Hispanic black	16 448 (9.9)	16 008 (9.8)	440 (29.2)	
Hispanic black	191 (0.1)	184 (0.1)	7 (0.5)	
Hispanic, race unknown	4769 (2.9)	4707 (2.9)	62 (4.1)	
Hispanic white	4407 (2.7)	4365 (2.7)	42 (2.8)	
Unknown	12 500 (7.5)	12 418 (7.6)	82 (5.4)	
Non-Hispanic white	122 994 (74.3)	122 168 (74.5)	826 (54.8)	
Sex				<.001
Male	67 183 (40.6)	66 370 (40.4)	813 (54.0)	
Female	98 417 (59.4)	97 724 (59.6)	693 (46.0)	
Age, mean (SD), y[a]	55.4 (16.8)	55.4 (16.8)	59.6 (15.1)	<.001
Preoperative Status				
Diabetes mellitus with oral agents or insulin	27 347 (16.5)	26 764 (16.3)	583 (38.7)	<.001
Functional health status prior to surgery				<.001
Independent	155 536 (93.9)	154 574 (94.2)	962 (63.9)	
Partially dependent	7479 (4.5)	7203 (4.4)	276 (18.3)	
Totally dependent	2585 (1.6)	2317 (1.4)	268 (17.8)	
History of severe COPD	7719 (4.7)	7581 (4.6)	138 (9.2)	<.001
CHF within 30 d before surgery	1281 (0.8)	1144 (0.7)	137 (9.1)	<.001
MI within 6 mo before surgery	721 (0.4)	654 (0.4)	67 (4.4)	<.001
Angina within 1 mo before surgery	969 (0.6)	936 (0.6)	33 (2.2)	<.001
Hypertension requiring medication	77 879 (47.0)	76 656 (46.7)	1223 (81.2)	<.001
History of TIA	3453 (2.1)	3366 (2.1)	87 (5.8)	<.001
CVA or stroke				
With neurological deficit	2867 (1.7)	2773 (1.7)	94 (6.2)	<.001
Without neurological deficit	2613 (1.6)	2522 (1.5)	91 (6.0)	<.001
Prior operation within 30 d	4005 (2.4)	3757 (2.3)	248 (16.5)	<.001
Preoperative BUN, mean (SD), mg/dL	14.9 (9.0)	14.7 (8.5)	38.8 (21.5)	<.001
Preoperative serum albumin, mean (SD), g/dL	3.8 (0.7)	3.8 (0.7)	2.9 (0.9)	<.001
Preoperative hematocrit, mean (SD), %	38.3 (5.3)	38.3 (5.3)	33.5 (6.1)	<.001
Surgical Profile				
Wound classification				<.001
Clean	26 347 (15.9)	26 113 (15.9)	234 (15.5)	
Clean/contaminated	107 566 (65.0)	106 843 (65.1)	723 (48.0)	
Contaminated	21 354 (12.9)	21 085 (12.8)	269 (17.9)	
Dirty/infected	10 333 (6.2)	10 053 (6.1)	280 (18.6)	
ASA classification				<.001
Missing	146 (0.1)	145 (0.1)	1 (0.0)	
No disturbance	6916 (4.2)	6914 (4.2)	2 (0.0)	
Mild disturbance	72 292 (43.7)	72 260 (44.0)	32 (2.1)	
Severe disturbance	78 174 (47.2)	77 395 (47.2)	779 (51.7)	
Life threatening	7959 (4.8)	7289 (4.4)	670 (44.5)	
Moribund	113 (0.1)	91 (0.1)	22 (1.5)	
CPT group				<.001
Gastric, small bowel, peritoneal	55 226 (33.3)	54 712 (33.3)	514 (34.1)	
Hepatic, biliary, pancreatic	35 285 (21.3)	34 899 (21.3)	386 (25.6)	
Colon, appendix, rectum	34 698 (21.0)	34 432 (21.0)	266 (17.7)	
Spleen, laparoscopic, hernia	29 728 (18.0)	29 475 (18.0)	253 (16.8)	
Respiratory, thoracic	9738 (5.9)	9700 (5.9)	38 (2.5)	
Skin, node dissections, head/neck	925 (0.6)	876 (0.5)	49 (3.3)	
Work relative value units, mean (SD)	21.6 (10.0)	21.7 (10.0)	18.6 (8.6)	<.001
Total operation time, mean (SD), min	144.0 (100.0)	144.2 (100.1)	117.3 (86.8)	<.001

Abbreviations: ASA, American Society of Anesthesiologists; BUN, blood urea nitrogen; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; *CPT*, *Current Procedural Terminology*; CVA, cerebrovascular accident; MI, myocardial infarction; TIA, transient ischemic attack.

SI conversion factors: To convert BUN to millimoles per liter, multiply by 0.357; to convert albumin to grams per liter, multiply by 10; and to convert hematocrit to proportion of 1.0, multiply by 0.01.

[a] Truncated at age 90 years.

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Table 2. Postoperative Outcomes in Dialysis vs Nondialysis Patients Who Underwent General Surgery

Postoperative Outcome	No. (%) Total (N = 165 600)	Not on Dialysis (n = 164 094)	On Dialysis (n = 1506)	*P* Value
Surgical site infection	11 377 (6.9)	11 227 (6.8)	150 (10.0)	<.001
PE or DVT/thrombophlebitis	2426 (1.5)	2391 (1.5)	35 (2.3)	.005
Stroke/CVA with neurological deficit	320 (0.2)	311 (0.2)	9 (0.6)	<.001
Return to operating room	8396 (5.1)	8117 (4.9)	279 (18.5)	<.001
Myocardial infarction	289 (0.2)	279 (0.2)	10 (0.7)	<.001
Urinary tract infection	4336 (2.6)	4292 (2.6)	44 (2.9)	.46
Pneumonia	4028 (2.4)	3917 (2.4)	111 (7.4)	<.001
Failure to wean	4228 (2.6)	3978 (2.4)	250 (16.6)	<.001
Unplanned intubation	3338 (2.0)	3217 (2.0)	121 (8.0)	<.001
Pulmonary outcome	7566 (4.6)	7241 (4.4)	325 (21.6)	<.001
Vascular outcome	602 (0.4)	583 (0.4)	19 (1.3)	<.001
Composite outcome	18 017 (10.9)	17 587 (10.7)	430 (28.6)	<.001
Death within 30 d of operation[a]	2685 (1.6)	2494 (1.5)	191 (12.7)	<.001
Length of postoperative surgical stay, mean (SD), d				
All patients	5.9 (8.1)	5.8 (7.9)	13.4 (20.2)	<.001
Excluding those with 30-d mortality	5.8 (8.1)	5.8 (7.9)	13.8 (21.4)	<.001

Abbreviations: CVA, cerebrovascular accident; DVT, deep venous thrombosis; PE, pulmonary embolism.
[a] For patients with 30-day mortality (n = 2685), it is unknown whether death occurred prior to hospital discharge.

Table 3. Unadjusted and Adjusted Odds Ratios of Postoperative Outcomes for Dialysis Patients Who Underwent General Surgery

Postoperative Outcome	Odds Ratio (95% CI)[a] Unadjusted	Adjusted[b]
Surgical site infection	1.51 (1.27-1.78)	1.16 (0.98-1.39)
PE or DVT/thrombophlebitis	1.61 (1.15-2.26)	0.82 (0.58-1.16)
Pneumonia	3.25 (2.68-3.96)	1.28 (1.04-1.57)
Unplanned intubation	4.37 (3.62-5.28)	1.82 (1.48-2.23)
Failure to wean	8.01 (6.97-9.21)	1.94 (1.65-2.29)
Urinary tract infection	1.12 (0.83-1.51)	0.72 (0.53-0.98)
Stroke/CVA with neurological deficit	3.17 (1.63-6.15)	1.64 (0.82-3.30)
Myocardial infarction	3.92 (2.08-7.39)	1.72 (0.89-3.35)
Return to operating room	4.37 (3.83-4.99)	1.94 (1.68-2.25)
Pulmonary outcome	5.96 (5.26-6.75)	1.89 (1.64-2.18)
Vascular outcome	3.58 (2.26-5.68)	1.69 (1.04-2.75)
Composite outcome	3.33 (2.97-3.73)	1.55 (1.37-1.75)
Death within 30 d of operation	9.41 (8.05-11.01)	2.57 (2.15-3.08)

Abbreviations: CVA, cerebrovascular accident; DVT, deep venous thrombosis; PE, pulmonary embolism.
[a] Odds ratios are presented in relation to patients not currently on dialysis. Patients with missing observations for American Society of Anesthesiologists classification were excluded from the analysis, including the following: unadjusted analysis, 1506 patients with end-stage renal disease and 164 094 patients without end-stage renal disease; and adjusted analysis, 1505 patients with end-stage renal disease and 163 949 patients without end-stage renal disease.
[b] Adjusted for fixed effects of race, sex, age, work relative value units, American Society of Anesthesiologists classification, and whether the patient had undergone an operation within the past 30 days. Surgical site infection was additionally adjusted for wound classification.

in Table 1. More than 98% of the surgical procedures were done by general surgeons as a surgical specialty.

The incidence of postoperative adverse events is presented in **Table 2**. Dialysis patients compared with nondialysis patients had a markedly greater rate of 30-day overall complications (composite outcome, 28.6% vs 10.7%, respectively; $P < .001$), death (12.7% vs 1.5%, respectively; $P < .001$), and return to the operating room (18.5% vs 4.9%, respectively; $P < .001$). Most of the increase in complications was attributed to increased rates of pulmonary complications. Additionally, the average length of postoperative surgical stay was more than twice as long for dialysis patients compared with nondialysis patients (13.4 vs 5.8 days, respectively; $P < .001$).

There were no reported complications for 84.3% of nondialysis patients compared with 62.1% of dialysis patients. Among nondialysis patients, 10.9% had 1 complication and 2.9% had 2 complications; among dialysis patients, 19.6% had 1 complication and 9.8% had 2 complications. There were 3 or more complications in 2.1% of nondialysis patients compared with 8.7% of dialysis patients ($P < .001$).

The ORs of postoperative events adjusted for race, sex, age, work relative value units, American Society of Anesthesiologists class, and prior operation within 30 days are presented in **Table 3**. Dialysis patients undergoing elective surgery were significantly more likely to develop pneumonia (OR = 1.28; 95% CI, 1.04-1.57), unplanned intubation (OR = 1.82; 95% CI, 1.48-2.23), ventilator dependence (OR = 1.94; 95% CI, 1.65-2.29), and return to the operating room within 30 days (OR = 1.94; 95% CI, 1.68-2.25) than nondialysis patients. In addition, dialysis patients were more likely to develop a composite pulmonary outcome (OR = 1.89; 95% CI, 1.64-2.18), vascular outcome (OR = 1.69; 95% CI, 1.04-2.75), composite outcome (OR = 1.55; 95% CI, 1.37-1.75), and death (OR = 2.57; 95% CI, 2.15-3.08) within 30 days from surgery. This model was further adjusted for procedure type using 6 different *Current Procedural Terminology* procedure groups outlined in Table 1. Further adjustment for procedure type resulted in no significant change in the results presented in Table 3 (data not shown).

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Table 4. Failure-to-Rescue Rates and Relative Risk of Death Across Patients Who Experienced 1 or More Major Complications

Major Complication	Mortality Rate, No. (%)		RR (95% CI)
	Not on Dialysis	On Dialysis	
Surgical site infection	226/11 227 (2.0)	19/150 (12.7)	6.29 (4.05-9.77)
PE or DVT/thrombophlebitis	175/2391 (7.3)	9/35 (25.7)	3.51 (1.97-6.28)
Stroke/CVA with neurological deficit	72/311 (23.2)	6/9 (66.7)	2.88 (1.74-4.77)
Myocardial infarction	70/279 (25.1)	5/10 (50.0)	1.99 (1.04-3.83)
Urinary tract infection	157/4292 (3.7)	7/44 (15.9)	4.35 (2.17-8.73)
Pneumonia	520/3917 (13.3)	34/111 (30.6)	2.31 (1.72-3.09)
Ventilator >48 h	793/3978 (19.9)	77/250 (30.8)	1.55 (1.27-1.88)
Unplanned intubation	810/3217 (25.2)	46/121 (38.0)	1.51 (1.19-1.91)
Return to operating room	598/8117 (7.4)	54/279 (19.4)	2.63 (2.04-3.38)
Overall risk of mortality after any major complication	1646/25 762 (6.4)	124/571 (21.7)	3.40 (2.89-4.00)

Abbreviations: CVA, cerebrovascular accident; DVT, deep venous thrombosis; PE, pulmonary embolism; RR, relative risk.

We examined whether certain procedure types carried a higher risk of postoperative complications. Secondary to sample size, we ran analysis only for the first 4 groups listed under the *Current Procedural Terminology* groupings in Table 1 (group 1, gastric, small bowel; group 2, hepatobiliary; group 3, colorectal; and group 4, spleen, hernia). Dialysis patients in groups 1 and 3 had much higher frequencies of SSI (13.0% and 13.5%), composite pulmonary outcome (30.7% and 21.4%), all complications combined (39.3% and 31.6%), and mortality (19.6% and 16.2%) compared with groups 2 and 4 (SSI, 5.1% and 7.5%; composite pulmonary outcome, 10.7% and 15.0%; all complications, 15.4% and 15.0%; and mortality, 6.3% and 5.7%).

Further stratification of dialysis patients based on age (<65 years, n = 918 [61.0%]; ≥65 years, n = 588 [39.0%]) was performed. Older dialysis patients undergoing elective general surgery were significantly more likely to die postoperatively compared with younger dialysis patients (OR = 2.65; 95% CI, 1.88-3.74).

The FTR rates, or mortality rates following a complication, were significantly elevated for dialysis patients (**Table 4**). The FTR rate was significantly higher for all complications studied, with stroke (66.7%), MI (50.0%), and unplanned intubation (38.0%) being the most lethal complications among patients on dialysis (Table 4). The top 3 complications leading to mortality were the same in nondialysis patients, but the order was different: unplanned intubation (25.2%), MI (25.1%), and stroke (23.2%). The likelihood of surviving a complication was the highest following SSI in both groups (98.0% in nondialysis patients vs 87.3% in dialysis patients). The overall risk of dying after any major complication was also significantly higher in the dialysis patients than in the nondialysis patients (21.7% vs 6.4%, respectively; relative risk = 3.40; 95% CI, 2.89-4.00).

We examined the effect of potentially modifiable preoperative variables (preoperative nutrition for albumin level; preoperative dialysis for BUN level; preoperative transfusion for hematocrit) on the risk of developing any postoperative complication or death within 30 days in multivariable analysis (data not shown). All variables were studied as continuous variables. There was clear evidence of more liberal use of intraoperative blood transfusion in dialysis patients. One or more units of blood was received by 14.2% of dialysis patients compared with 6.1% of nondialysis patients. As a limitation of the data, potential interventions to improve low preoperative albumin levels or high BUN levels could not be studied. We did not find that the effect of these variables (low albumin level, high BUN level, low hematocrit) in predicting mortality or morbidity was higher in dialysis patients vs nondialysis patients.

COMMENT

This study is one of the largest on the complication rate and short-term outcomes of nonemergent general surgery in dialysis patients. Dialysis patients had significantly higher rates of postoperative morbidity and mortality in both unadjusted and adjusted analyses compared with their nondialysis counterparts. The elevated number of pulmonary complications (pneumonia, unplanned intubation, ventilator dependence) and reoperations accounted for most of the differences in morbidity. As a result, dialysis patients also had a significantly prolonged postsurgical length of stay and a markedly increased risk of postoperative death. Mortality rates in dialysis patients aged 65 years and older were significantly elevated compared with those of their younger counterparts. Once a complication occurred, dialysis patients were less likely to survive compared with nondialysis patients, with stroke, MI, and unplanned intubation being the most lethal complications in dialysis patients. Potentially modifiable preoperative variables (albumin level, BUN level, hematocrit) did not differentially affect complication rates or the risk of postoperative mortality in dialysis patients compared with nondialysis patients.

Despite reasonable outcomes from small single-center studies arguing for the relative safety of operating on dialysis patients,[5,8] larger population-based studies had significantly different findings.[15] Patients on long-term dialysis were found to have an increased risk of postoperative adverse events, longer length of stay, and higher rate of death following colorectal surgery.[15] While the overall in-hospital mortality for all patients was 3.7% (including emergent cases), elective admissions for colorectal surgery were still associated with a 10.3% mor-

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tality in the setting of dialysis. After multivariable adjustment, dialysis patients had a 6-fold risk of mortality compared with their nondialysis counterparts. More than half of the dialysis patients had at least 1 complication, with infectious complications being the most common.

The lower morbidity and mortality rates from single-institution series can be attributed to mixing minor procedures with major interventions, combining a relatively small number of laparotomies with endoscopic procedures, anal fissure operations, dialysis access operations, and parathyroidectomies. The complication and death rates following the latter operations are obviously much lower. The postoperative mortality rate reported in small single-institution series of 1% to 6%[5,6,8] is in sharp contrast with findings from larger database studies such as that by Drolet at al[15] (10.3%) and our study (12.7%). Some of the small single-institution series reported about a 1% postoperative death rate for dialysis patients,[5,8] which is lower than the death rate for nondialysis patients in our study (1.5%). A likely explanation for this discrepancy is that less complex surgical procedures are reported in the single-institution series.

The rate of pulmonary complications in dialysis patients was high in our study (21.6%) and comparable to that reported by Drolet et al.[15] The exact reason for the high rate of pulmonary complications in dialysis patients remains unknown. Some studies speculate that dialysis treatment induces hypoxemia and carbon dioxide diffuses in the dialysate, leading to hypocapnia and reflex hypoventilation.[16] These events combined may lead to a higher risk of developing atelectasis and pneumonia in the postsurgical setting.

Other studies found correlation between mortality and nutritional parameters in the setting of long-term dialysis. A low serum albumin level was a predictor of mortality and an independent risk factor for death in dialysis patients.[17,18] A small single-institution study found that a high BUN level, low hematocrit, and low albumin level increased the rate of postoperative complications in dialysis patients undergoing abdominal surgery.[9] As all these variables are potentially modifiable preoperatively in a nonemergent setting (dialysis for a high BUN level; blood transfusion for a low hematocrit; preoperative nutrition for a low albumin level), we thought to further examine the effects of these factors on postoperative complication and death rates. We found no clear evidence that a high BUN level, a low hematocrit, and a low albumin level affect postoperative outcomes differentially in dialysis patients compared with nondialysis patients in multivariable analysis.

The combined systemic effects of chronic renal disease create an altered physiological state for dialysis patients in the perioperative period. This altered physiological state influences the way complications are handled by the body and decreases our ability to rescue the patient once a complication happens. This leads to a significantly higher mortality rate in dialysis patients for all complications studied once an adverse event happens. While MI and stroke with neurological deficit are rare postoperative events even in dialysis patients (0.6%-0.7%), the mortality rate for both of these complications is higher than 50%. Admittedly, the high mortality rate following MI and stroke has to be interpreted with caution given the low number of events in the dialysis group. The third most important FTR complication in both groups was reintubation (38.0% in the dialysis group vs 25.2% in the nondialysis group). In both groups, SSIs were the least likely events to cause death; however, the rate of mortality in the dialysis group compared with that in the nondialysis group was still substantially higher (12.7% vs 2.0%, respectively) and the relative risk of dying was 6.29 (95% CI, 4.05-9.77).

Using age 65 years as a cutoff, we found significantly elevated mortality rates in older dialysis patients compared with their younger counterparts. We chose age 65 years because this is the point at which the average mean life expectancy for dialysis patients decreases to less than 5 years according to the US Renal Data Service. Showing a higher number of serious complications and mortality in elderly patients should caution clinicians and would argue for a less liberal use of general surgery interventions in a patient population with an already significantly limited lifespan.

Our study has several limitations. The database that we used and the analyses that were conducted contain a large number of different types of general surgical operations. The sample size is not large enough to perform analyses for each type of operation. Despite a large number of patients overall, the dialysis subgroup is relatively small (n = 1506). Based on the codes used to define long-term dialysis, there is a chance that some patients with acute renal failure were included. However, the exclusion of emergent operations from the analysis makes this less likely. Furthermore, while all operations related to creation or revision of hemodialysis access as a primary procedure were excluded, the higher rate of 30-day reoperations in dialysis patients may be related to vascular access–related complications.

In summary, we found that long-term dialysis patients undergoing elective general surgery operations who were included in the ACS-NSQIP database have a significantly longer postoperative length of stay and elevated risks of postoperative complications and death compared with their nondialysis counterparts. The most common postoperative adverse events in dialysis patients were pulmonary complications, while the most lethal complications were vascular events (MI or stroke). Older dialysis patients (aged ≥65 years) were more likely to die postoperatively compared with younger patients. The significantly elevated risks of postoperative complications and death deserve an in-depth discussion with dialysis patients preoperatively.

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ONLINE FIRST

Elective Surgery in Dialysis Patients

Realistic Risk Information From the American College of Surgeons National Surgical Quality Improvement Program Database

Nationally validated registries allow investigators to assess "real world" surgical outcomes that are more widely generalizable. In this study using data from the American College of Surgeons National Surgical Quality Improvement Program registry, Gajdos and colleagues found that patients on long-term dialysis undergoing nonemergent procedures are at high risk for complications and have an operative mortality rate of 13%.[1] Results from this study represent a more realistic estimate of operative risk in dialysis patients than the 1% to 6% operative mortality rate reported in single-center series.[2-4] These findings highlight the importance of dialysis dependence as a risk factor for poor surgical outcomes. It should be considered along with old age and functional dependence as a characteristic that identifies patients at extremely high risk. Identifying high-risk patients informs surgical decision making, allows patients to be appropriately counseled about the risks of surgery, and should prompt efforts aimed at preoperative optimization.

Unfortunately, analyses of potentially modifiable factors—albumin level, blood urea nitrogen level, and hematocrit—did not identify these variables as mediators of increased risk in dialysis patients. These findings underscore the need to identify new targets for preoperative optimization that could potentially ameliorate risk in this high-risk population. The use of American Society of Anesthesiologists class as the sole adjustment for comorbidities, however, is problematic. This approach limits the ability to identify subgroups of dialysis patients in whom surgery is safer. This limitation, though, should not serve as fodder for those who argue that operative risk in dialysis patients is low. This study conclusively shows that patients on long-term dialysis—particularly older dialysis patients—have high rates of morbidity and mortality following elective surgery. Given the poor surgical outcomes in this population, we agree with

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