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Coronary artery bypass grafting in dialysis patients: a propensity score-matched analysis

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Abstract

Background Patients undergoing dialysis treatment have long been recognized as having an elevated risk of developing coronary artery disease necessitating coronary artery bypass grafting (CABG). However, the prognostic implications of CABG in dialysis-dependent patients remain underexplored. This study aimed to comprehensively assess both short- and long-term outcomes in dialysis-dependent patients undergoing CABG.

Methods In this retrospective analysis, we meticulously matched 55 dialysis-dependent patients with 55 non-dialysis patients, controlling for baseline characteristics including age, sex, etiology, and date of surgery. All patients underwent CABG treatment at our institution between January 2014 and June 2022. We conducted a comparative analysis of postoperative complications and survival rates between the two groups.

Results Our findings revealed that the dialysis-dependent group exhibited a significantly higher incidence of postoperative complications compared to the non-dialysis group (92.7% vs. 61.8%; $p < 0.001$). Furthermore, the 5-year survival rates were notably diminished among dialysis patients relative to their non-dialysis counterparts (46.2 ± 7.9% vs. 58.2 ± 12.1%, $p = 0.045$). Consistently, dialysis patients exhibited decreased 5-year cardiac-event-free rates in contrast to non-dialysis patients (31.6 ± 7.6% vs. 58.8 ± 11.3%, $p = 0.041$). Predictably, several baseline parameters were identified as significant risk factors contributing to adverse outcomes among dialysis patients, including a history of smoking, diabetes mellitus, congestive heart failure upon admission, and the requirement for intraoperative concomitant surgery ($p = 0.006$, $p = 0.043$, $p = 0.017$, $p = 0.003$, respectively).

Conclusions This study underscores the poorer prognosis associated with CABG treatment in dialysis-dependent patients. Notably, baseline factors such as a smoking history, diabetes mellitus, congestive heart failure upon admission, and the need for intraoperative concomitant surgery were all independently linked to increased mortality in this patient population.

Keywords Coronary artery bypass grafting, Dialysis, Mortality, Morbidity, Outcome

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Introduction

It has been well understood that patients with end-stage renal disease (ESRD) have an increased risk of not only developing cardiovascular diseases but are also associated with worse outcomes following cardiac surgery [1–3]. It has been estimated that the annual mortality rate for patients with ESRD is about 20% per year and nearly 50% of the death can be attributed to cardiovascular events [4]. Coronary-artery bypass grafting (CABG) is a well-established procedure in which autologous arteries or veins are used as grafts to bypass coronary arteries that are partially or completely obstructed by atherosclerotic plaque. Given the hemodynamic instability often observed in dialysis patients (resulting from rapid fluctuations in heart rate and mean blood pressure during hemodialysis), it is crucial to assess the prognosis and identify risk factors in dialysis patients undergoing CABG.

Treating coronary artery disease (CAD) in patients with end-stage renal failure often presents significant challenges to surgeons. Previous studies showed that dialysis-dependent patients who required immediate dialysis following CABG were associated with a two-fold- to threefold- increase of hospital mortality [5–9]. However, most previous studies did not adjust potential confounding baseline factors or evaluate long-term prognosis. Therefore, we performed a retrospective case-control analysis to compare the prognosis of dialysis-dependent patients after receiving CABG treatment to matching non-dialysis-dependent patients.

Methods

Patients and setting

The Institutional Review Ethics Committee of Nanjing Drum Tower Hospital approved the study design and waived the need for informed consent considering the retrospective nature of the study. Fifty-five dialysis-dependent end-stage renal failure patients who received CABG at our center between the years of 2014 and 2022 were identified and retrospectively included in this study. These patients accounted for 1.2% of all patients who received CABG during this period. 55 non-dialysis patients who received the CABG at the same period were enrolled in this study as controls after matching for baseline parameters such as age, sex, cause, and operation date. Patients who received isolated CABG or other concomitant cardiac surgeries (valve repair or replacement, aorta, and MAZE) were included except for those who received acute type A aortic dissection surgical repair. Dialysis dependency was defined as receiving continuous dialysis for at least one month before surgery. Patients with chronic renal failure or chronic renal insufficiency but who did not receive continuous dialysis were excluded from the analysis. Non-dialysis patients who required dialysis after the surgery were also excluded. Most of the dialysis patients received hemodialysis 1 day before surgery and hemofiltration during cardiopulmonary bypass surgery and after intensive care unit admission.

The medical records and the results of laboratory investigations of patients admitted to the Nanjing Drum Tower Hospital were reviewed. Preoperative cardiac disease history, known risk factors for CAD, and angiographic data were collected. The emergent operation was defined as non-selective surgery conducted within 24 h of the decision to proceed with CABG regardless of the patient's hemodynamic status. The occurrence of cardiac events including recurrent angina, myocardial infarction, percutaneous transluminal coronary angioplasty, reoperation, and cardiac death was documented. The grading of angina was determined according to the Canadian Cardiovascular Society and symptoms of congestive heart failure (CHF) were defined by the New York Heart Association (NYHA). A cerebrovascular event was defined as developing new clinically relevant central nervous system symptoms after completion of the surgery. Perioperative death was defined as any death occurring during the hospitalization period, from the day of surgery until discharge. Late death was defined as any death occurring after the patient had been discharged from the hospital.

Patient follow-up

Patient follow-up was conducted by a telephone survey and the cause, as well as date, were collected from patients' relatives if the patient was deceased at the time of the interview.

Statistical analysis

Statistical analyses were performed with SPSS software for Windows (Version 25, Armonk, NY, USA). Data were expressed as mean ± standard deviations. Normally distributed continuous variables were analyzed using Student's *t*-test, while categorical variables were analyzed with chi-square test or Fisher's exact probability test as appropriate. To exclude baseline confounders, a one-to-one propensity score matching was conducted between the two groups. Cumulative survival and freedom from cardiac events were calculated by the Kaplan-Meier method, and the differences were examined by the log-rank test. Univariate regression analysis and multivariate regression analysis were applied to identify potential risk factors for postoperative mortality. Variables with $p < 0.2$ in the univariate regression analysis were entered into the multivariate regression analysis. All tests were two-sided and considered statistically significant when the p-value was < 0.05.

Table 1 Characteristics of the renal disease

Variable	*n* (%)
Causes of chronic renal failure	
Diabetes mellitus (%)	21 (38.2)
Chronic glomerulonephritis (%)	18 (32.7)
Polycystic kidney (%)	3 (5.5)
Nephrosclerosis (%)	1 (1.8)
Unknown (%)	13 (23.6)
Type of dialysis	
Hemodialysis (%)	45 (81.8)
Peritoneal (%)	10 (18.2)
Duration of dialysis (years)	6.4 ± 4.2

Table 2 Comparison of preoperative variables

Variables	Dialysis (*n* = 55)	Control (*n* = 55)	*p*
Demographic data			
Age (year)	68.6 ± 9.4	69.5 ± 9.5	0.614
Male (%)	40 (72.7)	38 (69.1)	0.675
BMI (kg/m2)	24.2 ± 3.6	24.9 ± 4.1	0.378
Smoker (%)	35 (63.6)	37 (67.3)	0.688
Alcohol (%)	32 (58.2)	28 (50.9)	0.444
Medical history			
Hypertension (%)	48 (87.3)	47 (85.5)	0.781
Diabetes mellitus (%)	25 (45.5)	26 (47.1)	0.848
Cerebrovascular disease (%)	16 (29.1)	14 (25.5)	0.669
COPD (%)	19 (34.5)	23 (41.8)	0.432
Atrial fibrillation (%)	9 (16.4)	10 (18.2)	0.801
Preoperative laboratory data			
Haemoglobin (g/L)	104.5 ± 23.4	103.6 ± 23.3	0.851
Platelet (10^9/L)	172.0 ± 71.8	167.0 ± 74.0	0.719
Fibrinogen (g/L)	4.1 ± 1.2	4.1 ± 1.3	0.706
D-dimer (ng/mL)	2.9 ± 7.2	2.7 ± 7.0	0.922
Albumin (g/L)	36.2 ± 4.0	35.1 ± 4.2	0.113
NYHA classification ≥ III (%)	45 (81.8)	43 (78.2)	0.634
Ejection fraction (%)	44.1 ± 8.2	42.9 ± 7.2	0.411
CHF on admission (%)	30 (54.5)	31 (56.4)	0.848
Unstable angina (%)	44 (80.0)	42 (76.4)	0.644
Old myocardial infarction (%)	22 (40.0)	21 (38.2)	0.845
Three-vessel disease (%)	36 (65.5)	33 (60.0)	0.554
Left main trunk stenosis ≥ 50% (%)	20 (36.4)	25 (45.5)	0.332
Number of diseased vessels	2.9 ± 1.2	3.0 ± 1.1	0.776
Hypotension* (%)	24 (43.6)	25 (45.5)	0.848
IABP support (%)	11 (20.0)	10 (18.2)	0.808
Location of AV Access			
Ipsilateral to left IMA (%)	18 (32.7)	NA	NA
Contralateral to left IMA (%)	15 (27.3)	NA	NA

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; NYHA, New York Heart Association; CHF, congestive heart failure; IABP, intro-aortic balloon pumping; AVF, arteriovenous; IMA, internal mammary artery; NA, not applicable

*Refers to documented episodes of low blood pressure measured during the preoperative hospital stay

Table 3 Comparison of operative variables

Variables	Dialysis (*n* = 55)	Control (*n* = 55)	*p*
Emergent surgery (%)	16 (29.1)	18 (32.7)	0.680
On-pump CABG (%)	30 (54.5)	31 (56.4)	0.848
Aortic cross-clamp time (min)	110.2 ± 78.1	107.3 ± 75.3	0.876
CPB time (min)	160.3 ± 100.0	152.7 ± 95.1	0.746
Surgery time (min)	378.2 ± 101.5	375.5 ± 106.6	0.891
Concomitant surgery (%)	31 (56.4)	33 (60.0)	0.699
Aortic valve replacement (%)	7 (12.7)	5 (9.1)	0.541
Double valve replacement (%)	2 (3.6)	4 (7.3)	0.679
Mitral valve replacement (%)	11 (20.0)	12 (21.8)	0.815
Mitral annuloplasty (%)	9 (16.4)	9 (16.4)	1.000
Dor procedure (%)	2 (3.6)	3 (5.5)	1.000
SVG only (%)	3 (5.5)	4 (7.3)	1.000
Left IMA (%)	46 (83.6)	49 (89.1)	0.405
Bilateral IMA (%)	1 (1.8)	1 (1.8)	1.000

Abbreviations: CPB, cardiopulmonary bypass; IABP, intra-aortic balloon pumping; SVG, saphenous vein graft; IMA, internal mammary artery

Results

Baseline characteristics of dialysis patients who received CABG

The primary causes of renal failure in dialysis patients were diabetes mellitus which consisted of 38.2% of all patients and chronic glomerulonephritis which accounts for 32.7% of all patients. The remaining common causes included polycystic kidney and nephrosclerosis (Table 1). As shown in Table 2, of the dialysis patients, 72.7% were male. The mean age at the time of operation was 68.6±9.4 years (range, 45 to 87 years). The average time of patients who relied on hemodialysis was 6.4±4.2 years (range, 1 to 20 years). 44 dialysis patients (80%) had unstable angina and required heparin and nitrate infusion before surgery. 30 patients (54.5%) had symptoms of congestive cardiac failure and 45 patients (81.8%) were diagnosed as NYHA class III or IV. The mean left ventricular function of dialysis patients was 44.1±8.2% and 40% of patients had previously documented myocardial infarction. 30 patients accepted on-pump CABG with a mean cardiopulmonary bypass time of 160.3±100.0 min. In the dialysis group, 31 patients underwent concomitant surgeries, the details of which are presented in Table 3. Notably, the duration of surgery, cardiopulmonary bypass time, and aortic cross-clamp time significantly increased when concomitant surgeries were performed in the dialysis group (Table 4).

Short-term mortality and morbidity

As shown in Table 5, the mean time of intensive care unit stay was not significantly different between the dialysis group and the control group (12.5±14.4 days vs. 11.8±13.6 days). However, total hospital stay was significantly prolonged in the dialysis group compared with the control group (23.5±6.6 days vs. 20.9±5.6 days, p=0.029). In addition, our data showed that dialysis

Table 4 Comparison of operative variables regarding whether accompanied by concomitant surgery

Variables	Concomitant surgery (*n* = 31)	CABG only (*n* = 24)	*p*
Emergent surgery (%)	6 (19.4)	10 (41.7)	0.071
Aortic cross-clamp time (min)	131.1 ± 69.5	31.9 ± 54.8	< 0.001
CPB time (min)	191.4 ± 80.7	44.6 ± 76.8	< 0.001
Surgery time (min)	435.6 ± 90.3	297.9 ± 70.0	< 0.001
SVG only (%)	2 (6.5)	1 (4.2)	1.000
Left IMA (%)	25 (80.6)	21 (87.5)	0.716
Bilateral IMA (%)	0 (0)	1 (4.2)	0.436

Abbreviations: CPB, cardiopulmonary bypass; SVG, saphenous vein graft; IMA, internal mammary artery

Table 5 Comparison of postoperative variables

Variables	Dialysis (*n* = 55)	Control (*n* = 55)	*p*
Dopamine use (%)	38 (69.1)	27 (49.1)	0.033
Dobutamine use (%)	18 (32.7)	11 (20.0)	0.130
Epinephrine use (%)	8 (14.5)	4 (7.3)	0.221
Norepinephrine use (%)	23 (41.8)	15 (27.3)	0.109
Postoperative complications* (%)	51 (92.7)	34 (61.8)	< 0.001
Prolonged mechanical ventilation (%)	32 (58.2)	21 (38.2)	0.036
New onset arterial fibrillation (%)	17 (30.9)	14 (25.5)	0.525
Gastrointestinal complication (%)	3 (5.5)	2 (3.6)	1.000
Septicemia (%)	9 (16.4)	5 (9.1)	0.252
Pneumonia (%)	25 (45.5)	11 (20.0)	0.004
Reoperative for bleeding (%)	6 (10.9)	7 (12.7)	0.768
Transfusion requirement (%)	25 (45.5)	14 (25.5)	0.028
Cerebrovascular events (%)	8 (14.5)	5 (9.1)	0.376
Deep sternal wound infection (%)	5 (9.1)	3 (5.5)	0.716
IABP support (%)	18 (32.7)	9 (16.4)	0.046
ECMO support (%)	4 (7.3)	2 (3.6)	0.401
ICU Stay time (day)	12.5 ± 14.4	11.8 ± 13.6	0.771
Hospital stays time (day)	23.5 ± 6.6	20.9 ± 5.6	0.029
30-Day mortality (%)	9 (16.4)	6 (10.9)	0.405
In-hospital mortality (%)	10 (18.2)	7 (12.7)	0.429

Abbreviations: IABP, intra-aortic balloon pumping; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit

*Postoperative complications considered in this table include the following categories: prolonged mechanical ventilation, new onset arterial fibrillation, gastrointestinal complications, septicemia, pneumonia, reoperation for bleeding, transfusion requirements, cerebrovascular events, deep sternal wound infection, intra-aortic balloon pump support, and extracorporeal membrane oxygenation support

patients were associated with an increased chance of requiring prolonged mechanical ventilation (58.2% vs. 38.2%; p=0.036), increased occurrence of pneumonia (45.5% vs. 20.0%; p=0.004), and requirement of transfusion (45.5% vs. 25.5%; p=0.028) as well as intra-aortic balloon pumping support (32.7% vs. 16.4%; p=0.046) compared to the control group.

Table 6 Causes of death in the dialysis/control patients

Cause of Death	Perioperative Death	Late Death
Cardiac (n, dialysis/control)	5/4	8/3
Pulmonary (n, dialysis/control)	2/2	3/1
Sepsis (n, dialysis/control)	1/0	
Renal failure (n, dialysis/control)	1/0	1/0
Multisystem organ failure (n, dialysis/control)	1/1	1/0
Unknown (n, dialysis/control)		4/2

In-hospital mortality rates were 18.2% (10 of 55) in the dialysis group and 12.7% (7 of 55) in the control group. Even though a trend was noticed, the difference was not statistical significance. In the dialysis group, 5 patients died of cardiac causes, 2 of respiratory failure, 1 of sepsis, 1 of renal failure, and 1 of multisystem organ failure. While in the control group, 4 patients died of cardiac problems, 2 of respiratory failure, and 1 of multisystem organ failure (Table 6).

Long-term follow-up

The mean follow-up time of all patients was 35 months (range, 6 to 88 months) and only 4 patients were lost to follow-up. A total of 23 deaths were identified during long-term follow-up with 17 in the dialysis group and 6 in the non-dialysis group. In the dialysis group, the causes of late death included cardiac events (8 patients), pulmonary failure (3 patients), renal failure (1 patient), and multisystem organ failure (1 patient) (Table 6).

The Kaplan-Meier curves showed that the 3-year and 5-year survival rates were significantly decreased in the dialysis group compared to the control group (56.1±7.2% vs. 75.4±7.0% and 46.2±7.9% vs. 58.2±12.1%, respectively, p=0.045) (Fig. 1). In addition, dialysis patients were also associated with decreased cardiac event-free rates compared to the control group at both 3- and 5-year periods (52.1±7.5% vs. 68.5±7.9% and 31.6±7.6% vs. 58.8±11.3%, respectively, p=0.041) (Fig. 2a). However, the occurrence of late cerebrovascular events was not significantly different between the two groups (p=0.101) (Fig. 2b).

Next, we stratified these dialysis patients based on whether they had baseline diabetes and noticed that the 5-year survival rate was significantly decreased among patients with concomitant diabetes compared to those without concomitant diabetes (57.6±11.0% vs. 18.6±8.3%, p=0.043) (Fig. 3a). Similar result was identified with patients had smoking histories. Kaplan-Meier survival curve showed that the 5-year survival was significantly decreased in smokers compared to non-smokers among dialysis patients who received CABG (21.7±10.5% vs. 43.5±10.4%, p=0.006) (Fig. 3b). In addition, baseline presence of CHF was another risk factor

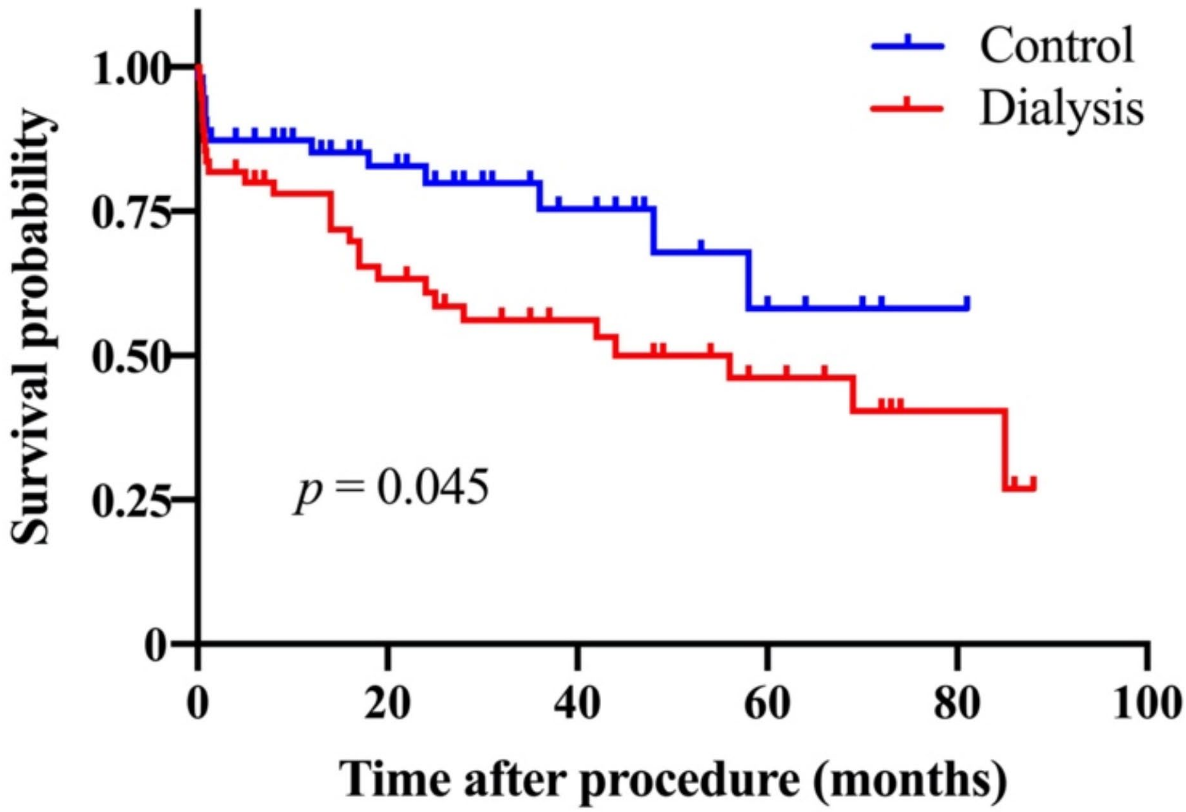

Fig. 1 Overall survival between dialysis patients and control patients

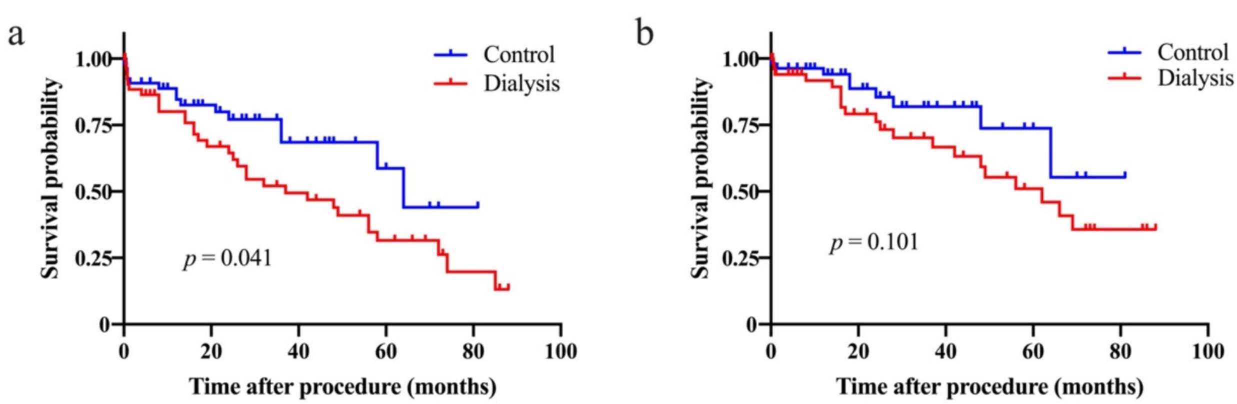

Fig. 2 Cardiac-event-free survival (**a**) and cerebrovascular-event-free survival (**b**) between dialysis patients and control patients

that associated with decreased long-term survival rate ($p=0.017$) (Fig. 3c). As shown in Table 7, multivariate regression analysis revealed that concomitant diabetes (OR=4.273; $p=0.010$), smoking history (OR=5.159; $p=0.004$), CHF on admission (OR=1.272; $p=0.047$), and concomitant heart surgery during the surgery (OR=4.386; $p=0.003$) were risk factors for postoperative mortality.

Unsurprisingly, dialysis patients who received concomitant heart surgery beside CABG had worse 3-and 5-year survival rates compared to those who received isolated CABG (36.9±9.9% vs. 78.2±8.7% and 11.1±9.3% vs. 66.6±10.6% respectively, $p=0.003$) (Fig. 4a). Similarly, patients who received concomitant heart surgery were also associated with decreased 3-and 5-year cardiac-event free rates (30.7±10.0% vs. 75.8±9.5% and

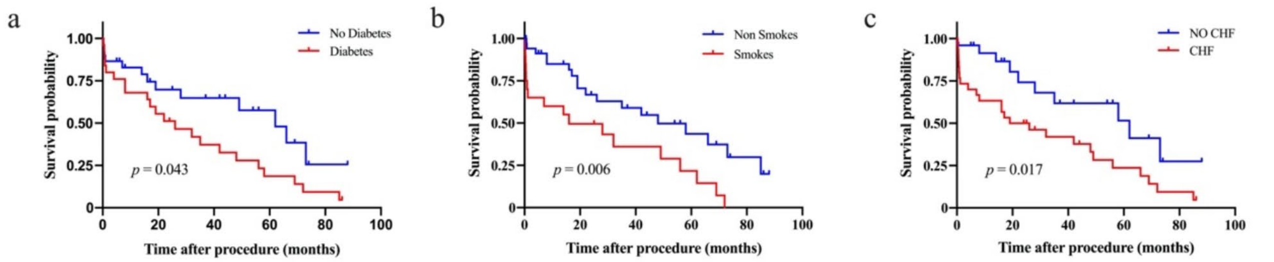

Fig. 3 Comparison of late survival of diabetes versus no diabetes (**a**), smokers versus non-smokers (**b**), and CHF upon admission patients versus non-CHF patients (**c**) in dialysis patients. CHF, congestive heart failure

Table 7 Multivariate regression analysis for postoperative mortality

Variables	OR	95% CI	*p*
Age	0.256	0.880–1.035	0.954
BMI	0.884	0.703–1.111	0.290
Diabetes mellitus	4.273	0.759–24.060	0.010
Smoker	5.159	0.973–27.350	0.004
CHF on admission	1.272	0.281–5.754	0.047
Concomitant surgery	4.386	0.981–19.601	0.003

CHF, congestive heart failure

20.5±10.7% vs. 45.5±11.1%, respectively, $p=0.014$) (Fig. 4b). In addition, dialysis patients who received concomitant heart surgery were associated with decreased 3- and 5-year cerebrovascular-event free rates (51.0±12.0% vs. 88.9±7.4% and 34.0±16.0% vs. 65.2±11.5%, respectively ($p=0.016$) (Fig. 4c).

Discussion

This case-control study evaluated the prognosis of patients with or without preoperative dialysis dependency and who received CABG treatment. We found that patients with preoperative dialysis dependency had worse short-term and long-term outcomes after receiving CABG compared to non-dialysis patients. We also noticed that late cardiac events were more likely to occur in dialysis patients with only 31.6% of them did not develop any events at 5 years. It is worth noticing that more than half of the late deaths were associated with cardiac events. This result indicates that close follow-up surveillance is needed for dialysis patients who have undergone CABG. Furthermore, our data showed that a history of smoking, co-existing diabetes, CHF on admission, and concomitant surgery might be risk factors for decreased long-term mortality in dialysis patients who received cardiac surgery.

The number of dialysis dependence patients is increasing rapidly and it has been estimated that it will be doubled to approximately 5.4 million by the year 2030 [10] with diabetic nephropathy being a major culprit [11]. Compared to the general patient population, dialysis patients only consisted of a small portion (0.8-5%) of those who accepted CABG but it is most likely to increase due to the increasing prevalence of dialysis [12]. Our study showed that 1.2% of patients undergoing CABG had preoperative dialysis dependence. Almost 40% of ESRD patients died of cardiogenic causes such as acute coronary syndrome or heart failure.

The preferred treatment of revascularization for patients had CAD and complicated with ESRD has not been well established by global society [13–18]. The advance of drug-eluting stents had made percutaneous coronary intervention (PCI) more reliable and dramatically reduced restenosis rate and improved clinical outcomes [19]. Meanwhile, the relative benefit of CABG is compromised by the occurrence of surgical complications. In this study, even though not statistically significant, the postoperative mortality of dialysis patients

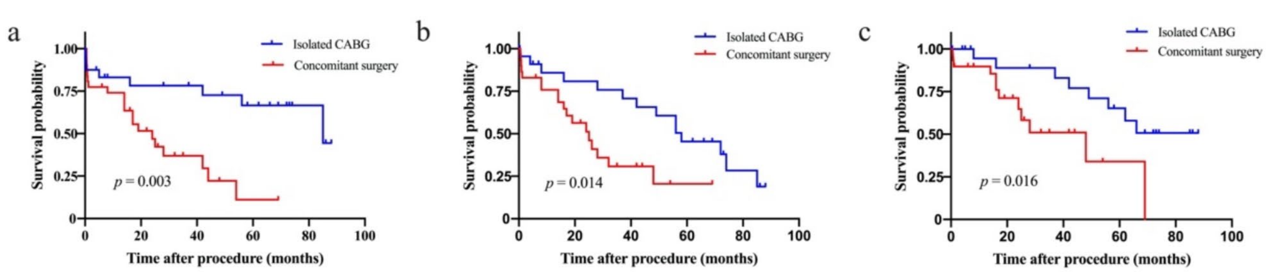

Fig. 4 The overall survival rate (**a**), the postoperative major adverse cardiovascular (**b**), and the cerebrovascular (**c**) event-free rate from surgical procedure in dialysis patients

seemed higher compared to the general population. This may be due to the complicated nature of their diseases or the occurrence of early graft occlusion. An alternative treatment for this group of patients is a PCI whose efficacy and safety should be evaluated in future studies to determine the optimal option.

Our study indicated that the postoperative mortality was 16.4% among patients in the dialysis group which was comparable to two previous studies [15, 20] but higher than some other studies [8]. Literature have suggested that the overall 5-year survival rates of dialysis patients who received CABG were 35.4-63.7%, and the cardiac-event-free rates at 5 years after CABG were 46.6-51.7% [9, 21, 22]. Both incidences were higher than the results we observed in this study. Notably, the elevated mortality and morbidity rates in the control group in our study can be attributed to the strict matching of preoperative and intraoperative variables between the dialysis and control groups, resulting in a cohort with more severe conditions.

Preoperative intro-aortic balloon pumping assistance, concomitant surgery, and presentation of NYHA congestive heart failure at baseline were identified as risk factors for early death in previous studies [9]. Unfortunately, a relatively large portion of patients enrolled in this study had the above characteristics and might contribute to the elevated mortality and morbidity rates.

Our study concluded that concomitant surgery is another risk factor for mortality and development of cardiac as well cerebrovascular adverse events in dialysis patients after receiving CABG. Yamamura et al. [23] reported that the hospital mortality rate for CAD patients who received concomitant surgery was 33.3% and the 1-year survival rate of patients who accepted concomitant surgery was significantly lower than those who received isolated CABG (21% versus 92%, $p < 0.001$). However, another study showed that the long-term prognosis of patients who received isolated CABG without concomitant surgery even though indicated was depressing [9]. This highlights the need for careful consideration when choosing the treatment strategy for complex cases. Earlier CABG or valve replacement/repair may be beneficial before other conditions worsen, thereby avoiding the need for concomitant surgery in ESRD patients requiring dialysis. Further head-to-head studies are warranted to determine the optimal treatment approach for this patient population.

Our data showed that 92.7% of the dialysis patients experienced complications compared with 61.8% in the control group. This difference indicates that the surgical techniques for dialysis patients need to be refined and improved to decrease the occurrence of complications. Despite aggressive dialysis being conducted to remove extra fluid on the first postoperative day to reduce the hemodynamic pressure, our data showed that dialysis patients still had prolonged ventilator time.

14.5% of dialysis patients developed cerebrovascular accidents compared to the 9.1% of the control group. It has been known that cerebrovascular accident is a leading cause of death in dialysis patients, after cardiovascular disease and sepsis [24]. It is unclear whether the cerebrovascular events in these patients were induced by embolism or carotid vascular obstructive disease. We hypothesized that more liberal use of aortic ultrasound examination before cross-clamping and routine non-invasive carotid artery screen before operation might help to reduce the occurrence of cerebrovascular events in such patients.

In conclusion, the decision to perform CABG in dialysis patients is complex and should be carefully considered on a case-by-case basis. While many patients may benefit from this treatment, others may not. These conflicting results emphasize the need for a multidisciplinary approach, including medication management and dialysis oversight, in the treatment of severe CAD in dialysis-dependent patients.

There are some limitations of the study. Firstly, the sample size was relatively small and conducted in a single center with a retrospective nature that might not be representative to the general population. Secondly, despite the rigorous use of the case-control strategy in this study, some unknown baseline confounders might be neglected and affect the results. Thirdly, the follow-up was conducted through telephone surveys rather than in-person clinic visits. While telephone interviews provide valuable data, they cannot fully replace in-person visits, as physical examination findings are essential for comprehensive follow-up assessments. Additionally, the result of this report should be interpreted with caution due to the limited follow-up period and incomplete demographic data from some patients. Prospective studies with large sample sizes are needed to better confirm these findings in the future.

Conclusions

In conclusion, this study highlights that dialysis-dependent patients experience significantly worse long-term outcomes following CABG compared to non-dialysis patients. Furthermore, among dialysis patients, those with a history of smoking, coexisting diabetes, CHF at the time of admission, and those receiving concomitant surgery were identified as being at increased risk of mortality.

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Author contributions
XYB, JXY, and JFX designed the study; CC, YMW, and XFC collected the data; CC, JFX, and LFZ analyzed the data; JFX and XYB analyzed and interpreted the results; XYB support and encourage the study; JFX and CC wrote this article; All the authors have read and reviewed this manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The study protocol was approved by the ethics committee at Nanjing Drum Tower Hospital, and all experimental methods were performed in accordance with the relevant guidelines and regulations.

Consent for publication
Consent was obtained from the patients or their relatives.

Competing interests
The authors declare no competing interests.

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