Late outcomes of endovascular aortic stent graft therapy in patients with chronic kidney disease

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Abstract

Endovascular aneurysm repair (EVAR) and thoracic endovascular aortic repair (TEVAR) are effective and minimally invasive treatment options for high-risk surgical candidates. Nevertheless, knowledge about the management of aortic stent graft therapy in chronic kidney disease (CKD) is scarce. This study aimed to examine outcomes after EVAR and TEVAR in patients with CKD.

Utilizing data from the Taiwan National Health Insurance Research Database, we retrospectively assessed patients who underwent EVAR and TEVAR therapy between January 1, 2006, and December 31, 2013. Patients were divided into CKD and non-CKD groups. Outcomes were in-hospital mortality, all-cause mortality, readmission, heart failure, and major adverse cardiac and cerebrovascular events.

There were 1019 patients in either group after matching. The CKD group had a higher in-hospital mortality rate than the non-CKD group (15.2% vs 8.3%, respectively; odds ratio, 1.92; 95% confidence interval [CI], 1.46–2.54). Patients with CKD had higher risks of all-cause mortality including in-hospital death (46.1% vs 33.1%; hazard ratio [HR], 1.61; 95% CI, 1.35–1.92), readmission rate (62.6% vs 55.0%; subdistribution HR [SHR], 1.61; 95% CI, 1.32–1.69), redo stent (7.8% vs 6.2%; SHR, 1.50; 95% CI, 1.09–2.07), and major adverse cardiac and cerebrovascular events (13.3% vs 8.8%; SHR, 1.50; 95% CI, 1.15–1.95). The subgroup analysis did not demonstrate a variation in mortality between the TEVAR and EVAR cohorts (P for interaction = .725). The dialysis group had higher risks of all-cause mortality and readmission than the CKD without dialysis and non-CKD groups.

Among EVAR/TEVAR recipients, CKD was independently associated with higher in-hospital mortality, postoperative complication, and all-cause mortality rates. Patients with end-stage renal disease on dialysis had worse outcomes than those in the CKD non-dialysis and non-CKD groups.

Abbreviations: AAA = abdominal aortic aneurysm, CCI = Charlson Comorbidity index, CI = confidence interval, CKD = chronic kidney disease, ESRD = end-stage renal disease, EVAR = endovascular aneurysm repair, HR = hazard ratio, ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification, MACCE = major adverse cardiac and cerebrovascular event, NHI = National Health Insurance, NHIRD = National Health Insurance Research Database, PSM = propensity score matching, SHR = subdistribution hazard ratio, STD = standardized difference, TEVAR = thoracic endovascular aortic repair.

Keywords: chronic kidney disease, endovascular, stent

1. Introduction

Over the last few decades, endovascular aneurysm repair (EVAR) and thoracic endovascular aortic repair (TEVAR) have become extensively accepted over open repair as standard treatment approaches to treating various aortic pathologies, due to their markedly lower invasiveness and innovations in relevant treatment devices.[1–5] Although long-term outcomes remain unclear compared with open repair in the general population, multiple randomized controlled trials have reported that EVAR and TEVAR were associated with lower perioperative morbidity and mortality rates[6–8]; accordingly, patients with complex comorbidities who are considered to be at "high risk" for open surgery could benefit from EVAR and TEVAR.[9–11]

Patients with chronic kidney disease (CKD) are at increased risk of cardiovascular morbidity and mortality[12] and are susceptible to perioperative adverse events.[13] Studies have shown that patients with CKD who underwent open aortic repair exhibited poorer outcomes than other patients. According to the study conducted by Aranson et al,[14] —which included more than 47,000 patients and is by far the most extensive study examining CKD severity survival and postoperative complications after elective abdominal aortic aneurysm (AAA) repair (open and endovascular approach)—CKD caused a 5-fold increase in 30-day mortality. For thoracic aortic disease, Marrocco-Trischitta et al[15] showed that glomerular filtration rate is an accurate prognostic predictor in patients submitted to TEVAR. However, how CKD influences the long-term outcomes of EVAR and TEVAR has yet to be clarified.

Taiwan has the highest incidence and prevalence of end-stage renal disease (ESRD) in the world.[16] Following the launch of the National Health Insurance (NHI) program in 1995, long-term dialysis therapy has been provided free of charge without co-payment. Moreover, the NHI program provides coverage for various innovative treatment modalities, including EVAR and TEVAR, if patients meet relevant indications.

We believe that by investigating NHI data, we can estimate the real-world and long-term consequences of aortic stent graft therapy in patients with CKD. Therefore, this national cohort study aimed to analyze the effect of preoperative CKD on short- and long-term mortality risks and adverse outcomes after EVAR/TEVAR.

2. Materials and methods

2.1. Data source

This national population-based cohort study used the data of the Taiwan National Health Insurance Research Database (NHIRD). The NHIRD includes claims data acquired from the government-operated single-payer NHI program, which started in 1995 and covers nearly all (>99.5%) of the 23 million inhabitants of Taiwan.[17] A considerable number of published articles have used NHIRD data.[11,18,19] Disease diagnoses are based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). The Chang Gung Memorial Hospital Ethics Review Committee evaluated and approved this study.

2.2. Patient selection

We extracted the medical claims data of inpatients admitted to NHI-contracted hospitals for EVAR and TEVAR from the NHIRD. Patients with an ICD-9 primary diagnosis code of aortic disease including aortic dissection (441.0), traumatic aortic injury (901.0 or 901.2), or aortic aneurysm (441.xx) with ICD-9 procedure codes for TEVAR (39.73 or 39.79) or EVAR (39.71) between January 1, 2006 and December 31, 2013 were identified. If 1 patient had multiple events, we chose the first event as the index admission. Exclusion criteria included age younger than 20 years, history of endovascular aortic stent surgery, and had concurrent cardiac surgery (any cardiac surgery that required cardiopulmonary bypass or off-pump coronary artery bypass grafting) during the index admission. Finally, 4132 patients treated with EVAR or TEVAR were included in this study. Next, according to the diagnosis of CKD (ICD-9-CM codes 585.1–585.6), the patients were separated into the CKD and the non-CKD groups (Fig. 1). To further analyze the effect of CKD severity on outcomes, we identified ESRD patient by utilizing the Registry for Catastrophic Illness Patient Database.

2.3. Covariates and outcomes

Covariates were age, sex, surgical details (aortic pathology, emergent surgery, stent location), comorbidities, hospital level, hospital volume of aortic stent, and surgical year. We utilized the ICD-9-CM diagnostic or procedure codes and the Taiwan NHI reimbursement codes to obtain the patients' baseline characteristics and surgical details based on the inpatient claims data. Comorbidities and Charlson comorbidity index (CCI) score were detected using previous inpatient diagnoses, which can be tracked back to 1997. The disease codes are provided in Supplementary Table 1, http://links.lww.com/MD/E850.

The study outcomes included in-hospital and late outcomes detected by ICD-9-CM diagnostic or Taiwan NHI reimbursement codes. Details of the ICD-9-CM diagnostic codes are shown in Supplementary Table 1, http://links.lww.com/MD/E850. Late outcomes were all-cause mortality, readmission due to any cause, redo stent surgery, and major adverse cardiac and cerebrovascular events (MACCE). MACCE included myocardial infarction, heart failure, or stroke. Mortality was identified as withdrawal from the NHI program.[20] Cases of redo stent surgery were inferred by Taiwan NHI reimbursement codes. The occurrence of acute myocardial infarction, heart failure admission, or stroke was defined as the principal diagnosis of admission, as these diagnostic codes have been validated in previous NHIRD studies.[21–24]

Each patient was followed until death or December 31, 2013, whichever came first.

2.4. Statistical analysis

There were substantial differences in the patients' characteristics between the CKD and non-CKD groups, which could have biased the results. Therefore, a propensity score matching (PSM) method was employed to reduce selection bias. The propensity score was the predicted probability of a patient being in the CKD group given values of covariates using the logistic regression. The variables selected to calculate propensity score are listed in Table 1, in which the follow-up year is replaced with the index date (Table 1). The CCI total score was also not included because CKD is an element of the CCI score in which moderate to severe CKD is assigned 2 points. Each patient in the CKD group was matched with a corresponding patient in the non-CKD group. The matching was processed using a greedy nearest-neighbor
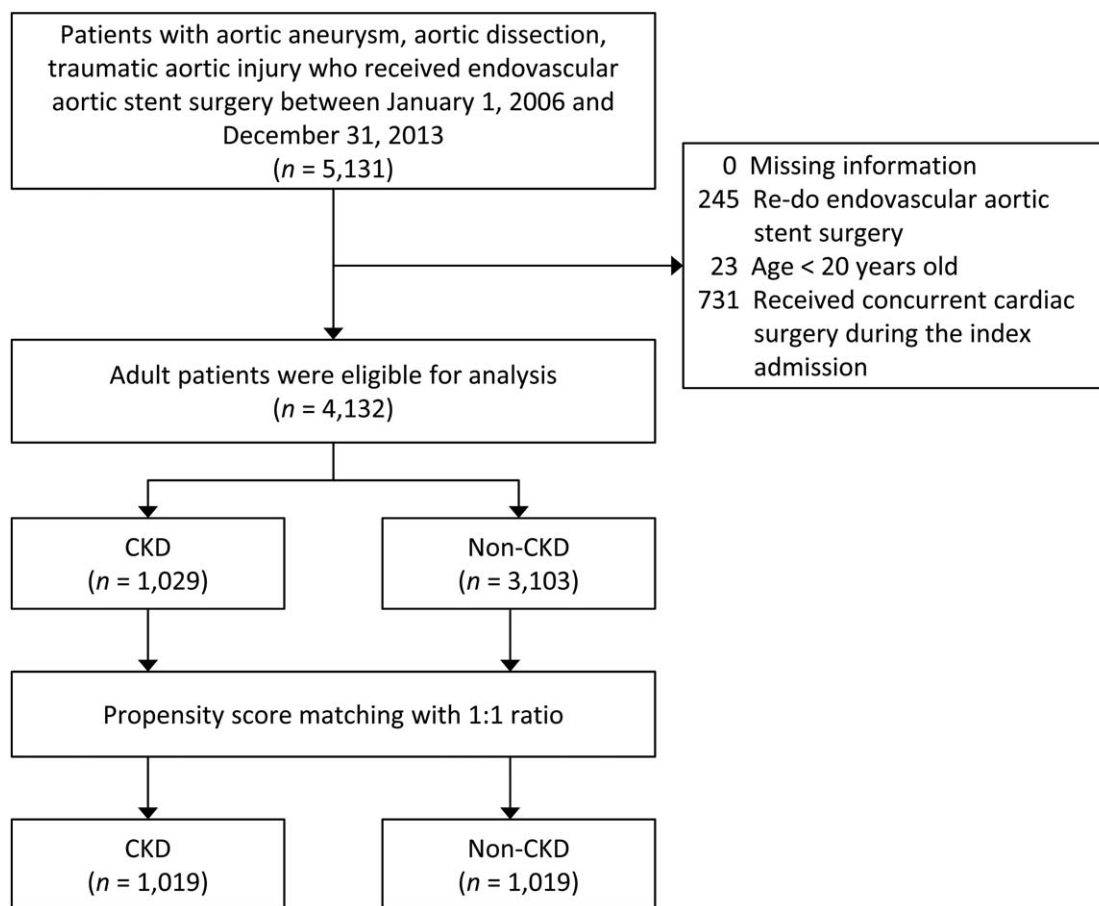
Figure 1. Patient selection.

algorithm with a caliper of 0.2 times of the standard deviation of the logit of the propensity score, with random matching order and without replacement. The matching quality was checked using the absolute value of the standardized difference (STD) between the groups, where a value of less than 0.1 was considered negligible.

In-hospital categorical outcomes between groups were compared by conditional logistic regression analysis in which the matching pairs were stratified to account for the outcome dependency within the same matching pair. In-hospital continuous outcomes between groups were compared using the Wilcoxon signed-rank test, in which 2 patients within the same matching pair were considered correlated. Regarding time to event outcomes, the mortality rates between groups were compared by a Cox proportional hazard model. The incidences of non-fatal outcomes between groups were compared using the Fine and Gray subdistribution hazard model, which considered death as a competing risk. Matching pairs were also stratified in the survival analyses. Study group (CKD vs non-CKD) was the only explanatory variable. In a further subgroup analysis comparing the effects of renal function (non-CKD, CKD without dialysis, CKD with dialysis) on late outcomes, we performed the aforementioned survival analyses with multivariate adjustment containing the same variables as the propensity score.

To investigate the risk factors of in-hospital death in the CKD group, univariate analyses (t-test or Chi-square test) were

performed; those variables with values of $P < .2$ in the univariate analysis were introduced into the multivariable logistic regression analysis with backward selection. A 2-sided P-value $< .05$ was considered to be statistically significant; no adjustment of multiple testing (multiplicity) was made in this study. All statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC), including the procedures of "psmatch" for propensity score matching, "phreg" for survival analysis, and the macro of "%cif" for generating cumulative incidence function under the Fine and Gray subdistribution hazard method.

3. Results

3.1. Patient characteristics

Table 1 lists the patients' baseline characteristics. Before matching, CKD patients were older; had more incidents of ruptured aortic aneurysm but fewer traumatic aortic injuries for aortic pathology; had more emergent surgeries; underwent more EVAR; had a higher prevalence of diabetes, hypertension, heart failure, coronary artery disease, stroke, and myocardial infarction; had higher CCI total scores; and had shorter follow-up duration (absolute STD >0.1). After matching, the group difference in characteristics was negligible with all absolute values of STD <0.1 except for CCI total score and follow-up duration. Higher CCI score is likely related to the presence of

Table 1

Baseline characteristics of patients who received aortic stent surgery by the status of renal function before and after propensity score matching.

Variables	Before matching			After matching		
	CKD (n = 1029)	Non-CKD (n = 3103)	STD	CKD (n = 1019)	Non-CKD (n = 1019)	STD
Age (yr)	74.7 ± 10.7	71.4 ± 13.6	0.27	74.7 ± 10.8	75.3 ± 10.1	−0.05
Age ≥65 yr	870 (84.5)	2289 (73.8)	0.27	861 (84.5)	882 (86.6)	−0.06
Male	860 (83.6)	2630 (84.8)	−0.03	853 (83.7)	836 (82.0)	0.04
Aortic pathology						
Un-ruptured aortic aneurysm	575 (55.9)	1690 (54.5)	0.03	574 (56.3)	593 (58.2)	−0.04
Ruptured aortic aneurysm	180 (17.5)	371 (12.0)	0.16	173 (17.0)	162 (15.9)	0.03
Aortic dissection	225 (21.9)	769 (24.8)	−0.07	223 (21.9)	217 (21.3)	0.01
Traumatic aortic injury	6 (0.6)	129 (4.2)	−0.24	6 (0.6)	6 (0.6)	<0.01
Unknown	43 (4.2)	144 (4.6)	−0.02	43 (4.2)	41 (4.0)	0.01
Emergent surgery	499 (48.5)	1344 (43.3)	0.10	490 (48.1)	467 (45.8)	0.05
Stent location						
TEVAR	480 (46.6)	1616 (52.1)	−0.11	473 (46.4)	468 (45.9)	0.01
EVAR	549 (53.4)	1487 (47.9)	0.11	546 (53.6)	551 (54.1)	−0.01
Comorbidity						
Dialysis	126 (12.2)	–	NA	125 (12.3)	–	NA
Diabetes mellitus	303 (29.4)	553 (17.8)	0.28	293 (28.8)	284 (27.9)	0.02
Hypertension	888 (86.3)	2392 (77.1)	0.24	878 (86.2)	879 (86.3)	<0.01
Heart failure	147 (14.3)	257 (8.3)	0.19	141 (13.8)	133 (13.1)	0.02
Atrial fibrillation	62 (6.0)	179 (5.8)	0.01	62 (6.1)	68 (6.7)	−0.02
Coronary artery disease	461 (44.8)	1119 (36.1)	0.18	455 (44.7)	441 (43.3)	0.03
Prior stroke	235 (22.8)	502 (16.2)	0.17	229 (22.5)	230 (22.6)	<0.01
Prior myocardial infarction	135 (13.1)	270 (8.7)	0.14	130 (12.8)	123 (12.1)	0.02
Peripheral arterial disease	151 (14.7)	391 (12.6)	0.06	149 (14.6)	148 (14.5)	<0.01
Chronic obstructive pulmonary disease	207 (20.1)	568 (18.3)	0.05	204 (20.0)	199 (19.5)	0.01
Malignancy	131 (12.7)	375 (12.1)	0.02	130 (12.8)	148 (14.5)	−0.05
CCI total score[*]	4.4 ± 2.2	2.5 ± 1.8	0.96	4.4 ± 2.1	2.8 ± 1.8	0.80
Hospital level						
Regional/district hospital	190 (18.5)	556 (17.9)	0.01	189 (18.5)	180 (17.7)	0.02
Teaching hospital (medical center)	839 (81.5)	2547 (82.1)	−0.01	830 (81.5)	839 (82.3)	−0.02
Hospital volume of aortic stent						
1st quartile (1–128)	277 (26.9)	775 (25.0)	0.04	274 (26.9)	264 (25.9)	0.02
2nd quartile (136–204)	237 (23.0)	681 (21.9)	0.03	236 (23.2)	241 (23.7)	−0.01
3rd quartile (227–413)	233 (22.6)	706 (22.8)	<0.01	230 (22.6)	241 (23.7)	−0.03
4th quartile (591–960)	282 (27.4)	941 (30.3)	−0.06	279 (27.4)	273 (26.8)	0.01
Surgery year						
2006–2008	105 (10.2)	342 (11.0)	−0.03	104 (10.2)	115 (11.3)	−0.03
2009–2011	412 (40.0)	1269 (40.9)	−0.02	411 (40.3)	405 (39.7)	0.01
2012–2013	512 (49.8)	1492 (48.1)	0.03	504 (49.5)	499 (49.0)	0.01
Propensity score	0.284 ± 0.092	0.238 ± 0.091	0.50	0.285 ± 0.096	0.285 ± 0.096	<0.01
Follow-up year[*]	1.4 ± 1.5	1.9 ± 1.7	−0.30	1.4 ± 1.5	1.7 ± 1.7	−0.21

Data were expressed as mean ± SD or n (%).

CCI = Charlson Comorbidity Index, CKD = chronic kidney disease, EVAR = endovascular aortic repair, NA = not applicable, STD = standardized difference, TEVAR = endovascular thoracic aortic repair.

[*] Not included in the calculation of propensity score.

CKD, and shorter follow up duration is likely related to the higher mortality rate in the CKD group.

3.2. Perioperative complications and outcomes

The CKD group had a higher in-hospital mortality rate than did the non-CKD group (15.2% vs 8.3%; odds ratio 1.92, 95% confidence interval [CI] 1.46–2.54) (Table 2). Preoperative CKD was also associated with higher risks of prolonged ventilation, postoperative infection, de novo dialysis, and any blood transfusion. Patients with CKD had more transfusion amount, longer intensive care unit stay, longer hospital stay, and more in-hospital cost (Table 2).

We further compared the baseline characteristic between patients who survived or died during the admission in the CKD group (Supplementary Table 2, http://links.lww.com/MD/E851). Figure 2 identified that older age, emergent surgery, ruptured aortic aneurysm, and aortic dissection were associated with higher risks of in-hospital mortality in the CKD group.

Figure 3 depicts the trend of aortic stent volume, prevalence of CKD, and in-hospital mortality rate of CKD patients. There was an inclination of expanding aortic stent quantity, increasing prevalence of CKD, and decreasing in-hospital mortality rate in the CKD patients, though not statistically significant.

The results showed that patients with CKD had higher risks of all-cause mortality including in-hospital death (46.1% vs 33.1%;

Table 2

In-hospital outcome of patients in the CKD and non-CKD groups after propensity score matching.

Outcome	CKD (*n*=1 019)	Non-CKD (*n*=1 019)	CKD versus Non-CKD	
			OR (95% CI)	*P* value
Categorical outcome	n (%)	n (%)		
In-hospital mortality	155 (15.2)	85 (8.3)	1.92 (1.46, 2.54)	<.001
Prolonged ventilation (≥7 d)	179 (17.6)	94 (9.2)	2.15 (1.63, 2.83)	<.001
Postoperative infection	104 (10.2)	54 (5.3)	2.04 (1.45, 2.88)	<.001
New onset stroke	34 (3.3)	31 (3.0)	1.10 (0.67, 1.78)	.710
de novo dialysis	220 (21.6)	34 (3.3)	8.75 (5.74, 13.35)	<.001
Acute myocardial infarction	18 (1.8)	8 (0.8)	2.25 (0.98, 5.18)	.056
Ischemic leg needed amputation or fasciotomy	5 (0.5)	3 (0.3)	1.67 (0.40, 6.97)	.484
Any blood transfusion	779 (76.4)	613 (60.2)	2.12 (1.75, 2.58)	<.001
Continuous outcome	Median [Q1, Q3]	Median [Q1, Q3]	Wilcoxon signed-rank test	
Packed red blood cell (U)	2.0 [0.5, 6.0]	1.0 [0.0, 3.0]	–	<.001
Fresh frozen plasma (U)	0.0 [0.0, 2.0]	0.0 [0.0, 1.0]	–	<.001
Platelet (U)	0.0 [0.0, 3.0]	0.0 [0.0, 0.0]	–	<.001
ICU duration (days)	2.0 [1.0, 7.0]	2.0 [1.0, 4.0]	–	<.001
Hospital stays (d)	15.0 [9.0, 28.0]	13.0 [8.0, 21.0]	–	<.001
In-hospital cost (NTD $\times 10^4$)	66.5 [56.7, 84.7]	62.3 [55.1, 74.8]	–	<.001

CI=confidence interval, CKD=chronic kidney disease, ICU=intensive care unit, NTD=New Taiwan Dollar, OR=odds ratio.

hazard ratio [HR] 1.61, 95% CI 1.35–1.92), readmission rate (62.6% vs 55.0%; subdistribution HR [SHR] 1.61, 95% CI 1.32–1.69), redo stent (7.8% vs 6.2%; SHR 1.50, 95% CI 1.09–2.07) and MACCE (13.3% vs 8.8%; SHR 1.50, 95% CI 1.15–1.95) (Fig. 4A–D). After excluding patients who died during the admission, CKD was still associated with poor survival (36.5% vs 27.0%; SHR 1.47, 95% CI 1.16–1.86) (Supplement Table 3, http://links.lww.com/MD/E852).

The CKD group owned significant higher all-cause mortality than non-CKD group (46.1% vs 33.1%; p < 0.001). Preoperative CKD was also associated with higher mortality after discharge (36.5% vs 27.0%; *P*=.002), cardiovascular death (18.1% vs 12.1%; *P*=.009), readmission (62.6% vs 55.0%; *P* <.001), redo aortic surgery (8.1 vs 5.8; *P*=.002), redo stent (7.8 vs 6.2; *P*=.014), and MACCE (13.3% vs 8.8%; *P*=.003). A pre-defined subgroup analysis of all-cause mortality between stent locations

is presented in Supplementary Table 4, http://links.lww.com/MD/E853. The result did not demonstrate a variation in confronting mortality between the TEVAR and EVAR cohorts (*P* for interaction=.725).

We further compared the outcomes (all-cause mortality including in-hospital death, readmission, redo stent and MACCE) among the 3 groups by renal function (non-CKD, CKD without dialysis, dialysis). The dialysis group had higher risks of all-cause mortality and readmission than the CKD without dialysis group than the non-CKD group (Supplementary Fig. 1A and B, http://links.lww.com/MD/E849). The dialysis group had comparable risks of redo stent with the other 2 groups (Supplementary Fig. 1C, http://links.lww.com/MD/E849). Finally, the dialysis group also had higher risks of redo stent with the other 2 groups (Supplementary Fig. 1D, http://links.lww.com/MD/E849)
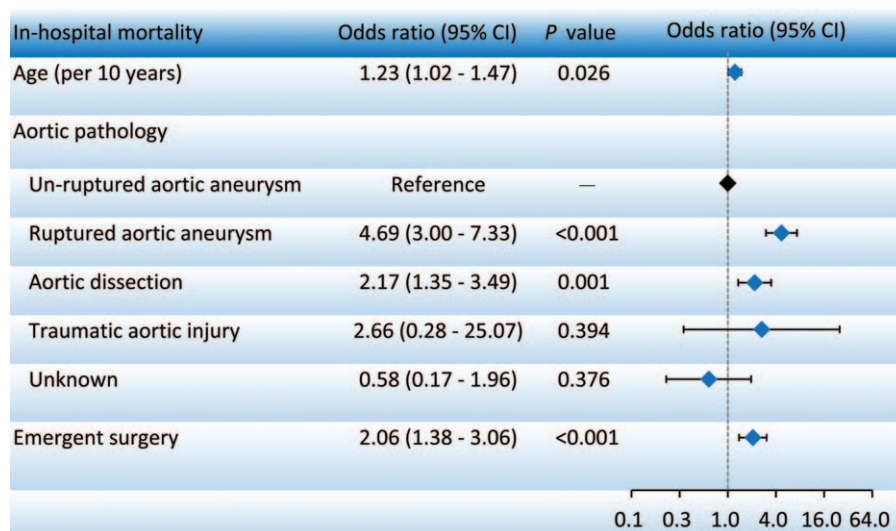

Figure 2. Risk factor analysis of in-hospital deaths among patients with chronic kidney disease.
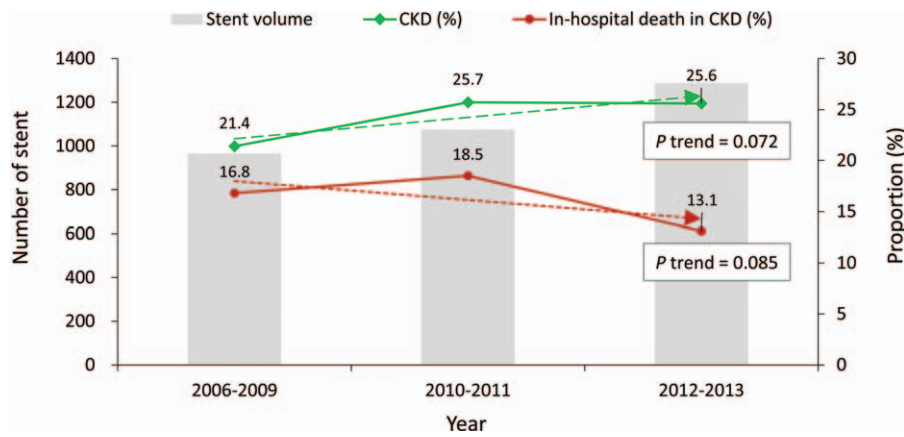
Figure 3. The trends of aortic stent volume, prevalence of CKD, and in-hospital mortality rate of CKD patients. CKD=chronic kidney disease.

4. Discussion

CKD increases cardiovascular risk and prompts critical clinical difficulty in patients requiring EVAR and TEVAR. Our research revealed an in-hospital mortality rate of 15.2% among CKD patients after aortic stent therapy compared with 8.3% among patients in the control group. We also discovered that CKD independently correlated with higher peri- and postoperative complications and all-cause mortality. Furthermore, ESRD

patients had even worse outcomes than CKD non-dialysis patients.

The prevalence of CKD in Taiwan is about 11% to 13%, which is comparable to that of the USA and the rest of the world.[25–27] However, Taiwan has the highest percentage of ESRD patients receiving dialysis therapy in the world, which generates an enormous healthcare expense burden.[28] By utilizing data from the Taiwan NHIRD, which comprises all
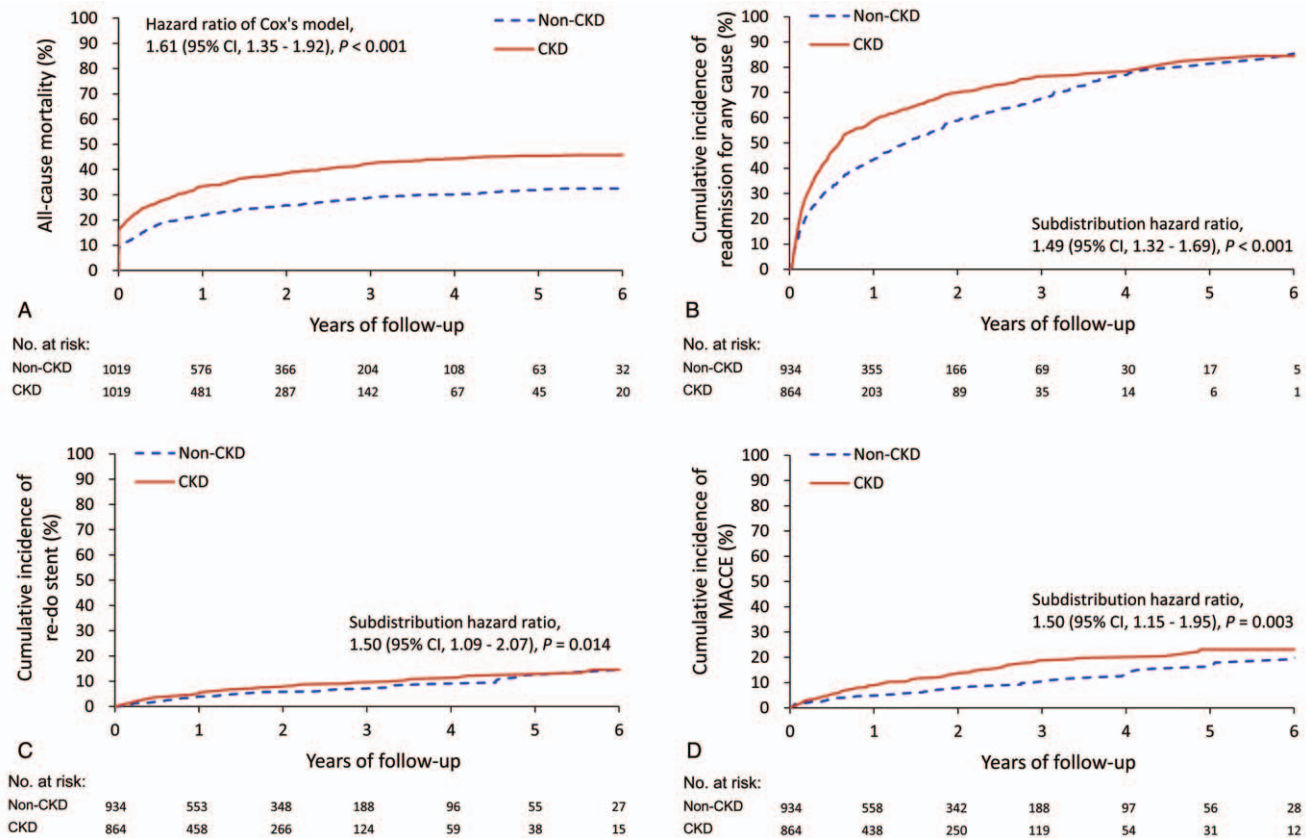

Figure 4. Unadjusted cumulative event rate of all-cause mortality, (A) unadjusted cumulative incidence function of readmission due to any cause (B), redo stent surgery (C), and MACCE (D) of patients with or without CKD in the propensity score–matched cohort. CKD=chronic kidney disease, MACCE=major adverse cardiac and cerebrovascular events.

likely individuals in Taiwan and is one the most substantial population datasets worldwide, we were able to analyze nearly all EVAR/TEVAR cases in a single nation.

Several previous studies outlined the relationship between renal insufficiency and unfavorable outcomes in patients undergoing elective AAA repair using the open or endovascular approach. Patel et al[29] identified 8701 patients undergoing repair of an intact AAA using the National Surgical Quality Improvement Program database and pointed out that moderate and severe CKD predicts increased operative mortality and morbidity rates after EVAR or open aortic repair. The same institution published another extensive investigation using a Medicare database, by far the most massive in sample size, and demonstrated a 2-fold increase in mortality in patients with moderate CKD and a 6-fold increase in mortality in patients with severe CKD receiving open or endovascular repair of AAA.[14] Our findings not only showed that preoperative CKD significantly connected with higher mortality and complications after EVAR, which agrees with the previous publications, but further point out the unsatisfactory outcome of ESRD patients. The study by Komshian et al,[30] which included over 28,000 patients using Vascular Quality Initiative database data, also showed that ESRD was independently associated with higher perioperative mortality (7% vs 2.4%) and lower 1-year survival (78% vs 94%) rates. Although our study did not include the most extensive study population, its mean follow-up duration exceeded 5 years, which contributes a much longer-term result of CKD patients receiving aortic stent graft therapy.

Studies discussing TEVAR and renal insufficiency are relatively limited compared to those of EVAR, which were often confined to a single institution and had a short-term follow-up duration. Marrocco-Trischitta et al[15] revealed that glomerular filtration rate is an accurate prognostic predictor in patients submitted to TEVAR and correlates directly with perioperative and midterm mortality. Wang et al[31] found that patients with renal insufficiency defined by a serum creatinine level ≥ 1.5 mg/dL undergoing TEVAR had a statistically significantly higher 30-day mortality and myocardial infarction rates. Nathan et al[32] described that TEVAR provided short-term outcome benefits for ESRD patients over open repair but a lower 1-year survival rate of 50% despite treatment modality. Matched with previous publications, we interpreted a national group, which by far included the largest population and longest-term follow-up period, and presented a long-term outcome for CKD patients undergoing TEVAR. Ultimately, regardless of stent graft location, CKD patients had poorer short- and long-term survival rates.

For more reduced survival after EVAR/TEVAR for CKD patients, there are a few explanations. First, vascular calcification and accelerated atherosclerosis are constant in CKD.[33] In EVAR/TEVAR, poor vascular quality may preclude endograft landing and fixation, leading to complications of access vessels. In our study, we likewise noted that CKD patients were significantly more likely to have experienced a ruptured aortic aneurysm, which leads to a more unfortunate outcome. Second, CKD was associated with immune dysregulation and infection susceptibility, including stent graft infection.[34] Third, the use of contrast agents could be hardly avoided in EVAR/TEVAR, which likely further damaged the kidney function of CKD non-dialysis patients.[35,36]

In the present study, the prevalence of CKD patients was 24.9%, much higher than those of previous studies. According to

prior research, the prevalence of CKD was 11% to 13% and increased with aging.[12,28] The major aortic pathologies of patients undergoing stent graft therapy were aortic aneurysm and aortic dissection, which were more widespread and advance with older age as well. We believe that our data reflect the current practice within Taiwan. These also highlight the advantage of using a nationwide database for designing our study. The NHIRD universally includes all individuals in Taiwan. Besides, the database was connected to outpatient clinics and hospital admissions, which produces a robust program for specifying long-term follow-up outcomes, including readmission and causes of death. Moreover, the NHI program covers the therapeutic expenses of high-priced interventions or devices such as stent graft therapy. This comprehensive coverage lessens the socioeconomic or living location barriers that may have otherwise induced selection bias.

5. Limitations

Our study was limited by its use of the nationwide ICD-9 database. First, we incorporated CKD patients by diagnosis code instead of measuring the estimated glomerular filtration rate to define the CKD stage. Accordingly, we could have overestimated the adverse post-EVAR/TEVAR outcomes, as the CKD group could have been primarily constituted of patients with advanced-stage CKD. Second, detailed clinical, imaging, and surgery-related information including aortic size, stent graft size, landing zone, and adjunctive endovascular procedure, is not accessible in the database. Furthermore, it is difficult to determine indications for reintervention, such as endoleak or stent graft migration. Nevertheless, because of the link between outpatient clinics and hospital admissions and the NHIRD, we can overcome the lacking of specific accurate data by investigating the exact reasons for readmissions. Finally, being a national cohort study in Asia, our results might not be undeviatingly extrapolated to other population groups. Despite the limitations mentioned above, we conclude that the robustness of this investigation still presents a meaningful augmentation to outcome examinations of patients with CKD who receive aortic stent graft therapy.

6. Conclusion

Despite the innovation of endovascular therapy for aortic disease, patients with CKD have inferior short- and long-term outcomes compared to those without CKD. Furthermore, ESRD patients exhibit poorer outcomes. Further attention is required to design specific approaches to enhancing the postoperative outcomes of this challenging patient population.

Author contributions

Conceptualization: An-Hsun Chou, Shao-Wei Chen.

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