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The influence of statins on aortic aneurysm after operation

A retrospective nationwide study

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Abstract

Aortic aneurysm (AA) is a disease with substantially higher health care costs and very high mortality upon rupture. Statins have a non-lipid-lowering pleiotropic mechanism that may be beneficial for AA in disease progression and improvement of AA patient outcomes. Previous studies have been conducted with some limitations and without considering immortal time bias, lag time, and adherence. The aim of our study was to analyze the effect of statin use on AA postoperation after controlling for these factors.

All postoperative patients with a diagnosis of AA in Taiwan from 2004 to 2012 were included from the National Health Insurance Research Database. We excluded patients without computed tomography within 1 year after diagnosis and those who died within 30 days after the operation. We also analyzed the medication, medication possession ratio (MPR), immortal time bias, and lag time. Statin users were defined as those using statins for more than 30 days. Primary composite outcomes included mortality, reoperation for AA and rehospitalization for AA during the study period.

Among the whole study population (n = 1633), 199/1633 (12.19%) patients were statin users, while the others (n = 1434) were not. Mortality was higher in statin nonusers than in statin users, with a mortality rate of 40% versus 22.61% ($P < .0001$). There was no significant difference in reoperation or rehospitalization for AA.

Statin use may be beneficial for AA patients in our observational study. Prospective randomized controlled studies are needed to define the effect of statin therapy in this population.

Abbreviations: AAA = abdominal aortic aneurysm, CAD = coronary artery disease, CI = confidence interval, CKD = chronic kidney disease, COPD = chronic obstructive pulmonary disease, CVD = cardiovascular disease, DM = diabetes mellitus, EVAR = endovascular aneurysm repair, HF = heart failure, HR = hazard ratio, HTN = hypertension, MPR = medication possession ratio, NHIRD = National Health Insurance Research Database, OPR = open repair of aortic aneurysm, PVD = peripheral vascular disease, TAA = thoracic aortic aneurysm, TAAA = thoracoabdominal aortic aneurysm.

Keywords: aortic aneurysm, HMG-CoA reductase inhibitor, prognosis

1. Introduction

Aortic aneurysms (AAs) have a high mortality when they rupture. AAs can be divided into 3 types according to their anatomic position: abdominal aortic aneurysm (AAA), thoracic aortic aneurysm (TAA), and thoracoabdominal aortic aneurysm (TAAA). Risk factors for AAAs include increasing age, gender, smoking, and dyslipidemia.[1] Most TAAs were found in patients older than 65 years, and TAAs share many of the same risk factors as AAAs. TAAs in patients less than 65 years of age are often associated with a genetic disorder such as Marfan syndrome. Approximately one-fourth of patients with TAA will also have an AAA.[2]

Previous studies analyzed the influence of statins on AA development and progression with discordant results because of small sample sizes and residual confounders.[3–6] Mansi et al[7] examined the association of statins with the risk of developing aortic, peripheral, and visceral artery aneurysms and showed that statin use does not confer a clinically significant benefit or harm from being diagnosed with arterial aneurysms.

Recently, Huang at al[8] performed a meta-analysis and found that statin therapy has a beneficial clinical impact on mortality for patients receiving open or endovascular AAA repair. Conversely, in the same period, Tyerman el al[9] used a database consisting of 1804 patients who received ascending aortic repair and showed

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S-WW contributed equally to this study compared with the first author

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that statins have no beneficial effect on perioperative outcomes after ascending AA repair. Due to worry about the risk of acute kidney injury in the period around surgery, the authors did not suggest using a statin before ascending aortic repair. However, most studies did not mention the duration of statin use or medication adherence. Previous studies also did not consider the effects of immortal time bias and lag time. The aim of our study was to evaluate the effect of statins on AAs, including AAA, TAA, and TAAA, post operation after adjusting for immortal time bias, lag time, and medication adherence.

2. Material and methods

2.1. Data sources

This is a population-based study using claim data from the National Health Insurance Research Database (NHIRD) in Taiwan. The National Health Insurance program was established in 1995 and covers more than 99% of the 23 million residents in Taiwan. All postoperative patients with a diagnosis of AA from 2004 to 2012 in Taiwan were included in the database. The data included inpatient care, outpatient care, emergency visits, and medications used. This study was approved by the institutional review board (IRB) of Kaohsiung Medical University Hospital on December 25, 2014, KMUH-IRB-20130199.

2.2. Patient definition

We enrolled patients who were diagnosed with AA (International Classification of Diseases, ninth revision, Clinical Modification [ICD-9-CM]: 441.1-441.7, 441.9) between January 1, 2004 and December 31, 2012. The day of diagnosis with AA was the index date. We excluded patients without computed tomography within 1 year after diagnosis and those patients who died within 30 days after the operation. Comorbidities were retrieved from at least 2 ambulatory or 1 hospitalization diagnosis. We also analyzed medications, including α-blocker, β-blocker, calcium channel blocker, angiotensin-converting enzyme inhibitor, angiotensin II receptor blocker, diuretics, vasodilators, antiplatelet agents (including aspirin, clopidogrel, dipyridamole, and cilostazol), and HMG-CoA reductase inhibitors (statins). Statin users were defined as those who had used statins for more than 30 days. To assess the robustness of the outcomes, a subgroup analysis was performed, and the subgroups were defined by medication adherence, which was divided into 3 groups according to the MPR ≥80%, 50%< MPR <80%, and MPR ≤50%. Operated status was defined by using ICD-9-CM procedure code (open repair [OPR]: 38.44, 38.45; endovascular repair [EVAR]: 39.71, 39.73).

2.3. Immortal time and lag time

Immortal time refers to a period of follow-up during which the study outcome (eg, mortality) cannot occur. When we defined the statin user group, AA patients had to survive and receive a prescription for a statin, and then the follow-up time was observed. This period before statin treatment is considered immortal because patients who end up in the treatment group have to be alive until the treatment definition (statins) is satisfied. If patients died before statin treatment, they were classified in the untreated group. Bias occurred when mortality cases were either misclassified with statin nonusers or excluded from the analysis. The biases result in favor of the treatment group under study by conferring a survival advantage to the treated group. Patients receiving therapy may have a better outcome because patients with severe disease died before they could receive treatment (statins). To survey the immortal time bias, we divided the observation period from post operation to mortality or end of study into ≤30 days, 31 to 60 days, 61 to 90 days, 91 to 180 days, 181 to 365 days, and ≥365 days. The lag time period was defined from discontinued statin (without taking the statin) to censor (mortality or end of study).

Another condition that needed to be considered was lag time, which is the time period from discontinuing the treatment (statins) to the occurrence of the outcome. The lag time was also divided into ≤30 days, 31 to 60 days, 61 to 90 days, 91 to 180 days, 181 to 365 days, and ≥365 days.

2.4. Outcomes

Primary composite outcome measurements included all-cause mortality, reoperation for AA and rehospitalization for AA during the study period. The secondary endpoint was all-cause mortality, reoperation, or rehospitalization. Study subjects were followed until the abovementioned events occurred or until the end of the study. In addition, a lag time of 90 days was applied to the statin user group. The censor date was adjusted to evaluate the long-term effects of statins.

We used 3 models to test the influence of statins on AA. Model 1 considered only whether AA patients were ever treated with a statin regardless of the MPR, immortal time and lag time. In model 2, the statin user should have a statin MPR ≥80%, without management of the immortal time bias and lag time. In model 3, the statin user should have a statin MPR ≥80% and management of immortal time and lag time.

2.5. Statistical analysis

Continuous data are expressed as the mean and standard deviation; categorical data are expressed as count and percentage. Categorical and continuous variables were compared between the statin users and statin nonusers using χ^2 tests and Student *t* tests, as appropriate. The primary composite outcome and secondary endpoint of the AA patients during the follow-up period were examined by Cox regression after adjusting for age, sex, subtype, surgery type, location, comorbidities, and medication therapy.

The difference in the cumulative probability of primary composite outcome between the statin users and statin nonusers was calculated using Kaplan–Meier estimates with the log-rank test.

The survival time of a patient started at the index date and ended at the event or at last follow-up (censoring).

The analyses and calculations were performed using SAS V.9.4. Statistical significance was inferred at a 2-sided *P* value of <.05.

3. Results

Among the whole study population (n=1633), 199/1633 (12.19%) patients were statin users, while the others (n=1434) were not. Table 1 shows baseline characteristics, and there were no significant differences in age, gender, area, operation type, and operation status (urgent or elective). There were significantly different types of AA, including 1078 (66%) patients with AAA, 354 (21.7%) patients with TAA, and 183 patients (11.2%) with TAAA.

Table 1

Baseline characteristics of patients with aortic aneurysms.

	Total (N = 1633) n (%)	Statin user (N = 199) n (%)	Statin nonuser (N = 1434) n (%)	*P*-value
Age				
Mean ± SD	71.79 ± 11.78	71.33 ± 9.23	71.86 ± 12.09	.5576
Gender				
Male	1395 (85.4)	176 (88.4)	1219 (85)	.1981
Female	238 (14.6)	23 (11.6)	215 (15)	
Elderly				
≥65	1279 (78.3)	158 (79.4)	1121 (78.2)	.6945
<65	354 (21.7)	41 (20.6)	313 (21.8)	
Area				
Urban	1210 (74.1)	153 (76.9)	1057 (73.7)	.3381
Country	423 (25.9)	46 (23.1)	377 (26.3)	
Subtype				
AAA	1078 (66)	140 (70.4)	938 (65.4)	.0337*
TAA	354 (21.7)	31 (15.6)	323 (22.5)	
TAAA	183 (11.2)	28 (14.1)	155 (10.8)	
Unknown	18 (1.1)	0 (0)	18 (1.3)	
Operation type				
EVAR	570 (34.9)	84 (42.2)	486 (33.9)	.0645
OPR	1049 (64.2)	113 (56.8)	936 (65.3)	
Both	14 (0.9)	2 (1)	12 (0.8)	
Operation status				
Urgent	817 (50)	92 (46.2)	725 (50.6)	.2527
Elective	816 (50)	107 (53.8)	709 (49.4)	.5576
Medication				
Aspirin	819 (50.2)	129 (64.8)	690 (48.1)	<.0001
Clopidogrel	473 (29.0)	99 (49.8)	374 (26.1)	<.0001
Dipyridamole	295 (18.1)	38 (19.1)	257 (17.9)	.004
Cilostazol	295 (18.1)	42 (21.1)	253 (17.6)	.234
Warfarin	297 (18.2)	41 (20.6)	256 (17.9)	.346
α-Blocker	797 (48.8)	111 (55.8)	686 (47.8)	.036
DM	298 (18.3)	58 (29.2)	240 (16.7)	<.0001
Antigout	495 (30.3)	89 (44.7)	406 (28.3)	<.0001
ACEI	403 (24.7)	64 (32.2)	339 (23.6)	.009
ARB	754 (46.2)	117 (58.8)	637 (44.4)	.0001
CCB	1144 (40.7)	163 (81.9)	981 (68.4)	<.0001
β-Blocker	965 (59.1)	147 (73.8)	818 (57.0)	<.0001
Diuretics	1003 (61.4)	141 (70.9)	862 (60.1)	.004
Vasodilator	708 (43.4)	128 (64.3)	580 (40.5)	<.0001

AAA = abdominal aortic aneurysm, ACEI = angiotensin-converting enzyme inhibitor, ARB = angiotensin II receptor blocker, CCB = calcium channel blocker, DM = diabetes mellitus, EVAR = endovascular aneurysm repair, OPR = open repair of aortic aneurysm, TAA = thoracic aortic aneurysm, TAAA = thoracoabdominal aortic aneurysm.

* Significant, $P < .05$.

Table 2 shows baseline comorbidities and their outcomes in patients with AA. There were no significant differences in hypertension, diabetes mellitus, chronic obstructive pulmonary disease, heart failure, coronary artery disease (CAD), cardiovascular disease, peripheral vascular disease, chronic kidney disease, transplant, cancer, thyroid disease, atherosclerosis, arrhythmia, and gout. Indeed, patients taking statins had an increased prevalence of comorbidities of CAD and dyslipidemia ($P < .0001$). Mortality was higher in statin nonusers than in statin users, for whom the mortality rate was 40% versus 22.61% ($P < .0001$) after operation for AA. However, there was no significant difference in reoperation or rehospitalization for AA. Kaplan–Meier analysis (Fig. 1) showed that survival free from the occurrence of the primary composite outcome (mortality, rehospitalization, and reoperation) was significantly improved in statin users compared with that in statin nonusers.

Table 3 shows the distribution of immortal time and lag time for statin users. Among 199 statin users, 44 (22.11%) patients were prescribed statins within 30 days after an operation for AA. Approximately 35% of patients were prescribed statins 1 year after an operation for AA. A total of 105 (52.76%) patients continued to use statins until censor (mortality or end of follow-up). Forty-two patients (21.11%) discontinued statin use more than 1 year before censor.

In model 1, model 2, and model 3, statin users tended to have a lower risk of primary composite outcome compared with statin nonusers with adjusted hazard ratio (HR): 0.574 (95% confidence interval [CI]: 0.464–0.709), 0.767 (95% CI: 0.573–1.028), and 0.258 (95% CI: 0.167–0.398), respectively (Table 4). For the secondary outcome, there was no significant difference in rehospitalization and reoperation for AA in models 1, 2, and 3. The mortality was lower in statin users than in statin nonusers after AA operation in models 1, 2, and 3 with adjusted HR: 0.5

Table 2

Comorbidities in patients with aortic aneurysms and their outcomes.

	Total (N = 1633) n (%)	Statin user (N = 199) n (%)	Statin nonuser (N = 1434) n (%)	*P*-value
Comorbidities				
Dyslipidemia	381 (23.3)	82 (41.2)	299 (20.9)	<.0001*
HTN	1089 (66.7)	142 (71.4)	947 (66)	.1358
DM	255 (15.6)	34 (17.1)	221 (15.4)	.5421
COPD	338 (20.7)	42 (21.1)	296 (20.6)	.8797
HF	227 (13.9)	26 (13.1)	201 (14)	.7162
CAD	613 (37.5)	106 (53.3)	507 (35.4)	<.0001*
CVD	276 (16.9)	36 (18.1)	240 (16.7)	.6329
PVD	25 (1.5)	2 (1)	23 (1.6)	.7596
CKD	118 (7.2)	8 (4)	110 (7.7)	.0623
Transplant	3 (0.2)	0 (0)	3 (0.2)	1
Cancer	175 (10.7)	16 (8)	159 (11.1)	.1928
Thyroid disease	20 (1.2)	2 (1)	18 (1.3)	1
Atherosclerosis	51 (3.1)	3 (1.5)	48 (3.3)	.1621
Arrhythmia	182 (11.1)	18 (9)	164 (11.4)	.3151
Gout	268 (16.4)	36 (18.1)	232 (16.2)	.495
Endpoint				
Death	617 (37.8)	45 (22.61)	572 (40.0)	<.0001*
Reoperation†	51 (3.1)	5 (2.51)	46 (3.2)	.5972
Rehospitalization‡	109 (6.7)	13 (6.53)	96 (6.7)	.9317

AAA = abdominal aortic aneurysm, CAD = coronary artery disease, CKD = chronic kidney disease, COPD = chronic obstructive pulmonary disease, CVD = cardiovascular disease, DM = diabetes mellitus, EVAR = endovascular aneurysm repair, HF = heart failure, HTN = hypertension, OPR = open repair of aortic aneurysm, PVD = peripheral vascular disease, TAA = thoracic aortic aneurysm, TAAA = thoracoabdominal aortic aneurysm.

* Significant, *P* value <.05.

† Rehospitalizition, hospitalization for aortic aneurysm.

‡ Reoperation, receive operation for aortic aneurysm.

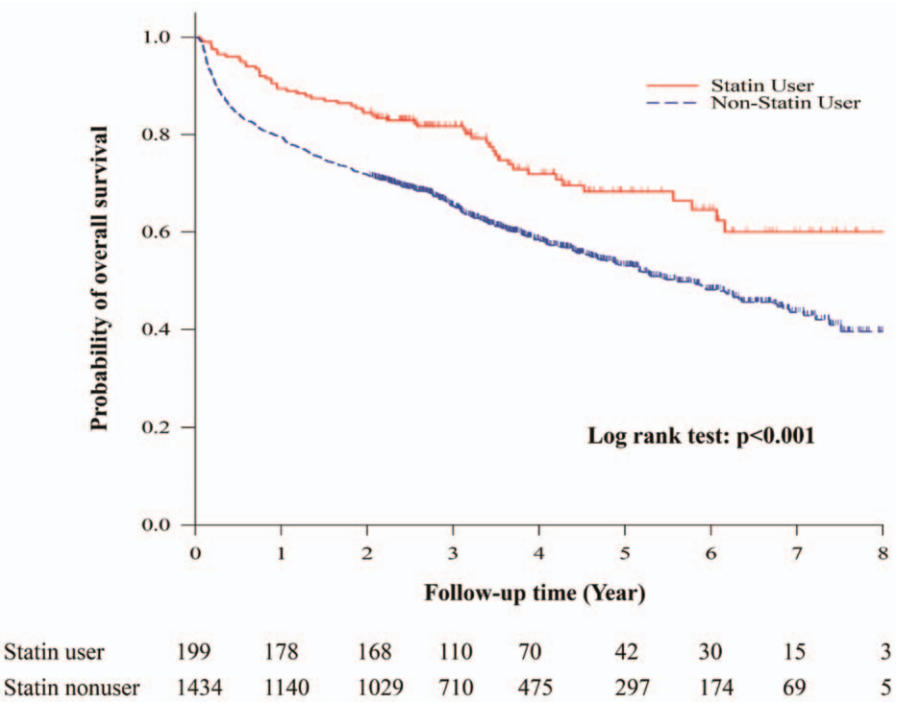

Figure 1. Kaplan–Meier estimate the survival free from the occurrence of the primary composite outcome (mortality, rehospitalization, and reoperation) in statin users and statin nonusers.

Table 3

Distribution of immortal time and lag time for statin users.

	Immortal time N = 199 (%)	Lag time N = 199 (%)
0 days	–	105 (52.76)
≤30 days	44 (22.11)	18 (9.05)
31–60 days	27 (13.57)	10 (5.03)
61–90 days	19 (9.55)	4 (2.01)
91–180 days	17 (8.54)	4 (2.01)
181–365 days	22 (11.06)	16 (8.04)
≥365 days	70 (35.18)	42 (21.11)

(95% CI: 0.395–0.633), 0.785 (95% CI: 0.571–1.081), and 0.279 (95% CI: 0.175–0.444), respectively.

Table 5 presents the subgroup analysis of statin users in different MPR groups. Patients with MPR ≥80% had favorable primary composite outcomes and slightly decreased mortality compared with patients with MPR <50% with adjusted HR of 0.736 (95% CI: 0.539–0.986) and 0.763 (95% CI: 0.554–0.1.049), respectively, after adjustment for age, sex, AA subtype, surgery type, AA location, comorbidities, and medications.

4. Discussions

There are some interesting findings in our study. First, we found that statin users have a lower risk of mortality than statin nonusers after AA operation in our model, which included only an MPR ≥80% population and adjusted for immortal time bias, lag time, age, sex, subtype, surgery type, location, all comorbidities, and medication therapy. Second, there was no significant difference in rehospitalization and reoperation for AA between statin users and statin nonusers. Third, compared with patients with MPR <50%, patients with MPR ≥80% had a statistically significant primary composite outcome.

In addition to assessing statin-induced improvements in AA outcome after surgery, Randall et al[10] analyzed the impact of statins and antiplatelet therapy in patients who received AAA repair, elective carotid endarterectomy, carotid stenting, and suprainguinal and infrainguinal bypass from 2005 to 2012 in New England and found that patients who used antiplatelet and

Table 4

Univariable and multivariable Cox regression models for all the endpoints of statin users versus nonusers.

	Model 1				Model 2				Model 3			
	Crude HR (95% CI)*	*P*-value	Adjusted HR (95% CI)§	*P*-value	Crude HR (95% CI)*	*P*-value	Adjusted HR (95% CI)§	*P* value	Crude HR (95% CI)*	*P*-value	Adjusted HR (95% CI)§	*P*-value
Primary composite outcome	0.390 (0.324–0.469)	<.0001*	0.574 (0.464–0.709)	<.0001*	0.561 (0.425–0.741)	<.0001*	0.767 (0.573–1.028)	.0756	0.157 (0.081–0.303)	<.0001*	0.258 (0.167–0.398)	<.0001*
Secondary endpoint												
Death	0.309 (0.251–0.380)	<.0001*	0.500 (0.395–0.633)	<.0001*	0.515 (0.380–0.698)	<.0001*	0.785 (0.571–1.081)	.1379	0.301 (0.183–0.495)	<.0001*	0.279 (0.175–0.444)	<.0001*
Rehospitalization†	1.154 (0.789–1.690)	.4599	1.057 (0.682–1.641)	.8031	0.9 (0.504–1.607)	.7226	0.645 (0.243–1.712)	.3784	0.702 (0.326–1.513)	.3329	0.485 (0.246–0.955)	.3364
Reoperation‡	0.826 (0.465–1.468)	.515	0.667 (0.336–1.325)	.2477	0.714 (0.284–1.796)	.4736	0.844 (0.398–1.79)	.658	0.892 (0.320–2.480)	.826	0.605 (0.234–1.569)	.3015

CI = confidence interval, HR = hazard ratio.

* Significant, $P < .05$.

† Rehospitalization, hospitalization for aortic aneurysm.

‡ Reoperation, receive operation for aortic aneurysm.

§ Adjusted for age, sex, subtype, surgery type, location, all comorbidities, and medication therapy.

Table 5

Subgroup analysis of statin users in different MPR groups.

	Crude HR (95% CI)	*P*-value	Adjusted HR (95% CI)	*P*-value
Primary composite endpoint				
MPR ≥80	0.531 (0.403–0.700)	<.0001*	0.736 (0.539–0.986)	.04*
80> MPR ≥50	0.479 (0.341–0.674)	<.0001*	0.702 (0.492–1.002)	.05*
MPR <50 (Nonuser)	–	–	–	–
Death				
MPR ≥80	0.489 (0.362–0.660)	<.0001*	0.763 (0.554–1.049)	.0958
80> MPR ≥50	0.460 (0.320–0.660)	<.0001*	0.744 (0.509–1.086)	.1258
MPR <50 (nonuser)	–	–	–	–
Rehospitalization†				
MPR ≥80	0.895 (0.499–1.605)	.7099	0.710 (0.382–1.320)	.2791
80> MPR ≥50	1.099 (0.586–2.061)	.7677	0.944 (0.488–1.825)	.8638
MPR <50 (nonuser)	–	–	–	–
Reoperation†				
MPR ≥80	0.720 (0.284–1.825)	.4894	0.633 (0.235–1.703)	.3653
80> MPR ≥50	1.246 (0.528–2.941)	.6153	0.967 (0.388–2.410)	.9434
MPR <50 (nonuser)	–	–	–	–

CI = confidence interval, HR = hazard ratio.

* Significant, $P < .05$.

† Rehospitalization, hospitalization for aortic aneurysm.

† Reoperation, receive operation for aortic aneurysm.

statin therapy preoperatively showed a trend towards lower 30-day mortality (odds ratio, 0.75; 95% CI, 0.5–1.05; $P = .09$). Although there was no significant difference in 30-day mortality, patients using antiplatelet and statin therapy had improved 5-year survival (HR, 0.5; 95% CI, 0.4–0.7; $P < .01$) with different types of vascular surgery.

Our study has similar results. We included only patients with AA after surgery and surveyed only the effect of statins. Patients improved in the primary composite outcome (mortality, rehospitalization or reoperation) in the statin treatment group. Patients with AA had a higher percentage of hypertension (71%), CAD (53%) or dyslipidemia (41%), and these patients benefited from statin treatment. Low-density lipoprotein cholesterol is associated with cardiovascular disease and death. Statins can reduce the level of low-density lipoprotein and improve the mortality and outcome in patients with cardiovascular disease.[11] In addition to improving endothelial function, statins can also modulate inflammatory responses, maintain plaque stability, and reduce thrombus formation.[12] All of these mechanisms produce particular effects to prevent cardiovascular complications and the progression of atherosclerosis and can be expected to ameliorate long-term cardiovascular disease and mortality.

Sven et al conducted a retrospective study in a single center to compare mortality for all AAA patients with open surgery and showed a significant beneficial effect of statin use on early and long-term survival.[13] Another study[14] also used ICD-9-CM codes to analyze the impact of preoperative statin use on the outcomes of Medicare patients who received either OPR or EVAR and showed mortality reduction at 90 days and 1 year. A systematic review and meta-analysis performed by Huang et al[8] also showed the benefit of statin therapy on survival after AAA. All of these studies showed the positive effect of statins on AA patients, but most of them did not manage immortal time bias, lag time or medication adherence. Our analysis further managed these confounders and demonstrated lower overall postoperative mortality rates in the postoperative statin treatment group of patients with AA who either received open surgery or EVAR. Otherwise, we found that only patients with higher medication adherence with an MPR ≥80% received a protective effect regarding the primary composite outcome.

In clinical practice, patients' medication adherence may not be satisfactory, and the outcome may not result from drug exposure. The outcome occurred even after patients did not take this medication for a long time. The relationship between drug exposure and outcome may not be true, but it is often ignored in observational studies. Our study performed a sensitivity analysis to show the time period from discontinuation of medication to outcome. We found that 53% of patients maintained statin use before censor. We further adjusted the immortal time and lag time in the model and found that statins had a protective effect on AA patients after the operation. There are some direct and indirect ways to measure medication adherence. MPR measures the percentage of time a patient has access to statins and is the sum of the total supply for all fills of a statin during a prescription period, divided by the number of days in the observation period. There is no real consensus on the optimal level of adherence, although higher adherence gives higher disease treatment and prevention. In most studies, authors have supposed that 80% is acceptable for many disease states. Perreault et al found that patients with ≥80% adherence to statins had a significantly lower risk of CAD (18%) than patients with an adherence rate <20%.[15] A study also showed that there are associations between statin adherence level, health care costs, and medical utilization. The authors stratified statin MPR from 40% to 59%, 60% to 69%, 80% to 84%, 85% to 89%, 90% to 95%, and 96% to 100% and found that compared with the reference group (MPR <40%), the patients with higher statin adherence had fewer visits to the emergency room.[16] For other diseases, even greater levels of adherence are needed to prevent negative outcomes. In an observational study, medication adherence plays a very important role in prognosis but is frequently ignored in the study.

There are some limitations to our study. Our study is not a prospective double-blinded randomized controlled trial, but this retrospective study used a nationwide claim database with a large population. Our study enrolled patients by selecting ICD-9-CM codes from multiple hospitals and may have had bias and coding errors. However, the NHIRD has been validated in many studies.[17–19] Moreover, our database lacks images, and we cannot provide the diameter of the AA. Our patients received their operations from a variety of surgeons, eliminating standardization, and there may have been variability in techniques and experience. Furthermore, all aspects of pre- and postoperative care, including medication selection, dosage, administration, and postoperative care, are all at the discretion of the attending physician, introducing further variability and cannot be explained due to the basic nature of an observational study.

5. Conclusion

Patients were found to have a statistically significant lower rate of all-cause mortality after AA surgery if treated preoperatively with statins based on an observational relationship. Further prospective high-quality studies are needed to define the effect of statin therapy on patients undergoing AA surgery.

Author contributions

Data curation: Shih-Wei Wang.
Formal analysis: Shih-Wei Wang.
Methodology: Chung-Yu Chen, Chun-Hui Lu.
Project administration: Chung-Yu Chen.
Supervision: Yaw-Bin Huang.
Writing – original draft: Kuang-Ming Liao.
Writing – review and editing: Chung-Yu Chen.

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