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ScienceDirect

Journal of the Chinese Medical Association 78 (2015) 241–248

www.jcma-online.com

Original Article

Outcome comparison between thoracic endovascular and open repair for type B aortic dissection: A population-based longitudinal study

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Received June 5, 2014; accepted October 15, 2014

Abstract

Background: Management of diseases of the descending thoracic aorta is trending from open surgery toward thoracic endovascular aortic repair (TEVAR), because TEVAR is reportedly associated with less perioperative mortality. However, comparisons between TEVAR and open surgery, adjusting for patient comorbidities, have not been well studied. In this nationwide population-based study, we compared the outcomes between TEVAR and open surgery in type B aortic dissection.
Methods: From 2003 to 2009, data on patients with type B aortic dissection who underwent either open surgery or TEVAR were obtained from the National Health Insurance Research Database. Survival, length of stay, and complications were compared between TEVAR and open repair. To minimize possible bias, we performed an additional analysis after matching patients by age, sex, and propensity score.
Results: A total of 1661 patients were identified, of whom 1542 underwent open repair and 119 TEVAR. Patients in the TEVAR group were older (63.0 ± 15.4 years vs. 58.1 ± 13.1 years; $p = 0.001$), included more males, and had more preoperative comorbidities. Thirty-day mortality in the TEVAR group was significantly lower than that in the open repair group (4.2% vs. 17.8%; $p < 0.001$). The midterm survival rates in the unmatched cohort between the open surgery and TEVAR groups at 1 year, 2 years, 3 years, and 4 years were 76%, 73%, 71%, and 68% vs. 92%, 86%, 82%, and 79%, respectively. The length of stay in the TEVAR group was shorter than that in the open repair group ($p = 0.001$). The TEVAR group had less respiratory failure ($p = 0.022$) and fewer wound complications than the open repair group ($p = 0.008$). The matched cohort showed similar results.
Conclusion: TEVAR for type B aortic dissection repair has less perioperative mortality, a shorter length of hospitalization, a higher midterm survival rate, less postoperative respiratory failure, and fewer wound complications than open surgery.

Keywords: aneurysm; dissecting; endovascular procedures; postoperative period; propensity score

Conflicts of interest: The authors declare that there are no conflicts of interest related to the subject matter or materials discussed in this article.

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http://dx.doi.org/10.1016/j.jcma.2014.10.003
1726-4901/

1. Introduction

Management of diseases of the descending thoracic aorta (DTA; e.g., aneurysm, dissection, and rupture) is trending from open surgery toward thoracic endovascular repair (TEVAR).[1] In 2004, approximately 21% and 79% of patients with DTA disease underwent TEVAR and open surgery, respectively, compared with 55% and 45% in 2007.[2] TEVAR is reportedly associated with less perioperative mortality than open surgery in the treatment of thoracic aortic aneurysm (TAA): about 2.1–5% with TEVAR versus 6.7–12% with open surgery.[2,3]

Aortic dissection is uncommon but fatal. Clouse et al[4,5] reported that between 1980 and 1994, the overall incidence of TAA was 10.4 per 100,000 person-years and that of acute aortic dissection (AAD) was 3.5 per 100,000 person-years. The overall 5-year survival rate is 56% for TAA and 32% for AAD, and the perioperative mortality rate of aortic dissection ranges from about 9% to 13%.[6,7] The etiology, patient demographics, and pathophysiology of aortic dissection differ between TAA and AAD, and patients with AAD tend to be younger and have fewer comorbidities.[4,8] Open surgery repair was proved to improve the long-term survival of patients with chronic aortic dissection.[9] Although whether a patient receives open or TEVAR repair may be dependent on the patient's comorbidities, comparison of the survival rate and complications after baseline comorbidity adjustment between open repair and TEVAR for aortic dissection to avoid potential bias has not been performed.

In this study, we conducted a population-based cohort comparison of the long-term outcomes of elective open and endovascular aortic repair for aortic dissection using data from the Taiwan National Health Insurance Research Database, which enrolled 99.6% of the inhabitants of Taiwan from 1995 to 2009.

2. Methods

2.1. Database

Data were obtained from the National Health Insurance Research Database, which comprises deidentified secondary data derived from the registration and claims data of the Taiwan National Health Insurance program. As the single payer of the medical insurance of Taiwan, the National Health Insurance program began in 1995 and enrolled 99.6% of the inhabitants of the country as of 2009. Each year, the Taiwan National Health Research Institute collects and publishes the registration and claims data released by the National Health Insurance, cross-checked and validated on medical charts and claims to ensure its accuracy. This study used the inpatient claim datasets containing all inpatient claim and registration data from 1996 to 2010. This study was exempted from review by the Institutional Review Board of Taipei Veterans General Hospital, Taipei, Taiwan because the datasets were deidentified, and informed consent was waived because of the anonymous nature of the data.

2.2. Study cohort

We identified the patients who had undergone open repair (ICD-9-CM [International Classification of Diseases, 9th version, Clinical Modification] procedure codes 38.35 and 38.45) or endovascular repair (ICD-9-CM procedure codes 39.73 and 39.79) with a diagnosis of thoracic aortic dissection (ICD-9-CM disease code 441.01) from 2003 to 2009; the admission date for the operation was designated as the index date. We excluded patients with a follow-up period (look-back period) of <2 years from enrollment into the National Health Insurance plan and date of the operation. We also excluded those who underwent any aortic operation (codes 35.93, 38.14, 38.34, 38.35, 38.44, 38.45, 38.64, 38.84, 39.22, 39.24, 39.25, 39.54, or 39.71) during the look-back period. Patients with diagnostic codes for aortic dissection involving only unspecified segments or only abdominal segments other than the thoracic aorta (ICD-9-CM disease codes 441.00 and 441.02) before or during the index hospitalization period were excluded. Those who underwent concomitant open repair and endovascular repair during the same hospitalization period were also excluded. We used the strategy previously described; patients with concomitant codes for cardiac procedures such as coronary artery bypass (36.1x–36.3x), valve replacement (35.2x), aorta-to-great-vessel bypass (39.22 and 39.23), cardioplegia (39.63), and hypothermic arrest (39.62) were excluded. This strategy eliminated patients with type A dissections, and limited the study population to those with DTA and thoracoabdominal aorta disease.

2.3. Comorbidities

Baseline comorbidities including previous myocardial infarction (410.x), chronic renal failure (585.x), chronic obstructive pulmonary disease (490.x–496.x), hypertension (401.x–405.x), diabetes mellitus (250.x), stroke (430.x–431.x, 433.x1, and 434.xx, excluding 434.x0 and 436.x), peripheral arterial occlusive disease (440.x, 441.2, 441.4, 441.7, 441.9, 443.1–443.9, 447.1, 557.1–557.9, and V434), dyslipidemia (272.x), and valvular heart disease (093.20–093.24, 394.0–397.1, 424.0–424.91, 746.3–746.6, V42.2, and V43.3) were identified. Patients were divided into groups according to a baseline Charlson comorbidity index of 0, 1–2, 3–4, or ≥5, as previously described.[10,11]

2.4. Identification of matched cohort for alternative analysis

We matched each endovascular repair patient to an open repair patient by propensity score matching. The propensity score was constructed by age, sex, and all identified comorbidities mentioned, including previous myocardial infarction, chronic renal failure, chronic obstructive pulmonary disease, hypertension, diabetes mellitus, stroke, peripheral arterial occlusive disease, dyslipidemia, valvular heart disease, and Charlson comorbidity index. The matching process also required that the age of each open repair patient be within 2 years of that of their respective endovascular repair patient, and that they be of the same sex.

2.5. Outcomes

The primary endpoint of this study was all-cause 30-day mortality. The secondary endpoints were length of stay, midterm mortality, and perioperative and late complications. Each patient was followed up for a maximum of 4 years for the midterm mortality analysis. Perioperative complications were defined as complications occurring during the index hospitalization period and included medical complications (respiratory failure, pneumonia, urinary tract infection, acute renal failure, stroke, and paraplegia) and surgical complications (tracheostomy, upper- and lower-limb vascular complications including thrombectomy or amputation, bowel ischemia or resection, wound complications requiring surgical treatment, and hemorrhage requiring surgical exploration). Late complications were defined as complications occurring after the index hospitalization period and included additional aortic aneurysm repair procedures, bowel adhesions requiring surgical treatment, bowel obstruction, and graft-related complications including graft infection, enteric fistula, and incisional hernia repair.

2.6. Statistical analysis

Data management and computing were carried out using Microsoft SQL Server 2012 (Microsoft Corporation, Redmond, WA, USA). Data analysis was performed using *R* statistics (Version 2.15.2; The R Foundation for Statistical Computing, Vienna, Austria). Categorical variables were compared using the χ^2 test or Fisher's exact test, as appropriate, and continuous variables were compared using Student *t* test. Thirty-day and midterm survival were estimated using Kaplan−Meier analysis, and the statistical significance of differences was determined using the log-rank test. Hazard ratios (HRs) for survival according to the repair method were analyzed using Cox proportional hazards regression analysis after adjustment for patient characteristics and comorbidities and hospital and surgeon characteristics. A p value <0.05 was considered statistically significant.

3. Results

3.1. Patient characteristics

A total of 1661 patients who underwent thoracic aortic repair for aortic dissection were identified from the population (Fig. 1). This unmatched cohort comprised 1542 patients who underwent open repair and 119 patients who underwent TEVAR (Table 1). Patients in the TEVAR group (63.0 ± 15.4 years of age) were older than those in the open repair group (58.1 ± 13.1 years) ($p = 0.001$). In addition, the TEVAR group contained more male patients, with a higher incidence of previous myocardial infarcts, chronic pulmonary disease, hypertension, peripheral arterial occlusive disease, and dyslipidemia, but a lower incidence of valvular heart disease. The matched cohort consisted of 113 patients in the TEVAR group and 113 patients in the open repair group; there was no significant difference in age (62.5 ± 15.1 years vs. 62.6 ± 15.3 years, $p = 0.955$) and proportion of male patients (83.2% vs. 83.2%, $p = 1.000$) between the TEVAR and open repair groups. Both groups had similar proportions of patients having comorbidities from each category.

3.2. Mortality

In the unmatched cohort, the 30-day mortality rates in the TEVAR and open repair groups were 4.2% and 17.8%, respectively. The 30-day mortality rate in the TEVAR group was significantly lower than that in the open repair group ($p < 0.001$) (Table 2). In the matched cohort, the 30-day mortality rates in the TEVAR and open repair groups were 4.4% and 19.5%, respectively. Patients in the TEVAR group had a significantly lower 30-day mortality rate than those in the open repair group.

In the unmatched cohort, the midterm survival rates at 1 year, 2 years, 3 years, and 4 years were 76%, 73%, 71%, and 68%, respectively, in the open repair group and 92%, 86%, 82%, and 79%, respectively, in the TEVAR group (Fig. 2). In the matched cohort, the survival rates at 1 year, 2 years, 3 years, and 4 years were 73%, 72%, 69%, and 67%, respectively, in the open repair group and 92%, 85%, 83%, 81%, and 78%, respectively, in the TEVAR group (Fig. 3). The risk analysis for mortality showed that TEVAR for aortic dissection had a lower risk of mortality than open repair (adjusted HR = 0.45, 95% confidence interval = 0.27−0.73, $p = 0.001$) after adjustment for age, sex, previous myocardial infarction, chronic renal failure, chronic obstructive pulmonary disease, hypertension, diabetes mellitus, stroke, peripheral vascular disease, dyslipidemia, and valvular heart disease. In the matched cohort, the TEVAR group had a lower risk of mortality than the open repair group (HR = 0.51, 95% confidence interval = 0.28−0.94, $p = 0.032$).

3.3. Length of stay

In the unmatched cohort, the length of stay in the TEVAR group was 19.8 ± 18.5 days (mean ± SD), which was significantly shorter than that in the open repair group (26.0 ± 25.3 days, $p = 0.001$). In the matched cohort, the length of stay in the TEVAR group was 20.3 ± 18.9 days, which was also significantly shorter than that in the open repair group (26.7 ± 19.7 days, $p = 0.021$) (Fig. 4).

3.4. Complications

Complications are listed in Table 3. In the unmatched cohort, the most common complication was respiratory failure, which was noted in 14.2% of patients in the open repair group and in 6.7% of patients in the TEVAR group. The TEVAR group had less respiratory failure ($p = 0.022$) and fewer wound complications ($p = 0.008$). Although the patients in

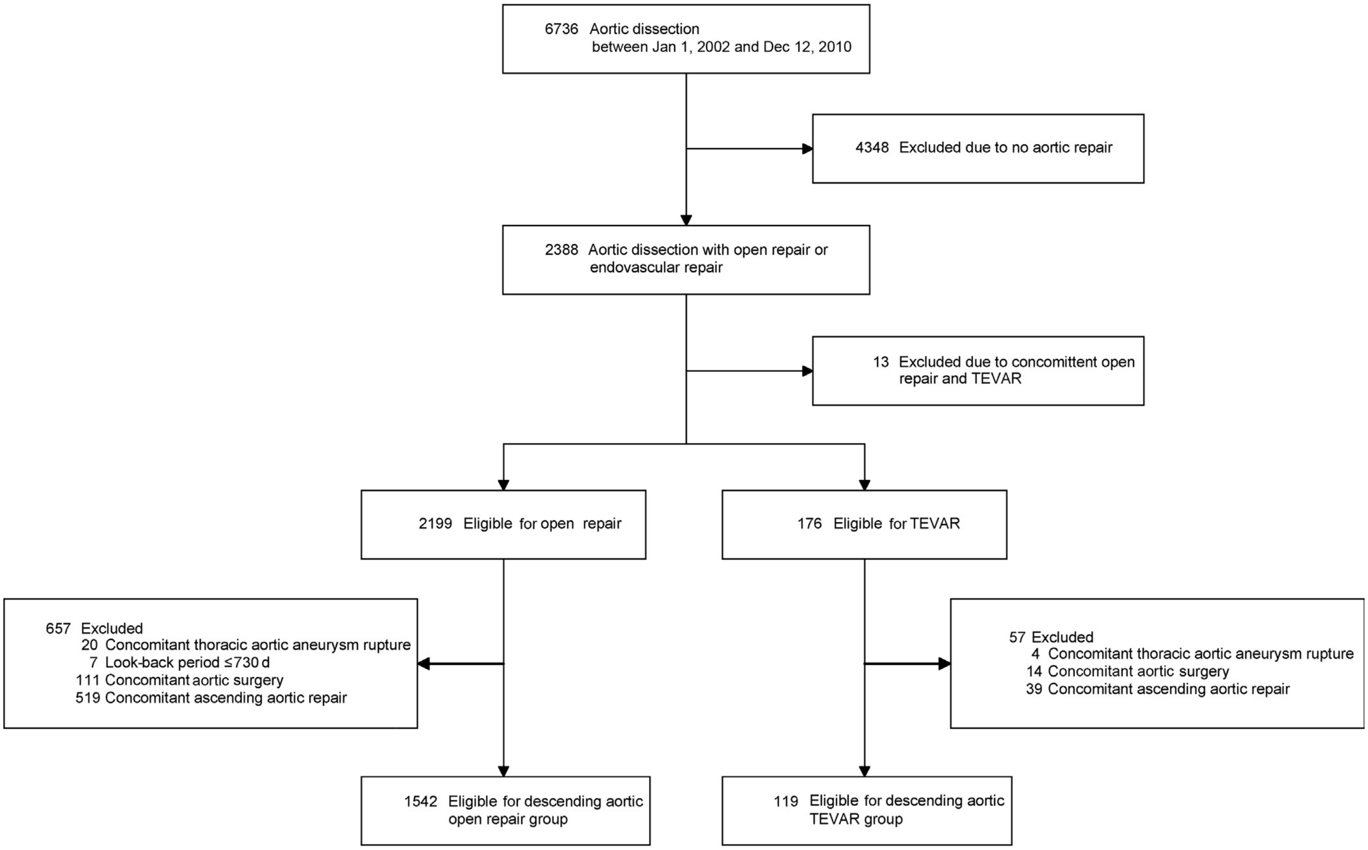

Fig. 1. Study cohort selection flow chart. Of 6736 patients in the study cohort, 1441 underwent open repair and 117 underwent TEVAR. TEVAR = thoracic endovascular aortic repair.

the TEVAR group had a higher percentage of stroke ($p = 0.063$), higher rate of graft complication ($p = 0.077$), and lower percentage of acute renal failure ($p = 0.075$), the difference did not reach the preset significance level. Five patients in the TEVAR group received reintervention for additional aortic repair. Two received endovascular repair, two received open repair, and one received two additional repairs, one endovascular and one open repair. Thirty-five patients in the open repair group underwent 16 open repairs and 19 endovascular repairs. The TEVAR group had higher rates of reintervention of open aortic repair (2.5%), additional endovascular repair (2.5%), and additional repair with either open

Table 1
Patient characteristics.

	Unmatched			Matched		
	Open repair ($n = 1542$)	TEVAR ($n = 119$)	p	Open repair ($n = 113$)	TEVAR ($n = 113$)	p
Patient						
Mean age (SD)	58.1 (13.1)	63.0 (15.4)	<0.001	62.5 (15.1)	62.6 (15.3)	0.955
Male sex (%)	1068 (69.3)	99 (83.2)	0.002	94 (83.2)	94 (83.2)	>0.99
Previous myocardial infarct (%)	24 (1.6)	8 (6.7)	<0.001	4 (3.5)	3 (2.7)	>0.99
Chronic renal failure (%)	19 (1.2)	3 (2.5)	0.205	2 (1.8)	2 (1.8)	>0.99
Chronic pulmonary disease (%)	89 (5.8)	13 (10.9)	0.024	11 (9.7)	11 (9.7)	>0.99
Hypertension (%)	1096 (71.1)	97 (81.5)	0.015	90 (79.6)	92 (81.4)	0.737
Diabetes mellitus (%)	134 (8.7)	12 (10.1)	0.605	17 (15.0)	12 (10.6)	0.320
Old stroke (%)	106 (6.9)	8 (6.7)	0.950	9 (8.0)	7 (6.2)	0.604
Peripheral arterial occlusive disease (%)	1 (8.4)	17 (14.3)	0.028	12 (10.6)	13 (11.5)	0.832
Dyslipidemia (%)	103 (6.7)	15 (12.6)	0.015	11 (9.7)	14 (12.4)	0.525
Valvular heart disease (%)	349 (22.6)	11 (9.2)	<0.001	8 (7.1)	10 (8.8)	0.623
Charlson index score level (%)			0.095			0.382
1–2	1190 (77.2)	84 (70.6)		82 (72.6)	80 (70.8)	
3–4	220 (14.3)	18 (15.1)		22 (19.5)	18 (15.9)	
≥5	132 (8.6)	17 (14.3)		9 (8.0)	15 (13.3)	

SD = standard deviation; TEVAR = thoracic endovascular aortic repair.

Table 2
Thirty-day mortality.

	Unmatched			Matched		
	Open repair ($n = 1542$)	TEVAR ($n = 119$)	p	Open repair ($n = 113$)	TEVAR ($n = 113$)	p
30-d mortality			<0.001			<0.001
Yes, n (%)	274 (17.8)	5 (4.2)		22 (19.5)	5 (4.4)	
No, n (%)	1268 (82.2)	114 (95.8)		91 (80.5)	108 (95.6)	

TEVAR = thoracic endovascular aortic repair.

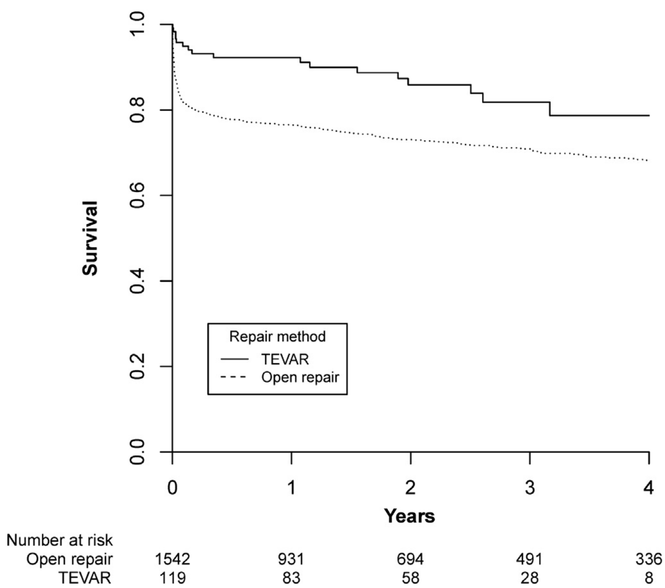

Fig. 2. Survival of unmatched cohort. Kaplan−Meier curves showing midterm survival of the TEVAR and open repair groups for type B aortic dissection in the unmatched cohort. TEVAR = thoracic endovascular aortic repair.

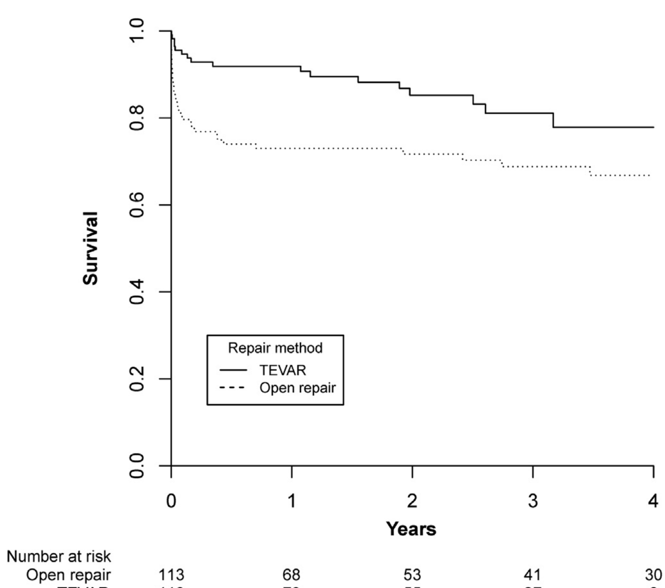

Fig. 3. Survival of matched cohort. Kaplan−Meier curves showing midterm survival of the TEVAR and open repair groups for type B aortic dissection in the matched cohort. TEVAR = thoracic endovascular aortic repair.

or endovascular repair (4.2%). The graft complication rate was higher in the TEVAR group than in the open repair group (3.4% vs. 1.2%, $p = 0.077$). In the matched cohort, the TEVAR group had less respiratory failure ($p = 0.004$), less acute renal failure ($p = 0.049$), and less wound complication ($p = 0.029$) (Fig. 5).

4. Discussion

This nationwide, population-based cohort study showed that the 30-day mortality rate of patients with aortic dissection who underwent TEVAR was significantly lower than that of patients who underwent surgical repair in both the unmatched (4.2% vs. 17.8%, $p < 0.001$) and the matched (4.4% vs. 19.5%, $p < 0.001$) groups. In addition, patients with aortic dissection who underwent TEVAR showed significantly shorter lengths of stay and better midterm survival rates.

The perioperative mortality rate after TEVAR is low.[2,12] Conrad et al[2] reported perioperative mortality rates of 9% and 21% in patients with aortic dissection who underwent TEVAR and open surgery, respectively. In our study, patients who underwent TEVAR were older and had more comorbidities, including hypertension, previous myocardial infarcts, peripheral arterial occlusive disease, chronic

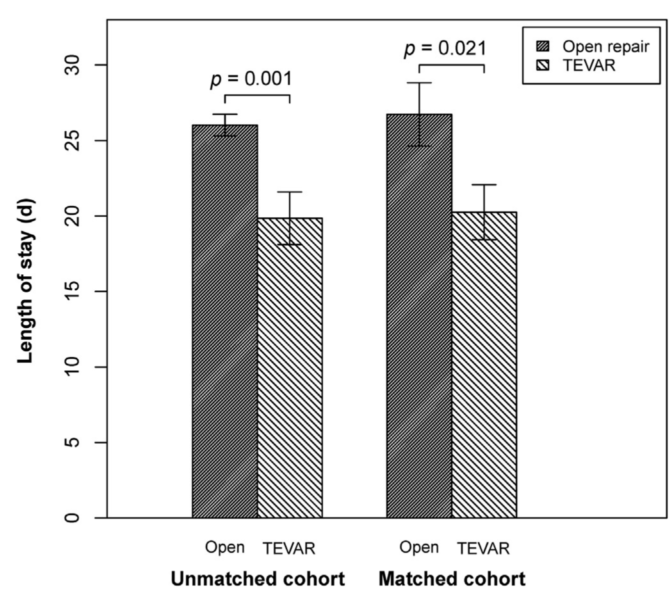

Fig. 4. Length of stay comparison. Bar chart comparing length of stay between the open repair and TEVAR groups in both matched and unmatched cohorts. The error bars indicate standard errors. TEVAR = thoracic endovascular aortic repair.

Table 3
Complications.

	Unmatched			Matched		
	Open repair (n = 1542)	TEVAR (n = 119)	p	Open repair (n = 113)	TEVAR (n = 113)	p
Perioperative (%)						
Respiratory failure	219 (14.2)	8 (6.7)	0.022	23 (20.4)	8 (7.1)	0.004
Urinary tract infection	57 (3.7)	2 (1.7)	0.435	3 (2.7)	2 (1.8)	>0.99
Acute myocardial infarction	17 (1.1)	1 (0.8)	>0.99	0 (0)	1 (0.9)	>0.99
Acute renal failure	155 (10.1)	6 (5.0)	0.075	13 (11.5)	5 (4.4)	0.049
Paralysis	16 (1.0)	1 (0.8)	>0.99	1 (0.9)	1 (0.9)	>0.99
Stroke	4 (0.3)	2 (1.7)	0.063	1 (0.9)	2 (1.8)	>0.99
Tracheostomy	79 (5.1)	4 (3.4)	0.395	9 (8.0)	4 (3.5)	0.153
Lower-limb vascular complication	23 (1.5)	3 (2.5)	0.427	2 (1.8)	3 (2.7)	>0.99
Upper-limb vascular complication	4 (0.3)	1 (0.8)	0.311	1 (0.9)	1 (0.9)	>0.99
Wound complication	69 (4.5)	0 (0)	0.008	6 (5.3)	0 (0)	0.029
Operation for hemorrhage	48 (3.1)	1 (0.8)	0.255	4 (3.5)	1 (0.9)	0.369
Late complication						
Open aortic repair	16 (1.0)	3 (2.5)	0.150	1 (0.9)	3 (2.7)	0.622
Additional endovascular repair	19 (1.2)	3 (2.5)	0.205	0 (0)	2 (1.7)	0.498
Graft complication	19 (1.2)	4 (3.4)	0.077	1 (0.9)	4 (3.5)	0.369
Fistula	3 (0.2)	0 (0)	>0.99	1 (0.9)	0 (0)	>0.99
Incisional hernia	5 (0.3)	1 (0.8)	0.360	1 (0.9)	1 (0.9)	>0.99

TEVAR = thoracic endovascular aortic repair.

pulmonary disease, and dyslipidemia, than those who underwent open surgery. However, the 30-day mortality rates in the TEVAR and open surgery groups were 4.2% and 17.8%, respectively. Compared with Conrad's study, mortality in our study was lower. There were no baseline data on comorbidities in the study by Conrad et al[2]; we speculated that this was probably due to the inclusion of older patients in Conrad's study (mean age 71.4 years vs. 58.1 years in our study). The midterm results of TEVAR for descending aortic dissection varies in previous studies, with survival ranging from 59.1% to 100% and a median follow-up of 2 years.[12] The 1- and 5-year survival rates were 86% and 65%, respectively, and perioperative mortality was 4% in a study by Andersen et al.[13] Results of the study of Xu et al[14] revealed that the 5-year survival rate was 84% and perioperative mortality was only 1.2%. Compared to open surgical repair, Conway et al[15] reported that the 1-, 5-, and 7-year survival rates were 92%, 83%, and 70%, respectively, but the rate of perioperative

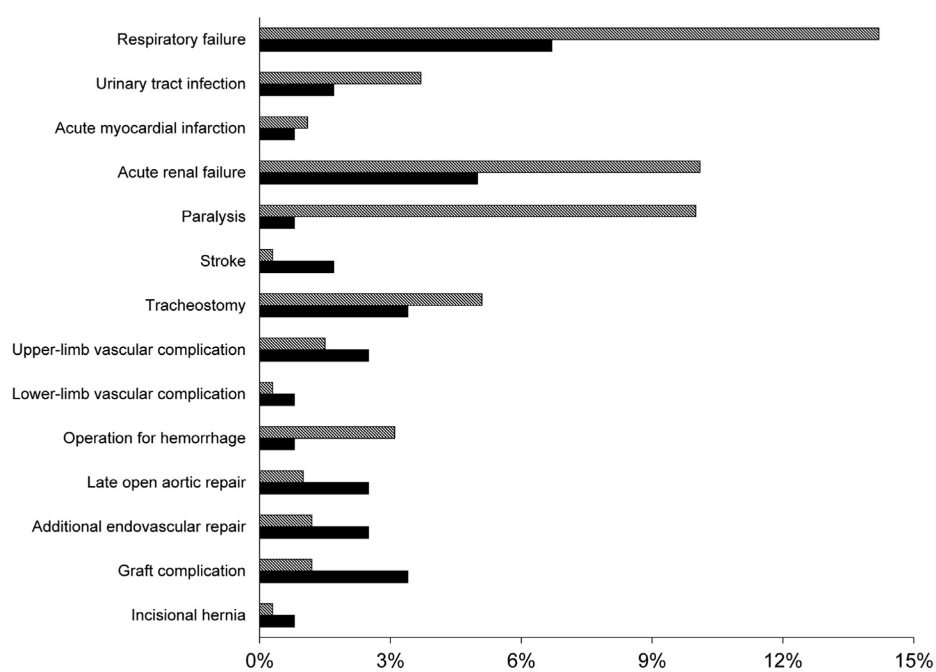

Fig. 5. Complications. Bar chart showing complications of the open repair and TEVAR groups in unmatched cohort. TEVAR = thoracic endovascular aortic repair.

mortality was higher, 5.8%. The results of the unmatched TEVAR group in our study showed comparable survival rates, which were 92%, 86%, 82%, and 79% at 1 year, 2 years, 3 years, and 4 years, respectively (Appendix 1). In addition, the shorter length of stay in the TEVAR group compared with the surgical group in both the unmatched and the matched groups was significant.

Common complications of DTA disease management include spinal cord ischemia, respiratory failure, and renal failure.[16−18] In terms of such complications, TEVAR has shown better outcomes than surgery, whereas TEVAR is associated with higher rates of peripheral vascular complications and reintervention.[3,19] Andersen et al[13] stated that the reintervention rate was 24%, whereas in our study it was 4.2%. The differences were assumed to be because the cases who were treated for residual chronic DTA disease following acute type A aortic dissection repair were included in the study of Andersen et al.[13] Nevertheless, our result regarding additional repair is comparable with the 4.8% rate of secondary TEVAR or open repair for reintervention reported in the study of Xu et al.[14] In our study, the graft complication rate was higher with TEVAR than with open surgery. The wound complication rate was higher with open surgery than with TEVAR. Czerny et al[20] have stated that pronounced remodeling of the descending aorta with extensive stent coverage is warranted to achieve success. Although statistical significance was not reached, higher rates of associated complications such as stroke were seen with TEVAR than with open surgery. The incidence of perioperative stroke that most likely resulted from embolism during TEVAR was about 1.2−4.6% in recent studies.[16,21] In our study, the perioperative stroke rate was 1.7%, which is comparable with that in previous studies. Spinal cord ischemia in TEVAR is correlated with the length of aorta covered and the number of stents deployed, and occurs with an incidence of about 7.5%.[22] In open surgery, however, the number of sacrificed segmental arteries, sufficiency of the collateral supply, and postoperative blood pressure maintenance are important for the outcome, with immediate or delayed paraplegia occurring in about 1.2−5.3% of patients and paraparesis in about 1.2−3%.[15,23,24] In our study, there was no significant difference in the rate of paraplegia between the TEVAR and the open surgery groups. While TEVAR without drainage was shown to be associated with a high rate of spinal cord injury (SCI) at 7.5%,[22] proactive prevention, as utilized in actual clinical practice, may lower the incidence of SCI.[25] Moreover, the diagnosis of SCI may not be registered in administrative databases because the SCI may have been recovered at discharge. The lack of significance in the statistical analysis was most likely due to the small total number of observed complications, which made it difficult to detect statistical significance. Our study showed higher rates of wound complications ($p = 0.029$), respiratory failure ($p = 0.004$), and acute renal failure ($p = 0.049$) in the open surgery group than in the TEVAR group. The possible mechanisms of renal failure were that open surgery has to have cross-clamping of the aorta and possible reimplantation of visceral arteries would affect the perfusion of the kidney, predisposing to postoperative renal failure. Clamping and declamping of the aorta after prolonged torso ischemia during open repair may cause pulmonary failure.[26] In terms of late (>5-year) mortality and complications (e.g., reintervention, renal insufficiency, and stroke), previous studies have shown that the late complication rates of TEVAR and open surgery are similar.[2,13,27] Hanna et al[28] have reported long-term outcomes of TEVAR for acute complicated type B dissection with 0% 30-day mortality and 84% survival rate at 5 years and 7 years; however, more clinical trials are required to address this similarity.

This study has several limitations. First, there is unfortunately no code for ascending aortic dissection among the ICD-9-CM codes; thus, aortic dissection involving the ascending aorta could be included. However, the method that we used, which incorporated procedure codes that excluded patients with aortic dissection involving the ascending aorta, may have minimized the selection bias. This is because it is very unusual that ascending aorta repair is performed without concomitant coronary artery bypass, valve replacement, aorta-to-great-vessel bypass, cardioplegia, or hypothermic arrest, which we used as criteria to identify our study cohort and which have also been used in previous studies.[2] Therefore, we believe that the selection bias may be minimal. Nonetheless, this selection bias was present in both the open repair and the TEVAR groups; therefore, the relationship and comparison between the two groups may still be valid. Second, the complications may have been overestimated. The database we used in this study was a secondary database, and we did not have original charts to review; however, the validity of the database was analyzed and published in a previous study.[29] Third, complications were recorded based on the claims database, and the complication rates may have been overestimated because it could not be determined if the complications were directly associated with aortic repair. The complications may also have been underestimated because the claims database is limited to five diagnostic codes in the reimbursement application. If many complications occurred during the reimbursement application period, some complications, especially minor ones, may not have been recorded. However, because this potential overestimation applied to both repair groups, the comparison results between the two groups may still be valid. Fourth, we acknowledge that baseline hemostatic status parameters such as the blood pressure and fluid status were not available in this study. Moreover, patients with unstable vital signs tend to favor endovascular repair, increasing the mortality of TEVAR because of the bias of the baseline fluid status and thus minimizing the differences in the observed results in our study. However, our results still showed that the risks of short- and midterm mortality with TEVAR were lower than those with open repair.

In conclusion, TEVAR for type B aortic dissection showed less perioperative mortality, higher survival rates, shorter lengths of stay, higher midterm survival rates, and fewer wound and graft complications than open repair in this nationwide longitudinal cohort study.

Appendix 1. Comparison of outcomes after thoracic endovascular aortic repair between current and previous studies.

Authors	Perioperative mortality (%)	Survival	Morbidity (%)				Complications (%)		Length of stay (d)
			Respiratory failure	Acute renal failure	Stroke	Paralysis	Wound	Reintervention	
Conrad et al[2]	9.1	58% at 5 y	—	—	—	—	—	—	11.5
Kato et al[17]	5.3	92% at 1 y	5.3	—	2.6	2.8	2.6	13.2	—
Hanna et al[28]	0	84% and 84% at 5 y and 7 y, respectively	8.0	4.0	2.0	2.0	—	26.0	5
Xu et al[14]	1.2	84% at 5 y	—	4.5	—	—	—	4.8	10
Andersen et al[13]	4.0	86% and 65% at 1 y and 5 y, respectively	2.7	4.0	0	0	—	24.0	4
Current study	2.6	92%, 86%, 82%, and 79% at 1 y, 2 y, 3 y, and 4 y, respectively	6.8	5.1	1.7	0.9	0	4.2	20

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