

## CLINICAL RESEARCH

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# Treatment of Acute Type-B Aortic Dissection

## Thoracic Endovascular Aortic Repair or Medical Management Alone?

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**Objectives** This study sought to evaluate the early and long-term effect of thoracic endovascular aortic repair (TEVAR) on type-B acute aortic dissection (AAD).

**Background** Uncomplicated type-B AAD is generally treated with medical management; complicated dissections require surgery or TEVAR. Studies have demonstrated that long-term outcomes with medical management are suboptimal. Therefore, we sought to determine the long-term effect of TEVAR compared with medical management alone on type-B AAD.

**Methods** From January 2004 to May 2008, 193 consecutive patients in 2 hospitals were treated and retrospectively placed into 1 of 2 groups: 1) the TEVAR group—type-B AAD treated with TEVAR and antihypertensive medications (n = 152); and the 2) medicine group—uncomplicated type-B AAD treated medically alone (n = 41). All TEVAR procedures were performed in the acute phase.

**Results** There were no significant differences in demographics, comorbidity profiles, or early events between groups. The cumulative freedom from all late adverse events at 1, 3, and 5 years was 97%, 89%, and 67% in the TEVAR group and 97%, 63%, and 34% in the medicine group. Log-rank tests showed that medically treated patients had more late adverse events than TEVAR-treated patients did (p = 0.003). The 5-year cumulative survival rate from all-cause death was not significantly different between the 2 groups.

**Conclusions** Patients with type-B AAD treated with TEVAR experienced fewer late adverse events than those treated with medical management, but there was no significant difference among the groups in 5-year mortality rates. Further studies of longer-term survival rates are needed to determine whether TEVAR could be an effective treatment for type-B AAD. (J Am Coll Cardiol Intv 2013; 6:185–91) © 2013 by the American College of Cardiology Foundation

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Type-B acute aortic dissection (AAD) is a life-threatening condition that is associated with high morbidity and mortality (1,2). Complicated type-B AAD is defined as dissection associated with rupture, malperfusion syndromes, refractory pain, or rapid aortic expansion at onset or during the hospital stay (3). Uncomplicated type-B AAD is defined as dissection without the aforementioned complications at presentation (4). Despite advances in cardiovascular surgery, rates of post-operative complications and mortality remain high for patients with complicated type-B AAD (3,5). Since thoracic endovascular aortic repair (TEVAR) was first introduced by Dake et al. (6), this procedure has been shown to be a safe alternative to surgery for complicated type-B AAD (2,6). For patients with uncomplicated type-B AAD, medical management alone has been widely accepted as the standard treatment; however, this treatment course has been shown to lead to less than optimal long-term outcomes, with an overall survival rate of 60% at 5 years (7). The exact effect of TEVAR on patients with type-B AAD remains unclear or controversial (8,9).

In this retrospective study, we attempted to evaluate the role of TEVAR in treating type-B AAD by analyzing the early and late morbidity and mortality associated with this procedure and comparing them with outcomes associated with medical therapy.

#### Abbreviations and Acronyms

**AAD** = acute aortic dissection

**LCCA** = left common carotid artery

**SBP** = systolic blood pressure

**TEVAR** = thoracic endovascular aortic repair

#### Methods

**Study design.** Two tertiary medical centers participated in

this study, which was approved by the research ethics committees of both hospitals.

All cases of type-B AAD were identified retrospectively through a review of the hospital admitting notes and radiology departmental procedural logs. Information about baseline characteristics (including age; sex; and history of peripheral arterial disease, hypertension, smoking, diabetes mellitus, renal insufficiency, and coronary artery disease) was collected from the medical records and outpatient clinic notes. Images were retrieved from the imaging archiving system, including initial diagnostic and follow-up computed tomography angiography scans.

Patients were excluded if TEVAR was performed during the chronic phase ( $\geq 14$  days), or if they had aortic dissection secondary to trauma, intramural hematoma, complete thrombosis in false lumen on admission, or Marfan syndrome. For all eligible patients, the thrombosis status of the false lumen was evaluated with computed tomography angiography (10).

**Treatment groups.** Patients were categorized into 1 of 2 groups on the basis of treatment: 1) the TEVAR group—

type-B AAD (both complicated and uncomplicated) treated with TEVAR and antihypertensive medications; and 2) the medicine group—uncomplicated type-B AAD treated with medical management exclusively.

**TEVAR and adjunctive procedures.** TEVAR was performed in all patients in the TEVAR group according to the procedure described by Dake et al. (11). When the primary tear was close to the left subclavian artery and/or the left common carotid artery (LCCA), the origins of the left subclavian artery and/or the LCCA were covered by the stent graft. Debranching of the CCA was performed before the procedure by a right CCA–LCCA bypass. An LCCA–left subclavian artery bypass was performed either immediately before or after the TEVAR on the basis of radiographic assessments of vertebrobasilar circulation. Adjunctive stenting of visceral branches and iliac arteries was performed for static malperfusion when it was deemed necessary on the basis of angiographic evaluation after deployment of the thoracic stent graft.

**Medical management.** Patients in medicine group were treated with medical management only. Antihypertensive medications (calcium-channel blockers, nitroglycerin, beta-blockers, or a combination) were also administered in all patients (TEVAR and medicine group) with a systolic blood pressure (SBP)  $>120$  mm Hg at presentation. The initial goals for medical therapy were to reduce SBP to 100 to 120 mm Hg and to relieve pain. If chest pain was persistent, a non-narcotic analgesic (buprenorphine hydrochloride) or narcotic analgesic (morphine hydrochloride) was administered intravenously in all patients (TEVAR and medicine group).

After discharge, all patients (TEVAR and medicine group) with hypertension required treatment with calcium antagonists, angiotensin-converting enzyme inhibitors, angiotensin-receptor blockers, or beta-blockers, either alone or in combination, to maintain morning SBP  $<140$  mm Hg.

**Definitions.** Primary technical success of TEVAR was defined as closure of the primary tear without endoleak and successful aortic debranching and/or reperfusion of previously ischemic visceral/renal territory or lower extremity arteries in complicated dissections immediately after TEVAR.

In this study, an early event was defined as an event (progression of dissection, death, organ failure, stroke, paraplegia, or endoleak) that occurred within 30 days after the initial treatment. A late event was defined as an event associated with the dissection that occurred  $>30$  days after the initial treatment. Late events included rupture, aortic enlargement ( $>60$  mm), retrograde dissection, endoleak, ulcerlike projection (defined as a localized blood-filled pouch protruding from the true lumen into the thrombosed false lumen of the aorta [12]), and late death related to these complications. Endoleaks were reported according to the standard established by Chaikof et al. (13).

**Statistical analysis.** Significant difference in variables between groups was determined with the Fisher exact test for categor-

ical variables and the *t* test for continuous variables. Kaplan-Meier analysis was used to estimate freedom from late events and survival, with log-rank tests used to discriminate between Kaplan-Meier curves. All statistical tests were 2-sided with a 0.05 level of significance. Statistical analyses were performed using SPSS software (version 13.0, SPSS, Inc., Chicago, Illinois).

## Results

**Baseline characteristics.** Between January 2004 and May 2008, 213 consecutive patients with type-B AAD, including 101 complicated and 112 uncomplicated type-B AAD cases, were admitted to the 2 medical centers. Among the 213 patients, 193 patients were included in this study. TEVAR were performed in 152 patients with type-B AAD (TEVAR group) for rupture (hemothorax, *n* = 18; hemo-mediastinum, *n* = 12), malperfusion (acute limb ischemia, *n* = 6; intestinal ischemia, *n* = 3; renal ischemia, *n* = 11; celiac trunk ischemia, *n* = 2; multiple branches involved, *n* = 3), persistent pain (*n* = 18), acute dilation of false lumen (*n* = 20), uncontrollable hypertension (*n* = 7), retrograde dissection into the ascending aorta (*n* = 8), more than 1 indication (*n* = 29), and patient's preference (*n* = 15). The baseline characteristics and comorbidity profiles were evenly distributed between 2 groups (Table 1). In TEVAR group patients, there were more extensive dissections (below the orifice of the celiac trunk) than there were in medicine group patients (*p* = 0.006). The distribution of

	TEVAR Group ( <i>n</i> = 152)	Medicine Group ( <i>n</i> = 41)	<i>P</i> Value
<b>Demographics</b>			
Age at intervention, yrs	63.61 ± 9.61	66.93 ± 12.35	0.067
Male	137 (90.1)	37 (90.2)	0.624
<b>Comorbidities</b>			
Peripheral arterial disease	78 (51.3)	22 (53.7)	0.465
Hypertension	108 (71.1)	26 (63.4)	0.225
Smoking	49 (32.2)	17 (41.5)	0.178
Diabetes mellitus	16 (10.5)	7 (17.1)	0.188
Renal insufficiency	5 (3.3)	4 (9.8)	0.098
Coronary arterial disease	50 (32.9)	11 (26.8)	0.294
<b>Extent of dissection</b>			
Confined in thoracic aorta	25 (16.4)	15 (36.6)	0.006
Extended to abdominal aorta	127 (83.6)	26 (63.4)	
<b>False lumen patency</b>			
Patent false lumen	102 (67.1)	30 (73.2)	0.294
Partial thrombosis in false lumen	50 (32.9)	11 (26.8)	
Values are mean ± SD or <i>n</i> (%).			
TEVAR = thoracic endovascular aortic repair.			

	TEVAR Group	Medicine Group
<b>Early events</b>		
Retrograde dissection	2	0
Organ failure	1	0
Stroke	2	0
Paraplegia	2	0
Type-I endoleak	4	0
<b>Aortic-related late events*</b>		
Rupture	4	2
Retrograde dissection	3	2
Aortic enlargement	19	6
Ulcerlike projection	0	4
Type-I endoleak	3	0
Type-II endoleak	2	0
<b>Late death</b>		
Aortic-related	3	1
Aortic-unrelated	9	2
Unknown	6	1
*Thirty-one aortic-related late events occurred in 26 patients treated with TEVAR. TEVAR = thoracic endovascular aortic repair.		

the patent false lumen was not significantly different among the groups (*p* = 0.294).

**TEVAR and adjunctive procedures.** Primary technical success of TEVAR was achieved in 144 (94.7%) cases in the TEVAR group: 2 TEVAR procedures were converted to surgery because of a retrograde type-A dissection; type-I endoleak was confirmed by angiography after TEVAR in 4 patients; and in 2 patients, there was failure in stenting because of static malperfusion (celiac trunk in 1 patient and left renal artery in 1 patient). In the TEVAR group, 10 visceral branches and 2 iliac arteries with static malperfusion were identified after deployment of a stent graft and were appropriately stented. No secondary interventional or surgical procedures were required in the remaining cases within 30 days after TEVAR.

**Medical management.** Among the 193 qualified patients, 134 (69.4%) patients (TEVAR group, *n* = 108; medicine group, *n* = 26) had elevated SBP. In all of these patients, SBP was lowered to <120 mm Hg with medication during hospitalization. After discharge, clinic visits ensured that all patients were receiving oral antihypertensive medications, and BP was controlled to approximately 120/80 mm Hg for the first month and <140/90 mm Hg thereafter.

**Early events.** Early events included retrograde dissection, organ failure, stroke, paraplegia, type-I endoleak, and 30-day mortality (Table 2). Patients in TEVAR group had significantly longer hospital stays than those in medicine group did (16.84 vs. 13.10 days, respectively; *p* = 0.002).

Patients in the TEVAR group also had a higher incidence of early events than those in medicine group did (7.2% vs. 0%, respectively), although this difference was not significant

	TEVAR Group	Medicine Group	p Value
Hospital stay, days	16.84 ± 6.49	13.10 ± 3.80	0.002
Follow-up time, months	45.3 ± 16.4	40.6 ± 15.7	0.957
Early events	11/152	0/41	0.125
30-day death	3/152	0/41	1.000
Aortic-related late events	26/149	14/41	0.029
Late death	18/149	4/41	0.790

Values are mean ± SD or n/N.  
TEVAR = thoracic endovascular aortic repair.

(Table 3). In the TEVAR group, 1 patient had persistent chest pain after TEVAR; this patient underwent immediate surgical conversion with ascending aortic replacement for retrograde dissection with a favorable outcome. Two patients had a transient stroke and completely recovered before discharge. Two patients experienced temporary paraplegia, which resolved after cerebrospinal fluid drainage. Minor type-I endoleak was seen in 4 patients immediately after stent graft angiography; continued observation was permitted.

The 30-day mortality rate was 2.0% (3 of 152) for TEVAR group patients versus 0% for patients in the medicine group (Table 3). One patient died of cardiac arrest when TEVAR was converted to open surgery for a retrograde dissection. A second patient presented with right limb ischemia and acute renal failure on admission and died of multiorgan failure on day 6 after TEVAR. A third patient presented with hemothorax and died of an acute stroke at 12 days after TEVAR.

**Late events.** Late events included aortic rupture, retrograde dissection, aortic enlargement, type-I and -II endoleaks, ulcerlike projection, and late death (Table 2). Follow-up was available for all 190 survivors, with an average follow-up time of 44.3 ± 16.3 months. A total of 22 deaths were reported among these patients (Table 2). There were 4 late aortic-related deaths: 3 patients had ruptured false lumen on the descending aorta at 32, 32, and 57 months, respectively; and 1 patient died of infrarenal false lumen rupture at 41 months. A total of 11 deaths were classified as unrelated to the dissection (cardiac-related deaths, n = 5; cancer-related deaths, n = 3; pulmonary infection-related deaths, n = 2; death caused by traffic accident, n = 1). The etiology in the other 7 deaths could not be determined.

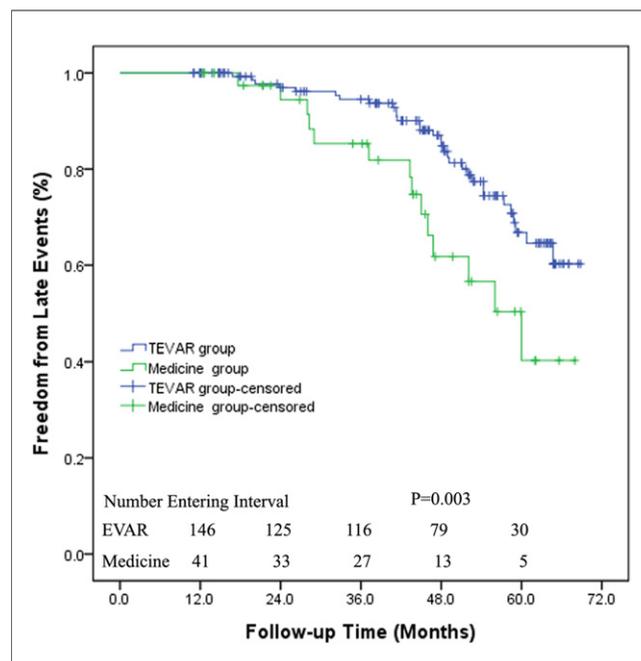
The cumulative freedom from all late events at 1, 3, and 5 years was 97%, 89%, and 67% in the TEVAR group and 97%, 63%, and 34% in the medicine group. Log-rank tests demonstrated that patients treated with medical management had significantly more late adverse events than did those treated with TEVAR (p = 0.003) (Fig. 1).

The cumulative survival rates from all-cause death at 1, 3, and 5 years were 100%, 93%, and 66% in the TEVAR group and 100%, 89%, and 59% in the medicine group. Log-rank tests did not demonstrate significant differences between the

2 groups (p = 0.735) (Fig. 2A). Additionally, no significant difference was found between the 2 groups in cumulative survival from aortic-related death (p = 0.667) (Fig. 2B). The cumulative survival rates from aortic-related and unknown death at 3 and 5 years were 94% and 89% in the TEVAR group and 95% and 63% in the medicine group, respectively (p = 0.896) (Fig. 2C).

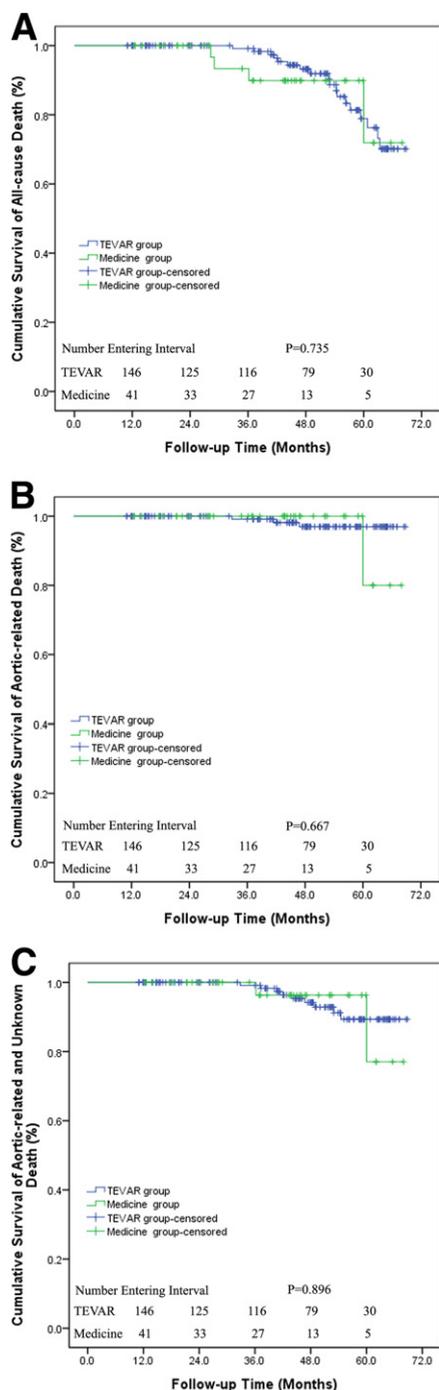
## Discussion

Type-B AAD is a life-threatening condition; however, with the initiation of aggressive antihypertensive management and endovascular therapy, the morbidity and mortality rates for type-B AAD have decreased significantly over the past decade (14–16). The consensus is that uncomplicated type-B AAD requires only conservative therapy (medical management) (15) and that patients with complicated dissections should undergo either TEVAR or surgical repair (2,3,11,14,17). TEVAR has become an attractive alternative to surgery in recent years, with major in-hospital complication rates ranging from 3.4% (18) to 11.1% (19,20), compared with a complication rate of 40% with surgery (3). Meanwhile, the 5-year complication rate for patients with uncomplicated type-B AAD who are treated with medical management can be as high as 50% (21). This raises questions regarding the effectiveness of the current standard therapy for managing type-B AAD.



**Figure 1. Kaplan-Meier Curves of Freedom From Late Events After TEVAR of Type-B AAD**

Patients were subdivided into 2 groups (thoracic endovascular aortic repair [TEVAR] group vs. medicine group), and the cumulative freedom from all post-procedure events was analyzed. AAD = acute aortic dissection.



**Figure 2.** Kaplan-Meier Curves of Cumulative Survival Rate After TEVAR of Type-B AAD

(A) Log-rank test did not demonstrate significant differences between 2 groups in the cumulative survival rate from all-cause related death. (B) Cumulative survival rate from aortic-related death was not significantly different among the groups. (C) Cumulative survival rate from aortic-related and unknown death was not significantly different among the groups. Abbreviations as in Figure 1.

In this study, early event rates in the TEVAR and medicine groups were 7.2% and 0%, respectively. In previous studies, the early event rate in patients with complicated type-B AAD who were treated with TEVAR has ranged from 2.4% to 33.3% (8,18,19,21,22). However, most of these early events were minor and transient, and continued observation was permitted. The early event rate in patients with uncomplicated type-B AAD who are treated with TEVAR remains largely unknown. The only data available are from a study by Nienaber et al. (14), in which both acute and chronic uncomplicated type-B dissections were treated with TEVAR. The early event rate in these patients was 8.3%. No early events occurred in patients with type-B AAD who were treated with medical management. These results are consistent with those of previous studies, which reported early event rates of 0% to 10% in patients with uncomplicated type-B AAD who were treated with medical therapy (23–25).

Three (2.0%) early deaths occurred in this study, all in patients with complicated type-B AAD. In previous studies, the rate of early death in patients with complicated type-B AAD treated with TEVAR has ranged from 3% to 13.3% (8,21,22,26–30). In this study, no early deaths occurred in patients in the medicine group; we attributed this to the effectiveness of aggressive antihypertensive management of uncomplicated type-B AAD. These results are consistent with those previously reported in the literature (6,24,25,31).

To assess late events, we used the outcome “freedom from all aortic-related late events.” We chose this outcome rather than “freedom from reintervention,” the outcome widely used in previous studies (17,29,32), because not all aortic-related late events need emergent reinterventions and not all patients with aortic-related late events are willing to accept reintervention. Patients treated with medical management (the medicine group) experienced more late adverse events than patients treated with TEVAR; aortic enlargement (14.6%) and ulcerlike projection (9.8%) were the most common findings in medicine group patients. Aortic enlargement is associated with rupture of the aorta in patients with uncomplicated type-B AAD who are treated with medical therapy only (23,33) and is therefore an important late adverse event (34–37). Ulcerlike projection is generally thought to represent the site of an intimal disruption during the follow-up period and may be considered a new intimal disruption (12). Development of ulcerlike projections in patients with type-B AAD is associated with lower survival and event-free rates and is an important risk factor for late aorta-related events (38,39).

Previous studies in patients with type-B AAD treated with TEVAR have reported 1- and 5-year overall survival rates of 82% and 79% (8), 81% and 76% (21), and 82% and 78% (39), respectively. Overall survival rates in patients with type-B AAD treated with medical management have been described as 95.7% and 90.9% at 1 and 5 years (40), 77.6%

at 3 years (41), and 82% and 69% at 5 and 10 years (42), respectively. Aortic rupture is the main cause of aortic-related late death after TEVAR, comprising 50% to 100% of all causes of death (14,43-47). In the longest follow-up to date of overall survival in patients with type-B AAD treated with medical management, overall survival rates of 35% and 17% at 10 and 15 years, respectively, were reported (48); aortic-related risk factors for late death included false lumen patency, arch involvement, and rupture (10,48,49). The aortic-related deaths in our series were all the result of aortic rupture. There were also 7 deaths of unknown etiology that occurred during follow-up; we cannot exclude the possibility that these deaths may have been the result of aortic-related events, such as retrograde type-A aortic dissection. Therefore, the cumulative survival rate free from both aortic-related and unknown deaths was analyzed, and there was no significant difference between 2 groups at 3 and 5 years. Nienaber et al. (14) previously reported 2-year survival rates in mixed acute and chronic uncomplicated type-B aortic dissection cases treated with TEVAR or medical management; to our knowledge, this is the only study in the literature that assessed the use of TEVAR for uncomplicated type-B aortic dissection.

**Study limitations.** This study was retrospective in nature which is less strong compared with a prospective, randomized controlled study. The baseline differences between 2 groups may have influenced results, as some are close to significant. Additionally, the study was performed across 2 institutions that may have varied in their management of cases, including TEVAR procedure and medical therapy regimens. Although both institutions agreed to the study's inclusion criteria, there may have been a selection bias for TEVAR in patients with uncomplicated dissection. In addition, a range of stent grafts were used in this study on the basis of local preference and availability.

## Conclusions

This study demonstrated a favorable late adverse event profile for patients with type-B AAD who were treated with TEVAR compared with those treated with medical management alone. However, there was no significant difference between the groups in 5-year mortality rates, suggesting that further investigation of long-term survival rates is necessary to determine whether TEVAR is a better alternative for the treatment of type-B AAD than medical management.

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