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ABSTRACT

Background. Acute type B aortic dissection (TBAD) is catastrophic event associated with significant mortality and lifelong morbidity. The optimal treatment strategy of TBAD is still controversial. *Methods.* This analysis includes patients treated for TBAD at the Helsinki University Hospital, Finland in 2007–2019. The endpoints were early and late mortality, and intervention of the aorta. *Results.* There were 205 consecutive TBAD patients, 59 complicated and 146 uncomplicated patients (mean age of 66 ± 14, females 27.8%). In-hospital and 30-day mortality rates were higher in complicated patients compared with uncomplicated patients with a statistically significant difference ($p = 0.035$ and $p = 0.015$, respectively). After a mean follow-up of 4.9 ± 3.8 years, 36 (25.0%) and 22 (37.9%) TBAD-related adverse events occurred in the uncomplicated and complicated groups, respectively ($p = 0.066$). Freedom from composite outcome was $83 \pm 3\%$ and $69 \pm 6\%$ at 1 year, $75 \pm 4\%$ and $63 \pm 7\%$ at 5 years, $70 \pm 5\%$ and $59 \pm 7\%$ at 10 years in the uncomplicated group and in the complicated group, respectively ($p = 0.052$). There were 25 (39.1%) TBAD-related deaths in the overall series and prior aortic aneurysm was the only risk factor for adverse aortic-related events in multivariate analysis (HR 3.46, 95% CI 1.72–6.96, $p < 0.001$). *Conclusion.* TBAD is associated with a significant risk of early and late adverse events. Such a risk tends to be lower among patients with uncomplicated dissection, still one fourth of them experience TBAD-related event. Recognition of risk factors in the uncomplicated group who may benefit from early aortic repair would be beneficial.

Introduction

Aortic dissection is a life-threatening condition with increasing prevalence in western countries [1]. 67% of aortic dissections are of type A, and the remaining 33% are of type B (TBAD) [2]. The Stanford classification defines a type B dissection as an intimal tear sited distal to the left subclavian artery and directing blood flow between intima and media layers resulting into true and false lumens. TBAD can be classified as hyperacute, acute, subacute, or chronic depending on the time interval from the onset of symptoms [3].

The initial treatment of acute TBAD includes treatment of arterial hypertension and relieving pain in order to decrease dissected aortic wall stress. A recent meta-analysis, summarized drawbacks of the conservative treatment including sudden death, increased risk of disease progression, and the need of late intervention for aortic dissection-related events [3]. European guidelines on the treatment of TBAD defined this condition as complicated

if medical therapy fails or there are signs of aortic rupture, progression of dissection, or malperfusion of distal aortic branches, that is, visceral, renal, lower limb arteries [4–6]. The latter conditions indicate early surgical or endovascular interventions to decrease the risk of mortality.

The shift from medical and surgical treatment towards endovascular or hybrid treatment during the past decade has been depicted by the IRAD investigators [2]. Nowadays, thoracic endovascular aortic replacement (TEVAR) for complicated TBAD is recommended by international guidelines with promising long-term survival [6–8]. In addition, a recent study suggested that TEVAR may be a beneficial prophylactic therapy for uncomplicated TBAD patients in the acute phase to improve freedom from aortic intervention [9].

The aim of the present study was to evaluate the early and late outcomes of patients treated at a tertiary referral center with uncomplicated and complicated TBAD patients.

Materials and methods

Two-hundred and five consecutive patients were managed as acute TBAD from January 2007 to December 2019 at the Helsinki University Hospital, Finland. The Institutional Review Board gave the permission to conduct this study. The Helsinki University Hospital is the largest of five tertiary-level centers in Finland providing hospital care for over 2.2 million residents. This is the only hospital providing care for patients with aortic diseases and therefore, the present series is representative of all TBAD cases occurred in our catchment area during the study period. During the study period the European definition criteria of complicated and uncomplicated TBAD patients were applied [4]. All the patients received first medical therapy, and invasive treatment of TBAD was performed if there were signs of complications. The uncomplicated TBAD patients did not receive scheduled delayed TEVAR.

Data were retrospectively collected into an electronic datasheet with prespecified variables and underwent review of radiological and clinical data for completeness and consistency. Data on the date and causes of death was retrieved from the national registry Statistics Finland, which collects this information from local authorities. The most recent causes of death were classified as unknown when they were not available from this registry. TBAD-related deaths included patients which had the main cause of death dissection or dissection was contributing factor in the process, whereas cardiovascular deaths were other than dissection-related deaths i.e. myocardial infarction.

Statistical analysis

Statistical analyses were performed using SPSS statistical software (IBM SPSS Statistics, version 26.0 IBM Corp., Armonk, NY). Categorical data are reported in counts (n) and percentages (%), and continuous variables are reported as means and standard deviation. Categorical data was tested using the Pearson's X^2 test or Fisher's exact test, whereas continuous variables were analyzed using the Mann-Whitney U test. Survival as well as freedom from adverse events were estimated using the Kaplan-Meier methods with the log-rank test. A backward stepwise regression model was used to identify risk factors affecting late outcomes. Adjusted risk estimated was reported as hazard ratio (HR) with 95% confidence interval (CI). Statistical significance was set at p less than 0.05.

Results

Two-hundred and five consecutive patients (mean age 67 ± 14, females 27.8%) were treated during the study period for acute TBAD and included in the analysis after careful radiological and clinical evaluations. There were 146 uncomplicated and 59 complicated TBAD patients. Demographics of patients with acute TBAD are summarized in Table 1. Complicated TBAD patients were significantly younger (mean age, 64 ± 13 vs. 68 ± 14, $p = 0.038$) and had more often bicuspid aortic valve (6.8 vs. 0.7%, $p = 0.025$) compared with uncomplicated patients.

Uncomplicated TBAD patients were conservatively treated with intravenous administration of antihypertensive and analgetic drugs followed by gradual oral administration during the follow-up at the hospital. Whereas the majority of complicated TBAD patients underwent aortic intervention during the initial hospital stay (Table 2). In the complicated group, 12 patients (20.3%) were conservatively treated after careful clinical evaluation or patients refused from invasive interventions. Malperfusion ($n = 23$, 39.0%) was the most common indication for early intervention followed by progression of aortic dissection ($n = 11$, 18.6%) and aortic rupture ($n = 10$, 16.9%). There were 23 surgical procedures and 26 underwent TEVAR treatments which was associated with carotid-subclavian bypass in six cases. After 2008, TEVAR was more common compared with open thoracic aortic surgery. Whereas open fenestration was the most common surgical aortic procedure and regularly performed during the years 2007–2015 (Table 2).

In-hospital mortality (10.2% vs. 2.7%) and 30-day mortality (11.9% vs. 2.7%) rates were also higher among the complicated acute type B dissection patients compared with the uncomplicated patients ($p < 0.05$). Cause of early death was TBAD-related in all patients but one who died of cardiovascular event. Hospital and ICU stays were significantly longer in the complicated TBAD group compared with the uncomplicated group ($p < 0.05$).

Spinal ischemia deficit was detected in five (8.5%) complicated patients when admitted to the hospital. Two of these patients resolved their paraparesis over the follow-up. During the initial hospital stay, two additional patients experienced spinal ischemia: one patient with permanent symptoms in a complex TEVAR and surgical abdominal aorta procedure, and the other patient with temporary symptoms after TEVAR.

The mean follow-up time was 4.9 ± 3.8 years. Despite a significant difference in early mortality, late all-cause mortality and TBAD-related mortality did not differ between the study groups. The most common causes of death were TBAD-related death along with cancer and cardiovascular diseases in both study groups. Additionally, a significant number of patients died of neurological diseases (19.5%), including acute and chronic neurological causes, in the uncomplicated group, whereas renal failure was the cause of death in 8.7% in the complicated group (Tables 3 and 4).

Survival was 91 ± 2% at 1 year, 74 ± 4% at 5 years, and 64 ± 5% at 10 years in the uncomplicated group, whereas in the complicated group survival was 83 ± 5% at 1 year, 60 ± 7% at 5 years, and 42 ± 11% at 10 years ($p = 0.102$, Figure 1). Freedom from the composite TBAD-related outcome was 83 ± 3% and 69 ± 6% at 1 year, 75 ± 4% and 63 ± 7% at 5 years, 70 ± 5% and 59 ± 7% at 10 years in the uncomplicated group and in the complicated group, respectively ($p = 0.052$, Figure 2). In univariate analysis age above 65 years (HR 2.68, 95% CI 1.50–4.80), female gender (HR 1.97, 95% CI 1.18–3.29), preoperative cerebrovascular event (HR 2.37, 95% CI 1.12–5.00), hypertension (HR 2.13, 95%

Table 1. Demographics of acute type B dissection patients.

	All patients $n = 205$	Uncomplicated type B group $n = 146$	Complicated type B group $n = 59$	p-Value	Missing data (n)
Age (years)	67 ± 14	68 ± 14	64 ± 13	**0.038**	
BMI (kg/m^2)	28 ± 6	28 ± 6	27 ± 4	0.749	67
Female	57 (27.8%)	43 (29.5%)	14 (23.7%)	0.408	
Hypertension	127 (62.0%)	89 (61.0%)	38 (64.4%)	0.645	
CAD	33 (16.1%)	23 (15.8%)	10 (16.9%)	0.833	
Extracardiac arteriopathy	15 (7.3%)	13 (8.9%)	2 (3.4%)	0.240	
DM				**0.028**	
NIDD	15 (7.3%)	7 (4.8%)	8 (13.6%)		
IDD	3 (1.5%)	1 (0.7%)	2 (3.4%)		
Pulmonary disease	22 (10.7%)	17 (11.6%)	5 (8.5%)	0.507	
Smoking				0.323	
Current smoker	60 (29.3%)	47 (32.2%)	13 (22.0%)		
Ex-smoker	28 (13.7%)	20 (13.7%)	8 (13.6%)		
Non-smoker	117 (57.1%)	79 (54.1%)	38 (64.4%)		
Bicuspic aortic valve	5 (2.4%)	1 (0.7%)	4 (6.8%)	**0.025**	
Connective tissue disease					
Marfan's disease	12 (5.9%)	9 (6.2%)	3 (5.1%)	1.00	
Ehlers-Danlos disease	1 (0.5%)	0 (0.0%)	1 (1.7%)	0.288	
Loeys-Dietz syndrome	0 (0%)	0 (0.0%)	0 (0.0%)	…	
Preoperative cerebrovascular accident					
Prior Stroke	12 (5.9%)	9 (6.2%)	3 (5.1%)	1.00	
Prior TIA	4 (2.0%)	4 (2.7%)	0 (0.0%)	0.580	
Laboratory markers					
Creatinine (μmol/L)	84 ± 36	80 ± 23	96 ± 55	**0.039**	6
eGFR (mL/min/1.73 m^2)	88 ± 28	89 ± 26	84 ± 32	0.125	6
Hemoglobin (g/L)	132 ± 17	132 ± 15	133 ± 20	0.609	6
Platelets (10^9/L)	209 ± 79	209 ± 71	209 ± 95	0.644	7
C-reactive protein (mg/L)	8 [3-69]	6 [3-63]	27 [5-109]	**0.022**	9
Leukocytes (10^9/L)	10.1 ± 3.6	9.6 ± 3.0	11.2 ± 4.6	**0.017**	7
Prior Aorta Aneurysm				0.400	
Ascending aorta	13 (6.3%)	10 (6.8%)	3 (5.1%)		
Aortic arch	1 (0.5%)	1 (0.7%)	0 (0.0%)		
Descending aorta	4 (2.0%)	3 (2.1%)	1 (1.7%)		
Abdominal aorta	10 (4.9%)	9 (6.2%)	1 (1.7%)		
Combination of aneurysms	12 (5.9%)	7 (4.8%)	5 (8.5%)		
Previous Aortic Surgery				0.206	
-Ascending aorta	6 (2.9%)	3 (2.1%)	3 (5.1%)		
-Abdominal aorta	11 (5.4%)	10 (6.8%)	1 (1.7%)		
-Ascending and abdominal aorta	3 (1.5%)	2 (1.4%)	1 (1.7%)		
-Descending and abdominal aorta	1 (0.5%)	0 (0.0%)	1 (1.7%)		
Previous aortic stentgrafting	1 (0.5%)	0 (0.0%)	1 (1.7%)	0.288	
Previous Cardiac surgery	14 (6.8%)	8 (5.5%)	6 (10.2%)	0.234	
Prior PCI	14 (6.8%)	9 (6.2%)	5 (8.5%)	0.550	
Prior arterial catherization	15 (7.3%)	9 (6.2%)	6 (10.2%)	0.375	

Data are reported as counts and percentages in parentheses. Continuous variables are reported as mean and standard deviation or median and interquartile range. Significance values are in bold.
BMI: body mass index; CAD: coronary artery disease; DM: diabetes mellitus; eGFR: estimated glomerular filtration rate; IDD: insulin-dependent diabetes; NIDD: non-insulin dependent diabetes; PCI: percutaneous coronary intervention; TIA: transient ischemic attack.

CI 1.20–3.77), extracardiac arteriopathy (HR 3.65, 95% CI 1.70–7.82), and previous aortic surgery (HR 1.19, 95% CI 1.03–1.36) were associated with increased early and late mortality after TBAD. In multivariate analysis, age above 65 years (HR 2.52, 95% CI 1.40–4.55) and extracardiac arteriopathy (HR 2.52, 95% CI 1.14–5.57) were the independent predictors of mortality (Supplementary Table 3).

During the follow-up, aneurysmal degeneration was detected in about 20% of the patients in both study groups. There were 25 (17.1%) late aortic interventions in the uncomplicated group, and 14 (23.7%) late aortic interventions in the complicated group ($p = 0.275$). Overall, 35 (17.1%) procedures were performed for TBAD-related events. Reinterventions on the aorta were most often performed in patients primarily treated with an invasive procedure. During the follow-up, only one patient required open thoracic surgery among patients who underwent primary surgical fenestration. The mean interval for the first TBAD -related intervention was

1.0 ± 1.5 years, 0.9 ± 1.4 in the uncomplicated group and 1.1 ± 1.6 in the complicated group ($p = 0.511$). Composite outcome was defined as TBAD-related death or TBAD-related intervention or re-intervention during the follow-up time. There were 22 (37.9%) composite adverse events in the complicated TBAD group compared with 36 (25.0%) in the uncomplicated group, a difference which did not reach statistical significance ($p = 0.066$, Table 4).

Connective tissue disorder (HR 5.76, 95% CI 2.69–12.38, $p < 0.001$) and prior aortic aneurysm (HR 2.85, 95% CI 1.43–5.67, $p = 0.003$) were risk factors for TBAD-related aortic events in univariate analysis. Age above 65 years was a protective factor for TBAD-related aortic event both in univariate (HR 0.33, 95% CI 0.17–0.67, $p = 0.002$) and in multivariate analysis (HR 0.29, 95% CI 0.14–0.58, $p = 0.001$) analyses. In addition, prior aortic aneurysm was an independent risk factor in multivariate analysis (HR 3.46, 95% CI 1.72–6.96, $p < 0.001$, Supplementary Tables 1 and 2).

Table 2. Clinical characteristics of acute type B dissection patients.

	All patients n = 205	Uncomplicated type B group n = 146	Complicated type B group n = 59	p-Value	Missing data (n)
Clinical characteristics					
-Chest/Back pain	184 (89.8%)	129 (88.4%)	55 (93.2%)	0.298	
-Hypotension/Shock	7 (3.4%)	0 (0.0%)	7 (11.9%)	**<0.05**	
-Neurological deficit	7 (3.4%)	0 (0.0%)	7 (11.9%)	**<0.05**	
-Clinical malperfusion	28 (13.7%)	0 (0.0%)	28 (47.5%)	**<0.05**	
-Iatrogenic dissection	3 (1.5%)	2 (1.4%)	1 (1.7%)	1.00	
Radiological malperfusion	29 (14.1%)	0 (0.0%)	29 (49.2%)	**<0.05**	
-Celiac trunk malperfusion	3 (1.5%)	0 (0.0%)	3 (5.1%)	**<0.05**	
-SMA malperfusion	13 (6.3%)	0 (0.0%)	13 (22.0%)	**<0.05**	
-IMA malperfusion	1 (0.5%)	0 (0.0%)	1 (1.7%)	0.288	
-Renal malperfusion l.sin.	14 (6.8%)	0 (0.0%)	14 (23.7%)	**<0.05**	
-Renal malperfusion l.dx.	14 (6.8%)	0 (0.0%)	14 (23.7%)	**<0.05**	
-Limb malperfusion l.sin.	1 (0.5%)	0 (0.0%)	1 (1.7%)	0.288	
-Limb malperfusion l.dx.	8 (3.9%)	0 (0.0%)	8 (13.6%)	**<0.05**	
Pseudoaneurysm	0 (0.0%)	0 (0.0%)	0 (0.0%)	…	
PAU	22 (10.7%)	12 (8.2%)	10 (16.9%)	0.067	
Atherosclerosis	167 (82.7%)	119 (83.2%)	48 (81.4%)	0.751	
Intramural hematoma	72 (35.5%)	56 (38.9%)	16 (27.1%)	0.111	
Aortic rupture	16 (7.8%)	0 (0.0%)	16 (27.1%)	**<0.05**	
-Contained	12 (5.9%)	0 (0.0%)	12 (20.3%)	**<0.05**	
-Free	4 (2.0%)	0 (0.0%)	4 (6.8%)	**<0.05**	
Conservative treatment	158 (77.1%)	146 (100.0%)	12 (20.3%)	**<0.05**	
Indication for Intervention			47 (79.7%)	…	
-Malperfusion		…	23 (39.0%)	…	
-Progression of dissection		…	11 (18.6%)	…	
-Aortic rupture		…	10 (16.9%)	…	
-PAU		…	3 (5.1%)	…	
Number of aortic interventions					
-one intervention	40 (19.7%)	0 (0.0%)	40 (67.8%)	**<0.05**	
-two interventions	4 (2.0%)	0 (0.0%)	4 (6.8%)	**<0.05**	
-three interventions	2 (1.0%)	0 (0.0%	2 (3.4%)	**<0.05**	
Aortic Intervention	47 (22.9%)	0 (0.0%)	47 (79.7%)	**<0.05**	
-Thoracic aorta intervention	32 (15.6%)	0 (0.0%)	32 (54.2%)	**<0.05**	
-Open aortic surgery	23 (11.2%)	0 (0.0%)	23 (39.0%)	**<0.05**	
-Thoracic aorta surgery	6 (2.9%)	0 (0.0%)	6 (10.2%)	**<0.05**	
-Abdominal aorta surgery	3 (1.5%)	0 (0.0%)	3 (5.1%)	**<0.05**	
-Abdominal fenestration	12 (5.9%)	0 (0.0%)	12 (20.3%)	**<0.05**	
-Extra-anatomic bypass	4 (2.0%)	0 (0.0%)	4 (6.8%)	**<0.05**	
-Visceral artery bypass	11 (5.4%)	0 (0.0%)	11 (18.6%)	**<0.05**	
-Renal artery bypass	7 (3.4%)	0 (0.0%)	7 (11.9%)	**<0.05**	
-TEVAR	26 (12.7%)	0 (0.0%)	26 (44.1%)	**<0.05**	
-TEVAR, proximal landing				**<0.05**	
zone1	3 (1.5%)	0 (0.0%)	3 (5.1%)		
zone2	6 (2.9%)	0 (0.0%)	6 (10.2%)		
zone3	17 (8.3%)	0 (0.0%)	17 (28.8%)		
-Carotico-subclavian bypass	6 (2.9%)	0 (0.0%)	6 (10.2%)	**<0.05**	
-Endovascular treatment of visceral arteries	5 (2.4%)	0 (0.0%)	5 (8.5%)	**<0.05**	

Data are reported as counts and percentages in parentheses. Continuous variables are reported as mean and standard deviation. Significance values are in bold.
IMA: inferior mesenteric artery; PAU: penetrating aortic ulcer; SMA: superior mesenteric artery; TEVAR: thoracic endovascular aortic replacement.

In total, there were 72 (35.5%) patients presenting with intramural hematoma (IMH), 16 (27.1%) patients in the complicated group and 50 (41.7%) patients in the uncomplicated group. When compared with uncomplicated TBAD patients, IMH patients were older (73 ± 9, females 35.6%) than typical TBAD patients (65 ± 15, females 26.3%, $p = 0.004$). Eleven patients had IMH and dissection CT findings, these patients were included in the typical TBAD group. There were 22 (15.3%) TBAD-related aortic interventions during the follow-up, 17 (17.2%) in the typical TBAD group and 5 (11.1%) in the IMH group ($p = 0.349$). The most common cause of death was TBAD-related death 12 (42.9%) in the typical TBAD group, whereas patients in the IMH group died due to cardiovascular causes 6 (50.0%) (Table 5). Survival of these patients is summarized in the Supplementary Figure 1.

Discussion

The findings of the present analysis can be summarized as follows: First, late survival in complicated and uncomplicated TBAD is similar. Second, patients with uncomplicated TBAD tended to have higher freedom from adverse events. Last, one fourth of patients with uncomplicated TBAD required an aortic intervention during the follow-up.

In 1999, Dake et al. [10] reported patients who underwent endovascular stent-grafting covering the primary tear in acute aortic dissection with encouraging results. Over, the past two decades the shift from open surgery to endovascular repair together with optimal medical treatment has reduced morbidity and mortality among acute complicated TBAD patients [9]. In our study population, both endovascular and open aortic procedures were performed during

Table 3. In-hospital outcome of acute type B dissection patients.

	All patients n = 205	Uncomplicated type B group n = 146	Complicated type B group n = 59	p-Value	Missing data (n)
In-hospital outcome					
-RBC transfusion	21 (10.4%)	5 (3.5%)	16 (27.6%)	**<0.05**	3
-Aortic rupture	7 (3.4%)	1 (0.7%)	6 (10.2%)	**<0.05**	2
-Bowel ischemia	12 (5.9%)	1 (0.7%)	11 (18.6%)	**<0.05**	2
-Renal ischemia	24 (11.8%)	4 (2.8%)	20 (33.9%)	**<0.05**	2
-Renal failure (dialysis)	9 (4.5%)	2 (1.4%)	7 (12.1%)	**<0.05**	3
-Spinal ischemia	7 (3.4%)	0 (0.0%)	7 (11.9%)	**<0.05**	2
-Limb ischemia	10 (4.9%)	0 (0.0%)	10 (16.9%)	**<0.01**	2
-Stroke	9 (4.4%)	5 (3.5%)	4 (6.8%)	0.288	2
-Myocardial infarction	0 (0.0%)	0 (0.0%)	0 (0.0%)	…	2
-Drug resistant hypertension	18 (8.9%)	10 (6.9%)	8 (13.6%)	0.132	2
-Hospital stay (days)	15 ± 9	13 ± 7	18 ± 11	**<0.05**	5
-ICU stay (days)	1.5 ± 4	0.5 ± 2	4 ± 5	**<0.05**	4

	Uncomplicated type B group n = 146	Intervention compl. type B group n = 47	Conservative compl. type B group n = 12	
In-hospital outcome				
-RBC transfusion	5 (3.5%)	14 (30.4%)	2 (16.7%)	3
-Aortic rupture	1 (0.7%)	5 (10.6%)	1 (8.3%)	2
-Bowel ischemia	1 (0.7%)	11 (23.4%)	0 (0.0%)	2
-Renal ischemia	4 (2.8%)	18 (38.3%)	2 (16.7%)	2
-Renal failure (dialysis)	2 (1.4%)	6 (13.0%)	1 (8.3%)	3
-Spinal ischemia	0 (0.0%)	5 (10.6%)	2 (16.7%)	2
-Limb ischemia	0 (0.0%)	9 (19.1%)	1 (8.3%)	2
-Stroke	5 (3.5%)	4 (8.5%)	0 (0.0%)	2
-Myocardial infarction	0 (0.0%)	0 (0.0%)	0 (0.0%)	2
-Drug resistant hypertension	10 (6.9%)	6 (12.8%)	2 (16.7%)	2
-In-hospital mortality	4 (2.7%)	5 (10.6%)	1 (8.3%)	0

Data are reported as counts and percentages in parentheses. Continuous variables are reported as mean and standard deviation. Significance values are in bold.
ICU: intensive care unit; RBC: red blood cell.

Table 4. Follow-up outcome of acute type B dissection patients.

	All patients n = 205	Uncomplicated type B group n = 146	Complicated type B group n = 59	p-Value	
Mortality					
-In-hospital mortality	10 (4.9%)	4 (2.7%)	6 (10.2%)	**0.035**	
-30-day mortality	11 (5.4%)	4 (2.7%)	7 (11.9%)	**0.015**	
-All cause mortality	64 (31.2%)	41 (28.1%)	23 (39.0%)	0.127	
Causes of death				0.368	
-TBAD-related death	25 (39.1%)	15 (36.6%)	10 (43.5%)		
-Cardiovascular	16 (25.0%)	10 (24.4%)	6 (26.1%)		
-Cancer	7 (10.9%)	5 (12.2%)	2 (8.7%)		
-Neurological	9 (14.1%)	8 (19.5%)	1 (4.3%)		
-Pulmonary	2 (3.1%)	1 (2.4%)	1 (4.3%)		
-Renal failure	2 (3.1%)	0 (0.0%)	2 (8.7%)		
-Unknown	3 (4.7%)	2 (4.9%)	1 (4.3%)		
Follow-up events					
-New aortic dissection	1 (0.5%)	1 (0.7%)	0 (0.0%)	1.00	
-Aneurysm degeneration	45 (22.0%)	32 (21.9%)	13 (22.0%)	0.288	
-Antegrade extension of dissection	2 (1.0%)	1 (0.7%)	1 (1.7%)	0.494	
-New stroke	8 (3.9%)	5 (3.4%)	3 (5.1%)	0.692	
-New myocardial infarction	3 (1.5%)	3 (2.1%)	0 (0.0%)	0.559	
Late aortic intervention					
-Aortic intervention	39 (19.0%)	25 (17.1%)	14 (23.7%)	0.275	
-TEVAR	13 (6.3%)	7 (4.8%)	6 (10.2%)	0.203	
-Surgical TAA repair	20 (9.8%)	14 (9.6%)	6 (10.2%)	0.899	
-EVAR	1 (0.5%)	0 (0.0%)	1 (1.7%)	0.288	
-Surgical AAA repair	10 (4.9%)	8 (5.5%)	2 (3.4%)	0.727	
-Aortic fenestration	1 (0.5%)	1 (0.7%)	0 (0.0%)	1.00	
-TBAD-related intervention	35 (17.1%)	22 (15.1%)	13 (22.0%)	0.123	
-TBAD-related intervention (years)	1.0 ± 1.5	0.9 ± 1.4	1.1 ± 1.6	0.511	
-TBAD-related composite outcome	58 (28.7%)	36 (25.0%)	22 (37.9%)	0.066	3
-Length of follow-up time (years)	4.9 ± 3.8	5.1 ± 3.9	4.4 ± 3.5	0.392	

Data are expressed as number of cases unless otherwise stated. Significance values are in bold.
AAA: abdominal aortic aneurysm; EVAR: endovascular aortic repair; ICU: intensive care unit; TAA: thoracic aortic aneurysm; TBAD: type B aortic dissection; TEVAR: thoracic endovascular aortic replacement.
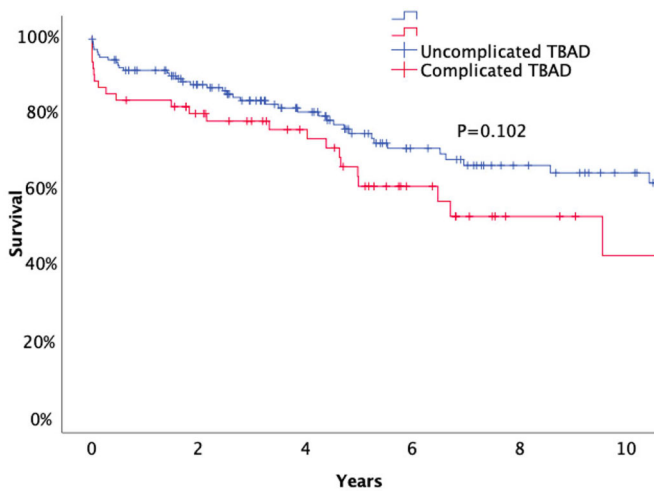
Figure 1. Survival of complicated and uncomplicated acute type B aortic dissection patients. TBAD: type B aortic dissection.
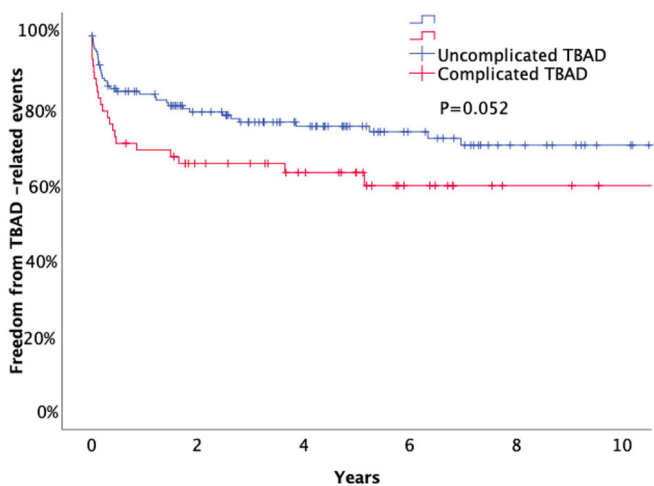

Figure 2. Freedom from composite TBAD-related outcome of complicated and uncomplicated acute type B aortic dissection patients. TBAD: type B aortic dissection.

the study period. The gradual shift towards a prevalent endovascular treatment took place since 2008. However, open aortic fenestration was still commonly performed until 2015. In complicated patients, TBAD-related reinterventions were required in 13 (22.0%) patients during the follow-up. Approximately, 50% of complicated patients received early TEVAR with encouraging results since only six (10.2%) open thoracic and six (10.2%) TEVAR procedures were performed in the uncomplicated group during the follow-up (Tables 2 and 4). These findings compared well with previous studies. Indeed, Afifi et al. [11] reported reintervention rate of 10.8% after TEVAR in complicated TBAD patients.

Our data reports 8.5% rate of spinal ischemia, whereas Afifi et al. [11] report 18 (4.1%) patients suffering from paraplegia at the arrival and they report four patients with postoperative paraplegia among 442 studied patients. Intramural hematoma was present in 72 (35.5%) patients in our study, which is a much higher prevalence than 7% as reported in the IRAD registry [2]. This finding might be explained due to rescreening the radiological data by an experienced radiologist. In the uncomplicated group, IMH

patients were older than classical type B dissection patients. During the follow-up, TBAD-related interventions were performed in both subgroups, TEVAR was favored among IMH patients whereas open surgical procedures were more common in the typical TBAD group. Typical TBAD was associated with higher risk of mortality due to TBAD-related causes. In the survival curves steep decline was detected in the IMH when follow-up progressed. Cardiovascular cause, which is the most common cause of death among Finnish population over 65 years-old, was the most typical cause of death in the IMH group (National Statistics, Finland).

In our study in-hospital mortality rate was 4.9% which is more favorable what reported in the IRAD registry (12–14%) in TBAD patients [2]. In addition, we observed higher in-hospital and 30-day mortality rates among complicated TBAD patients. Interestingly, a recent large meta-analysis reported no difference in in-hospital mortality and 5-year survival between complicated and uncomplicated patients. Still, 30-day and 1-year follow-up was worse in the complicated group compared with uncomplicated group indicating the fragile period during the early period after aortic dissection [3]. One third of our patients died during the follow-up period in a relatively young study population. Approximately 40% of patients died due to TBAD-related causes, 15 (36.6%) in complicated and 10 (43.5%) in uncomplicated group, followed by cardiovascular and cancer deaths in both study groups. Similarly, aorta-, cardiac-, and cancer-related mortality were reported as the most common causes of death in a single-center study [12].

Recent interest has focused on the management of uncomplicated acute TBAD patients and their follow-up outcome. In our study, 15.1% uncomplicated patients needed aortic interventions due to dissection-related aneurysm during the follow-up, and the mean interval of TBAD-related aortic interventions was 0.9 ± 1.4 years (range 0.05–6.3 years) which stands for close surveillance of these patients. Late aortic operations in the uncomplicated group were usually surgical aortic procedure on the thoracic ($n = 14$, 9.6%) and abdominal ($n = 8$, 5.5%) aorta with higher risk of morbidity and mortality than endovascular procedures. Similarly, a rate of late aortic intervention of 15.3% was reported in other series [11]. In addition, previous known aneurysm was threefold risk factor for later TBAD-related aortic event among our study population. The INSTEAD, INSTEAD XL, and ADSORB trials focused on the optimal treatment strategy of uncomplicated TBAD patients in acute and chronic settings reporting favorable aortic remodeling and aortic-specific mortality during the follow-up in TEVAR-treated groups [13–15]. Consequently, TEVAR as a prophylactic therapeutic strategy of uncomplicated TBAD patients should be targeted based on high-risk features [8,16,17].

The study set-up with retrospective design sets its own limitations. First, we did not collect systematically the details of optimal medical treatment. Second, the collection of follow-up data was based on patient records without contacting the patients. Finally, herein we applied the European

Table 5. Baseline characteristics and outcomes of patients with acute intramural hematoma and typical type B aortic dissection.

	All patients $n = 144$	Classical type B aortic dissection group $n = 99$	IMH group $n = 45$	*p*-value	Missing values data (*n*)
Age (years)	68 ± 14	65 ± 15	73 ± 9	**0.004**	
Female	42 (29.2%)	26 (26.3%)	16 (35.6%)	0.255	
Previous aneurysm	28 (19.4%)	19 (19.2%)	9 (20.0%)	0.910	
Previous aortic surgery	13 (9.0%)	8 (8.1%)	5 (11.1%)	0.545	
Hospital stay (days)	13 ± 7	13.5 ± 8	11.5 ± 5	0.251	5
ICU stay (days)	0.5 ± 2.5	0.5 ± 3	0 ± 0	0.169	2
Mortality					
-In-hospital mortality	4 (2.8%)	3 (3.0%)	1 (2.2%)	1.00	
-30-day mortality	4 (2.8%)	3 (3.0%)	1 (2.2%)	1.00	
-All cause mortality	40 (27.8%)	28 (28.3%)	12 (26.7%)	0.841	
Causes of death				0.230	
-TBAD-related death	15 (37.5%)	12 (42.9%)	3 (25.0%)		
-Cardiovascular	10 (25.0%)	4 (14.3%)	6 (50.0%)		
-Cancer	5 (12.5%)	4 (14.3%)	1 (8.3%)		
-Neurological	7 (17.5%)	6 (21.4%)	1 (8.3%)		
-Pulmonary	1 (2.5%)	1 (3.6%)	0 (0.0%)		
-Unknown	2 (5.0%)	1 (3.6%)	1 (8.3%)		
Aortic-related events					
-New aortic dissection	1 (0.7%)	1 (1.0%)	0 (0.0%)	0.499	
-Aneurysm degeneration	32 (22.2 %)	25 (25.3%)	7 (15.6%)	0.195	
-Antegrade extension of dissection	1 (0.7%)	0 (0.0%)	1 (2.2%)	0.313	
Late aortic intervention					
-Aortic intervention	25 (17.4%)	18 (18.2%)	7 (15.6%)	0.700	
-TEVAR	7 (4.9%)	3 (3.0%)	4 (8.9%)	0.205	
-Surgical repair of TAA	14 (9.7%)	12 (12.1%)	2 (4.4%)	0.226	
-EVAR	0 (0%)	0 (0%)	0 (0%)	…	
-Surgical repair of AAA	8 (5.6%)	5 (5.1%)	3 (6.7%)	0.705	
-Aortic fenestration	1 (0.7%)	1(1.0%)	0 (0%)	1.00	
-TBAD-related intervention	22 (15.3%)	17 (17.2%)	5 (11.1%)	0.349	
-TBAD-related intervention, years	0.9 ± 1.4	1.0 ± 1.6	0.6 ± 1.0	0.543	2
-TBAD-related composite outcome	36 (25.4%)	28 (28.6%)	8 (18.2%)	0.188	
-Length of follow-up (years)	5.2 ± 3.9	5.1 ± 4.0	5.3 ± 3.8	0.619	

Data are reported as counts and percentages in parentheses. Continuous variables are reported as mean and standard deviation. Significance values are in bold.
AAA: abdominal aortic aneurysm; EVAR: endovascular aortic repair; ICU: intensive care unit; TAA: thoracic aortic aneurysm; TBAD: type B aortic dissection; TEVAR: thoracic endovascular aortic repair.

definition criteria of complicated and uncomplicated TBAD patients as used in clinical practice at that time [4]. Instead, the recent Reporting Standards from the Society for Vascular Surgery and Society of Thoracic Surgeons for TBAD introduce the concept of a high-risk class between uncomplicated and complicated acute TBAD patients. In this new classification complicated dissections involve only rupture and malperfusion patients [16].

This study showed that patients suffering from acute TBAD are exposed to a significant lifelong risk of aortic-related death or need or aortic intervention. In patients with uncomplicated TBAD, there was a trend towards favorable early and late outcome. Still, one fourth of these patients had TBAD-related events. Therefore, recognition of risk factors underlying any aortic-related events in uncomplicated TBAD is crucial for a patient-oriented primary aortic repair.

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