



# Contemporary Unplanned Readmission Trends Following Management of Type B Aortic Dissection

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**Purpose:** Large studies have demonstrated improved survival outcomes with thoracic endovascular aortic repair (TEVAR) at two and five years compared to medical therapy; however, early TEVAR for acute type B aortic dissection (TBAD) remains controversial. We aimed to evaluate trends and clinical predictors of hospital readmissions in patients undergoing medical management and TEVAR for acute TBADs.

**Materials and Methods:** The Nationwide Readmissions Database was queried for all 30-day and 90-day index readmissions (30D-IR and 90D-IR, respectively) after a diagnosis of a TBAD from January 2012 to September 2015. Data on readmission diagnosis, patient demographics, and hospital characteristics were collected from readmitted patients and analyzed. Multivariable logistic regression models were used to identify the predictors of readmission after TEVAR or medical management of TBAD.

**Results:** We identified 53,117 patients with acute TBAD. Medical management was the initial treatment modality in 46,985 (88.4%) patients, while 6,132 (11.5%) underwent TEVAR. Factors including older patient age, lower household income, severity of comorbidities, initial hospital length of stay, and urgent procedure demonstrated an increased likelihood of experiencing 30D-IR and 90D-IR ( $P < 0.05$ ). The rate of unplanned readmission for patients undergoing medical management remained stable (11.3% vs. 10.0% for 30D-IR; 19.1% vs. 15.5% for 90D-IR). Reasons for unplanned readmission in the TEVAR cohort were largely related to technical complications. There was no significant difference in readmission costs between medical management and TEVAR.

**Conclusion:** Number of unplanned readmissions in the TEVAR arm decreased significantly over time, whereas the number of readmissions for medical management remained stable.

**Key Words:** Aortic dissection, Thoracic endovascular aortic repair, Readmission, Type B dissection, Nationwide readmissions database

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## INTRODUCTION

The short-term benefit of treatment of complicated type B aortic dissection (TBAD) with thoracic endovascular aortic repair (TEVAR) is well described, and aorta specific benefit of treating uncomplicated TBAD with TEVAR have been reported at 2 and 5 years [1]. Mounting data continues to suggest potential mortality benefit in the use of TEVAR for acute uncomplicated TBAD [2,3]. While the cost of TEVAR is initially more expensive than medical management for TBAD, access to care and the long-term cost of medication pose unique challenges to long-term medical management. Furthermore, the overall long-term compliance with surveillance and follow-up of the patient population remains poor [4]. As more TEVARs are performed for TBADs, more data are available to assess short-term complications, specifically readmission. We sought to investigate the factors that predict readmission after TEVAR and medical management of acute TBADs and how they differ between the groups.

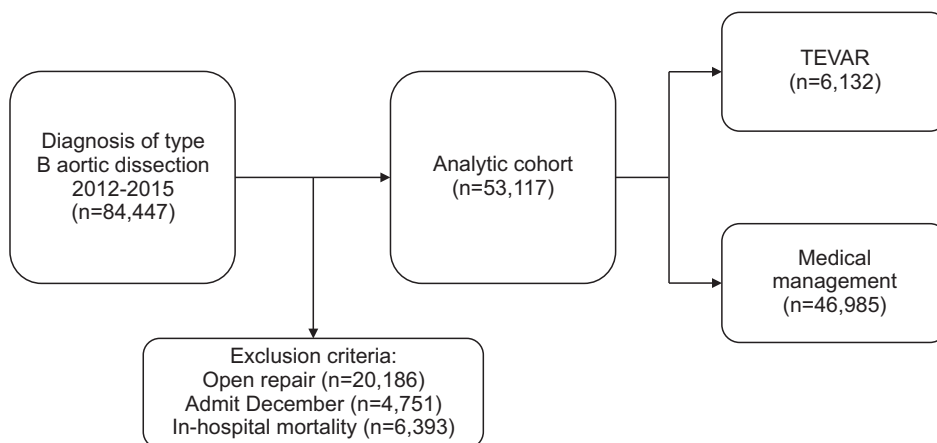
## METHODS AND MATERIALS

The data source used was the Nationwide Readmissions Database (NRD) from January 2012 to September 2015, which is available to the public and has been exempt from IRB review. The NRD is an inpatient database created by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project (HCUP). The diagnosis and procedure codes for the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) are available in the NRD. The Clinical Classifications Software (CCS), developed as part of the HCUP, was used to collapse ICD-9-CM diagnoses into a smaller number of clinically meaningful categories. All hospitalizations for patients aged 18 years or older with a primary or secondary diagnosis of dissection of the thoracic or thoracoabdominal

aorta (ICD-9-CM: 441.01, 441.02, or 441.03) were included. Patients with procedure codes for open repair were excluded (ICD-9-CM: 38.34, 38.35, 38.44, 38.45, 39.57, or 39.58). Patients were categorized as receiving TEVAR (ICD-9-CM: 39.73) or medical management. Concomitant procedures for proximal debranching (ICD-9-CM: 39.22) and iliac access (ICD-9-CM: 39.29) were also identified. Patients admitted in December were excluded to allow for at least one month of follow-up for each patient. Additionally, patients who died at the index admission were excluded.

Patients with non-urgent and urgent index admission were included in the analysis. Patient demographic and socioeconomic characteristics collected included age, sex, primary insurance, median household income by ZIP code, and patient location. Patient location was based on urban-rural and population classifications developed by the National Center for Health Statistics (central metropolitan:  $\geq 1$  million, fringe metropolitan:  $\geq 1$  million, metropolitan: 250,000-999,999, and small metro/micropolitan:  $< 250,000$ ). Comorbidities were summarized using a modified version of the Elixhauser score for administrative databases, which is based on the presence of 30 comorbidities [5]. The characteristics of the index admission were as follows: urgent admission, surgical treatments, the Patient Refined Diagnosis Related Group (DRG) severity of illness subclass [6], length of stay (LOS), and total charges in United States dollars. DRG severity categorizes patient complications and comorbidities into minor, moderate, major, or extreme loss of function, based on ICD-9-CM diagnosis codes. Hospital characteristics included small, medium, or large bed number and metropolitan teaching status (metro nonteaching, metro teaching, not metro). Hospital characteristics of readmission were also collected.

The primary outcome of the study was all-cause readmission within 30 or 90 days of index admission. The secondary outcomes were the rate of TEVAR over time, unplanned readmission rates, reasons for readmission based



**Fig. 1.** Patient selection, exclusion criteria, and final cohort chosen for analysis between thoracic endovascular aortic repair (TEVAR) and medical management.

on CCS categories, hospital characteristics of readmissions, and cost of readmissions as measured by total charges. All statistical analyses were performed using weighted numbers and percentages, which allowed estimates of national statistics to be computed. Univariate comparisons between those with and without the index at 30- and 90-day all-cause readmissions were assessed using the Wald chi-squared test for categorical variables and the survey linear regression model for continuous variables. Survey logistic regression with a contrast of orthogonal polynomial coefficients was used to assess the linear trends in TEVAR and readmission rates over time. Comparisons of readmission reasons and surgical treatments between index medical management and TEVAR patients were performed using survey logistic regression. All patient and hospital covariates were entered into a multivariable survey logistic regression model to identify the factors independently associated with 30-day index readmission (30D-IR) and 90-day index readmission (90D-IR). Total charges for readmissions were stratified by hospital characteristics and compared between index medical management and TEVAR using survey linear regression. The analysis of all readmissions was repeated for the unplanned readmissions. All statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC, USA) with two-tailed tests, and statistical significance was set at  $P < 0.05$ .

## RESULTS

We identified 84,447 patients diagnosed with TBAD in the United States between January 2012 and September 2015. We excluded 20,186 patients who underwent open aortic repair and 6,393 patients who experienced in-hospital mortality. An additional 4,751 patients were excluded in December each year from 2012 to 2014, as patients treated in this time period could not be assessed at the 30-day mark. Thus, 53,117 patients met the inclusion criteria for the analysis. Medical management was the initial treatment modality in 46,985 (88.4%) while 6,132 underwent TEVAR (11.5%) (Fig. 1). At 30 days there were 5,770 (10.9%) unplanned readmissions, and 9,187 (17.2%) unplanned readmissions by 90 days.

Univariate analysis of patient demographics, city demographics, hospital characteristics, and year of procedure are summarized in Table 1. Older age was significantly associated with unplanned 90D-IR. Univariate analysis also revealed that city size, lower household income, extreme DRG score, higher Elixhauser comorbidity score, earlier year, urgent procedure, concomitant iliac access, and long hospital LOS were more likely to experience unplanned 30D-IR and 90D-IR ( $P < 0.05$ ).

**Table 1.** Baseline patient characteristics of unplanned readmissions following type B aortic dissection

Characteristic	Overall	NR at 30 days	R at 30 days	P-value	NR at 90 days	R at 90 days	P-value
Total	53,117	47,347 (89.1)	5,770 (10.9)	-	43,930 (82.7)	9,187 (17.2)	-
Age, y	66.6±0.2	66.6±0.2	67.1±0.3	0.1082	66.4±0.2	67.6±0.3	0.0002*
Age group, y				0.3212			0.0039*
<60	16,978 (32.0)	15,191 (32.1)	1,788 (31.0)		14,256 (32.5)	2,722 (29.6)	
≥60	36,139 (68.0)	32,157 (67.9)	3,982 (69.0)		29,675 (67.5)	6,465 (70.4)	
Sex				0.7313			0.0597
Male	31,322 (59.0)	27,941 (59.0)	3,380 (58.6)		26,044 (59.3)	5,278 (57.5)	
Female	21,796 (41.0)	19,407 (41.0)	2,389 (41.4)		17,887 (40.7)	3,909 (42.5)	
Location of hospital				0.0342*			<0.0001*
Central metro (≥1 million)	15,717 (29.7)	13,971 (29.5)	1,773 (30.7)		12,798 (29.1)	2,956 (32.2)	
Fringe metro (≥1 million)	14,024 (26.5)	12,448 (26.3)	1,625 (28.2)		11,544 (26.3)	2,530 (27.5)	
Metro (250,000-999,999)	10,447 (19.7)	9,440 (20.0)	1,164 (20.2)		8,766 (20.0)	1,837 (20.0)	
Small metro/micropolitan (<250,000)	12,740 (24.1)	11,488 (24.3)	1,208 (20.9)		10,821 (24.6)	1,864 (20.3)	

Table 1. Continued

Characteristic	Overall	NR at 30 days	R at 30 days	P-value	NR at 90 days	R at 90 days	P-value
Insurance							
Private/Medicare	42,495 (80.1)	37,956 (80.3)	4,539 (78.9)	0.1523	35,151 (80.2)	7,344 (80.1)	0.9720
Medicaid/other	10,525 (19.9)	9,311 (19.7)	1,214 (21.1)		8,704 (19.8)	1,822 (19.9)	
Median household income for zip code, quartiles				0.0048*			0.0005*
1st quartile (0%-25%)	16,223 (31.1)	14,262 (30.6)	1,960 (34.6)		13,098 (30.3)	3,125 (34.6)	
2nd quartile (26%-50%)	12,968 (24.8)	11,631 (25.0)	1,337 (23.6)		10,859 (25.1)	2,109 (23.3)	
3rd quartile (51%-75%)	12,009 (23.0)	10,769 (23.1)	1,240 (21.9)		10,043 (23.3)	1,966 (21.7)	
4th quartile (76%-100%)	11,026 (21.1)	9,897 (21.3)	1,129 (19.9)		9,183 (21.3)	1,843 (20.4)	
DRG severity				<0.0001*			<0.0001*
Minor	6,132 (11.5)	5,461 (11.5)	671 (11.6)		5,065 (11.5)	1,067 (11.6)	
Moderate	10,635 (20.0)	9,709 (20.5)	925 (16.0)		9,153 (20.8)	1,482 (16.1)	
Major	26,451 (49.8)	23,745 (50.2)	2,706 (46.9)		22,088 (50.3)	4,363 (47.5)	
Extreme	9,899 (18.6)	8,433 (17.8)	1,467 (25.4)		7,625 (17.4)	2,274 (24.7)	
Elixhauser Comorbidity Score	4.9±0.1	4.7±0.1	6.1±0.2	<0.0001*	4.6±0.1	6.0±0.2	<0.0001*
Year				0.0465*			<0.0001*
2012	12,991 (24.4)	11,445 (24.2)	1,546 (26.8)		10,457 (23.8)	2,534 (27.6)	
2013	13,554 (25.5)	12,151 (25.7)	1,404 (24.3)		11,291 (25.7)	2,263 (24.6)	
2014	14,331 (27.0)	12,765 (27.0)	1,566 (27.1)		11,820 (26.9)	2,511 (27.3)	
2015	12,241 (23.0)	10,988 (23.2)	1,254 (21.7)		10,363 (23.6)	1,878 (20.4)	
Management				0.0003*			0.0723
Medical	46,985 (88.5)	42,035 (88.8)	4,950 (85.8)		38,951 (88.7)	8,035 (87.5)	
Thoracic endovascular aortic repair	6,132 (11.5)	5,313 (11.2)	820 (14.2)		4,980 (11.3)	1,152 (12.5)	
Urgent procedure	46,350 (87.3)	41,225 (87.1)	5,125 (88.8)	0.0319*	38,150 (86.8)	8,200 (89.3)	0.0004*
Concomitant procedures							
Proximal debranching	1,206 (2.3)	1,038 (2.2)	168 (2.9)	0.0894	955 (2.2)	251 (2.7)	0.0940
Iliac access	604 (1.1)	479 (1.0)	125 (2.2)	0.0033*	432 (1.0)	172 (1.9)	0.0012*

Values are presented as number (%) or mean±standard error.

NR, not readmitted; R, readmitted; DRG, Patient Refined Diagnosis Related Group.

\*Statistically significant P<0.05.

Over the study period, the 30D-IR and 90D-IR for patients undergoing TEVAR decreased significantly (17.7% in 2012 vs. 11.6% in 2015 for 30D-IR; 23.6% in 2012 vs. 14.6% in 2015 for 90D-IR) as the number of TEVARs performed increased slightly (9.0% in 2012 vs. 14.3% in 2015). During this time, the rate of unplanned readmissions for patients undergoing medical management remained stable (11.3% in 2012 vs. 10.0% in 2015 for 30D-IR; 19.1% in 2012 vs. 15.5% in 2015 for 90D-IR) (Fig. 2).

The primary reasons for unplanned readmissions were analyzed for both the medical and TEVAR cohorts at 30D-IR and 90D-IR, and are shown in Table 2. Overall, the most common reasons for unplanned readmission were vascular complications (aortic, peripheral, and visceral artery aneurysms, 24%), congestive heart failure (CHF, 6%), and septicemia (6%). Patients who underwent TEVAR were significantly more likely to be readmitted for procedural complications related to TEVAR than for other reasons; TEVAR-related complications included aortic, peripheral, and visceral artery aneurysms at both 30D-IR and 90D-IR. Patients who underwent medical management were significantly more likely to be readmitted for medical conditions including CHF, septicemia, renal failure, and respiratory failure.

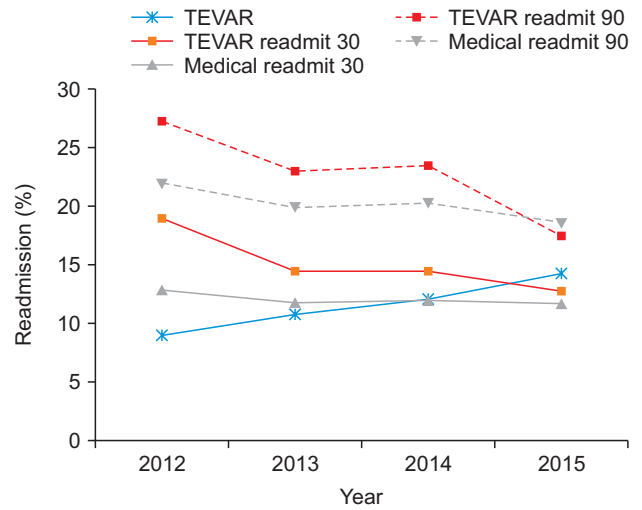


Fig. 2. Readmissions trends following management of type B aortic dissections. As the number of thoracic endovascular aortic repair (TEVAR) procedures performed increased, the percentage of readmissions significantly decreased over time. The percentage of medical management readmissions remained stable throughout the study.

Table 2. Primary reasons for 30- and 90-day unplanned index readmission following type B dissection

Variable	All	Medical	TEVAR	P-value
<b>30-day</b>				
Total patients	5,770	4,950	820	-
Total readmissions	6,457	5,535	932	-
Aortic, peripheral, and visceral artery aneurysms	1,395 (24.2)	1,011 (20.4)	384 (46.8)	<0.0001*
Congestive heart failure; nonhypertensive	340 (5.9)	319 (6.4)	20 (2.4)	0.0001*
Septicemia (except in labor)	340 (5.9)	316 (6.4)	25 (3.0)	0.0041*
Complication of device; implant or graft	201 (3.5)	152 (3.1)	49 (6.0)	0.2559
Hypertension with complications and secondary HTN	160 (2.8)	147 (3.0)	12 (1.5)	0.0416*
Cardiac dysrhythmias	163 (2.8)	155 (3.1)	7 (0.9)	0.0003*
Nonspecific chest pain	105 (1.8)	94 (1.9)	12 (1.5)	0.4108
Pneumonia (except that caused by TB or STD)	143 (2.5)	131 (2.6)	12 (1.5)	0.0917
Acute and unspecified renal failure	132 (2.3)	128 (2.6)	4 (0.5)	<0.0001*
Respiratory failure, insufficiency, arrest (adult)	113 (2.0)	105 (2.1)	8 (1.0)	0.0483*
Complications of surgical procedures or medical care	163 (2.8)	132 (2.7)	31 (3.8)	0.2768
Acute myocardial infarction	94 (1.6)	89 (1.8)	5 (0.6)	0.0215*
Acute cerebrovascular disease	107 (1.9)	101 (2.0)	6 (0.7)	0.0193*
COPD and bronchiectasis	77 (1.3)	77 (1.6)	0 (0.0)	-
UTIs	80 (1.4)	64 (1.3)	16 (2.0)	0.3531
Gastrointestinal hemorrhage	102 (1.8)	88 (1.8)	14 (1.7)	0.9371
Fluid and electrolyte disorders	90 (1.6)	76 (1.5)	14 (1.7)	0.7939
Peripheral and visceral atherosclerosis	51 (0.9)	47 (0.9)	4 (0.5)	0.2840
Intestinal obstruction without hernia	50 (0.9)	46 (0.9)	4 (0.5)	0.3660
Deficiency and other anemia	55 (1.0)	46 (0.9)	9 (1.1)	0.7848

Table 2. Continued

Variable	All	Medical	TEVAR	P-value
90-day				
Total patients	9,187	8,035	1,152	-
Total readmissions	12,295	10,723	1,572	-
Aortic, peripheral, and visceral artery aneurysms	2,178 (23.7)	1,614 (20.1)	563 (48.9)	<0.0001*
Congestive heart failure; nonhypertensive	543 (5.9)	509 (6.3)	34 (3.0)	0.0002*
Septicemia (except in labor)	519 (5.6)	483 (6.0)	36 (3.1)	0.0024*
Complication of device; implant or graft	336 (3.7)	274 (3.4)	63 (5.5)	0.2488
Hypertension with complications and secondary HTN	294 (3.2)	271 (3.4)	23 (2.0)	0.1014
Cardiac dysrhythmias	272 (3.0)	266 (3.3)	6 (0.5)	<0.0001*
Nonspecific chest pain	225 (2.5)	210 (2.6)	16 (1.4)	0.0174*
Pneumonia (except that caused by TB or STD)	233 (2.5)	214 (2.7)	19 (1.6)	0.1135
Acute and unspecified renal failure	210 (2.3)	199 (2.5)	11 (1.0)	0.0069*
Respiratory failure, insufficiency, arrest (adult)	203 (2.2)	193 (2.4)	10 (0.9)	0.0015*
Complications of surgical procedures or medical care	187 (2.0)	153 (1.9)	34 (3.0)	0.1788
Acute myocardial infarction	172 (1.9)	164 (2.0)	8 (0.7)	0.0042*
Acute cerebrovascular disease	179 (1.9)	160 (2.0)	18 (1.6)	0.5294
COPD and bronchiectasis	171 (1.9)	165 (2.1)	6 (0.5)	0.0004*
UTIs	125 (1.4)	111 (1.4)	15 (1.3)	0.8588
Gastrointestinal hemorrhage	119 (1.3)	108 (1.3)	11 (1.0)	0.3594
Fluid and electrolyte disorders	113 (1.2)	104 (1.3)	9 (0.8)	0.2183
Peripheral and visceral atherosclerosis	91 (1.0)	86 (1.1)	4 (0.3)	0.0299*
Intestinal obstruction without hernia	90 (1.0)	84 (1.0)	6 (0.5)	0.2105
Deficiency and other anemia	87 (0.9)	78 (1.0)	9 (0.8)	0.7000

Values are presented as number (%).

TEVAR, thoracic endovascular aortic repair; HTN, hypertension; TB, tuberculosis; STD, sexually transmitted disease; COPD, chronic obstructive pulmonary disease; UTI, urinary tract infection.

\*Statistically significant  $P < 0.05$ .

A multivariate analysis of predictors for index unplanned readmission was completed, which found that older age, hospital locations in metro or small metro/micropolitan areas, lower household income, increased comorbidity score, earlier year of diagnosis, TEVAR procedure, need for urgent procedures, and concomitant procedures such as iliac devices were statistically significant predictors of both 30D-IR and 90D-IR (Table 3). Medicaid insurance was found to be a predictor of 30D-IR but not 90D-IR. These factors remained statistically significant in the sub-analysis of urgent procedures, whereas the sub-analysis of non-urgent procedures showed no difference in the rate of readmission by comorbidity, year of diagnosis, TEVAR, or concomitant procedures (Table 3).

When looking at the hospital characteristics of unplanned IRs, TEVAR patients were more likely to be admitted to a larger teaching hospital than those who received medical management (Table 4). Furthermore, no significant difference in the cost of readmission was found between

the medical and TEVAR readmission groups for 30D-IR or 90D-IR.

## DISCUSSION

TBADs have historically been treated with medical management rather than operative interventions. DeBakey et al. [7] and Daily et al. [8] initially recognized this treatment paradigm in the late 1960s when they discovered that the anatomic distribution of dissections directly affected patient outcomes. Mortality was found to be significantly improved when patients with aortic dissection in the ascending aorta underwent surgery compared to medical treatment, but this benefit was not seen in dissection of the descending aorta. The Stanford classification, developed from this finding, has been used to drive treatment for the last 50 years. Therefore, operative intervention has been reserved for type B dissections that are considered complicated, including those with end-organ malperfusion, aortic

**Table 3.** Multivariable analysis of predictors for unplanned readmissions following type B dissection

Variable	Total						Urgent						Elective					
	30 Days		90 Days		30 Days		90 Days		30 Days		90 Days		30 Days		90 Days			
	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value		
Age, per year increase	1.05 (1.01-1.08)	0.0147*	1.06 (1.03-1.10)	0.0003*	1.04 (1.01-1.08)	0.0221*	1.05 (1.02-1.09)	0.0017*	1.08 (0.96-1.21)	0.1941	1.16 (1.05-1.29)	0.0054*						
Sex																		
Male	0.99 (0.89-1.10)	0.8064	0.95 (0.87-1.03)	0.1821	1.01 (0.90-1.12)	0.8878	0.96 (0.88-1.05)	0.3573	0.82 (0.61-1.10)	0.1803	0.82 (0.64-1.05)	0.1164						
Female	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-						
Location of hospital																		
Central metro (≥1 million)	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-						
Fringe metro (≥1 million)	1.02 (0.90-1.15)	0.7990	1.01 (0.91-1.13)	0.8402	1.02 (0.89-1.17)	0.7847	1.01 (0.91-1.14)	0.8088	0.93 (0.63-1.36)	0.6901	0.94 (0.68-1.29)	0.6905						
Metro (250,000-999,999)	0.96 (0.84-1.09)	0.4994	0.86 (0.77-0.96)	0.0068*	1.00 (0.87-1.17)	0.9871	0.88 (0.78-0.99)	0.0361*	0.64 (0.42-0.97)	0.0350*	0.68 (0.47-0.96)	0.0299*						
Small metro/micropolitan (<250,000)	0.81 (0.69-0.95)	0.0076*	0.71 (0.63-0.81)	<0.0001*	0.81 (0.69-0.95)	0.0101*	0.70 (0.61-0.81)	<0.0001*	0.76 (0.47-1.23)	0.2589	0.74 (0.52-1.05)	0.0931						
Insurance																		
Private/medicare	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-						
Medicaid/other	1.16 (1.01-1.33)	0.0325*	1.09 (0.97-1.22)	0.1438	1.13 (0.99-1.30)	0.0674	1.06 (0.95-1.18)	0.3321	1.48 (0.96-2.26)	0.0730	1.45 (1.01-2.08)	0.0453*						
Median household income for zip code, quartiles																		
1st quartile (0%-25%)	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-						
2nd quartile (26%-50%)	0.84 (0.74-0.95)	0.0045*	0.81 (0.72-0.90)	<0.0001*	0.86 (0.75-0.99)	0.0291*	0.83 (0.74-0.93)	0.0016*	0.67 (0.45-1.01)	0.0550	0.65 (0.47-0.88)	0.0061*						
3rd quartile (51%-75%)	0.81 (0.71-0.93)	0.0018*	0.78 (0.70-0.87)	<0.0001*	0.80 (0.70-0.93)	0.0023*	0.78 (0.69-0.88)	<0.0001*	0.86 (0.57-1.28)	0.4575	0.77 (0.55-1.09)	0.1412						
4th quartile (76%-100%)	0.79 (0.69-0.91)	0.0010*	0.75 (0.67-0.84)	<0.0001*	0.79 (0.69-0.92)	0.0017*	0.76 (0.68-0.86)	<0.0001*	0.74 (0.49-1.13)	0.1649	0.66 (0.45-0.94)	0.0220*						
DRG severity																		
Minor	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-						
Moderate	0.75 (0.63-0.89)	0.0013*	0.75 (0.64-0.86)	<0.0001*	0.82 (0.68-0.98)	0.0279*	0.79 (0.67-0.92)	0.0021*	0.46 (0.26-0.81)	0.0076*	0.52 (0.33-0.82)	0.0050*						
Major	0.83 (0.70-0.98)	0.0301*	0.85 (0.74-0.98)	0.0257*	0.86 (0.72-1.02)	0.0856	0.87 (0.75-1.01)	0.0578	0.69 (0.41-1.09)	0.1074	0.75 (0.49-1.15)	0.1842						
Extreme	1.13 (0.92-1.38)	0.2375	1.16 (0.98-1.36)	0.0772	1.18 (0.97-1.44)	0.0988	1.18 (1.00-1.39)	0.0502	0.79 (0.42-1.49)	0.4671	1.00 (0.58-1.73)	0.9974						
Elixhauser Comorbidity Score, per unit increase	1.02 (1.01-1.03)	<0.0001*	1.02 (1.02-1.03)	<0.0001*	1.02 (1.01-1.03)	<0.0001*	1.02 (1.02-1.03)	<0.0001*	1.02 (0.99-1.06)	0.1628	1.01 (0.98-1.05)	0.3727						
Year																		
2012	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-						
2013	0.91 (0.79-1.04)	0.1527	0.89 (0.79-0.99)	0.0464*	0.89 (0.76-1.03)	0.1080	0.88 (0.77-0.99)	0.0430*	1.13 (0.75-1.71)	0.5678	1.05 (0.71-1.54)	0.8149						
2014	0.96 (0.84-1.10)	0.5355	0.94 (0.83-1.06)	0.2867	0.94 (0.81-1.09)	0.3878	0.92 (0.81-1.06)	0.2403	1.15 (0.74-1.71)	0.5419	1.06 (0.68-1.64)	0.8090						
2015	0.81 (0.71-0.93)	0.0021*	0.73 (0.65-0.81)	<0.0001*	0.80 (0.70-0.92)	0.0022*	0.72 (0.63-0.82)	<0.0001*	0.99 (0.64-1.54)	0.9641	0.84 (0.57-1.22)	0.3493						

Table 3. Continued

Variable	Total						Urgent						Elective					
	30 Days		90 Days		30 Days		90 Days		30 Days		90 Days		30 Days		90 Days			
	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value		
<b>Management</b>																		
<b>Medical</b>																		
TEVAR	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-		
Urgent procedure	1.43 (1.24-1.66)	<0.0001*	1.26 (1.11-1.44)	0.0005*	1.48 (1.25-1.76)	<0.0001*	1.31 (1.13-1.52)	0.0003*	1.22 (0.90-1.67)	0.2041	1.10 (0.82-1.47)	0.5291	1.21 (1.02-1.42)	0.0290*	1.23 (1.07-1.42)	0.0042*		
<b>Concomitant procedures</b>																		
<b>Proximal debranching</b>																		
Proximal debranching	1.24 (0.91-1.70)	0.1764	1.33 (1.03-1.74)	0.0308*	1.11 (0.76-1.62)	0.5867	1.26 (0.92-1.72)	0.1570	1.45 (0.90-1.67)	0.1391	1.49 (0.95-2.33)	0.0828	2.05 (1.40-3.02)	0.0003*	1.93 (1.40-2.67)	<0.0001*		
Iliac access	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-		
<b>Hospital bed size</b>																		
<b>Small</b>																		
Small	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-		
<b>Medium</b>																		
Medium	1.04 (0.85-1.26)	0.7249	0.97 (0.82-1.14)	0.7014	0.99 (0.81-1.21)	0.9120	0.95 (0.79-1.13)	0.5556	1.65 (0.94-2.91)	0.0837	1.19 (0.74-1.90)	0.4708	0.99 (0.83-1.18)	0.8888	0.94 (0.81-1.09)	0.3834		
<b>Large</b>																		
Large	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-		
<b>Hospital teaching status</b>																		
<b>Metro nonteaching</b>																		
Metro nonteaching	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-		
<b>Metro teaching</b>																		
Metro teaching	0.95 (0.85-1.06)	0.3250	0.94 (0.86-1.02)	0.1499	0.92 (0.82-1.03)	0.1639	0.91 (0.83-1.00)	0.0513	1.23 (0.86-1.76)	0.2488	1.29 (0.96-1.73)	0.0950	1.35 (1.03-1.78)	0.0313*	1.36 (1.08-1.73)	0.0106*		
<b>Not metro</b>																		
Not metro	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-	Reference	-		

DRG, Patient Refined Diagnosis Related Group; TEVAR, thoracic endovascular aortic repair; OR, odds ratio; CI, confidence interval.

\*Statistically significant P<0.05.



**Table 4.** Hospital characteristics of unplanned readmissions following type B aortic dissection

Hospital characteristic	30-Day				90-Day			
	Total	Medical	TEVAR	P-value	Total	Medical	TEVAR	P-value
Total patients	5,770	4,950	820	-	9,187	8,035	1,152	-
Total readmissions	6,457	5,535	932	-	12,295	10,723	1,572	-
Hospital bed size				<0.0001*				0.0003*
Small	515 (8.9)	473 (9.6)	42 (5.1)		875 (9.5)	783 (9.8)	91 (7.9)	
Medium	1,344 (23.3)	1,198 (24.2)	146 (17.9)		2,123 (23.1)	1,925 (24.0)	198 (17.2)	
Large	3,910 (67.8)	3,279 (66.2)	631 (77.0)		6,189 (67.4)	5,326 (66.3)	863 (74.9)	
Same bed size as index	4,900 (84.9)	4,206 (85.0)	694 (84.6)	0.8764	7,662 (83.4)	6,722 (83.7)	941 (81.6)	0.3293
Hospital teaching status				0.0484*				0.0451*
Metro nonteaching	1,572 (27.3)	1,372 (27.7)	200 (24.4)		2,615 (28.5)	2,334 (29.1)	281 (24.4)	
Metro teaching	3,863 (67.0)	3,273 (66.1)	590 (72.0)		6,005 (65.4)	5,192 (64.6)	814 (70.6)	
Not metro	334 (5.8)	305 (6.2)	30 (3.6)		566 (6.2)	509 (6.3)	58 (5.0)	
Same teaching status as index	4,904 (85.0)	4,200 (84.9)	703 (85.8)	0.6394	7,749 (84.4)	6,802 (84.7)	947 (82.2)	0.2032
Same hospital as index admission	4,104 (71.1)	3,510 (70.9)	593 (72.4)	0.5695	6,316 (68.7)	5,547 (69.0)	769 (66.7)	0.3051
Total charges, in thousands of dollars	71.8±2.6	72.6±2.8	66.9±5.0	0.3110	68.0±2.5	66.3±2.0	79.4±11.3	0.2356

Values are presented as number (%) or mean±standard error.

TEVAR, thoracic endovascular aortic repair.

\*Statistically significant P<0.05.

rupture, hypotension or shock, neurologic sequelae, recurrent or refractory pain, hypertension refractory to medical therapy, early aortic dilation, or propagation of the dissection. It has been well described that patients with complicated type B dissection have worse in-hospital survival than those with uncomplicated type B dissection [9].

Despite technical innovation in TEVAR and a growing body of evidence, medical treatment focused on blood pressure and heart rate control to minimize stress on the aortic wall remains the gold standard of treatment for acute uncomplicated type B dissection. However, chronic medical treatment is not without challenges. Multiple antihypertensive medications are often required to reach blood pressure and heart rate goals in outpatients, and this treatment fails in younger and obese patients [10]. Furthermore, lack of access to care makes sustainable medical management challenging, especially for lower-income families. As such, our dataset demonstrates that lower household income led to a higher rate of unplanned readmissions for both medical and TEVAR-managed TBADs, highlighting the continued disparity seen in the outcomes of patients with complex diseases.

Literature comparing medical management and TEVAR for uncomplicated type B dissection is mixed and evolving. Early studies favored the medical management of TEVAR with regard to cost and outcomes [11]. Initial studies demonstrated technical success using TEVAR for TBAD, but most studies were designed to compare open vs. en-

dovascular approaches for complicated type B dissections and are less likely to be applicable now [12]. Development of the International Registry of Acute Aortic Dissection (IRAD) has allowed for a large analysis of aortic dissection management. Using this registry, Boohar et al. [2] identified that performing TEVAR for acute uncomplicated TBADs improved survival 30 days after the onset of dissection symptoms. Similar studies using state registries have demonstrated that although initially more expensive, TEVAR repair for acute uncomplicated TBAD results in improved survival at one and five years [3].

Larger studies using the IRAD have favored decreased 5-year mortality in patients treated with TEVAR when compared to those treated with medical management [13]. Durham et al. [14] reported their experience in treating acute uncomplicated TBADs with TEVAR vs. medical management: over 50% of the medical group ultimately failed medical therapy, leading to 38% mortality and 29% aortic repair. Furthermore, patients who underwent TEVAR demonstrated increased survival starting at the 2-year mark compared with the medical group. The data were further supported by the Investigation of STEnt Grafts in Aortic Dissection trial (INSTEAD-XL) [15]. This study is one of the few randomized controlled trials studying patients with uncomplicated TBAD in the subacute and chronic phases, treated with medical therapy alone, or with medical therapy and TEVAR. Again, following patients for up to five years revealed that patients undergoing TEVAR experienced

lower aorta-specific mortality (7% vs. 19%) and trended toward lower all-cause mortality (11% vs. 19%) compared to the medical treatment group [1].

The timing and execution of TEVAR for TBAD are dynamic. Although long-term mortality benefits have been established, immediate complications and costs are less well understood. We have demonstrated that TEVAR and medical management for acute TBAD reach similar unplanned readmissions over time. Importantly, the readmission rates for patients who underwent TEVAR were significantly lower. We also found that unplanned readmission rates in the TEVAR group were driven by the following procedural variables: urgent vs. elective surgery, adjunct procedures, and hospital characteristics. We believe this suggests that hospital and surgeon experience with TEVAR for acute TBADs affects unplanned readmissions. Furthermore, this suggests that performing TEVAR for acute TBADs as first-line treatment in aortic centers of excellence should be studied.

Recently, a group in Boston completed a similar analysis of readmissions in patients with acute TBADs. Carroll et al. [16] reported high rates of unplanned readmissions within 90 days, which were the highest among patients who underwent TEVAR and the lowest among those who underwent medical management alone. In their analysis, patients who underwent medical management were more likely to receive aortic intervention on readmission. Mortality and costs were similar between the two groups. Mody et al. [17] also evaluated readmission in the Medicare population in 2011 and found lower readmission rates in the medical management patients (19.8% medical vs. 25.5% open vs. 22.3% TEVAR).

However, our conclusions differ from these findings. Our data accumulation included a more recent timeframe. As noted above, we demonstrate that the performance of TEVAR has increased, whereas unplanned readmissions from TEVAR have decreased. We postulate that our results may differ because our patient population included more patients who underwent TEVAR more recently. Furthermore, our data demonstrated that patients who underwent TEVAR were readmitted for complications, notably in the iliac or peripheral systems. We also postulate that readmissions may have decreased with time in our dataset due to device improvements such as lower profiles and better conformability, translating into a reduction in procedural complications. In addition, our data did not include patients who underwent open repair for TBAD. We believe that by excluding open repair, we can more clearly compare medical management with TEVAR, and thus evaluate the two most common treatment modalities for acute TBADs.

## 1) Study limitations

We acknowledge that when using an ICD coding system, coding only exists for thoracic aortic dissection and does not distinguish between type A and type B dissection. To limit the inclusion of type A dissections, we excluded patients who underwent open repair, as this is the gold standard for type A dissections. However, we were unable to confirm that our patient population did not exclusively represent those with dissections involving the descending aorta. In addition, the complex survey design of the NRD must be acknowledged. Our results are based on nationally representative estimates from a smaller (20%) population sample. In addition, the limitation of using a coding database, such as the NRD, includes the inability to abstractly or directly correlate patient-level information from the encounter. As such, we cannot comment directly on the specifics of the aortic changes that resulted in readmission and the reason for TEVAR or other procedures, nor qualitatively discern the specific development of all the diagnoses coded with that specific readmission encounter. We can only indirectly surmise that an aorta-related issue arose to a high degree given that the collective inclusion of a vascular procedure, a code for graft complication, or aneurysmal dilation were coded for that patient encounter.

## CONCLUSION

Recent data suggest a role for TEVAR in acute, uncomplicated TBAD. We found that readmission from TEVAR was related to the technical aspects of the procedure. As operative experience increased, the number of unplanned readmissions after TEVAR statistically decreased, whereas unplanned readmissions for medical management remained unchanged. Thus, we conclude that there continues to be support for TEVAR as the initial treatment for acute uncomplicated TBAD in experienced aortic centers.

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## CONFLICTS OF INTEREST

The authors have nothing to disclose.

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