Impact of Ethnicity and Race on Outcomes after Thoracic Endovascular Aortic Repair

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March 23, 2022

Abstract

Introduction Thoracic endovascular aortic repair (TEVAR) became the standard of care for treating type B aortic dissections and descending thoracic aortic aneurysms. We aimed to describe the racial/ethnic differences in TEVAR utilization and outcomes. *Methods* The National Inpatient Sample was reviewed for all TEVARs performed between 2010 and 2017 for Type B aortic dissection and descending thoracic aortic aneurysm (DTAA). We compared groups stratifying by their racial/ethnicity background in whites, black, Hispanic, and others. A mixed-effects logistic regression was performed to assess the relationship between race/ethnicity and the primary outcome, in-hospital mortality. *Results* A total of 25,260 admissions for TEVAR during 2010–2017 were identified. Of those, 52.74% (n= 13,322) were performed for aneurysm and 47.2% (n= 11,938) were performed for type B dissection. 68.1% were white, 19.6% were black, 5.7% Hispanic, and 6.5% were classified as others. White patients were the oldest (median age 71 years; <0.001), with TEVAR being performed electively more often for aortic aneurysm (58.8% vs. 34% vs. 48.3% vs. 48.2%; p<0.001). In contrast, TEVAR was more likely urgent or emergent for type B dissection in black patients (65.6% vs 41.1% vs 51.6% vs 51.7%; p<0.001). Finally, the black population showed a relative increase in the incidence rate of TEVAR over time. The adjusted multivariable model showed that race/ethnicity was not associated with in-hospital mortality. *Conclusion* Although there is a differential distribution of thoracic indication and comorbidities between race/ethnicity in TEVAR, racial disparities do not appear to be associated with in-hospital mortality after adjusting for covariates.

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Conflicts of Interest : IS receives institutional research support from Abbott, Boston Scientific, Medtronic and Atricure. None of these are related to this manuscript.

Source of Funding : None.

Keywords : Aorta, Acute aortic dissection, Aortic aneurysm, Thoracic endovascular aortic repair, Racial disparities, Socioeconomic determinants of health

Running Head : Ethnicity, race, and TEVAR

Manuscript word count : 4439

Clinical trial registration : not applicable

IRB: STUDY18120143 approved and consent waived April 17, 2019

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Thoracic endovascular aortic repair (TEVAR) became the standard of care for treating type B aortic dissections and descending thoracic aortic aneurysms. We aimed to describe the racial/ethnic differences in TEVAR utilization and outcomes.

Methods

The National Inpatient Sample was reviewed for all TEVARs performed between 2010 and 2017 for Type B aortic dissection and descending thoracic aortic aneurysm (DTAA). We compared groups stratifying by their racial/ethnicity background in whites, black, Hispanic, and others. A mixed-effects logistic regression was performed to assess the relationship between race/ethnicity and the primary outcome, in-hospital mortality.

Results

A total of 25,260 admissions for TEVAR during 2010–2017 were identified. Of those, 52.74% (n= 13,322) were performed for aneurysm and 47.2% (n= 11,938) were performed for type B dissection. 68.1% were white, 19.6% were black, 5.7% Hispanic, and 6.5% were classified as others. White patients were the oldest (median age 71 years; <0.001), with TEVAR being performed electively more often for aortic aneurysm (58.8% vs. 34% vs. 48.3% vs. 48.2%; p<0.001). In contrast, TEVAR was more likely urgent or emergent for type B dissection in black patients (65.6% vs 41.1% vs 51.6% vs 51.7%; p<0.001). Finally, the black population showed a relative increase in the incidence rate of TEVAR over time. The adjusted multivariable model showed that race/ethnicity was not associated with in-hospital mortality.

Conclusion

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Abstract word count : 250

INTRODUCTION

Ever since its first description in 1994 by Dake and colleagues, thoracic endovascular aortic repair (TEVAR) has become the standard of care for the treatment of various pathologies involving the descending thoracic aorta (DTA), including aneurysm, acute dissection, intramural hematoma, and aortic rupture . Aided by technological advances and increasing operator familiarity with endovascular approaches, TEVAR has been associated with improved short-term outcomes compared to open surgical repair, including operative mortality, spinal cord ischemia, acute kidney injury, and cardiac and pulmonary complications

Nevertheless, access to surgical procedures and their benefits is often inequitable due to structural disparities at the health systems level . For example, racial disparities have persisted in the utilization of 9 major surgical procedures, including coronary angioplasty, spinal fusion, carotid endarterectomy, appendectomy, colorectal resection, coronary artery bypass grafting, total hip arthroplasty, total knee arthroplasty, and worsened for one-third of them from 2012-2017 period . Likewise, the Transcatheter Valve Therapy (TVT) Registry suggests minorities have been underrepresented among the recipients of transcatheter aortic valve replacement (TAVR) .

However, the incursion of TEVAR technology into medical practice suggested a process of "democratizing technology." Historically, black patients were more likely to undergo open repair for thoracic aortic aneurysms (TAA) at low-volume hospitals with higher operative mortality than white patients (13). This paradigm was challenged by two reports, including data from 1999 to 2008, were we could observed a setting-off of traditional racial disparities with TEVAR utilization . Given that more than a decade has already passed, our objective is to reevaluate if TEVAR continues to be a procedure where access to surgical services is not affected by racial differences using a contemporary database.

METHODS

Data source

We obtained data from the Nationwide Inpatient Sample (NIS) Database from 2010 to 2017. The Agency for Healthcare Research and Quality sponsors the NIS as part of the Healthcare Cost and Utilization Project. The NIS is the largest publicly available all-payer inpatient healthcare database designed to produce national estimates of inpatient utilization, access, cost, quality, and outcomes. Unweighted, it contains data from more than 7 million hospital stays each year. Weighted, it estimates more than 35 million hospitalizations nationally. The data include diagnosis and procedure codes from the International Classification of Diseases, Ninth and Tenth Revision, Clinical Modification (ICD-9-CM and ICD-10-CM), and Clinical Classifications Software diagnosis and procedure classifications. The Institutional Review Board at the University of Pittsburgh evaluated this study and deemed it not to qualify as human subject research. The research team completed relevant HCUP training modules and signed the NIS Data Use Agreement.

Study Population

We identified all adult hospitalizations (aged >18 years) that were associated with a diagnosis code of dissection or aneurysm of the thoracic aorta without rupture (ICD-9-CM 441.00, 441.01, 441.03, 441.9, and ICD-10-CM I71.00, I71.01, I71.03, I71.2, I71.5). Then, we proceed to identify admissions associated with a TEVAR procedure. To exclude patients undergoing TEVAR in the aortic arch surgical reconstruction setting, patients with codes indicating Type A dissection, cardioplegia, valve repair, or an operation on vessels of the heart were excluded (see **Supplemental Table 1**). Patients were stratified by race and ethnicity. **Figure 1** is a CONSORT diagram depicting the patient population and groups of analysis.

Statistical methods and analysis

The cohort was stratified by their racial/ethnicity background in whites or Caucasians, black or African American, Hispanic, and others to assess baseline characteristics and outcomes comparatively. Sampling weights provided by the NIS were used for national estimations. TEVAR incidence rates were calculated for White, Black, and Hispanic patients using race-specific US Census population data for each year (**Supplementary Table 2**). Univariate comparison between groups was performed with Pearson Chi^2 test for categorical variables. Continuous data, including patient age, hospital length of stay, and total charges, were compared using the Kruskal-Wallis or ANOVA after testing for normality using the Shapiro–Wilk test. Bonferroni correction and Tukey's multiple comparison adjustment prevented Type I error. We have four groups which mean six pairwise; the significance value of p used was less than 0.05/6=0.008 to reject the null hypothesis. The primary outcome was in-hospital mortality. Secondary outcomes included complications identified through ICD codes (**Supplementary Table 3**) and resources utilization, such as length of stay and hospital charges. A mixed-effects multivariable logistic regression assessed the relationship between race and the primary outcome, using hospitals as the random effect to account for interhospital variability. Adjusting covariates were selected through a correlation matrix. R (4.0.0 'Arbor Day') was utilized for the analysis.

RESULTS

Baseline demographic and clinical variables

Selection of the study cohort is described in **figure 1** . In 2010–2017, a total of 25,260 hospital admissions having coded a TEVAR procedure were estimated, of which 52.7% (n= 13,322) and 47.2% (n= 11,938) were secondary to an DTAA and type B dissection, respectively. The median age of the cohort was 69 years (IQR 59-77), with 40.7% (n= 10,297) being female and 55% (n= 13,901) catalogued as elective admissions. Most of the included admissions had hypertension as a comorbidity (85.7%, n= 21,663), followed by dyslipidemia (46.9%, n= 11,856) and coronary artery disease (31.4%, n= 7,948). Furthermore, 54.8% (n= 13,859) of the admission were from patients whose median household incomes fell under the 50^{th} percentile (30.2% in the $<25^{\text{th}}$ and 24.6% in the 25-50^{th} percentile). Regarding hospital characteristics, 83.3% (n= 21,041) and 74.2% (n= 3,758) of TEVARs were performed in Urban non-teaching and in large bed size hospitals, respectively.

Racial/Ethnic Groups

Out of the 25,260 hospital admissions, 68.1% (n= 17,197) were whites/Caucasian, 19.6% (n= 4,959) were black/African American, 5.7% (n= 1,462) Hispanic and 6.5% (n= 1,642) were classified as "others" (2.9% Asian or pacific islanders and 0.4% native Americans). Overall, there was a relative marginal increase in the proportion of TEVARs performed from 2013 onwards. Specifically, the race-adjusted procedural incidence rate for black population went from 1.14 cases per 100 000 persons in 2012 to 2.03 cases per 100 000 persons in 2015 (**Figure 2**)

Overall, TEVAR was more frequently secondary to DTAA (58.8% vs 34% vs 48.3% vs 48.2%; p<0.001) among white population; they had more often CAD (34.6% vs 24.1% vs 26.8% vs 24.7%; p<0.001), and COPD (28.7% vs 15.6% vs 15.1% vs 16.5%; p<0.001). In contrast, black population had a younger median age, presented more frequently with type B dissection (41.1% vs 65.6% vs. 51.6% vs 51.7%; p<0.001), or hypertension as a comorbidity (83% vs 92% vs 85% vs 84%; p<0.001). A higher proportion of the black population had a median household income below the percentile 25^{th} (24.2% vs 52.1% vs 34.9% vs 22.6%; p<0.001) (**Table 1**).

Outcomes after TEVAR

Hemorrhage or transfusion-related complications were the most common complication identified among all TEVAR admissions with 23.1% (n= 5.850), followed by conduction abnormalities 22.9% (n= 5,807) and acute kidney failure with 15.3% (n= 3,870). The median length of stay was 6 days (IQR 3 – 10), and the median total hospital charges were $165,500 (IQR 106,600 – 260,000). Adjusted pairwise comparison showed the black population had the highest proportion of acute kidney failure overall (13.3% vs. 21.7% vs. 16.1% vs. 15.4%; p<.008), and compared to white counterparts, presented more frequently paraplegia (2.62% vs 1.66%; p<.008). No differences were observed in the total hospital charges between white, black, and Hispanic populations (**Table 2**).

Mixed-effects logistic regression for in-hospital mortality

The overall estimated in-hospital mortality was approximately 4.3% (n= 1,087), being significantly higher for the Hispanic group after pairwise comparisons (4.1% vs. 4.2% vs. 6.2% vs. 4.1%; p<.001). However, the adjusted multivariable model showed that race was not an independent factor associated with in-hospital mortality (**Table 3**). Instead, the association with cerebrovascular disease (OR 2.3, CI 95% 1.6 – 3.4), a non-elective admission (OR 2.2, CI 95% 1.5 – 3.1), peripheral artery disease (OR 1.6, CI 95% 1.2 – 2.2), and chronic kidney disease (1.45 (1.01 – 2.07), were all highly associated with in-hospital mortality.

DISCUSSION

Historically, favorable results treating thoracic aortic pathologies were restricted to centers of excellence with extensive experience in open surgical repair , limiting the access of high-quality surgical services to underrepresented populations . However, the refinement of endovascular techniques and TEVAR becoming widely available translated into better perioperative outcomes.

This contemporary study reaffirms that racial or ethnic background is not associated with in-hospital mortality after TEVAR after adjusting for hospital-level and patient-level covariates, including median household income. Instead, we observed comorbidities determining unfavorable outcomes in the multivariable analysis; white patients were more likely to be treated electively after thoracic aortic aneurysms, and black and Hispanic patients were more likely to be treated non-electively for type B aortic dissection. Most importantly, there seems to be a relative increase in the proportion of the black population having access to TEVAR technology over the last years.

Our data corresponds with previous reports. An analysis of the Vascular Quality Initiative database showed that despite increased comorbidities and advanced disease, black patients were not associated with an increased risk of perioperative complications compared to white populations (OR 0.9; 95% CI, 0.7-1.1; P = .42) . Additionally, data from 12,500 Medicare patients showed that the increased risk of perioperative mortality seen in open repairs for black patients (OR = 2.0, 95% CI1.5– 2.5, p<0.001) was offset when TEVAR was utilized compared to the white population (OR = 0.9, 95% CI=0.6–1.5, p=0.72), a relationship that remained constant across different hospital volume strata . Rather than being associated with race or ethnicity, all these studies suggest TEVAR mortality is affected by other factors such as the underlying pathologic process or clinical acuity. For example, patients with type B dissection have traditionally had lower in-hospital mortality rates than aortic aneurysms or repair of ruptured thoracic aneurysms usually have a higher risk of death than non-ruptured aneurysms.

Additionally, this analysis adds to the body of literature describing the influence of the comorbidities profile on TEVAR outcomes. For example, perioperative mortality is significantly higher in patients with chronic renal disease compared to non-renal failure patients ; chronic heart failure has been associated with TEVAR-related adjusted-mortality for both thoracic aneurysm and type B dissection ; chronic obstructive pulmonary disease has also been independently associated with increased mortality after adjusting for gender and other comorbidities (OR 4.31, CI 1.01–16.88; p=0.03) . Finally, increasing age has been identified to be interdependently associated with mortality; patients [?]80 years have higher odds for mortality than younger patients (OR, 2.32; 95% CI, 1.25 – 4.31) . In our analysis, comorbidities such as cerebrovascular disease, peripheral artery disease, and chronic kidney disease were independently associated with in-hospital mortality, reflecting the association between atherosclerosis and mortality . Worth mentioning, hypertension was associated with increased odds for hospital survival, which can be explained by hypertension being related to younger patients with Type B dissection .

Racial or ethnic disparities in health services follow a multifactorial framework; patient characteristics and preferences, surgical providers' background, and surgical health services availability determine access to care . Thoracic endovascular grafting has demonstrated that technological advancements can effectively bridge access and outcomes gaps; namely, TEVAR made managing complex aortic pathologies simpler and safer, encouraging widespread utilization. Data from 2000 to 2012 already showed a progressive increase of thoracic endovascular aortic repair supplanting open repairs with better results . Furthermore, earlier reports even suggested that underrepresented populations (Black, Hispanic, and Native American) and patients with lower median household incomes had a higher propensity for undergoing TEVAR procedures . We could observe a relative increase in the TEVAR incidence rate during 2013 -2015 for the black population in this opportunity. This trend could be related to some national health reforms implemented during the same period. For example, the Health and Human Services Action Plan to Reduce Racial and Ethnic Health Disparities (HHS Disparities Action Plan), The Affordable Care Act insurance, and the Medicaid expansions have a temporal relationship . Likewise, it can be argued that the extension of indication criteria might have also positively impacted the underrepresented population. For example, endovascular treatment of traumatic aortic lesions could benefit minority-serving trauma centers where the uninsured population tends to cluster or the tendency to treat acute type B dissections with TEVAR may have helped the black population .

Limitations

The limitations of this study are inherent to the nature of the database. Although administrative databases are a great source of national data, coding systems are prone to oversimplification of pathologies, registry errors, and missed entries. For example, a patient with a chronic type B dissection and degenerative dilation can be coded as an aortic aneurysm in some institutions and as dissection in others. Furthermore, more comprehensive data to address race disparities holistically is not possible with administrative databases such as the NIS database. Another limitation is that decompensated comorbid conditions or other important clinical factors present at admission cannot be differentiated from chronic stable ones, leading to confounding. Also, despite these data demonstrating the short-term advantages of an endovascular approach regardless of race, the longer-term effects are uncertain. Significant racial/ethnic disparities might be essential in explaining clinical outcomes concerning antihypertensive therapy variability, treatment adherence, and surveillance programs.

Conclusion

This contemporary real-world data reconfirms racial or ethnic background is not associated with in-hospital mortality after adjusting for covariates, demonstrating TEVAR has been a successful case where one aspect of health services disparities has been covered. Instead, the burden of comorbidities seems to affect clinical outcomes among TEVAR patients.

References:

Table 1. Weighted patient demographics and hospital characteristics with univariate comparisons between race groups

Variable	Total N= 25,260	White/Caucasian N= 17,197	Black/AA N= 4,959	Hispanic N= 1,462	Other N= 1,642	P-Value
Age, median (IQR)	69 (59 -77)	71 (62-78)	62 (53-72)	66 (57-76)	67 (58-77)	<.001
Female, n (%)	10,297 (40.77%)	7,046 (40.9%)	2,147 (43.3%)	543 (37.1%)	561 (34.1%)	<.001
Indication, n (%)						<.001
Type B dissection	11,938 (47.26%)	7,079 (41.16%)	3,255 (65.64%)	755 (51.63%)	850 (51.74%)	
Thoracic Aneurysm	13,322 (52.74%)	10,118 (58.84%)	1,704 (34.36%)	707 (48.37%)	793 (48.26%)	
Elective admission, n(%)	13,901 (55.03%)	10,169 (59.14%)	2,142 (43.20%)	697 (47.70%)	893 (54.35%)	<.001
Comorbidities, n (%)						
Diabetes Mellitus	5,346 (21.16%)	3,315 (19.27%)	1,199 (24.18%)	403 (27.57%)	429 (26.12%)	<.001

Variable	Total N= 25,260	White/Caucasian N= 17,197	Black/AA N= 4,959	Hispanic N= 1,462	Other N= 1,642	P-Value
Dyslipidemia	11856 (46.94%)	8478 (49.30%)	1939 (39.11%)	709 (48.50%)	730 (44.44%)	<.001
Coagulation Disorder	3125 (12.37%)	2082 (12.11%)	644 (12.98%)	171 (11.68%)	228 (13.88%)	0.08
Heart Valve Disorder	2662 (10.54%)	1930 (11.22%)	425 (8.57%)	150 (10.27%)	158 (9.59%)	<.001
Hypertension	21,663 (85.76%)	14,440 (83.97%)	4,580 (92.37%)	1,255 (85.83%)	1,388 (84.53%)	<.001
Coronary Artery Disease	7948 (31.47%)	5954 (34.62%)	1195 (24.11%)	392 (26.81%)	407 (24.77%)	<.001
Congestive Heart Failure	2633 (10.42%)	1687 (9.81%)	668 (13.46%)	120 (8.22%)	158 (9.64%)	<.001
CVD	2706 (10.71%)	1893 (11.01%)	483 (9.75%)	166 (11.36%)	164 (10.00%)	0.05
PAD	5727 (22.67%)	4181 (24.31%)	1000 (20.17%)	270 (18.47%)	276 (16.81%)	<.001
COPD	6220 (24.62%)	4949 (28.78%)	778 (15.69%)	222 (15.15%)	271 (16.52%)	<.001
Chronic Kidney Disease	4647 (18.40%)	2680 (15.58%)	1368 (27.59%)	250 (17.12%)	349 (21.23%)	<.001
Hospital Variables, n (%)						<.001
Rural	400 (1.59%)	330 (1.92%)	46 (0.93%)	5 (0.34%)	19 (1.18%)	
Urban Non-Teaching	3,709 (14.68%)	2,715 (15.79%)	453 (9.13%)	264 (18.06%)	277 (16.89%)	
Urban Teaching	21,041 (83.30%)	14,102 (82.01%)	4,439 (89.51%)	1,177 (80.48%)	1,324 (80.60%)	
Small bed size	364 (7.19%)	257 (7.46%)	44 (4.44%)	24 (8.25%)	39 (11.82%)	
Medium bed size	917 (18.12%)	620 (17.99%)	168 (16.94%)	68 (23.37%)	61 (18.48%)	
Large bed size	3,758 (74.27%)	2,560 (74.27%)	776 (78.23%)	196 (67.35%)	226 (68.48%)	

Table 2. Weighted clinical outcomes with univariate comparisons between race groups

Variables	Total N= 25,260	White/Caucasian N= 17,197	Black/AA N= 4,959	Hispanic N= 1,462	Other N= 1,642	P-value
In-hospital Mortality, n (%)	**1,087 (4.3%)**	**717 (4.17%) [a]**	**211 (4.26%) [a]**	**91 (6.24%) [b]**	**68 (4.15%) [a]**	<.001
LOS in days, median (IQR)	6 (3-10)	5 (3-10)	7 (4-13)	6 (3- 9)	5 (3-11)	<.001

Variables	Total N= 25,260	White/Caucasian N= 17,197	Black/AA N= 4,959	Hispanic N= 1,462	Other N= 1,642	P-value
Discharge Location, n (%)						<.001
Home	14,486 (57.3%)	9,741 (56.6%)	2,828 (57%)	918 (62.7%)	1,000 (60.8%)	
STH/SNF/ICF/IHC	9,628 (38.1%)	6,700 (38.9%)	1,905 (34.4%)	448 (30.6%)	574 (34.9%)	
Complications, n (%)						
Heart Failure	706 (2.79%)	461 (2.68%)	141 (2.84%)	46 (3.12%)	59 (3.58%)	0.16
Arrhythmia	5,807 (22.99%)	4,393 (25.54%)	832 (16.79%)	229 (15.68%)	352 (21.44%)	<.001
Pneumonia	1,832 (7.25%)	1,198 (6.97%)	453 (9.14%)	110 (7.50%)	71 (4.32%)	<.001
Respiratory Failure	1502 (5.95%)	1002 (5.83%)	334 (6.73%)	81 (5.52%)	85 (5.20%)	0.05
Acute Kidney Injury	3,870 (15.32%)	2,301 (13.38%) [a]	1,079 (21.76%) [b]	236 (16.17%) [a]	254 (15.45%) [a]	<.001
Paraplegia	456 (1.81%)	285 (1.66%) [a]	130 (2.62%) [b]	31 (2.12%) [a, b]	10 (0.61%) [c]	<.001
Spinal Cord Ischemia	331 (1.31%)	236 (1.37%)	60 (1.20%)	20 (1.37%)	15 (0.89%)	0.35
Bowel Ischemia	549 (2.18%)	389 (2.26%) [a]	110 (2.22%) [a]	31 (2.11%) [a]	20 (1.20%) [b]	0.04
Stroke	940 (3.72%)	666 (3.87%)	159 (3.21%)	46 (3.12%)	70 (4.24%)	0.06
Hemorrhage or Transfusion-related	5,850 (23.16%)	3,775 (21.95%) **[b]**	1,268 (25.58%) [a]	370 (25.27%) [a]	437 (26.63%) [a]	<.001
Hospital Charges (x $1000), median (IQR)	165.5 (106.6-260.0)	158.3 (103.8-247.2) [a]	178.5 (116.4-269.2) [a]	173.9 (111.7-291.6) [a]	189.5 (107.2-310.5) [b]	<.001

* Pairwise comparison: same letter means no significant difference i.e.: a vs a or b vs b or c vs c. If they have different letter, it means the difference was statistically significant i.e.: a vs b or b vs c.

Table 3. Mixed effect logistic regression model for in-hospital mortality

Individual center			0.38 (0.24)	0.02
Race	*White as reference*			
Black	0.86 (0.58– 1.28)	0.46		
Hispanic	1.54 (0.88– 2.68)	0.13		
Other	0.78 (0.41 – 1.49)	0.45		
Non-elective admission	2.23 (1.56 – 3.18)	<0.001		

Indication	*Aneurysm as reference*	
Type B	*0.49 (0.35 – 0.70)*	<0.001
Comorbidities		
Dyslipidemia	0.56 (0.40 – 0.77)	<0.001
Hypertension	0.50 (0.35 – 0.73)	<0.001
Congestive heart failure	1.24 (0.82 – 1.88)	0.32
Cerebrovascular disease	2.39 (1.65 – 3.46)	<0.001
Peripheral artery disease	1.62 (1.18 – 2.23)	0.001
Chronic Kidney Disease 1.45 (1.01 – 2.07) 0.04		

*Non-significant covariates also included in the model: Congestive heart failure, Coagulopathy, median household income, Type of hospital (rural, urban non-teaching, urban teaching), Size of hospital (small, medium, and large bed size).

Figures

Figure 1. Flow chart of Cohort selection. *NE= National Estimation*

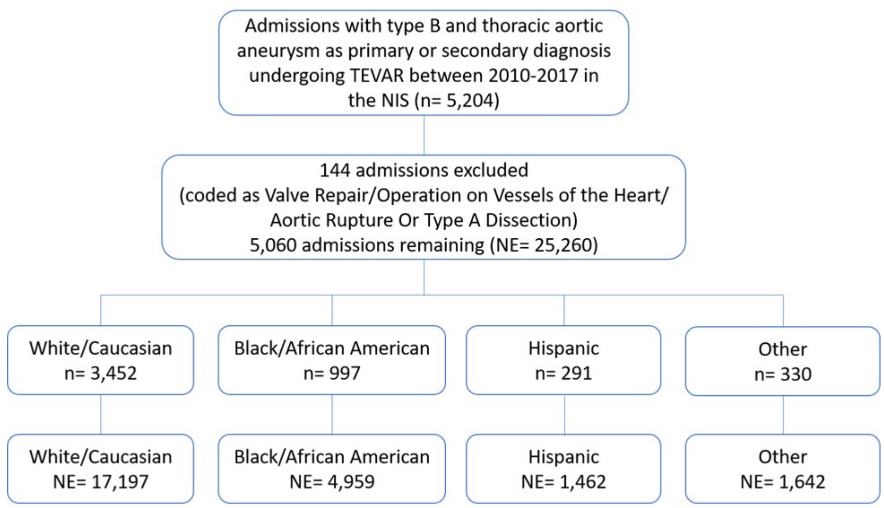

Figure 2. Population adjusted TEVAR incidence rate of TEVAR by year using the U.S. national census.

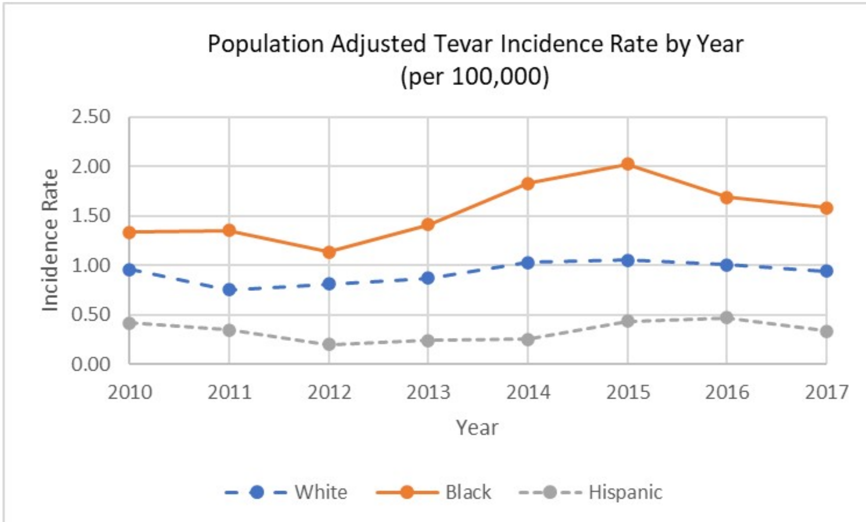

Figure 3. Distribution of TEVAR per median household income stratified by race