Aortic Atheroma Increases the Risk of Long-Term Mortality in 20,000 patients

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Abstract

Background—The association between long-term mortality and aortic atheroma in cardiac surgical patients has not been comprehensively investigated. In this study we determine the relationship between grade of atheroma and the risk of long-term mortality in a retrospective cohort of over 20,000 patients undergoing cardiac surgery over a 20 - year period.

Methods—We included 22,304 consecutive intraoperative transesophageal and epiaortic ultrasound examinations performed at Brigham and Women's Hospital between 1995 and 2014, with long-term follow-up. The extent of atheromatous disease recorded in each examination was used for analysis. Mortality data was obtained from our institution's data registry. Mortality analyses were done using Cox proportional hazard regression models with follow-up as a time scale. We repeated the analysis in a subgroup of 14,728 patients with more detailed demographics, including postoperative stroke, queried from the institutional Society of Thoracic Surgeons database.

Results—A total of 7,722 mortality events and 872 stroke events occurred. Patients with atheromatous disease demonstrated a significant increase in mortality across all grades of severity, both for the ascending and descending aorta. This relationship remained unchanged after adjusting

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for additional covariates. Adjustments for postoperative stroke resulted in only minimal attenuation in the risk of postoperative mortality related to aortic atheroma.

Conclusions—Aortic atheromatous disease of any grade in the ascending and descending aorta is a significant long-term risk of long-term, all-cause mortality in cardiac surgery patients. This association remains independent of other conventional risk factors, and is not related to postoperative cerebrovascular accidents.

Thoracic aortic atheroma is associated with increased risk of postoperative complications after cardiac surgery. (1-5) In a study of 189 patients undergoing multivessel coronary artery bypass grafting (CABG) surgery, 45.5% of patients with severe atheromatous disease in the descending aorta sustained strokes in the first week following surgery, compared to patients with no disease or mild disease who experienced no strokes.(4) Furthermore, significant aortic atheroma burden has been associated with a nearly five-fold increase in neuropsychological dysfunction, and is an independent risk factor for renal dysfunction in the first week after cardiac surgery.(1,6)

Patients with a history of stroke and thoracic aortic atheromatous disease have increased mortality and an increased rate of embolic events when compared to those with no atheromatous disease.(7) Ascending aortic atherosclerosis is also associated with a 1.5 fold increase in mortality over a three year period.(2) However, these studies were lacking in patient number and duration of follow-up, were limited to the ascending aorta, or were deficient in the quality of the assessment of aortic disease. Furthermore, the association between long-term mortality and aortic atheroma has not been comprehensively investigated.

Therefore, we examined the relationship between grade of aortic atheromatous disease and long-term mortality in a retrospective cohort of over 20,000 patients undergoing cardiac surgery at a single center over a 19-year period. We hypothesized that given the large number of patients we would be able to identify an association with long-term mortality even at lower grades of atheromatous severity, and that this would be independent of cerebrovascular events or other comorbidities.

Material and Methods

Study Population

In our analysis we included 22,304 consecutive intraoperative cardiac ultrasound examinations performed at the Brigham and Women's Hospital between 1995 and 2014. The study population consisted of all cardiac surgical patients who had undergone intraoperative epiaortic ultrasound examinations (EPI) and/or transesophageal echocardiography (TEE). The study and the retrospective review of the patients' medical records were approved by the Partners Healthcare Institutional Review Board.

Data Collection

All patients received standard medical care. Baseline demographics, comorbidities, and imaging data were recorded and stored in an encrypted online database. The extent of ascending and descending thoracic aorta atheromatous disease was graded as none, mild,

moderate, or severe by National Board of Echocardiography certified anesthesiologists using a modified version of the Kronzon scale.(8,9) Specifically, mild atheroma was defined as localized atherosclerotic thickening less than 3mm, moderate atheroma as atherosclerotic thickening between 3 and 5 mm, and severe atheroma as atherosclerotic thickening greater than 5 mm or the presence of mobile plaque. Patients without atheroma grading data were excluded from the study. For a discrepancy between the EPI and TEE, the more severe grade was chosen.

Endpoint

The primary endpoint was defined as all-cause mortality. Operative records from our departmental TEE database were matched with the Partners Healthcare System Research Patient Data Registry to obtain mortality data, which is updated from the National Death Index.

Subgroup analysis

We repeated the analysis in a subgroup of **14,728** patients with more detailed demographics queried from the institutional Society of Thoracic Surgeons database. Additional variables include body mass index, race, smoking history, history of diabetes, hypertension, hyperlipidemia, peripheral vascular disease, creatinine, and urgency of operation.

Statistical analysis

Statistical analyses were performed in R 3.1.1 (https://www.r-project.org) using the "survival" package. Kaplan-Meier survival curves were compared using a two-sided non-parametric log-rank test. Univariate analyses were initially performed to examine the association between potential predictors and outcomes, followed by a multivariate model including all potential predictors. Mortality analyses were performed using Cox proportional hazard regression models with follow-up as a time scale. We repeated the analysis in a subgroup of 14,728 patients with more detailed demographics queried form the institutional Society of Thoracic Surgeons database, to further control for variables that were not in our original database but might be associated with an increase in mortality.

In the subgroup analysis, we were also interested in the effect of atheroma on mortality risk that is not related to cerebrovascular accident (CVA). Thus a control direct effect model was performed, including CVA as a variable in the multivariate Cox model under the assumption that after adjusting for other covariates, no unobserved confounding remained for the joint effects of atheroma and CVA on mortality. We also assumed that atheroma did not confound the relationship between CVA and mortality. The proportional hazards assumption was validated by a goodness-of-test based on scaled Schoenfeld residuals.(10) We stratified by variables for which the proportional hazards assumption did not hold. For all analyses, a two-sided p value <0.05 was considered statistically significant.

Results

The average years of follow-up was 6.6 years (a total of 146,767 person years). 7,722 mortality events and 872 CVA events occurred. Of the 22,304 patients with complete

information on atheromatous disease and follow-up data, more than 50% had a diseased ascending aorta and over 70% had a diseased descending aorta. The number of patients with moderate and severe disease was much higher in the descending than the ascending aorta (34% versus 14%). Demographic and preoperative data are shown in Table 1.

Univariate analysis

Univariate predictors of long-term, all-cause mortality are listed in Table 2. Patients with atheromatous disease demonstrated a significant increase in mortality across all grades of severity, both for the ascending and descending aorta (Table 2). The Kaplan-Meier curves differentiated between all grades of atheroma in the ascending aorta (Figure 1a) and the descending aorta (Figure 1b) (P<0.001). The significant association was apparent early, with an increase throughout follow-up. In addition, other significant univariate predictors of mortality are age, left and right ventricular function, the type of surgery performed, race, urgent or emergent surgery, past smoking history, diabetes, hyperlipidemia, hypertension, increased creatinine value, peripheral vascular disease and postoperative CVA (table 2).

Cox proportional regression

In multivariate Cox Proportional Regression analyses, the association between moderate and severe ascending and descending atheromatous disease and mortality remained strong after adjusting for other predictors (Table 3). We observed an incremental increase in the risk of death beginning with mild disease, compared to normal aorta. Age, left ventricular and right ventricular function, urgent surgery status, past smoking history, increasing creatinine value, diabetes, hypertension, peripheral vascular disease, and postoperative CVA were also significantly and independently associated with all-cause mortality. As a matter of fact, the hazard ratio of severe atheromatous disease (1.89 for the ascending and 2.2 for the descending aorta) was greater than any other included variable, in the complete dataset as well as the subgroup analysis. Thus, in the subgroup the risk of dying as a result of having moderate or severe atheromatous disease is greater than having urgent surgery, diabetes, or peripheral vascular disease.

Subgroup analysis

In the subgroup analysis of **14,728** patients, aortic atheroma continued to be an independent risk factor for postoperative mortality with hazard ratios that were very similar to the complete dataset after adjusting for additional covariates (Table 4). The addition of postoperative CVA to the cox regression model as an independent variable resulted in only minimal attenuation in the risk of postoperative mortality related to aortic atheroma (Table 5).

Comment

The presence of significant aortic atheromatous disease has been associated with collateral cardiovascular disease in ambulatory patients, and short-term adverse postoperative outcomes in cardiac surgical patients. (1-3,11) The results of this investigation now demonstrate a robust relationship between grade of aortic atheroma and long-term mortality in a retrospective cohort of over 20,000 patients at a single center. While patients with high-

grade aortic atheromatous disease had the greatest increase in mortality, patients with mild disease also showed a significant increase in mortality. This relationship remained even after controlling for patient demographics, comorbidities, and known confounders. Furthermore, previous studies were often limited to the ascending aorta while we were able to show an equally strong effect in the ascending and descending aorta.

The mechanism by which aortic atheroma confers an increased risk of mortality has not been definitively established. Atheroma is believed to be a rich source of cerebral emboli following surgical manipulation of the atherosclerotic aorta. (3,4) Blauth and colleagues reported that a significant percentage of patients who died following cardiac surgery had evidence at autopsy of atheroembolism of multiple organs.(12) These investigators observed that atheroembolic events occurred in 37% of patients with severe atheromatous disease of the ascending aorta, but in only 2% of patients without significant disease. In our analysis, mortality risk was independent of whether patients had a postoperative stroke, suggesting that other mechanisms may be involved. In addition, as can be seen in the Kaplan-Meier curves, the majority of deaths cannot be attributed to the perioperative period.

Alternatively, the presence of atheroma in the thoracic aorta may be a hallmark of severe systemic cardiovascular disease.(8) Aortic plaque is associated with increased inflammatory markers and elevated levels of homocysteine and prothrombin, and increased aortic wall thickness assessed by multidetector computed tomography predicts coronary artery disease severity; over ninety percent of patients with thoracic aorta calcification also present with coronary artery plaque. (11,13) Hypertension, DM, PVD, and a history of stroke are also correlated with advanced aortic atheromatous disease.(4) It may be that atheromatous burden is a surrogate marker for a multitude of variables both caused by the disease process (HTN, renal disease, PVD, CAD), and also the severity of disease. However, after controlling for comorbidities associated with systemic vascular disease (HTN, HLD, PVD, CVA), aortic atheroma continued to be an independent risk factor for mortality in our patient population.

More comprehensive analysis of aortic atherosclerotic disease may provide insight into the relationship between atheroma grade and cause of death. Previous studies have suggested that the location and characteristics of atherosclerotic disease may impact postoperative stroke and mortality. In a review of 921 patients undergoing CABG surgery, van der Linden et al. found that location of atheroma in the middle-lateral segment of the ascending aorta is an independent predictive factor for postoperative stroke (RR 26.2).(14) Ferrari et al. found that patients with mobile aortic atheroma had increased mortality when compared to patients with non-mobile atheromatous disease.(15) Atherosclerotic load in major vessel beds is associated with an increased risk of death.(16) When comparing atheromatous disease in the coronary arteries, aortic arch, extracranial carotid arteries, and intracranial carotid, Bos. et al found that aortic arch atherosclerosis was found to be associated with the greatest increase in mortality.

The authors postulate that given its central location in the arterial system, aortic arch atherosclerosis represents a better reflection of the total burden of atherosclerosis.(16) Nonetheless, we found an equally strong association between the ascending and descending aortic atheroma and risk of mortality.

It is well established that adjustments in surgical technique, such as minimizing aortic manipulation and adjustment of cross clamp position when atheroma is present, can decrease the incidence of perioperative stroke.(17) Further research is warranted to determine whether patients found to have atheromatous disease on intraoperative TEE may benefit from further modification of surgical plan and surgical technique. In a casematched comparative study of patients with severe atheromatous disease, Sharony et al. found that off-pump coronary artery bypass technique was associated with lower morbidity and mortality when compared to coronary artery bypass.(18) Demaria et al. have found that off-pump coronary artery bypass technique was associated with less operative mortality and strokes in octogenarians then conventional CABG under CBP.(19) Patients with high grade atheroma may benefit from adjustment of surgical plan.

Limitations

Observational, retrospective studies are susceptible to limitations associated with potential inconsistency in data collection, the lack of prospectively delineated definitions of predictors and outcomes, and missing data. Data in our study was collected using departmental and institutional databases that have been validated historically for accuracy and consistency. Furthermore, the data was collected by experienced, National Board of Echocardiography certified cardiac anesthesiologists who specifically adhered to published, guideline recommended criteria for grading aortic atheroma using simple measurements of atheroma thickness that are highly reproducible. [4]

Quality of echo technology, and practice patterns of echocardiography, evolved over the 20 year period of the study. It is possible that the relatively poorer quality of echo in the early period of this study could have affected the grading of atheroma relative to the later part of the study. Patients in the earlier years of our study who only received TEE and not epiaortic ultrasound exams may have had under-reporting of atheroma in the aortic arch and ascending aorta due to limited visualization with the TEE probe. However, multiple studies indicated that there is a good correlation between atheromatous disease in the three aortic segments.(8,20) In addition, despite decreased ability to image the aortic arch and ascending aorta with the TEE probe, the interobserver variability within these segments was similar to that of the better visualized descending aorta.(8)

Another limitation is that we could not adjust for surgical practice patterns with respect to how surgical technique was modified in response to the presence of atheromatous disease found on intraoperative ultrasound exams. It is possible that changes in surgical planning, such as modifying cross clamp location, modified aortic crossclamp time, aortic endarterectomy, and circulatory arrest with retrograde cerebral perfusion, improved outcomes and led to an underestimation of the effect of atherosclerosis on mortality.

Mortality data was obtained through the research patient data registry, which is updated from the national death index. Another limitation is that this database did not provide information about cause of death, or allow for the ability to differentiate between cardiovascular and non-cardiovascular mortality. Finally, the inclusion of over 20,000 patients in this investigation not only contributes to the robust strength of the results, but also represents the largest published series on this topic from a single center.

Conclusions

Aortic atheromatous disease of any grade is a significant risk factor of all-cause, longterm mortality in cardiac surgical patients. This association remains independent of other conventional risk factors, and is not related to postoperative cerebral vascular accidents. Further research is warranted to elucidate whether direct mechanisms are responsible for the observed increase in postoperative mortality, or if atheromatous disease serves as a marker for systemic cardiovascular disease.

References

1. Davila-Roman VG. Kouchoukos NT. Schechtman KB. Barzilai B. Atherosclerosis of the ascending aorta is a predictor of renal dysfunction after cardiac operations J Thorac Cardiovasc Surg. 1999; 117:111. [PubMed: 9869764]

2. Davila-Roman VG. Murphy SF. Nickerson NJ. Kouchoukos NT. Schechtman KB. Barzilai B. Atherosclerosis of the ascending aorta is an independent predictor of long-term neurologic events and mortality J Am Coll Cardiol. 1999; 33:1308. [PubMed: 10193732]

3. Evered LA. Silbert BS. Scott DA. Postoperative cognitive dysfunction and aortic atheroma Ann Thorac Surg. 2010; 89:1091. [PubMed: 20338312]

4. Hartman GS. Yao FS. Bruefach M. Severity of aortic atheromatous disease diagnosed by transesophageal echocardiography predicts stroke and other outcomes associated with coronary artery surgery: a prospective study Anesth Analg. 1996; 83:701. [PubMed: 8831306]

5. Hogue, CW, Jr. Murphy SF. Schechtman KB. Davila-Roman VG. . Risk factors for early or delayed stroke after cardiac surgery Circulation. 1999; 100:642. [PubMed: 10441102]

6. Goto T. Baba T. Yoshitake A. Shibata Y. Ura M. Sakata R. Craniocervical and aortic atherosclerosis as neurologic risk factors in coronary surgery Ann Thorac Surg. 2000; 69:834. [PubMed: 10750769]

7. Ferreira RG. Worthington A. Huang CC. Aranki SF. Muehlschlegel JD. Sex differences in the prevalence of diastolic dysfunction in cardiac surgical patients J Card Surg. 2015; 30:238. [PubMed: 25571945]

8. Hartman GS. Peterson J. Konstadt SN, et al. High reproducibility in the interpretation of intraoperative transesophageal echocardiographic evaluation of aortic atheromatous disease Anesth Analg. 1996; 82:539. [PubMed: 8623958]

9. Katz ES. Tunick PA. Rusinek H. Ribakove G. Spencer FC. Kronzon I. Protruding aortic atheromas predict stroke in elderly patients undergoing cardiopulmonary bypass: experience with intraoperative transesophageal echocardiography J Am Coll Cardiol. 1992; 20:70. [PubMed: 1607541]

10. Xue X. Xie X. Gunter M, et al. Testing the proportional hazards assumption in case-cohort analysis BMC Med Res Methodol. 2013; 13:88. [PubMed: 23834739]

11. Jeltsch M. Klass O. Klein S, et al. Aortic wall thickness assessed by multidetector computed tomography as a predictor of coronary atherosclerosis Int J Cardiovasc Imaging. 2009; 25:209. [PubMed: 19051056]

12. Blauth CI. Cosgrove DM. Webb BW, et al. Atheroembolism from the ascending aorta. An emerging problem in cardiac surgery J Thorac Cardiovasc Surg. 1992; 103:1104. discussion 1111-2. [PubMed: 1597974]

13. Kronzon I. Tunick PA. Aortic atherosclerotic disease and stroke Circulation. 2006; 114:63. [PubMed: 16818829]

14. van der Linden J. Hadjinikolaou L. Bergman P. Lindblom D. Postoperative stroke in cardiac surgery is related to the location and extent of atherosclerotic disease in the ascending aorta J Am Coll Cardiol. 2001; 38:131. [PubMed: 11451262]

15. Ferrari E. Vidal R. Chevallier T. Baudouy M. Atherosclerosis of the thoracic aorta and aortic debris as a marker of poor prognosis: benefit of oral anticoagulants J Am Coll Cardiol. 1999; 33:1317. [PubMed: 10193733]

16. Bos D. Leening MJ. Kavousi M, et al. Comparison of Atherosclerotic Calcification in Major Vessel Beds on the Risk of All-Cause and Cause-Specific Mortality: The Rotterdam Study Circ Cardiovasc Imaging. 2015; 8

17. Moss E. Puskas JD. Thourani VH, et al. Avoiding aortic clamping during coronary artery bypass grafting reduces postoperative stroke J Thorac Cardiovasc Surg. 2015; 149:175. [PubMed: 25293356]

18. Sharony R. Bizekis CS. Kanchuger M, et al. Off-pump coronary artery bypass grafting reduces mortality and stroke in patients with atheromatous aortas: a case control study Circulation. 2003; 108(Suppl 1):II15. [PubMed: 12970201]

19. Demaria RG. Carrier M. Fortier S, et al. Reduced mortality and strokes with off-pump coronary artery bypass grafting surgery in octogenarians Circulation. 2002; 106:I5. [PubMed: 12354700]

20. Marschall K. Kanchuger M. Kessler K, et al. Superiority of transesophageal echocardiography in detecting aortic arch atheromatous disease: identification of patients at increased risk of stroke during cardiac surgery J Cardiothorac Vasc Anesth. 1994; 8:5. [PubMed: 8167285]
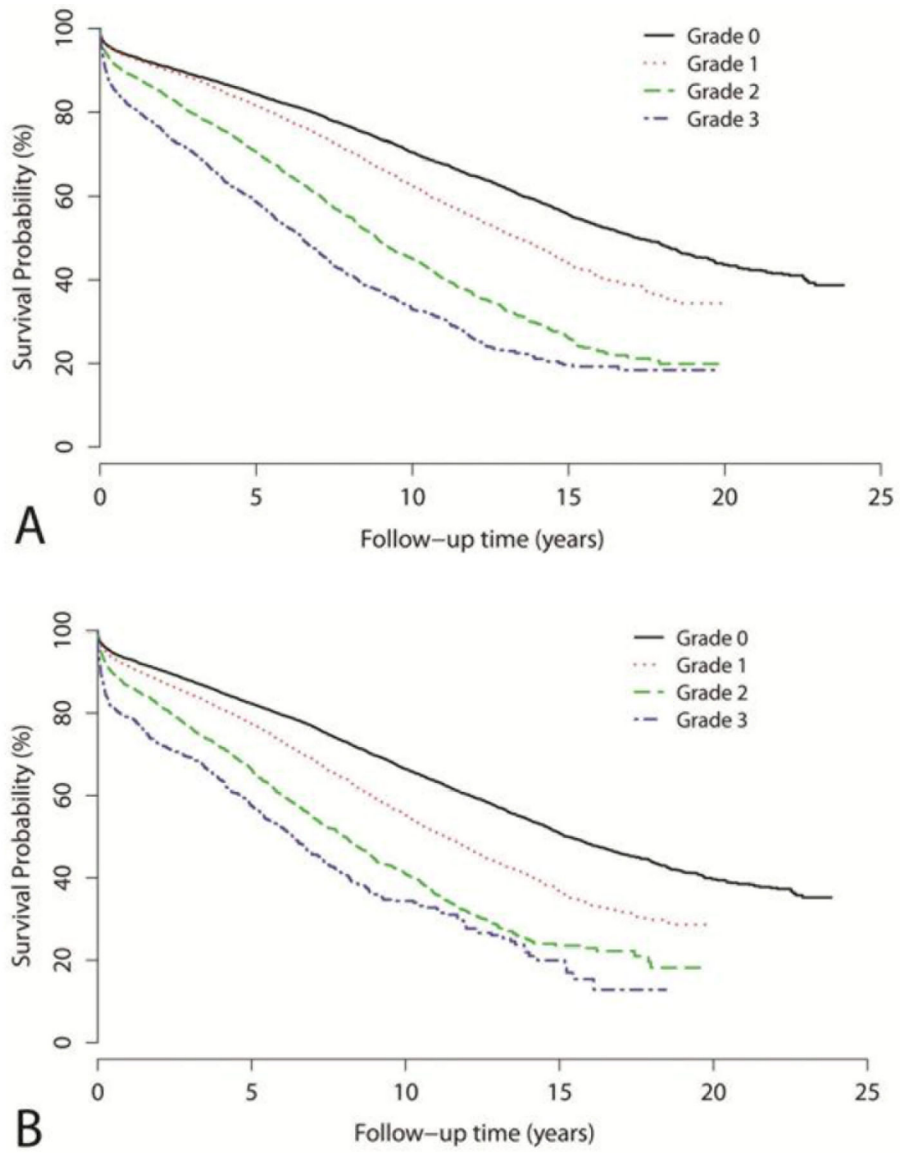
Figure 1.
Kaplan Meier Curves showing percent survival in relation to aortic atheroma grade in the ascending (A) and descending (B) aorta. (P<0.001), Grade 0 - No atheroma Grade 1 - Mild atheroma Grade 3 - Moderate atheroma Grade 4 - Severe Atheroma

Table 1

Demographic Information and Baseline Characteristics

Characteristics	Total cohort
Number of subjects (22,304)	
Mean age at the time of surgery (SD)	66.4 (13.5)
Mean BMI, N=14,728, (SD)	28.3 (6.1)
Male	14333 (64.3%)
Past Medical History (N= 14,728)	
Past smoker	6844 (46.5%)
Present smoker	1203 (8.2%)
Diabetes	3844 (26.1%)
HLD	10522 (71.4%)
HTN	10237 (69.5%)
PVD	2031 (13.8%)
Creatinine, N= 14,720, (SD)	1.2 (0.8)
Grade of LV Dysfunction (N=18,568)	
None	11488 (61.9%)
Mild	2988(16.1%)
Moderate	2297 (12.4%)
Severe	1795 (9.7%)
Grade of RV Dysfunction (N=18,461)	
None	15350 (83.1%)
Mild	2031 (11%)
Moderate	792 (4.3%)
Severe	288 (1.6%)
Urgency of Surgery (N= 14,728)	
Elective surgery	9718 (66%)
Emergent surgery	289 (2%)
Urgent surgery	4721 (32.1%)
History of Postoperative CVA (N=14,728)	872 (5.9%)
Grade of Atheroma Ascending (N=19,191)	
None	8465 (44.1%)
Mild	7844 (40.9%)
Moderate	2282 (11.9%)
Severe	600 (3.1%)
Grade of Atheroma Descending (N=18176)	
None	4446 (24.5%)
Mild	7414 (40.8%)
Moderate	4505 (24.8%)
Severe	1811 (10%)

LV – left ventricle, RV – right ventricle, HLD- hyperlipidemia, HTN – hypertension, PVD – peripheral vascular disease, BMI – body mass index, CVA – cerebrovascular accident

Table 2

Univariate Predictors of Long-Term, All-cause Mortality

VARIABLES	Categories	COMPLETE DATASET		SUBGROUP DATASET	
		HR (95% CI)	P-value	HR (95% CI)	P-value
MALE SEX		0.84 (0.81 to 0.88)	<.001	0.79 (0.73 to 0.84)	<.001
LV DYSFUNCTION					
	None	Reference	-	Reference	-
	Mild	1.60 (1.5 to 7.1)	<.001	1.67 (1.51 to 1.84)	<.001
	Moderate	1.94 (1.81 to 2.07)	<.001	2.10 (1.89 to 2.34)	<.001
	Severe	2.14 (1.99 to 2.3)	<.001	2.26 (2.02 to 2.35)	<.001
RV DYSFUNCTION					
	None	Reference	-	Reference	-
	Mild	1.57 (1.46 to 1.68)	<.001	2.00(1.8 to 2.21)	<.001
	Moderate	1.68 (1.51 to 1.86)	<.001	2.05 (1.76 to 2.39)	<.001
	Severe	1.80 (1.53 to 2.13)	<.001	2.24 (1.76 to 2.84)	<.001
SURGERY STATUS					
	Tricuspid Valve	Reference	-	Reference	-
	Mitral Valve	0.64 (0.57 to 0.72)	<.001	0.58 (0.49 to 0.67)	<.001
	CABG	0.71 (0.64 to 0.8)	<.001	0.61 (0.53 to 0.7)	<.001
	Aortic Valve	0.50 (0.45 to 0.57)	<.001	0.53 (0.46 to 0.63)	<.001
	Other	0.81 (0.72 to 0.91)	<.001	0.76 (0.64 to 0.9)	<.001
BMI		-	-	0.98 (0.98 to 0.99)	<.001
RACE					
	Caucasian	-	-	Reference	-
	Asian	-	-	0.55 (0.36 to 0.85)	<.001
	Black	-	-	0.90 (0.71 to 1.13)	0.368
	Hispanic	-	-	0.73 (0.56 to 0.96)	<.001
	Native American	-	-	0.52 (0.34 to 0.79)	<.001
PAST SMOKER		-	-	1.28 (1.19 to 1.37)	
CURRENT SMOKER		-	-	0.91 (0.81 to 1.03)	

VARIABLES	Categories	COMPLETE DATASET		SUBGROUP DATASET	
		HR (95% CI)	P-value	HR (95% CI)	P-value
DIABETES		-	-	1.7 (1.58 to 1.83)	
HLD		-	-	1.18 (1.09 to 1.28)	
HTN		-	-	1.74 (1.61 to 1.89)	
PVD		-	-	1.97 (1.81 to 2.13)	
CREATININE				1.36 (1.33 to 1.39)	
SURGERY STATUS					
	Elective	-	-	Reference	
	Urgent	-	-	1.72 (1.60 to 1.84)	<.001
	Emergency	-	-	2.18 (1.80 to 2.64)	<.001
CVA		-	-	1.78 (1.58 to 2.00)	<.001
ATHEROMA					
ASCENDING AORTA	None	Reference	-	Reference	-
	Mild	1.59 (1.5 to 1.67)	<.001	1.76 (1.61 to 1.92)	<.001
	Moderate	2.44 (2.28 to 2.62)	<.001	2.85 (2.56 to 3.19)	<.001
	Severe	3.09 (2.76 to 3.45)	<.001	4.03 (3.41 to 4.76)	<.001
DESCENDING AORTA	None	Reference	-	Reference	-
	Mild	1.79 (1.67 to 1.93)	<.001	2.02 (1.77 to 2.31)	<.001
	Moderate	3.03 (2.81 to 3.26)	<.001	3.75 (3.28 to 4.29)	<.001
	Severe	4.28 (3.93 to 4.66)	<.001	5.2 (4.48 to 6.03)	<.001

LV- left ventricle, RV – right ventricle, BMI – body mass index, HLD – hyperlipidemia, HTN – hypertension, PVD – peripheral vascular disease, CVA – cerebrovascular accident

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Table 3

Grade of Atheroma and Mortality: Cox Proportional Hazard Regression Model of the complete dataset

VARIABLE	Categories	ASCENDING AORTA (N=18,515)		DESCENDING AORTA (N= 18,905)	
		Hazard Ratio (95% CI)	P-value	Hazard Ratio (95% CI)	P-value
GRADE	None	Reference			
	Mild	1.18 (1.11 to 1.26)	<.001	1.27 (1.17 to 1.38)	<.001
	Moderate	1.46 (1.34 to 1.59)	<.001	1.67 (1.53 to 1.83)	<.001
	Severe	1.89 (1.65 to 2.16)	<.001	2.20 (1.99 to 2.44)	<.001
MALE SEX		0.96 (0.90 to 1.01)	0.117	0.97 (0.91 to 1.02)	0.24

Model stratified by year of operation, age, left and right ventricular function, and surgical type.

Table 4

Grade of Atheroma and Mortality: Cox Proportional Hazard Regression Model of the subgroup

VARIABLE	Categories	ASCENDING AORTA (N=10849)		DESCENDING AORTA (N=11232)	
		Hazard Ratio (95% CI)	P-value	Hazard Ratio (95% CI)	P-value
GRADE					
	None	Reference			
	Mild	1.12 (0.99 to 1.26)	0.068	1.34 (1.12 to 1.61)	.002
	Moderate	1.36 (1.17 to 1.58)	<.001	1.64 (1.36 to 1.99)	<.001
	Severe	1.81 (1.45 to 2.26)	<.001	2 (1.62 to 2.46)	<.001
MALE SEX		0.86 (0.77 to 0.95)	0.004	0.86 (0.78 to 0.95)	0.004
BMI		0.99 (0.98 to 1)	0.013	0.99 (0.98 to 1)	0.011
RACE					
	Caucasian	Reference			
	Asian	0.71 (0.37 to 1.34)	0.288	0.7 (0.37 to 1.31)	0.261
	Black	0.82 (0.57 to 1.16)	0.257	0.82 (0.57 to 1.18)	0.277
	Hispanic	0.64 (0.42 to 0.97)	0.034	0.72 (0.49 to 1.07)	0.104
	Others	0.68 (0.4 to 1.17)	0.165	0.74 (0.43 to 1.27)	0.281
PAST SMOKER		1.28 (1.15 to 1.42)	<.001	1.28 (1.16 to 1.42)	<.001
CURRENT SMOKER		1.12 (0.93 to 1.36)	0.231	1.03 (0.85 to 1.24)	0.778
DIABETES		1.49 (1.33 to 1.66)	<.001	1.49 (1.34 to 1.66)	<.001
HLD		0.88 (0.78 to 0.99)	0.030	0.89 (0.79 to 1)	0.052
HTN		1.34 (1.18 to 1.53)	<.001	1.28 (1.13 to 1.45)	<.001
PVD		1.44 (1.28 to 1.62)	<.001	1.40 (1.25 to 1.58)	<.001
CREATININE		1.47 (1.39 to 1.56)	<.001	1.48 (1.39 to 1.56)	<.001
STATUS					
	Elective	Reference		Reference	
	Urgent	1.32 (1.19 to 1.48)	<.001	1.32 (1.19 to 1.46)	<.001
	Emergent	1.56 (1.13 to 2.14)	.006	1.48 (1.08 to 2.05)	0.016

Model stratified by year of operation, age, left and right ventricular function, and surgical type. BMI – body mass index, HLD – hyperlipidemia, HTN – hypertension, PVD – peripheral vascular disease, CVA – cerebrovascular accident

Table 5

Grade of atheroma and mortality, further adjusted for cerebrovascular accident

VARIABLE	Categories	ASCENDING AORTA		DESCENDING AORTA	
		Hazard Ratio (95% CI)	P-value	Hazard Ratio (95% CI)	P-value
GRADE					
	Mild	1.11 (0.99 to 1.25)	0.08	1.34 (1.12 to 1.61)	.002
	Moderate	1.35 (1.16 to 1.57)	<.001	1.63 (1.35 to 1.97)	<.001
	Severe	1.80 (1.44 to 2.25)	<.001	1.98 (1.61 to 2.44)	<.001

Shown are the hazard ratios for atheroma in the ascending and descending aorta from the regression model in Table 4, when further adjusted for CVA. Minimal attenuation is noted.