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ORIGINAL RESEARCH

Left Ventricular Concentric Geometric Patterns Are Associated With Worse Prognosis Among Patients With Type-A Aortic Dissection

Walter E. M. Rocha, MD*; Matheus F. R. A. Oliveira, MD*; Julia D. Soares; Victor M. F. S. L'Armée; Mayara P. G. Martins, MD; Aloísio M. Rocha, MD, PhD; Audes D. M. Feitosa, MD, MSc; Ricardo C. Lima, MD, PhD; Pedro P. M. Oliveira, MD, PhD; Lindemberg M. Silveira-Filho, MD, PhD; Otavio R. Coelho-Filho, MD, PhD; José R. Matos-Souza, MD, PhD; Orlando Petrucci, Jr, MD, PhD; Andrei C. Sposito, MD, PhD; Wilson Nadruz Jr, MD, PhD

BACKGROUND: This study compared left ventricular (LV) characteristics between patients with type-A and type-B aortic dissection (AD) and evaluated the ability of LV remodeling phenotypes (hypertrophy, concentricity, or geometric patterns) to predict mortality in both AD types.

METHODS AND RESULTS: We evaluated 236 patients with type A and 120 patients with type B who had echocardiograms within 60 days before or after AD diagnosis (median [25th, 75th percentiles] time difference between echocardiogram and AD diagnosis=1 [0, 6] days) from 3 centers. Patients were stratified according to LV phenotypes, and early (90-day) and late (1-year) mortality after AD diagnosis were assessed. In adjusted logistic regression analysis, patients with type A had higher and lower odds of concentric and eccentric hypertrophy (odds ratio [OR], 2.56; 95% CI, 1.50–4.36; $P<0.001$; and OR, 0.55; 95% CI, 0.31–0.97; $P=0.039$, respectively) than those with type B. Results of multivariable Cox-regression analysis showed that LV remodeling phenotypes were not related to mortality in patients with type B. By contrast, LV concentricity was associated with greater early and late mortality (hazard ratio [HR], 2.22; 95% CI, 1.24–3.96; $P=0.007$ and HR, 2.06; 95% CI, 1.20–3.54; $P=0.009$, respectively) in type A. In further analysis considering normal LV geometry as reference, LV concentric remodeling and concentric hypertrophy were associated with early mortality (HR, 7.78; 95% CI, 2.35–25.78; $P<0.001$ and HR, 4.38; 95% CI, 1.47–13.11; $P=0.008$, respectively), whereas concentric remodeling was associated with late mortality (HR, 5.40; 95% CI, 1.91–15.26; $P<0.001$) among patients with type A. Assessment of LV geometric patterns and concentricity provided incremental prognostic value in predicting early and late mortality beyond clinical variables in patients with type A based on net reclassification improvement and integrated discrimination improvement.

CONCLUSIONS: LV geometric patterns derived from LV concentricity were associated with greater mortality among patients with type A and may be markers of adverse prognosis in this population.

Key Words: aortic dissection ■ concentricity ■ echocardiogram ■ hypertrophy ■ left ventricular remodeling

Aortic dissection (AD) is a cardiovascular emergency with high morbidity and mortality, especially among patients with proximal (type A) as compared with those with distal (type B) dissection.[1,2] Hypertension is the most common risk factor for AD[2] and is a major determinant of left ventricular

Correspondence to: Wilson Nadruz Junior, MD, PhD, Departamento de Clínica Médica, Faculdade de Ciências Médicas, Universidade Estadual de Campinas, Cidade Universitária "Zeferino Vaz," 13081-970 Campinas, SP, Brazil. E-mail: wilnj@fcm.unicamp.br

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*Dr Rocha and Dr Oliveira contributed equally to this work.

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CLINICAL PERSPECTIVE

What Is New?

- This multicenter study showed that left ventricular (LV) concentric remodeling and concentric hypertrophy were associated with higher 90-day mortality after aortic dissection diagnosis among patients with type A.
- LV concentric remodeling was associated with higher 1-year mortality after aortic dissection diagnosis among patients with type A.
- Patients with type A had greater prevalence of LV concentric hypertrophy, but lower frequency of LV eccentric hypertrophy than those with type B.

What Are the Clinical Implications?

- LV geometric patterns related to LV concentricity, especially concentric remodeling, may be markers of worse prognosis among patients with type A.
- These results suggest that assessment of LV geometry patterns and LV concentricity may be useful for stratification of mortality risk in type A aortic dissection.

Nonstandard Abbreviations and Acronyms

AD	aortic dissection
NRI	net reclassification improvement

(LV) remodeling, including LV hypertrophy (LVH).[3] Not surprisingly, both patients with type A and type B have high rates of LVH.[4–9]

Theoretically, type B carries higher risk of presenting LV remodeling than type A, because of greater expected prevalence of hypertension and age.[2,8] However, data comparing LV structural alterations between AD types are very limited, and a previous study suggested similar LVH rates in both AD types.[10] Conversely, more recent data indicated that LVH may be seen in patients with type A and type B regardless of hypertension,[7,9] indicating that hypertension-induced chronic pressure overload might not fully explain the development of LVH in AD.

LVH and alterations in LV geometry, particularly LV concentricity and concentric hypertrophy, are acknowledged risk markers of adverse outcomes in general populations and patients undergoing cardiac surgery.[3,11–14] Given the elevated death rate and prevalence of LV remodeling among patients with AD, it can be suggested that LV structural alterations could be a risk marker for worse prognosis in this population. However, knowledge regarding the prognostic value of LVH is restricted to a study enrolling 90 patients with type B, among whom LVH did not predict mortality in unadjusted analysis.[9] Furthermore, whether LV geometry predicts outcomes in patients with AD has not been assessed yet.

This study aimed to compare LV characteristics between patients with type A and type B and to evaluate the ability of LV remodeling phenotypes (LVH, concentricity or geometric patterns) in predicting mortality in both AD types.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Study Population and Design

This retrospective study evaluated patients with AD who had available echocardiogram exams within 60 days before or after the diagnosis of AD and were treated at 3 Brazilian centers (Clinics Hospital of the University of Campinas, Hospital of the Pontifical Catholic University of Campinas, Cardiology Emergency Room of Pernambuco) from 1993 to January 2020. Exclusion criteria were (1) age less than 18 years; (2) AD of traumatic origin; (3) LV remodeling owing to previous myocardial infarction; (4) moderate or severe valvar disease except aortic valve regurgitation; and (5) prior AD. Initially, 685 patients with AD diagnosis were identified, but 329 did not meet inclusion criteria, leaving 356 for the current analysis (Figure S1). The study protocol conforms to the principles of the Declaration of Helsinki and was approved by the ethics committee of all participant centers, which waived the requirement for informed consent.

Clinical Variables Definition

Type A was defined as a dissection involving the ascending aorta and/or aortic arch, and type B was defined as a dissection with an entry tear beyond the left subclavian artery origin and sparing the ascending aorta and aortic arch. AD diagnosis was performed by multislice computed tomography angiography imaging or transesophageal echocardiography. Information regarding clinical presentation and medical history at the time of AD diagnosis was systematically collected from medical charts and included data on age, sex, body mass index, blood pressure (BP) at the arm with highest value, presence of any limb pulse deficit, cardiac tamponade, hypotension (systolic BP<90 mm Hg),[2] pleural

effusion, AD presentation (acute [symptom onset up to 7 days], subacute [symptom onset 8–30 days], and chronic [symptom onset >30 days or asymptomatic]),[2] AD extension and creatinine levels, history of ever smoking, hypertension, diabetes mellitus, coronary heart disease, Marfan syndrome, and use of antihypertensive medications. Hypertension and diabetes mellitus were defined based on self-reported diagnosis or reported use of antihypertensive or antidiabetic medications at admission, respectively. Coronary heart disease was defined as a history of previous myocardial infarction or documentation of cardiac ischemia by noninvasive tests (exercise test, stress echocardiography or myocardial perfusion scintigraphy) or coronary angiography. In-hospital data were also collected and included information on definitive treatment modality used to manage AD (medical therapy, endovascular therapy, or surgery), aortic valve replacement and descending aorta stent placement (solely for patients with type A who underwent surgery), and hospital-acquired infections.

Echocardiography

Included patients had transthoracic echocardiography within 60 days before or after AD diagnosis. This time range was selected because we assumed that significant changes on LV structure owing to therapeutic interventions would not occur within that period. The median (25th, 75th percentiles) time difference between the date when echocardiogram was performed relative to the date of AD diagnosis was 1 (0, 6) days. Two-dimensional echocardiography was performed as previously reported,[15–17] according to the recommendations of the American Society of Echocardiography.[18] LV ejection fraction was estimated by the Teicholz method. LV mass was indexed by body surface area. Relative wall thickness was measured as 2*posterior wall thickness/LV diastolic diameter. LVH was defined as LV mass index >95 and 115 g/m^2 in women and men, respectively, and LV concentricity was considered if the relative wall thickness was >0.42.[18] LV geometric patterns were defined as follows: normal geometry (no LVH or LV concentricity), concentric remodeling (LV concentricity without LVH), eccentric hypertrophy (LVH without LV concentricity), and concentric hypertrophy (LVH with LV concentricity).[3]

Outcomes

The primary outcomes were all-cause death up to 90 days (early mortality; n=92) and up to 1 year (late mortality; n=107) post-AD diagnosis. Follow-up was assessed by last hospital visit or telephone contact. Death was ascertained by medical record review in 95 cases and by the national social security number database in 12 patients. The causes of death were established in all patients whose death was ascertained by medical record review but were not available among the 12 patients whose death was certified by the national social security number database. Therefore, the cause of death for these 12 patients was defined as unknown. There were 347 patients (97% of the sample) and 326 (92% of the sample) with complete follow-up at 90 days and 1 year of follow-up, respectively.

Statistical Analysis

Continuous variables with normal and nonnormal distribution are shown as mean±SD and median (25th, 75th percentiles), respectively, and categorical variables are shown as numbers and proportions. Differences in studied variables according to the number of studied groups were evaluated by unpaired *t* test or 1-way analysis of variance for normally distributed variables, Mann–Whitney or Kruskal–Wallis test for nonnormally distributed variables and χ^2 test for categorical variables. Differences in LV parameters between patients with type A and type B were further assessed by linear and logistic regression analysis adjusted for age, sex, center, and baseline relevant characteristics that were statistically different between type A and type B. Kaplan–Meier method calculated cumulative event rate, and comparisons between the curves were made by log-rank test. Multivariable Cox regression models were used to evaluate the adjusted association of LV parameters with early and late mortality for each AD type. Adjusted Cox-regression models were built for each AD type and included age, sex, center, calendar time, and variables that were statistically different between patients who were dead or not at 1 year of follow-up within type A or type B groups. The incremental value of LV phenotypes when added to clinical covariates in predicting death was evaluated using C-statistic, continuous net reclassification improvement (NRI), and integrated discrimination improvement with time-to-event data.[19] NRI values above >0.6 suggest strong, those around 0.4 suggest intermediate, and those <0.2 suggest weak reclassification improvement.[20] As sensitivity analysis, we evaluated (1) the characteristics and outcome of participants who had echocardiograms before or after AD diagnosis and according to studied centers; (2) the relationship between LV continuous variables and the primary outcomes in adjusted models assessed by linear Cox-regression analysis and restricted cubic splines with 4 knots; and (3) the association between AD type and death not adjusted and adjusted for LV concentricity or geometric patterns. *P* values <0.05 were considered significant, except in

multivariable Cox-regression analysis when assessing the relationship between LV geometric patterns and mortality, where Bonferroni-corrected *P* values (*P*<0.0083) were considered significant. Statistical analysis was performed using Stata software V.14.2 (Stata Corp LP, College Station, Texas, USA). NRI and integrated discrimination improvement analyses were performed using R software version 3.2.3.

RESULTS

Clinical and Echocardiographic Characteristics

Clinical and in-hospital characteristics of the total sample (n=356) and split by AD type (236 type A and 120 type B) are shown in Table 1. The total sample had 69% males, mean age of 57 years, and 82% had hypertension. Patients with type B were more likely to be older, to have higher BP levels and lower creatinine levels at admission, and to be treated by medical and endovascular therapy and were less likely to have Marfan syndrome and cardiac tamponade at presentation and to develop hospital-acquired infection than those with type A. Notably, 87% of patients with type A were treated surgically.

Unadjusted echocardiography characteristics of the sample are shown in Table 2. Among all participants, the prevalence of LVH and LV concentricity was 70% and 57%, respectively, whereas concentric hypertrophy was the most prevalent LV geometric pattern (43%), followed by eccentric hypertrophy (26%), normal geometry (17%), and concentric remodeling (14%). In unadjusted analysis, patients with type A had greater posterior wall thickness and relative wall thickness, and higher prevalence of concentric hypertrophy and moderate/severe aortic regurgitation than patients with type B (Table 2). The prevalence of concentric hypertrophy tended to be greater in patients with type A in comparison with patients with type B even in the presence of moderate/severe aortic regurgitation (Table S1). Adjusting for age, sex, center, systolic BP, and aortic regurgitation grade, type A was significantly associated with greater LV wall thickness and relative wall thickness, higher odds of LV concentricity and concentric hypertrophy, and lower odds of eccentric hypertrophy than type B AD (Table 3).

The characteristics of patients with type A and type B according to LV geometric patterns are presented in Tables S2 and S3. In both AD types, BP levels were greater in patients with concentric hypertrophy, whereas LV ejection fraction values were lower among those with eccentric hypertrophy. In type A, BP levels were lower and the prevalence of hypotension was greater among patients with concentric remodeling.

Outcomes

After 1 year of follow-up, there were 81 (34%) and 26 (22%) deaths among patients with type A and type B, respectively. Kaplan–Meier analysis showed no impact of LVH on 1-year mortality in both AD types, whereas LV concentricity was associated with greater mortality solely in type A (Figure A and B). Regarding LV geometric patterns, concentric remodeling had the highest risk of death, normal geometry had the lowest rate, and concentric hypertrophy and eccentric hypertrophy had intermediate event rates between concentric remodeling and normal geometry in type A, whereas no differences in 1-year mortality were observed according to LV geometric patterns in type B (Figure C). As observed in Kaplan–Meier curves (Figure), most deaths occurred in both AD types up to 90 days of follow-up (73 deaths in type A and 19 deaths in type B). Patients with type A who were dead at 1 year of follow-up were more likely to be older, to have hypotension and acute AD presentation, and to develop hospital-acquired infection and were less likely to be previously using beta blockers and to be treated by surgical therapy, whereas patients with type B who were dead at 1 year of follow-up were more likely to be treated by surgical therapy and to be previously using angiotensin-converting enzyme inhibitors or angiotensin receptor blockers (Table S4).

Results of multivariable Cox-regression analysis adjusted for relevant covariates split by AD types are shown in Tables 4 and 5. In type A, LVH was not related to death, whereas LV concentricity was associated with greater risk of early (hazard ratio [HR], 2.22; 95% CI, 1.24–3.96; *P*=0.007) and late (HR, 2.06; 95% CI, 1.20–3.54; *P*=0.009) mortality (Table 4). Regarding LV geometric patterns, concentric remodeling was associated with the greatest risk of early and late mortality (HR, 7.78; 95% CI, 2.35–25.78; and HR, 5.40; 95% CI, 1.91–15.26; both *P*<0.001) whereas concentric hypertrophy was significantly associated with early mortality (HR, 4.38; 95% CI, 1.47–13.11; *P*=0.008) when compared with normal geometry in type A. Conversely, concentric hypertrophy showed a trend toward greater later mortality and eccentric hypertrophy showed a trend toward greater early and later mortality, but these associations did not reach statistical significance considering a Bonferroni-corrected *P* value (*P*=0.0083) (Table 4). When considering participants with type B, LVH, LV concentricity, and geometric patterns were not associated with mortality (Table 5). The composite of hypovolemic or cardiogenic shock was the main cause of death in both AD types, especially among those with concentric remodeling in type A (Table S5).

When solely considering type A patients, LV geometric patterns and LV concentricity provided significant incremental value based on continuous NRI and

Table 1. Clinical and In-Hospital Characteristics of the Total Sample and According to Aortic Dissection Type

Variables	Total	Type A	Type B	*P* Value
N (%)	356 (100)	236 (66)	120 (34)	
Clinical presentation				
Male sex, n (%)	247 (69)	161 (68)	86 (72)	0.50
Age, y	57.1±12.2	55.8±12.4	59.8±11.3	0.003
Body mass index, kg/m^2	27.2±5.2	27.1±5.2	27.4±5.3	0.67
Systolic BP, mm Hg	148.0±39.1	142.3±37.3	159.2±40.3	<0.001
Diastolic BP, mm Hg	85.4±23.8	80.3±22.3	95.4±23.6	<0.001
Creatinine, mg/dL	1.12 (0.91, 1.53)	1.17 (0.93, 1.60)	1.06 (0.88, 1.41)	0.05
Any limb pulse deficit, n (%)	116 (33)	79 (33)	37 (31)	0.62
Cardiac tamponade, n (%)	12 (3)	12 (5)	0 (0)	0.012
Hypotension, n (%)	12 (3)	11 (5)	1 (1)	0.06
Pleural effusion, n (%)	57 (16)	36 (15)	21 (18)	0.58
AD presentation, n (%)				0.79
Acute	268 (75)	178 (75)	90 (75)	
Subacute	31 (9)	19 (8)	12 (10)	
Chronic	57 (16)	39 (17)	18 (15)	
AD extension, n (%)				
Descending aorta (type A)	–––	160 (68)	–––	–––
Abdominal aorta (type B)	–––	–––	98 (82)	–––
Medical history				
Hypertension, n (%)	291 (82)	190 (81)	101 (84)	0.40
Ever smoking, n (%)	136 (38)	85 (36)	51 (42)	0.26
Diabetes mellitus, n (%)	32 (9)	18 (8)	14 (12)	0.21
Coronary heart disease, n (%)	35 (10)	21 (9)	14 (12)	0.41
Marfan syndrome, n (%)	8 (2)	8 (3)	0 (0)	0.041
Angiotensin-converting enzyme inhibitor or angiotensin receptor blocker, n (%)	169 (47)	114 (48)	55 (46)	0.66
Diuretic, n (%)	82 (23)	54 (23)	28 (23)	0.92
Calcium channel blocker, n (%)	70 (20)	48 (20)	22 (18)	0.65
Beta blocker, n (%)	112 (31)	73 (31)	39 (32)	0.76
In-hospital data				
Definitive treatment, n (%)				<0.001
Medical therapy	71 (20)	24 (10)	47 (39)	
Endovascular	48 (13)	8 (3)	40 (33)	
Surgery	237 (67)	204 (87)	33 (28)	
Aortic valve replacement (type A), n (%)	–––	58 (25)	–––	–––
Descending aorta stent (type A), n (%)	–––	67 (29)	–––	–––
Hospital-acquired infection, n (%)	115 (32)	86 (36)	29 (24)	0.019

AD indicates aortic dissection; and BP, blood pressure.

integrated discrimination improvement in predicting early and late mortality when added to clinical variables (sex, age, center, calendar time, presence of hypotension, aortic dissection presentation, previous use of beta blocker, development of hospital-acquired infection, and in-hospital treatment modality). NRI values ranged from 0.168 to 0.212, which would suggest a weak improvement of LV parameters in predicting mortality.[20] Conversely, LV concentricity and LV geometric patterns showed a trend toward increasing C-statistic values in predicting early and late mortality when added to clinical variables, which did not reach statistical significance (Table 6).

Sensitivity Analysis

There were 30 participants who had echocardiograms before AD diagnosis. This subsample comprised 18 participants with hypertension, aortic regurgitation, or bicuspid aortic valve who had echocardiograms for

Table 2. Echocardiography Characteristics of the Total Sample and According to Aortic Dissection Type

Variables	Total	Type A	Type B	*P* Value
N (%)	356 (100)	236 (66)	120 (34)	
LV diastolic diameter, mm	52.6±8.3	52.5±8.6	52.8±7.4	0.75
Septum wall thickness, mm	11.8±2.5	11.9±2.7	11.6±2.3	0.25
Posterior wall thickness, mm	11.5±2.3	11.7±2.4	11.2±2.0	0.030
LV mass index, g/m^2	144.3±59.2	145.9±61.0	141.2±55.7	0.48
Relative wall thickness	0.45±0.12	0.46±0.13	0.43±0.10	0.028
LV hypertrophy, n (%)	248 (70)	171 (73)	77 (64)	0.11
LV concentricity, n (%)	203 (57)	142 (60)	61 (51)	0.09
Normal geometry, n (%)	59 (17)	35 (15)	24 (20)	0.21
Concentric remodeling, n (%)	49 (14)	30 (13)	19 (16)	0.42
Eccentric hypertrophy, n (%)	94 (26)	59 (25)	35 (29)	0.40
Concentric hypertrophy, n (%)	154 (43)	112 (48)	42 (35)	0.025
LV ejection fraction, n (%)	63.9±10.6	63.3±10.3	65.2±10.9	0.11
Bicuspid aortic valve, n (%)	5 (1)	5 (2)	0 (0)	0.11
Aortic regurgitation grade, n (%)				<0.001
No	183 (52)	96 (41)	87 (73)	
Mild	101 (28)	74 (31)	27 (23)	
Moderate/severe	72 (20)	66 (28)	6 (5)	

LV indicates left ventricular.

routine evaluation of the aforementioned conditions and had a confirmed diagnosis of AD within 60 days afterwards; and 12 participants who were under investigation of acute chest pain and had an echocardiogram before a multislice computed tomography angiography imaging confirmed the diagnosis of AD.

Table 3. Comparison of Echocardiographic Characteristics Between Aortic Dissection Types Adjusted for Potential Confounders

Variables	Mean Difference±SE	*P* Value
LV diastolic diameter, mm	–1.8±1.0	0.06
Septum wall thickness, mm	0.8±0.3	0.005
Posterior wall thickness, mm	0.9±0.3	<0.001
LV mass index, g/m^2	6.5±7.2	0.37
Relative wall thickness	0.06±0.01	<0.001
LV ejection fraction, %	–1.9±1.3	0.14
	Odds ratio (95% CI)	
LV hypertrophy	1.61 (0.94–2.74)	0.08
LV concentricity	2.18 (1.30–3.67)	0.003
Normal geometry	0.62 (0.32–1.19)	0.15
Concentric remodeling	0.73 (0.37–1.50)	0.40
Eccentric hypertrophy	0.55 (0.31–0.97)	0.039
Concentric hypertrophy	2.56 (1.50–4.36)	<0.001

Mean difference and odds ratio values regard to the comparison of LV variables of participants with type A considering LV variables of participants with type B as reference.

Analyses were adjusted for sex, age, center, systolic blood pressure, and aortic regurgitation grade. LV indicates left ventricular.

Participants with echocardiograms before AD diagnosis were more likely to have bicuspid aortic valve (7% versus 1%), moderate/severe aortic regurgitation (37% versus 19%), and chronic AD at presentation (53% versus 13%) (all $P<0.05$) but had no significant differences in 90-day and 1-year mortality than participants with echocardiograms after AD diagnosis.

Clinical and outcome data of the participants according to the studied centers are shown in Table S6. The adjusted association of continuous LV variables obtained by echocardiography with early or late mortality in both AD types assessed by linear Cox-regression analysis is shown in Table S7. We further evaluated the relationship between continuous LV variables and the primary outcomes by restricted cubic splines with 4 knots and found a nonlinear relationship of early and late mortality with relative wall thickness among patients with type A AD and with LV ejection fraction among patients with type B (Figure S2). Notably, LV ejection fraction values <50% tended to show greater mortality among participants with type B. In alternative analysis, type A was associated with greater risk of early and late death than type B in unadjusted analysis, and this association remained significant after adjusting for LV geometric patterns and LV concentricity (Table S8).

DISCUSSION

This multicenter study evaluating patients with type A and type B AD who had echocardiograms at the

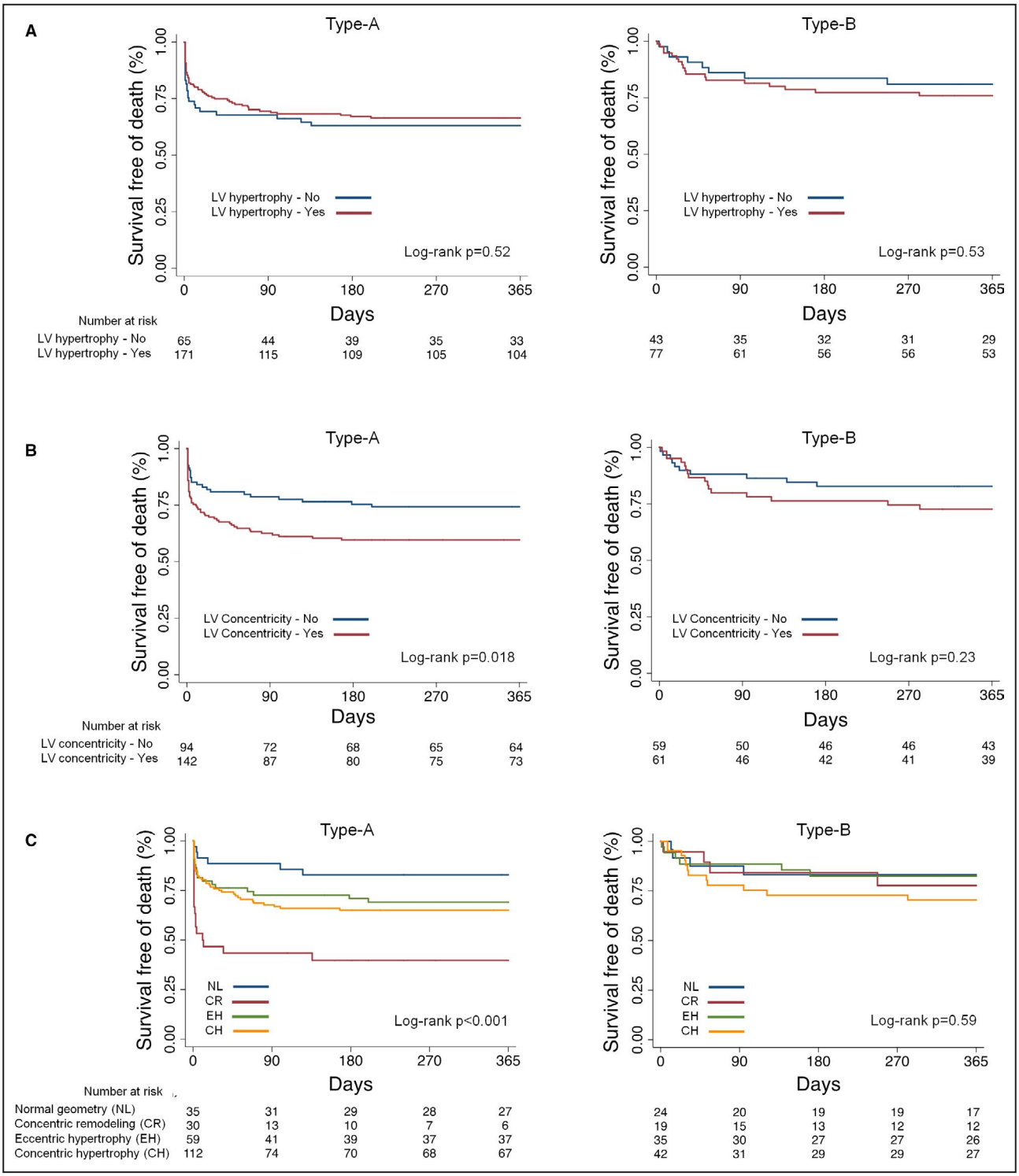

Figure 1. Kaplan–Meier curves for 1-year mortality in patients with type A and type B according to (A) left ventricular (LV) hypertrophy; (B) LV concentricity; and (C) LV geometric patterns.
CH indicates concentric hypertrophy; CR, concentric remodeling; EH, eccentric hypertrophy; and NL, normal geometry.

time of AD diagnosis has 2 major findings. First, LV concentric remodeling and concentric hypertrophy were associated with higher 90-day mortality, and LV concentric remodeling was associated with higher 1-year mortality after AD diagnosis among patients with type A. Second, patients with type A had greater prevalence of concentric hypertrophy but lower frequency of eccentric hypertrophy than type B. Our

Table 4. Adjusted Cox-Regression Analysis Between LV Remodeling Phenotypes and Early (90-day) and Late (1-year) Mortality in Patients with Type A

Independent variables	Events/Number at Risk	HR (95% CI)	*P* Value
Outcome: 90-d mortality			
Model 1: LV hypertrophy			
No	21/65	Ref	––
Yes	52/171	1.15 (0.66–2.02)	0.62
Model 2: LV concentricity			
No	20/94	Ref	––
Yes	53/142	2.22 (1.24–3.96)	0.007
Model 3: LV geometric patterns			
Normal geometry	4/35	Ref	––
Concentric remodeling	17/30	7.78 (2.35–25.78)	<0.001*
Eccentric hypertrophy	16/59	3.15 (1.02–9.74)	0.046
Concentric hypertrophy	36/112	4.38 (1.47–13.11)	0.008*
Outcome: 1-y mortality			
Model 1: LV hypertrophy			
No	24/65	Ref	––
Yes	57/171	1.16 (0.68–1.98)	0.57
Model 2: LV concentricity			
No	24/94	Ref	––
Yes	57/142	2.06 (1.20–3.54)	0.009
Model 3: LV geometric patterns			
Normal geometry	6/35	Ref	––
Concentric remodeling	18/30	5.40 (1.91–15.26)	<0.001*
Eccentric hypertrophy	18/59	2.39 (0.92–6.23)	0.07
Concentric hypertrophy	39/112	3.34 (1.32–8.43)	0.011

All analyses were adjusted for sex, age, center, calendar time, presence of hypotension, aortic dissection presentation, previous use of beta blocker, development of hospital-acquired infection, and in-hospital treatment modality.

HR indicates hazard ratio; LV, left ventricular; Ref, reference.

**P* values in Model 3 were considered significant when less than 0.0083 (Bonferroni-corrected *P* value).

results indicate that LV geometric patterns related to LV concentricity, especially concentric remodeling, may be markers of worse prognosis among patients with type A. Furthermore, they suggest that AD types may be associated with distinct preferential LV geometric patterns.

One major finding of our study was that LV concentricity was associated with greater mortality at follow-up among patients with type A, which agrees with data obtained in general populations and patients undergoing cardiac surgery, among whom LV concentricity was a predictor of increased mortality.[11,12,14,21] Individuals with greater LV concentricity usually have higher arterial load and vascular damage, elevated neuroendocrine components, reduced coronary flow reserve, and high risk of LV dysfunction.[11,12,21,22] These characteristics could predispose to a lower cardiovascular reserve to deal with the challenges of pronounced hemodynamic volatility induced by type A AD itself and its therapeutic strategies, including aggressive BP and heart rate control and major cardiac surgery,[1,2] thus contributing to explain the worse prognosis among patients with LV concentricity. In agreement with this assumption, most deaths among patients with type A occurred within 90 days after AD diagnosis, which comprises the period of high risk of complications owing to AD itself and surgery.[23]

Regarding LV geometric patterns, concentric hypertrophy was associated with greater mortality than normal geometry, and had the highest LV mass index and BP values among the LV geometric patterns in type A, which are consistent with evidence obtained in several other clinical settings.[3,13,24] Interestingly, concentric remodeling tended to have the greatest mortality rate in patients with type A, a somewhat unexpected result because concentric hypertrophy is usually assumed to carry the worst prognosis among all LV geometric patterns.[3,13] It was noteworthy that concentric remodeling also had lower BP values at admission and death mainly owing to hypovolemic or cardiogenic shock among participants with type A in our analysis and has been consistently associated with low cardiac output and intravascular volume.[3] This body of evidence supports the notion that concentric remodeling might be

Table 5. Adjusted Cox-Regression Analysis Between LV Remodeling Phenotypes and Early (90-day) and Late (1-year) Mortality in Patients with Type B

Independent variables	Events/Number at Risk	HR (95% CI)	*P* Value
Outcome: 90-d mortality			
Model 1: LV hypertrophy			
No	6/43	Ref	––
Yes	13/77	1.05 (0.37–2.98)	0.92
Model 2: LV concentricity			
No	7/59	Ref	––
Yes	12/61	1.54 (0.60–3.95)	0.37
Model 3: LV geometric patterns			
Normal geometry	3/24	Ref	––
Concentric remodeling	3/19	1.88 (0.34–10.35)	0.47
Eccentric hypertrophy	4/35	1.08 (0.22–5.31)	0.92
Concentric hypertrophy	9/42	1.54 (0.40–5.96)	0.53
Outcome: 1-y mortality			
Model 1: LV hypertrophy			
No	8/43	Ref	––
Yes	18/77	1.09 (0.44–2.71)	0.86
Model 2: LV concentricity			
No	10/59	Ref	––
Yes	16/61	1.47 (0.66–3.28)	0.34
Model 3: LV geometric patterns			
Normal geometry	4/24	Ref	––
Concentric remodeling	4/19	1.91 (0.44–8.34)	0.39
Eccentric hypertrophy	6/35	1.19 (0.31–4.64)	0.80
Concentric hypertrophy	12/42	1.55 (0.48–5.05)	0.47

All analyses were adjusted for sex, age, center, calendar time, previous use of angiotensin-converting enzyme or angiotensin receptor blocker, and in-hospital treatment modality.

HR indicates hazard ratio; LV, left ventricular; Ref, reference.

**P* values in Model 3 were considered significant when less than 0.0083 (Bonferroni-corrected *P* value).

more susceptible to cardiovascular and hemodynamic dysfunction because of AD itself and major cardiac surgery. Likewise, a previous study evaluating patients undergoing aortic valve replacement showed a trend toward highest early mortality among patients with concentric remodeling when compared with the other LV geometric patterns, suggesting that patients with concentric remodeling might have worse prognosis when undergoing major cardiac surgery.[14]

In our analysis, LV geometric patterns and LV concentricity had incremental value based on continuous NRI and integrated discrimination improvement in predicting early and late mortality when added to clinical factors among patients with type A. Conversely, LVH did not associate with mortality in both AD types, a finding that agrees with a previous report evaluating patients with type B, which found no association of LVH with all-cause mortality after 3.4 years of follow-up in unadjusted analysis.[9] Together, these results indicate that assessment of LV geometric patterns and LV concentricity, rather than LVH alone, may be useful to stratify the risk among patients with type A.

The prevalence of LVH in our sample was 70% (72% in type A and 64% in type B), which is similar to those reported in other AD series,[4,8,10] whereas concentric hypertrophy was the most common LV geometric pattern seen in both AD types. This latter finding contrasts with results of a previous report evaluating 50 patients with type A, among whom normal geometry was the most common LV geometric pattern, followed by eccentric hypertrophy.[5] Patients from that study had lower average BP, body mass index, and prevalence of men than our studied population, which might have accounted for the discrepancies in LV geometry. We also found that concentric hypertrophy was more prevalent in type A than in type B in our sample, although the former group had lower BP values at admission and similar prevalence of hypertension compared with the latter group. These results agree with the notion that type A is not expected to have higher BP or hypertension than type B[2] and indicate that mechanisms other than elevated BP influences LV remodeling in patients with AD. For instance, differences in aortic segments stiffness could play a role in this regard. A previous

Table 6. Incremental Value of LV Concentricity and Geometric Patterns in Predicting Early (90-day) and Late (1-year) Mortality Among Patients with Type A

Variable	C-statistic (95% CI)	*P* Value*	Integrated Discrimination Improvement (95% CI)	*P* Value*	Net Reclassification Improvement (95% CI)	*P* Value*
Outcome: 90-d mortality						
Clinical	0.732 (0.676–0.788)	––	––	––	––	––
Clinical+LV concentricity	0.747 (0.676–0.788)	0.17	0.025 (0.000–0.070)	0.044	0.185 (0.046–0.298)	0.028
Clinical+LV geometric patterns	0.751 (0.696–0.806)	0.15	0.037 (0.004–0.087)	0.024	0.212 (0.043–0.331)	0.024
Outcome: 1-y mortality						
Clinical	0.726 (0.672–0.780)	––	––	––	––	––
Clinical+LV concentricity	0.741 (0.687–0.794)	0.13	0.023 (0.000–0.064)	0.040	0.168 (0.053–0.278)	0.020
Clinical+LV geometric patterns	0.744 (0.690–0.797)	0.13	0.034 (0.003–0.077)	0.020	0.191 (0.039–0.307)	0.016

Clinical variables were the following: sex, age, center, calendar time, presence of hypotension, aortic dissection presentation, previous use of beta blocker, development of hospital-acquired infection, and in-hospital treatment modality.

LV indicates left ventricular.

**P* values compared with the model containing clinical variables.

study showed that ascending aortic stiffness is more related to LV concentricity than descending aortic stiffness.[25] Given that aortic segments developing AD are supposed to be associated with local increases in aortic stiffness,[26,27] it can be argued that patients with type A might have greater proximal aortic stiffness, thus contributing to the development of concentric hypertrophy. However, further studies are necessary to confirm this hypothesis.

Some aspects of this report deserve further comments. First, the frequency of men and the prevalence of hypertension, diabetes mellitus, bicuspid aortic valve, and Marfan syndrome were similar to those reported in alternative large AD cohorts,[2,28] and we confirmed that type A AD and lower BP at admission were associated with worse prognosis.[2] These data indicate that our sample had characteristics commonly seen in standard practice, strengthening the validity of our findings. Second, although type A had higher prevalence of concentric hypertrophy and LV concentricity than type B, LV geometry did not account for the higher mortality of type A. This could be explained by the similar prevalence of concentric remodeling in both AD types, which was the LV geometric pattern associated with remarkably greater mortality in type A. Third, LV ejection fraction did not associate with mortality among patients with type A, which contrasts with previous data suggesting a higher risk of 30-day mortality among patients with type A with reduced LV ejection fraction.[29] The reason for these discrepancies are not apparent, but differences in the characteristics of the sample and on follow-up period might have played a role in this regard. Conversely, our results of restricted cubic splines analysis indicated that LV ejection fraction values <50% tended to show increased risk of mortality in participants with type B, suggesting that reductions in systolic function might be a marker of adverse prognosis in type B.

This report has some limitations. First, this is an observational and retrospective study and only patients who had echocardiograms were included. Most of the patients who were excluded from our analysis did not have available echocardiograms because the exam was not clinically indicated or the patient was not able to have access to one. Therefore, it cannot be discarded that unmeasured confounding factors and selection bias might have influenced the reported associations. Second, the participating centers are tertiary hospitals and patients who did not survive to reach these centers were not enrolled. Thus, our findings may not be generalizable to all patients with AD. Third, the echocardiogram images were not reviewed by a core laboratory, and data on more sensitive measures of LV function, including global strain and tissue Doppler were not available. Fourth, the relatively low sample size and number of events among participants with type B might have limited our ability to detect significant association between LV phenotypes and mortality in this group.

In conclusion, the results of the present multicenter study demonstrated that LV concentric remodeling and concentric hypertrophy were associated with greater risk of mortality among patients with type A AD and therefore might be markers of worse prognosis in this population. These findings suggest that assessment of LV geometric patterns and LV concentricity may be useful for stratification of mortality risk in type-A AD.

ARTICLE INFORMATION

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Affiliations

From the Department of Internal Medicine, School of Medical Sciences, State University of Campinas, São Paulo, Brazil (W.E.R., M.F.O., O.R.C., J.R.M., A.C.S., W.N.); Pronto Socorro Cardiológico de Pernambuco (PROCAPE), University of Pernambuco, Recife, PE, Brazil (J.D.S., V.M.L., A.D.F., R.C.L.); Department of Cardiology, Pontifical Catholic University of Campinas,

Campinas, SP, Brazil (M.P.M., A.M.R.); Laboratory of Immunopathology Keizo Asami, Federal University of Pernambuco, Recife, PE, Brazil (A.D.F.); and Department of Surgery, School of Medical Sciences, State University of Campinas, São Paulo, Brazil (P.P.O., L.M.S., O.P.).

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Disclosures

None.

Supplementary Material

Tables S1–S8
Figures S1–S2

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SUPPLEMENTAL MATERIAL

Table S1. Characteristics of patients according to aortic dissection type and presence of moderate/severe aortic regurgitation.

Variables	Type-A without MSAoR n=170	Type-A with MSAoR n=66	Type-B without MSAoR n=114	Type-B with MSAoR n=6	p-value
LV mass index, g/m^2	140.5 ± 56.1	159.9 ± 70.7	140.4 ± 54.6	155.4 ± 78.4	0.11
Relative wall thickness	0.47 ± 0.13	0.43 ± 0.11	0.43 ± 0.09	0.38 ± 0.12	0.013
LV hypertrophy, n (%)	119 (70)	52 (79)	73 (64)	4 (67)	0.23
LV concentricity, n (%)	108 (64)	34 (52)	59 (52)	2 (33)	0.09
Normal geometry, n (%)	28 (16)	7 (11)	23 (20)	1 (17)	0.43
Concentric remodeling, n (%)	23 (14)	7 (11)	18 (16)	1 (17)	0.80
Eccentric hypertrophy, n (%)	34 (20)	25 (38)	32 (28)	3 (50)	0.019
Concentric hypertrophy, n (%)	85 (50)	27 (41)	41 (36)	1 (17)	0.06

Continuous normal variables and categorical variables were compared by one-way analysis of variance and chi-squared tests, respectively.
LV – left ventricular; MSAoR – moderate/severe aortic regurgitation.

Table S2. Characteristics of type-A patients according to LV geometric patterns.

Variables	Normal geometry (n=35)	Concentric remodeling (n=30)	Eccentric hypertrophy (n=59)	Concentric hypertrophy (n=112)	p-value
Clinical Characteristics					
Male sex, n (%)	28 (80)	21 (70)	38 (64)	74 (66)	0.40
Age, years	56.4 ± 13.2	58.7 ± 12.8	54.3 ± 12.9	55.6 ± 11.7	0.45
Body mass index, kg/m^2	26.2 ± 4.7	27.6 ± 4.7	26.8 ± 5.9	27.4 ± 5.1	0.60
Systolic BP, mmHg	141.8 ± 32.3	124.6 ± 42.2	138.6 ± 33.1	149.2 ± 38.0	0.010
Diastolic BP, mmHg	77.3 ± 19.1	72.4 ± 21.6	74.6 ± 18.9	86.4 ± 23.6	<0.001
Creatinine, mg/dL	1.10 [0.90, 1.40]	1.30 [1.00, 1.97]	1.11 [0.89, 1.35]	1.20 [0.96, 1.69]	0.12
Any limb pulse deficit, n (%)	9 (26)	13 (43)	16 (27)	41 (37)	0.28
Cardiac tamponade, n (%)	4 (11)	5 (17)	0 (0)	3 (3)	<0.001
Hypotension, n (%)	0 (0)	7 (23)	2 (3)	2 (2)	<0.001
Pleural effusion, n (%)	5 (14)	3 (10)	8 (14)	20 (18)	0.71
Aortic dissection presentation, n (%)					0.037
Acute	24 (69)	27 (90)	39 (66)	88 (79)	
Subacute	4 (11)	3 (10)	8 (14)	4 (4)	
Chronic	7 (20)	0 (0)	12 (20)	20 (18)	
Descending aorta extension, n (%)	24 (69)	18 (60)	37 (63)	81 (72)	0.46
Hypertension, n (%)	24 (69)	23 (77)	45 (76)	98 (88)	0.05
Ever smoking, n (%)	14 (40)	8 (28)	21 (36)	42 (38)	0.75
Diabetes mellitus, n (%)	2 (6)	2 (7)	6 (10)	8 (7)	0.85
Coronary heart disease, n (%)	3 (9)	2 (7)	6 (10)	10 (9)	0.96
Marfan syndrome, n (%)	2 (6)	1 (3)	4 (7)	1 (1)	0.19
ACEI or ARB, n (%)	14 (40)	12 (40)	30 (51)	58 (52)	0.48

Diuretic, n (%)	8 (23)	1 (3)	18 (31)	27 (24)	0.036
Calcium channel blocker, n (%)	7 (20)	5 (17)	9 (15)	27 (24)	0.54
Beta-blocker, n (%)	11 (31)	5 (17)	19 (32)	38 (34)	0.34
Definitive treatment, n (%)					0.80
Medical therapy	2 (6)	4 (13)	5 (8)	13 (12)	
Endovascular	2 (6)	0 (0)	2 (3)	4 (4)	
Surgery	31 (89)	26 (87)	52 (88)	95 (85)	
Aortic valve replacement, n (%)	11 (31)	8 (27)	17 (29)	22 (20)	0.39
Descending aorta stent, n (%)	10 (29)	8 (27)	13 (22)	36 (32)	0.55
Hospital-acquired infection, n (%)	14 (40)	7 (23)	17 (29)	48 (43)	0.12
Echocardiography					
LV diastolic diameter, mm	52.1 ± 7.0	43.2 ± 4.3	61.1 ± 7.5	50.6 ± 6.5	<0.001
Septum wall thickness, mm	8.9 ± 1.1	11.2 ± 2.0	10.7 ± 1.4	13.7 ± 2.3	<0.001
Posterior wall thickness, mm	8.9 ± 1.1	11.2 ± 2.0	10.7 ± 1.4	13.7 ± 2.3	<0.001
LV mass index, g/m^2	89.7 ± 18.1	89.5 ± 19.9	165.8 ± 55.1	168.1 ± 59.3	<0.001
Relative wall thickness	0.34 ± 0.04	0.54 ± 0.11	0.35 ± 0.04	0.53 ± 0.10	<0.001
LV ejection fraction, n (%)	64.4 ± 9.6	65.1 ± 10.0	59.5 ± 12.1	64.4 ± 9.2	0.013
Bicuspid aortic valve, n (%)	1 (3)	1 (3)	0 (0)	3 (3)	0.63
Aortic regurgitation grade, n (%)					0.18
No	16 (46)	13 (43)	21 (36)	46 (41)	
Mild	12 (34)	10 (33)	13 (22)	39 (35)	
Moderate/severe	7 (20)	7 (23)	25 (42)	27 (24)	

Continuous normal variables, continuous non-normal variables and categorical variables were compared by one-way analysis of variance, Kruskal-Wallis and chi-squared tests, respectively.

BP – blood pressure; LV – left ventricular; ACEI or ARB – angiotensin-converting enzyme inhibitor or angiotensin receptor blocker.

Table S3. Characteristics of type-B patients according to LV geometric patterns.

Variables	Normal geometry (n=24)	Concentric remodeling (n=19)	Eccentric hypertrophy (n=35)	Concentric hypertrophy (n=42)	p-value
Clinical Characteristics					
Male sex, n (%)	20 (83)	15 (79)	22 (63)	29 (69)	0.31
Age, years	60.6 ± 13.9	58.2 ± 9.7	58.3 ± 12.5	61.4 ± 9.2	0.58
Body mass index, kg/m^2	27.5 ± 4.5	27.6 ± 4.1	26.9 ± 5.0	27.6 ± 6.5	0.95
Systolic BP, mmHg	146.0 ± 29.8	153.8 ± 45.7	154.7 ± 36.3	172.9 ± 43.3	0.04
Diastolic BP, mmHg	93.4 ± 22.8	93.0 ± 24.1	91.2 ± 26.2	101.2 ± 21.0	0.25
Creatinine, mg/dL	1.06 [0.88, 1.34]	0.96 [0.80, 1.72]	1.03 [0.90, 1.41]	1.10 [0.94, 1.41]	0.88
Any limb pulse deficit, n (%)	7 (29)	5 (26)	12 (34)	13 (31)	0.94
Cardiac tamponade, n (%)	—	—	—	—	
Hypotension, n (%)	0 (0)	1 (5)	0 (0)	0 (0)	0.15
Pleural effusion, n (%)	3 (12)	4 (21)	8 (23)	6 (14)	0.66
Aortic dissection presentation, n (%)					0.037
Acute	21 (88)	14 (74)	25 (71)	30 (71)	
Subacute	1 (4)	1 (5)	6 (17)	4 (10)	
Chronic	2 (8)	4 (21)	4 (11)	8 (19)	
Abdominal aorta extension, n (%)	19 (79)	16 (84)	29 (83)	34 (81)	0.97
Hypertension, n (%)	18 (75)	16 (84)	29 (83)	38 (90)	0.42
Ever smoking, n (%)	8 (33)	8 (42)	15 (43)	20 (48)	0.73
Diabetes mellitus, n (%)	1 (4)	2 (11)	4 (11)	7 (17)	0.5
Coronary heart disease, n (%)	5 (21)	1 (5)	4 (11)	4 (10)	0.41
Marfan syndrome, n (%)	—	—	—	—	
ACEI or ARB, n (%)	10 (42)	8 (42)	19 (54)	18 (43)	0.7

Diuretic, n (%)	6 (25)	3 (16)	9 (26)	10 (24)	0.86
Calcium channel blocker, n (%)	3 (12)	4 (21)	7 (20)	8 (19)	0.87
Beta-blocker, n (%)	10 (42)	4 (21)	14 (40)	11 (26)	0.29
Definitive treatment, n (%)					0.007
Medical therapy	4 (17)	6 (32)	17 (49)	20 (48)	
Endovascular	14 (58)	10 (53)	9 (26)	7 (17)	
Surgery	6 (25)	3 (16)	9 (26)	15 (36)	
Hospital-acquired infection, n (%)	3 (12)	4 (21)	11 (31)	11 (26)	0.39
Echocardiography					
LV diastolic diameter, mm	52.1 ± 7.0	43.2 ± 4.3	61.1 ± 7.5	50.6 ± 6.5	<0.001
Septum wall thickness, mm	8.9 ± 1.1	11.2 ± 2.0	10.7 ± 1.4	13.7 ± 2.3	<0.001
Posterior wall thickness, mm	8.9 ± 1.1	11.2 ± 2.0	10.7 ± 1.4	13.7 ± 2.3	<0.001
LV mass index, g/m^2	89.7 ± 18.1	89.5 ± 19.9	165.8 ± 55.1	168.1 ± 59.3	<0.001
Relative wall thickness	0.34 ± 0.04	0.54 ± 0.11	0.35 ± 0.04	0.53 ± 0.10	<0.001
LV ejection fraction, n (%)	64.4 ± 9.6	65.1 ± 10.0	59.5 ± 12.1	64.4 ± 9.2	0.013
Bicuspid aortic valve, n (%)	1 (3)	1 (3)	0 (0)	3 (3)	0.63
Aortic regurgitation grade, n (%)					0.18
No	16 (46)	13 (43)	21 (36)	46 (41)	
Mild	12 (34)	10 (33)	13 (22)	39 (35)	
Moderate/severe	7 (20)	7 (23)	25 (42)	27 (24)	

Continuous normal variables, continuous non-normal variables and categorical variables were compared by one-way analysis of variance, Kruskal-Wallis and chi-squared tests, respectively.

BP – blood pressure; LV – left ventricular; ACEI or ARB – angiotensin-converting enzyme inhibitor or angiotensin receptor blocker.

Table S4. Characteristics of patients who were dead or not at 1 year of follow-up.

Variables	Type-A			Type-B		
	Survived (n=155)	Deceased (n=81)	p	Survived (n=94)	Deceased (n=26)	p
Male sex, n (%)	110 (71)	51 (63)	0.21	66 (70)	20 (77)	0.50
Age, years	54.4 ± 11.8	58.4 ± 13.2	0.021	59.8 ± 11.4	59.8 ± 11.1	0.99
Body mass index, kg/m^2	27.0 ± 5.5	27.3 ± 4.7	0.74	27.7 ± 5.4	26.3 ± 4.7	0.25
Systolic BP, mmHg	146.4 ± 36.5	134.7 ± 37.9	0.022	159.6 ± 41.1	157.6 ± 37.9	0.82
Diastolic BP, mmHg	82.2 ± 21.9	76.8 ± 22.8	0.08	95.0 ± 23.9	96.8 ± 22.7	0.73
Creatinine, mg/dL	1.14 [0.92, 1.48]	1.28 [0.93, 1.85]	0.06	1.04 [0.87, 1.38]	1.08 [0.95, 1.41]	0.42
Any limb pulse deficit, n (%)	52 (34)	27 (33)	0.97	30 (32)	7 (27)	0.63
Cardiac tamponade, n (%)	6 (4)	6 (7)	0.24	0 (0)	0 (0)	.
Hypotension, n (%)	4 (3)	7 (9)	0.037	1 (1)	0 (0)	0.60
Pleural effusion, n (%)	27 (17)	9 (11)	0.20	14 (15)	7 (27)	0.15
Aortic dissection presentation, n (%)			0.034			0.49
Acute	109 (70)	69 (85)		69 (73)	21 (81)	
Subacute	14 (9)	5 (6)		11 (12)	1 (4)	
Chronic	32 (21)	7 (9)		14 (15)	4 (15)	
Aortic dissection extension, n (%)						
Descending aorta (Type-A)	100 (65)	60 (74)	0.14	—	—	
Abdominal aorta (Type-B)	—	—	—	76 (81)	22 (85)	0.66
Hypertension, n (%)	123 (79)	67 (83)	0.54	81 (86)	20 (77)	0.25
Ever smoking, n (%)	59 (38)	26 (33)	0.44	42 (45)	9 (35)	0.36
Diabetes mellitus, n (%)	10 (6)	8 (10)	0.35	13 (14)	1 (4)	0.16
Coronary heart disease, n (%)	14 (9)	7 (9)	0.92	10 (11)	4 (15)	0.50
Marfan syndrome, n (%)	6 (4)	2 (2)	0.57	0 (0)	0 (0)	1.00

ACEI or ARB, n (%)	76 (49)	38 (47)	0.76	48 (51)	7 (27)	0.029
Diuretic, n (%)	35 (23)	19 (23)	0.88	20 (21)	8 (31)	0.31
Calcium channel blocker, n (%)	33 (21)	15 (19)	0.62	19 (20)	3 (12)	0.31
Beta-blocker, n (%)	55 (35)	18 (22)	0.036	31 (33)	8 (31)	0.83
Definitive treatment, n (%)			0.001			0.009
Medical therapy	7 (5)	17 (21)		38 (40)	9 (35)	
Endovascular	7 (5)	1 (1)		36 (38)	4 (15)	
Surgery	141 (91)	63 (78)		20 (21)	13 (50)	
Aortic valve replacement (Type-A), n (%)	40 (26)	18 (22)	0.54	—	—	
Descending aorta stent (Type-A), n (%)	46 (30)	21 (26)	0.52	—	—	
Hospital-acquired infection, n (%)	66 (43)	20 (25)	0.007	24 (26)	5 (19)	
Bicuspid aortic valve, n (%)	2 (1)	3 (4)	0.22	0 (0)	0 (0)	
Aortic regurgitation grade, n (%)			0.49			0.22
No	63 (41)	33 (41)		69 (73)	18 (69)	
Mild	52 (34)	22 (27)		22 (23)	5 (19)	
Moderate/severe	40 (26)	26 (32)		3 (3)	3 (12)	

Continuous normal variables, continuous non-normal variables and categorical variables were compared by unpaired t-test, Mann-Whitney and chi-squared tests, respectively.

BP – blood pressure. ACEI or ARB – angiotensin-converting enzyme inhibitor or angiotensin receptor blocker.

Table S5. Causes of death according to left ventricular geometric patterns.

Causes of death	Type-A						Type-B					
	All	NL	CR	EH	CH	p-value	All	NL	CR	EH	CH	p-value
Early (90-day) mortality												
N	73	4	17	16	36		19	3	3	4	9	
Cardiogenic/hypovolemic shock, n (%)	49 (67)	2 (50)	15 (88)	10 (62)	22 (61)	0.19	11 (58)	1 (33)	2 (67)	3 (75)	5 (56)	0.72
Cardiogenic shock, n (%)	18 (25)	0 (0)	7 (41)	3 (19)	8 (22)	0.24	5 (26)	0 (0)	1 (33)	2 (50)	2 (22)	0.50
Hypovolemic shock, n (%)	31 (42)	2 (50)	8 (47)	7 (44)	14 (39)	0.93	6 (32)	1 (33)	1 (33)	1 (25)	3 (33)	0.99
Stroke, n (%)	5 (7)	0 (0)	0 (0)	0 (0)	5 (14)	0.14	1 (5)	0 (0)	0 (0)	1 (25)	0 (0)	0.27
Sepsis, n (%)	11 (15)	0 (0)	1 (6)	4 (25)	6 (17)	0.37	1 (5)	0 (0)	0 (0)	0 (0)	1 (11)	0.76
Multiorgan failure, n (%)	5 (7)	1 (25)	1 (6)	1 (6)	2 (6)	0.53	3 (16)	1 (33)	1 (33)	0 (0)	1 (11)	0.52
Unknown, n (%)	3 (4)	1 (25)	0 (0)	1 (6)	1 (3)	0.14	2 (11)	1 (33)	0 (0)	0 (0)	1 (11)	0.48
Late (1-year) mortality												
N	81	6	18	18	39		26	4	4	6	12	
Cardiogenic/hypovolemic shock, n (%)	49 (60)	2 (33)	15 (83)	10 (56)	22 (56)	0.10	12 (46)	1 (25)	2 (50)	3 (50)	6 (50)	0.84
Cardiogenic shock, n (%)	18 (22)	0 (0)	7 (39)	3 (17)	8 (21)	0.17	6 (23)	0 (0)	1 (25)	2 (33)	3 (25)	0.66
Hypovolemic shock, n (%)	31 (38)	2 (33)	8 (44)	7 (39)	14 (36)	0.93	6 (23)	1 (25)	1 (25)	1 (17)	3 (25)	0.98
Stroke, n (%)	7 (9)	0 (0)	0 (0)	1 (6)	6 (15)	0.19	1 (4)	0 (0)	0 (0)	1 (17)	0 (0)	0.33
Sepsis, n (%)	13 (16)	0 (0)	1 (6)	4 (22)	8 (21)	0.30	3 (12)	0 (0)	1 (25)	0 (0)	2 (17)	0.51
Multiorgan failure, n (%)	5 (6)	1 (17)	1 (6)	1 (6)	2 (5)	0.74	4 (15)	1 (25)	1 (25)	1 (17)	1 (8)	0.79
Unknown, n (%)	7 (9)	3 (50)	1 (6)	2 (11)	1 (3)	0.002	5 (19)	2 (50)	0 (0)	1 (17)	2 (17)	0.33

The variables were compared by chi-squared tests.

NL – normal geometry; CR – concentric remodeling; EH – eccentric hypertrophy; CH – concentric hypertrophy.

Table S6. Clinical characteristics and outcome of the participants according to studied centers.

Variables	Center=1 n=293	Center=2 n=15	Center=3 n=48	p-value
Clinical Presentation				
Type-A AD, n (%)	188 (64)	12 (80)	36 (75)	0.18
Male sex, n (%)	205 (70)	9 (60)	33 (69)	0.71
Age, years	56.8 ± 12.1	57.4 ± 14.2	59.2 ± 11.9	0.46
Body mass index, kg/m^2	27.1 ± 5.2	26.1 ± 5.7	28.2 ± 5.2	0.30
Systolic BP, mmHg	149.3 ± 41.0	128.2 ± 28.9	146.2 ± 27.0	0.14
Diastolic BP, mmHg	86.3 ± 24.7	77.5 ± 17.2	82.1 ± 18.7	0.24
Creatinine, mg/dL	1.14 [0.91, 1.56]	1.09 [0.74, 1.54]	1.06 [0.91,1.41]	0.64
Any limb pulse deficit, n (%)	107 (37)	4 (27)	5 (10)	0.001
Cardiac tamponade, n (%)	8 (3)	2 (13)	2 (4)	0.08
Hypotension, n (%)	10 (3)	2 (14)	0 (0)	0.034
Pleural effusion, n (%)	50 (17)	3 (20)	4 (8)	0.28
AD presentation, n (%)				0.001
Acute	233 (80)	9 (60)	26 (54)	
Subacute	16 (5)	3 (20)	12 (25)	
Chronic	44 (15)	3 (20)	10 (21)	
AD extension, n (%)				
Descending aorta (Type-A)	127 (68)	7 (58)	26 (72)	0.66
Abdominal aorta (Type-B)	84 (80)	3 (100)	11 (92)	0.43
Medical history				
Hypertension, n (%)	238 (81)	8 (53)	45 (94)	0.002
Ever smoking, n (%)	119 (41)	5 (33)	12 (25)	0.10
Diabetes mellitus, n (%)	20 (7)	5 (33)	7 (15)	<0.001
Coronary heart disease, n (%)	30 (10)	0 (0)	5 (10)	0.43
Marfan syndrome, n (%)	6 (2)	2 (13)	0 (0)	0.008
ACEI or ARB, n (%)	131 (45)	5 (33)	33 (69)	0.004
Diuretic, n (%)	58 (20)	4 (27)	20 (42)	0.004
Calcium channel blocker, n (%)	45 (15)	4 (27)	21 (44)	<0.001
Beta-blocker, n (%)	74 (25)	6 (40)	32 (67)	<0.001
In-hospital data				
Definitive treatment, n (%)				<0.001
Medical therapy	70 (24)	1 (7)	0 (0)	
Endovascular	33 (11)	1 (7)	14 (29)	
Surgery	190 (65)	13 (87)	34 (71)	
AoV replacement (Type-A), n (%)	49 (17)	2 (13)	7 (15)	0.89
Descending aorta stent (Type-A), n (%)	61 (32)	0 (0)	6 (17)	0.013
Hospital-acquired infection, n (%)	99 (34)	10 (67)	6 (12)	<0.001
Outcome				

90-day death, n (%)	74 (25)	2 (13)	16 (33)	0.26
1-year death, n (%)	86 (29)	2 (13)	19 (40)	0.13

Continuous normal variables, continuous non-normal variables and categorical variables were compared by one-way analysis of variance, Kruskal-Wallis and chi-squared tests, respectively.
AD – aortic dissection; AoV – aortic valve; BP – blood pressure; ACEI or ARB – angiotensin-converting enzyme inhibitor or angiotensin receptor blocker.

Table S7. Adjusted linear Cox-regression analysis between LV continuous variables and early (90-day) and late (1-year) mortality.

Independent variables	Type-A		Type-B	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Outcome: 90-day mortality				
LV diastolic diameter, mm	0.99 [0.96-1.02]	0.63	1.00 [0.93-1.06]	0.92
Septum wall thickness, mm	1.08 [0.99-1.18]	0.10	1.03 [0.85-1.26]	0.76
Posterior wall thickness, mm	1.09 [0.99-1.20]	0.08	1.11 [0.89-1.39]	0.36
LV mass index, g/m^2	1.00 [0.99-1.01]	0.50	1.00 [0.99-1.01]	0.28
Relative wall thickness*100	1.01 [0.99-1.03]	0.14	1.02 [0.98-1.07]	0.32
LV Ejection fraction, %	1.00 [0.98-1.03)	0.72	0.97 [0.96-1.05)	0.24
Outcome: 1-year mortality				
LV diastolic diameter, mm	0.99 [0.97-1.02]	0.74	1.00 [0.95-1.06]	0.97
Septum wall thickness, mm	1.09 [1.00-1.18]	0.047	1.02 [0.86-1.21]	0.84
Posterior wall thickness, mm	1.10 [1.00-1.20]	0.044	1.10 [0.91-1.32]	0.33
LV mass index, g/m^2	1.00 [0.99-1.01]	0.21	1.01 [0.99-1.01]	0.11
Relative wall thickness*100	1.01 [0.99-1.03]	0.14	1.02 [0.98-1.06]	0.32
LV Ejection fraction, %	1.00 [0.97-1.02)	0.87	0.97 [0.93-1.01]	0.16

All analyses in type-A were adjusted for sex, age, center, calendar time, presence of hypotension, aortic dissection presentation, previous use of beta-blocker, development of hospital-acquired infection and in-hospital treatment modality, while all analyses in type-B were adjusted for sex, age, center, calendar time, previous use of angiotensin-converting enzyme or angiotensin receptor blocker and in-hospital treatment modality.
HR – hazard ratio; CI – confidence interval; LV – left ventricular.

Table S8. Cox-regression analysis between AD type and early (90-day) and late (1-year) mortality among the whole studied sample not adjusted and adjusted for LV remodeling phenotypes.

Independent variables	HR (95% CI)	p-value
Outcome: 90-day mortality		
Type-A vs Type B	2.20 (1.33-3.65)	0.002
Type-A vs Type B adjusted for LV concentricity	2.11 (1.28-3.50)	0.004
Type-A vs Type B adjusted for LV geometric patterns	2.26 (1.36-3.77)	0.002
Outcome: 1-year mortality		
Type-A vs Type B	1.80 (1.15-2.79)	0.009
Type-A vs Type B adjusted for LV concentricity	1.73 (1.11-2.70)	0.015
Type-A vs Type B adjusted for LV geometric patterns	1.85 (1.18-2.89)	0.007

AD – aortic dissection; LV – left ventricular; HR – hazard ratio; CI – confidence interval

Figure S1. Study Design.

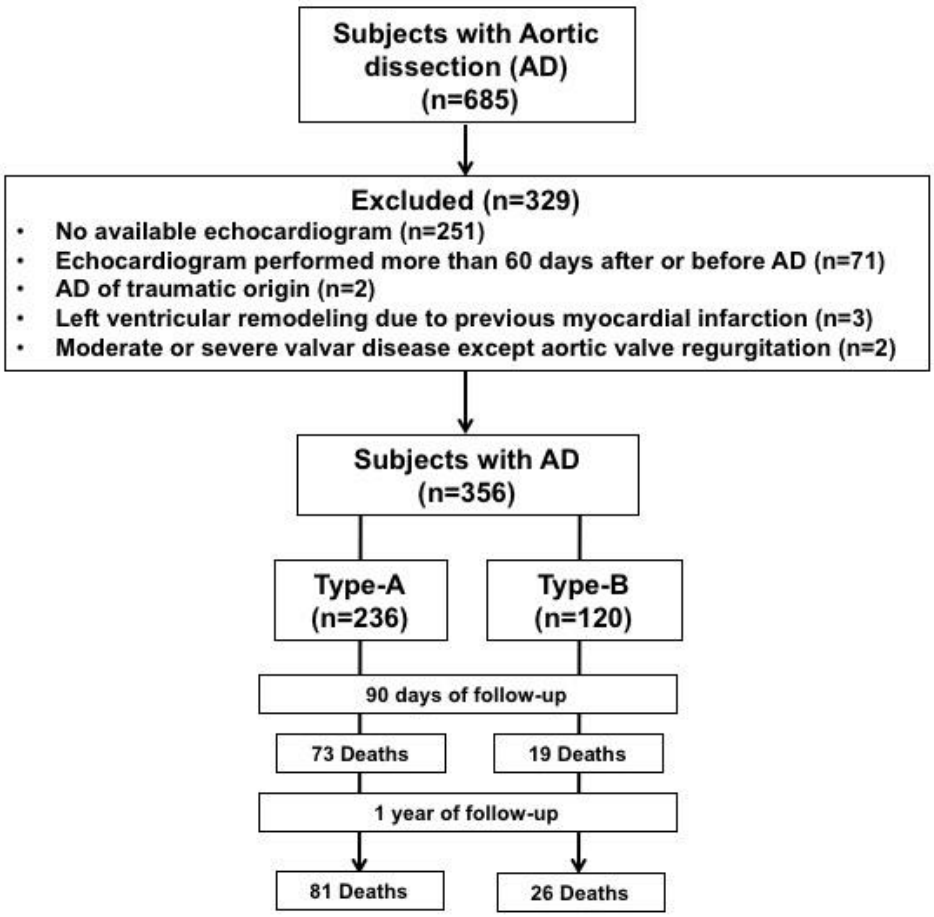
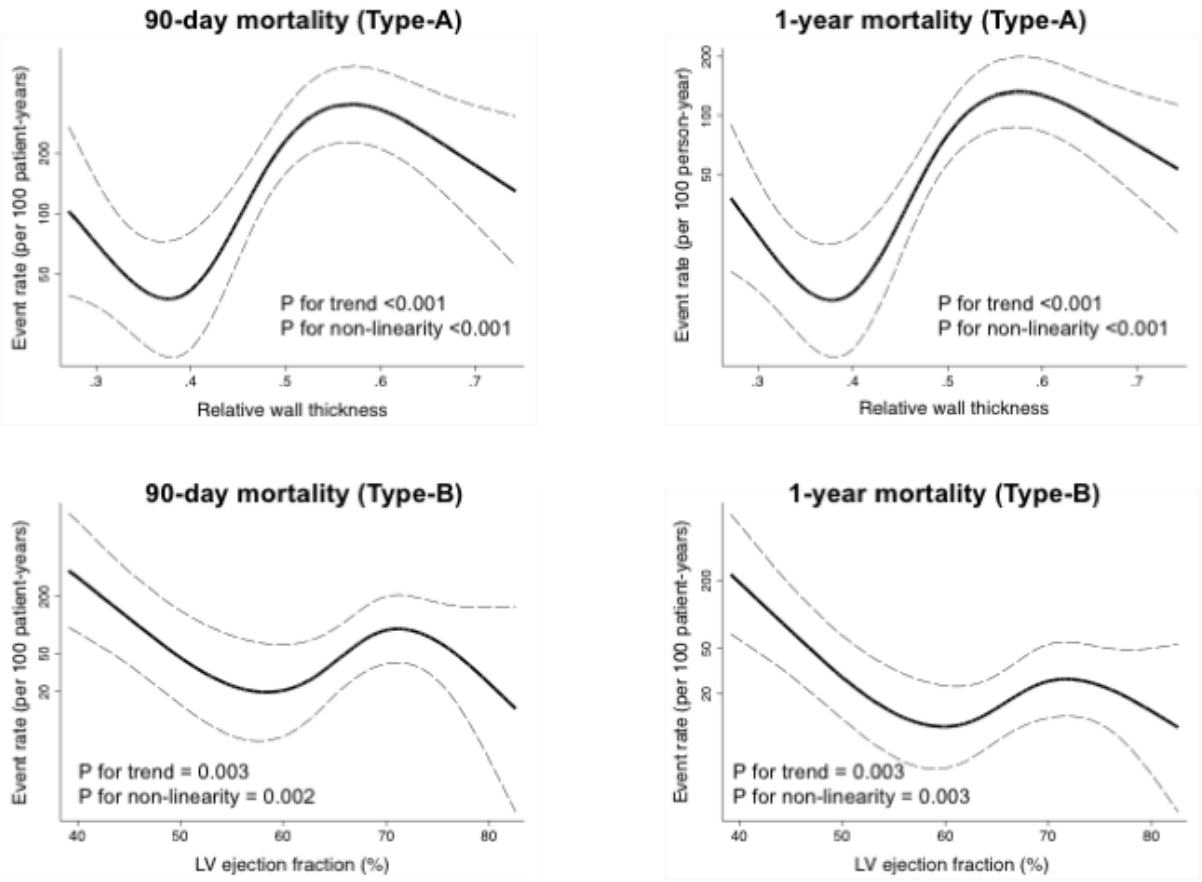


Figure S2. Restricted cubic spline analysis demonstrating the nonlinear association of continuous echocardiographic measures and the primary outcomes.



Analyses in type-A were adjusted for sex, age, center, calendar time, presence of hypotension, aortic dissection presentation, previous use of beta-blocker, development of hospital-acquired infection and in-hospital treatment modality, while analyses in type-B were adjusted for sex, age, center, calendar time, previous use of angiotensin-converting enzyme or angiotensin receptor blocker and in-hospital treatment modality.
Non-linearity was tested using the Likelihood-ratio test.
The dashed lines indicated 95% confidence intervals.
LV – left ventricular