Original Article

Left Ventricular Hypertrophy Is More Prevalent in Type B than Type A Aortic Dissection

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Objectives: Several factors determining differences between types A and B aortic dissection (AD) have been reported; however, little data exist examining their differences in left ventricular hypertrophy (LVH). We compared the prevalence of LVH in patients with types A and B AD.

Methods: We retrospectively analyzed 334 patients with acute AD (227 type A; 107 type B). Concentric hypertrophy (CH; increased left ventricular mass index [LVMI] and relative wall thickness [RWT]) is one of four types of left ventricular (LV) geometry thought to be most associated with hypertension. We compared LVMI and the prevalence of CH in patients with types A or B AD. Multivariate logistic regression analyses of variables associated with type B AD were performed.

Results: Comparing type A and B AD, LVMI (95 ± 26 vs.107 ± 28, $p < 0.001$) and prevalence of CH (26% vs. 44%, $p = 0.001$) were higher in type B AD. In multivariate analysis, CH was an independent factor associated with type B AD (odds ratio: 2.62, confidence interval: 1.54–4.47, $p < 0.001$).

Conclusions: Our data suggested LVH was more prevalent in type B than in type A AD. Considering LVH usually results from hypertension, patients with type B AD may be more affected by hypertension than those with type A.

Keywords: aortic dissection, left ventricular hypertrophy, type A, type B, hypertension

Introduction

Aortic dissection (AD) is a potentially fatal cardiovascular disorder, the etiology of which has not been fully elucidated. Furthermore, differences in etiology between Stanford types A and B AD have been suggested but remain undetermined. Several factors determining differences between types A and B AD have been reported[1,2]; however, little data exist comparing left ventricular hypertrophy (LVH) in types A and B AD.[3] Thus, the purpose of the present study was to compare the prevalence of LVH in patients with types A and B AD.

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Methods

Study population

We retrospectively examined consecutive patients diagnosed with acute AD, admitted to the Kawasaki Aortic Center between January 2016 and December 2017, whose left ventricular mass index (LVMI) and relative wall thickness (RWT) were obtained by echocardiography during hospital stays.

Patients with obvious connective tissue disorders and obstructive sleep apnea,[4] which were suspected to be associated with the development of AD by a different mechanism to that of ordinary individuals, were excluded. In addition, patients with other cardiovascular diseases that were supposedly associated with LVH, such as moderate or severe aortic stenosis, including status after aortic valve replacement for aortic stenosis and hypertrophic cardiomyopathy, were excluded. Finally, patients with type A AD having a history of type A or B AD, and those with type B AD having a history of type A or B AD, were excluded.

All patients underwent routine echocardiography at least once, undertaken with a Philips EPIQ 7C (Amsterdam, Netherlands) by experienced technicians, during their hospital stay. According to echocardiography findings, we divided patients into those with four types of LV geometry, such as normal, concentric remodeling, eccentric hypertrophy, and concentric hypertrophy (CH). We focused on only CH as an indicator of LVH since it was known to be the most strongly associated with hypertension out of the four types of LV geometry.[5,6] Patients' history, including systolic blood pressure (SBP) just before admission without the intravenous administration of an antihypertensive drug, and factors associated with atherosclerosis, were compared between those with types A or B AD. In addition, the following data regarding LV geometry as measured by echocardiography were compared between such patients: days from the onset of AD to evaluations with echocardiography, left ventricular end-diastolic dimension (LVDd), left ventricular end-systolic dimension (LVDs), left ventricular ejection fraction (LVEF), values of LVMI in total, those in males (mLVMI), those in females (fLVMI), the value of RWT, the prevalence of increased LVMI, the prevalence of increased RWT, and the prevalence of CH. Finally, univariate and multivariate logistic regression analyses were performed to determine the factors associated with type B AD.

The ethical committee of the Kawasaki Saiwai Hospital Council approved this study. Data collection was carried out by the opt-out method of the Kawasaki Saiwai Hospital website.

Definitions

Hypertension was defined as presenting with a SBP ≥140 mmHg, with or without an intravenous antihypertensive drug. Patients presenting with a SBP <140 mmHg and an intravenous antihypertensive drug were excluded for the assessment of hypertension. LVEF was calculated by the Teichholz method.[7] LVMI and RWT were calculated according to the following formula: $\text{LVM} = 0.8 [1.04\{(\text{IVST} + \text{LVDd} + \text{PWT})^3 - (\text{LVDd})^3\}] + 0.6 \text{ g}$.[8] $\text{LVMI} = \text{LVM}/\text{BSA}$, $\text{RWT} = (\text{IVST} + \text{PWT})/\text{LVDd}$. Increased mLVMI and fLVMI were defined as >115 and >95, respectively.[9] Increased RWT was defined as >0.42.[9] Based on a combination of values for LVMI and RWT, we divided left ventricle (LV) geometry into four types: "normal geometry" (normal LVMI and normal RWT), "concentric remodeling" (normal LVMI and increased RWT), "CH" (increased LVMI and increased RWT), and "eccentric hypertrophy" (increased LVMI and normal RWT), according to the American Society of Echocardiography's Guidelines.[9] Hypertrophic cardiomyopathy was defined as septal thickness ≥15 mm.[10] Diabetes mellitus was defined as HbA1c ≥6.5% (NGSP) or having a history of the active use of drugs for diabetes mellitus. Dyslipidemia was defined as serum total cholesterol ≥220 mg/dL, serum triglycerides ≥150 mg, or a history of active use of drugs for antihyperlipidemia.

Statistical analysis

Continuous variables were expressed as the mean ± standard deviation. Differences in continuous variables between two groups were calculated using Student's unpaired *t* test. Categorical variables were expressed as numbers (%) and were compared using Fisher's exact test. Univariate and multivariate logistic regression analyses were performed to identify factors associated with type B AD. SPSS for Windows, Version 16.0 (SPSS Inc., Chicago, IL, USA), was used for all statistical analyses.

Results

Patient selection flow is outlined in **Fig. 1**. Of 442 patients with AD admitted over 2 years, 227 patients
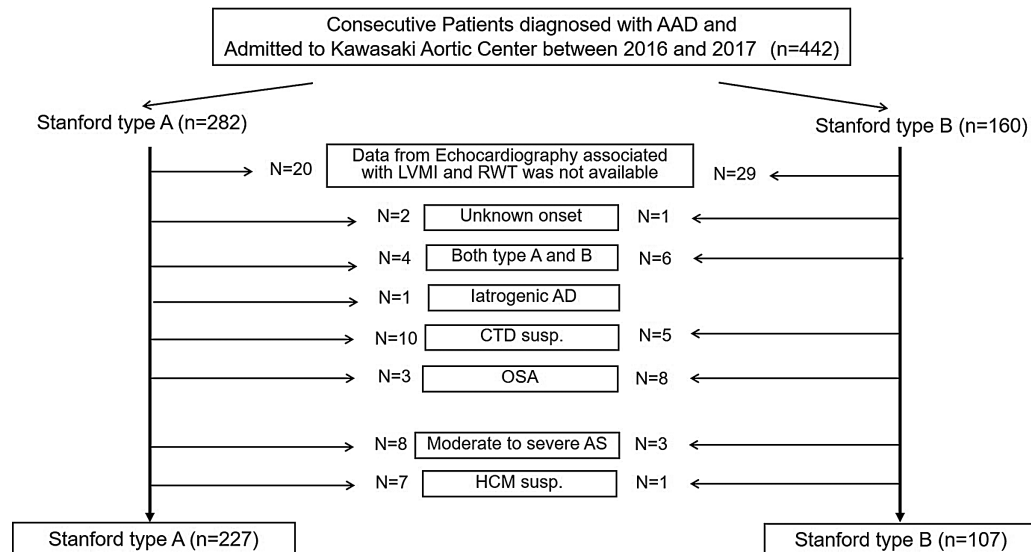
Fig. 1 Flow chart of patient selection. Of 442 patients with AD admitted over 2 years, 227 patients with type A and 107 patients with type B AD were studied in the present study. AAD: acute aortic dissection; AD: aortic dissection; AS: aortic stenosis; CTD: connective tissue disorder; HCM: hypertrophic cardiomyopathy; LVMI: left ventricular mass index; OSA: obstructive sleep apnea; RWT: relative wall thickness

with type A AD and 107 patients with type B AD were studied in the present study. The characteristics of patients with types A or B acute AD are compared in **Table 1**. In a comparison of patients with type A vs. type B AD, SBP just before admission was higher (124 ± 31 mmHg vs.167 ± 31 mmHg, p <0.001) in type B AD, and atherosclerotic factors, such as hypertension just before admission (47% vs. 89%, p <0.001), dyslipidemia (25% vs. 52%, p <0.001), being a current smoker (29% vs. 40%, p = 0.046), and having a history of smoking (43% vs. 66%, p <0.001) were more prevalent in type B AD. Parameters regarding LV geometry are shown in **Table 2**. In a comparison of patients with type A vs. type B AD, the number of days from the onset of AD to evaluations with echocardiography (8.0 ± 4.4 vs. 4.9 ± 6.6 days, p <0.001) were less in type B AD, and LVDd (41 ± 6 mm, 45 ± 6 mm, p <0.001), LVDs (27 ± 5 mm, 29 ± 6 mm, p = 0.019), LVEF (63 ± 7 %, 66 ± 7%, p = 0.012) were greater in type B AD. Increased LVMI values were more prevalent in type B than in type A AD; mLVMI >115 (24% vs. 47%, p = 0.002), fLVMI >95 (31% vs. 53%, p = 0.017). As for the types of LV geometry, CH (26% vs. 44%, p = 0.001) was more prevalent in type B AD (**Fig. 2**). The results of univariate and multivariate logistic regression analyses of factors associated with type B AD are shown in **Table 3**. Multivariate logistic regression analysis, including age, male gender, diabetes mellitus, dyslipidemia,

a history of smoking, and CH, showed that CH (odds ratio [OR] 2.62, confidence interval [CI] 1.54–4.47, p <0.001), dyslipidemia (OR 3.41, CI 2.02–5.75, p <0.001), and a history of smoking (OR 2.24, CI 1.19–4.20, p = 0.012) were independently associated with type B AD.

Discussion

The novel findings of the present study are that LVMI was greater and CH was more prevalent in type B than in type A AD.

Differences in backgrounds between types A and B AD

The etiology of AD is not fully determined. Furthermore, the etiologies of types A and B AD are thought to be different but also remain undetermined. A previous study reported differences in clinical findings between the two types of AD, such as age (higher in type B),[1,2] atherosclerosis (more frequent in type B),[1,2] and Marfan syndrome (less frequent in type B).[2] Hypertension is also generally considered to be one of the differences between types A and B AD but is yet to be fully elucidated.

Hypertension and AD

In previous studies, hypertension was reported in 44–86% of patients with AD[1,2,11–16)] and was considered one of the representative causes of AD. High SBP on

Table 1 Patients' characteristics

	Type A (n = 227)	Type B (n = 107)	*p* Value
Age (years)	69 ± 13	69 ± 13	0.995
Male (n, %)	110 (48%)	64 (60%)	0.061
BSA (m²)	1.64 ± 0.24	1.67 ± 0.22	0.237
BSA/male (m²)	1.82 ± 0.19	1.77 ± 0.20	0.119
BSA/female (m²)	1.47 ± 0.12	1.52 ± 0.14	0.038
SBP just before admission (mmHg)	124 ± 31 (n = 94)	167 ± 31 (n = 39)	<0.001
Hypertension just before admission (n, %)	60/127 (47%)	59/66 (89%)	<0.001
Dyslipidemia (n, %)	56 (25%)	56 (52%)	<0.001
Diabetes mellitus (n, %)	15 (7%)	14 (13%)	0.061
Current smoker (n, %)	66 (29%)	43 (40%)	0.046
History of smoking (n, %)	98 (43%)	71 (66%)	<0.001

BSA: body surface area; SBP: systolic blood pressure

admission[2,11,13,14] and a past history of hypertension[1,2,12,14–16] are frequently observed in patients with AD.

Higher SBP on admission has been observed more frequently in patients with type B than in those with type A AD.[2,11,13] However, the differences in SBP on admission do not necessarily mean the different prevalence of preexisting hypertension, even if they measured SBP in very early after the symptom onset. SBP in type A AD in the acute period is affected by many factors that lower it, such as cardiac tamponade, aortic rupture, or dissection extending to the brachiocephalic artery and/or subclavian artery.[13] The present study also showed that higher SBP just before admission was observed more frequently in patients with type B than in those with type A AD.

Some retrospective studies have been reported past history of hypertension was more prevalent in type B than type A.[1,2] However, a prospective population-based study over 10 years reported no difference between types A and B AD.[12] It is sometimes difficult to strictly determine whether patients had a history of hypertension or not. Furthermore, the effects of hypertension and antihypertensive drugs on patients during various periods were not uniform and complex.

Thus, the difference in hypertension between types A and B is not as obvious as generally thought.

Hypertension and LVH

The classification of LV geometry (normal, concentric remodeling, eccentric hypertrophy, and CH) based on LVMI and RWT has been widely used in population studies.[5,6,9] Of the four types of LV geometry, a previous study showed that CH presented with the highest SBP and was considered to be related to hypertension.[5,6] CH is induced by pressure overload,[17] such as hypertension, aortic stenosis, hypertrophic cardiomyopathy, and storage diseases, among others, while LVH was classically considered to be the result of hypertension.[18] Thus, the presence of CH may be regarded as a marker of preexisting hypertension if other causes of CH are carefully excluded.

AD and LVH

There are a few reports regarding the prevalence of LVH in AD. LVH in patients with AD was assessed by various methods such as heart weight in autopsy cases (AD 549 g vs. control 422 g, *p* <0.01)[19]; (AD 257 g vs. control 199 g, >99th percentile of normal volume)[20]; and heart weight calculated on echocardiography (AD 310 g vs. control 156 g, *p* <0.0001).[21] Moreover, studies comparing the prevalence of LVH between types A and B AD were rare. A registration study revealed LVH defined by electrocardiogram showed no difference in prevalence between types A and B AD (25% vs. 32%, *p* = 0.11).[3]

In the present study, we analyzed echocardiographic parameters to study the prevalence of LVH between patients with types A and B AD. LVMI values were greater in type B AD than in type A AD. Furthermore, CH was more frequently observed in patients with type B AD than with type A AD. Multivariate regression analysis revealed that CH was an independent factor associated with type B AD, along with dyslipidemia and a history of smoking.

AD and echocardiographic parameters other than LVMI

The values of LVDd, LVDs, and LVEF were greater in type B than those in type A. Based on the calculation formula for LVMI by Devereux,[8] which was used in the present study, one of the reasons of greater LVMI in type B AD might be estimated to be caused by greater LVDd in type B AD. Greater LVEF in type B AD can be

Table 2 Variables related to left ventricular geometry

	Type A (n = 227)	Type B (n = 107)	*p* Value
Days from onset to examination (days)	8.0 ± 4.4	4.9 ± 6.6	<0.001
LVDd (mm)	41 ± 6	45 ± 6	<0.001
LVDs (mm)	27 ± 5	29 ± 6	0.019
LVEF (%)	63 ± 7	66 ± 7	0.012
LVMI	95 ± 26	107 ± 28	<0.001
LVMI / male (g/m²)	103 ± 29 (n = 110)	111 ± 29 (n = 64)	0.095
LVMI / female (g/m²)	89 ± 22 (n = 117)	101 ± 25 (n = 43)	0.007
LVMI >115/male (n, %)	26 (24%)	30 (47%)	0.002
LVMI >95/female (n, %)	36 (31%)	23 (53%)	0.017
RWT	0.54 ± 0.10	0.50 ± 0.09	<0.001
RWT >0.42 (n, %)	209 (92%)	93 (87%)	0.163
Left ventricular geometry			
Concentric hypertrophy (n, %)	58 (26%)	47 (44%)	0.001
Others (n, %)	169 (74%)	60 (56%)	

IVST: interventricular septum thickness; LVEF: left ventricular ejection fraction; LVDd: left ventricular end-diastolic dimension; LVDs: left ventricular end-systolic dimension; LVMI: left ventricular mass index; PWT: posterior left ventricular wall thickness; RWT: relative wall thickness
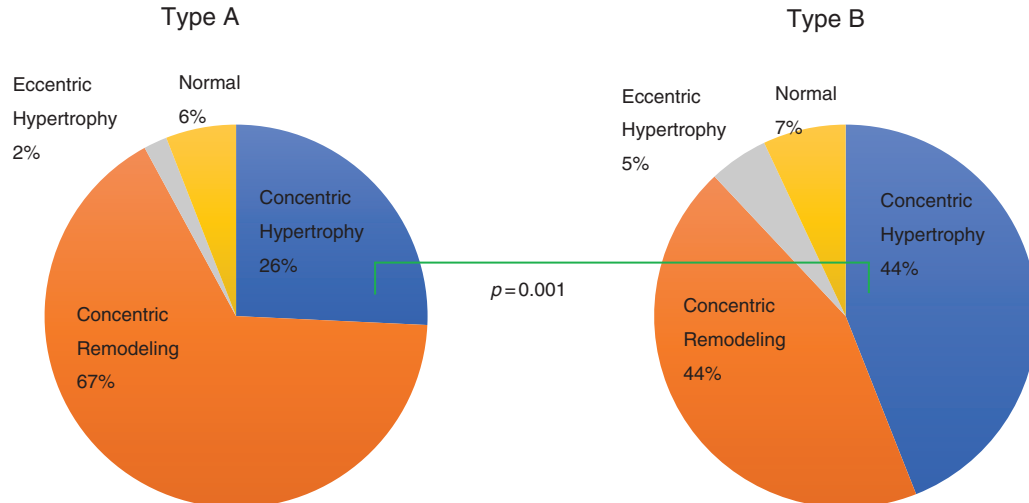

Fig. 2 Left ventricular geometry in types A and B ADs. CH was more prevalent in type B AD. AD: aortic dissection; CH: concentric hypertrophy

explained by the fact that type B AD is not be associated with myocardial ischemia resulted from AD.

Effect of AD itself and vascular prosthesis on LV afterload

A previous report showed that the augmentation index in the carotid artery was elevated in patients with AD in the chronic period, which means that LV afterload is higher in patients with chronic AD.[22] Furthermore, another report described that a stiff vascular prosthesis used for the proximal aorta might cause LVH.[23] Thus, the effect of AD and the replacement of a dissected ascending aorta by a vascular prosthesis on the LV afterload should be considered.

However, in the present study, the timing of echocardiography was close to in an acute period (8.0 ± 4.4 days after onset in type A and 4.9 ± 6.6 days after onset in type B AD), and not in a chronic period. These periods are considered not to be long enough for the progression of LVH. Thus, at least, the effect of AD and the replacement of a dissected ascending aorta by vascular prosthesis to the LVH might not be obvious in the present study.

Why is LVH associated with type B AD?

The mechanism concerning how LVH is associated with type B AD is not clear. As is well understood, LVH is caused not only by hypertension but also by aortic stenosis, hypertrophic cardiomyopathy, storage diseases as

Table 3 Univariate and multivariate analysis of factors associated with type B aortic dissection

Variables	Univariate			Multivariate		
	OR	95% CI	*p* Value	OR	95% CI	*p* Value
Age	1.00	0.98–1.02	0.995	1.02	0.99–1.04	0.182
Male gender	1.58	0.99–2.52	0.053	1.28	0.68–2.42	0.441
Diabetes Mellitus	2.13	0.99–4.59	0.054	1.50	0.63–3.56	0.355
Dyslipidemia	3.35	2.07–5.44	<0.001	3.41	2.02–5.75	<0.001
History of smoking	2.60	1.61–4.19	<0.001	2.24	1.19–4.20	0.012
Concentric hypertrophy	2.34	1.42–3.85	0.001	2.62	1.54–4.47	<0.001

Multivariate analysis was performed including all above six factors.

well as other diseases. However, patients with these causes other than hypertension were excluded from the present study. Therefore, it is reasonable to assume that LVH was caused by long-standing hypertension. As mentioned above, LVH was more prevalent in type B than A. Therefore, patients with type B AD may be more affected by hypertension than those with type A. Atherosclerotic factors, such as dyslipidemia and a history of smoking, were more likely to be present in type B than type A AD, and the fact will support above hypothesis.

Moreover, a previous report showed that LVH was associated with the diameter of the aortic arch and descending aorta of an AD, not that of the proximal and ascending aorta.[21] This result may imply that LVH was associated with stress in the aortic wall of the distal arch, which may be linked to the development of type B AD other than hypertension.

Study limitations

Our study had some limitations. First, a history of hypertension, including the duration of taking antihypertensive drugs, was not elucidated in this study because of its retrospective nature. Second, although the effect of the AD itself and the vascular prosthesis to the LV afterload should not have been so large, we could not deny their effects on our results. Third, we assessed LV geometry using echocardiography, which is known to be less reproducible compared with magnetic resonance imaging or autopsy. Fourth, we may not have completely excluded patients with connective tissue disorders, hypertrophic cardiomyopathy, and storage disease. Finally, the definition of dyslipidemia relied on the value of total serum cholesterol and triglycerides instead of LDLC and HDLC.

Conclusion

Our data suggest that LVH was more prevalent in type B than in type A AD. Considering that LVH is generally regarded to be caused by long-standing hypertension, patients with type B AD may be more affected by hypertension than those with type A. This is not as obvious as generally thought. Further study is necessary to examine the association of LVH with type B AD.

Acknowledgments

Disclosure Statement

The authors have no conflicts of interest to declare.

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