Left ventricular aneurysm in patients with idiopathic dilated cardiomyopathy: clinical analysis of six cases

Shudong Xia, Bifeng Wu, Xiaolian Zhang, Xiaosheng Hu

Background. Left ventricular aneurysm (LVA) in patients with idiopathic dilated cardiomyopathy (IDCM) is rarely reported, and the incidence, pathogenesis and clinical features of LVA in IDCM are poorly understood.

Methods. The diagnosis of IDCM with LVA formation was made in six patients between January 2003 and September 2008. Left ventriculography, coronary angiography, echocardiogram and electrocardiogram were performed in all patients. The hospital records of these patients with IDCM in our hospital and related literature were reviewed.

Results. LVA was located at the posterobasal wall in five patients and at the anterolateral wall in one patient. Two patients had abnormal Q waves and no patients had sustained ST-segment elevation on electrocardiogram. No significant coronary stenosis or mural thrombi was detected in these patients. All patients had severe ventricular arrhythmia, such as frequent multifocal ventricular premature contractions and ventricular tachycardia.

Conclusion. IDCM could be a rare cause of LVA. The LVA in IDCM was mainly located at the posterobasal wall. It was seldom accompanied by abnormal Q waves and sustained ST-segment elevation. The pathogenesis of LVA in IDCM seems to be less likely to be related to coronary emboli. Ventricular arrhythmia occurred frequently in these patients. (Neth Heart J 2009;17:475-80.)

Keywords: left ventricular aneurysm, idiopathic dilated cardiomyopathy, pathogenesis

Shudong Xia
Bifeng Wu
Xiaolian Zhang
Xiaosheng Hu

Department of Cardiology, the First Affiliated Hospital,
College of Medicine, Zhejiang University, Hangzhou, China

Correspondence to: X. Hu
Department of Cardiology, the First Affiliated Hospital, College
of Medicine, Zhejiang University, Hangzhou, 310003, China
E-mail: xia1314@gmail.com

Left ventricular aneurysm (LVA) is strictly defined as a distinct area of abnormal left ventricular diastolic contour with systolic dyskinesia or paradoxical bulging.¹ LVA generally results from myocardial infarction or coronary artery malformations (i.e. fistula)² but rarely, LVA can be associated with causes other than coronary artery disease including hypertrophic cardiomyopathy (HCM),³ Chagas' disease,⁴ sarcoidosis,⁵ congenital LVA⁶ and idiopathic LVA.⁷ However, LVA formation in patients with idiopathic dilated cardiomyopathy (IDCM) is rarely reported, and the incidence, clinical features and pathogenesis of LVA formation in patients with IDCM is poorly understood. This study summarises the findings of six cases of LVA formation in patients with IDCM and reviews the literature.

Subjects and Methods

Six patients with IDCM were diagnosed to have LVA between January 2003 and September 2008 in the First Affiliated Hospital of Zhejiang University Medical College, Hangzhou, China. IDCM was diagnosed according to the World Health Organisation guidelines.⁸ LVA was defined as a distinct area of abnormal left ventricular diastolic contour with systolic dyskinesia or paradoxical bulging as visualised by ventriculography.⁹

A detailed review of these patients' hospital records was conducted with special emphasis on clinical findings, electrocardiograms, echocardiograms, angiocardiograms, and left ventriculography. We also searched the records of all IDCM patients admitted to our institution from January 2003 to September 2008. The literature related to LVA formation in dilated cardiomyopathy published since 1985 was also reviewed.

Cardiac catheterisation

Selective coronary angiographies were performed in all study patients using the Judkins technique. Left ventriculography was performed in 30° right anterior oblique and 60° left anterior oblique views. Left ventricular wall motion was assessed in nine segments according to the AHA classification method.¹⁰ Aneurysm size was expressed as (width of sac x depth

of sac), where the origin of the sac was derived by extrapolation from the 'normal' ventricular contour. All haemodynamic measurements were calculated as the average of five consecutive cycles during sinus rhythm. Ejection volume was calculated using the area-length Dodge method.

To evaluate the haemodynamic influence of LVA formation in IDCM, the haemodynamic parameters of the six patients in the study group were compared with those of a control group of 18 patients with IDCM but without LVA, matched for age, sex and left ventricular diameter.

Echocardiographic evaluation

Two-dimensional M-mode echocardiography was performed according to the American Society of Echocardiography guidelines.¹¹ Left ventricular (LV) end-diastolic internal diameter, interventricular septal thickness, and LV posterior wall thickness were measured over three consecutive cardiac cycles.

Electrocardiographic evaluation

An abnormal Q wave was defined as a Q wave with a width of more than 0.04 seconds or showing Q/R >1/4. Ventricular tachycardia was defined as sustained ventricular tachycardia lasting more than 30 seconds. Non-sustained ventricular tachycardia was defined as three or more successive premature ventricular contractions terminating within 30 seconds. Occurrence of ventricular tachycardia was examined by Holter monitoring.

Results

Clinical characteristics

The diagnosis of IDCM was made in a total of 1218 patients in our hospital from January 2003 to September 2008, of whom only six were confirmed to have LVA formation, (prevalence 0.48%). The clinical characteristics of the six patients (five men and one woman with a mean age of 58.3 ± 13.4 years) are

shown in table 1. Onset age ranged from 37 to 67, mean 54.8 ± 13.5 years. The main symptom at presentation was dyspnoea in five patients and palpitations in one patient. None of them had episodes of chest pain or elevated serum cardiac enzyme activity (AST, CK, or LDH) suggesting acute myocardial infarction. None had positive serum markers of enterovirus, or flu-like syndrome at the time of onset suggesting acute myocarditis. None of them had family history of heart disease.

Morphological findings

All six patients showed the typical echocardiographic presentation of IDCM: enlarged left ventricle, thin ventricular wall and diffuse hypokinesis (table 1). The average left ventricular end-diastolic internal diameter (LVIDd) was 7.2 ± 0.7 cm. The average left ventricular end-diastolic posterior wall thickness (LVPWd) was 0.80 ± 0.14 cm. The left ventricular wall motion was diffusely decreased, while the area of the LVA displayed paradoxical movement and the area adjacent to LVA displayed lower wall motion amplitude when compared with the area not adjacent to LVA.

The LVA was mainly located at the posterobasal wall in five patients. Four aneurysms were limited to the posterobasal wall (figure 1), and one extended to the laterobasal wall (figure 2). In the remaining patient, the aneurysm was located at the apical section of anterolateral wall (figure 2). The LVA size ranged from 3.9×1.6 cm to 6.4×2.1 cm, with an average size of 5.0×1.7 cm. The LVA wall thickness ranged from 0.20 to 0.40 cm, mean 0.26 ± 0.07 cm. The LVA size was not associated with the thickness of the LVA wall or the LVIDd.

Haemodynamic findings

The haemodynamic findings of the patients and controls are summarised in table 2. The left ventricular end-diastolic volume and end-systolic volume in the study group were greater than in the control group (272 ± 57 ml vs. 210 ± 58 ml; 201 ± 61

Table 1. Patients characteristic and morphological findings.

Subjects	Age	Sex	Presenting symptom	Age of onset	NYHA	LVA location	LVA size (cm)	Thickness of LVA (cm)	LVPWd (cm)	LVIDd (cm)
1	72	M	Dyspnoea	64	IV	PB	4.8×1.6	0.20	0.73	7.4
2	69	M	Dyspnoea	65	IV	PB	5.2×1.7	0.20	0.64	7.6
3	67	M	Dyspnoea	67	III	PB	5.0×1.7	0.25	0.98	7.0
4	57	M	Dyspnoea	57	IV	PB&LB	6.4×2.1	0.25	0.66	8.1
5	45	M	Palpitations	37	III	PB	4.5×1.8	0.30	0.87	6.8
6	40	F	Dyspnoea	39	II	AL	3.9×1.6	0.40	0.90	6.0

PB=posterobasal wall, LB=laterobasal wall, AL=anterolateral wall, LVPWd=left ventricular posterior wall thickness in diastole, LVIDd=left ventricular internal dimensions in diastole.

Figure 1. Echocardiogram of LVA in patients with IDCM. Long-axis view of left ventricle showing the aneurysm (indicated by arrows) located at the posterobasal wall, also showing the enlarged left ventricle and the thin posterior wall. Top left top: Case 5: LVIDd=6.79 cm, LVPWd=0.88 cm. Top right panel: Case 3: LVIDd=7.04 cm, LVPWd=0.98 cm. Bottom left panel: Case 2: LVIDd=7.59 cm, LVPWd=0.64 cm. Bottom right panel: Case 1: LVIDd=7.41 cm, LVPWd=0.73 cm. LVIDd=left ventricular internal dimensions in diastole, LVPWd=left ventricular posterior wall thickness in diastole.

Figure 2. Coronary angiography and left ventriculography of case 4 (top panel) and 6 (bottom panel). Top panel showing the normal coronary artery and the large aneurysm at the posterobasal wall extended to laterobasal wall (30° right anterior oblique view, indicated by arrows). Bottom panel showing the normal coronary artery and the aneurysm at the anterolateral wall (30° right anterior oblique view, indicated by arrows).

ml vs. 136 ± 46 ml, respectively, $p=0.05$), while the left ventricular ejection fraction (LVEF) and cardiac index (CI) in study group were slightly lower than those in control group but the difference was not

statistically significant. The left ventricular peak systolic pressure of the study group was greater than in control subjects (130 ± 9.9 mmHg vs. 119 ± 11 mmHg, $p<0.05$).

Table 2. Haemodynamic and electrocardiographic findings in IDCM patients with LVA.

Subjects	LVPSP (mmHg)	LVEDV (ml)	LVESV (ml)	LVEF (%)	Abnormal Q wave	Number of VPC	Number of NSVT	Number of VT
1	130	290	220	24	None	6980	8	5
2	137	306	244	20	None	1970	4	4
3	133	261	203	22	None	4381	0	
4	142	355	280	21	II, III, aVF	3400	4	3
5	124	232	146	37	None	8178	91	6
6	114	192	115	40	I, aVL	2880	1	1
Study group (n=6)	130±9.9	272±57	201±61	27±9	2	4631±2442	18±36	4±2
Control group (n=18)	119±11	210±58	136±46	35±6	None	1908±1289	3±4	1±1
P	0.04*	0.05*	0.05*	0.10		0.04*	0.36	0.01*

LVPSP=left ventricular peak systolic pressure, LVEDV=left ventricular end-diastolic volume, LVESV=left ventricular end-systolic volume, LVEF=left ventricular ejection fraction, VPC=ventricular premature contraction, VT=(sustained) ventricular tachycardia, NSVT=non-sustained ventricular tachycardia. Study group: the IDCM patients with LVA; control group: the IDCM patients without LVA. * $p \leq 0.05$ (study group vs. control group).

Electrocardiographic findings

All patients were in sinus rhythm. Two patients had abnormal Q waves. One patient with a large posterior wall LVA had abnormal Q waves in leads II, III, and aVF, whilst one patient with an anterolateral wall LVA had abnormal Q waves in leads I, and aVL. The other four patients did not have abnormal Q waves. No patients exhibited sustained ST-segment elevation. All patients showed frequent ventricular premature contractions in Holter recordings. Three patients had non-sustained ventricular tachycardia and two had sustained ventricular tachycardia. The morphology of ventricular tachycardia was multiform. One patient had more than two types of ventricular tachycardia (table 2).

Follow-up

All patients are still alive, and have survived for one to eight years since the date of diagnosis. All received conventional medical therapy for heart failure including digoxin, diuretic, vasodilator, β -blocker, and angio-

tensin-converting enzyme inhibitor. Two patients received an implantable cardiac defibrillator due to their severe ventricular arrhythmia. One patient with an anterolateral aneurysm had the aneurysm resected; the remaining five with posterobasal aneurysm could not be resected due to the proximity of the aneurysm to the aortic root. Follow-up echocardiograms showed the LVA size was stable and no mural thrombus was detected.

Literature review

The literature on LVA formation in patients with dilated cardiomyopathy published since 1985 was reviewed (table 3).¹²⁻¹⁶ In total, eight case reports were identified, but five were confirmed as familial dilated cardiomyopathy (FDCM), in whom all LVAs described were located at the LV apex. The remaining three patients were diagnosed with IDCM, and the LVA was located at the posterobasal wall in two patients, and the anterolateral wall in one patient. Most patients were reported to have ventricular arrhythmia.

Table 3. Review of the literature.

Author	Case number	Race	Diagnosis	Location	Arrhythmia
Sadoshima (1987) ¹⁰	2	Japanese	IDCM	One in AL One in PB	None
Hirakawa (1990) ¹¹	2	Japanese	FDCM	AP	VT
Mestroni (1994) ¹²	1	Italian	FDCM	AP	VT
De Biase (1999) ¹³	1	Italian	IDCM	Not available	Not available
Forissier (2003) ¹⁴	2	French	FDCM	AP	One with VT One with NSVT

IDCM=idiopathic dilated cardiomyopathy, FDCM=familial dilated cardiomyopathy, AL=anterolateral wall, PB=posterobasal wall, AP=apex, VT=ventricular tachycardia, NSVT=non-sustained ventricular tachycardia.

Discussion

LVA usually results from myocardial infarction. Other rare aetiologies of LVA include hypertrophic cardiomyopathy, Chagas' disease, sarcoidosis, congenital LVA and idiopathic LVA. However, LVA formation in patients with IDCM is rarely reported. This study showed that IDCM could also be a rare cause of LVA and reports six cases to add to the world literature, which previously numbered three cases.

The cases we describe were subject to detailed examination to exclude other possible causes of LVA. Our patients were characterised by a long history of left heart failure and left ventricular dysfunction associated with diffuse hypokinesia and a localised aneurysm. Coronary angiography revealed no significant stenoses in the coronary arteries, which may exclude the possibility of ischaemic-dilated cardiomyopathy but if a complete or partial regression of coronary obstruction had occurred, then the coronary arteries could appear nearly normal at the time of an angiographic examination. Thus, it may be possible that our patients had suffered myocardial infarction with normal coronary arteries. However, this is unlikely since the diffuse hypokinesia of the entire left ventricle wall, which was present in our patients, cannot easily be accounted for by a local coronary event, and the location of the LVA did not appear to be related to the coronary distribution.

Other possible aetiologies of LVA, such as hypertrophic cardiomyopathy, Chagas' disease, sarcoidosis, congenital LVA and idiopathic LVA could be ruled out based on the medical history, clinical and laboratory investigations.

Possible pathogenesis of LVA in IDCM

The pathogenesis of LVA formation in patients with IDCM is not clear. One acceptable hypothesis is that coronary artery emboli originate from mural thrombus, present in some patients with IDCM, and LVA develops due to local wall infarction and fibrosis.¹² However, as our patients did not have any episodes of chest pain or ST changes or elevated cardiac enzymes suggestive of acute myocardial infarction and the location of LVA was unrelated to the coronary artery distribution, the possibility of mural thrombus-derived emboli is less likely.

We therefore propose an alternative hypothesis for the mechanism of LVA formation in IDCM.

Hypothesis

Although IDCM is characterised by diffuse wall hypokinesia, regional variations in left ventricular contractility and myocardial perfusion are frequent in IDCM. The regional asynergy may be related to the heterogeneity of local wall fibrosis and local wall stress.¹⁷⁻¹⁹ Juillière et al. demonstrated that regional myocardial perfusion abnormalities were predominant in the myocardial regions delineating the anteroposterior axis of the left ventricle.¹⁷ Local fibrosis occurred more

Figure 3. The pathogenesis of LVA formation in patients with IDCM, showing the wall stress is highest at the posterior wall. When local fibrosis occurs on the posterior wall, LVA may develop under the high wall stress.

frequently on the anterior wall or posterior wall, while less frequently on the lateral or septal wall. Hayashida et al. showed that wall stress in patients with IDCM was maximal in the basal segments and minimal in the apical segments.¹⁹ Based on the above findings, we suggest that LVA formation in patients with IDCM occurs when high peak systolic pressure in the left ventricle (as shown in our patients) imposes high levels of stress on a posterobasal wall which is weakened by fibrosis in a manner similar to the expansion of a soap bubble (figure 3). The LVA location in FDCM is mainly at the anterior or apical walls, and the mechanism of cardiac damage differs, which suggests that the pathogenesis of LVA formation in FDCM and IDCM may differ.

Clinical features of LVA in IDCM

Abnormal Q waves and sustained ST elevation were the main features of post-myocardial infarction aneurysm, while these rarely occurred in IDCM patients with LVA. Furthermore, no mural thrombus was detected in our patients, which indicates that the pathogenesis of LVA in IDCM is less likely to be related to coronary emboli.

Ventricular arrhythmia occurred more frequently in patients with LVA. Ventricular arrhythmia is also often observed in post-infarction aneurysm, idiopathic aneurysm and congenital aneurysm. Previous studies had shown the tissue of LVA was significantly non-homogeneous with viable, normal myocytes, fibrotic tissue, and/or hypertrophic myocytes.⁸ As in non-transmural myocardial infarction, this may well represent an arrhythmogenic substrate due to local

conduction delay and dispersion of excitability and refractoriness. These factors may increase the propensity to ventricular arrhythmias in IDCM patients with LVA.

Study limitations

We did not perform endomyocardial biopsy so do not have histological confirmation, but all of our patients had the typical clinical presentation and echocardiographic features of IDCM. Alternative conditions that might cause LV dilation and confuse the diagnosis of IDCM had been ruled out by the detailed investigation protocol followed.

Conclusions

IDCM could be a rare cause of LVA. The LVA in IDCM was mainly located at the posterobasal wall. It was seldom accompanied by abnormal Q wave and sustained ST-segment elevation. The pathogenesis of LVA in IDCM seems to be less likely related to coronary emboli. Ventricular arrhythmia occurred frequently in these patients. ■

References

- Antman EM, Braunwald E. Acute myocardial infarction, in: Heart Disease, A Textbook of Cardiovascular Medicine, Braunwald E, Ed. 5th edition, W.B. Saunders Company, Philadelphia, 1997: 1256-7.
- Tikiz H, Atak R, Balbay Y, Genc Y, Kutuk E. Left ventricular aneurysm formation after anterior myocardial infarction: clinical and angiographic determinants in 809 patients. *Int J Cardiol.* 2002;82:7-14.
- Hauser TH, Manning WJ, Haas TS, Lesser JR, Udelson JE, Ackerman MJ, et al. Prevalence, clinical significance, and natural history of left ventricular apical aneurysms in hypertrophic cardiomyopathy. *Circulation.* 2008;118:1541-9.
- Takeno M, Seto S, Kawahara F, Yamachika S, Yano K, Tsuda N, et al. Chronic Chagas' heart disease in a Japanese-Brazilian traveller. A case report. *Jpn Heart J.* 1999;40:375-82.
- Kosuge H, Noda M, Kakuta T, Kishi Y, Isobe M, Numano F. Left ventricular apical aneurysm in cardiac sarcoidosis. *Jpn Heart J.* 2001;42:265-9.
- Papagiannis J, Van Praagh R, Schwint O, D'Orsogna L, Qureshi F, Reynolds J, et al. Congenital left ventricular aneurysm: Clinical, imaging, pathologic, and surgical findings in seven new cases. *Am Heart J.* 2001;141:491-9.
- Tada H, Kurita T, Ohe T, Shimizu W, Suyama K, Aihara N, et al. Clinical and electrophysiologic features of idiopathic left ventricular aneurysm with sustained ventricular tachycardia. *Int J Cardiol.* 1998;67:27-38.
- Richardson P, McKenna W, Bristow M, Maisch B, Mautner B, O'Connell J, et al. Report of the 1995 World Health Organization/International Society and Federation of Cardiology Task Force on the definition and classification of cardiomyopathies. *Circulation.* 1996;93:841-2.
- Rutherford JD, Braunwald E, Cohn PE. Chronic ischemic heart disease, in Braunwald E (ed): Heart Disease: A Textbook of Cardiovascular Medicine. Philadelphia, WB Saunders, 1988; p 1364.
- Austen WG, Edwards JE, Frye RL, Gensini GG, Gott VL, Griffith LS, et al. A reporting system on patients evaluated for coronary artery disease. Report of the Ad Hoc Committee for Grading of Coronary Artery Disease, Council on Cardiovascular Surgery, American Heart Association. *Circulation.* 1975;51:5-40.
- Schiller NB, Shah PM, Crawford M, DeMaria A, Devereux R, Feigenbaum H, et al. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. *J Am Soc Echocardiogr.* 1989;2: 358-67.
- Sadoshima J, Taira Y, Shimokawa H, Koyanagi S, Takeshita A, Nakamura M. Two Cases of Dilated Cardiomyopathy Complicated by Left Ventricular Aneurysm. *Chest.* 1987;92:377-9.
- Hirakawa Y, Koyanagi S, Matsumoto T, Itaya R, Takeshita A, Nakamura M. Familial dilated cardiomyopathy complicated by left ventricular aneurysm. *Jpn Heart J.* 1990;31:245-9.
- Mestroni L, Morgera T, Miani D, Pinamonti B, Sinagra G, Tangenelli P, et al. Idiopathic left ventricular aneurysm: a clinical and pathological study of a new entity in the spectrum of cardiomyopathies. *Postgrad Med J.* 1994;70(Suppl 1):S13-20.
- De Biase L, Berni A, Giorda GP, Grutter G, Nigri A, Campa PP. Left ventricular aneurysm in a patient with mildly dilated cardiomyopathy. *Cardiologia.* 1999;44:191-2.
- Forissier JF, Bonne G, Bouchier C, Duboscq-Bidot L, Richard P, Wisniewski C, et al. Apical left ventricular aneurysm without atrioventricular block due to a lamin A/C gene mutation. *Eur J Heart Fail.* 2003;5:821-5.
- Juillière Y, Marie PY, Danchin N, Gillet C, Paille F, Karcher G, et al. Radionuclide assessment of regional differences in left ventricular wall motion and myocardial perfusion in idiopathic dilated cardiomyopathy. *Eur Heart J.* 1993;14:1163-9.
- Fauchier L, Eder V, Casset-Senon D, Marie O, Babuty D, Cosnay P, et al. Segmental Wall Motion Abnormalities in Idiopathic Dilated Cardiomyopathy and Their Effect on Prognosis. *Am J Cardiol.* 2004;93:1504-9.
- Hayashida W, Kumada T, Nohara R, Tanio H, Kambayashi M, Ishikawa N, et al. Left ventricular regional wall stress in dilated cardiomyopathy. *Circulation.* 1990;82:2075-83.