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Recurrent Severe Mitral Regurgitation Due to Left Ventricular Apical Wall Motion Abnormality Caused by Coronary Vasospastic Angina: A Case Report

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Abstract

A 76-year-old man developed congestive heart failure due to severe mitral regurgitation after episodes of vasospastic angina. Echocardiography demonstrated left ventricular apical akinesis with ballooning and deformity of the anterior mitral leaflet becoming concave toward the left atrium. The acetylcholine provocation test induced diffuse coronary vasospasm in the distal segments of both right and left coronary arteries and reproduced severe mitral regurgitation. Follow-up echocardiography demonstrated decreased mitral regurgitation with ameliorated apical wall motion. Coronary vasospasm remained refractory to antivasospastic medications and severe mitral regurgitation relapsed 1 month after discharge. Mitral valve annuloplasty with a Carpentier-Edwards physio ring was performed, and no recurrence of mitral regurgitation was observed despite some episodes of vasospastic angina. We speculate that vasospastic angina and the resultant apical wall motion abnormality caused tethering of the mitral subvalvular apparatus, leading to inappropriate mitral coaptation and severe regurgitation.

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Key Words

■**Mitral regurgitation** ■**Mitral valve, repair** ■**Coronary vasospasm**
■**Echocardiography, transthoracic** ■**Cardiomyopathies, other (ischemic)**

INTRODUCTION

Coronary vasospasm induces regional myocardial dysfunction, which is either transient or permanent according to the severity of coronary vasospasm[1]. The left ventricular apex is susceptible to multivessel coronary vasospasm, and dysfunction of the left ventricular apex influences the wall motion at the root of the papillary muscles. In these circumstances, the chordae tendineae and mitral leaflets could be displaced apically and outward, resulting in mitral regurgitation due to the tethering of the mitral valve[2].

CASE REPORT

A 76-year-old man, complaining of chest dis-

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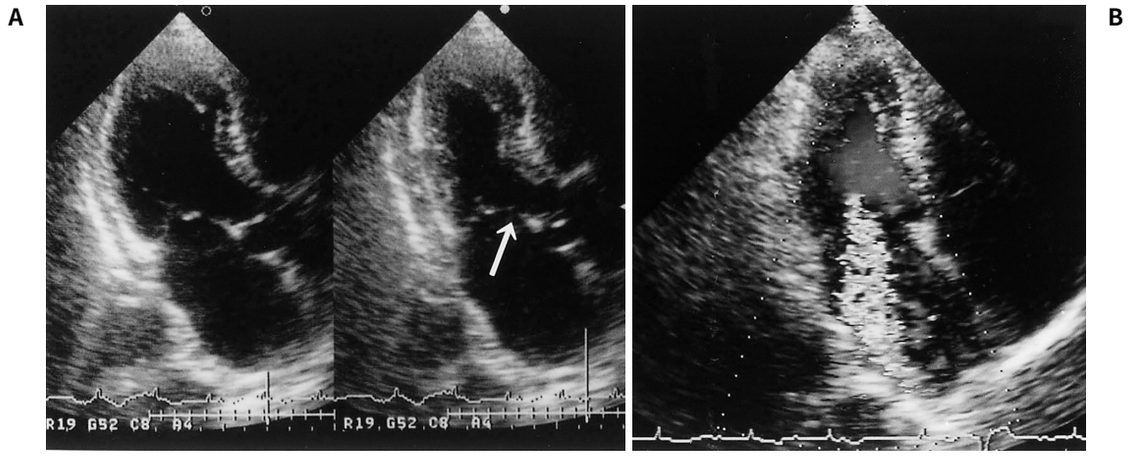

Fig. 1 Initial echocardiographic examinations
A: Left ventricular apical akinesis showing ballooning and concave deformity of the anterior mitral leaflet (*arrow*).
Left: Enddiastole. *Right*: Endsystole.
B: Severe mitral regurgitation with the electrocardiogram showing an inverted T wave.

comfort and severe dyspnea lasting for 2 hr, was admitted to our hospital because of congestive heart failure on November 23, 2003. He started to experience anterior chest oppression 12 years before. At the age of 73 years, coronary angiography revealed spontaneous coronary vasospasm in the left anterior descending and circumflex coronary arteries, and left ventriculography showed normal wall motion. Nifedipine and nitrate were administered, and echocardiography showed normal left ventricular contraction with moderate aortic regurgitation. However, anginal attacks occurred more frequently in the preceding weeks.

Physical examination found his heart rate was 90 beats /min with irregularity and blood pressure was 102/62 mmHg. Fine crackles were heard over both lower lung fields, and there was a grade Ⅳ/Ⅵ holosystolic murmur at the apex of the heart. Arterial blood gas analysis revealed Pa_{O_2} of 52 mmHg. Laboratory studies, including cardiac enzymes, were unremarkable except for positive serologic tests for syphilis. Electrocardiography revealed atrial fibrillation and ST-segment elevation in the chest leads V_2 to V_6, and subsequent T-wave inversion in these leads after sublingual nitroglycerin administration. Chest radiography showed cardiomegaly with a cardiothoracic ratio of 64%, pulmonary congestion, and left pleural effusion.

Echocardiography demonstrated severe mitral regurgitation and left ventricular apical akinesis with ballooning. The anterior mitral leaflet presented a concave configuration toward the left atrium (**Fig. 1**). The mitral valve coaptation depth, that is the distance between the point of coaptation of the mitral leaflets and the plane of the mitral annulus measured at endsystole, was 11.6 mm. Left atrial dimension was 49 mm, and left ventricular diameter was 42 mm at enddiastole and 28 mm at endsystole. Percentage fractional shortening was 33%. On the third hospital day, resting thallium-201 myocardial scintigraphy detected a perfusion defect in the apex (**Fig. 2**), and echocardiography demonstrated a less concave anterior mitral leaflet and decreased mitral regurgitation (**Fig. 3**).

He recovered from congestive heart failure after treatment with carperitide, nitroglycerin infusion, and dobutamine. On the seventh hospital day, coronary angiography revealed no organic stenosis, but the acetylcholine provocation test induced diffuse coronary vasospasm in the distal segments of both right and left coronary arteries (**Fig. 4−A**) accompanied by chest oppression and ST-T changes in the electrocardiogram. Simultaneous echocardiography showed severe mitral regurgitation. After intracoronary nitroglycerin infusion, left ventriculography showed dyskinetic wall motion of the apex (**Fig. 4−B**). Left ventricular end-diastolic and end-systolic volumes were 100 and 61 m*l*, respectively. Left ventricular ejection fraction was 39%. Follow-up echocardiography 11 days after admission demonstrated a non-concave anterior mitral leaflet along with ameliorated apical wall motion (**Fig. 5−**

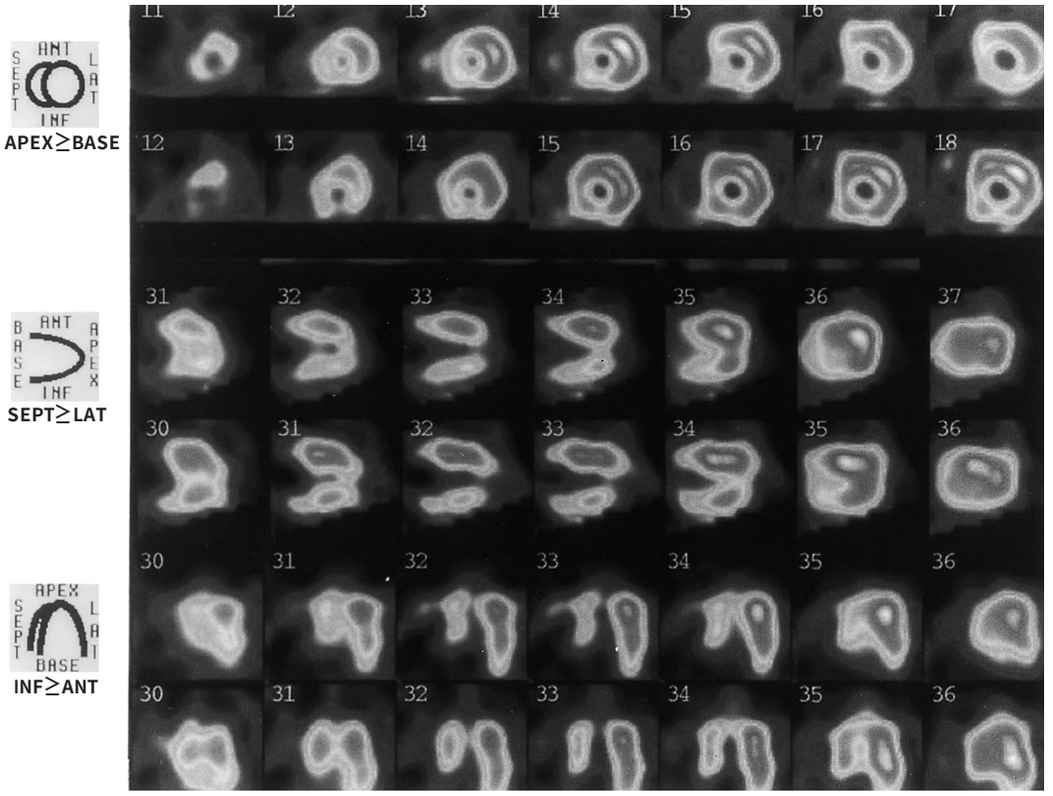

Fig. 2 Resting thallium-201 myocardial scintigrams showing a myocardial perfusion defect in the left ventricular apex
ANT = anterior; SEPT = septal; LAT = lateral; INF = inferior.

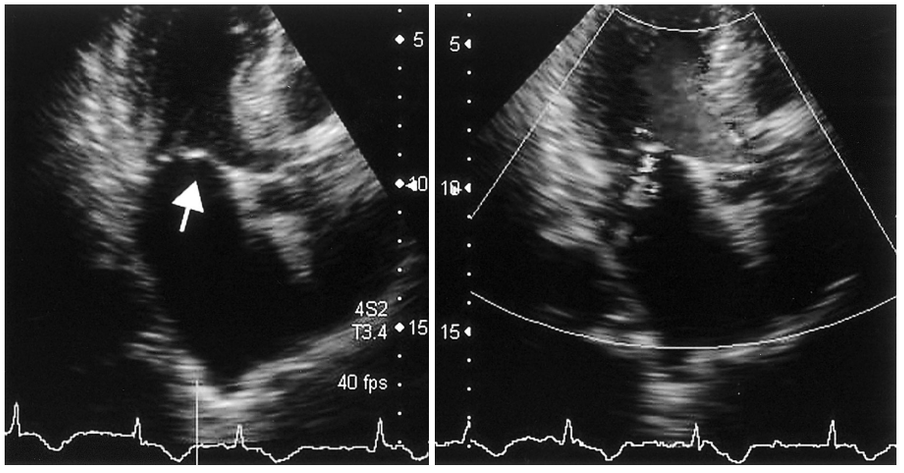

Fig. 3 Echocardiograms on the third hospital day
A less concave anterior mitral leaflet (*arrow*; *left*) and decreased mitral regurgitation (*right*) are shown.

A). The mitral valve coaptation depth was 10.4 mm.

The patient was followed up with additional administration of diuretic, nicorandil, and angiotensin receptor blocker. However, further episodes of vasospastic angina occurred, and congestive heart failure recurred 1 month after discharge. Echocardiography again demonstrated left

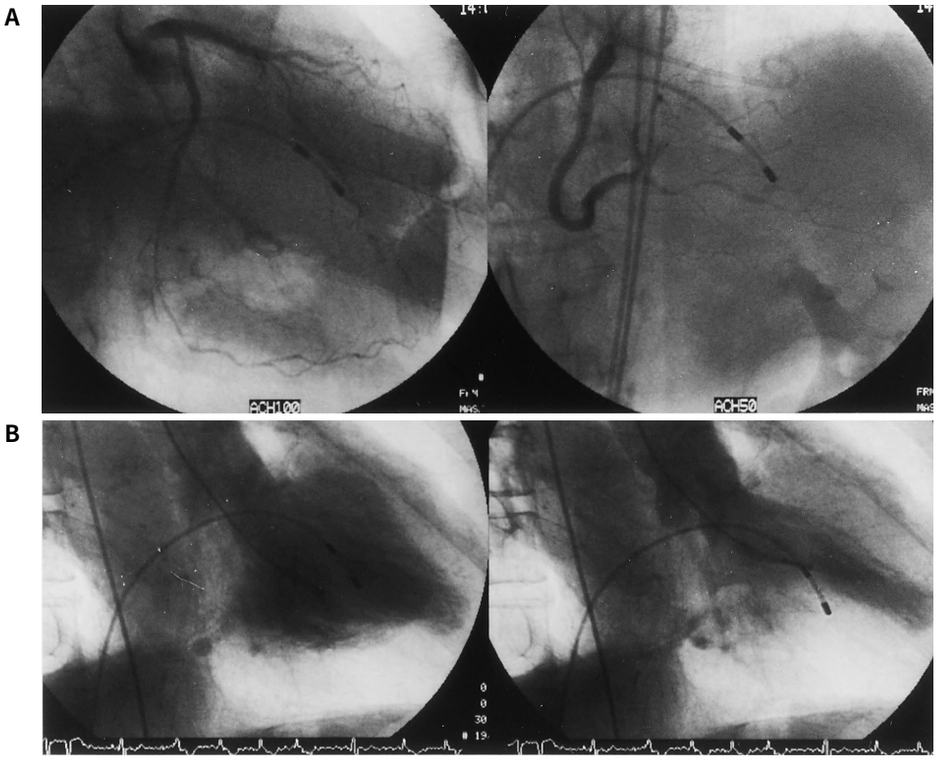

Fig. 4 Catheter examinations
A: Acetylcholine provocation test inducing diffuse multivessel coronary vasospasm(*left*: left coronary artery, *right*: right coronary artery).
ACH = acetylcholine.
B: Left ventriculography showing dyskinetic wall motion of the apex(*left*: enddiastole, *right*: endsystole).

ventricular apical wall motion abnormality and severe mitral regurgitation. The concave deformity of the anterior mitral leaflet reappeared with an increase in the mitral valve coaptation depth to 12.3 mm(**Fig. 5−B**). The preexisting aortic regurgitation remained unchanged throughout the clinical course. Notwithstanding the successful recovery from congestive heart failure, severe mitral regurgitation was expected to recur because of intractable vasospastic angina. Therefore, management of mitral regurgitation by surgical intervention was indicated. In addition, chest computed tomography incidentally detected an aortic arch aneurysm of a saccular type. On March 9, 2004, mitral valve annuloplasty with a 26 mm Carpentier-Edwards physio ring was performed concurrently with total aortic arch replacement and aortic valve replacement. No organic lesions were found in the mitral valve itself. The postoperative course was uneventful, and no recurrence of mitral regurgitation was observed despite some episodes of vasospastic angina.

DISCUSSION

Severe mitral regurgitation occurred after recurrent episodes of vasospastic angina. The acetylcholine provocation test induced multivessel coronary vasospasm and reproduced severe mitral regurgitation. Moreover, vasospastic anginal attacks caused left ventricular apical akinesis with ballooning. We speculate that multivessel coronary vasospasm induced stunned myocardium in the left ventricular apex. Although myocardial scintigraphy showed a perfusion defect in the left ventricular apex suggesting severe myocardial damage, echocardiography demonstrated amelioration of the apical wall motion. There are very few case reports of severe mitral regurgitation due to coronary vasospasm. Transient severe mitral regurgitation was observed in a patient with hypokinesis of the left ventricular anteroseptal and anterolateral walls. The mitral regurgitation was probably related to coronary vasospasm of the left anterior descending artery, but the acetylcholine provocation test did

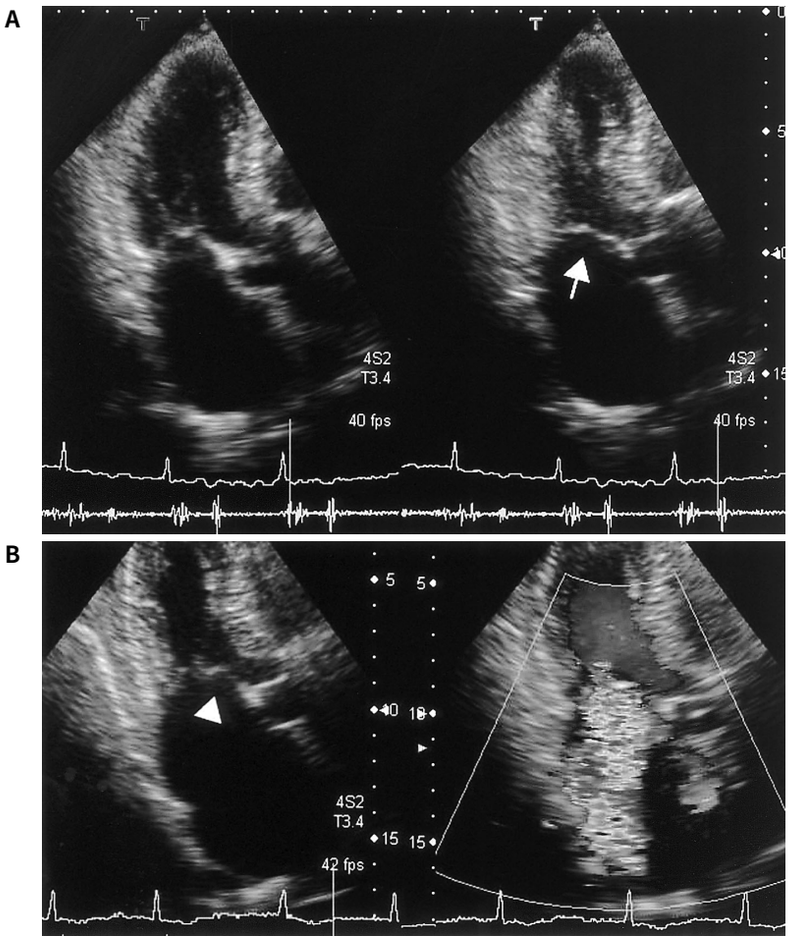

Fig. 5 Follow-up echocardiograms
A: A non-concave anterior mitral leaflet (*arrow*) with ameliorated apical wall motion. Note the electrocardiogram showing a flattened T wave. *Left*: Enddiastole. *Right*: Endsystole. *B*: Reappearance of the concave deformity of the anterior mitral leaflet (*arrowhead*; *left*) when severe mitral regurgitation recurred (*right*). Note the electrocardiogram showing the inverted T wave.

not induce mitral regurgitation[3]. Transient severe mitral regurgitation was demonstrated during ergonovine stress echocardiography in another patient who had presented with acute pulmonary edema, but regional wall motion changes were not detected[4].

How vasospastic angina produced severe mitral regurgitation remained unclear. No organic lesions were found in the mitral valve itself. Left atrial enlargement due to atrial fibrillation could be associated with mitral regurgitation, but mitral annular enlargement secondary to atrial fibrillation does not usually promote important mitral regurgitation[5]. Vasospastic angina may have caused left ventricular dysfunction and diminished mitral leaflet closing force, however, functional mitral regurgitation in the setting of acute myocardial ischemia is not fully explained by the inadequate mitral leaflet closing force[6].

Severe mitral regurgitation was closely associated with left ventricular apical wall motion abnormality. As the apical wall motion improved, the amount of mitral regurgitation subsequently decreased. On the other hand, the apical wall motion deteriorated when vasospastic angina and severe mitral regurgitation relapsed. It is important to note that echocardiography demonstrated concave deformity of the anterior mitral leaflet and increased mitral valve coaptation depth when severe mitral regurgitation occurred. These findings suggest that the severe mitral regurgitation derived from dysfunction of subvalvular mitral apparatus such as the chordae tendineae, papillary muscles, and the adjacent myocardial wall. The impaired apical wall motion could cause tethering of the chordae tendineae by displacing the papillary muscles outward. Then, the mitral leaflets were coapted inappropriately, leading to severe regurgitation[7]. It is possible that the papillary muscle contraction was preserved and the tethering force was augmented, because the coronary branches feeding the papillary muscles differ from the apical myocar-

dium[2,8]. The apical myocardium is perfused by the distal left anterior descending artery, whereas the posterior papillary muscle is fed by the right coronary artery and the anterior papillary muscle is fed by the first obtuse marginal branch and the first diagonal branch[9]. These mechanisms are comparable to mitral regurgitation in ischemic heart disease. There is growing evidence that ischemic mitral regurgitation results from tethering of the mitral leaflets. Bulging of the ventricular segment overlying the papillary muscle displaces the mitral leaflets outward, leading to incomplete coaptation[2,7]. The concave deformity of the anterior mitral leaflet is consistent with tethering by intermediate chords attached to the belly of the anterior leaflet[10]. In addition, experiments have proven that ischemic mitral regurgitation diminishes if the tethering force is relieved by an extracardiac patch device or chordal cutting[11,12]. Therefore, the present case represents an atypical case of ischemic mitral regurgitation, in that coronary vasospasm caused left ventricular apical wall motion abnormality, which in turn resulted in severe mitral regurgitation through displacement of the mitral leaflets.

The present patient underwent mitral valve annuloplasty with a Carpentier-Edwards physio ring. Although antivasospastic drugs had been administered as the first-line treatment to prevent mitral regurgitation, coronary vasospasm remained refractory to medications and severe mitral regurgitation recurred. Mitral valve annuloplasty increases the coaptational surface of the mitral leaflets and counteracts the tethering force[13]. These hemodynamic effects may resemble those of takotsubo cardiomyopathy. Takotsubo cardiomyopathy has a prominent feature of left ventricular apical akinesis and basal hyperkinesis[14]. Apical ballooning would generate potent tethering force for the mitral leaflets, but basal annulus narrowing would prevent inadequate coaptation of the mitral leaflets. In fact, mitral regurgitation is uncommon in takotsubo cardiomyopathy except for secondary regurgitation resulting from systolic anterior motion of the mitral valves and outflow tract obstruction. The present case differs from takotsubo cardiomyopathy in that basal hyperkinesia was absent and apical wall motion abnormality was partially irreversible. However, we believe that these explanations support the rationale for mitral valve annuloplasty to prevent severe mitral regurgitation secondary to apical wall motion abnormality in the present case.

要　　約

冠攣縮性狭心症による左室心尖部壁運動異常が原因となった再発性高度僧帽弁逆流の1例

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症例は76歳，男性．冠攣縮性狭心症発作時に高度僧帽弁逆流によるうっ血性心不全の合併をみた例である．心エコー図では，僧帽弁逆流とともに左室心尖部の風船様無収縮が認められ，僧帽弁前尖は左房側に対し凹状に変形して後尖との接合不全をきたしていた．冠動脈造影ではアセチルコリン負荷で左右冠動脈の末梢にび漫性冠攣縮が誘発され，僧帽弁逆流の再現が得られた．心エコー図の経過上，心尖部壁運動の改善とともに僧帽弁逆流の減少が認められた．冠攣縮性狭心症は治療抵抗性で，退院1ヵ月後に再び高度僧帽弁逆流を発症した．Carpentier-Edwards physio ringを用いた僧帽弁形成術後では，冠攣縮発作にもかかわらず僧帽弁逆流は再発していない．冠攣縮性狭心症による高度僧帽弁逆流の成因として，心尖部壁運動異常による僧帽弁装置の心尖方向への牽引が弁の接合不全を引き起こしていたと考えられた．

J Cardiol 2006 Jan; 47(1): 31−37

References

1) Sadamatsu K, Tashiro H, Maehira N, Yamamoto K: Coronary microvascular abnormality in the reversible systolic dysfunction observed after noncardiac disease. Jpn Circ J 2000; **64**: 789−792
2) Kono T, Sabbah HN, Rosman H, Alam M, Jafri S, Stein PD, Goldstein S: Mechanism of functional mitral regurgitation during acute myocardial ischemia. J Am Coll Cardiol 1992; **19**: 1101−1105
3) Inoue H, Horimoto M, Hamasakai S, Takenaka T, Igarashi K, Miyata S: Transient severe mitral regurgitation complicating myocardial stunning due to coronary vasospasm. Intern Med 1999; **38**: 660−662
4) Epureanu V, San Roman JA, Vega JL, Fernandez-Aviles F: Acute pulmonary edema with normal coronary arteries: Mechanism identification by ergonovine stress echocardiography. Rev Esp Cardiol 2002; **55**: 775−777 (in Spanish with Eng abstr)
5) Otsuji Y, Kumanohoso T, Yoshifuku S, Matsukida K, Koriyama C, Kisanuki A, Minagoe S, Levine RA, Tei C: Isolated annular dilation does not usually cause important functional mitral regurgitation: Comparison between patients with lone atrial fibrillation and those with idiopathic or ischemic cardiomyopathy. J Am Coll Cardiol 2002; **39**: 1651−1656
6) Otsuji Y, Handschumacher MD, Schwammenthal E, Jiang L, Song JK, Guerrero JL, Vlahakes GJ, Levine RA: Insights from three-dimensional echocardiography into the mechanism of functional mitral regurgitation: Direct in vivo demonstration of altered leaflet tethering geometry. Circulation 1997; **96**: 1999−2008
7) Yiu SF, Enriquez-Sarano M, Tribouilloy C, Seward JB, Tajik AJ: Determinants of the degree of functional mitral regurgitation in patients with systolic left ventricular dysfunction: A quantitative clinical study. Circulation 2000; **102**: 1400−1406
8) Messas E, Guerrero JL, Handschumacher MD, Chow CM, Sullivan S, Schwammenthal E, Levine RA: Paradoxic decrease in ischemic mitral regurgitation with papillary muscle dysfunction: Insights from three-dimensional and contrast echocardiography with strain rate measurement. Circulation 2001; **104**: 1952−1957
9) Voci P, Bilotta F, Caretta Q, Mercanti C, Marino B: Papillary muscle perfusion pattern: A hypothesis for ischemic papillary muscle dysfunction. Circulation 1995; **91**: 1714−1718
10) Nesta F, Otsuji Y, Handschumacher MD, Messas E, Leavitt M, Carpentier A, Levine RA, Hung J: Leaflet concavity: A rapid visual clue to the presence and mechanism of functional mitral regurgitation. J Am Soc Echocardiogr 2003; **16**: 1301−1308
11) Hung J, Guerrero JL, Handschumacher MD, Supple G, Sullivan S, Levine RA: Reverse ventricular remodeling reduces ischemic mitral regurgitation: Echo-guided device application in the beating heart. Circulation 2002; **106**: 2594−2600
12) Messas E, Pouzet B, Touchot B, Guerrero JL, Vlahakes GJ, Desnos M, Menasche P, Hagege A, Levine RA: Efficacy of chordal cutting to relieve chronic persistent ischemic mitral regurgitation. Circulation 2003; **108**: II-111−II-115
13) Lai DT, Timek TA, Tibayan FA, Green GR, Daughters GT, Liang D, Ingels NB Jr, Miller DC: The effects of mitral annuloplasty rings on mitral valve complex 3-D geometry during acute left ventricular ischemia. Eur J Cardiothorac Surg 2002; **22**: 808−816
14) Kawai S, Suzuki H, Yamaguchi H, Tanaka K, Sawada H, Aizawa T, Watanabe M, Tamura T, Umawatari K, Kawata M, Nakamura T, Yamanaka O, Okada R: Ampulla cardiomyopathy (Takotsubo 'cardiomyopathy): Reversible left ventricular dysfunction with ST segment elevation. Jpn Circ J 2000; **64**: 156−159