Isolated Cleft in the Posterior Mitral Valve Leaflet: A Congenital Form of Mitral Regurgitation

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ABSTRACT

Background: Isolated congenital cleft of the posterior leaflet of the mitral valve is a rare cause of mitral regurgitation (MR). This study describes the clinical, echocardiographic, and intraoperative findings as well as treatment options.

Methods: Adults with an isolated cleft of the posterior mitral valve leaflet diagnosed by transthoracic echocardiography were evaluated with respect to clinical, echocardiographic, preoperative and intraoperative findings, and different surgical strategies.

Results: The prevalence of isolated cleft of the posterior mitral valve leaflet in all patients examined was 0.11% (n = 22 out of 19 320 evaluated echocardiograms); male gender was predominant (73%). Dyspnea on exertion was present in almost all patients with at least moderate regurgitation. The predominant localization of the cleft was within segment P2 (59%), followed by a cleft between P1/P2 (18%). An isolated cleft in segment P3 or segment P1 occurred twice in each segment (n = 2; 9%) and between P2/P3 once (n = 1; 5%). Regurgitation was severe in 50% (n = 11), moderate in 9% (n = 2), mild in 27% (n = 6), and only trivial in 14% (n = 3) of the patients. Surgical treatment involved reconstruction with ring annuloplasty in 45% (n = 10) and replacement in 4.5% (n = 1). A total of 11 patients (50%) with mostly mild or trivial mitral regurgitation were treated medically only.

Conclusion: Two-dimensional high-resolution cross-sectional echocardiography allows the distinct diagnosis of a clefted posterior leaflet, whereas clinical presentation, electrocardiogram, chest x-ray, and angiography are failing to identify the correct etiology of MR in patients with isolated posterior leaflet cleft mitral valve (IPLCMV). Patients with moderate to severe MR were treated surgically with excellent outcome.

Introduction

Mitral valve insufficiency in congenital heart disease occurs most frequently in patients with partial or complete atrioventricular septal defects due to a cleft in the anterior leaflet of the mitral valve. Before introduction of high-resolution echocardiography the diagnosis of a cleft in the mitral valve was usually not established until autopsy or surgery.[1] Several series of patients with isolated anterior cleft have been studied, especially in pediatric populations,[1,2] but isolated clefts in the posterior mitral valve (IPLCMV) was published only in a few earlier case reports.[3,4] For optimal planning of the surgical technique, if applicable, clefts in the posterior leaflet have to be distinguished from false commissures. Moreover, planning of the optimal surgical approach may be supported by valid echocardiographic data about the segmental localization of a cleft. We report an institutional experience in diagnosis and management of IPLCMV in adults and highlight its anatomical, clinical, and echocardiographic features, as well as treatment options.

CAW and FE contributed equally to the present work.

Methods

Patients

We reevaluated all echocardiographic studies (n = 19 320) in adults (>16 years old) from January 2001 to January 2005 performed at our echocardiographic laboratory to identify patients with an isolated cleft in the posterior mitral valve leaflet. The patients' history, their preoperative and postoperative clinical data, and intraoperative findings were obtained from the medical and surgical records.

Received: January 24, 2009
Accepted: February 5, 2009

Published online in Wiley InterScience. (www.interscience.wiley.com)
DOI:10.1002/clc.20608 © 2009 Wiley Periodicals, Inc.

Enlargement of the heart was defined as a cardiothoracic ratio >0.5 in a posterior-anterior chest roentgenogram.[5]

Doppler Echocardiography

Doppler echocardiography was performed according to standard techniques using a real-time phased array sector scanner with integrated color Doppler facilities (3.5 MHz). Severity of mitral regurgitation (MR) was determined by the vena-contracta method[6,7] and was graded as trivial, mild, moderate, or severe. The cleft of the posterior mitral valve leaflet was best visualized by 2-dimensional echocardiography (2DE) from a parasternal short axis view through the left ventricle at the level of the mitral valve in closed position, presenting a T-like morphology. Left ventricular measurements and the diameter of the left atrium were measured using M-mode in the parasternal long axis view and corrected for body surface area (BSA) where appropriate. Left ventricular mass was calculated using the formula described by Devereux et al[8] and eccentric hypertrophy was defined as elevated left ventricular mass with a relative wall thickness $\leq$0.42, as described by Ganau et al.[9] Left atrial diameter was measured during end-systole and was defined as a left atrial diameter/BSA >2.3 cm/m^2.[10] Left ventricular volume was calculated using the modified Simpson's rule and ejection fraction was then calculated.[10] Systolic pressure difference was measured between the right ventricle and the right atrium to estimate systolic pulmonary artery pressure. Values above 30 mm Hg were classified as elevated systolic pulmonary artery pressure.

Results

Clinical Presentation

Data were collected between January 2001 and January 2005 from our echocardiographic database and the patients were followed until April 2008 (mean follow-up time = 32.4 mo) and are summarized in Table 1. A total of 22 adults from a total of 19 320 patients with an isolated cleft in the posterior mitral valve leaflet were identified (prevalence = 0.11%). Male gender was predominant (16/22 patients [pts], 73%), mean age at diagnosis was 56 years (range, 19–82 y; Table 1). None of the patients suffered chest trauma or previous endocarditis, but 1 patient presented with florid mitral valve endocarditis and vegetations on the posterior leaflet at the time of diagnosis. The degree of regurgitation at diagnosis of IPLCMV ranged from trivial to severe (Table 1).

Dyspnea on exertion was present in almost all patients with at least moderate regurgitation (New York Heart Association [NYHA] functional class ranged from I to III-IV). Moreover, 5 patients presented with palpitations (5/22 pts, 23%) and in 4 patients atrial fibrillation/atrial flutter was documented (4/22 pts, 18%). In 2 patients, frequent supraventricular premature beats were reported (2/22 pts, 9%). One patient with severe regurgitation was free of symptoms. Posterior-anterior chest roentgenogram revealed marked enlargement of heart size in 7 patients (7/22 pts, 32%). Most patients had 1/6 to 4/6 grade systolic murmur; in patients with only trivial regurgitation, the murmur was audible only during late systole with the presence of a mid-systolic click. Restrictive cardiomyopathy was present in 1 patient at the time of his first evaluation. Two patients had a patent foramen ovale, 1 patient had a secundum atrial septal defect. Concomitant coronary artery disease could be identified in 6 patients. An abnormal origin of the coronary arteries was reported in 1 patient: left anterior descending artery (LAD), left circumflex artery (LCX), and a septal branch rose separately from the right sinus of Valsalva. This patient suffered from ventricular fibrillation, and implantable cardioverter-defibrillator (ICD)-implantation was performed after successful reanimation. One patient had been successfully treated for AV node reentrant tachycardia (AVNRT) with radiofrequency ablation. Cardiac pacemakers had been implanted in 2 patients with sick sinus syndrome and atrial fibrillation with slow ventricular conduction, respectively.

Echocardiography

The predominant localization of the congenital cleft of the posterior mitral valve leaflet was the segment P2 (13/22 pts, 59%; Figure 1), followed by a cleft between P1/P2 (4/22 pts, 18%; Table 2). An isolated cleft in the segment P3 or in the segment P1 occurred twice each (2/22 pts, 9%) and between P2/P3 once (1/22 pts, 5%). Regurgitation was severe in 50% (11/22 pts), moderate in 9% (2/22 pts), mild in 27% (6/22 pts), and only trivial in 14% (3/22 pts) of the patients. A prolapsed posterior leaflet alone was present in 41% (9/22 pts), whereas the combination of prolapsed anterior and posterior leaflet was detected in 36% (8/22 pts) of the patients. Myxoid thickening of the valve was reported in 59% (13/22 pts) and ruptured chordae tendineae in 41% (9/22 pts) of the patients. Distinctly elongated chordae and an accessory papillary muscle were each noted once. Markedly elongated posterior leaflets were described in 18% (4/22) of patients. End-diastolic diameter index (EDDI) of the left ventricle at the time of diagnosis was 3.1 $\pm$ 0.4 cm/m^2. Left ventricular hypertrophy was present in 59% (13/22 pts) of the patients. Left atrial dilatation was noted in 59% (13/22 pts) of the cases. Systolic pressure difference between the right atrium and the right ventricle could be measured in only 18 patients and was 36 $\pm$ 14.4 mm Hg, whereas 10/18 patients (55%) had elevated systolic pulmonary artery pressure. Left ventricular ejection fraction (LVEF) was 61 $\pm$ 8.2%; only 1 (4.6%) patient, suffering from previous myocardial infarction, had an ejection fraction (EF) <50%.

Surgical Treatment

Mitral valve surgery was performed in 50% of patients (11/22 pts) with moderate (1/22 pts) or severe (10/22 pts) MR during the observational period (treatment details are

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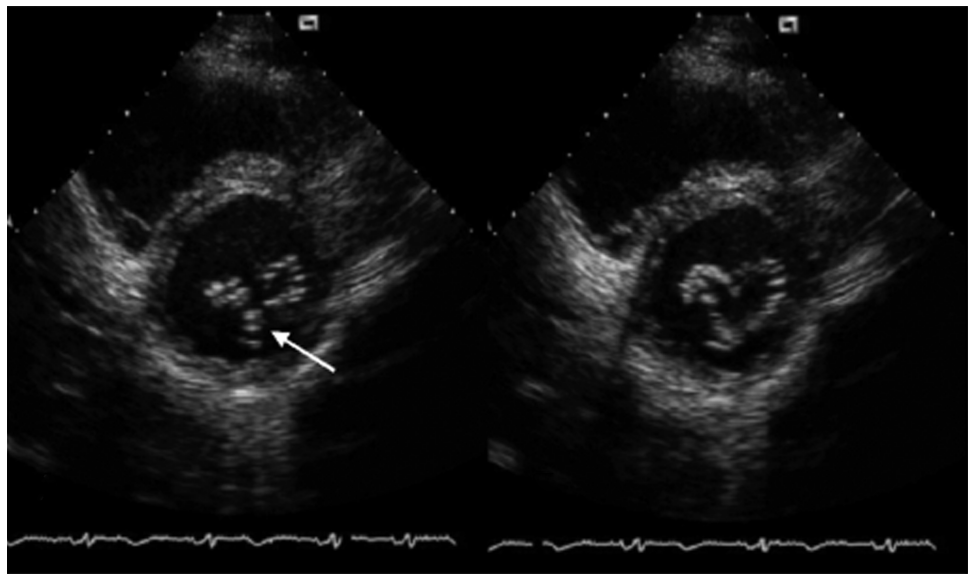
Table 1. Clinical Data.

Patient No.	Gender	Age	Grade of Mitral Regurgitation	NYHA Class	Other Symptoms/ Clinical Findings	Concomitant Disease	Concomitant Cardiac Disease	ECG	X-ray
1	F	47	Severe	II-III	Palpitations			SR	
2	M	70	Severe	II-III			CAD	SR	
3	M	52	Moderate	III-IV	Congestive heart failure (CHF)	Hypertension		AF	+
4	M	23	Trivial	I	Asymptomatic	Migraine accompagnée		SR	
5	M	66	Severe	II	CHF	Gout with nephropathy and NTX	CAD	SR	+
6	M	45	Severe		Left-sided thoracic pain		CAD	SR	
7	M	60	Mild					SR/Supraventricular Premature Beats (PB)	
8	M	59	Moderate	I	Palpitations	Myelodysplastic syndrome, hypertension, bipolar disorder		SR	
9	M	51	Severe	I			AVNRT	SR	
10	M	51	Mild	I	Palpitations, recurrent syncope, reanimation	Major depression, migraine accompagnée, exploding head syndrome	Coronary anomaly, CAD	SR	
11	F	70	Severe	II		Hypertension, focal epilepsy, restless legs syndrome, hyperlipidemia, diverticulitis		SR	+
12	M	53	Mild	I	Palpitations	Diabetes mellitus, hypothyroidism, reflux esophagitis	RCMP	SR/AF	+
13	M	26	Trivial	I				SR	
14	M	82	Severe	II		Inguinal hernia, hypertension		AF	+
15	M	46	Severe					SR	
16	M	46	Mild	I	Left sided thoracic pain		CAD	SR	
17	F	19	Mild	I				SR	
18	F	58	Mild	I	Palpitations	Colon polyposis, iliacal thrombosis	ASD II, bigeminus	SR/PB	
19	F	78	Severe	III		Renal insufficiency, hyperthyroidism,	Sick sinus syndrome, hypertension	AF	+
20	F	32	Trivial	I			PFO	SR	
21	M	68	Severe	II	Endocarditis		CAD	SR	+
22	M	67	Severe			Hypertension, chronic obstructive pulmonary disease, renal insufficiency	PFO	SR	

Abbreviations: AF = atrial fibrillation; ASD II = atrial septal defect of the secundum type; AVNRT = AV node reentrant tachycardia; CAD = coronary artery disease; Concomitant disease = concomitant disease other then cardiac; NTX = renal transplantation; NYHA class = dyspnea according to New York Heart Association functional class; PFO = patent foramen ovale; RCMP = restrictive cardiomyopathy; SR = sinus rhythm; x-ray = + means enlargement of heart size in posterior to anterior chest x-ray.



(A) (B)

Figure 1. Parasternal short axis view of the mitral valve with a cleft in the segment P2 of the posterior mitral leaflet (arrow). (A) shows the valve in closed position (early systolic still-frame); the cleft looks like a "T." In (B), the valve is open (early diastolic still-frame).

shown in Table 3). Mean age at cardiac surgery was 60 years (range, 47–78 y). Quadrangular resection of the posterior leaflet and ring annuloplasty was performed successfully in 5 patients and triangular resection of the posterior leaflet was performed in 1 patient. A representative example for the most often performed resection in segment P2 is shown in Figure 2. Two patients underwent direct closure of the cleft and ring annuloplasty. Mitral valve replacement was required in 1 patient, because intraoperative echocardiography after attempted reconstruction revealed severe regurgitation. The Cox-Maze procedure was performed in the presence of atrial fibrillation in 1 patient. Postoperative echocardiographic examination revealed minimal to mild residual regurgitation in all patients. One patient showed a dynamic obstruction in the left ventricular outflow tract with a maximal systolic pressure gradient of 50 mm Hg at a heart rate of 96 beats per minute.

Follow-up

Mean follow-up duration was 32.4 months. During follow-up, patients who were operated on remained clinically stable; no patient underwent reoperation for mitral regurgitation. Patients were initially treated medically; those with minimal to mild MR did not need surgery during follow-up.

Discussion

This study, for the first time, describes clinical characteristics, echocardiographic findings, and treatment in a series of adults with isolated cleft in posterior mitral valve leaflet and consecutive mitral regurgitation. The mitral leaflets are complex anatomical structures with a wide spectrum of interindividual variability. To provide adaptation during valve closure, a well-choreographed interaction between annulus, chordae, leaflets, and papillary muscles is essential. The relatively straight segment of the mitral annulus between the 2 fibrous trigones does not alter in length during systole and the anterior leaflet hanging down from this segment has therefore no need to become folded. In contrast, the C-shaped annulus of the posterior leaflet changes in contour and size during atrial and ventricular systole. Hence, pleating of the posterior leaflet provides precision for the closing mechanism.[11] Pleating is provided by slits or indentations at the free edge of the posterior leaflet. These slits or indentations are present in almost every posterior leaflet, but vary in size and number and are unique in each heart.[12] In mitral regurgitation, determination of the cause is needed, because the morphologic features of the mitral valve can have impact on medical therapy or the applied surgical technique, if indicated. Although a rare condition, a cleft in the posterior leaflet of the mitral valve is a cause of "unexplained" mitral regurgitation.

The patients in our series demonstrate a broad spectrum of this specific congenital anomaly, reaching from echocardiographic incidental diagnosis in asymptomatic patients to severe symptomatic MR with need for surgical treatment. Blunt chest trauma is described as a cause of cleft in the mitral valve,[13] but it was not observed in our patients. We therefore suggest a congenital origin, as most of our patients

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Table 2. Echocardiographic Features

Patient No.	Mitral Regurgitation	Clefted Segment	False Commissure	Prolapse		Thick.	Ruptured Chordae	Commentary	EDDI	dLA	dpRV/RA	LVH	EF
				Post.	Ant.								
1	Severe	P2		+	+	+		Elongated chordae	3.1	+	25	+	61
2	Severe	P2		+			+		2.8	+	62		55
3	Moderate	P1/P2							3.4	+		+	55
4	Trivial	P3							2.5		15		63
5	Severe	P1	+	+		+	+	EPL	3.6	+	51	+	70
6	Severe	P1/P2					+	Accessory papillary muscle	3.2			+	55
7	Mild	P2		+	+	+			2.8	+	20		51
8	Moderate	P3		+	+	+			2.8		30		55
9	Severe	P2		+	+	+		EPL	3.0	+	31	+	77
10	Mild	P2		+	+	+			2.9		28		62
11	Severe	P1/P2					+		3.7	+	51	+	72
12	Mild	P2		+					2.8	+	36	+	56
13	Trivial	P2		+					2.6		22		61
14	Severe	P2		+	+	+	+		3.4	+	56	+	56
15	Severe	P2		+		+	+	EPL	3.7	+	42	+	67
16	Mild	P2							2.6				69
17	Mild	P2		+	+	+			3.2				56
18	Mild	P2/P3		+		+		EPL, previous myocardial infarction	3.3	+	28	+	40
19	Severe	P1	+	+		+	+		4.1	+	44	+	63
20	Trivial	P2		+	+	+			3.1		16		65
21	Severe	P2		+			+		2.7		34	+	65
22	Severe	P1/P2		+		+	+		3.3	+	58	+	72

Abbreviations: dLA = dilated left atrium; dpRV/RA = systolic pressure difference between the right atrium and the right ventricle (mm Hg); EDDI = end-diastolic diameter index (cm/m²); EF = ejection fraction (%); EPL = elongated posterior leaflet; LVH = eccentric left ventricular hypertrophy; Prolapse ant. = prolapsing anterior leaflet; Prolapse post. = prolapsing posterior leaflet; Thick. = myxoid thickening of the mitral valve.

did not have any previous diseases with the potential to alter structural appearance of the mitral valve (eg, endocarditis, trauma, mitral balloon valvuloplasty, heart surgery).

There are a large number of concomitant findings, for example, prolapse, ruptured chordate, and elongated leaflet and chordae in our series, all of which have implications on the surgical strategy. Hence, an isolated cleft can be sutured without additional resection of the leaflet. Therefore, direct suture of the isolated posterior clefts should be preferred over valve reconstruction.[14] If direct suture is not feasible, mitral valve repair is preferable to mitral valve replacement in adults.[15] In the absence of valvular tissue or the need for resection due to thickened cleft edges, extension of the leaflet with glutaraldehyde-treated autologous pericardium is possible. Although no differences between certain localizations of the posterior

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Table 3. Treatment

Patient No.	Medical	Surgical
1	bisoprolol	Mitral valve reconstruction with closure of the cleft and ring annulopasty 30 mm
2		Mitral valve reconstruction with quadrangular resection posterior and ring annuloplasty Baxter 28 mm, ACBP
3	phenprocoumon, lisinopril, hydrochlorothiazide, carvedilol	Mitral valve reconstruction triangular resection of the posterior mitral leaflet, implantation of 2 artificial chordae anterior leaflet, ring annuloplasty 34 mm, Cox-Maze
4	No	No
5	lisinopril, allopurinol, cyclosporine	Mitral valve replacement Carbo Medics 29 mm, ACBP
6		Mitral valve reconstruction with quadrangular resection and ring annuloplasty Carpentier Edwards 32 mm, ACBP
7	No	No
8	irbesartan, carvedilol, spironolactone, lithium, sertraline	No
9	sotalol	Mitral valve reconstruction with ring annuloplasty 32 mm Edwards Lifescience
10	aspirin, pravastatin, amidarone, paroxetine, mirtazapine	No
11	irbesartan, torasemide, clobazame, carbamazepine, phenobarbitale	Mitral valve reconstruction with quadrangular resection of posterior leaflet and ring annuloplasty with Edwards Lifescience 28 mm
12	torasemide, phenprocoumon, verapamil, amiodarone, spironolactone, paoxetine, levothyroxine	No
13	No	No
14	enalapril, torasemide, potassium, aspirin	No
15	irbesartan, hydrochlorothiazide, calcium	Mitral valve reconstruction with quadrangular resection P2 and ring annuloplasty with Edwards Lifescience 34 mm
16	aspirin, propranolol, simvastatin, nitroglycerin, pentaerythrityltetranitrat, diazepam	No
17	No	No
18	phenprocoumon, spironolactone, aspirin, metoprolol, lisinopril	No
19	phenprocoumon, lisinopril, furosemide, propylthiouracil	Mitral valve reconstruction with closure of the cleft P1/P2, implantation of 2 artificial chordae, ring annulopasty 32 mm
20	No	No
21	ramipril	Mitral valve reconstruction with resection in segment P2 ring annulopasty Physioring 32 mm and ACBP × 4
22	indapamide, perindopril, aspirin	Mitral valve reconstruction with quadrangular resection P2 and transfer of chordae to P2, ring annulopasty Edwards Lifescience 30 mm, direct closure of PFO

Abbreviations: ACBP = aorto coronary artery bypass operation; Cox-Maze = Maze procedure; PFO = patent foramen ovale.

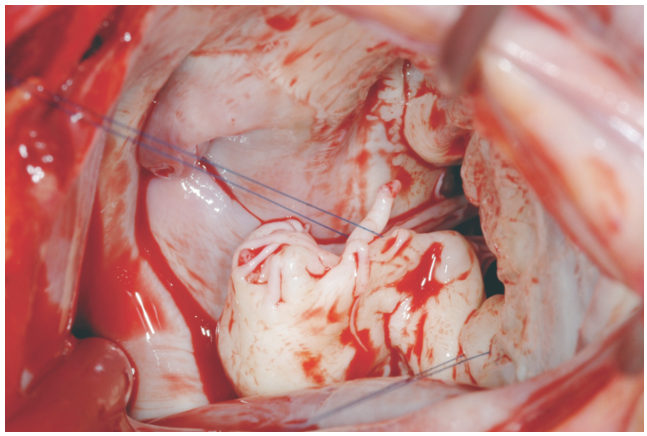

Figure 2. Intraoperative view from the left atrium onto the mitral valve. An isolated cleft in the segment P2 of the posterior mitral leaflet is shown.

cleft and severity of mitral regurgitation or clinical outcome was found, high-resolution echocardiography should be performed in order to plan the surgical procedure. In our surgically treated patients, the most applied technique was quadrangular resection with annuloplasty, reflecting the increased complexity of the lesion in adults with accompanying prolapse, ruptured chordae, dilated annulus, and thickened cleft edges. However, our patients had a favorable outcome after surgery, only 1 patient showed a dynamic obstruction in the left ventricular outflow tract with a maximal systolic pressure gradient of 50 mm Hg at a heart rate of 96 beats per minute, a well-known complication after mitral valve repair with ring annuloplasty.[16,17] During follow-up, this patient remained asymptomatic under a β-blockade.

Several approaches have been made to describe mitral valve morphology. Carpentier et al introduced the functional classification of mitral insufficiency.[18–20] Given the various anatomical findings in our cohort, a functional classification alone does not seem sufficient. Several attempts have been made to define the terms commissures, splits, and clefts. According to the literature, commissures are defined as tissue joining 2 leaflets,[21] junctional zones of valvular tissue,[11] points of attachment of the mitral annulus to the fibrous trigones,[22] indentations at either end of the aortic leaflet,[23] the space between identifiable components of the skirt of leaflet tissue.[24] Less is published about the definition of clefts. To distinguish congenital clefts from normal splits, pathological studies of the chordal attachment has been proposed.[12] We propose an echocardiographic definition by denominating a finding as a cleft if the valve leaflet is completely split up to the annulus and produces some degree of mitral regurgitation. The 2 constant wide indentations, which separate the anterior from the posterior leaflet, should be called commissures. A small indentation without extension to the annulus should be called a false commissure, if it contributes to some degree of regurgitation or split, if the valve closes properly.

Clinical presentation, electrocardiogram, chest x-ray, or angiography may identify patients with mitral regurgitation or its associated features; however, echocardiography remains the gold standard imaging method to identify the degree of regurgitation as well as the underlying mechanism causing the valvular incompetence. However, 3-dimensional echocardiography (3DE) was introduced recently into clinical practice and may provide complementary information and improve quantitative accuracy and reproducibility compared to 2D techniques.[25] Hence, we could not incorporate data from 3DE into the study because data was collected between 2001 and 2005 and 3DE had not yet been introduced into clinical practice in our department.

Conclusions

This is the first series of clinical characteristics, echocardiographic findings, and treatment in adults with isolated cleft in posterior mitral valve leaflet and consecutive mitral regurgitation. A 2D high-resolution cross-sectional echocardiography allows the distinct diagnosis of a clefted posterior leaflet, whereas clinical presentation, electrocardiogram, chest x-ray, and angiography are failing to identify the correct etiology of MR in patients with IPLCMV. Patients with moderate to severe mitral regurgitation were treated surgically with excellent outcome.

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Published online in Wiley InterScience. (www.interscience.wiley.com)
DOI:10.1002/clc.20608

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