Significance of commissural calcification on outcome of mitral balloon valvotomy

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Abstract

Objective—To evaluate the significance of commissural calcification, identified by transthoracic echocardiography, on the haemodynamic and symptomatic outcome of mitral balloon valvotomy.

Methods—Commissural calcification was graded from 0–4 using parasternal short axis transthoracic views. The morphology of the mitral valve was also assessed using the Massachusetts General Hospital echo score.

Setting—A tertiary cardiac centre in Scotland.

Patients—300 patients were studied, 85 retrospectively and 215 prospectively. Mean (SD) age was 59.8 (12.7) years, range 13 to 87; 30% had been judged unsuitable for surgery. Median echo score was 6.8 (3.0), range 2–16.

Main outcome measures—Immediate increase in mitral valve area and in New York Heart Association functional class 1–3 months after balloon valvotomy.

Results—On univariate and multivariate analysis, commissural calcification grade was a significant predictor of achieving a mitral valve area of $> 1.50 \text{ cm}^2$ without severe mitral reflux. Its influence was greatest in patients with an echo score ≤ 8 : those with commissural calcification grade 0/1 had significantly greater improvement in valve area and symptom status than those with grade 2/3; the proportions of patients achieving a final valve area of $> 1.50 \text{ cm}^2$ were 67% and 46%, respectively ($p < 0.05$). In patients with an echo score of > 8 , the influence of commissural calcification was smaller and not significant.

Conclusions—Commissural calcification as assessed by transthoracic echocardiography is a useful predictor of outcome in patients with otherwise “good” valves (echo score ≤ 8). Calcification of one commissure or more predicts a less than 50% probability of achieving a valve area above 1.50 cm^2 and is an indication for valve replacement in those who are suitable for surgery. (Heart 2000;84:398–402)

Keywords: mitral balloon valvotomy; commissure calcification

The introduction of percutaneous transseptal mitral balloon valvotomy by Inoue and colleagues in 1984¹ was an important new option for the treatment of patients with mitral stenosis. In patients judged to have a mitral valve anatomically suitable for a commissurotomy, randomised trials^{2–5} have shown that balloon dilatation gives haemodynamic, echocardiographic, and symptomatic results equivalent to open and closed surgical valvotomy. In addition, in older patients with pronounced mitral valve degenerative change who are very high risk candidates for surgery, percutaneous balloon valvotomy can be undertaken safely and may provide palliative symptomatic improvement.^{6–7}

When closed surgical valvotomy began in the 1950s, only physical signs and fluoroscopy were available to predict valve anatomy.⁸ The early surgical experience^{9–11} and necropsy data¹² showed leaflet rigidity, subvalvar change, and commissural fusion to be the three components that could contribute to obstruction in rheumatic mitral stenosis. The surgeons recognised that some commissures were sclerosed by fibrosis or calcification and resisted separation. The introduction of balloon valvotomy came at a time when echocardiography was available to examine mitral valve anatomy in more detail. To help predict the result of mitral balloon valvotomy, a transthoracic echo score was devised at the Massachusetts General Hospital^{13–14} to make a semiquantitative assessment of some of

the degenerative changes found with stenosed mitral valves. This echo score assesses four valve characteristics: leaflet thickening, subvalvar change, leaflet mobility, and valve calcification. It does not, however, include assessment of commissural morphology. We have examined the effect of commissural calcification on the haemodynamic outcome after percutaneous mitral balloon valvotomy in a group of patients, many of whom were elderly, as is now typical in western countries.

Methods

PATIENTS

In 311 consecutive patients in whom mitral balloon valvotomy was attempted between 1986 and 1996, dilatation of the mitral valve was achieved in 300 (97%). Of these 300 patients, 235 (78%) were women and 65 (22%) were men. Mean (SD) age was 59.8 (12.7) years, range 13–87. A previous surgical valvotomy had been carried out in 23%. Twenty four per cent were in New York Heart Association (NYHA) functional class II, 50% in class III, and 26% in class IV. Atrial fibrillation was present in 215 (72%), while 82 (27%) were in sinus rhythm, and three (1%) in atrial flutter or nodal rhythm. The median echo score was 6.8 (3.0), range 2–16.

Patients were selected for percutaneous mitral balloon valvotomy if their mitral valves appeared anatomically suitable for improvement by a commissurotomy or if, regardless of

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Accepted 23 March 2000

Figure 1 Grading system for commissural calcification.

valve morphology, they had unacceptably severe symptoms on medical treatment but were high risk candidates for cardiac surgery. Of the 300 patients, 89 (30%) had been judged unsuitable for surgical treatment. There was thus a wide spectrum of degenerative mitral valve change. Patients had been referred for mitral balloon valvotomy from hospitals throughout Scotland, and 97% were born in the UK.

ECHOCARDIOGRAPHIC ASSESSMENT

Before balloon valvotomy, all patients underwent full transthoracic cross sectional echocardiography using an ATL Ultramark 9 (Bothell, Washington, USA), Hewlett-Packard Sonos 2000 (Andover, Massachusetts, USA), or Acuson 128 XP/10 ultrasound scanner (Mountain View, California, USA). The final 196 patients also had a transoesophageal study immediately before the procedure to identify left atrial thrombus.

The mitral valve was scored on the transthoracic images as described by Wilkins and colleagues and Abascal and associates.^{13 14} This involves semiquantitative assessment of leaflet mobility and thickening, subvalvar change, and valve calcification; each abnormality has a possible score of 0 or 1 to 4, corresponding to zero/mild to severe abnormality and giving a possible total echo score of between 2–16.

For assessment of the commissures the mitral valve was examined in the short axis parasternal view. The echo beam was scanned

Figure 2 Illustrative examples of commissural calcification. Upper panel: thickening and brightness at leaflet tips but no bright echos extending across either commissure; grade 0000 = 0. Middle panel: bright echos extend across half of posteromedial commissure; grade 1000 = 1. Lower panel: postdilatation the anteromedial commissure has opened well but the posteromedial commissure had bright echos throughout its length and had resisted splitting; grade 1100 = 2.

repeatedly through the mitral apparatus to assess commissure anatomy and to determine if any bright echos were present across either commissure. High intensity bright echos extending across the commissure were taken to be areas of commissural calcification. Although by strict terminology the mitral valve has only one commissure between its two leaflets,¹² we have followed the common convention of considering that the mitral valve has two commissures: posteromedial and anterolateral. The extent of commissural calcification was quantified by giving each half commissure with such echos a score of 1. Commissural calcification could therefore range from grade 0 to grade 4 (figs 1 and 2). A grade of 2 could correspond to calcification of

Table 1 Relation between the mitral valve area before and after balloon dilatation and the echo score

	Echo score				p Value
	1-4	5-8	9-12	13-16	
Number of patients	79	149	57	15	
Valve area before dilatation (cm ²)	1.10 (0.31)	0.89 (0.25)	0.79 (0.28)	0.63 (0.25)	< 0.0001
Valve area after dilatation (cm ²)	2.12 (0.92)	1.67 (0.55)	1.49 (0.57)	1.19 (0.53)	< 0.0001
Increase in valve area (cm ²)	1.01 (0.77)	0.77 (0.51)	0.70 (0.50)	0.56 (0.47)	< 0.001

Values are mean (SD).

Table 2 Relation between the mitral valve area before and after balloon dilatation and the commissure calcification grade

	Commissure calcification grade				p Value
	0	1	2	3	
Number of patients	214	37	45	4	
Valve area before dilatation (cm ²)	0.97 (0.30)	0.83 (0.25)	0.74 (0.23)	0.72 (0.09)	< 0.0001
Valve area after dilatation (cm ²)	1.84 (0.74)	1.66 (0.78)	1.40 (0.49)	1.21 (0.42)	< 0.001
Increase in valve area (cm ²)	0.87 (0.62)	0.83 (0.67)	0.66 (0.46)	0.49 (0.41)	NS

Values are mean (SD). No patient had a commissure grade of 4.

Figure 3 Correlation between increase in mitral valve area after balloon dilatation and echo score.

one commissure or to calcification of half of both commissures; in 96% of such cases the calcification was localised to one commissure.

During the 10 year period, echocardiographic assessment was by consensus of two observers who each performed a transthoracic echocardiogram before the procedure in the final 215 patients and retrospectively from blinded video recordings in the first 85.

TECHNIQUE OF BALLOON VALVOTOMY

The first 70 patients were treated by single or double cylindrical balloons based on the methods described by Lock and colleagues and Al Zaibag and colleagues,¹⁵⁻¹⁷ and in the subsequent 230 cases the Inoue balloon was used.¹⁸ We found that each technique gave the same increase in valve area.¹⁹

Measurement of mitral gradient was by planimetry. Cardiac output was calculated by the Fick principle using assumed oxygen uptake.²⁰ Valve area before and after dilatation was calculated by the Gorlin equation.²¹ Calculation of valve area after dilatation used oxygen saturations from the venae cavae to avoid any influence of left to right shunting at the atrial puncture site. Mitral reflux was assessed at left ventricular angiography and graded as absent, mild, moderate, or severe.

Inoue balloon size was chosen on the basis of the patient's height.²² The mean effective balloon dilatation area/m² body surface area²³ was 3.41 (0.52).

We used the increase in Gorlin mitral valve area as the measure of haemodynamic improvement because echocardiographic assessment of mitral orifice by planimetry is inaccurate when there is pronounced degenerative change—as was common in our more elderly patients—and Doppler pressure half time is also inaccurate immediately after balloon valvotomy.²⁴ A successful immediate haemodynamic outcome was defined as a final mitral valve area greater than 1.50 cm² without severe mitral reflux. As patients were referred from a wide geographical area, longer term follow up echocardiograms could not be obtained in all patients; follow up symptom status was obtained by clinic visit or telephone contact.

STATISTICS

Results are expressed as mean (SD). Statistical analysis between groups was by unpaired Student's *t* test, the χ^2 test, and analysis of variance. To identify predictors of a successful haemodynamic outcome, discrete data were compared by χ^2 test and continuous data by Student's two tailed *t* test. A stepwise logistic regression model was used to identify independent predictors of this outcome. A value of *p* < 0.05 was considered significant.

Results

HAEMODYNAMIC CHANGE

Before balloon dilatation in these 300 patients, the mean (SD) gradient across the mitral valve was 12.8 (5.2) mm Hg, mean cardiac output was 3.65 (1.01) l/min, and mean valve area was 0.91 (0.30) cm². After final balloon dilatation, the gradient was 5.8 (2.9) mm Hg, cardiac output 4.4 (1.60) l/min, and valve area was 1.74 (0.73) cm² (all *p* < 0.001). The mean increase in valve area after balloon dilatation was 0.83 (0.60) cm². A final valve area above 1.50 cm² without severe mitral reflux was obtained in 173 patients (58%).

ECHO SCORE, COMMISSURAL CALCIFICATION, AND VALVE AREA

The echo score was significantly related to severity of mitral stenosis before dilatation (table 1) but also to the increase in valve area produced by balloon dilatation. The commissure calcification grade was also significantly related to valve area before and after dilatation, but the increase in valve area did not reach significance (table 2).

The different types of degenerative mitral valve change tended to develop together. Increasing echo score, reflecting leaflet and subvalvar changes, was significantly associated with increasing commissural calcification (table 3).

In patients with an echo score of ≤ 8 , a smaller increase in valve area was achieved in those with commissure calcification grade 2/3 than in those with grade 0/1 (table 4). No significant difference was found in patients with an echo score of > 8.

Table 3 Commissural calcification grade in each of four ranges of echo score*

Echo score	Commissure calcification grade	Number of patients
1-4	0.13 (0.37)	79
5-8	0.50 (0.84)	149
9-12	0.61 (0.82)	57
13-16	1.33 (1.05)	15

Values are mean (SD).

* $p < 0.001$.

The proportions of patients who had a final valve area $> 1.50 \text{ cm}^2$ are included in table 4. In patients with an echo score of ≤ 8 , 67% of those with commissure calcification grade 0/1 achieved this valve area, compared with only 46% of those with commissure calcification grade 2/3 ($p < 0.05$).

Echo score had a significant but weak correlation with increase in valve area (fig 3).

PREDICTORS OF OUTCOME

By univariate analysis, the following patient characteristics were predictive of a final valve area $> 1.50 \text{ cm}^2$ without severe mitral reflux: younger age, lower commissural calcification grade, lower echo score, less fluoroscopic calcification, lower Parsonnet score (all $p < 0.001$), sinus rhythm, male sex, and absence of mitral reflux (all $p < 0.01$). Previous valvotomy, effective balloon dilation area/ m^2 body surface area, type of balloon, left ventricular impairment, and coronary disease were not significantly related to this outcome.

On multivariate analysis, less fluoroscopic calcification, male sex, sinus rhythm, and lower commissure calcification grade ($p < 0.01$) were independent predictors of this outcome.

MITRAL REFLUX AFTER FINAL DILATATION

An increase in mitral reflux by two or more grades occurred in 4.1% of patients with commissure calcification grade 2/3 and in 2.8% of those with grade 0/1 (NS).

Table 4 Effect of commissural calcification on increase in mitral valve area in patients with echo score of ≤ 8 and > 8

Commissure calcification grade	Increase in valve area (cm^2)	Final valve area $> 1.50 \text{ cm}^2$	Number of patients
<i>Patients with echo scores ≤ 8</i>			
0/1	0.90 (0.64)	67%	200
2/3	0.67 (0.47)	46%	28
	($p < 0.01$)	($p < 0.05$)	
<i>Patients with echo scores > 8</i>			
0/1	0.69 (0.51)	43%	51
2/3	0.62 (0.45)	19%	21
	(NS)	(NS)	

Values are mean (SD).

Table 5 Symptom class before mitral balloon valvotomy and alive at 1-3 months follow up in patients with echo score ≤ 8 and > 8

Commissure calcification grade	Number of patients	NYHA symptom class before balloon valvotomy	NYHA symptom class at 1-3 month follow up	Change in NYHA symptom class
<i>Patients with echo score ≤ 8</i>				
0/1	200	2.9 (0.7)	1.6 (0.8)	1.2 (0.7)
2/3	27	3.1 (0.6)	2.2 (0.8)	0.9 (0.8)
		(NS)	($p < 0.01$)	($p < 0.05$)
<i>Patients with echo score > 8</i>				
0/1	48	3.4 (0.7)	2.2 (1.0)	1.2 (0.8)
2/3	19	3.4 (0.7)	2.2 (0.7)	1.2 (0.8)
		(NS)	(NS)	(NS)

Values are mean (SD).

ECHO SCORE, COMMISSURAL CALCIFICATION, AND SYMPTOMATIC IMPROVEMENT

Table 5 shows the NYHA symptom class scores before mitral balloon valvotomy and at follow up 1-3 months later. In patients with an echo score of ≤ 8 , those with commissure calcification grade 0/1 had a significantly greater improvement in symptoms than those with grade 2/3. No difference was seen in those with an echo score of > 8 .

Discussion

Percutaneous mitral balloon valvotomy has two roles: as an alternative to open or closed surgical valvotomy in patients with a mitral valve judged suitable for commissurotomy, and as a palliative procedure in patients requiring valve replacement but considered to be very high risk surgical candidates. Our series contained many elderly patients and 30% had been judged unsuitable for surgery, so there was a wide spectrum of degenerative mitral valve change. We confirmed the relation between the Massachusetts General Hospital echo score and haemodynamic and symptomatic status before and after mitral balloon valvotomy, but the echo score was a weak predictor of increase in valve area in individual cases. In those patients with an echo score of 8 or less, who are generally held to be suitable for balloon valvotomy, we found that commissural calcification had a significant influence on both the increase in mitral valve area and the degree of symptomatic improvement. Assuming that valve replacement is necessary if there is less than a 50% probability of achieving a valve area of more than 1.50 cm^2 by balloon dilatation, then commissural calcification occupying the equivalent of one of the two mitral commissures would be an indication for valve replacement rather than for balloon valvotomy. In patients with a low echo score (≤ 8) and little or no commissural calcification, percutaneous balloon dilatation would be the preferred option when cardiac catheterisation facilities and transeptal puncture skills are available, in view of reduced patient discomfort, short convalescence, and equivalent outcome.²⁻⁵

Fatkin and colleagues also found that commissural echo calcification predicted commissural splitting in their group of 30 patients.²⁵ Cannan and colleagues showed that commissural calcium was the only factor significantly affecting clinical outcome after mitral balloon valvotomy in 149 patients.²⁶ In these smaller studies, the extent of commissure calcification was not quantified. Hernandez and colleagues noted that commissural calcium, identified by echocardiography, had been present in patients who developed severe mitral reflux at Inoue mitral balloon valvotomy.²⁷ This could occur if resistance to commissural splitting led to leaflet tear. We found that a pronounced increase in mitral reflux was uncommon, although slightly more frequent in those with pronounced commissural calcification (4.1% *v* 2.8%). It has been suggested²⁷ that if balloon dilatation is undertaken in a patient with commissural calcification then

smaller initial balloon size and a cautious progressive increase in balloon diameter should be used.

In patients with an echo score of > 8 , we were not able to show a separate significant effect of commissural calcification on increase in valve area, although the same trend was present. Although such mitral valves are not ideal for a commissurotomy, percutaneous balloon dilatation may be justified if the patient is unsuitable for surgery because of comorbidity. Even limited haemodynamic improvement may give sufficient symptomatic relief to maintain independence.^{6,7}

Mitral valve calcification seen at fluoroscopy was also a predictor of outcome. However, fluoroscopy cannot accurately localise the calcific change, and calcification can affect outcome either through leaflet rigidity or commissural resistance. Echocardiography is preferred to localise any mitral calcification to the annulus, the body of the leaflets, or the commissures. This is helpful when there is slight calcification localised at the commissure or, with generalised calcification, when splitting of commissures may give a useful palliative result.

LIMITATIONS OF STUDY

We used transthoracic echocardiography of the mitral valve but in some elderly patients transthoracic imaging is difficult and localisation of calcification may have been imprecise. Very bright echoes may not always correspond to calcification but may reflect dense fibrosis. The consensus grading of commissural calcification involved a variety of observers over a 10 year period.

It would be desirable to improve the echocardiographic predictability of outcome of mitral balloon valvotomy. The echo score is semiquantitative and subjective. In a multicentre registry study, the echo score did not show a significant link with outcome,²⁸ but Post and colleagues found that on review of 87 patients initially judged to have an echo score of ≥ 10 , 18 were reclassified as having lower scores when judged by single centre observers.²⁹

CONCLUSIONS

When commissural calcification grade was assessed at transthoracic echocardiography, it was found that calcification equivalent to one commissure was associated with less than a 50% probability of achieving a good haemodynamic outcome. Transoesophageal examination of both commissural calcification and fusion may lead to further improved prediction of outcome by balloon commissurotomy,³⁰ particularly in patients who are difficult to scan transthoracically.

This study was supported by a grant from the Clinical Resource and Audit Group (CRAG) of the Scottish Office Department of Health. The views expressed are those of the authors and do not necessarily reflect those of either CRAG or the Scottish Office Department of Health.

- Inoue K, Owaki T, Nakamura T, *et al.* Clinical application of transvenous mitral commissurotomy by a new balloon catheter. *J Thorac Cardiovasc Surg* 1984;87:394-402.
- Turi ZG, Reyes VP, Raju S, *et al.* Percutaneous balloon versus surgical closed valvotomy for mitral stenosis. A prospective, randomised trial. *Circulation* 1991;83:1179-85.
- Patel JJ, Sharma D, Mithra AS, *et al.* Balloon valvuloplasty versus closed commissurotomy for pliable mitral stenosis: a prospective haemodynamic study. *J Am Coll Cardiol* 1991;18:1318-22.
- Reyes VP, Raju BS, Wynne J, *et al.* Percutaneous balloon valvuloplasty compared with open surgical commissurotomy for mitral stenosis. *N Engl J Med* 1994;331:961-7.
- Farhat MB, Ayari M, Maatouk F, *et al.* Percutaneous balloon versus surgical closed and open mitral commissurotomy. Seven year follow-up results of a randomised trial. *Circulation* 1998;97:245-50.
- Bernard Y, Bassand JP, Schiele F, *et al.* Percutaneous mitral valvulotomy in non-optimal candidates. *Eur Heart J* 1992;12(suppl B):90-4.
- Sutaria N, Elder AT, Shaw TRD. Long term outcome of percutaneous mitral balloon valvotomy in patients aged 70 and over. *Heart* 2000;83:433-8.
- Wood P. An appreciation of mitral stenosis. *BMJ* 1954;i:1051-63; 1113-24.
- Ellis LB, Singh JB, Morales DD, *et al.* Fifteen to twenty year study of one thousand patients undergoing closed mitral valvuloplasty. *Circulation* 1973;53:357-64.
- Logan A, Lowther CP, Turner RWD. Reoperation for mitral stenosis. *Lancet* 1962;i:443-9.
- Kirklin JW, Barratt-Boyes BG, eds. Mitral valve disease with and without tricuspid valve disease. In: *Cardiac surgery*. New York: Churchill Livingstone, 1993.
- Anderson RH, Becker AE. Anatomy and pathology of valvular stenosis. In: Cheng TO, ed. *Percutaneous balloon valvuloplasty*. New York: Igaku-Shoin, 1992:12-39.
- Wilkins GT, Weyman AE, Abascal VM, *et al.* Percutaneous balloon dilatation of the mitral valve: an analysis of echocardiographic variables related to outcome and the mechanism of dilatation. *Br Heart J* 1988;60:299-308.
- Abascal VM, Wilkins GT, O'Shea JP, *et al.* Prediction of successful outcome in 130 patients undergoing percutaneous balloon mitral valvotomy. *Circulation* 1990;82:448-56.
- Lock JE, Kalilullah M, Shrivastava S, *et al.* Percutaneous catheter commissurotomy in rheumatic mitral stenosis. *N Engl J Med* 1985;313:1515-18.
- Al Zaibag M, Ribeiro PA, Al Kasch SA, *et al.* Percutaneous double-balloon mitral valvotomy for rheumatic mitral valve stenosis. *Lancet* 1986;i:757-61.
- Block PC, Tuzcu EM, Palacios IF. Percutaneous mitral balloon valvotomy. *Cardiol Clin* 1991;9:271-87.
- Inoue K. Percutaneous transvenous mitral commissurotomy using the Inoue balloon. *Eur Heart J* 1991;12(suppl B):99-108.
- Shaw TRD, Turnbull CM, Currie P, *et al.* A comparison of cylindrical and Inoue balloon techniques for mitral valvotomy in patients in the United Kingdom. *Br Heart J* 1994;72:486-91.
- Hall RJC, Julian DG. *Diseases of the cardiac valves*. Edinburgh: Churchill Livingstone, 1989.
- Cohen MV, Gorlin R. Modified orifice equation for the calculation of mitral valve area. *Am Heart J* 1972;84:839.
- Inoue K, Hung J-S, Chen C-R, *et al.* Mitral stenosis: Inoue balloon catheter technique. In: Chang TO, ed. *Percutaneous balloon valvuloplasty*. New York: Igaku-Shoin, 1992:237-79.
- Roth RB, Block PC, Palacios IF. Predictors of increased mitral regurgitation after percutaneous mitral balloon valvotomy. *Cathet Cardiovasc Diagn* 1990;20:17-21.
- Thomas JD, Wilkins GT, Choong CYP, *et al.* Inaccuracy of percutaneous mitral valvotomy: dependence on transmitral gradient and left atrial and ventricular compliance. *Circulation* 1988;78:980-93.
- Fatkin D, Roy P, Morgan JJ, *et al.* Percutaneous balloon mitral valvotomy with the Inoue single-balloon catheter: commissural morphology as a determinant of outcome. *J Am Coll Cardiol* 1993;21:390-7.
- Cannan CR, Nishimura RA, Reeder GS, *et al.* Echocardiographic assessment of commissural calcium: a simple predictor of outcome after percutaneous mitral balloon valvotomy. *J Am Coll Cardiol* 1997;29:175-80.
- Hernandez R, Macaya C, Banuelos C, *et al.* Predictors, mechanisms and outcome of severe mitral regurgitation complicating percutaneous mitral valvotomy with the Inoue balloon. *Am J Cardiol* 1992;70:1169-74.
- Herrmann HC, Ramaswamy K, Isner JM, *et al.* Factors influencing immediate results, complications and short-term follow-up status after Inoue balloon valvotomy: a North American multicenter study. *Am Heart J* 1992;124:160-6.
- Post JR, Feldman T, Isner J, *et al.* Inoue balloon mitral valvotomy in patients with severe valvular and subvalvular deformity. *J Am Coll Cardiol* 1995;25:1129-36.
- Sutaria N, Shaw TRD, Prendergast B, *et al.* Effect of commissural fusion on outcome of balloon mitral valvotomy: a transoesophageal study. *Heart* 1998;76(suppl 1):337.