CLINICAL OUTCOME OF MITRAL REGURGITATION DUE TO FLAIL LEAFLET

LIENG H. LING, M.B., B.S., MAURICE ENRIQUEZ-SARANO, M.D., JAMES B. SEWARD, M.D., A. JAMIL TAJIK, M.D., HARTZELL V. SCHAFF, M.D., KENT R. BAILEY, PH.D., AND ROBERT L. FRYE, M.D.

ABSTRACT

Background Mitral regurgitation due to flail leaflet is difficult to manage, because it is frequently asymptomatic yet carries a high risk of left ventricular dysfunction and because the natural history of the condition is poorly defined.

Methods We obtained clinical follow-up data through 1994–1995 in 229 patients with isolated mitral regurgitation due to flail leaflet; this condition was first diagnosed by echocardiography between 1980 and 1989.

Results The 86 patients who were treated medically had a mortality rate significantly higher than expected (6.3 percent yearly, $P=0.016$ for the comparison with the expected rate in the U.S. population according to the 1990 census). Independent determinants of mortality were an older age, the presence of symptoms, and a lower ejection fraction. Patients who were even transiently in New York Heart Association functional class III or IV had a high mortality rate (34 percent yearly), but the rate was also notable (4.1 percent yearly) among those in class I or II. At 10 years, the mean ($\pm$SE) rates of heart failure, atrial fibrillation, and death or surgery were 63 ± 8, 30 ± 12, and 90 ± 3 percent, respectively. In a multivariate analysis, surgical correction of mitral regurgitation (performed in 143 patients) was associated with a reduced mortality rate (hazard ratio, 0.29; 95 percent confidence interval, 0.15 to 0.56; $P<0.001$).

Conclusions When treated medically, mitral regurgitation due to flail leaflet is associated with excess mortality and high morbidity. Surgery is almost unavoidable within 10 years after the diagnosis and appears to be associated with an improved prognosis; this finding suggests that surgery should be considered early in the course of the disease. (N Engl J Med 1996;335:1417-23.)

MITRAL regurgitation is a common heart-valve disorder that is often difficult to manage. Symptoms may be absent for years,[1] despite severe regurgitation. Surgical correction of mitral regurgitation can relieve symptoms,[2] but when it is performed in symptomatic patients, it frequently leaves residual postoperative left ventricular dysfunction, which carries a poor prognosis.[3,4] This serious complication, in conjunction with the feasibility of valve repair,[5] has led to the suggestion that surgical correction be performed early in the course of mitral regurgitation.[3-6] The value of this approach is unclear, however, because of the lack of data on the course of medically treated mitral regurgitation.

Previous studies of the natural history of mitral regurgitation[7-16] have provided little information on morbidity and reported widely variable mortality rates. Reported survival rates at five years have ranged between 27 and 97 percent.[9,10] Such conflicting data may be the result of poorly defined degrees of regurgitation,[9,11,16] various selection biases,[14-16] small study populations,[7,11-14] and the presence of coexisting conditions that may be associated with mitral regurgitation.[17] The discrepancies are difficult to reconcile, and they impede clinical decision making.

In patients with mitral regurgitation due to flail leaflet, the lesion results in uniformly high degrees of regurgitation[18] and is reliably diagnosed noninvasively by echocardiography.[19,20] In Western countries, flail mitral leaflet is the most frequent cause of mitral regurgitation requiring surgical correction.[21,22] Nevertheless, little is known about long-term clinical outcome, and the prognosis in patients treated medically has been characterized variously as poor[23] and good.[24]

We conducted a follow-up study of patients with mitral regurgitation due to flail leaflet, confirmed by echocardiography. The purpose of the study was to determine the long-term survival, the incidence of cardiac complications, factors that predict the outcome, and the effect of surgical treatment on the prognosis.

METHODS

Patients were included in the study if they had flail mitral leaflet that had first been diagnosed with the use of two-dimensional echocardiography between January 1, 1980, and December 31, 1989, at the Mayo Clinic. Exclusion criteria were papillary-muscle rupture, previous valve surgery, and associated aortic-valve or congenital heart disease. Patients who had coronary artery disease or had undergone bypass grafting were not excluded. Base-line symptoms were defined as those occurring within one month before the diagnosis.

The 229 patients enrolled in the study were not followed only at our institution, and information on postdiagnostic events was obtained for all but 1 of the patients between March 1994 and February 1995. Cardiac events and causes of death were ascertained by contacting the patients' physicians and reviewing death certificates, coroners' reports, or autopsy records. The occurrence of arrhythmias had to be confirmed by electrocardiography. Associated medical conditions were assigned weights, and the results were summed as a modified comorbidity index.[17]

From the Division of Cardiovascular Diseases and Internal Medicine (L.H.L., M.E.-S., J.B.S., A.J.T., R.L.F.), the Section of Cardiovascular Surgery (H.V.S.), and the Section of Biostatistics (K.R.B.), Mayo Clinic and Mayo Foundation, Rochester, Minn. Address reprint requests to Dr. Enriquez-Sarano at the Mayo Clinic, 200 First St. SW, Rochester, MN 55905.

Echocardiographic Methods

Two-dimensional echocardiography was performed as described previously,[25] and the diagnosis of flail leaflet was based on the failure of leaflet coaptation, with rapid systolic movement of the involved leaflet tip in the left atrium.[19,20] The degree of mitral regurgitation was assessed semiquantitatively on a scale of 1+ to 4+.[26,27] Cardiac diameters were indexed to the body-surface area. End-systolic wall stress was calculated[28] with the use of noninvasive methods for estimating end-systolic pressure.[29] The left ventricular ejection fraction was measured as described previously.[30,31]

Statistical Analysis

Continuous variables are expressed as means ±SD. The rates of mortality and other end points were estimated with the use of the Kaplan–Meier method and linearized yearly rates. To determine the outcome with medical treatment, data for patients who underwent surgical treatment were censored at the time of the surgery. To determine the effect of surgery on the outcome, data during the entire follow-up period, including the immediate postsurgical phase, were used. Survival was compared with the expected survival of age- and sex-matched white members of the U.S. population in 1990; differences in survival were determined with the one-sample log-rank test. Base-line predictors of outcome were identified with a proportional-hazards analysis. To determine the effect on survival of events occurring after the diagnosis (surgery, congestive heart failure, and atrial fibrillation), a time-dependent proportional-hazards analysis was performed within a multivariate model that included the base-line predictors of survival with and without the comorbidity index.

The effect of potential referral biases was tested by including the geographic origin of the patient and comorbidity in the multivariate analysis of survival and by repeating the analysis with data from patients not referred for surgery within the first three months and not initially in New York Heart Association (NYHA) functional class I or II. A P value of less than 0.05 was considered to indicate statistical significance.

RESULTS

Base-Line Characteristics

The clinical characteristics of the 229 patients who met the inclusion criteria are shown in Table 1. A total of 188 patients (82 percent) had a history of an apical cardiac murmur or cardiac symptoms for more than three months.

The presumed cause of the flail leaflet was an idiopathic condition in 176 patients, infective endocarditis in 45, trauma in 5, and miscellaneous factors in 3. The posterior leaflet was involved in 187 patients, the anterior leaflet in 37, and both leaflets in 5. Base-line echocardiographic data are shown in Table 1. The degree of mitral regurgitation was reported as grade 3+ or 4+ in 168 of the 193 patients (87 percent) who were evaluated by Doppler echocardiography and in 71 of the 75 patients (95 percent) evaluated by left ventriculography.

Coronary angiography was performed in 92 patients, 28 of whom had stenosis of 70 percent or more of the diameter of at least one coronary artery.

TABLE 1. BASE-LINE CHARACTERISTICS OF 229 PATIENTS WITH MITRAL REGURGITATION DUE TO FLAIL LEAFLET.*

CHARACTERISTIC	VALUE
	no. of patients (%)
Categorical variables	
Male sex	161 (70)
Primary reason for consultation	
Dyspnea or congestive heart failure	81 (35)
Noncardiac disease	41 (18)
Follow-up of heart murmur	40 (17)
Infective endocarditis	20 (9)
General medical examination	15 (7)
Palpitations	14 (6)
Chest pain	7 (3)
Other	11 (5)
NYHA class†	
I	110 (48)
II	52 (23)
III	40 (17)
IV	26 (11)
Atrial fibrillation at presentation	54 (24)
Hypertension	62 (27)
History of coronary artery disease	18 (8)
Comorbidity index	
0	139 (61)
1	46 (20)
2	32 (14)
3	7 (3)
4	5 (2)
	mean ±SD
Continuous variables	
Age — yr	65.5±13
Serum creatinine — mg/dl	0.91±0.24
Serum sodium — mmol/liter	140±3
Echocardiographic data	
Left ventricular measurements	
Ejection fraction — %	65±9
End-diastolic dimension — mm/m²	34±5
End-systolic dimension — mm/m²	19±4
End-diastolic wall thickness — mm	11±2
End-systolic wall thickness — mm	18±3
Ratio of end-diastolic dimension to wall thickness	5.9±1.1
Ratio of end-systolic dimension to wall thickness	2.1±0.5
End-systolic wall stress — dyn×10⁻³/cm²	51±18
Left atrial dimension — mm/m²	29±6

*Percentages may not sum to 100 because of rounding. To convert the value for creatinine to micromoles per liter, multiply by 88.4.

†The New York Heart Association (NYHA) class could not be determined for one patient.

Overall Outcome with Medical Treatment

The mortality and morbidity rates during medical treatment are shown in Table 2. Of the 229 patients, 45 (20 percent) died during medical treatment. The cause of death was cardiovascular in 31 patients (intractable heart failure in 13, cardiac arrest in 11, cerebral thromboembolism or hemorrhage in 3, and miscellaneous factors in 4), noncardiac in 12, and unknown in 2. Long-term survival with medical treatment was shorter than the expected survival (P=0.016) (Fig. 1). The rate of death from cardiac causes was 21±4 percent at 5 years and 33±7 percent at 10 years.

TABLE 2. OUTCOME AT 5 AND 10 YEARS WITH MEDICAL TREATMENT OF MITRAL REGURGITATION DUE TO FLAIL LEAFLET.*

EVENT	OVERALL POPULATION				10-YEAR RATE ACCORDING TO NYHA CLASS		
	NO. OF EVENTS	5-YEAR RATE	10-YEAR RATE	LINEARIZED YEARLY RATE	CLASS I	CLASS II	P VALUE
		percent					
Death from any cause	45	28±4	43±7	6.3	32±9	34±11	0.26
Death from cardiac cause	31	21±4	33±7	4.3	25±9	32±11	0.10
Congestive heart failure	55	30±4	63±8	8.2	53±10	82±14	0.015
Chronic atrial fibrillation†	13	8±3	30±12	2.2	30±16	29±17	0.13
Thromboembolism	13	12±3	12±3	1.9	10±3	19±9	0.36
Hemorrhage	3	1±1	3±2	0.4	2±2	8±8	0.62
Endocarditis	10	5±2	8±3	1.5	9±4	0	0.45
Mitral-valve surgery	143	57±3	82±4	20.0	71±7	93±6	0.001
Mitral-valve surgery or death	188	69±3	90±3	26.3	80±5	96±4	0.001
Outcome in subgroups of patients							
Death							
NYHA class III or IV		86±9	—	34.0			
NYHA class I or II‡		18±4	33±9	4.1			
Ejection fraction ≥60%		24±4	39±8	5.3			
Ejection fraction <60%§		47±11	60±12	11.3			
Congestive heart failure							
Left atrial diameter ≤30 mm/m²‡		18±5	59±12	5.4			
Left atrial diameter >30 mm/m²		47±9	75±10	14.5			

*Plus–minus values are means ±SE. NYHA denotes New York Heart Association.

†The 175 patients presenting in sinus rhythm were at risk for chronic atrial fibrillation, and all 229 patients were at risk for all the other end points.

‡P<0.001 as compared with the higher category.

§P=0.034 as compared with the higher category.

In the multivariate analysis (Table 3), the base-line variables that were independently predictive of survival were age, NYHA class, and ejection fraction. Figures 2 and 3 show the Kaplan–Meier survival curves according to NYHA class and ejection fraction, respectively.

The incidence of congestive heart failure was 30±4 percent at 5 years and 63±8 percent at 10 years (Fig. 4). Multivariate predictors of the development of congestive heart failure were age, ejection fraction, and left atrial diameter adjusted for body-surface area (Table 3). Of the 55 patients with a first episode of heart failure after the diagnosis of mitral regurgitation, 27 (49 percent) underwent surgery. Most of the remaining patients had symptomatic improvement with medical treatment, but these patients nevertheless had a higher mortality rate than those without an episode of heart failure (adjusted hazard ratio, 16.53; 95 percent confidence interval, 8.72 to 31.36; P<0.001).

Of the 175 patients who were in sinus rhythm at

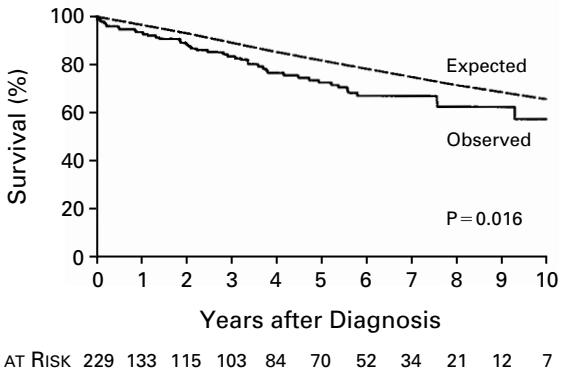


Figure 1. Long-Term Survival with Medical Treatment, as Compared with Expected Survival, in 229 Patients with Mitral Regurgitation Due to Flail Leaflet.

TABLE 3. MULTIVARIATE PREDICTORS OF THE OUTCOME OF MITRAL REGURGITATION DUE TO FLAIL LEAFLET.*

OUTCOME	NO. OF PATIENTS IN MODEL	NO. OF EVENTS	ADJUSTED HAZARD RATIO (95% CI)†	P VALUE
Survival with medical treatment	228	44		
Age			1.08 (1.05–1.12)	0.001
NYHA class			1.93 (1.45–2.59)	0.001
Ejection fraction			0.96 (0.93–0.98)	0.001
Congestive heart failure	196	48		
Age			1.06 (1.02–1.09)	<0.001
NYHA class			1.39 (0.96–2.01)	0.084
Ejection fraction			0.95 (0.91–0.98)	0.035
Left atrial dimension			1.05 (1.01–1.09)	<0.001
Survival with medical and surgical treatment	228	63		
Age			1.09 (1.06–1.12)	<0.001
NYHA class			1.60 (1.25–2.05)	<0.001
Ejection fraction			0.96 (0.94–0.98)	0.001
Mitral-valve surgery			0.29 (0.15–0.56)	<0.001
Survival with medical and surgical treatment and comorbidity	228	63		
Age			1.09 (1.06–1.12)	<0.001
NYHA class			1.62 (1.26–2.09)	<0.001
Ejection fraction			0.96 (0.94–0.98)	<0.002
Mitral-valve surgery			0.28 (0.15–0.55)	<0.001
Comorbidity index			1.07 (0.83–1.37)	0.61

*CI denotes confidence interval, and NYHA New York Heart Association.

†The hazard ratio is expressed per year of age, per NYHA class, per percent of ejection fraction, per millimeter of left atrial diameter per square meter, per surgery performed, and per unit of the comorbidity index.

presentation, 13 had chronic atrial fibrillation (Table 2 and Fig. 4), which was independently predicted only by age. Atrial fibrillation during follow-up was not associated with excess mortality ($P=0.19$).

The incidence of infective endocarditis, thromboembolic events, and major bleeding is shown in Table 2.

Mitral-Valve Surgery

Surgery was performed in 143 patients a mean of 23 ± 32 months after the diagnosis. The remaining 86 patients were treated medically. Indications for surgery were NYHA class III or IV dyspnea in 107 patients, the physician's preference in 24, infective endocarditis in 5, angina pectoris in 4, and thromboembolism in 1; the indications could not be determined in the cases of 2 patients. The mitral valve was repaired in 95 patients and replaced in 47; in 1 patient, operated on elsewhere, the nature of the procedure was not known. Concomitant coronary-artery bypass grafting was performed in 29 patients. The operative mortality was 4 percent (6 deaths among 143 patients) overall and 2 percent (3 among 121) for the patients operated on at our institution.

The cumulative likelihood of mitral-valve surgery and of the combined end point of death or surgery is shown in Figure 4.

Effect of Symptoms on Outcome

The presence of symptoms was a major predictor of survival (Table 2 and Fig. 2), but there was no difference in survival between patients in NYHA class III and those in class IV ($P=0.28$) or between patients in class I and those in class II ($P=0.26$).

Of the 66 patients in NYHA class III or IV at base line, 49 (74 percent) eventually underwent surgery. The other 17 patients continued to be treated medically because of the high estimated risk associated with surgery (in 6 patients) or functional improvement with treatment (in 11). Despite the frequent functional improvement, the outcome for these patients was poor (yearly mortality, 34 percent) and worse than the outcome for the patients in class I or II (hazard ratio, 8.23; 95 percent confidence interval, 4.22 to 16.05; $P<0.001$).

Nevertheless, the patients in NYHA class I or II had a notable annual mortality rate (4.1 percent). Of the 27 deaths that occurred during medical treatment, 19 (70 percent) were from cardiac causes, 7 of which were not preceded by class III or IV symptoms. No group was devoid of risk, with a 10-year survival of 69 ± 10 percent among the 92 patients in class I with an ejection fraction higher than 60 percent and 78 ± 6 percent among the 100 patients in class I or II with a comorbidity index of 0. Morbidity was high among both patients in class I and those in class II, but the likelihood of heart failure and surgery was higher among the patients in class II (Table 2).

Effect of Surgery on Survival

Among the patients who underwent surgery, survival at 5 and 10 years was 79 ± 3 and 66 ± 4 percent, respectively (97 and 100 percent of the expected survival, respectively; $P=0.68$). Thus, when the effect of surgery on survival was considered, no excess mortality was observed.

In a multivariate proportional-hazards analysis that included the significant base-line predictors of survival, surgery performed at any time (time-dependent variable) independently and favorably influenced survival (adjusted hazard ratio, 0.29; 95 percent confidence interval, 0.15 to 0.56) (Table 3). This effect persisted even when the comorbidity index was included in the model (Table 3).

Effect of Referral Patterns on Outcome

The geographic origin of the referral (<120 miles [193 km] from Rochester, Minn., or ≥120 miles) had no effect on the outcome in the multivariate analysis ($P>0.20$). The comorbidity rate at diagnosis (Table 1) was low, indicating that the choice of medical over surgical treatment was influenced by the cardiac status of the patients and not by coexist-

ing conditions. The inclusion of comorbidity in the multivariate proportional-hazards models did not modify the base-line predictors of outcome.

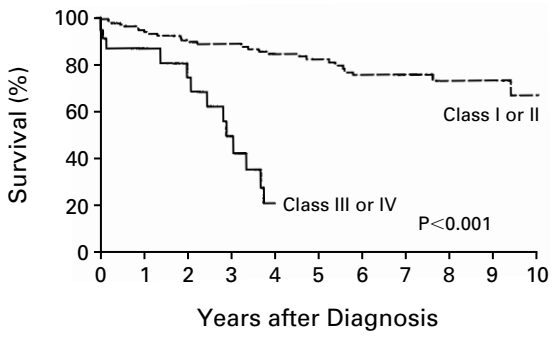
Among the 157 patients who were not immediately referred for surgery (i.e., within 3 months after the diagnosis), the 10-year cumulative incidence of surgery and surgery or death was 73±6 and 85±4 percent, respectively; these rates are similar to the rates for the total study population. Among the 162 patients initially in NYHA class I or II, the 10-year incidence of heart failure, atrial fibrillation, and surgery or death was 61±9, 29±12, and 85±4 percent, respectively, values that are similar to the rates for the total study population.

DISCUSSION

In this study we investigated the long-term outcome of mitral regurgitation due to flail leaflet. Among the patients treated medically there was an excess mortality directly related to the cardiac disease; a high incidence of cardiovascular complications; and an increased risk of late death among older patients, those with advanced symptoms, and those with a reduced ejection fraction at diagnosis. Death or the need for surgery is almost unavoidable within 10 years after the diagnosis. Surgical correction of mitral regurgitation appeared to improve long-term survival.

The natural history of mitral regurgitation is poorly defined, with widely disparate estimates of long-term survival. Reported survival rates of 95 percent at 20 years,[9] 70 percent at 10 years,[16] 46 and 50 percent at 5 years,[11,15] and even as low as 27 percent at 5 years[10] are difficult to reconcile. These disparities are probably due to small study populations[7,10-12,14] and multiple selection biases[8,10,11,14-16] associated with ill-defined degrees of regurgitation,[7,9,11,15,16,32,33] which together may have resulted in underestimation or overestimation of the hazards of medically treated mitral regurgitation. The earlier predominance of rheumatic disease as the cause of mitral regurgitation[9,11,16,32,33] also makes these data less applicable to contemporary practice, since other causes are now more common.[21,22]

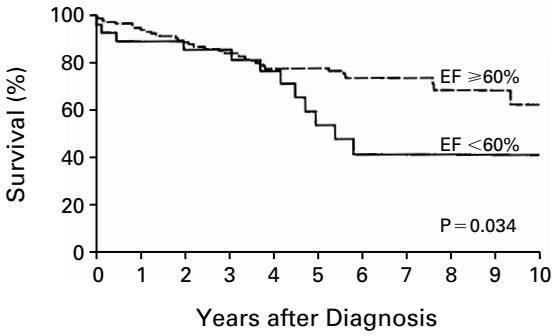
Mitral regurgitation due to flail leaflet is uniformly associated with a large volume overload,[18,34,35] whether the presentation of regurgitation is acute[35] or (as it more frequently is) chronic,[18,36,37] and the condition is diagnosed reliably with echocardiography.[19,20] Nevertheless, different observations have been made about the clinical outcome, which has been noted to be poor[23,35,38,39] or good,[37,40,41] and different recommendations have been made about the need for immediate surgery[23,39] or conservative treatment even for patients with hemodynamic decompensation.[13,24] These inconsistent findings are based on data from small series and are not helpful in making clinical decisions, which are critically important because of the high incidence of postoperative left



No. at Risk											
Class I or II	162	117	102	95	80	69	50	33	20	12	7
Class III or IV	66	15	12	7	3						

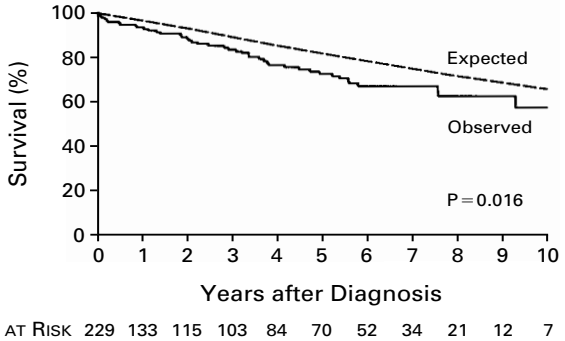
Figure 2. Long-Term Survival with Medical Treatment, According to New York Heart Association Class.

The New York Heart Association class was not available for one patient.



No. at Risk											
EF ⩾60%	185	109	94	83	69	61	45	30	19	11	6
EF <60%	44	24	21	20	15	9	6	4	1	1	1

Figure 3. Long-Term Survival with Medical Treatment, According to the Ejection Fraction (EF).



No. at Risk											
	229	133	115	103	84	70	52	34	21	12	7

Figure 4. Incidence of Atrial Fibrillation (AF), Congestive Heart Failure (CHF), Mitral-Valve Surgery, and Surgery or Death.

A total of 175 patients were initially at risk for atrial fibrillation, and 229 were initially at risk for the other end points. The numbers in parentheses are numbers of events for each end point. Plus–minus values are mean (±SE) event rates at 10 years.

ventricular dysfunction in patients who undergo mitral-valve surgery at a symptomatic stage.[3,4] The suggestion that earlier surgery may be appropriate,[4,6] especially given the current feasibility[42] and safety[5] of valve repair, is debatable without firm information about the natural history of mitral regurgitation due to flail leaflet.

The present study shows that patients treated medically have excess mortality, as compared with the general population. This excess mortality is due to cardiac causes and appears to be directly related to the valvular heart disease, underscoring the severity of the disease. The 6.3 percent yearly mortality rate in our study is similar to the rate among patients with triple-vessel coronary disease.[43] The incidence of related cardiac morbidity, which has not been consistently recognized,[9,12] was also high in our study, with a 63 percent incidence of congestive heart failure and a 30 percent incidence of chronic atrial fibrillation at 10 years, although most of the patients were initially in NYHA class I or II. Ten years after the diagnosis, either death or surgery is almost unavoidable, even taking into account the potential bias associated with direct referrals for surgery. The observation of excess mortality and high morbidity, during an era when both medical and surgical[2,3,5,6,42] treatments have been available, should raise awareness of the serious prognostic implications of the diagnosis of mitral regurgitation due to flail leaflet and should lead to a consideration of surgery based on the patient's condition at the time of the diagnosis.

Base-line predictors of death in our study were older age, higher NYHA class, and reduced ejection fraction. The high predictive power of the functional class was related in part to the poor outcome among patients in class III or IV who were not treated surgically. In the cases of these patients and those not operated on after an episode of heart failure, the attending physician was falsely reassured by rapid improvement with medical treatment. The clinical implication of this finding is that class III symptoms, even if transient, should trigger the consideration of immediate surgery, even in patients at notable operative risk.

The importance of the ejection fraction in predicting the outcome underscores the clinical significance of left ventricular dysfunction as a complication of mitral regurgitation.[3,4] Despite profound changes in loading conditions,[44] the ejection fraction is a powerful predictor of the outcome of mitral regurgitation.[2,3,7,8] Even a mildly decreased ejection fraction (<60 percent) carries an increased risk of late mortality and heart failure and should lead to the consideration of immediate surgery.

The left atrial size, which is related to the degree of regurgitation,[45,46] significantly predicted the occurrence of congestive heart failure but not of subsequent atrial fibrillation.[47] If the atrial diameter is larger than 30 mm per square meter of body-surface area, surgery should be considered.

Surgical treatment of mitral regurgitation unequivocally improves symptoms and has been considered indicated primarily for patients with NYHA class III or IV symptoms.[2,3] Evidence that surgery improves the prognosis for patients with a decreased ejection fraction is limited.[7] Although there are no definitive data from randomized trials, the present, nonrandomized study provides evidence that surgery, whenever it is performed, is associated with improved survival independently of base-line characteristics and comorbid conditions.

Our study does not document the true natural history of mitral regurgitation due to flail leaflet — that is, the natural history of the disorder when both medical and surgical treatments are withheld. The only clinically relevant consideration is the risk incurred when surgical treatment is delayed. In our patients, the overriding reason for deferring surgical treatment was the absence of severe symptoms during medical therapy, whereas in previous series, many patients received medical treatment because of an unacceptably high operative risk.[10,11,15]

In asymptomatic patients it is impossible to date the onset of the flail leaflet exactly.[48] Echocardiography is the only reliable method of diagnosing partial flail leaflet, however,[19,20] and it provides a meaningful starting point. In our study, all 143 patients examined at surgery had flail leaflets (141 with ruptured chordae and 2 with elongated chordae).

We used echocardiographic measurements of the ejection fraction because they were available for all patients. The value of these measurements[30,31] in mitral regurgitation has been verified[3-5] and is confirmed by the prognostic importance of the ejection fraction in our study. Use of the echocardiographic diagnosis of flail leaflet also allowed the inclusion of a large number of asymptomatic or minimally symptomatic patients — those most commonly seen in routine clinical practice.

Since our study could not be population-based, a referral bias cannot be ruled out. However, adjustment for the geographic origin of the referrals, the presence of coexisting conditions, and the possibility of direct referrals for surgery did not affect the results, suggesting a low probability of referral bias.

CONCLUSIONS

In this study, mitral regurgitation due to flail leaflet was associated with excess mortality and high morbidity. Most patients either died or required mitral-valve surgery within 10 years after the diagnosis, underscoring the severity of the disease. A lower ejection fraction and the presence of symptoms at base line were predictors of mortality, and a larger left atrial size was a predictor of heart failure. However, even asymptomatic patients had a substantial

mortality rate. Multivariate analyses suggest that surgical correction of mitral regurgitation improves survival and that surgery should therefore be considered early in the disease in patients with repairable valves and a low surgical risk.

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