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VALVULAR HEART DISEASE

# Failure of Guideline Adherence for Intervention in Patients With Severe Mitral Regurgitation

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**Objectives** This study sought to evaluate the incidence with which adult patients with significant mitral regurgitation (MR) do not undergo surgical intervention despite guideline recommendations, and the associated considerations resulting in no intervention.

**Background** Despite the existence of accepted guidelines, many patients with severe symptomatic heart valve disease might not undergo intervention.

**Methods** At a single large tertiary medical center, patients were retrospectively identified who had moderate-to-severe or severe MR on echocardiographic imaging during 2005. Clinical data were reviewed to determine indications for intervention and whether surgery was performed.

**Results** During 2005, 300 patients were identified with significant MR, including 188 with functional MR and 112 with organic MR. Mitral surgery was performed in 30 of 188 patients with functional MR, mostly to treat heart failure or during another cardiac surgical procedure. Mitral surgery was performed in 59 (53%) of 112 patients with organic MR. Among unoperated patients with organic MR, common reasons included stable left ventricular size or function, absence of symptoms, and prohibitive comorbidities. Using American College of Cardiology/American Heart Association guidelines, 1 or more indication for intervention was present in 39 (74%) of 53 unoperated patients. Perioperative mortality risk was not higher for patients who did not undergo surgery (median 1.2%, interquartile range [IQR] 0.4% to 3.3%) than for those who did (median 1.1%, IQR 0.6% to 5.3%; $p = 0.71$). During follow-up, there were 12 cardiac and 2 unexplained deaths.

**Conclusions** Among patients with severe organic MR, surgical intervention occurred in approximately one-half. However, accepted guideline indications for intervention were present in the majority of unoperated patients. Objectively assessed operative risk was not prohibitive in many unoperated patients. (J Am Coll Cardiol 2009;54:860–5)


Chronic, severe organic mitral regurgitation (MR) results in left ventricular (LV) dilation and systolic dysfunction, with eventual heart failure (1) and death (2). With no acceptable medical therapy, American College of Cardiology (ACC)/American Heart Association (AHA) (3,4) and European Society of Cardiology guidelines (5) recommend surgical intervention in patients with chronic, severe organic MR and heart failure, LV systolic dysfunction or significant LV enlargement, or new atrial fibrillation or pulmonary hypertension. In the setting of ischemic (6) or nonischemic LV dysfunction (7), functional MR also is associated with excess mortality. However, there remains broad variation in indications to intervene on patients with functional MR (1,3–5).

Despite unequivocal recommendations for intervention in the setting of severe organic MR with symptoms, LV dilation, or LV systolic dysfunction, prevalence studies suggest that it is not uncommon that patients do not undergo surgery (8,9). In addition, a survey of cardiologists treating adults in Canada showed that only 57.2% recognized an ejection fraction (EF) of 50% to 60% and only 15.6% recognized functional class II symptoms as indications for intervention (10). No studies to date directly address the level of undertreatment of patients with MR. The purpose of this study was to evaluate the incidence with which adult patients with significant MR do not undergo surgical intervention, and the associated considerations resulting in no intervention.

## Methods

**Study population.** The University of Michigan Echocardiography Laboratory database was retrospectively reviewed to identify adult patients with moderate-to-severe or severe MR documented on any echocardiogram during 2005.

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Patients with organic MR and patients with functional MR were considered separately.

**MR.** MR severity was determined at the time of clinical echocardiographic analysis based on overall clinical assessment using all available echocardiographic and Doppler criteria, including color-flow Doppler jet size, jet eccentricity, characteristics of the proximal flow convergence zone, and jet duration; a semiquantitative system of none, trivial, mild, mild-to-moderate, moderate, moderate-to-severe, and severe was used (11). For purposes of determining intervention and outcomes, significant (severe) MR was defined as moderate-to-severe or severe.

MR was defined as organic in the setting of an identifiable anatomic mitral valve abnormality. Patients with active infective endocarditis were excluded from analysis. MR was defined as functional in the setting of LV enlargement and/or regional or global LV dysfunction responsible for malcoaptation of functionally normal mitral leaflets. Ischemic MR was defined as functional MR in patients with ischemic LV systolic dysfunction.

**Clinical data.** University of Michigan electronic medical records were reviewed for pertinent medical information including age, sex, and cardiac and noncardiac diseases and comorbidities. Records were further reviewed for symptoms referable to chronic MR, including exertional or nocturnal dyspnea, orthopnea, peripheral edema, or progressive decline in functional status without other explanation. End points were referral to cardiology, referral to cardiothoracic surgery, and performance of mitral valve surgery. For patients who did not undergo surgery, reasons were determined by review of all available records. Estimated perioperative (30-day) risks of mortality and morbidity for operated and unoperated patients were calculated using the Society of Thoracic Surgery Adult Cardiac Surgery Risk Calculator (12), using historical and clinical data at the time of the echocardiogram documenting severe MR. The study protocol was reviewed and approved by the institutional review board of the University of Michigan.

**Statistical analysis.** Data with normal distribution (age, echocardiography/Doppler variables) are presented as mean ± 1 SD or as number and percent; comparisons between groups were made using Student *t* tests (2-sided). Data with nonnormal distribution (perioperative risk) are presented as median and interquartile range (IQR); comparisons between groups were made using Mann-Whitney *U* tests. Comparisons of categorical variables between groups were made using chi-square tests or Fisher exact tests (when the frequency of any event was <5). Survival was determined using the Kaplan-Meier method. Differences were considered significant at a p value <0.05. Statistical analysis was performed using SPSS version 11.5 (SPSS, Inc., Chicago, Illinois).

## Results

**Patients.** During calendar year 2005, 303 patients had echocardiographic evidence of moderate-to-severe or severe MR. Of these, 3 (1%) were excluded from analysis because no medical information was available other than the echocardiogram. The remaining 300 patients included 172 men (57%) and 128 women (43%), mean age 60.1 ± 16.5 years (range 18 to 91 years). There were 112 (37%) patients with organic MR and 188 (63%) with functional MR related to an underlying cardiomyopathy (95 [32% of total] nonischemic and 93 [31% of total] ischemic).

**Abbreviations and Acronyms**

ACC = American College of Cardiology
AHA = American Heart Association
EF = ejection fraction
IQR = interquartile range
LV = left ventricle/ventricular
MR = mitral regurgitation

**Functional MR.** Demographic and echocardiographic data for patients with nonischemic and ischemic functional MR are summarized in Tables 1 and 2, respectively. Patients who underwent surgery did not differ substantially from unoperated patients other than a slightly higher LVEF. No patient underwent heart transplant or LV assist device placement. Predicted risk of perioperative mortality was not different for patients who underwent surgery (median 1.1%, IQR 0.7% to 1.8%, range 0.4% to 8.8%) compared with those who did not (median 0.9%, IQR 0.5% to 2.2%, range 0.3% to 14.1%; p = 0.70). More patients who underwent intervention were referred to the institution directly to a cardiac surgeon (5 of 15 vs. 0 of 80, p < 0.001). Of 15 operated patients, 12 (80%) underwent intervention for intractable symptoms of heart failure and 3 underwent mitral valve surgery for functional MR at the time of another cardiac procedure.

Patients with ischemic MR who underwent surgery were similar to unoperated patients. Predicted risk of perioperative mortality was not different for patients who underwent surgery (median 3.2%, IQR 1.7% to 6.4%, range 0.7% to 37.2%) compared with those who did not (median 2.8%, IQR 1.4% to 4.7%, range 0.3% to 23.7%; p = 0.57). Mitral valve surgery was performed at the time of other cardiac

**Table 1** Demographic and Echocardiographic Data for Patients With Functional Nonischemic Mitral Regurgitation

| | All Patients | Operated | Unoperated | p Value |
|---|---|---|---|---|
| n | 95 | 15 (16%) | 80 (84%) | |
| Age (yrs) | 53.0 ± 15.9 | 56.1 ± 14.2 | 52.4 ± 16.2 | 0.42 |
| Range | 18–89 | 33–79 | 18–89 | |
| Male sex | 51 (60%) | 10 (67%) | 41 (51%) | 0.27 |
| Echocardiography | | | | |
| LA diameter (mm) | 50.9 ± 8.2 | 53.6 ± 8.4 | 50.6 ± 8.1 | 0.26 |
| LVIDD (mm) | 66.3 ± 12.5 | 69.3 ± 12.5 | 65.7 ± 12.5 | 0.34 |
| LVIDS (mm) | 56.5 ± 15.7 | 58.5 ± 13.8 | 56.1 ± 16.0 | 0.62 |
| LVEF (%) | 25.6 ± 16.5 | 33.5 ± 15.1 | 24.1 ± 16.1 | 0.05 |
| RVSP (mm Hg) | 49.3 ± 15.1 | 52.6 ± 20.9 | 48.9 ± 14.4 | 0.50 |

LA = left atrium; LVEF = left ventricular ejection fraction; LVIDD = left ventricular internal diameter in diastole; LVIDS = left ventricular internal diameter in systole; RVSP = right ventricular systolic pressure.

JACC Vol. 54, No. 9, 2009
August 25, 2009:860–5

**Table 2** Demographic and Echocardiographic Data for Patients With Ischemic Mitral Regurgitation

| | All Patients | Operated | Unoperated | p Value |
|---|---|---|---|---|
| n | 93 | 15 (16%) | 78 (84%) | |
| Age (yrs) | 67.6 ± 12.4 | 67.2 ± 11.2 | 67.7 ± 12.7 | 0.88 |
| Range | 44–91 | 52–83 | 44–91 | |
| Male sex | 58 (62%) | 9 (60%) | 49 (63%) | 0.84 |
| Echocardiography | | | | |
| LA diameter (mm) | 49.4 ± 7.6 | 50.5 ± 6.2 | 49.2 ± 7.8 | 0.56 |
| LVIDD (mm) | 59.1 ± 11.5 | 57.2 ± 11.6 | 59.4 ± 11.5 | 0.54 |
| LVIDS (mm) | 46.6 ± 13.8 | 41.4 ± 18.6 | 47.5 ± 12.8 | 0.16 |
| LVEF (%) | 32.3 ± 17.2 | 34.6 ± 20.5 | 31.8 ± 16.6 | 0.58 |
| RVSP (mm Hg) | 51.2 ± 15.8 | 61.0 ± 18.8 | 49.4 ± 14.7 | 0.02 |

Abbreviations as in Table 1.

surgery in 8 patients. The remaining 7 patients underwent mitral valve surgery for treatment of heart failure.

**Organic MR.** Etiologies of organic MR included myxomatous degeneration in 55 patients (49%), rheumatic disease in 18 patients (16%), healed endocarditis in 16 patients (14%), degenerative calcific disease or other nonspecific leaflet thickening in 6 patients (5%), congenital disease in 5 patients (4%), hypertrophic cardiomyopathy in 1 patient (1%), radiation valvulopathy in 1 patient (1%), structural prosthetic valve dysfunction in 2 patients (2%), and degeneration of mitral repair in 8 patients (7%). Demographic and echocardiographic data are summarized in Table 3. In general, operated and unoperated patients were similar. The distribution of indications for mitral valve surgery based on the 1998 ACC/AHA guidelines (3) is shown in Table 4. The 2 patients who underwent surgery without an identified indication underwent mitral valve repair for myxomatous degeneration.

Of 53 unoperated patients, 43 (81%) were followed up by a cardiologist; only 5 (9%) were referred to a cardiothoracic surgeon for evaluation. Stated reasons not to refer for intervention are shown in Table 5. Among 9 patients for whom absence of symptoms was cited, 6 (67%) had at least 1 1998 ACC/AHA Class I or IIa indication for intervention. Similarly, an indication for intervention was present in 8 of 17 patients (47%) in whom surgery was not recommended because of stable LV size and EF.

**Table 3** Demographic and Echocardiographic Data for Patients With Organic Mitral Regurgitation

| | All Patients | Operated | Unoperated | p Value |
|---|---|---|---|---|
| n | 112 | 59 (53%) | 53 (47%) | |
| Age (yrs) | 59.8 ± 17.2 | 57.2 ± 17.4 | 62.8 ± 16.7 | 0.09 |
| Range | 20–90 | 20–88 | 23–90 | |
| Male sex | 63 (56%) | 33 (56%) | 30 (57%) | 0.94 |
| Echocardiography | | | | |
| LA diameter (mm) | 48.4 ± 7.8 | 48.4 ± 7.1 | 48.4 ± 8.5 | 0.97 |
| LVIDD (mm) | 52.2 ± 8.0 | 52.1 ± 8.8 | 52.4 ± 7.4 | 0.87 |
| LVIDS (mm) | 33.6 ± 8.0 | 33.2 ± 7.6 | 33.9 ± 8.4 | 0.70 |
| LVEF (%) | 58.6 ± 11.4 | 57.6 ± 11.2 | 59.5 ± 11.5 | 0.42 |
| RVSP (mm Hg) | 46.3 ± 19.0 | 45.6 ± 17.8 | 46.8 ± 19.9 | 0.80 |

Abbreviations as in Table 1.

**Table 4** Prevalence of Indications for Surgical Intervention for Chronic Severe Mitral Regurgitation in Patients With Organic Mitral Regurgitation Based on the 1998 ACC/AHA Guidelines*

| | All Patients | Operated | Unoperated | p Value |
|---|---|---|---|---|
| n | 112 | 59 | 53 | |
| Symptoms | 53 (47%) | 29 (49%) | 24 (45%) | 0.68 |
| LVIDS ≥45 mm | 11 (10%) | 5 (8%) | 6 (11%) | 0.61 |
| LVEF ≤60% | 50 (45%) | 26 (44%) | 24 (45%) | 0.90 |
| Atrial fibrillation | 26 (23%) | 14 (24%) | 12 (23%) | 0.89 |
| RVSP >50 mm Hg | 25 (22%) | 9 (15%) | 16 (30%) | 0.06 |
| Any indication | 96 (86%) | 57 (97%) | 39 (74%) | <0.0001 |

*See Bonow et al. (3) for the 1998 ACC/AHA guidelines.
ACC/AHA = American College of Cardiology/American Heart Association; other abbreviations as in Table 1.

During a median interval of 776 days (IQR 193 to 1,002 days, range 0 to 1,225 days) after echocardiography, 17 patients (32%) with organic MR died (Table 5), including 12 patients who died of a cardiac cause, 3 who died of a noncardiac cause, and 2 in whom cause of death was not documented. The Kaplan-Meier 6- and 12-month freedom from cardiac death was 86% and 79%, respectively.

There were 4 patients in whom the diagnosis of MR was never acknowledged after the echocardiogram. All 4 had indications for intervention, including pulmonary hypertension in 1 patient, pulmonary hypertension and atrial fibrillation in 1 patient, LV enlargement and systolic dysfunction in 1 patient, and symptoms, LV enlargement, atrial fibrillation, and pulmonary hypertension in 1 patient. In 2 patients, the diagnosis was acknowledged but surgery was never addressed. One patient had LV dysfunction, and 1 patient had symptoms and atrial fibrillation.

Risks of perioperative mortality and morbidities are shown in Table 6; distributions of risk are shown in Figure 1. In all categories, risks were not significantly different for operated and unoperated patients. The risk of perioperative mortality

**Table 5** Rationale by Which Mitral Valve Surgery Was Not Performed in 53 Unoperated Patients With Organic MR

| Rationale | n | Death | Cardiac Death | Interval to Cardiac Death (days) |
|---|---|---|---|---|
| Asymptomatic | 9 (17%) | 1 | 0 | — |
| Stable LVEF, stable chambers | 17 (32%) | 3 | 3 | 186, 839, 855 |
| MR improved on subsequent echocardiogram | 6 (11%) | 1 | 1 | 213 |
| Comorbidities/risk | 10 (19%) | 7* | 4 | 3, 5, 26, 43 |
| Patient refused | 4 (%) | 2 | 2 | 3, 32 |
| Died before planned evaluation | 1 (%) | 1 | 1 | 5 |
| MR unrecognized | 4 (%) | 1† | 0 | — |
| MR ignored | 2 (%) | 1 | 1 | 232 |

*There were 4 cardiac deaths, 2 noncardiac deaths, and 1 death of undocumented cause. †The single death was of undocumented cause.
MR = mitral regurgitation; other abbreviations as in Table 1.

**Table 6** Calculated Percent Operative Risks* for Patients With Organic Mitral Regurgitation

| | All Patients | Operated | Unoperated | p Value |
|---|---|---|---|---|
| n | 112 | 59 | 53 | |
| Mortality (%) | 1.2 (0.5–3.4) | 1.1 (0.6–3.5) | 1.2 (0.4–3.3) | 0.71 |
| Total morbidity or mortality (%) | 15.0 (8.1–23.9) | 14.4 (9.4–23.5) | 14.9 (7.8–25.5) | 0.93 |
| Prolonged length of stay (%) | 6.2 (2.6–12.4) | 5.7 (3.1–11.8) | 6.7 (2.2–12.7) | 0.68 |
| Permanent stroke (%) | 1.3 (0.8–2.1) | 1.2 (0.8–2.0) | 1.5 (0.8–2.7) | 0.22 |
| Prolonged ventilation (%) | 7.3 (4.1–14.1) | 7.7 (4.5–13.5) | 7.2 (3.8–15.4) | 0.73 |
| Infection (%) | 0.1 (0.1–0.2) | 0.1 (0.1–0.2) | 0.1 (0.1–0.2) | 0.45 |
| Renal failure (%) | 2.5 (1.1–5.3) | 2.5 (1.2–5.0) | 2.5 (0.9–5.4) | 0.79 |
| Reoperation (%) | 6.9 (5.1–9.7) | 6.7 (5.1–9.6) | 7.5 (5.1–10.7) | 0.70 |

*Values are median (interquartile range).

for 10 patients who did not undergo surgery because of cited comorbidities and high operative risk (median 3.7%, IQR 3.1% to 6.3%, range 2.5% to 49.8%) was higher than for the cohort who underwent mitral valve surgery ($p = 0.002$). However, calculated perioperative mortality in 8 of these 10 patients (2.5%, 2.9%, 3.1%, 3.1%, 3.3%, 4.1%, 6.0%, 6.4%) was substantially <10%, and the calculated operative risk for all but 1 (49.8%) was lower than the upper range of operative risks for patients who underwent surgery.

## Discussion

Organic MR and functional MR are inherently different in their management as well as their causes (1). Functional MR may respond to treatment of the underlying cardiomyopathy, whereas no accepted medical therapy exists for organic MR. Although there are discrete indications for operative intervention in patients with chronic severe organic MR, there are no widely accepted indications for surgery in patients with functional MR other than as a concomitant procedure at the time of other cardiac surgical intervention (1,3–5).

**Functional MR.** By definition, patients with functional MR had underlying disease of the LV; patients were evenly divided between nonischemic and ischemic etiologies. The majority of patients who underwent surgery for nonischemic MR did so because of intractable symptoms of heart failure. Most patients who underwent intervention for ischemic MR did so at the time of another cardiac surgical procedure. Recent (3) and current (4,5) guidelines do not stress surgical intervention for functional MR. As such, the observed low rates of intervention could be anticipated, and are not in conflict with guideline recommendations (3–5) or standard of care (1).

**Organic MR.** Approximately one-half of 112 patients with severe organic MR underwent surgical intervention. Based on the 1998 ACC/AHA guidelines on the management of patients with heart valve disease (3), which were pertinent at the time when echocardiograms were performed, class I and IIa indications for intervention are symptoms, LV enlargement (systolic dimension ≥45 mm) or systolic dysfunction (EF ≤60%), new atrial fibrillation, or pulmonary artery hypertension (systolic pressure >50 mm Hg). Almost all patients who underwent surgery had 1 or more indication for intervention; only 2 patients underwent prophylactic mitral valve repair for myxomatous degeneration. However, nearly three-fourths of patients who did not undergo surgery also had 1 or more indication for intervention.

**Unoperated patients with organic MR.** The rationales for not performing surgery could be divided into several common themes. The most common related to a belief that MR was not a current threat based on stable chamber sizes (17 of 53 patients), absence of symptoms (n = 9), or less MR noted on a subsequent echocardiogram (n = 6). Although subsequent MR improvement could be a logical reason to defer intervention, most patients met other criteria for intervention. Further, guidelines do not recommend continued follow-up once an indication for intervention is present. Together, these finding suggest a lack of familiarity with longstanding guideline recommendations or a lack of respect for them.

This study was not powered to address the survival of unoperated patients. However, mortality was significant (12-month freedom from cardiac death 79%). Only 3 of 17 patients died of noncardiac causes.

Among patients who did not undergo intervention, there was a broad range of estimated operative mortality risk. However, most operated and unoperated patients with organic MR had low estimated risks of perioperative mortality and morbidity, with outliers notably present in both groups. Even among 10 patients in whom surgery was not performed because of a perception of excessive operative risk, the estimated mortality risk in 8 patients was well below 10%, and exceeded the upper range of risk of operated patients in only 1 patient. Although most unoperated patients were followed by a cardiologist, few were referred for evaluation by a cardiothoracic surgeon. Many patients for whom surgical risk was thought to be prohibitive likely would have been acceptable surgical candidates.

**Low rate of intervention in perspective.** It may be surprising that almost one-half of patients with organic MR and an indication for intervention did not undergo surgery. Admittedly, this single-center experience may not be representative of broader practice patterns. However, published studies suggest that this scenario may be common. Studies on the prevalence of MR suggest that many patients with

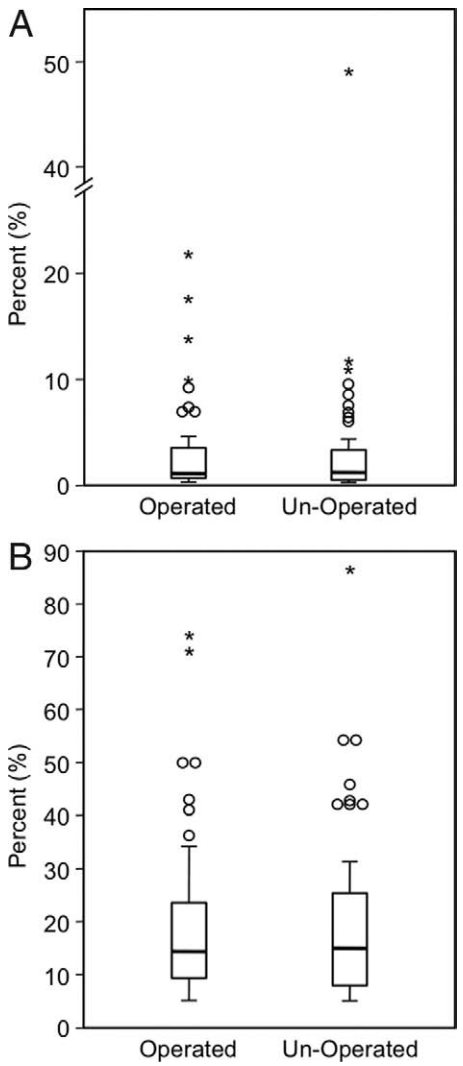


**Figure 1** **Risks of Perioperative Mortality and Total Morbidity and Morbidity**

Risks of **(A)** perioperative mortality and **(B)** total morbidity and mortality. Distribution of calculated (STS Adult Cardiac Surgery Risk Calculator) operative risk among operated and unoperated patients with severe organic mitral regurgitation. The first and third quartile for each dataset are defined by the **rectangle**; the data median by the **heavy crossbar**; **bars** define the lowest and greatest values that are not outliers (falling within 1.5 times the interquartile range); outliers are depicted as **open circles** and extreme outliers (values outside 3 times the interquartile range) as **asterisks**. The distribution of risk was skewed but similar among operated and unoperated patients.

significant organic MR do not undergo intervention (8,9). The Euro Heart Survey (13) suggested that no intervention was performed in 31.8% of patients despite both severe single-valve disease and severe symptoms. In addition, studies of aortic stenosis suggest that between 40% and 60% of patients with severe symptomatic aortic stenosis do not undergo valve replacement (14–17).

The reasons that so many patients do not undergo intervention likely are complex. Previous studies on why physicians fail to adhere to published guidelines note common themes including lack of awareness, lack of familiarity, lack of agreement with recommendations, and inertia of previous practice (18). However, the 1998 ACC/AHA guidelines had been in place for years at the time of this study, arguing against inertia. Rather, the relatively small role played by heart valve disease in the overall practice of cardiovascular medicine may result in lack of familiarity with practice guidelines. Other contributing factors may include the subtle nature of symptoms, patient denial, and lifestyle adjustment to avoid symptoms. Further, there may be a tendency to overestimate operative risk in some patients (17), and to both overestimate the risk and underestimate the benefit of surgery for elderly patients (14,16). Practice improvement may come from education about current guidelines as well as a means to objectively estimate perioperative risk.

**Study limitations.** This was an observational retrospective survey of patient management at a single institution; findings might not be representative of broader practice patterns. Patient characteristics were dependent on the tertiary referral nature of the institution. It is not always possible in retrospect to definitively reconstruct the rationale for medical recommendations; however, with careful review, rationale typically was apparent. The survey was not designed to address the prevalence of MR or the outcomes of patients with the diagnosis of MR with or without intervention. Significant MR in this study was taken to include both severe and moderate-to-severe MR; it is possible that less than severe MR, as well as the subjective nature of echocardiographic determination of MR severity, could have influenced management decisions. Although various causes of organic MR were considered together (including prosthesis dysfunction), guidelines for intervention are the same regardless of etiology.

## Conclusions

Surgical intervention occurred in just over one-half of patients with severe organic MR. One or more indication for intervention was present in approximately three-fourths of unoperated patients, suggesting poor adherence to guideline recommendations. Despite a cited concern for high operative risk, objectively assessed risks did not seem prohibitive in most unoperated patients.

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## REFERENCES

1. Carabello BA. The current therapy for mitral regurgitation. J Am Coll Cardiol 2008;52:319–26.
2. Ling LH, Enriquez-Sarano M, Seward JB, et al. Clinical outcomes of mitral regurgitation due to flail leaflet. N Engl J Med 1996;335:1417–23.
3. Bonow RO, Carabello B, De Leon AC, et al. ACC/AHA guidelines for the management of patients with valvular heart disease: a report of

the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Management of Patients with Valvular Heart Disease). J Am Coll Cardiol 1998;32:1486–582.
4. Bonow RO, Carabello BA, Chatterjee K, et al. ACC/AHA 2006 guidelines for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Valvular Heart Disease). J Am Coll Cardiol 2006;48:e1–148.
5. Vahanian A, Baumgartner H, Bax J, et al. Guidelines on the management of valvular heart disease: the Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology. Eur Heart J 2007;28:230–68.
6. Grigioni F, Enriquez-Sarano M, Zehr KJ, Bailey KR, Tajik AJ. Ischemic mitral regurgitation: long-term outcome and prognostic implications with quantitative Doppler assessment. Circulation 2001; 103:1759–64.
7. Koelling TM, Aaronson KD, Cody RJ, Bach DS, Armstrong WF. Prognostic significance of mitral regurgitation and tricuspid regurgitation in patients with left ventricular systolic dysfunction. Am Heart J 2002;144:524–9.
8. Avierinos JF, Gersh BJ, Melton LJ 3rd, et al. Natural history of asymptomatic mitral valve prolapse in the community. Circulation 2002;106;1355–61.
9. Singh JP, Evans JC, Levy D, et al. Prevalence and clinical determinants of mitral, tricuspid, and aortic regurgitation (Framingham Heart Study). Am J Cardiol 1999;83:897–902.
10. Toledano K, Rudski LG, Huynh T, Béïque F, Sampalis J, Morin J-F. Mitral regurgitation: determinants of referral for cardiac surgery by Canadian cardiologists. Can J Cardiol 2007;23:209–14.
11. Zoghbi WA, Enriquez-Sarano M, Foster E, et al. Recommendations for the evaluation of the severity of native valvular regurgitation with two-dimensional and Doppler echocardiography. A report from the American Society of Echocardiography's Nomenclature and Standards Committee and the Task Force on Valvular Regurgitation, developed in conjunction with the American College of Cardiology Echocardiography Committee, The Cardiac Imaging Committee Council on Clinical Cardiology, the American Heart Association, and the European Society of Cardiology Working Group on Echocardiography. J Am Soc Echocardiogr 2003;16:777–802.
12. STS National Database Risk calculator (STS Adult Cardiac Surgery Database Risk Model Variables, Data version 2.61). Available at: http://www.sts.org/sections/stsnationaldatabase/riskcalculator/. Accessed November 30, 2008.
13. Iung B, Baron G, Butchart E, et al. A prospective survey of patients with valvular heart disease in Europe: the Euro Heart Survey on Valvular Heart Disease. Eur Heart J 2003;24:1231–43.
14. Bouma BJ, van den Brink RBA, van der Meulen JHP, et al. To operate or not on elderly patients with aortic stenosis: the decision and its consequences. Heart 1999;82:143–8.
15. Varadarajan P, Kapoor N, Bansal RC, Pai RG. Clinical profile and natural history of 453 nonsurgically managed patients with severe aortic stenosis. Ann Thorac Surg 2006;82:2111–5.
16. Charlson E, Legedza ATR, Hamel MB. Decision-making and outcomes in severe symptomatic aortic stenosis. J Heart Valve Dis 2006;15:312–21.
17. Bach DS, Cimino N, Deeb GM. Unoperated patients with severe aortic stenosis. J Am Coll Cardiol 2007;50:2018–9.
18. Cabana MD, Rand CS, Powe NR, et al. Why don't physicians follow clinical practice guidelines? A framework for improvement. JAMA 1999;282:1458–65.

**Key Words:** mitral regurgitation ■ mitral valve surgery ■ operative risk ■ guidelines ■ adherence/compliance.