Does Coronary Artery Bypass Grafting Alone Correct Moderate Ischemic Mitral Regurgitation?

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***Background*—**The optimal management of moderate (3+ on a scale of 0 to 4+) ischemic mitral regurgitation (MR) remains controversial. Some advocate CABG alone, whereas others favor concomitant mitral annuloplasty. To clarify the optimal management of these patients, we evaluated the early impact of isolated CABG on moderate ischemic MR.

***Methods and Results*—**Between January 1992 and August 1999, 136 patients (54% male, mean age 70.5 years, mean New York Heart Association class 2.7, mean ejection fraction 38.1%) with a preoperative diagnosis of moderate ischemic MR, without leaflet prolapse or pathology, underwent isolated CABG. Thirty-eight (28%) of 136 patients had intraoperative transesophageal echocardiography (TEE) before CABG, and 68 (50%) had postoperative transthoracic echocardiography (TTE) within 6 weeks of surgery. The subgroups of patients undergoing intraoperative TEE and postoperative TTE had preoperative characteristics similar to the overall group. The 30-day operative mortality was 2.9% (4/136). Intraoperative TEE downgraded the severity of MR to mild or less (0 to 2+) in 89% (34/38). On postoperative TTE, 40% (27/68) continued to have at least moderate MR (3 to 4+), 51% (35/68) improved somewhat to mild (2+) MR, and only 9% (6/68) had resolution of their MR (0 to 1+). The mean preoperative, intraoperative, and postoperative MR grades were 3.0 ± 0.0, 1.4 ± 1.0, and 2.3 ± 0.8, respectively ($P<0.001$).

***Conclusions*—**CABG alone for moderate ischemic MR leaves many patients with significant residual MR and may not be the optimal therapy for most patients. Intraoperative TEE may significantly underestimate the severity of ischemic MR. A preoperative diagnosis of moderate MR may warrant concomitant mitral annuloplasty. **(*Circulation*. 2001;104[suppl I]:I-68-I-75.)**

Key Words: coronary disease ■ echocardiography ■ mitral valve ■ regurgitation ■ surgery

Although most surgeons would agree that severe mitral regurgitation (MR) should be corrected at the time of CABG and that trace to mild MR can probably be left alone, the optimal management of moderate ischemic MR remains controversial. Those favoring a conservative approach make several arguments. First, revascularizing ischemic areas will improve regional wall motion and correct the MR.[1,2] Second, several studies[3–5] suggest that performing CABG alone, even if some residual MR persists, does not affect long-term survival or functional status. Third, mitral valve surgery adds significantly to the operative risk of CABG, with most series reporting operative mortality rates >10%.[6–11] Next, patients with ischemic MR tend to have relatively small left atria, which makes mitral valve exposure and repair difficult for many surgeons. Finally, mitral valve replacement, if necessary, carries the added burden of long-term anticoagulation or risk of reoperation.

Many surgeons, however, have advocated more liberal use of mitral annuloplasty in patients with moderate ischemic MR at the time of CABG. They present several key arguments. (1) Chronic ischemic MR is a dynamic condition that is very dependent on preload and afterload. The preoperative echocardiogram merely represents a brief snapshot of the severity of MR at the time of the study. The fact that many patients with "moderate" or less MR present with significant symptoms of congestive heart failure or enlarged left atria suggests that they probably have frequent episodes of more severe MR. (2) CABG alone will not correct moderate ischemic MR in many patients, especially those with scarring from myocardial infarction and those with annular and ventricular dilatation.[12] (3) According to several studies,[13,14] significant residual MR can result in late symptoms and decreased long-term survival. (4) Mitral annuloplasty is nearly always technically feasible, and it alone will almost always correct moderate ischemic MR, which makes mitral valve replacement almost never necessary.[15] (5) The high operative mortality rate for combined mitral valve surgery and CABG reported in the literature is outdated and reflects a significant number of patients undergoing mitral valve replacement. Mitral valve repair can now be performed at the time of CABG with an operative mortality rate as low as 3% to 4%.[16–18] (6) When significant residual MR remains, it ex-

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TABLE 1. Definition of Moderate Ischemic MR

Significant symptomatic multivessel coronary artery disease, with or without documented prior myocardial infarction
Grade 3+ MR on a scale of 0 to 4+
Documented on preoperative echocardiogram or vetriculogram while patient is not actively ischemic
Regurgitant jet to posterior wall of left atrium without reversal or blunting of pulmonary venous flow
No mitral stenosis
Type I or IIIb by Carpentier functional classification
Annular dilatation with normal leaflet motion (type I) OR
Restricted leaflet motion during systole (type IIIb)
No leaflet prolapse (type II) or other leaflet pathology

poses the patient to the potential need for reoperative mitral valve surgery in the presence of patent grafts, which carries significant operative risk.[19]

Before the long-term effects of these 2 strategies is evaluated, it is important to first answer the simpler question of whether CABG alone corrects the MR in the short term. There is conflicting literature on this issue, with 2 studies reporting dramatic improvements[1,2] and another study[12] showing significant residual MR after CABG alone. We retrospectively reviewed all patients at our institution who underwent CABG alone for moderate ischemic MR over an 8-year period and determined the severity of residual MR in those who underwent early postoperative echocardiography.

Methods

Patient Population

Between January 1992 and August 1999, 269 patients were referred for first-time CABG to Brigham and Women's Hospital with a preoperative diagnosis of moderate ischemic MR by echocardiography, ventriculography, or both. Of these patients, 133 (49%) underwent concomitant mitral valve repair. The remaining 136 (51%) underwent CABG alone and constitute the study population for this report. Patients undergoing all other procedures were excluded except for 2 patients who underwent concomitant carotid surgery and 2 who underwent placement of internal defibrillator devices.

To be classified as having moderate ischemic MR, the patient had to fulfill all of the criteria listed in Table 1. Although the majority of patients did have a recent or remote history of myocardial infarction, documentation of a specific infarction involving the inferior or posterolateral walls was not required.

Operative Techniques

All patients underwent conventional multivessel CABG through a full midline sternotomy on cardiopulmonary bypass. The decision to forgo mitral valve repair was at the surgeon's discretion and was not typically well documented in the patient records. The most common reason was probably simple surgeon preference. The threshold and criteria for addressing the mitral valve at the time of CABG differed significantly among the 7 surgeons in the group, mirroring the controversy in the literature. Another likely common reason to forgo mitral valve repair was reliance on the intraoperative transesophageal echocardiogram, which would frequently downgrade the severity of the MR and could lead the surgeon to conclude that the MR was not clinically significant. Finally, in some patients, the surgeon probably believed that the risk of combined mitral valve surgery and CABG was prohibitive because of poor ventricular function, comorbid conditions, or the emergency nature of the operation.

Echocardiography

Intraoperative Transesophageal Echocardiography

Intraoperative transesophageal echocardiography (TEE) was performed by the cardiac anesthesiologist in 28% (38/136) of patients. The study was performed after induction of general anesthesia and before the surgical incision at the discretion of the surgeon and anesthesiologist. There were no systematic attempts to induce MR by increasing afterload or preload. A single echocardiographer later reviewed the videotape of the study, and the severity of MR was graded in a semiquantitative fashion (0+, none; 1+, trace; 2+, mild; 3+, moderate; and 4+, severe) based on the size and geometry of the regurgitant jet. Only prebypass TEE was recorded. The results of the postbypass TEE were more difficult to interpret because it was performed less systematically and during a period of rapidly changing hemodynamics.

Postoperative Transthoracic Echocardiography

A postoperative transthoracic echocardiogram (TTE) was performed by a noninvasive cardiologist at our hospital within 6 weeks of surgery in 68 patients (50%). The severity of MR was recorded on the same scale as above. This study was also performed at the discretion of the surgeon.

Data Collection and Analysis

Preoperative, operative, and postoperative data were collected prospectively in the division's clinical database and confirmed by review of the actual medical records. Data were tabulated with Microsoft Excel (Microsoft Corp), and statistical analysis was performed with the SPSS statistical package (SPSS Inc). All means in the text are expressed as mean±SD. In the figures, the means are shown with their 95% CIs. Medians are reported for variables that did not conform to a normal distribution. Means were compared with an unpaired, 2-tailed Student's *t* test. Medians were compared with the nonparametric Mann-Whitney test. Categorical variables were compared with Fisher's exact test for 2×2 contingency tables and Pearson's χ^2 test for larger tables. A P value <0.05 was considered statistically significant.

Results

Patient Characteristics

Preoperative patient characteristics of the overall group (n=136) and the subsets of patients undergoing intraoperative TEE (n=38) and postoperative TTE (n=68) are shown in Table 2. The subgroups were very similar to the overall group in nearly all characteristics, and none of differences were statistically significant. Among the overall group, 54% were male. Mean age was 70.5±9.5 years (range 39 to 92 years).

On average, these patients had fairly advanced coronary artery disease. Specifically, the majority (57%) presented with unstable angina, and a significant number (28%) had left main coronary artery stenosis. A large majority (77%) had documented prior myocardial infarctions, split evenly between recent (within 21 days) and remote infarctions. This high incidence of prior ventricular damage is consistent with the presence of significant mitral regurgitation and left ventricular dysfunction (mean ejection fraction 38.1±12.3%, 53% moderate or severe dysfunction). It is also not surprising that the incidence of symptoms of congestive heart failure was significant, with 63% of patients in New York Heart Association class III or IV (mean 2.7±1.1). These 2 key findings are illustrated in Figure 1.

Significant noncardiac comorbid conditions, including diabetes mellitus (41%), peripheral and cerebrovascular disease (21% and 19%, respectively), renal insufficiency (17%), and

TABLE 2. Patient Characteristics

	All Patients (n=136)	Patients With Intraoperative TEE (n=38)	Patients With Postoperative TTE (n=68)
Age, y			
Mean*	70.5±9.5	68.3±9.3	69.9±10.2
Range	39–92	46–84	44–84
Sex, %			
Male	54	53	54
Female	46	47	46
Extent of coronary artery disease, %			
Left main disease	28	21	32
Two-vessel disease	22	26	22
Three-vessel disease	78	74	78
Left ventricular function, %			
Normal (EF ≥50%)	22	21	16
Mild dysfunction (EF 40–49%)	25	14	23
Moderate dysfunction (EF 30–39%)	34	38	35
Severe dysfunction (EF <30%)	19	28	26
Mean ejection fraction*	38.1±12.3	35.8±12.4	35.9±11.9
Cardiac presentation			
Unstable angina, %	57	47	63
Cardiogenic shock, %	7	5	12
Prior myocardial infarction, %	77	71	82
<6 h	1	4	2
6–24 h	3	7	4
1–21 d	46	41	43
>21 d	50	48	52
Prior PCI, %	10	16	3
Preoperative IABP, %	22	26	26
NYHA Functional Class			
I	20%	26%	12%
II	18%	15%	17%
III	37%	41%	38%
IV	26%	18%	33%
Mean*	2.7±1.1	2.5±1.1	2.9±1.0
Preoperative rhythm, %			
Normal sinus rhythm	81	87	79
Atrial fibrillation	13	11	13
Paced	6	3	6
Comorbid conditions, %			
Smoker	65	71	69
Diabetes mellitus	41	50	41
Hypertension	66	58	60
Renal insufficiency	17	16	22
COPD	15	21	22
Peripheral vascular disease	21	18	25
Cerebrovascular disease	19	21	21

*Mean±SD.

EF indicates ejection fraction; PCI, percutaneous coronary intervention; IABP, intra-aortic balloon pump; and COPD, chronic obstructive pulmonary disease.

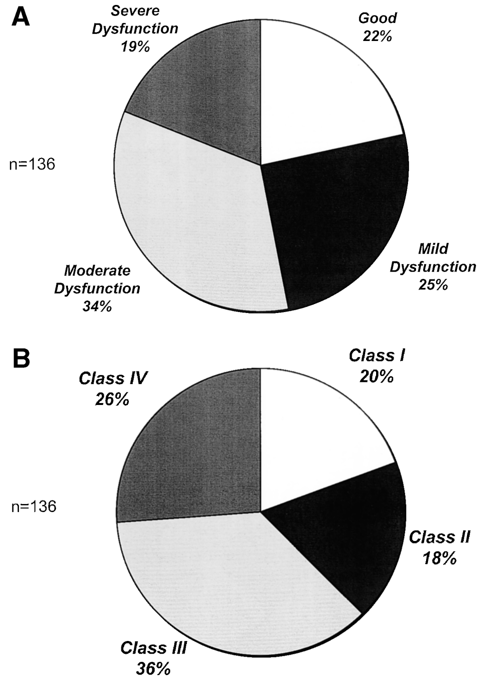

Figure 1. Distribution of preoperative left ventricular function (top) and functional status (bottom) among overall group of 136 patients.

chronic obstructive pulmonary disease (15%), were not uncommon.

Perioperative Results

Perioperative Data

Perioperative data are shown in Table 3. The majority of patients (57%) underwent elective surgery. The mean number of bypass grafts was 3.2±0.9. Mean ischemic (cross-clamp) time was 62.7±23.4 minutes, and mean cardiopulmonary bypass time was 90.3±29.3 minutes. Median ventilatory support time, intensive care unit stay, and hospital length of stay were 8 hours, 2 days, and 8 days, respectively.

TABLE 3. Perioperative Data

	All Patients (n=136)
Operative timing, %	
Elective	57
Urgent	34
Emergent	10
Number of grafts*	3.2±0.9
Internal mammary artery graft, %	65
Operative times, min*	
Ischemic	62.7±23.4
Cardiopulmonary bypass	90.3±29.3
Median recovery times	
Ventilatory support, h	8
Intensive care unit stay, d	2
Postoperative hospital stay, d	8

*Mean±SD.

TABLE 4. Operative Mortality and Morbidity

	All Patients (n=136)
Operative (30-day) mortality,* %	2.9
Perioperative complications, %	
Cardiac	
Perioperative MI	3.7
Postoperative IABP	5.1
New atrial fibrillation	32.4
Permanent heart block	2.9
Reoperation for bleeding	3.8
Cerebrovascular accident	2.9
Deep sternal wound infection	0.7

*Within 30 days or same hospitalization.
MI indicates myocardial infarction; IABP, intra-aortic balloon pump.

Operative Mortality

There were 4 operative deaths, 3 cardiac and 1 due to complications of a sternal wound infection, for an overall 30-day operative mortality rate of 2.9% (Table 4). The incidence of perioperative complications was within the expected range for this time period.

Echocardiographic Results

The results of intraoperative TEE and postoperative TTE are shown in Table 5 and summarized in Figures 2, 3, and 4. In 90% of the 38 patients who underwent intraoperative TEE, MR severity was downgraded from moderate (3+) to mild or less (0 to 2+). More than one third of patients were downgraded at least 2 grades to no more than trace MR (0 to 1+). The decrease in mean MR severity from 3.0 to 1.4 was statistically significant ($P<0.001$). Of the 68 patients who underwent postoperative TTE, 40% had residual MR of at least moderate severity (3 to 4+). This represented ≈20% of the overall group of 136 patients. Only 8% of patients had what can be described as resolution of their MR to trace or less (0 to 1+). The remaining 52% of patients showed some improvement but were left with mild (2+) residual MR. The decrease in mean MR severity from 3.0 to 2.3 was statistically significant ($P<0.001$).

Analysis of the 18 patients who had both intraoperative TEE and postoperative TTE showed very similar results (Table 5). The results for each of these 18 patients are illustrated in Figure 4. Although this represents a relatively small proportion of the overall group, it appears that downgrading of the severity of MR on intraoperative TEE does not predict improvement on postoperative TTE. For example, among the 7 patients who were downgraded to no MR on intraoperative TEE, 3 returned to 3+ MR and 4 returned to 2+ MR on the postoperative TTE.

Discussion

This retrospective analysis of 136 patients with moderate ischemic MR who underwent CABG was conducted in an attempt to determine whether CABG alone corrects the MR in the short term. The 2 key findings are that (1) nearly all patients had some downgrading of their MR on intraoperative

TABLE 5. Echocardiographic Results

	Preoperative (n=136)	Intraoperative TEE (n=38)	Postoperative TTE (n=68)	Patients With Both Intraoperative and Postoperative TEE (n=18)
MR severity, %				
0+	0	29	4	6
1+	0	8	4	6
2+	0	53	51	56
3+	100	11	37	33
4+	0	0	3	0
Mean MR grade*	3.0±0.0	1.4±1.0†	2.3±0.8†	2.2±0.8†

*Mean±SD.
†P<0.001 vs preoperative.

TEE, and (2) although most patients had some improvement in their MR, many patients were left with moderate or severe MR, and only a small number showed complete or near-complete resolution of the MR.

Downgrading of MR by Intraoperative TEE

Ninety percent of the patients with moderate (3+) MR who underwent intraoperative TEE had their MR downgraded to mild or less (0 to 2+). In nearly one third of these patients, there was no detectable MR on intraoperative TEE. This phenomenon has been described previously. Bach et al[19a] compared preoperative TEE under intravenous conscious sedation with intraoperative TEE under general anesthesia. They noted a significant decrease in the size of the regurgitant jet in patients with "functional" MR but with flail leaflets. Grewal et al[19b] performed a similar study limited to patients with moderate or severe MR. Half of their patients were downgraded at least 1 grade, and this effect was again limited to those with functional MR.

The mechanism underlying this phenomenon is almost certainly the unloading effect of general anesthesia. Arterial and venous vasodilatation decrease afterload and preload, respectively. Although the effects of afterload on MR are generally well recognized, the effects of preload are underappreciated and may in fact be more important. Functional MR is a dynamic phenomenon resulting from poor leaflet coaptation. Increased preload results in left atrial, left ventricular, and annular dilatation, which decreases the degree of coaptation and worsens MR. Grewal et al documented decreased end-diastolic and end-systolic volumes under general anesthesia that support the role of altered loading conditions in this phenomenon.

Our results show a more dramatic downgrading effect than either of these studies. This may be related to several factors. All of our patients had functional MR, whereas the other studies included patients with flail leaflets who did not show any downgrading, which may have diluted the overall effect. In addition, our patients had a preoperative TTE or ventriculogram, whereas theirs had a preoperative TEE. Intravenous conscious sedation during preoperative TEE may have a mild unloading effect that may not be present on preoperative TTE.

Although this finding supports the use of careful preoperative echocardiography in patients scheduled for CABG with suspected MR, it does not diminish the importance and utility of intraoperative TEE in this setting. On the contrary, TEE can providing important detailed anatomic information. In addition, intraoperative TEE with provocative testing to increase both preload and afterload may clarify the physiological importance of the MR and assist with intraoperative decision making.[7,20]

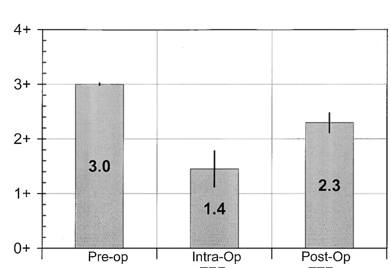

Figure 2. Mean severity of MR preoperatively (Pre-op), on intraoperative (Intra-Op) TEE, and on postoperative (Post-Op) TTE. Error bars indicate 95% CIs for means.

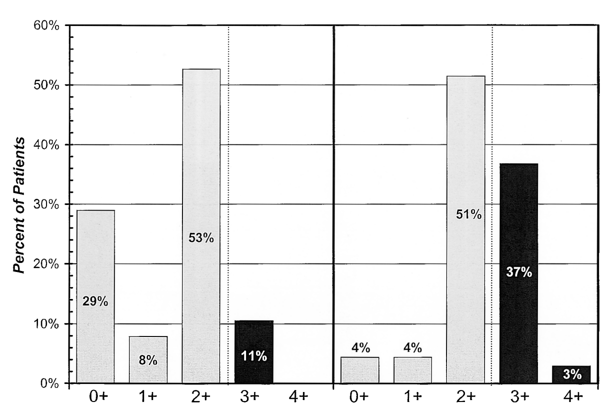

Figure 3. Distribution of MR severity on intraoperative (Intra-op) TEE and postoperative (Post-op) TTE. Light bars to left of dotted line represent patients in whom MR severity improved; dark bars to right of dotted line represent patients in whom MR severity stayed the same or worsened.

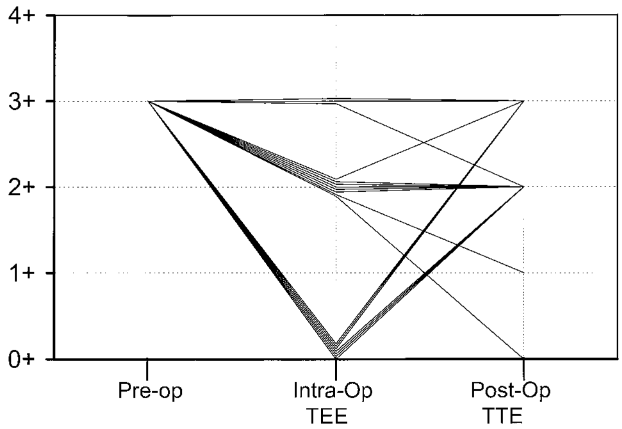

Figure 4. Evolution of MR severity in each of a subset of 18 patients who underwent both intraoperative (Intra-Op) TEE and postoperative (Post-Op) TTE. Each line represents a single patient.

Effect of CABG on MR by Postoperative TTE

Forty percent of our patients who underwent postoperative TTE showed no improvement with CABG alone and were left with moderate or severe (3 to 4+) residual MR. Approximately 50% of patients had some improvement and were left with mild (2+) residual MR. Only a few remaining patients (<10%) had significant improvement, with no more than trace (0 to 1+) residual MR. These results suggest that CABG alone has an inconsistent and relatively weak impact on moderate ischemic MR. Only a few previous studies address this issue directly, and they differ in their conclusions.

Two reports have suggested that CABG alone can correct ischemic MR. Balu et al,[1] in a report from 1982, presented preoperative and postoperative ventriculography data on a heterogeneous group of 12 patients with ischemic MR and suggested that CABG alone improves MR and functional status. This older study is limited by the small, heterogeneous patient population.

In a more recent report, Christenson et al[2] reviewed 56 patients with severe left ventricular dysfunction (ejection fraction ≤25%) and various degrees of MR by preoperative echocardiography who underwent CABG alone. They observed that 93% of patients had no more than trace (0 to 1+) MR, and the remaining patients had mild (2+) MR on postoperative echocardiography. They concluded that "moderate co-existing MR seems to normalize after myocardial revascularization and should not be surgically corrected therefore at the primary operation."

The study by Christenson et al,[2] however, has several limitations that, in our opinion, make it difficult to interpret and do not justify this broad recommendation. Most importantly, only 7 patients (13%) in the study had moderate (3+) preoperative MR, and >40% had trace (1+) MR. In addition, nearly 10% of these patients underwent concomitant left ventricular aneurysm repair, which can improve MR by decreasing ventricular dimensions. This may explain the unusually large increase in mean ejection fraction (18% to 44%) compared with most reports on CABG in severe left ventricular dysfunction. The postoperative echocardiogram was performed anywhere from 3 to 36 months after surgery, which makes comparison of these results difficult. Finally, their report was limited to the subset of patients with severe preoperative left ventricular dysfunction, which represented 19% of our group. Incidentally, this subgroup in the present report had results that were nearly identical to those of the overall group, with 34% of patients showing moderate to severe (3 to 4+) residual MR and only 7% with no more than trace (0 to 1+) MR, in sharp contrast to the results in the study by Christenson et al.[2]

One recent study by Czer et al[12] did suggest that revascularization alone was ineffective in correcting ischemic MR. Postbypass intraoperative TEE was used to compare 25 patients who underwent CABG alone with 24 patients who underwent suture annuloplasty. In the CABG-alone group, there was no change in annular diameter, leaflet-to-annulus ratio, or mean MR grade. That study was also limited by the fact that most patients had mild MR or less. In addition, the hazards of interpreting MR severity by TEE without controlling loading conditions have been described above.

Clinical Implications

The present study addressed the specific question of whether CABG alone corrects moderate ischemic MR in the short-term. Although many patients had some improvement in their MR, a significant proportion were left with moderate to severe (3 to 4+) MR. The long-term clinical implications of these results are not specifically addressed in the present study. Whether these results justify more liberal use of mitral annuloplasty depends on the answer to 2 follow-up questions: (1) Can mitral annuloplasty reliably and predictably correct moderate ischemic MR, and what is the additional operative risk of this procedure in the current era? (2) What is the long-term impact of residual MR on functional status and survival?

Success Rate and Operative Risk of Mitral Annuloplasty

Although it has been our recent experience that nearly all cases of Carpentier type I or IIIB moderate ischemic MR can be corrected with a restrictive annuloplasty, few reports specifically address this issue. Czer et al[15] and Bolling et al[17] found that ring annuloplasty was successful at correcting functional ischemic MR in nearly all patients. Dion et al[7] reported some residual MR in 15% of patients undergoing ring annuloplasty for ischemic MR.

The additional operative risk, in the current era, of concomitant mitral annuloplasty has been difficult to extract from the literature. We recently presented our improving results with this procedure and reported a 3.7% operative mortality rate in our most recent cohort of patients with moderate ischemic MR.[16] Other studies[17,18] also suggest improving operative results (4% to 6% mortality rates), but none address this specific patient population. Results from studies reporting relatively high operative mortality rates (8% to 15%) are difficult to extrapolate because they include a relatively heterogeneous group of patients, including those undergoing complex repairs or replacement,[6,7] those from the remote past,[6,9,21] and those with significant residual MR after repair.[7,10]

Impact of Residual MR on Late Survival

Although mitral annuloplasty may successfully correct moderate ischemic MR at the time of CABG with little additional operative risk, skeptics have argued that residual MR after CABG alone does not have an adverse effect on late functional status or survival. The Emory group has twice reported on a cohort of 58 patients undergoing CABG alone for moderate MR between 1977 and 1983.[3,5] In their most recent update,[3] 5- and 10-year actuarial survival was nearly identical to that of a control group without preoperative MR undergoing CABG during the same time period. The authors conclude that moderate ischemic MR should not be routinely corrected at the time of CABG.

Patients in the Emory cohort differ from ours in several important respects, possibly reflecting the 15-year interval between the groups. Our patients were more likely to be older (mean age 70 versus 63 years), to have left ventricular dysfunction (mean ejection fraction 35% versus 53%), and to have class III or IV congestive heart failure (62% versus 10%). These differences are important because by their own analysis, evidence of congestive heart failure and age were independent predictors of late death. Perhaps as important, nearly 25% of their patients had nonischemic etiologies such as leaflet prolapse or rheumatic heart disease, whereas we limited ourselves to those with functional MR. Their univariate analysis shows a trend toward higher mortality in patients with ischemic MR. Finally, they included patients undergoing reoperation and those undergoing repair of left ventricular aneurysms. These differences raise the question of whether these long-term findings from a heterogeneous cohort of patients from the remote past can be applied to patients in the current era with a different preoperative profile.

Two other studies[4,22] suggest that CABG alone does not affect long-term survival in patients with moderate ischemic MR. Both of these studies, however, were also limited by a heterogeneous patient population from the remote past with various degrees of MR. Two large studies in the 1980s suggest that MR is an independent risk factor for late death in patients undergoing CABG.[13,14]

Impact of Residual MR on Late Functional Status

There is limited information in the literature on the late functional status of patients undergoing CABG alone for moderate ischemic MR. The Emory study[3,5] reported a trend toward more class III and IV angina (29% versus 6%) and congestive heart failure (14% versus 6%) compared with case-matched controls. On the other hand, Bolling et al[17] reported that nearly all patients undergoing mitral valve repair at the time of CABG moved from class III or IV to class I or II. These findings raise the possibility that even if the significant rate of residual MR noted in the present study does not result in decreased long-term survival, it may adversely affect long-term functional status and quality of life. Concomitant mitral valve repair may therefore be justified, if it can be performed with relatively low operative risk, to improve long-term functional status. This may be particularly important in our patient population given the high incidence of preoperative left ventricular dysfunction and congestive heart failure. Bolling et al[23] and Chen et al[8] have clearly demonstrated improved functional status after mitral valve repair in a broad group of patients with severe left ventricular dysfunction, many with an ischemic etiology. This may suggest that patients with left ventricular dysfunction may extract greater benefit from mitral valve repair at the time of CABG for moderate ischemic MR.

Study Limitations

The primary limitation of the present study is that it is a retrospective analysis, susceptible to various sources of bias. The decision to forgo concomitant mitral valve repair was not based on specific preoperative criteria but solely on surgeon preference. Individual surgeons differed in their threshold for exploring the mitral valve based on their assessment of the literature, with some surgeons performing CABG alone as a matter of policy and others likely swayed by findings on intraoperative TEE.

We doubt this variability introduced significant bias for 2 reasons. First, one would suspect that in deciding to forgo mitral valve exploration, the surgeon had determined that in his clinical judgment, the patient would be adequately treated with CABG alone. This would suggest that unless the surgeon was fundamentally opposed to intervening under any circumstance, patients with a higher likelihood of benefiting from CABG alone would be selected. Second, we performed a separate analysis of data stratified by surgeon, and although the numbers in each group were relatively small, the patient profiles and echocardiographic results did not differ significantly.

A second limitation is the selective use of echocardiography, again based on surgeon discretion and not on specific preoperative criteria. This potential bias could have magnified the observed results and overstated the proportion of patients with downgrading of MR on intraoperative TEE and those with moderate to severe residual MR on postoperative TTE.

We think that it is unlikely that this had a significant effect on our key results for several reasons. First, even if the 68 patients undergoing postoperative TTE were more likely to have significant residual MR, the 27 patients with moderate to severe (3 to 4+) MR still represent a significant proportion of the overall group of 136 patients. We can confidently state that at a minimum, 20% to 40% of the overall group was left with significant residual MR.

Second, the preoperative profiles of the subgroups of patients who underwent intraoperative TEE and postoperative TTE were very similar to that of the overall group, as shown in Table 2. Given these similarities, it seems unlikely that the effects of general anesthesia on the intraoperative TEE results and the impact of CABG alone on the postoperative TTE would have been significantly different if all patients had undergone both studies.

Finally, not only were the patients who underwent intraoperative TEE similar in their preoperative characteristics, the 18 patients who underwent both studies had very similar results, as shown in Table 5. Figure 4 further suggests that downgrading of the MR by intraoperative TEE does not predict improvement or resolution of MR on postoperative TTE. This subgroup analysis again supports the notion that the 2 subgroups are generally representative and that the key

results of the present study can be safely extrapolated to a broad population of patients with moderate ischemic MR undergoing CABG.

Conclusions

Patients requiring surgical revascularization with suspected ischemic MR should be carefully assessed with preoperative echocardiography to determine the severity of the MR. Although intraoperative TEE can be very helpful in more precisely assessing anatomic details, the severity of MR will be downgraded in most patients, and provocative testing with increased preload and afterload may be necessary to counter this effect. CABG alone will leave many patients with moderate or severe (3 to 4+) residual MR and may not be the optimal therapy for many patients. Wider application of mitral annuloplasty may be warranted in this patient group. More detailed analysis is necessary to determine preoperative factors that predict residual MR after CABG alone, and long-term follow up is necessary to determine the impact of residual MR on late symptoms and survival. A prospective study with routine echocardiography is necessary to confirm our results, and a randomized trial of CABG with or without mitral annuloplasty may be warranted to determine the optimal treatment strategy.

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