MITRAL VALVE REPAIR: CURRENT METHODS AND RESULTS

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SURGICAL MITRAL VALVE REPAIR

- The Rationale for Mitral Repair over Mitral Replacement
- Mitral Valve Functional Anatomy
  - Basic Anatomy
  - Leaflet Classification
  - Carpentier Classification of Mitral Regurgitation
- The Basic Etiologic Subsets of Mitral Valve Disease
  - Degenerative
  - Rheumatic
  - Endocarditic
  - Functional Mitral Regurgitation
- Repair Methods and Results for the 4 Basic Etiologic Subsets
- Indications

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Source: UPHS Clinical Outcomes Database
MITRAL VALVE REPAIR vs REPLACEMENT

• Is Repair better than Replacement?
• Is there Evidence?
  – PRT’s?
THE RATIONALE FOR MITRAL REPAIR OVER MITRAL REPLACEMENT

• Current dogma: Repair is better than Replacement.
• All Surgeons/Cardiologists abide to this belief.
• AHA/ACC Guidelines for Mitral Surgery supports Repair over Replacement if:
  – Appropriate Valvular Substrate is present
  – Experienced surgical team/center
    • 60-90% Repair Rate for Mitral Regurgitation
• Evidence:
  – No PRT’s (and there never will be)
  – Large series
  – Multicenter trials
  – Meta-analysis
THE RATIONALE FOR MITRAL REPAIR OVER MITRAL REPLACEMENT

• Mayo Clinic (1995)
• Mitral Regurgitation
  – Mixed etiology
• N=409
  – 195 repair
  – 214 replacement

Valve Repair Improves the Outcome of Surgery for Mitral Regurgitation
A Multivariate Analysis

Maurice Enriquez-Sarano, MD, Hartzell V. Schaff, MD, Thomas A. Orens, MD, A. Janal Tajik, MD, Kent R. Bailey, PhD, Robert L. Frye, MD

From the Division of Cardiovascular Diseases and Internal Medicine (M.E.S., A.J.T., R.L.F.), Section of Cardiovascular Surgery (H.V.S., T.A.O.), and Section of Biostatistics (R.K.B.), Mayo Clinic and Mayo Foundation, Rochester, Minn.

Background: Mitral valve repair has been suggested as providing a better postoperative outcome than valve replacement for mitral regurgitation, but this impression has been obscured by differences in baseline characteristics and has not been confirmed in multivariate analyses.

Methods and Results: The outcomes in 195 patients with valve repair and 214 with replacement for organic mitral regurgitation were compared using multivariate analysis. All patients had preoperative echocardiographic assessment of left ventricular function. Before surgery, patients with valve repair were less symptomatic than those with replacement (42% in New York Heart Association functional class I or II versus 24%, respectively; *P*<.001), had less atrial fibrillation (41% versus 53%, *P*<.017), and had a better ejection fraction (63.6% versus 60.12%, *P*<.016). After valve repair, compared with valve replacement, overall survival at 10 years was
Plot of overall survival compared for valve repair and valve replacement groups (P=.0004)

Plots of overall survival compared for repair and replacement groups for patients who had (left) or did not have (right) associated coronary artery bypass graft surgery (CABG)

REPAIR VS REPLACEMENT

• UBC
• 2003
• 322 MVP vs 322 MVR
• Mixed etiology
• Propensity score analysis

Outcome of Mitral Valve Repair or Replacement: A Comparison by Propensity Score Analysis

Robert R. Moss, MD, Karin M. Humphries, PhD, Min Qiao, PhD, Christopher F. Thompson, MD, James G. Abel, MD, Gary Fredes, MD, Band I. Mintz, MD

Background—There are no randomized trials comparing outcomes after mitral valve (MV) repair and replacement. Propensity score analysis is a powerful tool that has the potential to reduce selection bias in nonrandomized studies.

Methods—From the BC Cardiac Registry, 2,660 patients presenting for MV surgery, with or without CABG between 2001 and 2002, were identified. MV repair was compared with 322 MVP and 322 MVR patients matched by propensity score to an equal number of MV replacement patients. We compared survival and freedom from re-operation outcomes using Cox proportional hazards model analysis. Multivariable analysis was then used to compare outcomes in 358 MV repair patients with 352 MV replacement patients who had undergone chordal sparing surgery.

Results—The comparison groups, generated using propensity scores, were well balanced with respect to all collected baseline risk factors. Median follow-up time was 3.4 years. Patients undergoing MV repair had significantly improved survival (RR 0.46; 95% CI 0.23 to 0.75) but a trend toward more reoperations (RR 2.51; 95% CI 1.60 to 4.47) compared with patients undergoing replacement. Mitral valve repair patients still had better survival (RR 0.52; 95% CI 0.32 to 0.88) compared with MV replacement patients who had undergone chordal sparing surgery.

Conclusions—We used propensity score methods to reduce selection bias in a population-based cohort of patients undergoing MV repair/replacement. Repair was associated with better survival, but a trend to increased re-operation (Circulation. 2005;112[Suppl III]:III-90-94).

Key Words: mitral valve • prosthesis • valvuloplasty • surgery

The last decade has seen a significant shift in the surgical management of mitral regurgitation. Mitral valve (MV) repair is now a practical alternative to mitral valve replacement in an increasing number of patients with myxomatous and other etiologies of mitral valve disease. Technical advances in operative procedures have allowed valve repair to be performed in patients with severe impairment of left ventricular systolic function and in those where ischemia is thought to be the cause of the mitral regurgitation. In simultaneous, it is not clear that mitral repair is superior to replacement in all clinical settings. The frequency of mitral valve repair is no longer restricted to scenarios of aortic valve replacement surgery; and it seems unlikely that such a trial will ever be undertaken.

Programs of aggressive repair strategy point toward the fact that mitral valve repair is superior to replacement in all clinical settings. There are no prospective randomized trials comparing outcomes after mitral valve (MV) repair versus replacement, and it seems unlikely that such a trial will ever be conducted.

Using traditional multivariable adjustment methods, several nonrandomized studies suggest that patients undergoing repair have improved survival, fewer postoperative left ventricular failures, and lower postoperative mortality compared with patients undergoing replacement, although this experience has not been universally confirmed. Traditional methods...
Kaplan-Meier curves for 30-day post-surgery survival in the MV repair and replacement patients (propensity-matched cohort)

Kaplan-Meier (KM) survival curves for the MV repair and replacement patients (propensity-matched cohort)


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Kaplan-Meier curves for freedom from reoperation in the MV repair and replacement patients (propensity-matched cohort)

Kaplan-Meier curves for MV reoperation free survival in MV repair and MV replacement patients (propensity-matched cohort)


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The hazard ratios for MV repair compared with MV replacement for all endpoints and their associated confidence intervals (propensity-matched cohort)


Circulation
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Mitral Valve Replacement Versus Repair: Propensity-Adjusted Survival and Quality-of-Life Analysis

Janne J. Jokinen, MD, Mikko J. Hippeläinen, MD, PhD, Otto A. Piltänen, MD, PhD, and Juha E. K. Hartikainen, MD, PhD

Department of Cardiothoracic Surgery, Helsinki University Hospital, Helsinki, and Department of Surgery, Anesthesiology, and Cardiology, Kuopio University Hospital, Kuopio, Finland

Background. We investigated whether mitral valve repair (MVR) is superior to mitral valve replacement (MVR) in terms of survival and quality of life during the long-term follow-up.

Methods. One hundred eighty-four consecutive patients underwent MVP or MVR for mitral regurgitation with or without concomitant coronary artery bypass grafting. Clinical data were recorded prospectively, and the data for the Nottingham Health Profile quality-of-life analysis was collected cross-sectionally. Propensity score analysis was used for the study group matching.

Results. The mean follow-up time was 7.3 ± 1.4 years. After adjustment for baseline characteristics by the propensity score method, there was a statistically significant survival benefit for the patients who underwent MVR (p = 0.02). Risk factors for death were preoperative unstable angina pectoris (relative risk ratio, 4.4; 95% confidence interval, 2.2 to 8.9; age older than 60 years (relative risk ratio, 1.4; 95% confidence interval, 1.0 to 1.8). Use of mitral prosthesis (relative risk ratio, 2.7; 95% confidence interval, 1.4 to 5.3), preoperative renal insufficiency (relative risk ratio, 1.9; 95% confidence interval, 1.0 to 3.6), and preoperative cerebrovascular disorder (relative risk ratio, 2.7; 95% confidence interval, 1.0 to 7.0). The quality of life of the MVP and MVR groups did not differ from each other, but the MVP and the MVR patients had lower energy and mobility scores than an age- and sex-matched reference population.

Conclusions. Survival is longer after MVP than after MVR. The quality of life of MVP and MVR patients does not differ from each other. In terms of most quality-of-life variables, patients who undergo mitral valve operations cope similarly to an age- and sex-matched reference population. Only the scores reflecting energy and mobility were lower in the patients who were operated on than in the reference population.


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Meta-Analysis: Mitral Valve Repair vs Replacement

• Meta-Analysis (2006)
• 29 studies
• Repair better than replacement for
  • Degenerative
  • Rheumatic
  • Endocarditic
  • ± IMR

1. Introduction

Repair and replacement of the mitral valve are two independent, though specific techniques for treating mitral valve disease. The surgical community has become aware of the known merits of mitral valve repair compared to replacement. Repair is associated with a lower risk of re-operation, thrombembolism and valve infection than mitral valve replacement [1]. Despite these perceived benefits, the results of such outcomes among studies that simultaneously compared the two treatment modalities have not been totally consistent. We believe that a meta-analysis comparing the two techniques, mitral valve replacement versus mitral valve repair, is timely and important, to provide stronger summary information and future directions.

Differences in understanding, surgical and institutional experience still remain key determining factors for selection of surgical therapy as a non-controlled setting.

Nonetheless, there has been a significant shift towards repair in the surgical management of mitral valve regurgitation towards the end of last century. Those who advocate repair understand that left ventricular function is better after repair than after replacement [1,2]; furthermore, repair may offer a lower risk for embolism. However, it has been reported that repair of moderate ischemic mitral valve increases the probability of the patient spending more time on cardiopulmonary bypass, with its associated potential risks [3]. In addition, the application of existing repair techniques requires acquisition of “years of experience” and mental cognition of the valve’s morphology. These two requirements for achieving successful repair make valve replacement an attractive and technically simpler alternative in certain circumstances. More recently, late survival outcome for ischemic mitral valve disease has been shown to be indifferent to repair versus replacement [4,5].

In this study, meta-analysis was used to summarize information from 29 studies using approximately 13,000 subjects, in an attempt to achieve a closer understanding of the comparison of some outcome measures for these two methods of treatment of mitral valve disease.
## REPAIR VS REPLACEMENT
### 30 day Survival

<table>
<thead>
<tr>
<th>Group by Etiology</th>
<th>Study name</th>
<th>Outcome</th>
<th>Odds ratio</th>
<th>Lower limit</th>
<th>Upper limit</th>
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<td>Early mortality</td>
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Overall: 2.24 (1.78, 2.80)
# Repair vs Replacement

## Total Survival

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<th>Study name</th>
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<th>Statistics for each study</th>
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<td>1.58 1.41 1.78</td>
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## Repair vs Replacement

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<th>Upper limit</th>
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Hazard ratio and 95% CI

Favors replacement  Favor repair

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<td>7.41</td>
</tr>
<tr>
<td>Thourani 2003</td>
<td>Reoperation</td>
<td>1.26</td>
<td>0.86</td>
<td>1.85</td>
</tr>
<tr>
<td>Yau 2000</td>
<td>Reoperation</td>
<td>0.19</td>
<td>0.10</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Hazard ratio and 95% CI

Favors replacement  Favor repair
SURGICAL MITRAL VALVE REPAIR

• The Rationale for Mitral Repair over Mitral Replacement

• Mitral Valve Functional Anatomy
  – Basic Anatomy
  – Leaflet Classification
  – Carpentier Classification of Mitral Regurgitation

• The Basic Etiologic Subsets of Mitral Valve disease
  – Degenerative
  – Rheumatic
  – Endocarditic
  – Functional MR

• Repair Methods and Results for the 4 Basic Etiologic Subsets
MITRAL ANATOMY

- **Leaflets**
  - Anterior (aortic) leaflet
  - Posterior (mural) leaflet
- **Commissures**
- **Zone of Coaptation**
- **Annulus**
- **Sub-valvular apparatus**
  - Chordae tendineae
  - Papillary muscles
  - Left Ventricle
    - Valvulo-ventricular interaction
MITRAL ANATOMY

Anterior (septal) leaflet

Posterior (mural) leaflet
Leaflet Classification
LEAFLET CLASSIFICATION

A. Yacoub
   • Four leaflets

B. Kumar
   • Six leaflets

C. Carpentier
   • Two leaflets (A&P)
   • Six scallops
**CARPENTIER CLASSIFICATION FOR MITRAL REGURGITATION: Leaflet Motion**

<table>
<thead>
<tr>
<th>Normal Leaflet Motion</th>
<th>Excessive Leaflet Motion</th>
<th>Restricted Leaflet Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leaflet motion above the plane of the annulus</td>
<td>Leaflet tethering</td>
</tr>
<tr>
<td></td>
<td>Annular Dilatation</td>
<td>Chordal thickening and shortening (Rheumatic)</td>
</tr>
<tr>
<td></td>
<td>Leaflet Perforation</td>
<td>Papillary muscle displacement (IMR)</td>
</tr>
</tbody>
</table>

I. Leaflet motion below the plane of the annulus  
- Annular Dilatation  
- Leaflet Perforation  

II. Leaflet motion above the plane of the annulus  
- Flail (torn chord)  
- Prolapse  
  (Myxomatous Degeneration)  

IIIa. Leaflet tethering  
- Chordal thickening and shortening (Rheumatic)  

IIIb. Leaflet Tethering  
- Papillary muscle displacement (IMR)
• Combined Type I and Type IIIb
ZONE OF LEAFLET COAPTATION

Mitral Annular Coaptation
“Coaptation Reserve”

- Clear zone
- Rough zone

Anterior leaflet
Posterior leaflet
Body zone (smooth)
Coaptation zone (rough)

Smooth zone
Rough zone
Alfieri (edge-to-edge) Repair (Coaptation Enhancement)
SURGICAL MITRAL VALVE REPAIR

• The Rationale for Mitral Repair over Mitral Replacement
• Mitral Valve Functional Anatomy
  – Basic Anatomy
  – Leaflet Classification
  – Carpentier Classification of Mitral Regurgitation
• The Basic Etiologic Subsets of Mitral Valve disease
  – Degenerative
  – Rheumatic
  – Endocarditic
  – Functional Mitral Regurgitation
    • Ischemic MR
    • MR Associated with Dilated Cardiomyopathy
• Repair Methods and Results for the 4 Basic Etiologic Subsets
Mitral Repair: The Significant Etiologic Categories
the framework for understanding the key concepts of mitral valve repair

Myxomatous
Rheumatic
Endocarditis
Functional MR
Mitral Repair: 
The Significant Etiologic Categories and resultant pathophysicsology

ETIOLOGY
• Degenerative
• Rheumatic
• Endocarditis
• Functional Mitral Regurgitation

PATHOPHYSIOLOGY
• Regurgitation
• Stenosis
• Mixed MR/MS
Mitral Repair:
The Significant Etiologic Categories
the framework for understanding the key concepts of mitral valve repair

<table>
<thead>
<tr>
<th></th>
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<th>Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degenerative</td>
<td>+++</td>
<td></td>
</tr>
<tr>
<td>Rheumatic</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Functional MR</td>
<td>+++</td>
<td></td>
</tr>
</tbody>
</table>
Causes of Mitral Insufficiency

N = 694

Edward H. AvD; Harrison's Advances in Cardiology
Mitral Valve Pathology

Mitral Repair: The Significant Etiologic Categories
the framework for understanding the key concepts of mitral valve repair

<table>
<thead>
<tr>
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<td>++++</td>
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<tr>
<td>Rheumatic</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Functional MR</td>
<td>++++</td>
<td></td>
</tr>
</tbody>
</table>
Mitral Repair: The Significant Etiologic Categories

the framework for understanding the key concepts of mitral valve repair

• DEGENERATIVE DISEASE
  A. Myxomatous (Barlow’s Disease)
  B. Fibroelastic Disease
  C. Marfan’s Syndrome

• Connective Tissue Disorder
MYXOMATOUS DEGENERATION
MYXOMATOUS DEGENERATION

- Heterogeneity of pathologic anatomy in degenerative disease
Methods of Mitral Valve Repair for Degenerative Disease
ALAIN CARPENTIER
the “French correction”

• Carpentier (1983)
• Concepts:

• Surgical Methods:
  – Resection of redundant mitral leaflet tissue
  – Chordal transfer
  – Chordal shortening
  – Remodeling Annuloplasty
POSTERIOR LEAFLET REPAIR

• The most common degenerative lesion
  – posterior leaflet
  – P2 prolapse or P2 flail
REDUNDANT LEAFLET RESECTION
(Quadrangular resection of the middle scallop of the posterior leaflet)

• Leaflet resection

• Reconstruction

The annulus is plicated with 2 pledgetted sutures. The leaflet edges are reapproximated with 5.0 braided suture and an annuloplasty is placed.
With or without sliding-plasty
Posterior Leaflet Resection

- P1 or P3 resection
- Less common than P2 resection
ANTERIOR LEAFLET REPAIR

- More complex
- Lower frequency of successful repair
- Lower freedom from reoperation
Prolapse Site and Repair Rate

- Posterior
- Bileaflet
- Anterior

%
• Triangular Resection

• Chordal Shortening

• Chordal Transfer

• Chordal Replacement
CHORDAL TRANSFER
ANTERIOR LEAFLET REPAIR

CHORDAL TRANSFER IS SUPERIOR TO CHORDAL SHORTENING

Several techniques are currently used to repair anterior leaflets with elongated or ruptured chordae. To evaluate the efficacy of these techniques, we analyzed the case histories of 108 patients operated on from 1989 through 1992 with degenerative mitral valve disease and prolapse of the anterior leaflet. The mean age was 59 ± 15 years (range 18 to 87 years) and 74 (69%) were male. Methods: Chordal shortening was performed in 33 (29%) and chordal transfer in 77 (71%) of the repairs. Of the transfers, 58 (75%) were from the posterior to the anterior leaflet and 16 (21%) were from the secondary to the primary position of the anterior leaflet. Three patients had both types of transfers. Seventy-one (66%) patients had isolated repairs and the remainder had associated procedures. The degree of preoperative mitral regurgitation was 3+ or greater for 107 (99%) of the patients, none 3+ for shortening and 3.7 for transfer. Results: Four (4.0%) hospital deaths occurred, nine after isolated repair. Follow-up of hospital survivors was 100% complete at a mean of 4.0 years. A total of 421 patient-years of follow-up were available for analysis. There were seven late deaths, for a 5-year actuarial survival of 93%. Eleven patients underwent reoperation for recurrent mitral regurgitation. Five-year actuarial freedom from reoperation was 94.9% after chordal transfer and 74.1% after chordal shortening. $p = 0.048$. Independent predictors for reoperation include mitral regurgitation and prooperative New York Heart Association functional class III or IV. The mechanism of valve failure in six of seven patients undergoing reoperation after chordal shortening was rupture of the previously shortened chord. Conclusions: We conclude that chordal transfer is superior to chordal shortening, providing a more predictable correction of mitral regurgitation and a lower incidence of reoperation. Reoperations after chordal shortening are a result of rupture of the previously shortened chord.

From The Cleveland Clinic Foundation Department of Thoracic and Cardiovascular Surgery, Cleveland, Ohio.

Received for publication June 21, 1985; revisions received April 12, 1986; accepted for publication April 3, 1986.

Address for reprints: Nicholas G. Snodgrass, MD, Department of Thoracic and Cardiovascular Surgery, The Cleveland Clinic Foundation, 9500 Euclid Avenue, F22, Cleveland, OH 44195.

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Correction of anterior leaflet prolapse has been more difficult than reconstruction of the posterior leaflet. Poor results after anterior leaflet resection led Carpentier et al. (3) to introduce the technique of chordal transposition for repair of ruptured anterior chordae.

Chordal shortening was originally the preferred method for handling elongated chordae, but a number of surgeons have applied chordal transfer in this situation with excellent short-term results. The relative effectiveness of these techniques is unknown. To address this issue, we examined our experience with degenerative prolapse of the anterior leaflet repaired by either chordal transfer or chordal shortening.

Patients and methods

From 1989 through 1992, 188 patients underwent re-reconstruction of the anterior mitral leaflet for mitral regurgitation (MR). Mitral chordae or rupture were present in 127 patients, with 108 undergoing repair by chordal transfer or shortening. This group forms the basis of the study.
Reoperation: Chordal Transfer vs. Chordal Shortening

- Chordal Transfer
- Chordal Shortening

Percentage over years with a significance level of P = 0.0003.

JTCVS: Smedira et al.
CHORDAL REPLACEMENT
ANNULOPLASTY

- Reduction Annuloplasty

- Remodeling Annuloplasty
DURABILITY OF MITRAL REPAIR FOR DEGENERATIVE DISEASE

- CCF 1998
- 1072 patients
- 60% of MR patients repaired
- 92% 10 year freedom from reoperation

Background: Degenerative mitral valve disease is the most common cause of mitral regurgitation in the United States. Mitral valve repair is applicable in the majority of these patients and has become the procedure of choice. Objective: This study was undertaken to identify factors influencing the durability of mitral valve repair. Methods: Between 1985 and 1997, 1072 patients underwent primary isolated mitral valve repair for annular or subvalvular regurgitation caused by degenerative disease. Repair durability was assessed by multivariable risk factor analysis of reoperation. It was supplemented by a search for valve-related risk factors for death before reoperation. Three hospital deaths occurred (0.3%); complete follow-up (1052 patient-years) was available in 1062 of 1072 hospital survivors (98.3%). Results: At 10 years, freedom from reoperation was 93%. Among 30 patients who required reoperation for late mitral valve dysfunction, the repair failed in 16 (53%) as a result of progressive degenerative disease. Durability of repair was adversely affected by pathologic conditions other than posterior leaflet prolapse, use of chordal shortening, annuloplasty alone, and posterior leaflet resection without annuloplasty. Durability was greatest after quadrangular resection and annuloplasty for posterior leaflet prolapse and was enhanced by the use of intraoperative echocardiography. Death before reoperation was increased in patients having isolated anterior leaflet prolapse or valvular calcification and by use of chordal shortening or annuloplasty alone. Conclusions: Repair durability is greatest in patients with isolated posterior leaflet prolapse who have posterior leaflet resection and annuloplasty. Chordal shortening, annuloplasty alone, and leaflet resection without annuloplasty jeopardize late results. (J Thorac Cardiovasc Surg 1999;118:734-43)

Degenerative mitral valve disease is the most common cause of mitral regurgitation in the United States. With the use of current techniques, up to 95% of degenerative mitral valves can be repaired. Several large studies confirm high rates of freedom from reoperation after mitral valve repair. However, information concerning risk factors for reoperation is scarce.

From the Departments of Thoracic and Cardiovascular Surgery and Biometry and Epidemiology, The Cleveland Clinic Foundation, Cleveland, Ohio.

Read at the Seventy-Eighth Annual Meeting of the American Association for Thoracic Surgery, Boston, Mass, May 4-6, 1998. Manuscript received April 26, 1998; revised manuscript received June 10, 1998; revised manuscript received July 8, 1998; accepted for publication July 16, 1998.

Address for reprints: A. Marc Gillinov, MD, Department of Thoracic
DURABILITY OF MITRAL REPAIR FOR DEGENERATIVE DISEASE

- Carpentier 2001
- 162 patients
- > 20 years
- Non-rheumatic MR
- 74% freedom from cardiac events at 20 years

Very Long Term Results (More Than 20 Years) of Valve Repair With Carpentier’s Techniques in Nonrheumatic Mitral Valve Insufficiency

E. Braunberger, MD; A. Deloque, MD; A. Berrebi, MD; F. Abdallah, MD; J. A. Celestin, MD; P. Assmaout, MD; G. Chastel, MD; S. Claisseaud, MD; J. N. Filsouf, MD; A. Carpentier, MD

Background—Mitral valve repair is considered the gold standard in surgery of degenerative mitral valve insufficiency (DVI), but the long-term results (>20 years) are unknown.

Methods and Results—We reviewed the first 162 consecutive patients who underwent mitral valve repair between 1970 and 1984 for DVI due to nonrheumatic disease. The cause of DVI was degenerative in 146 patients (90%) and bacterial endocarditis in 16 patients (10%). DVI was isolated or, in 18 cases, associated with mitral insufficiency. The mean age of the 162 patients (69 men and 93 women) was 60.4 ± 12.6 years (range 22 to 77 years). New York Heart Association functional class was I, II, III, and IV in 26%, 35%, 52%, and 7% of patients, respectively. The mean cardiac output was 4.78 ± 0.6 L/min (range 3.00 to 6.49), and 73.6% (49%) patients had atrial fibrillation. Valve analysis showed that the main mechanism of DVI was type II Carpentier’s functional classification in 152 patients. The leaflet prolapse involved the posterior leaflet in 92 patients, the anterior leaflet in 28 patients, and both leaflets in 32 patients. Surgical techniques included Carpentier’s ring annuloplasty in all cases, a valve excision in 126 patients, and shortening or transposition of chords in 49 patients. During the first postoperative month, there were 5 deaths (3%) and 3 reoperations (4% valve replacements and 1 repeat repair). Six patients were lost to follow-up. The remaining 151 patients with mitral valve repair were followed during a median of 17 years (range 1 to 39 years; 2273 patient-years). The 10-year Kaplan-Meier survival rate was 48% (95% CI 40% to 57%), which is similar to the survival rate for a normal population with the same age structure. The 30-year rates were 9.9% (95% CI 11% to 27%) for cardiac death and 26% (95% CI 17% to 35%) for cardiac morbidity-mortality (including death from a cardiac cause, stroke, and sepsis). During the 20 years of follow-up, 7 patients were reoperated on once, 3 on 2 occasions, and 1 on 3 occasions, all due to the initial operation. Valve replacement was carried out in 5 patients, and repeat repair was carried out in 2 patients. At the end of the study, 85 patients remained alive (median follow-up, 18 years). Their median age was 76 years (age range 43 to 95 years). All except 3 years in New York Heart Association functional class III.

Conclusions—Mitral valve repair using Carpentier’s techniques in patients with nonrheumatic DVI provides excellent long-term results with a morality rate similar to that of the normal population and a very low incidence of reoperation.

(Circulation. 2001;104[Suppl I]:I-3-I-11.)

Key words: regurgitation • valve • mitral valve • heart disease • surgery • rheumatic heart disease

Outcome of Mitral Repair

A. Freedom from reoperation in patients with posterior, anterior and bileaflet prolapse
(97% of patients with posterior leaflet, 86% with anterior leaflet and 83% of patients with bileaflet prolapse were free of re-operation at 20 years)

B. Freedom from recurrent MR (3+ or 4+) according to AL, PL, or BL prolapse
Outcome of Mitral Repair

- Flameng 2003
- 242 patients
- Serial ECHO q 6 months
- 71% freedom from moderate to severe MR at 7 years
- Linearized recurrence rate of MR
  > I/IV 8.3%/year
  > II/IV 3.7%/year

Recurrence of Mitral Valve Regurgitation After Mitral Valve Repair in Degenerative Valve Disease

William Flameng, MD, PhD, Paul Henein, MD, PhD; Kai Bogdanski, MD

Background—Despite advances in mitral valve repair for degenerative valve disease, linearized recurrence rates are high. To our knowledge, no study has systematically investigated the linearized recurrence rate of mitral valve regurgitation following mitral valve repair for degenerative valve disease. The aim of this study was to analyze the recurrence of mitral regurgitation in a series of patients undergoing mitral valve repair for degenerative valve disease. All patients were operated on in the same institution, by the same surgeon, and with the use of similar repair techniques.

Methods

Patient Population
A group of 242 consecutive patients (mean age 62 years, 52% male) underwent mitral valve repair for degenerative disease. The majority of patients had a prior mitral valve procedure (68%) and surgery of 3 or more decades (89%). Mean aortic root diameter was 65%, and average pulmonary artery pressure was 48 mm Hg. The mean age of patients was 59 years, 25% were in mitral stenosis, and 2% had a paradoxical mitral valve. No patient was in New York Heart Association functional class IV.

Results

The recurrence of mitral regurgitation was assessed using echocardiographic follow-up of valve function, rate of repair, survival, and clinical outcome was used at 1 year after repair. Clinical outcome was excellent, survival was 90.5 ± 3%, freedom from reoperation was 94.5 ± 3%, and freedom from structural valve deterioration was 99 ± 1.7%. However, freedom from postoperative mitral regurgitation (I/IV) was 94 ± 1.4% at 1 month, 86 ± 4.9% at 3 months, and 77 ± 5.0% at 7 years. Freedom from severe mitral regurgitation (I/IV) was 98 ± 1.9% at 1 month, 93 ± 2.3% at 3 months, 91 ± 2.3% at 1 year, and 71 ± 7.9% at 7 years. The 7-year recurrence rate of non-ischemic mitral regurgitation (I/IV) was 8.1% per year, and of severe mitral regurgitation (I/IV) was 3.7% per year. No significant influence of the valve repair technique on the rate of recurrence was detected. The 7-year recurrence rate of non-ischemic mitral regurgitation (I/IV) was 8.1% per year, and of severe mitral regurgitation (I/IV) was 3.7% per year. No significant influence of the valve repair technique on the rate of recurrence was detected.

Conclusions—The results of this study demonstrate the feasibility of mitral valve repair for degenerative valve disease, and that this should be taken into account when asymptomatic patients are offered early mitral valve repair. (Circulation, 2003, 107(16):1603-1610.)

Key Words: echocardiography • mitral valve • follow-up study • mitral valve regurgitation

Degenerative mitral valve disease is the leading cause of mitral regurgitation in the Western world. Recent advances in mitral valve repair have led to the development of new surgical techniques. However, debate remains about the indications for these techniques, and whether they are superior to conventional surgical techniques.

Therefore, the aim of this study was to analyze the recurrence of mitral regurgitation in a series of patients undergoing mitral valve repair for degenerative valve disease. All patients were operated on in the same institution, by the same surgeon, and with the use of similar repair techniques.

A high percentage of patients had a prior mitral valve procedure (68%) and surgery of 3 or more decades (89%). Mean aortic root diameter was 65%, and average pulmonary artery pressure was 48 mm Hg. The mean age of patients was 59 years, 25% were in mitral stenosis, and 2% had a paradoxical mitral valve. No patient was in New York Heart Association functional class IV.

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Key Words: echocardiography • mitral valve • follow-up study • mitral valve regurgitation
OPPOSITION TO THE “FRENCH CORRECTION”

• The “American Correction”
  – Leaflet preservation (no resection)
  – Chordal replacement (5-0 Gore-Tex) for flail or prolapse
  – Large flexible complete annuloplasty ring
    • With Chordal Replacement
      – Based on the entire complete closed valve
    • Without Chordal Replacement
      – For Barlow’s Syndrome
“AMERICAN CORRECTION”

- Baylor 2006
- 152 patients
- 90% repair rate for all MR
- 100% repair rate for degenerative MR
- No Leaflet resection
AMERICAN CORRECTION

• 90% 10 year Freedom from Reoperation based on etiology

• 90% 10 year Freedom from Reoperation – complex vs simple
Mitral Repair: The Significant Etiologic Categories

the framework for understanding the key concepts of mitral valve repair

- Myxomatous
- Rheumatic
- Endocarditis
- Functional MR
MITRAL STENOSIS
MITRAL COMMISSUROTOMY

A. Closed
  • Surgical
  • Balloon
OPEN MITRAL COMMISSUROTOMY
OPEN VS CLOSED COMMISSUROTOMY

- NEJM
- PRT (1994)
- 60 patients
- Highly Selected Patients
- MVA
  - Balloon: $0.9 \pm 0.3 \text{ cm}^2$ to $2.1 \pm 0.6 \text{ cm}^2$
  - Surgery: $0.9 \pm 0.3 \text{ cm}^2$ to $2.0 \pm 0.6 \text{ cm}^2$
Hemodynamic Variables at Base Line and One Week, Six Months, and Three Years after Balloon Mitral Valvuloplasty or Open Surgical Commissurotomy

OPEN MITRAL COMMISSUROTOMY

- Commissurotomy
- Sub-annular Repair
  - Papillary muscle spitting
  - Fenestration
- Decalcification
- Annuloplasty
- Debridement
Rheumatic Mitral Repair

- Open Mitral Commissurotomy (1999)
- 183 patients
- Age: 40 ± 10.3
- Open Mitral Repair is superior to closed Repair
- Valve related Mortality and Morbidity was lower in the Open vs Closed repair group

Mitrail Commissurotomy, a Technique Outdated? Long-Term Follow-up Over a Period of 35 Years

Christian Dettler, MD, Teddy Fischlein, MD, Christina Feldmeier, MD, Georg Nollert, MD, Hermann Reichenspurner, MD, PhD, and Bruno Rolchert, MD
Department of Cardiac Surgery, Klinikum Grosshadern, Ludwig-Maximilians-University, Munich, Germany

Background: The objective of this study was to evaluate long-term survival, valve-related complications as well as prognostic factors for early and late outcome after open and closed mitral commissurotomy covering a follow-up period of 35 years.

Methods: From 1955 to 1977, 183 patients with mitral stenosis underwent mitral commissurotomy at our institution. Closed valvotomy was performed on 183 patients (group A) and open valvotomy on 16 patients (group B).

Results: Survival rates after 10, 20, and 35 years were 95%, 76.8%, and 53.1% in group A and 91.7%, 66.7%, and 46.8% in group B (p = not significant). The risk of late death increased significantly with an advanced preoperative New York Heart Association functional class, atrial fibrillation, higher age at operation, pre- or postoperative mitral regurgitation, and fistula obliteration. Forty-four patients in group A and 3 patients in group B required reoperation (p < 0.04). Independent predictors for reoperation in a multivariate analysis were a remaining postoperative mitral stenosis or regurgitation. A total of 15 patients showed valve-related complications. The long-term rate of valve-related morbidity and mortality was 2.1% per patient-year in group A versus 11.1% per patient-year in B (p < 0.01).

Conclusions: Long-term survival for open and closed commissurotomy are excellent, showing no differences between the groups. However, the incidence of reoperation as well as valve-related morbidity and mortality were significantly lower after open commissurotomy. In well-selected patients with pure mitral stenosis and no fistula obliteration, open commissurotomy still remains a valid surgical option.
MITRAL REPAIR IN RHEUMATIC MR

• Mitral Repair for Rheumatic MR
• India 2006
• 898 patients; age 22.4 ± 10.1
• 45.9% pure MR; 54.1% mixed MR/MS
• Pathology:
  – Leaflet prolapse 30%
  – Annular dilatation 79.8%
  – Calcification 4.3%

Abstract

Between January 1988 and December 2003, 898 patients with rheumatic heart disease (mean age 22.4 ± 10.1 years) underwent mitral valve (MV) repair. Five hundred and sixty-five (65.9%) had pre-operative atrial fibrillation. Six hundred and ten (66.8%) patients were in mitral valve or or near normal and twelve (1.3%) had rheumatic mitral stenosis and AI. The pathology was mitral prolapse (n=230, 33%), annular dilatation (n=77, 10%) and calcification (n=139, 19%). Mitral valve replacement in 225 (25%) and annuloplasty in 141 (15%). All interventions were successful. At 15-year follow-up, 90-100% survival was observed. Mitral valve surgery and annuloplasty were performed in 25% and 15% of patients, respectively. Freedom from moderate or severe MR was 32.5 ± 15%. MV repair in the rheumatic population is feasible with acceptable long-term results.

Keywords: mitral valve repair; rheumatic heart disease; regurgitation.

1. Introduction

Rheumatic heart disease (RHD) is the leading cause of mitral valve (MV) disease in the developing world. Mechanical MV replacement has its attendant complications [1]. MV repair avoids these complications, permits growth and preserves leaflet geometry and function. MV repair in RHD is technically demanding (2-4). However, current techniques permit surgery to be carried out with acceptable late outcome (5-8). This study analyses the results of MV repair for RHD performed at our institution over the last 15 years.

2. Materials and methods

Between January 1988 and December 2003, 2718 MV procedures were performed by the author (AH) including isolated MV (n=882), combined aortic and MV replacement (n=452), open mitral commissurotomy (n=362) and MV repair (n=1022). Of the 1022 patients who underwent MV repair, 846 (83%) had pure mitral regurgitation (MR) or a combination of mitral stenosis (MS) and MR due to RHD. Patients with pure MS are not included as many of them underwent closed mitral valvuloplasty or open mitral commissurotomy. Also, only patients with successful MV repair in the operating room were included.

Preoperative transthoracic echocardiography was performed in all. Cardiac catheterization and coronary angiography was performed on suspicion of associated aortic valve disease or coronary artery disease. All was graded by Doppler echocardiography or angiography or both (9, 10). After January 1994, intra-operative transoesophageal echocardiography (TEE) was performed in all. Echocardiographic assessment included mitral annulus, leaflet thickness and mobility, commissural and chordal fusion, calcification, regurgitant jet, thickness of chordal tendinere, left atrial thrombus and other valvular lesions.

2.1. Surgical techniques

Surgical approach was via a mid-sternotomy (n=725) or a right anterolateral thoracotomy in young females (n=103) for cosmetic reasons. Anterolateral commissurotomy was used in all. Before 1996 moderately hypertrophic (32 °C) cardiopulmonary bypass was used. Since 1996 normothermic perfusion was used in all. Cold blood cardioplegia and topical ice slush was used for myocardial protection. MV was exposed through an incision behind the interventricular groove. In patients with associated aortic septal defect the approach was through the right atrium. Depending on the valve morphology, a combination of techniques was used including annuloplasty, commissurotomy, chordal resection, and/or leaflet repair. During the course of the present study, 542 patients underwent MV surgery.
MITRAL REPAIR IN RHEUMATIC MR

Surgical Procedures:

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annuloplasty</td>
<td>793 (88%)</td>
</tr>
<tr>
<td>Commisurotomy</td>
<td>530 (59%)</td>
</tr>
<tr>
<td>Chordal shortening</td>
<td>225 (25%)</td>
</tr>
<tr>
<td>Cusp excision/placement</td>
<td>41 (4.5%)</td>
</tr>
<tr>
<td>Cusp thinning</td>
<td>325 (36%)</td>
</tr>
<tr>
<td>Clot suture</td>
<td>142 (16%)</td>
</tr>
<tr>
<td>Decalcification</td>
<td>30 (3.3%)</td>
</tr>
<tr>
<td>Chordal transfer</td>
<td>13 (1.4%)</td>
</tr>
<tr>
<td>Neo chordae construction</td>
<td>30 (3.3%)</td>
</tr>
</tbody>
</table>

1. Introduction

Rheumatic heart disease (RHD) is the leading cause of mitral valve (MV) disease in the developing world. Mechanical MV replacement has its attendant complications [1]. MV repair avoids these complications, permits growth and preserves left ventricular geometry and function. MV repair in RHD is technically demanding [2-4]. However, current techniques permit surgery to be carried out with acceptable late outcome [5-8]. This study analyses the results of MV repair for RHD performed at our institution over the last 15 years.

2. Materials and methods

Between January 1988 and December 2003, 2178 MV procedures were performed by the author (AK) including isolated MV (n=852), combined aortic and MV replacement (n=452), open mitral commissurotomy (n=362) and MV repair (n=1022). Of the 1022 patients who underwent MV repair, 849 (83%) had pure mitral regurgitation (MR) or a combination of mitral stenosis (MS) and MR. Patients with pure MS are not included as they undergo closed mitral valvulotomy or open mitral commissurotomy. Also, only patients with successful MV repair in the operating room were included.

Pre-operative transoesophageal echocardiography was performed in all. Cardiac catheterization and coronary angiography was performed on suspicion of associated aortic valve disease or coronary artery disease. All was graded by Doppler echocardiography or angiography or both [9, 10].

After January 1994, intra-operative transoesophageal echocardiography (TEE) was performed in all. Echocardiographic assessment included mitral annulus, leaflet thickness and mobility, commissural and chordal fusion, calcification, regurgitant jet, thickness of chordal tendineae, left atrial thrombus and other valvular lesions.

2.1. Surgical techniques

Surgical approach was via a mid-sternotomy (n=723) or a right anterolateral thoracotomy in young females (n=103) for cosmetic reasons. Anterolateral commissurotomy was used in all. Cold blood cardioplegia and topical ice slush was used for myocardial protection. MV was exposed through one incision behind the sternum. In patients with associated aortic valve disease, the approach was through the right atrium. Depending on the valve morphology, a combination of techniques was used including annuloplasty, commissurotomy, chordal shortening...
MITRAL REPAIR IN RHEUMATIC MR

A. Actuarial Survival (92% 10 year)
B. Freedom from re-operation (81% 10 year)
C. Freedom from MR (32% 10 year)
Mitral Repair: The Significant Etiologic Categories

the framework for understanding the key concepts of mitral valve repair

• Degenerative
• Rheumatic
• Endocarditis
• Functional MR
  • Ischemic MR
  • MR associated with dilated cardiomyopathy
MITRAL VALVE REPAIR FOR ENDOCARDITIS

• Endocarditis is a very heterogeneous disease
  – Valve/annulus location
  – Extent of tissue destruction

• Active vs “Healed” Endocarditis

• Most patients with Mitral Endocarditis undergo Mitral Replacement
MITRAL VALVE REPAIR FOR HEALED ENDOCARDITIS
MITRAL VALVE REPAIR FOR HEALED ENDOCARDITIS
MITRAL VALVE REPAIR FOR HEALED ENDOCARDITIS
Mitral Repair for Endocarditis

• Post-Endocarditic Mitral Dysfunction
• Active Endocarditic Mitral Dysfunction
MITRAL REPAIR FOR ACTIVE ENDOCARDITIS

- Carpentier
- Europe (2005)
- 37 patients

Valvular Heart Disease

Long-Term Results of Mitral Valve Repair in Active Endocarditis

Rachid Zegdgi, MD, PhD; Mohamed Debiche, MD; Christian Larentsouille, MD, PhD; Djoulieme Lebied, MD; Catherine Chaudigny, MD, PhD; Jean-Michel Giraud, MD; Sylvain Chauvand, MD, Alain Debiche, MD; Alain Carpentier, MD, PhD; Jean-Noel Fabiani, MD

Background—Several investigations have reported the feasibility of mitral valve repair in active endocarditis, but the long-term results are still unknown.

Methods and Results—We reviewed 37 consecutive patients who underwent mitral valve repair with the Carpentier technique for active endocarditis in our center between 1999 and 2004. This repair involved prosthetic mitral surgery in 31 patients (84%), valve resuspension in 11 (30%), chordal shortening or transposition in 19 (51%), pericardial patch in 16 (43%), and direct suture of leaflet perforation in 11 (30%). Associated procedures were primary aortic valve repair or replacement in 14 (39%) and mitral repair in 2 (6%). Early complications included 1 operative death (3%; 95% CI, 0.0 to 15.5%) and 1 reoperation for pericardial patch dehiscence. Recurrence of endocarditis was observed in 1 patient (3%; 95% CI, 0 to 10). The 10-year survival rate and freedom from mitral valve reoperation were 90% (95% CI, 66 to 94) and 91% (95% CI, 81 to 100), respectively. At 10 years, most patients (96%) were in good functional status (NYHA class I or II) with no sternal mitral regurgitation (0%) on echocardiography.

Conclusions—Mitral valve repair using Carpentier’s techniques in patients with active endocarditis offers very good long-term results with a low rate of recurrence or reoperation. (Circulation. 2005;111:2532-2536)

Key Words: mitral valve • endocarditis • valves

There is a general consensus for preferring mitral valve repair (MVR) over mitral valve replacement (MVR) in the treatment of severe mitral regurgitation. When feasible, MVR has been shown to reduce operative mortality and to improve long-term survival and functional status.1-4 However, in the setting of active endocarditis (AE), existing series included only a few patients with relatively limited follow-up (mainly <5 years) (Table I).

Knowledgeable valve repair long-term durability and risk of endocarditis recurrance is necessary before recommending MVR in AE. We report here, for the first time, the long-term results at 10 years of MVR performed in the context of AE.

Methods

Study Population

Between January 1999 and December 1999, 37 patients with active native valve endocarditis underwent MVR in our department. Endocarditis was considered active when the operation was performed during the first 4 weeks of antibiotic therapy. Excluded from the study were 6 patients for whom a partial mitral hemiresection was made during valve surgery.

Patients age ranged from 9 to 72 years (median, 48 years). There were 20 male patients (54%) and 17 female patients (46%). Seventeen patients (46%) were operated on during the first 2 weeks of antibiotic therapy. The patients were in NYHA functional class I (83%) or II (17%). The prosthesis used most often was a bioprosthesis (58%). None had MV infection before the procedure. We excluded patients who had received antibiotics for >7 days before surgery. We also excluded patients who had undergone previous cardiac surgery. The operative mortality was 3% (1 patient). The 40 patients who were included in the study had no clinical signs of mitral regurgitation (0 to 5 cm) or 2+ and severe mitral regurgitation (15 patients, 41%). Operative mortality was defined as death occurring within 30 days after the operation. The diagnosis of infection was made by clinical criteria (43 patients, 108%), echocardiography (43 patients, 108%), or both (7 patients, 18%).

The following criteria were considered: severe mitral regurgitation (101 patients, 27%), left ventricular dilatation (104 patients, 28%), fever (101 patients, 27%), other clinical signs of infection (104 patients, 28%), and microbiological results (101 patients, 27%). There were no patients with concomitant stenosis (43 patients, 11%). Of the 40 patients operated on, 33 (83%) were in NYHA functional class III or IV. Recurrence of endocarditis was observed in 1 patient (3%; 90% CI, 0 to 10). The 10-year survival rate and freedom from mitral valve reoperation were 90% (95% CI, 66 to 94) and 91% (95% CI, 81 to 100), respectively. At 10 years, most patients (96%) were in good functional status (NYHA class I or II) with no sternal mitral regurgitation (0%) on echocardiography.

Conclusions—Mitral valve repair using Carpentier’s techniques in patients with active endocarditis offers very good long-term results with a low rate of recurrence or reoperation. (Circulation. 2005;111:2532-2536)

Key Words: mitral valve • endocarditis • valves

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**Figure 1.** Survival rate after MVRep for native mitral valve endocarditis. Numbers in parentheses indicate number of patients alive.

**Figure 2.** Rate of freedom from mitral reoperation after MVRep for native mitral valve endocarditis. Numbers in parentheses indicate number of patients at risk.
Reconstructive surgery in active mitral valve endocarditis: feasibility, safety and durability

Laurent de Kerchove, Jean-Louis Vanoverschelde, Alain Poncelet, David Glineur, Jean Rubay, Francis Zechi, Philippe Noelhomme, Gebrine El Khoury

Abstract

Objective: To evaluate timing of surgery and management of complex valve lesions in patients with active mitral valve (MV) endocarditis. Results: Between 1993 and 2005, 81 patients were operated for active MV endocarditis, of which 63 (79%) had MV repair. For all patients, the median time between diagnosis and surgery was 10 days. Various surgical techniques were applied to restore LV function, including autograft or partial MV homografts were used as leaflet substitute. In addition, prosthetic rings were employed in 44% of the patients. Results: The overall operative mortality was 17%, however, completing only patients in preoperative Killip class II or III, the operative mortality could be reduced to 4%. MV class 2, estimated age above 70 years and history of valvular were the three independent risk factors for early mortality in our multivariate analysis. The average follow-up time was 30.1 32 months. During this period, five late deaths occurred, two of which were cardiac-related. The overall 5- and 10-year survival were 75 ± 12% and 69 ± 13%, respectively. In hospital survivors, freedom from cardiac death after 5 and 10 years was 81% ± 4%, three and five late MV regurgitation occurred in seven patients, of these three could have MV re-repair. Only one endocarditic recurrence occurred after 4 months in a chronic haemodialysed patient. Freedom from MV replacement was 89% ± 7% and 72% ± 18% at 5 and 12 years, respectively. Ten-year freedom from MV re-replacement and from endocarditis recurrence were 59 ± 5% and 78 ± 13% respectively. Annular abscesses and calcification or thrombus. MV disease were two independent risk factors associated with reoperation in our multivariate analysis. During the follow-up period, all patients were in Killip class 0 or I. 99% of patients had initial ligation of side branch, only 11% had grade 3 transmural extension of the disease. Additional and advanced techniques of MV repair, a responsibility rate of 80% can be reached among patients with active endocarditis. We demonstrate that a high level of safety and excellent durability of MV repair can be obtained even for complex patients.

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Keywords: Mitral valve repair; Active endocarditis; Mitral valve endocarditis.
Fig. 2. (a) Kaplan–Meier overall actuarial survival; (b) Kaplan–Meier actuarial survival showing freedom from late cardiac death in hospital survivors; (c) Kaplan–Meier curve for freedom from MV reoperation in the all population and in the subgroups of patients having MV repair with or without patch; (d) Kaplan–Meier curve for cardiac-related event-free survival.
Use of the Posterior Leaflet of the Tricuspid Valve for Mitral Repair

• Tricuspid posterior leaflet autotransplantation

Partial Tricuspid Valve Transfer for Repair of Mitral Insufficiency Due to Ruptured Chordae Tendineae

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Background. A new technique is suggested for the reconstructive surgical treatment of mitral regurgitation. It involves partial transfer of the tricuspid valve of the patient to the mitral valve, in order to provide chords to correct anterior leaflet prolapse of the mitral valve, secondary to rupture of the chordae tendineae.

Methods. From January 1991 to May 1997, 20 patients with mitral insufficiency due to rupture of the chordae were operated on. The prevailing cause was myxomatous degeneration (95%). Patients were in New York Heart Association functional class III and IV.

Results. There were no hospital deaths. Two patients were reoperated on. Eighteen patients (90%) are alive with their own valves (class I and II). Doppler echocardiogram mean values were: ejection fraction, 0.6; left atrial diameter, 62 cm; mitral area, 2.4 cm²; mitral transvalvular gradient, 3.5 mm Hg. No regurgitation or mild regurgitation was observed in 16 of 19 patients in the 17 cases evaluated. Mean tricuspid valve area was 3.5 cm². In all cases, no tricuspid regurgitation was present or it was mild.

Conclusions. Partial transfer of the tricuspid valve to the mitral valve is an effective procedure for the surgical treatment of mitral valve insufficiency secondary to ruptured chordae tendineae of the anterior leaflet.


Rupture of the chordae, leading to prolapse of the corresponding leaflet was surgically treated at the beginning of cardiopulmonary bypass surgery by McGoon [1], by placement of the prolapsed portion of the leaflet. Initial results were positive; however, in the long term, ended in a loose mobility of the leaflet, especially the anterior one. Mancias and coworkers [2] proposed resection of the posterior leaflet of the mitral valve, thus eliminating the prolapse and suturing edges-to-edge, the remaining posterior leaflet, at the same time performing posterior mitral pllication. This technique is still utilized today [3] with excellent results, however it is restricted to rupture of the posterior leaflet chords. In 1978, Capuzzi and coworkers [4] introduced the technique, usual worldwide with positive results, of transferring chordae from the posterior leaflet to the anterior leaflet of the mitral valve in cases of rupture of chordae tendineae. The creation of a new chordae, using a patch of tissue from the anterior leaflet, was proposed by us [5] for prolapse repair in cases of anterior leaflet chordae rupture [5]. However, it was conditioned by an excess of tissues as found in myxomatous degeneration. In such cases, the surface of the anterior leaflet would not be reduced with consequent restrictions of its mobility.

Valvular prolapse has been treated with other techniques in an effort to avoid movement restriction of the anterior leaflet by tailoring artificial chords of bovine pericardium treated with glutaraldehyde [6] or polytetrafluoroethylene (PTFE).

Since January 1991, we have used a technique pioneered by us for repair of the anterior leaflet of the mitral valve prolapse due to rupture of the chordae tendineae. It involves providing chordae from partial transfer of the tricuspid valve to the mitral valve [4] of the same patient.

The objective of this study is to present the postoperative evolution of a consecutive series of patients, because of mitral valve insufficiency secondary to rupture of the chordae tendineae, submitted to repair surgery using the technique of partial transfer of the tricuspid valve to the mitral valve.

Material and Methods

A retrospective study of 20 patients submitted to reconstructive repair of the mitral valve from January 1991 to May 1997 was undertaken. Patients presented with mitral valve insufficiency due to rupture of the anterior leaflet chordae tendineae, having been consecutively operated on by the same surgical team, following the technique of partial transfer of the tricuspid valve to the anterior leaflet of the mitral valve for the supply of chordae.

Nine patients were male and 11 were female. Ages ranged from 6 to 68 years, mean of 45 years. All patients presented with mitral valve insufficiency; five presented...
Use of the Posterior Leaflet of the Tricuspid Valve for Mitral Repair

• Actuarial Survival

• Actuarial Event-free Survival
Mitral Repair: The Significant Etiologic Categories
the framework for understanding the key concepts of mitral valve repair

- Degenerative
- Rheumatic
- Endocarditis
- Functional MR
  - Ischemic MR
  - MR Associated with Dilated Cardiomyopathy
FUNCTIONAL MR

- Ischemic MR
- MR Associated with Dilated Cardiomyopathy
ISCHEMIC MITRAL REGURGITATION AND PROGNOSIS

• The Presence of IMR is Predictive of Poor Prognosis. (50-75% 3 year survival).
  – In diverse clinical situations:
    • Depressed LV Function
    • Acute MI
    • Chronic MI
    • PCI

• Therefore, Elimination of MR will Improve Survival.
Prognostic Significance of MR after Acute MI

- Mayo Clinic
- Worse prognosis dependent on MR grade after acute MI

![Figure 1](image)

Prognostic significance of echocardiographically defined mitral regurgitation early after acute myocardial infarction

Graham S. Hultin, MBChB, PhD; Jacob E. Moller, MD, PhD; Patricia A. Pellikka, MD; Malcolm B. Bell, MB, BS; Grace C. Caforio-Vernosa, MD, and Jan K. Ol: Rochester, MN

Background: There are limited data regarding the clinical correlates and prognostic significance of echocardiographically defined mitral regurgitation (MR) early after acute myocardial infarction (MI). The current study addressed these issues.

Methods: Seven hundred fifty patients with acute MI who underwent transthoracic echocardiography with assessment of MR during their index admission were identified. Patients were followed up a median of 19 months later. The study end point was all-cause mortality.

Results: The prevalence of MR increased with age. It was more common in women, in patients with non-ST-segment MI, and in those with a history of diabetes, hypertension, prior MI, or previous revascularization. Patients with MR had worse left ventricular (LV) systolic function, more LV dilation, and more clinical evidence of LV failure. Patients with moderate or severe MR had worse survival than those with mild or no MR (hazard ratio 2.3, 95% CI 1.6–3.2, P < .001). Even mild MR predicted a higher mortality when compared with no MR (hazard ratio 1.7, 95% CI 1.2–2.4, P = .004). Mild or moderate MR was not independently predictive of outcome, although, in multivariable analyses, a trend toward worse survival was maintained in patients with severe MR.

Conclusions: Mitral regurgitation identified by echocardiography, early after acute MI predicts poorer survival after acute MI. However, if mild or moderate, it is not an independent prognostic indicator. (Am J Cardiol 2005;105:1268–73)

Mitral regurgitation (MR) is common early after acute myocardial infarction (MI). However, the spectrum of severity is wide and the prevalence depends on the method of detection.23 Clinical examination and left ventriculography are invasive compared with the most frequently used technique—Doppler echocardiography and color flow imaging. This is routinely performed after acute MI and, in contrast to other methods, allows the etiology of MR to be defined. Despite this, most large studies of MR in this setting have relied on angiographic data. These have usually included highly selected clinical trial populations and have yielded conflicting results.24

A variety of echocardiographic methods are available to quantify the severity of MR.25 The most common approach in routine clinical practice is to use semi-quantitative color Doppler assessment, particularly where regurgitation is thought to be mild. Despite this, there are limited data regarding the clinical correlates and prognostic significance of MR detected by color flow Doppler echocardiography. In particular, there are no such data in cohorts where MR was defined using current criteria21 and no studies in which the mechanism of MR in this setting has been assessed. The current study addressed these issues.

Methods

Patients

Between January 1999 and July 2001, 755 patients admitted to St Mary’s Hospital (Rochester, MN) with acute MI had a clinically indicated transthoracic echocardiogram during their index admission. The severity of MI could be accurately assessed in 725 (96%) patients. Those patients formed the study cohort. Myocardial infarction was defined using the European Society of Cardiology/American College of Cardiology guidelines.26 The study complies with the Declaration of
ISCHEMIC MITRAL REGURGITATION

- Type II
  - Papillary Muscle Infarction 27%
  - Papillary Muscle Rupture 8%
- Functional IMR 65%
- Type IIIb and Type I
Carpentier Classification of Mitral Valvular Dysfunction

PAPILLARY MUSCLE DYSFUNCTION CAUSED BY CAD
PAPILLARY MUSCLE DYSFUNCTION/INFARCTION

- Papillary Muscle Reimplantation
- Papillary Muscle Repositioning
- Mitral Valve Replacement
ISCHEMIC MITRAL REGURGITATION
ISCHEMIC MITRAL REGURGITATION
Type IIIb (later, type I)

Normal:
- Leaflets
- Chordae
- Papillary muscles

MI
ISCHEMIC MITRAL REGURGITATION

Peri-infarct zone myopathy:
- Myopathic stretching of normal LV
- Myocyte apoptosis
- Extra-cellular Matrix disruption (activation of MMP’s)
PATHOPHYSIOLOGY OF FUNCTIONAL IMR

Ischemic cardiomyopathy
  Papillary muscle displacement
  Annular enlargement
  MR
    LA enlargement
    Atrial fibrillation
    Pulmonary hypertension
    Tricuspid regurgitation
  Ventricular dilatation
    Increased wall stress
    Decreased wall perfusion
Method of Treatment for Functional IMR?

- Revascularization ±
  1. Annuloplasty
  2. Mitral Valve Replacement

or
IMR and ANNULOPLASTY RING RECOMMENDATIONS

• All patient who need CABG should have ECHO pre-op to assess the mitral valve.
• Mitral repair should be done for all CABG patient with
  – >2+ MR
  – EROA > 20 mm²
• Annuloplasty Ring of Choice: complete remodelling annuloplasty
QUESTIONS

1. Does Revascularization Treat IMR?
2. Is Annuloplasty better than MVR?
3. Does Annuloplasty Work?
1. Does CABG treat IMR?

• Can CABG alone correct IMR?
  – Aklog
  – retrospective
  – 136 patients
  – Moderate 3+ IMR

CABG alone
Mean EF 38%
Operative mortality 2.9%

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

Lixin Aklog, MD; Faramarz Filsoufi, MD; Kathryn Q. Flores, MD; Raymond H. Chen, MD; Lawrence H. Cohn, MD; Nadia S. Nathan, MD; John G. Byrne, MD; David H. Adams, MD

Background—The optimal management of moderate (0+) to severe (3+) ischemic mitral regurgitation (IMR) remains controversial. Some advocate CABG alone, whereas others favor concurrent 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% males, mean age 70 ± 5 years, mean New York Heart Association class 3.7, mean ejection fraction 38 ± 13%) with a preoperative diagnosis of moderate ischemic MR, without leaflet prolapse or pathology, underwent isolated CABG. Thirty-eight (28%) of 136 patients had associated transesophageal echocardiography (TEE) before CABG, and 28 (20%) had preoperative transesophageal echocardiography (TEE) within 6 weeks of surgery. The subgroups of patients undergoing concomitant TEE and preoperative TEE had preoperative characteristics similar to the overall group. The 30-day operative mortality was 3.5% (4/116). Late postoperative TEE documented the severity of MR to mild or less (0 to 2+) in 85% (24/28). On postoperative TEE, 40% (17/43) remained to have at least moderate MR (3 to 4+), 21% (9/43) improved somewhat to mild (2 to 3+), and only 5% (2/43) had resolution of their MR (0 to 1+). The mean postoperative ischemic, and postoperative MR grade were 1.0 (0 to 2), 1.4 (1 to 2), and 2.3 (0 to 2), respectively (P < 0.001).

Conclusion—CABG alone for moderate ischemic MR leaves many patients with significant residual MR and may not be the optimal therapy for most patients. Late postoperative TEE may significantly underestimate the severity of ischemic MR. A preoperative diagnosis of moderate MR may warrant concurrent mitral annuloplasty. (Circulation. 2001;104(suppl 1):I-LIB36,78.)

Keywords: coronary disease • echocardiography • mitral valve • regurgitation • surgery

A liberal postoperative approach would agree that severe mitral annuloplasty (MVR) should be corrected at the time of CABG and that those with mild IMR can probably be left alone. The optimal management of moderate ischemic MR remains controversial. Those favoring a conservative approach make several arguments. First, reserve enrolling ischemic areas will improve regional wall motion and correct the MR. Second, several authors suggest that performing CABG alone, even if some residual MR persists, does not affect long-term survival or stroke risk. Third, mitral valve surgery adds significantly to the operative risk of CABG, with most series reporting operative mortality rates >10%. Lastly, patients with ischemic MR tend to have relatively small left atria, which makes mitral valve surgery and repair difficult for many surgeons. Finally, control valve replacement, if necessary, carries the added burden of long-term anticoagulation or risk of reoperation.

Many surgeons, however, have advocated a 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 volume. The preoperative echocardiographic severity represents a brief snapshot of the severity of MR at the time of the study. The fact that many patients with “mild” or <2+ MR present with significant symptoms of congestive heart failure or severe left ventricular dysfunction 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 regional or ventricular aneurysm. (3) According to several studies, 10-30% of patients with significant residual MR can result in late symptoms and decreased long-term survival. (4) Mitral valve repair is mainly done technically feasible, and it alone will almost always correct moderate ischemic MR, which makes mitral valve replacement almost never necessary. (5) The high operative mortality now for combined mitral valve surgery and CABG reported in the literature is certainly misleading if 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 2% to 4%. (6) When significant residual MR remains, it ex-
IMR and CABG

- Evolution of MR post CABG
  - 40% no improvement
  - 50% some improvement and left with 2+ MR
  - 10% worse

- Intra-Operative MR underestimates pre- and post-operative MR
2. IS REPAIR BETTER THAN REPLACEMENT FOR ISCHEMIC MITRAL REGURGITATION?

- CCF
- Repair (n=397) vs Replacement (n=85)
- Propensity score analysis (Blackstone)

Is repair preferable to replacement for ischemic mitral regurgitation?

A. Marc Gillinov, MD
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Eugene H. Blackstone, MD
Ershol B. Bishay, MD
Delos M. Cosgrove, MD
James F. White, MD
Emeka W. Nwogu, MD
Patrick M. McCarthy, MD

Objective: This study was undertaken to compare mitral valve repair and replacement as treatments for ischemic mitral regurgitation.

Methods: From 1975 through 1997, a total of 482 patients with ischemic mitral regurgitation underwent either valve repair (n = 397) or valve replacement (n = 85). Patients more likely to undergo repair had functional mitral regurgitation or coronary revascularization with an internal thoracic artery graft those more likely to receive valve replacement were in higher New York Heart Association functional classes or underwent emergency operations. These factors were used for multivariable propensity matching. Risk factors for early and late death were identified by multivariable, time-dependent hazard function analysis.

Results: Within the propensity-matched better-risk group, survival after valve replacement was 81%, 75%, and 69% at 30 days, 1 year, and 5 years, but survival after repair was 84%, 82%, and 78% at these intervals (P = 0.01). In contrast, within the poor-risk group, survival after repair and replacement were similar (P = 0.4). Risk factors (P ≤ 0.01) included older age, higher functional class, greater wall motion abnormalities, and renal dysfunction. Approximately 70% of patients were predicted to benefit from repair; the benefit increased or was negated if an internal thoracic artery graft was used, if a lateral wall motion abnormality was present, or if the mitral regurgitation jet pattern was complex. Freedom from repair failure at 5 years was 91%.

Conclusion: Late survival is poor after surgery for ischemic mitral regurgitation. Most patients with ischemic mitral regurgitation benefit from mitral valve repair. In the most complex, high-risk settings, survival after repair and replacement are similar.

Surgical treatment of ischemic mitral regurgitation is associated with a high operative mortality rate and poor long-term survival. Choosing the most appropriate surgical treatment to maximize survival for these patients is made difficult by inconsistent classification schemes for the entity, a paucity of long-term data to compare alternatives, and an absence of randomized trials of valve repair versus valve replacement. In fact, such trials are unlikely ever to be undertaken. The purposes of this study were therefore to develop a simple and clinically useful echocardiographic classification scheme, to determine which patients were more likely to receive valve repair rather than replacement at this center, to determine whether survival was better after mitral valve repair or replacement, to discover which patients benefit from valve repair and which from replacement, and to quantify the durability of valve repair.
REPAIR VS REPLACEMENT FOR ISCHEMIC MITRAL REGURGITATION

• Patients with IMR who had mitral surgery had poor prognosis.

• 50% 7 year survival

Figure 2. Survival after mitral valve surgery for all patients with ischemic mitral regurgitation. Each symbol represents a death according to Kaplan-Meier estimator. Vertical bars enclose asymmetric 68% confidence limits. Solid lines represent parametric survival estimates; these are enclosed between dashed 68% confidence limits. Numbers in parentheses are numbers of patients traced beyond that point.
REPAIR VS REPLACEMENT FOR ISCHEMIC MITRAL REGURGITATION

- Repair benefit of 66% compared to replacement
- In the sickest patients, there is no difference in survival between repair vs replacement
REPAIR VS REPLACEMENT FOR ISCHEMIC MITRAL REGURGITATION

• NYU
• 152 repair; 71 replacement
• 50% 5 year survival
• Equivocal difference in MVR vs MVP

Ischemic mitral valve reconstruction and replacement: Comparison of long-term survival and complications

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Xiang Yu, MD
Piotr Zaloga, MD
Martin Susanian, MD
Julia Galante, MA
Alfred T. Esposito, MD
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Stephen E. Cohen, MD

Objective: This study reviews the 223 consecutive mitral valve operations for ischemic mitral insufficiency performed at New York University Medical Center between January 1997 and January 1996. The results for mitral valve reconstruction are compared with those for prosthetic valve replacement.

Methods: From January 1997 to January 1996, 223 patients with ischemic mitral insufficiency underwent mitral valve reconstruction (n = 152) or prosthetic mitral valve replacement (n = 71). Coronary artery bypass grafting was performed in 89% of cases of mitral reconstruction and 69% of cases of prosthetic replacement. In the group undergoing reconstruction, 7% had subaortic stenosis with a ring annuloplasty and 25% had subaortic stenosis with a ring annuloplasty. In the group undergoing prosthetic replacement, 82% of patients received bioprostheses and 18% received mechanical prostheses.

Results: Follow-up was 85% complete (median 14.6 years, range 6.2–15.6 years). Thirty-day mortality was 10% for mitral reconstruction and 20% for prosthetic replacement. The short-term mortality rate was highest among patients in New York Heart Association functional class IV. Among those in classes 1 to III odds ratio 0.57, confidence interval [0.29–0.91] and was reduced among patients with angina relative to those with without angina odds ratio 0.36, confidence interval [0.18–0.71]. The 30-day death or complications rate was similarly elevated among patients in functional class IV (odds ratio 3.57, confidence interval 1.25–10.24). Patients with mitral valve reconstruction had lower short-term complications or death rates than did patients with prosthetic valve replacement odds ratio 0.41, confidence interval [0.24–0.71]. Eighty-two percent of patients with mitral valve reconstruction had an insufficiency or only trace insufficiency during the long-term follow-up period. Five-year complication-free survival was 69% (confidence interval 59%–79%) for patients undergoing mitral valve reconstruction and 47% (confidence interval 33%–60%) for patients undergoing prosthetic valve replacement. Results of a series of statistical analyses suggest that outcome was linked primarily to preoperative New York Heart Association functional class.
3. DOES ANNULOPLASTY WORK FOR IMR?

- CCF (2007)
  - (Gillinov, Blackstone, Lytle)
- 290 pts with 3+-4+ IMR CABG w/ annuloplasty
- 100 pts with 3+-4+ IMR CABG w/o annuloplasty
- Propensity matched

Impact of Mitral Valve Annuloplasty Combined With Revascularization in Patients With Functional Ischemic Mitral Regurgitation

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**Cardiac Surgery**

Objectives
The aim of this work was to determine whether mitral valve (MV) annuloplasty benefits patients with moderate/severe (3+ to 4+) functional ischemic mitral regurgitation (IMR) who undergo coronary artery bypass grafting (CABG).

Background
Mirtal regurgitation is a strong predictor of poor outcomes in patients with ischemic cardiomyopathy, whether correcting it at the time of CABG improves outcomes is less certain.

Methods
From 1991 to 2003, 390 patients with 3+ to 4+ ischemic IMR had CABG with (n = 290) or without (n = 100) MV annuloplasty. Groups were propensity-matched using demographics, extent of coronary disease, regional wall motion, and quantitative echocardiography. Survival, echocardiographic severity of MR, and New York Heart Association (NYHA) functional class were compared.

Results
One-5, and 10-year survival rates were 88%, 75%, and 47% after CABG alone and 92%, 74%, and 39% after CABG + MV annuloplasty (p = 0.06). Mortality was increased in patients with severe lateral wall motion abnormalities (p = 0.05), severe left ventricular hypertrophy (p = 0.004), and higher Killip class (p = 0.0001). Patients undergoing CABG alone were more likely to have 3+ or 4+ postoperative MR than those undergoing CABG + MV annuloplasty (46% vs. 22% at 1 year, p < 0.0001), the NYHA functional class substantially improved in both groups (p < 0.0001) and remained improved; at 5 years, 23% of patients having CABG + mitral annuloplasty and 20% having CABG alone were in NYHA functional class II/III.

Conclusions
Although CABG + MV annuloplasty reduces postoperative MR and improves early symptoms compared with CABG alone, it does not improve long-term functional status or survival in patients with severe functional ischemic MR. The MV annuloplasty in this setting, without addressing functional mitral regurgitation, is insufficient to improve long-term clinical outcomes.

Functional ischemic mitral regurgitation (MR) is strongly associated with poor outcomes in patients with advanced coronary artery disease. However, whether its correction improves outcomes is unclear.

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Ischemic MR is not caused by gross intrinsic disease of the valve, but by left ventricular (LV) remodeling, dilatation, and dysfunction leading to geometric reconfiguration of the mitroventricular apparatus, including papillary muscle displacement and annular dilation. Mitral valve (MV) leaflets become tethered, with failure of anterior-posterior leaflet coaptation, resulting in symmetric or asymmetric regurgitation. Surgical treatment options include coronary artery bypass grafting (CABG) alone or with concomitant MV annuloplasty or replacement. Currently, the most common technique to restore valve competence is placing an undersized annuloplasty ring to reduce mitral annulus size.

Whether or not MV annuloplasty improves outcomes over and above CABG alone is debated, however. Therefore, in the absence of evidence-based randomized trials, this clinical study has 2 objectives: 1) to determine the efficacy of MV annuloplasty in patients who are comparable.
DOES ANNULOPLASTY WORK FOR IMR?

<table>
<thead>
<tr>
<th>MR 3+/4+</th>
<th>MR 3+/4+ 1 year</th>
<th>Survival: 1 year</th>
<th>5 year</th>
<th>10 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABG</td>
<td>48%</td>
<td>88%</td>
<td>75%</td>
<td>47%</td>
</tr>
<tr>
<td>CABG plus Mitral</td>
<td>12%</td>
<td>92%</td>
<td>74%</td>
<td>39%</td>
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</table>

Survival:

| CABG plus Mitral | 12% |
| CAGB             | 88% |
| CABG plus Mitral | 92% |

Mortality was related to:
- Lateral wall motion abnormalities (p=0.05)
- ST elevation in lateral leads (p<0.004)
- Higher QRS voltage sum (p<0.0001)

“MV annuloplasty in this setting, without addressing fundamental ventricular pathology, is insufficient to improve long-term clinical outcomes.”
DOES ANNULOPLASTY WORK FOR IMR?

- 51 pts CABG
- 51 CABG + MVR
- Propensity Matched

Repair of Ischemic Mitral Regurgitation Does Not Increase Mortality or Improve Long-Term Survival in Patients Undergoing Coronary Artery Revascularization: A Propensity Analysis

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Background. The purpose of this study was to compare operative mortality and midterm outcome of patients with ischemic mitral regurgitation (IMR) undergoing either coronary artery bypass grafting (CABG) alone or CABG with mitral valve (MV) repair.

Methods. From 1996 to 2001, 51 consecutive patients underwent CABG with MV repair for ischemic IMR. All patients in this group were matched to similar patients with ischemic IMR undergoing CABG alone during the same 6-year period using propensity analysis (considering 31 covariates, including severity of IMR and New York Heart Association (NYHA) class).

Results. Propensity score matching yielded 31 closely matched control patients. Procedural mortality was 3% or 4% in 96% of CABG with MV repair and 96% of CABG alone patients, and 86% of patients in each group were NYHA class III or IV. Operative mortality was 3.8% ± 3.8% in both groups. Survival was also similar between CABG with MV repair and CABG alone at 1 year (84% ± 5% versus 92% ± 3%) and at 3 years (70% ± 7% versus 71% ± 7% (p = 0.45). Among survivors, NYHA class improved at follow-up (50 ± 20 months) from 3.4 ± 0.7 to 1.7 ± 1.0 for CABG with MV repair (p < 0.001) and from 3.4 ± 0.7 to 1.8 ± 1.0 for CABG alone (p < 0.001).

Conclusions. Operative mortality, midterm survival, and late functional class were similar between two well-matched groups of patients undergoing CABG for ischemic IMR, differing only in the addition of MV repair. Whence MV repair can be added safely to CABG in this group of high-risk patients without increasing mortality, its impact on late survival and functional class may be limited.

(Am J Cardiol 2006;97:94–9) © 2004 by The Society of Thoracic Surgeons

Material and Methods
From January 1996 to December 2001, 1,180 patients underwent CABG at Washington University Medical Center (Barnes-Jewish Hospital), including 71 patients who underwent simultaneous CABG with MV repair. Of these patients, 51 underwent combined CABG with MV repair for "functional" ischemic IMR with anatomically normal leaflets and intact papillary muscle (Carpentier I, IIIb). Based on echocardiography, MR severity was graded as absent (0+), trace (1+), mild (2+), moderate (3+), or severe (4+). Left ventricular (LV) function was...
EDITORIAL COMMENT

Adding Mitral Valve Annuloplasty to Surgical Revascularization Does Not Benefit Patients With Functional Ischemic Mitral Regurgitation*

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Truth reflected in 2 common-but-conflicting aphorisms must coexist in dynamic tension to produce favorable outcomes in cardiac surgical patients: “fix everything while you are there” must be balanced with “perfect is the enemy of good” to do all but not more than is needed for the welfare of the patient. Fixing a leaking heart valve while one is already performing coronary artery bypass grafting (CABG) does not seem like excessive striving for perfection.

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two major author-defined limitations must be considered before accepting their conclusion as definitive.

Limitation of an Observational Study

Experienced authors know that the publication of an observational study in any major journal requires an explicit confession that the study was not randomized. Neither manuscript reviewers nor journal editors appear to seriously expect the randomized study to occur in their lifetimes. Therefore, only a simple statement of need appears to maintain the scientific status of the journal while not encumbering authors with unnecessary work to propose the design of a randomized trial suggested by the results of their observational study. Results of this observational study would support proposing a randomized clinical trial addressing the hypothesis that “not adding mitral valve annuloplasty to CABG increases the 6-year survival of patients with ischemic cardiomyopathy and 3+ or 4+ mitral regurgitation.” A feasibility estimate using the 6% absolute, but statistically insignificant, 6-year mortality advantage of not adding mitral valve annuloplasty to CABG suggests that at least 1,200 patients would need to be randomized and followed for a mean of 6 years to demonstrate a 6% mortality difference with a 90% statistical power. Neither the National Institutes of Health nor purveyors of mitral annuloplasty rings could reasonably be expected to provide the $30 to $50 million required to complete this study. An alternate hypothesis likely to be more attractive to medical device companies would be “adding mitral valve annuloplasty to CABG reduces short-term mortality.” However, the statistically insignificant (Table E1 in Mihaljevic et al. [1]) 5% excess death rate in the CABG-only population at 1 year (Fig. 1R in Mihaljevic et al...
QUESTIONS

1. Does Revascularization Treat IMR?
   – CABG alone is inadequate to treat the majority of IMR patients

2. Is Annuloplasty better than MVR?
   – Annuloplasty decreases MR in variable and unpredictable ways. (Annuloplasty ring failure in >50% of cases (Liel-Cohen, Levine, Vlahakas, et al, MGH))
   – Annuloplasty shows transient improvement in LV function and NYHA class.
   – Annuloplasty does not improve the ultimate end-point: survival.

3. Does Annuloplasty Work?
   – No

   “IMR IS A VENTRICULAR DISEASE, NOT A VALVULAR DISEASE”
MECHANISM OF IMR

• Extensive Laboratory data in sheep and dogs:
  – Stanford Miller
  – UOP Edmunds and Gorman
  – MGH Levine
  – UW Cochran and Kunzelman

• Clinical analysis of complex 3-D geometry
  – CCF McCarthy and Gillinov

• Conclusions:
  – S-L dimension
  – Annular Dilatation
  – Contribution of LV geometry to IMR
MECHANISM OF IMR
Summary of Scientific Work:

A. Septal-Lateral dimension
B. Mural and septal portion of annulus undergoes dilation
C. Annular flattening
D. Papillary muscle displacement

CONCLUSION:
"IMR IS A VENTRICULAR DISEASE, NOT A VALVULULAR DISEASE"
“IMR is a ventricular disease, not a valvular disease”

- Dor or LV Plication Procedures
- Acorn
- MyoSplint
Functional MR

• Ischemic MR

• MR Associated with Dilated Cardiomyopathy
MR ASSOCIATED WITH DILATED CARDIOMYOPATHY
(Carpentier Type I +IIIb)
MR ASSOCIATED WITH DILATED CARDIOMYOPATHY

- Bolling (UOM)
- 1995
- 9 patients
- Reduction annuloplasty
MR ASSOCIATED WITH DILATED CARDIOMYOPATHY

• Follow-up from previous series
• 200 patients

Update on Mitral Repair in Dilated Cardiomyopathy
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Abstract. Heart failure is one of the leading causes of hospitalization worldwide. Mitral regurgitation (MR) is a known complication of end-stage cardiomyopathy and is associated with a poor prognosis due to progressive mitral annular dilation. A vicious cycle of continuing volume overload, ventricular dilation, progression of mitral disease, increased LV wall tension, and worsening of MR and CHF ensues. Consequently, these patients were managed medically with diuretics and afterload reduction, and frequently with mitral valve replacement, both of which have poor long-term survival in patients with CHF and MR. Over a 10-year period we prospectively studied over 200 patients with cardiomyopathy and severe MR who underwent mitral valve repair using an understanding of the underlying annuloventricular ring. The mortality was low with nine in-hospital deaths and eight 30-day mortalities. There were 25 late deaths. Of these patients had progression of heart failure and underwent transplantation. The 1-, 2-, and 5-year actuarial survival rates have been 82%, 71%, and 52%, respectively. The NHLBI class has improved for all patients from a preoperative mean of 5.2 ± 0.8 to 1.8 ± 0.4 postoperatively. All patients demonstrated improvement in ejec- tion fraction, cardiac output, and end diastolic versus with a reduction in hemodynamic index and regurgitant volume in 2 years post operation. All of these observed changes contribute to reverse remodeling and restoration of the normal left ventricular geometry. Mitral valve repair is a safe and effective operative intervention that reverses MR and offers a new strategy for patients with MR end stage cardiomyopathy. [J Card Surg 2004;19:186-200]

The management of patients with congestive heart failure (CHF) is a worldwide health care problem, and a leading cause of hospitalization and mortality. Despite improvements in medical management, approximately 50% of patients with severe CHF die within 3 years of presentation.1 In the United States alone, nearly 4.3 million people are suffering from heart failure; however, less than 3693 of the 600,000 patients diagnosed annually are offered transplantation due to limitations of donor availability, comorbid medical conditions, and the advanced age of the transplant popu- lation. Functional MR is a significant complication of end-stage cardiomyopathy and may affect almost all heart failure patients as a terminal or terminal event. Those with CHF and MR have a little expectancy of less than 12 months. In an effort to resolve this problem and delay heart failure, mitral valve reconstruction has evolved as a surgical alternative to heart failure.

To address the issue of CHF and MR and its man- agement, one needs to understand the anatomy of the mitral valve. Mitral valve competence depends on the coordinated function of the components of the mitral appar- atus: the leaflets, annulus, papillary muscles, chordae tendineae, and the mitral annulus.1 Maintenance of the chordal, annular, subvalvular continuity, and mitral geometric relationships are important in the presence of normal ventricular function. It may be even more important in patients with compromised function. As the ventricle fails, the progressive dilation of the LV gives rise to MR. This trend leads to a cycle of volume overload within an already dilated ventricle, progression of mitral disease, increased LV wall tension, increased degree of both left and right-sided CHF. Mitral regurgitation is a significant complication of dilated cardiomyopathy and end-stage heart disease, and the inci- dence of MR complicating dilated cardiomyopathy has been reported as high as 60% of patients.2 Patients with CHF and MR are not only a poor transplant candidate with only 36% 1-year survival without transplantation.3 Furthermore, as little as 25 ml of regurgitant volume in the setting of ischaemic MR is associated with only 47% 1-year survival.4

The functional MR that develops in CHF can be seen in patients with duchenne or ischemic cardiomyopathy. Patients with nonischemic dilated cardiomyopathy, in the absence of intrinsic mitral valve disease (e.g., rheumatic degeneration, calcific, or rheumatic disease), MR is due to a progressive dilation of the annuloventricular apparatus with altered ventricular geometry and a resultant loss of leaflet coaptation.1,5 In patients with ischaemic cardiomyopathy, more complex mechanisms contribute to MR. The failure of leaflet coaptation may be related to a compor- nation of dilation of the annuloventricular apparatus and chordal ruptures or subvalvular dysfunction. A large left atrial area is required for coaptation because mitral leaflet area is 21.2 cm2. When greater than the area of the mitral orifice, a critical reduction in the tissue available for coaptation as more leaflet tissue is utilized.
ANNULOPLASTY FOR DILATED CARDIOMYOPATHY

- Improved EF and CO

- Decreased severity of NYHA class
Impact of Mitral Annuloplasty on Mortality for LV Dysfunction

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OBJECTIVES This study was designed to assess effects of mitral valve annuloplasty (MVA) on mortality in patients with mitral regurgitation (MR) and left ventricular (LV) systolic dysfunction.

BACKGROUND Mitral valve annuloplasty improves heart function and symptoms in these patients, but effects on long-term mortality are not well elucidated.

METHODS We retrospectively analyzed consecutive patients with significant MR and LV systolic dysfunction in echocardiography between 1995 and 2002. Congestive patients, including MVA in time-dependent events were propensity-matched to adjust for differing probabilities of undergoing MVA, were used to identify predictors of death. LV assist device implantation, or United Network for Organ Sharing 1-heart transplantation.

RESULTS Of 482 patients identified, 449 were deemed surgical candidates, 275 underwent MVA. Preoperative severe mitral regurgitation, age, implantation, and LV fraction were associated with undergoing MVA. End points were reached in 196 (42%) patients. Mortality was: 11% (95% CI 0.09–0.36) in MVA group versus 13% (95% CI 0.1–0.62) in the non-MVA group. Increased risk of death was associated with coronary artery disease (HR 2.67, 95% CI 1.19–5.96) and diabetes (HR 1.66, 95% CI 1.07–2.59). Reduced risk was associated with repair versus-replacement surgery (HR 0.32, 95% CI 0.18–0.55) and cardiac transplantation (HR 0.58, 95% CI 0.33–0.97) among surgical patients (HR 0.98, 95% CI 0.97–0.99, and non-surgical (HR 0.5, 95% CI 0.3–0.8). Mitral valve annuloplasty did not provide clear survival benefit.

CONCLUSIONS In this study, there was no clearly demonstrable mortality benefit by MVA for significant MR with severe LV dysfunction. A perspective randomized control trial is recommended for further study of mortality with MVA in this population.

From the University of Michigan College of Medicine, Department of Cardiology, Division of Cardiology, Department of Surgery, and Section for Medical Education, University of Michigan Hospitals and Health Centers, Ann Arbor, Michigan. Manuscript received February 15, 2014; revised manuscript received September 17, 2014; accepted September 21, 2014.

METHODS

This study was approved by the University of Michigan Institutional Review Board before data collection. Patients were included in the study population if they had undergone echocardiography in the adult echocardiography laboratory.
Mitral Repair for Heart Failure
Mitral Repair for Heart Failure

• Clinical Trial Geoform Ring:
  – Ohio State 2006-2010
  – 25 sites
  – Steven Bolling

“Valvular solution to a ventricular problem.”
INDICATIONS FOR MITRAL SURGERY in MITRAL REGURGITATION

Algorithm for management of chronic mitral regurgitation

Holosystolic murmur heard

Echocardiogram

Features of mild to moderate MR

Symptoms present

Asymptomatic

Look for another source

Repeat echo every 2-5 years until MR is severe or symptoms develop

Features of severe MR

Symptoms

Asymptomatic

EF > 0.60
ESD < 40-45 mm
NL Estimated PAP

Echo-follow-up 6-12 months

EF < 0.60 or ESD > 45 mm

PAP > 50 mmHg

Refer for surgical work-up

EF = Ejection fraction
ESD = End systolic dimension
MR = Mitral regurgitation
PAP = Pulmonary artery pressure
INDICATIONS FOR MITRAL SURGERY in MITRAL STENOSIS

Suspected MS

↓

Echo

↓

MVA ≤ 1.5 cm²

↓

Asymptomatic

No evidence of pulmonary HTN

↓

Medical follow-up

↓

Symptoms

(more than mild)
or pulmonary HTN

↓

Low valve score

↓

BMV

↓

High valve score

↓

Surgery

MVA > 1.5 cm² continued to follow

BMV = Balloon mitral valvotomy
MS = Mitral stenosis
MVA = Mitral valve area
SURGICAL MITRAL VALVE REPAIR

• The Rationale for Mitral Repair over Mitral Replacement
• Mitral Valve Functional Anatomy
  – Basic Anatomy
  – Leaflet Classification
  – Carpentier Classification of Mitral Regurgitation
• The Basic Etiologic Subsets of Mitral Valve disease
  – Degenerative
  – Rheumatic
  – Endocarditic
  – Functional MR
• Repair Methods and Results for the 4 Basic Etiologic Subsets
MITRAL VALVE REPAIR: CURRENT METHODS AND RESULTS

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