Use of Mitral Valve Repair: Analysis of Contemporary United States Experience Reported to The Society of Thoracic Surgeons National Cardiac Database

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Background. **The Society of Thoracic Surgeons National Cardiac Database data indicate that the performance of mitral repair has increased significantly (1990 to 23.2%, 1999 to 32.0%, $p < 0.0001$). We examined contemporary (1999 to 2000) usage of mitral repair in the United States.**

Methods. **We analyzed National Cardiac Database data to determine the operative approach for a diagnosis of mitral regurgitation.**

Results. **A total of 21,741 isolated and combined mitral valve procedures were identified. The overall frequency of repair was 37.7% (8206). For procedures isolated to the mitral valve, the frequency of repair was 35.7% (3027/8486) whereas repair was more common with concomitant CABG (42.9% [3088/7193], $p < 0.0001$). The proportion of patients having repair decreased with age (41.2% [386/936] in 20 to 39 years, 36.1% [3513/9746] in > 70 years, $p = 0.0016$). Repair was more common in males (43.5% [4720/10860]) than females (32.0% [3472/10842], $p < 0.0001$). Repair was less common as NYHA Class increased (Class I, 47.8% [949/1984] vs Class IV, 33.2% [1803/5427]) and for emergent operative status (21.2% [156/736] vs 38.5% [8000/20773] for elective/urgent, both $p < 0.0001$). The number of prior operations did not affect the use of repair. Simple annuloplasty was performed in the majority of reported repairs (62.8% [3837/6115]), more so with associated CABG as compared to isolated repair (70.2% [2167/3088] vs 55.2% [1670/3027]; $p < 0.0001$).**

Conclusions. **Mitral repair was performed in over one-third of the patients reported in 1999 to 2000 and has increased since the National Cardiac Database inception. Repair usage differed based on sex, age, gravity of illness, and associated procedures. This provides a base line from which to expand the application of repair.**

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The advantages of mitral valve repair compared with replacement have been well documented and include maintenance of ventricular geometry, reduced requirement for chronic anticoagulation, excellent long-term durability, and reduced incidence of endocarditis. However mitral valve repair, beyond simple annuloplasty, requires skills additional to those necessary for replacement including an understanding of the three-dimensional structure of the mitral valve, conceptualization of the effects of various repair techniques, and the ability to integrate and combine these techniques for successful repair. Furthermore, mitral valve repair is time-consuming and may, despite the best efforts of the surgical team, result in immediate failure thereby requiring valve replacement. Many techniques for mitral valve repair have been developed and repair durability verified within the past 20 years. In fact, data from the Society of Thoracic Surgeons National Cardiac Database (NCD) demonstrate that the performance of mitral repair has increased relative to replacement over the last decade (1990 to 23.2%, 1999 to 32.0%, $p < 0.0001$, Fig 1). However mitral valve repair techniques can be complex, difficult to learn without specialized training and difficult to incorporate into a surgical practice if the volume of mitral surgery is low. The purpose of this study was to analyze in detail current utilization of mitral valve repair in the United States. Data from 1999 to 2000 were analyzed and interpreted to reflect current practice. Limitations of the NCD are discussed. Data were further compared with a gold standard and recommendations for future practice are made.

Material and Methods

The NCD was queried to extract all reported patients with a diagnosis of mitral insufficiency, inclusive of other diagnoses, that underwent a mitral valve procedure exclusively or as part of a multicomponent open-heart procedure. Queries and analysis were performed based on fields on the Cardiac Surgery Data Collection Form, version 2.35. Logistic regression was used to test for a significant increase in the use of repair over time (Fig 1). All other statistical comparisons were done using Chi-

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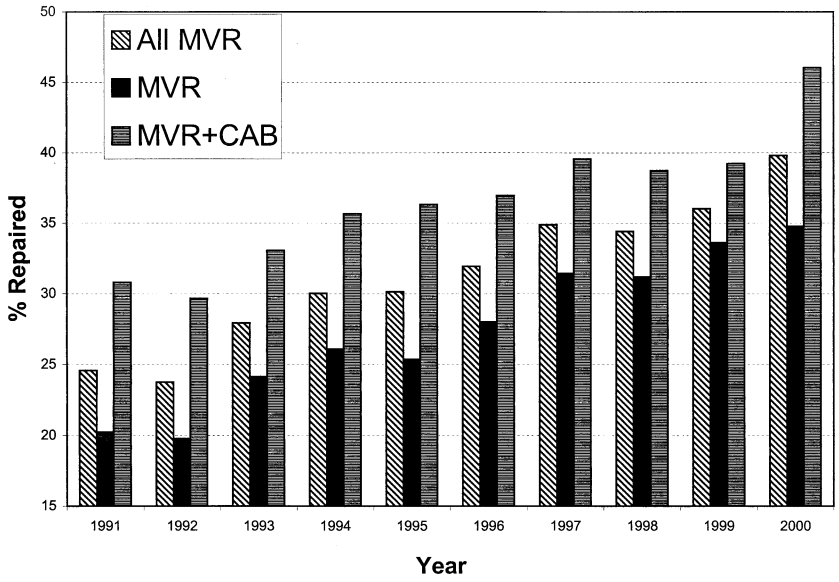

*Fig 1. Application of mitral valve repair with or without coronary artery bypass graft (*CAB*), for all mitral valve procedures both isolated and with associated procedures, is plotted as a percentage of the total number of mitral valve procedures. Application of repair increased overall from 24.6% to 39.8%. Without associated CAB from 20.3% to 34.8%. With associated CAB from 30.8% to 46.0%. (*All MVR = *inclusive of MVR and MVR + CAB;* MVR = *mitral valve procedure with or without associated "non-CAB" procedures;* MVR + CAB = *MVR with CAB.)*

square for an n×2 table where n was the number of groups. A p value less than 0.05 was considered significant.

Results

Data extraction for the years 1999 and 2000 identified 21,741 isolated and combined mitral valve procedures for patients carrying a diagnosis of mitral regurgitation. Of these, 8206 (37.7%) patients underwent mitral valve repair. A total of 8486 patients had isolated procedures on the mitral valve (Table 1). Of these, 3027 (35.7%) had valve repair. In contrast, of the 7193 patients that had mitral surgery with associated coronary artery bypass grafting, 3088 (42.9%, $p < 0.0001$) underwent valve repair. An associated diagnosis of mitral stenosis, in addition to mitral regurgitation, was reported for 5262 patients. Of these, only 1028 (19.7%) had the valve repaired. Excluding the patients with an additional diagnosis of mitral stenosis (Table 1), of 5943 patients who had isolated mitral valve procedures, 2517 (42.4%) had a repair, and of the 5401 patients who had an associated coronary artery bypass graft (CABG) procedure, 2503 (46.3%) had a repair ($p = 0.0083$). A majority of the repair procedures were isolated annuloplasty, with annuloplasty more common when associated CABG was performed (55.2% v. 70.2%, $p = 0.0001$).

Demographic data are detailed in Table 2. The use of repair decreased with age from 41.2% in patients 20 to 39 years old, to 36.1% in patients aged more than 70 years ($p = 0.0016$). Repair was more commonly performed in males (43.5%) than females (32.0%, $p < 0.0001$), and in Caucasians (38.4%) than other ethnic groups (33.0%, $p = 0.0004$). Subanalysis based on gender and age is presented in Table 3. Broken down into subgroups, the significantly greater use of mitral repair in males persisted when analyzed based on associated coronary disease, mitral stenosis, or age.

Table 1. Relative Use of Various Repair Techniques and Replacement for Isolated Mitral Valve Surgery With or Without Associated CABG

	IMV (8486)	IMV + CABG (7193)	Total (15679)
All patients			
Repair	3027 (35.7%)	3088 (42.9%)†	6115 (39.0%)
Annuloplasty (% of all, % of repairs)	1670 (19.7%, 55.2%)	2167 (30.1%, 70.2%)†	
Reconstruction w/annuloplasty (% of all, % of repairs)	1165 (13.7%, 38.5%)	808 (11.2%, 26.2%)	
Reconstruction w/o annuloplasty (% of all, % of repairs)	192 (2.3%, 6.3%)	113 (1.6%, 3.7%)	
Replacement	5429 (64.3%)	4105 (57.1%)	9564 (61.0%)
Excluding patients with diagnosis of mitral stenosis	IMV (5943)	IMV + CABG (5401)	Total (11344)
Repair	2517 (42.4%)	2503 (46.3%)*	5020 (44.3%)
Replacement	3426 (57.7%)	2898 (53.7%)	6324 (55.7%)

* $p = 0.0083$; † $p < 0.0001$.

IMV = isolated mitral valve procedure; IMV + CABG = isolated mitral valve procedure with coronary artery bypass. Isolated means no other associated procedures aside from CABG were performed.

Table 2. Demographics of Mitral Valve Repair Versus Replacement

	Number of Repairs (%)	Number of Replacements (%)	Total Valve Procedures
Age 20–39	386 (41.2)	550 (58.8)	936
Age 40–59	2183 (39.1)	3398 (60.9)	5581
Age 60–69	2124 (38.8)	3354 (61.2)	5478
Age ≥ 70	3513 (36.1)*	6233 (64.0)	9746
Total	8206 (37.7)	13535 (62.3)	21741
Male	4720 (43.5)	6140 (56.5)	10860
Female	3472 (32.0)	7370 (68.0)	10842
Total	8192 (37.8)	13510 (62.3)	21702
% Male	57.6†	45.5	50.0
Caucasian	7365 (38.4)†	11829 (61.6)	19194
Other	841 (33.0)	1706 (67.0)	2547
Total	8206 (37.7)	13535 (62.3)	21741
% Caucasian	89.8	87.4	88.3

* $p = 0.0016$; † $p = 0.0004$.

The impact of preoperative cardiac status on use of valve repair is detailed in Table 4. Repair was less common as NYHA Class increased from Class I (47.8%) to Class IV (33.2%, $p < 0.0001$). In contrast, repair was more common in patients with a left ventricular ejection fraction between 21% and 40% than in those with ejection fractions less than 21% or more than 40% ($p < 0.0001$). There was no difference in repair usage if the patient had suffered either a recent or a remote myocardial infarction. Repair was less commonly used if the patient was in atrial fibrillation (39.1% v. 31.1%, $p < 0.0001$); in the presence of active endocarditis (17.8%) as opposed to treated endocarditis (30.9%, $p < 0.0001$); and for procedures done as emergencies (21.2%) compared with procedures considered to be elective or urgent (38.5%, $p < 0.0001$). Repair was less common in patients having reoperations, but the number of prior procedures did not influence the use of repair. Repair was less common if the previous operative procedure was a valve procedure (11.6%) as opposed to coronary revascularization (30.0%, $p < 0.0001$).

As detailed in Table 5, repair was utilized less often in the presence of renal failure (31.8%) than in its absence (38.3%, $p < 0.0002$). The prevalence of repair was not changed if the patients had peripheral vascular disease, but was less common with the presence of cerebrovascular disease ($p < 0.0001$).

Table 6 summarizes patients in whom mitral valve repair was performed with associated procedures. Repair was much less common when the aortic valve was replaced with a mechanical prosthesis (14.2%) than when the valve was repaired (74.2%, $p < 0.0001$) or replaced with a bioprosthesis (40.4%, $p < 0.0001$).

Table 3. Subanalysis Based on Gender and Age

	Number of Repairs (%)	Number of Replacements (%)	Total Valve Procedures
All patients			
MVR-Male	1739 (42.9)	2314 (57.1)	4053
MVR-Female	1282 (29.0)	3138 (71.0)	4420
% Male	57.6%†	42.4%	47.8%
MVR + CABG-Male	1855 (46.1)	2166 (53.9)	4021
MVR + CABG-Female	1228 (38.9)	1932 (61.1)	3160
% Male	60.2%†	52.9%	56.0%
Excluding patients with a diagnosis of MS			
MVR-Male	1468 (46.8)	1672 (53.2)	3140
MVR-Female	1045 (37.4)	1749 (62.6)	2794
% Male	58.4%†	48.9%	52.9%
MVR + CABG-Male	1535 (48.4)	1634 (51.6)	3169
MVR + CABG-Female	967 (43.5)	1258 (56.5)	2225
% Male	61.4%*	56.5%	58.8%
All patients by age and gender			
Age 20–39-Male	204 (47.3)*	227 (52.7)	431
Age 20–39-Female	182 (36.2)	321 (63.8)	503
Age 40–59-Male	1422 (46.0)†	1668 (54.0)	3090
Age 40–59-Female	759 (30.5)	1727 (69.5)	2486
Age 60–69-Male	1218 (43.7)†	1571 (56.3)	2789
Age 60–69-Female	901 (33.6)	1779 (66.4)	2680
Age ≥70-Male	1876 (41.2)†	2674 (58.8)	4550
Age ≥70-Female	1630 (31.5)	3543 (68.5)	5173

* $p < 0.04$; † $p < 0.0001$.

CABG = coronary artery bypass graft; MS = mitral stenosis; MVR = mitral valve procedure.

Table 4. Use of Repair Based on Preoperative Cardiac Status

	Number of Repairs (%)	Number of Replacements (%)	Total Valve Procedures
NYHA class I	949 (47.8)*	1035 (52.2)	1984
NYHA class II	1737 (47.4)	1929 (52.6)	3666
NYHA class III	3185 (35.7)	5742 (64.3)	8927
NYHA class IV	1803 (33.2)	3624 (66.8)	5427
Ejection fraction < 20	1165 (38.4)	1872 (61.6)	3037
Ejection fraction 21%–40%	1541 (46.6)*	1765 (53.4)	3306
Ejection fraction > 40%	5500 (35.7)	9898 (64.3)	15398
Preoperative atrial fibrillaiton present	1176 (31.1)	2604 (68.9)	3780
Preoperative atrial fibrillation absent	7030 (39.1)	10931 (60.9)	17961
Previous myocardial infarction < 21 days	834 (44.7)	1032 (55.3)	1866
Previous myocardial infarction > 21 days	1233 (43.3)	1618 (56.8)	2851
Treated endocarditis	242 (30.9)	541 (69.1)	783
Active endocarditis	113 (17.8)*	521 (82.2)	634
Elective procedure	6142 (38.8)	9687 (61.2)	15829
% of group	75.31	72.55	
Urgent procedure	1858 (37.6)	3086 (62.4)	4944
% of group	22.78	23.11	
Emergent procedure	156 (21.2)*	580 (78.8)	736
% of group	1.91	4.34	
One previous cardiac operation	1021 (26.1)	2897 (73.9)	3918
Two previous cardiac operations	114 (23.3)	375 (76.7)	489
Three or more previous cardiac operations	30 (22.1)	106 (77.9)	136
Previous valve operation	246 (11.6)*	1880 (88.4)	2126
Previous CABG operation	645 (33.0)	1308 (67.0)	1953

* $p < 0.0001$.

CABG = coronary artery bypass graft; NYHA = New York Heart Association.

Comment

At the outset the limitations of the NCD should be set forth. Participation in the STS NCD is voluntary and data are submitted and compiled by participants. Participation incurs an institutional expense, which may be a disincentive for participation by smaller programs. Furthermore, the completeness and quality of the data may vary among institutions as personnel with variable knowledge of details of mitral valve surgery complete data collection forms. Participation has increased significantly since inception of the database, so it currently presents a more accurate reflection of trends than it did 10 years ago. The demographics of participating institu-

Table 5. Use of Repair Based on Comorbidities

	Number of Repairs (%)	Number of Replacements (%)	Total Valve Procedures
Preoperative renal failure present	597 (31.8)*	1280 (68.2)	1877
Preoperative renal failure absent	7609 (38.3)	12255 (61.7)	19864
Peripheral vascular disease present	982 (38.7)	1559 (61.4)	2541
Peripheral vascular disease absent	7224 (37.6)	11976 (62.4)	19200
Cerebrovascular disease present	821 (33.1)†	1663 (67.0)	2484
Cerebrovascular disease absent	7097 (38.2)	11491 (61.6)	18588

* $p < 0.0002$; † $p < 0.0001$.

Table 6. Use of Repair With Associated Procedures

	Number of Repairs (%)	Number of Replacements (%)	Total Valve Procedures
Tricuspid valve repair/replacement	572 (34.7)	1075 (65.3)	1647
Mechanical aortic prosthesis	232 (14.2)*	1405 (85.8)	1637
Aortic valve repair/reconstruction	95 (74.2)	33 (25.8)	128
Bioprosthetic aortic prosthesis	580 (40.4)	857 (59.6)	1437
Homograft aortic prosthesis	52 (55.3)	42 (44.7)	94
Autograft aortic prosthesis	17 (65.4)	9 (34.6)	26
Aortic root replacement	905 (27.5)	2391 (72.5)	3296
Left ventricular aneurysm repair	79 (55.2)	64 (44.8)	143
Ventricular septal defect repair	17 (36.2)	30 (63.8)	47

* $p < 0.0001$ versus aortic repair and bioprothesis.

tions has probably changed over the life of the database. Therefore, trends demonstrated by the database reflect, but do not absolutely represent national trends. An additional shortcoming is the limited information submitted by participating institutions due to the design of the data collection form. No information about valvular pathology or the etiology of the regurgitation is collected so an analysis of the surgical approach based on these parameters is not possible. Furthermore, although annuloplasty alone can be differentiated from reconstruction with or without annuloplasty, details of the reconstruction (eg, anterior or posterior leaflet repair) are not included so an analysis on the basis of type and complexity of repair is not possible. Finally, it should be noted on review of the data that the totals for many analysis groups differ; this represents missing data and is another potential source of error. Nevertheless given the penetration of the NCD, it is not unreasonable to draw certain conclusions and make recommendations based on the data.

Realizing these constraints, the NCD demonstrates that valve repair has clearly penetrated into the national practice of cardiac surgery. In the fifth quintile of the 1990s decade fully 42.4% of purely regurgitant valves (no stenosis reported) were repaired. However, a review of all the repairs reveals that the majority of these were repaired by simple annuloplasty. This suggests that many valves that might have been repairable using complex repair techniques were instead replaced. The fact that repair usage was reduced in patients more than 70 years of age could be attributed to the fact that these patients are candidates for bioprostheses that, like valve repair, do not obligate the long-term use of anticoagulation. Reduced rates of valve repair in females could be attributed to the noted higher use of repair with associated CABG (Table 1) combined with a greater prevalence of ischemic disease in men. However, this is not borne out in the data presented. When CABG is broken out, the prevalence of repair is still higher in men. We have tried to break this out in Table 3 by excluding an associated diagnosis of mitral stenosis, yet the higher prevalence of repair in males persists. Perhaps the greatest limitation of this analysis is the absence of data reported to the NCD about etiology. The most favorable situation for valve repair is a degenerative, ischemic, or dilated etiology of the regurgitation, rheumatic valves are much less amenable to repair [1]. In order to overcome this limitation, CABG has been used as a crude surrogate for ischemic etiology and the presence of mitral stenosis a crude surrogate for rheumatic etiology in the above analysis.

Mitral valve repair can be performed with low operative mortality (3.4%) as reported by Muehrcke and Cosgrove [2] who combined data from nine published series. In addition, multiple studies have documented the long-term durability and low incidence of long-term complications of mitral valve repair [3, 4]. At 15 years, these results include 93.9% freedom from thromboembolism, 96.6% freedom from endocarditis, 95.6% freedom from anticoagulant-related hemorrhage, 87.3% freedom from reoperation (degenerative disease, 92.7%; rheumatic disease, 76.1%), and little or no mitral regurgitation in 91% of survivors [5]. In comparison with replacement, the long-term results of mitral valve repair are better. Enriquez-Sarano and coworkers [6] compared repair with replacement and noted an independent beneficial effect of valve repair on overall survival (hazard ratio, 0.39; $p = 0.00001$), operative mortality (odds ratio, 0.27; $p = 0.026$), late survival (hazard ratio, 0.44; $p = 0.001$), and postoperative ejection fraction ($p = 0.001$). Most surgeons agree that every patient with mitral valve regurgitation who requires surgery should be approached with the intent to repair rather than replace the valve. The ability to repair the valve has been incorporated into the indications for referral for surgery [7].

To put this data in perspective it is useful to have a "gold standard" to point to for comparison. Mohty and colleagues [8] from the Mayo Clinic compared 679 repairs and 238 replacements performed from 1980 to 1995. Realizing a referral bias (those patients who had potentially repairable valves might be preferentially referred), this experience suggests a standard for rates of utilization of repair. Of the 917 patients reviewed, the overall rate of repair (74%) for isolated mitral insufficiency (from 1980 to 1995) is almost twice that of the national rate of 42.4% (1999 to 2000, excluding mitral stenosis, Table 1) suggesting that nationally many more patients could benefit from mitral valve repair.

To approach this standard it may behoove the cardiac surgical community to adopt a more formal approach to educating surgeons in these techniques. Many of these techniques were described after practicing surgeons finished their training, and many recent trainees may not have been exposed to these techniques in their training. The residency review committee does not distinguish repair from replacement in the minimum case requirements for certification. Furthermore, if mitral valve surgery is a small component of a surgeon's practice the opportunity to apply these techniques may be uncommon. Finally, although the benefits of repair are well described, many medical insurers do not differentiate between repair and replacement, and may not allow specific referral to a surgeon with expertise in mitral repair.

In summary, this analysis provides a snapshot of the current practice of mitral valve repair in the United States and discusses the limitations of data derived from the NCD. With this in mind, we suggest that mitral valve repair may be underutilized, consider some possible causes of this practice, and offer recommendations for increasing repair utilization.

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Requirements for Recertification/Maintenance of Certification in 2003

Diplomates of the American Board of Thoracic Surgery who plan to participate in the Recertification/Maintenance of Certification process in 2003 must hold an active medical license and must hold clinical privileges in thoracic surgery. In addition, a valid certificate is an absolute requirement for entrance into the recertification/maintenance of certification process. If your certificate has expired, the only pathway for renewal of a certificate is to take and pass the Part I (written) and the Part II (oral) certifying examinations.

The American Board of Thoracic Surgery will no longer publish the names of individuals who have not recertified in the American Board of Medical Specialties directories. The Diplomate's name will be published upon successful completion of the recertification/maintenance of certification process.

The CME requirements are 70 Category I credits in either cardiothoracic surgery or general surgery earned during the 2 years prior to application. SESATS and SESAPS are the only self-instructional materials allowed for credit. Category II credits are not allowed. The Physicians Recognition Award for recertifying in general surgery is not allowed in fulfillment of the CME requirements. Interested individuals should refer to the 2003 *Booklet of Information* for a complete description of acceptable CME credits.

Diplomates should maintain a documented list of their major cases performed during the year prior to application for recertification. This practice review should consist of 1 year's consecutive major operative experiences. If more than 100 cases occur in 1 year, only 100 should be listed.

Candidates for recertification/maintanance of certification will be required to complete all sections of the SESATS self-assessment examination. It is not necessary for candidates to purchase SESATS individually because it will be sent to candidates after their application has been approved.

Diplomates may recertify the year their certificate expires, or if they wish to do so, they may recertify up to two years before it expires. However, the new certificate will be dated 10 years from the date of expiration of their original certificate or most recent recertification certificate. In other words, recertifying early does not alter the 10-year validation.

Recertification/maintenance of certification is also open to Diplomates with an unlimited certificate and will in no way affect the validity of their original certificate.

The deadline for submission of applications for the recertification/maintenance of certification process is May 10 each year. A brochure outlining the rules and requirements for recertification/maintenance of certification in thoracic surgery is available upon request from the American Board of Thoracic Surgery, One Rotary Center, Suite 803, Evanston, IL 60201; telephone number: (847) 475-1520; fax: (847) 475-6240; e-mail: abts_evanston@msn.com. This booklet is also published on the website: www.abts.org.