Impact of Intraoperative Echocardiography/Surgery Team on Successful Mitral Valve Repair: A Community Hospital Experience

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Background and aim of the study: **Mitral valve (MV) repair is generally accepted as the preferred treatment of mitral regurgitation (MR) with MV prolapse secondary to myxomatous mitral valve disease (MMVD). However, the incidence of successful valve repair is variable between hospitals and among different surgeons at one hospital, and often results in needless MV replacement. The study aim was to measure the impact of a dedicated echocardiography/surgery team on MV repair at a community hospital.**

Methods: **The outcome was analyzed of a group of 116 consecutive patients with severe MR secondary to MMVD who underwent surgery by the same surgeon over a six-year period. A dedicated team approach, comprising one echocardiographer and one surgeon was established in January 1999. The results of MV repair between 1996 and 1998 (group I; n = 37) were compared to results obtained between 1999 and 2001 (group II; n = 79).**

Results: **In group I, MV repair was attempted in 25 patients (67.6%) and was successful in 21 (56.8%). In group II, MV repair was attempted in 68 patients (86.1%) and was successful in 67 (84.8%). The success rate between groups was significantly (p = 0.001) different. The rate of successful MV repair in patients with a diffusely redundant prolapsing valve involving both leaflets and multiple segments with chordae elongation was significantly higher in group II (14/20; 70%) than in group I (1/6; 14.3%) (p = 0.011).**

Conclusion: **A greater incidence of successful MV repair, even with more diffuse pathology of MMVD, was realized following the institution of dedicated echocardiography/surgery team at a community hospital. It is proposed that a combination of dedicated intraoperative echocardiography and surgical expertise is required for optimal results in MV repair.**

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Degenerative myxomatous mitral valve disease (MMVD) - also sometimes referred to as degenerative mitral valve disease - is a common cause of mitral regurgitation in the United States and Western Europe (1,2). Since the term degenerative valve disease also refers to calcific valve pathology in the elderly, mitral valve (MV) prolapse due to a 'degenerative' etiology will be described under the term 'myxomatous' mitral valve disease. MV repair is the preferred surgical treatment of MMVD because of the established advantages in terms of surgical mortality, durability of repair, thromboembolism, anticoagulation, risk of infection, and ventricular function and long-term survival (2-7). In addition, transesophageal echocardiography (TEE) - and especially intraoperative TEE - has been recognized as being a useful tool to provide the information useful for successful MV repair (8-13). Most of these studies, however, were reported from tertiary referral centers with a high throughput of patients. The surgical results at community hospitals are variable, and a large number of patients in whom the anatomy would appear to be suitable for successful repair still undergo replacement with a prosthetic device. An analysis of the STS National Cardiac Database revealed that the overall frequency of MV repair in year 2000 was a mere 37.7% (14). Since MMVD is a common cause of mitral regurgitation referral for surgery, these data emphasize an inadequate frequency of MV repair in North America. A dedicated echocardiography/surgery team was developed at the present authors' community hospital in order to optimize the results of MV

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repair and patient outcome. The aim of the present study was to measure the impact of this team on MV repair in patients with MMVD and severe mitral regurgitation.

Clinical material and methods

Patients

Between January 1996 and December 2001, a total of 116 consecutive patients (74 men, 42 women; mean age 61 ± 12 years) who underwent MV surgery for MMVD at Hoag Hospital performed by the same surgeon (A.A.R.). Forty-eight of these patients underwent concomitant surgery, including coronary artery bypass graft (n = 22), tricuspid valve repair (n = 22), aortic valve replacement (n = 1), and combinations of these procedures (n = 3).

A dedicated echocardiography (P.M.S.) and surgery (A.A.R.) team was established in January 1999 in order to optimize the results of MV repair and patient outcome. When the team had been established, all patients underwent systematic intraoperative TEE (15) before and after attempted repair. Before 1999, the patients underwent inconsistent intraoperative TEE, without a dedicated cardiologist communicating to the surgeon. On occasion, the echocardiographic interpretation was provided by a technician - a practice not uncommon in non-teaching community hospitals. The year 1998 was a transition year, when the echocardiography input was provided for about one-third of the patients. The decision was made to include this year in the pre-team approach data owing to a lack of consistency of echocardiography input in the remaining patients.

Those patients who underwent MV surgery during the three-year period prior to institution of the team approach were allocated to group I (n = 37), whilst those operated on during the three years after introduction of the team approach were allocated to group II (n = 79). The results of MV repair were compared between groups in order to assess any possible impact of the echocardiography/surgery team on surgical outcome.

Valve morphology

The term MMVD includes patients with degenerative myxomatous MV prolapse associated with mitral regurgitation. MMVD was divided into flail valve commonly associated with chordae rupture; and redundant billowing prolapse with chordal elongation and leaflet redundancy (Fig. 1). TEE evidence of the failure of the tip coaptation with a leaflet free margin displaced superiorly to mitral annulus plane represented flail valve, while severe prolapse of the redundant and thickened leaflets with free margins of both leaflets prolapsing equally represented billowing valve with prolapse. The flail valve was generally associated with evidence of ruptured chordae, and the prolapsing valve with redundant leaflets with diffuse superior

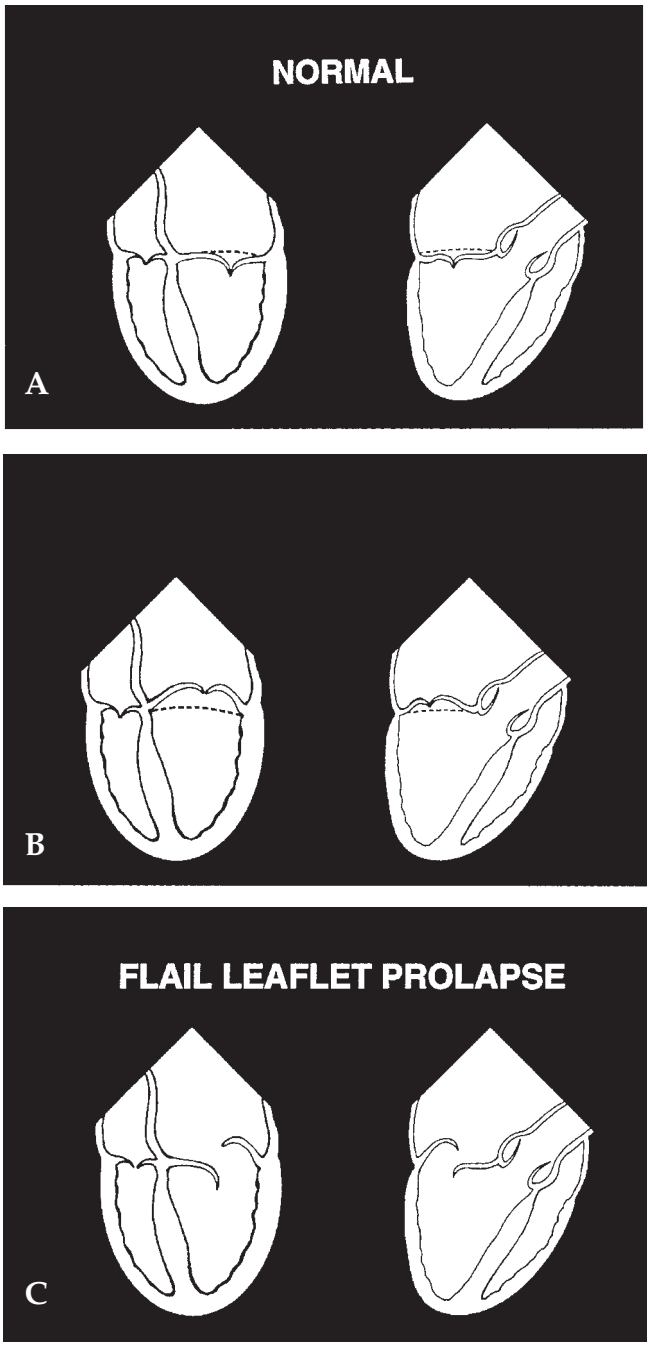

Figure 1: A) Schematic of normal valve coaptation below the annulus (dotted line) in four-chamber and long-axis views. B) Schematic of redundant prolapsing mitral valve with coapting margins prolapsing above the annulus plane, indicative of chordae elongation. C) Schematic of flail mitral valve with posterior leaflet prolapsing above the annulus and loss of coaptation, generally associated with rupture of free edge chords.

Table I: Patient characteristics.

Parameter	Group I (n = 37)	Group II (n = 79)	p-value
Age (years)*	63 ± 12	59 ± 12	0.07
Age >75 years	7 (18.9)	8 (10.1)	0.19
Gender ratio (M/F)	19/18	55/24	0.06
Concomitant surgery	15 (40.5)	33 (41.8)	0.90
CABG	10 (27.0)	12 (15.2)	0.13
TVRep	3 (8.1)	19 (24.1)	0.04
AVR	1 (2.7)	0 (0)	0.14
Combinations	1 (2.7)	2 (1.3)	0.96

*Values are mean ± SD.
Values in parentheses are percentages.
AVR: Aortic valve replacement; CABG: Coronary artery bypass graft; TVRep: Tricuspid valve repair.

motion resulted from multiple elongated chordae. If the chordae rupture involved multiple segments of one or both leaflets, it was designated as complex flail valve. Similarly, chordae rupture of one segment with marked chordal elongation of other segments of either leaflet was also considered as complex flail valve.

Statistical analysis

To assess inter-group differences, Student's *t*-test was used for continuous variables and a chi-square test for categorical variables. A p-value <0.05 was considered to be statistically significant.

Results

Characteristics of the patients undergoing MV surgery, and the associated surgical procedures are listed in Table I. There were no significant differences between the groups in terms of age and gender distribution. The total proportion of patients undergoing concomitant surgical procedures was not different between groups; however, the proportion of patients undergoing tricuspid valve repair in group II was significantly higher than in group I.

All patients in this series had mitral regurgitation severity graded as 3 or 4 on a scale of 1 to 4, with 4 being the most severe. Successful outcome was considered if the post-repair regurgitation was grade 0 or 1. This was measured by intraoperative TEE, as well as by echocardiography performed prior to hospital discharge. The outcome of MV surgery is detailed in Table II.

Among group I patients, MV repair was attempted in 25 (67.6%) and was successful in 21 (56.8%). Repair was unsuccessful and resulted in valve replacement in four cases; the rate of unsuccessful repair to attempted repair was 16.0% (4/25). Among 12 patients who underwent primary MV replacement, seven had billowing valves, two had complex flail valves, two required multiple coronary bypass grafts, and one patient had prior aortic valve replacement. During the period 1996-1998, the surgeon decided to proceed with valve replacement. None of the patients undergoing MV repair required a second pump run for revision of

Table II: Outcome of mitral valve surgery.

Procedure	Group I (n = 37)	Group II (n = 79)	p-value
Attempted repair	25/37 (67.6)	68/79 (86.1)	0.02
Successful repair	21/37 (56.8)	67/79 (84.8)	0.001
Unsuccessful repair (unsuccessful repair/attempted repair)	4/25 (16.0)	1/68 (1.5)	0.006
Second pump run needed (second pump run/attempted repair)	0/25 (0)	5/68 (7.4)	0.16
Late reoperation (late reoperation/successful repair)	1/21 (4.8)	1/67 (1.5)	0.46
Primary replacement	12/37 (32.4)	11/79 (13.9)	0.02

Values in parentheses are percentages.

the repair, and one (4.8%) of 21 patients had a late reoperation because of recurrent mitral regurgitation after MV repair.

Among group II patients, MV repair was attempted in 68 (86.1%) and was successful in 67 (84.8%). Repair was unsuccessful and resulted in valve replacement in only one patient; the rate of unsuccessful repair to attempted repair was 1.5% (1/68). Among 11 patients who underwent primary MV replacement, six were aged between 72 and 79 years with concomitant multiple coronary bypass grafts, and five patients were aged over 80 years with co-morbid conditions (diabetic nephropathy in two, chronic lung disease in two). Five (7.4%) of the 68 patients undergoing valve repair required a second pump run for revision of the repair, and one of these underwent replacement as the surgeon felt that no additional repair techniques could be employed. One (1.5%) of 67 patients had a late reoperation because of recurrent mitral regurgitation after MV repair. The rates of attempted MV repair and successful MV repair in group II were significantly higher than in group I (p = 0.02 and p = 0.001, respectively). The incidence of attempted repair being unsuccessful and resulting in MV replacement in group II was significantly (p = 0.006) lower than in group I. There was no difference in the rate of the second pump run and the late reoperation between the groups.

The rate of MV repair in each year of the study was 54.5% (6/11) in 1996, 50.0% (5/10) in 1997, 62.5% (10/16) in 1998, 81.0% (17/21) in 1999, 87.9% (29/33) in 2000, and 84.0% (21/25) in 2001 (Fig. 2).

The relationship between valve morphology and outcome is detailed in Table III. The rate of MV repair in flail valve was 64.0% (16/25) in group I, and 90.4% (47/52) in group II. This difference was significant (p = 0.005). The rate of MV repair in flail posterior mitral leaflet in group II (92.7%; 38/41) was significantly (p = 0.02) higher than in group I (70.0%; 14/20). There was no statistical difference in the rate of MV repair in flail anterior mitral leaflet (AML). Among three group I patients with flail AML, attempted valve repair was successful in only one case. In contrast, in group II patients with flail AML or complex flail, repair was successful in all cases. The rate of MV repair in redundant billowing valves with bileaflet prolapse increased from 41.7% (5/12) in group I to 74.1% (20/27) in group II, though this was not statistically different (p = 0.052).

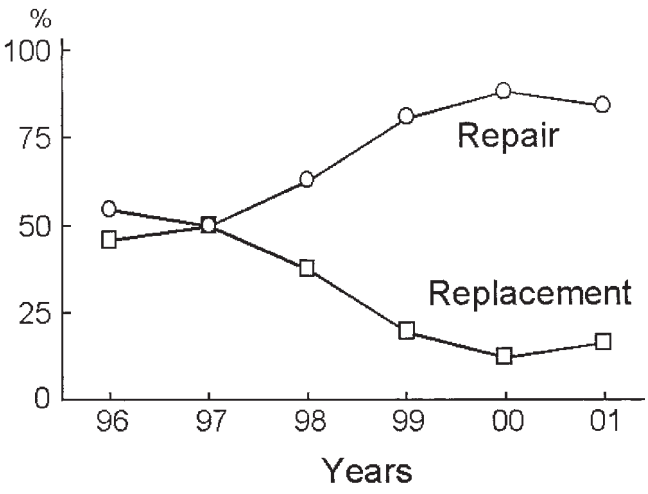

Figure 2: Incidences of mitral valve repair and replacement for degenerative myxomatous mitral valve disease over the six-year study period.

Table III: Relationship between mitral valve morphology and outcome.

Valve morphology	Group I (n = 37)			Group II (n = 79)			p-value
	MV repair	MV replacement*	Rate of MV repair (%)	MV repair	MV replacement*	Rate of MV repair (%)	
Flail valve	16	9 (3)	64.0	47	5 (1)	90.4	0.005
Flail PML	14	6 (1)	70.0	38	3 (1)	92.7	0.02
Flail AML	1	3 (2)	25.0	4	1	80.0	0.10
Complex flail	1	0	100.0	5	1	83.3	0.60
Redundant prolapsing valve	5	7 (1)	41.7	20	7	74.1	0.052
Without ruptured chordae	1	6 (1)	14.3	14	6	70.0	0.011
With ruptured chordae	4	1	80.0	6	1	85.7	0.793
Total	21	16 (4)	56.8	67	12 (1)	84.8	0.001

*Includes patients who underwent replacement following unsuccessful repair; values in parentheses indicate numbers of patients who underwent MV replacement following unsuccessful repair.
AML: Anterior mitral leaflet; MV: Mitral valve; PML: Posterior mitral leaflet.

The rate of MV repair in diffuse redundant prolapsing valve without ruptured chordae in group II (70%; 14/20) was significantly (p = 0.011) higher than in group I (14.3%; 1/6), and repair was successful in all 14 patients in group II in whom repair was attempted.

Discussion

Although numerous reports have shown the superiority of MV repair over replacement for degenerative MMVD in terms of surgical mortality, durability of repair, thromboembolism, anticoagulation, and ventricular function and long-term survival (2-7), MV replacement is more frequently undertaken at many community hospitals and some university hospitals. For the period 1999-2000, the Society of Thoracic Surgeons (STS) National Database (NCD) showed that 42.4% of patients underwent MV repair among those with isolated MV procedures in the absence of mitral stenosis. However, a majority of these (55.2%) consisted of isolated annuloplasty. In the present authors' institutions, the incidence of successful MV repair for degenerative MMVD was on average 56.8% for the years 1996 to 1998 before the echocardiography/surgery team approach was established. However, a sharp rise to more than 80% in the rate of successful MV repair in was realized 1999, the first year after establishing a dedicated team approach. This improved outcome was maintained in the subsequent years. None of these patients had isolated annuloplasty. The dedicated team approach provided a detailed preoperative assessment of the location and nature of valve pathology. The TEE information was used to tailor the surgical approach based on functional relevance of anatomic abnormalities. If the result of the repair was inadequate, in the post-repair TEE the cardiologist confirmed the origin and pathophysiological basis of the regurgitation by TEE and the surgeon proceeded to revise the repair on the second pump run in five patients; this revision was successful in four cases. As mentioned above, the dedicated echocardiography/surgery team improved the incidence of successful MV repair.

There are additional results supporting the usefulness of the team approach. Several patients with a diffusely redundant billowing valves with bileaflet prolapse without chordae rupture - a pathology often considered unrepairable in the earlier years - underwent successful MV repair following institution of the team approach. It has been reported that 20-30% of patients who underwent surgery for MV prolapse have bileaflet prolapse with redundant excessive tissue. MV repair in this group was successful in 60-85% of cases (9-12). Judging from these data, the greater incidence of successful MV repair after instituting a dedicated team approach is based on an increase in the rate of successful repair in bileaflet prolapse with chordal elongation, as well as in flail valves with chordae rupture. The repair was unsuccessful and resulted in MV replacement in four patients with this pathology before the team approach, whilst, among five patients in whom the repair was revised on the second pump run after institution of a dedicated team approach, it was successful in four. These data support the present authors' contention that a dedicated echocardiography/surgery team has the potential to provide an improved outcome.

An equally important consideration is that of expertise and dedication of a surgeon to achieving successful valve repair. In the present study, all MV operations were performed by one surgeon, though it is possible that the surgical expertise could have improved with increased experience. This study was not designed to measure an independent influence of improved surgical experience over time - a difficult undertaking at best. It is believed that an immediate increase in valve repair success during the first year following institution of a dedicated team supports a significant contribution of the team approach on outcome. This success was maintained for each of three subsequent years, and continued to remain at 84-90% for the years 2002 and 2003. The team approach increases the rate of MV repair, and the successful outcome results in an increased referral of patients with MMVD. By means of this cycle, the team approach may work synergistically in further augmenting the rate of successful MV repair.

The echocardiography/surgery team consists of a dedicated echocardiologist, who provides detailed information on the anatomy and pathology of the valve by TEE, and the surgeon, who is able to utilize this information for successful MV repair. The team jointly evaluates the feasibility of repair, plans the type of surgery, and assesses the adequacy of repair and precise approach of any revision during a second pump run in order to optimize results of MV repair and patient outcome.

Study limitations

This study was not designed as a prospective trial, and thus suffered from the limitations of a retrospective investigation. Since the results of surgical outcome by the same surgeon in the same institution are compared before and after institution of the team approach, the conclusions appear valid. This study did not attempt to measure the improved expertise of the surgeon. However, a sudden change in patient outcome supports value of the team approach, though improved surgical expertise cannot be discounted.

In conclusion, a greater incidence of successful MV repair, even with a more diffuse pathology of MMVD, was realized following the institution of a dedicated echocardiography/surgery team at a non-teaching community hospital. It is proposed that intraoperative echocardiography combined with surgical expertise are required for optimal results in MV repair. All major cardiothoracic centers - including community hospitals - may achieve higher volumes, thus providing across-the-board improvement in outcome for almost all patients with degenerative MMVD.

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Meeting discussion

DR. JOHN CHAMBERS (London, UK): May I add a comment? I think the team approach is vital in all valve disease - we are very used to having invasive interventional cardiologists and electrophysiological specialists. But we also need cardiologists - usually echocardiographers specializing in valve disease - so that at every stage, and not only at mitral valve repair, the patients are referred for surgery at the right time, they are identified correctly, and the data can be disseminated to our colleagues. I think at every level we should be reorganizing ourselves in this way - as you have elegantly demonstrated.

DR. A. OLIVESI (France): You spoke about valves with excessive tissue, but what about rheumatic valves with restrictive tissue? I also have a question about systolic anterior motion - SAM. If the anterior leaflet especially is enlarged, what happens with regard to SAM later on?

DR. PRAVIN M. SHAH (Newport Beach, CA, USA): First, I must restate that these data are only for myxomatous or degenerative valve disease, fibroelastic or degenerative or myxomatous. There is no rheumatic case included in this series. Our experience with rheumatic cases is that surgery is possible, but the long-term results are not good. In fact, there are some cases where - depending on the amount of subvalvar disease - you cannot perform a good repair. In terms of SAM - if it is present - we don't know what the long-term outcome will be, even if it is corrected with medication. The data seem to show that in patients with some residual SAM, but when everything improved and so it was decided not to do anything, there was a much higher reoperation rate over a short time period - within one or two years. But we don't have that particular

follow up experience. We almost never leave a patient with SAM in the operating room.

DR. JOEL A. STROM (Tampa, FL, USA): Is your team the only one doing mitral valve repairs at Hoag Hospital?

DR. SHAH: At Hoag we have unique circumstances. First, Dr. Raney has a group of three surgical partners who are in the same group, and he probably does over 90% of the repairs. Second, I go into the operating room for every single case. We not only look at the echo before surgery, and make decisions about timing - we also discuss issues relating to what the best approach might be. The final decisions - ring size, etc. - are Dr. Raney's, but I believe that this interaction helps us focus on what needs to be done for any one patient. I think that is what produces the good results.

DR. AIDAN A. RANEY (Newport Beach, CA, USA): I would just like to re-emphasize the point that for the surgeon to have accurate information is as important in valve surgery - especially for valve repairs - as it is in coronary artery surgery. It is a misconception that when the heart is flaccid and open, the surgeon can analyze and carefully decide on the pathology. For 60 to 70% of the time it's very straightforward, but for 20 to 30% of the time it can be much more subtle and is not evident to the surgeon at the time of surgery, when the heart is open. I think that if you expect the surgeon and the program to be successful, you must have dedicated echocardiography.

DR. CARLOS DURAN (Missoula, MT, USA): This is an important communication, because it should encourage people to move in this direction. Firstly, I must say that there has been a change, both of the surgeon and the cardiologist. You need such as change to make this combination useful, because if the cardiologist and surgeon are speaking different languages, the scheme is useless. Secondly, the investigative information that the cardiologist provides is surgical. Most cardiologists don't do this - they indicate the degree of regurgitation, the ejection fraction, PR pressure, and so on. But they don't tell you the size of the anterior or posterior leaflet, where the prolapse is, and how many millimeters of prolapse. It is that information that grabs the surgeon's interest - otherwise it's a waste of time. Do you agree?

DR. SHAH: Very much, Dr. Duran. Cardiologists must be trained, and surgeons must respect and accept cardiologists so that they can work together. In this way, it should be possible nowadays for all institutions to repair over 90% of myxomatous valves, irrespective of the patient's age and any associated coronary disease or other valve disease