A Simplified Approach to Degenerative Disease: Triangular Resections of the Mitral Valve

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Background. **Only 40% of patients with mitral valve (MV) regurgitation undergo operative repair rather than replacement. Quadrangular resection combined with ring annuloplasty has been the most common method of repair for degenerative posterior leaflet disease. Techniques such as sliding annuloplasty and artificial chord usage have increased the complexity of repair. These techniques have been perceived to be difficult and have possibly reduced the incidence of MV repair. We present our experience with a simplified approach to MV repair utilizing a triangular resection and larger rings.**

Methods. **Retrospective review of all MV repairs over a 7-year period (1999 to 2006) revealed 154 patients who underwent triangular resection for degenerative disease. Patients who underwent ring annuloplasty without leaflet resection and patients who had artificial chords or quadrangular resections were excluded.**

Results. **Of 154 patients who underwent triangular resection, isolated posterior leaflet resection was performed on 130 patients. Isolated anterior and combined anterior and posterior leaflet triangular resections were performed on 16 and 8 patients, respectively. Thirty-day postoperative mortality was 0%. Five-year freedom from reoperation for recurrent mitral regurgitation was 99.0%. No patients who had intended leaflet resection were converted to MV replacement. Intraoperative transesophageal echocardiogram revealed trace to 1+ mitral regurgitation. Mild systolic anterior motion was noted in 7.1% of cases initially, but resolved with volume loading in all.**

Conclusions. **Triangular leaflet resection of the mitral valve produces durable results and can be safely and efficiently performed with minimal morbidity and mortality. This technique should allow increased utilization of MV repair for degenerative disease.**

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Degenerative mitral valve (MV) disease is the most common indication for MV surgery in North America and Europe and is amenable to repair in approximately 90% of cases [1–3]. Despite the well-documented benefits of MV repair over mitral valve replacement, approximately 60% of patients with mitral valve regurgitation still undergo valve replacement rather than repair [2]. Patients who undergo mitral valve replacement are frequently relegated to lifelong anticoagulation therapy and the concomitant increased risk of hemorrhage and thromboembolism. In addition, mitral valve replacement increases the risk of endocarditis and hospital mortality, and results in worsened left ventricular dynamics compared with MV repair [4–7]. Secondary to the consequences of these risks, surgical correction of mitral regurgitation is often delayed, leading to left ventricular (LV) dilation, decreased LV function, and increased rates of atrial fibrillation and, thus, need for anticoagulation [1, 3, 8].

One of the issues implicit in the delay of mitral valve surgery and the choice of replacement over repair is the variety and complexity of surgical repairs available for degenerative mitral valve disease. Artificial chord implantation, chordal translocation, quadrangular resection with sliding annuloplasty, and flip-over techniques are a few of the currently employed techniques that have given MV repair an intimidating image. Although these repair techniques lead to good long-term results, the perceived complexity of these techniques may discourage many surgeons from repairing mitral valves [3, 9–12].

The purpose of this study is to present our experience of triangular leaflet resections with ring annuloplasty for degenerative MV disease as a straightforward, durable, and easily reproducible repair with the goal of improving upon the frequency of mitral valve repair.

Patients and Methods

This study was reviewed and approved by the Human Investigation Committee of the University of Virginia Health System with a waiver of individual patient consent. A retrospective analysis of all mitral valve operations for degenerative mitral valve disease over a 7-year period (1999 to 2006) was performed at a single institu-

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tion. A review based on intention to treat subsequently identified 154 consecutive triangular resections with ring annuloplasty for degenerative mitral valve disease. Comorbid conditions did not affect the selection of patients for triangular resections. Twenty-seven mitral valve replacements performed for degenerative disease during the study's time frame were excluded.

The most common indication for replacement over repair was severe mitral annular calcification. Degenerative mitral valve disease was diagnosed by direct surgical inspection, pathology reports, and echocardiograms. All included patients underwent triangular resection of the diseased portion of the mitral valve with subsequent ring annuloplasty. The decision in selecting the type of complex repair was determined by surgeon preference. Twenty-eight patients who underwent complex mitral valve repair other than a triangular resection (single surgeon preference) were excluded, as were 20 patients who received an annuloplasty ring as the sole treatment of mitral regurgitation. Follow-up information was obtained during outpatient appointments and phone interviews with the referring cardiologist and primary care physicians. The mean duration of follow-up was 28.0 ± 24.6 months (range, 4 to 72) and was 92.6% complete (143 of 154). The mean duration of echocardiographic follow-up (143 of 154 patients) was 16.9 ± 22.3 months (range, 1 to 84).

Operative Technique

After anesthetic induction, the mechanism of MR was assessed using transesophageal echocardiogram. The underlying cause of the MR was then confirmed with particular attention paid to the size of the annulus, the location of the regurgitation (central versus eccentric), the direction of the regurgitant jet, leaflet issues including prolapse, flail leaflets or chordae, and the underlying ventricular function. After thorough evaluation of the underlying pathology, we continued with the procedure.

All procedures were performed through full or partial sternotomy. Patients were placed on cardiopulmonary bypass using standard techniques. Dual venous cannulation was employed either percutaneously or directly and antegrade or retrograde cardioplegia, or both were utilized, depending on surgeon preference. If coronary artery bypass grafting or an atrial ablation procedure was performed, this was done before the mitral procedure. Tricuspid and aortic valve procedures were done after the mitral procedure.

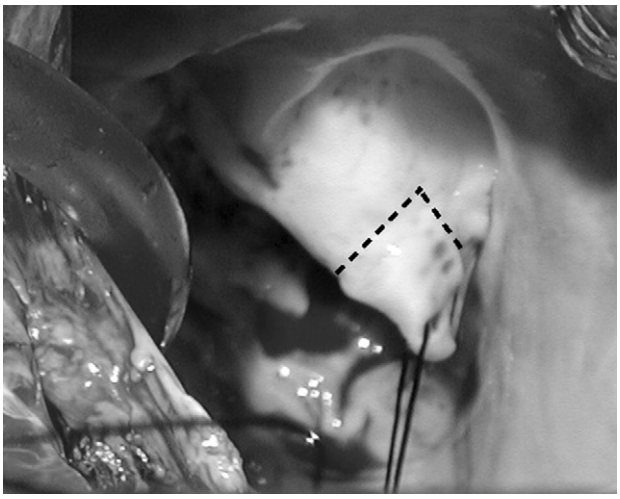

Fig 1. Prolapse of A2, before repair.

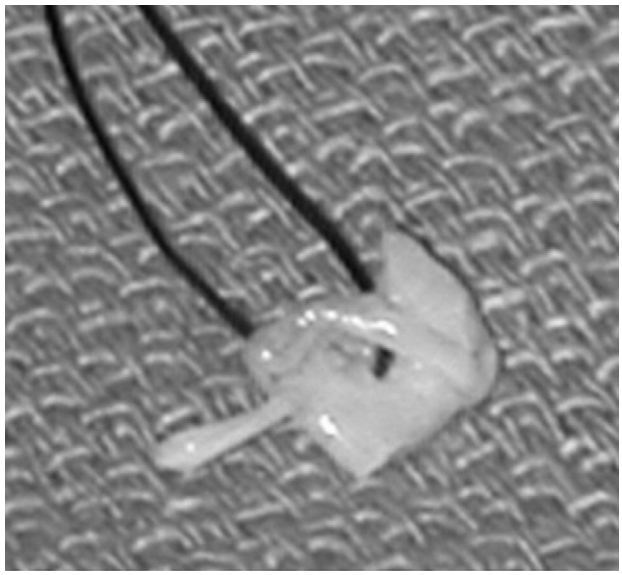

Fig 2. Resected segment from A2.

The mitral valve was approached by either the left atrium through Waterston's groove or using a biatrial approach, depending on surgeon preference and concomitant procedures. A variety of retractors were used to obtain good visualization, which is critical to the procedure. The valve was inspected to confirm the pathology. As the P1 segment of the posterior leaflet is most commonly free from prolapse, it served as the reference point for inspection of all other areas of the leaflets.

With the aid of a nerve hook, the free edge of P1 was compared with A1, then P2, A2, P3, and A3. This stepwise approach allowed for thorough inspection of the leaflets and created a three-dimensional understanding of the leaflet relationships. Moreover, prolapse was clearly defined by the overriding of one leaflet edge from another. Any chordal pathology was also clearly delineated with this technique.

At this point, chordal structures associated with both the segment to be resected and the portions to be retained were identified. Care was taken to ensure adequate support of the tissue to be retained. The flail or prolapsing segment of the leaflet (Fig 1) was then excised as a triangular-shaped segment (Fig 2) with the base of the triangle at the leading edge of the valve leaflet and the apex toward the annulus. The height and shape of the resection varied based on the amount of leaflet involved as well as on which leaflet was being repaired. The apex of the resection for posterior disease was adjacent to the posterior annulus. The apex did not extend to the

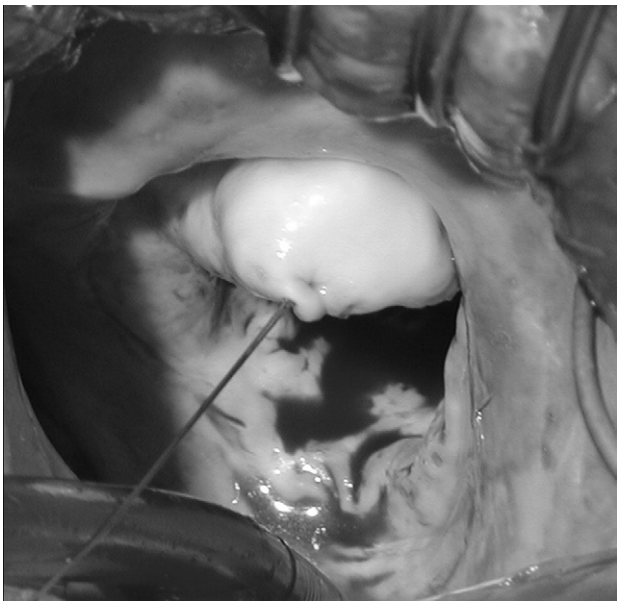

Fig 3. Anterior leaflet after triangular resection of a segment of A2.

posterior annulus. The leading edges were then approximated and the defect in the leaflet repaired with a running 4-0 Ticron suture (Syneture, Norwalk, CT).

The anterior leaflet (Fig 3) was repaired in a similar manner; however, it must be noted that there were some significant technical issues to consider. The height of the repair relative to the leaflet height should not exceed one third the distance from the free edge to the annulus as the center of the anterior leaflet is less pliable. There is, however, no absolute percentage or length of the free edge that guides the upper limit of area of resected

Table 1. Clinical Profile

Characteristic	n = 154
Male/female	102/52
Age (years)	59.8 ± 14.3
Follow-up duration (months)	28.0 ± 24.6
Diabetes mellitus	14 (9.1%)
Peripheral vascular disease	9 (5.8%)
Tobacco use	39 (25.3%)
COPD	17 (11.0%)
Hypertension	74 (48.1%)
Chronic renal insufficiency	10 (6.5%)
Cerebrovascular accident	10 (6.5%)
Redo sternotomy	6 (3.9%)
Left ventricular (LV) function	
Normal LV function	134 (87.0%)
Mild LV dysfunction	17 (14.9%)
Moderate LV dysfunction	3 (2.5%)
Severe LV dysfunction	0 (0%)
NYHA class	
I	26 (16.8%)
II	100 (64.9%)
III	23 (14.9%)
IV	5 (3.2%)
Atrial fibrillation	43 (27.9%)
Degree of preoperative MR (3 or 4+)	154 (100%)

COPD = chronic obstructive pulmonary disease; MR = mitral regurgitation; NYHA = New York Heart Association.

Table 2. Operative Details and Associated Procedures

Operative Detail	n = 154
Leaflet resection	
Anterior	16 (10.4%)
Posterior	132 (85.7%)
Anterior and posterior	8 (5.2%)
Ring size	32.6 ± 2.3
Coronary artery bypass	16 (10.4%)
Number of bypassed vessels	1.8 ± 0.99
Other valve surgery	
Aortic valve replacement	4 (2.6%)
Tricuspid annuloplasty	2 (0.6%)
Atrial fibrillation ablation	22 (14.3%)

Table 3. Outcomes

Outcome	n = 154 (%)
SAM on intraoperative echocardiogram	11 (7.1%)
Operative revision for SAM	0 (0%)
SAM not resolved with volume loading	0 (0%)
SAM resolved on predischarge transthoracic echocardiogram	11 (100%)
Conversion to MVR or other repair	0 (0%)
Intraoperative postrepair echocardiogram (TEE)	
0 to 1+ MR	154 (100%)
2+ MR	0 (0%)
3+ MR	0 (0%)
4+ MR	0 (0%)
Cross-clamp time (min)	72.9 ± 25.4
Cardiopulmonary bypass time (min)	102.3 ± 32.8
Discharge from ICU by POD 1	145 (94.2%)
Extubation by POD 1	151 (98.0%)
Postoperative hospital stay (days)	5.2 ± 2.7
Postoperative exploration for bleeding	5 (3.2%)
Mediastinitis	0 (0%)
Acute renal failure	1 (0.6%)
Cerebrovascular accident	4 (2.6%)
Endocarditis	0 (0%)
Anticoagulant related hemorrhage	0 (0%)
Death within 30 days of operation	0 (0%)
Predischarge transthoracic echocardiogram (n = 120)	
0 to 1+ MR	120 (100%)
2+ MR	0 (0%)
3+ MR	0 (0%)
4+ MR	0 (0%)

ICU = intensive care unit; MR = mitral regurgitation; MVR = mitral valve replacement; POD = postoperative day; SAM = systolic anterior motion; TEE = transesophageal echocardiography.

leaflet. Ultimately, the ability to reapproximate the defect created by the resection in a tension-free manner is the most important limiting factor when considering the upper limit of leaflet tissue to be resected.

Mitral annuloplasty was then performed in all patients using a complete or partial semirigid ring (surgeon preference). The ring was sized to the anterior mitral leaflet and the intertrigonal distance and then upsized by one. Interrupted braided 2-0 sutures were placed in a horizontal mattress fashion around the annulus and the prosthesis seated to them.

The adequacy of the repair was then tested with the left ventricular saline infusion test. The left atrial approach was closed, and the remainder of the procedure was performed. The patient was weaned from cardiopulmonary bypass in standard fashion. Immediate post–cardiopulmonary bypass transesophageal echocardiogram was then performed to confirm adequacy of the repair. Postoperatively, the patient was taken to the intensive care unit. Standard follow-up care was provided.

Statistical Analysis

Values are expressed as the mean ± SD unless otherwise indicated. The Kaplan-Meier method was used to determine survival and freedom from reoperation. All p values less than 0.05 were considered significant. The analysis was performed using SAS statistical software (SAS Institute, Cary, North Carolina) by an independent statistician.

Results

Patient Characteristics

Preoperative patient characteristics are shown in Table 1. All patients undergoing MV repair had 3+ to 4+ MR with a mean MR of 3.7 ± 0.2, preoperatively. The mean New York Heart Association functional class was 2.03 ± 0.65, and the majority of patients (134 of 154, 87.0%) had normal left ventricular function.

Operative Characteristics

Repair was most commonly performed for posterior degenerative disease (132 of 154 patients, 85.7%) with isolated P2 resections performed in 114 of the 132 posterior resections (86.3%; Table 2). Anterior and combined anterior and posterior resections were less common (24 of 154, 15.6%). The mean ring size was 32.6 ± 1.9. The mean ring sizes for men and women were 33.1 ± 2.2 and 31.6 ± 2.4, respectively. Atrial fibrillation ablation was the most common other procedure performed at the time of mitral valve repair (22 of 154, 14.3%). The 16 of 154 patients who underwent coronary artery bypass grafting at the time of MV repair clearly had degenerative disease without an associated ischemic component.

Outcomes

The postoperative course (Table 3) was largely unremarkable for the majority of patients. Acute renal failure occurred in 0.6% of patients (1 of 154) and stroke in 2.6% (4 of 154). The one episode of renal failure resolved with conservative management, as did the symptoms from the stroke in the 4 affected patients before discharge. Ninety-eight percent of patients were extubated by postoperative day one, and 94.2% were discharged from the intensive care unit by the end of the first postoperative day. The mean postoperative length of stay was 5.2 ± 2.7 days. A subgroup analysis comparing patients who had chronic atrial fibrillation (43 of 154, 27.9%) with patients who did not (111 of 154, 72.1%) revealed no significant differences in the outcomes evaluated in Table 3.

Systolic Anterior Motion, Recurrent Mitral Regurgitation, and Survival

While systolic anterior motion was present in 7.1% of patients (11 of 154) immediately after cardiopulmonary bypass, operative revision was not necessary in any patient. Systolic anterior motion resolved with adequate volume loading in these patients. Predischarge transthoracic echocardiogram confirmed the absence of systolic

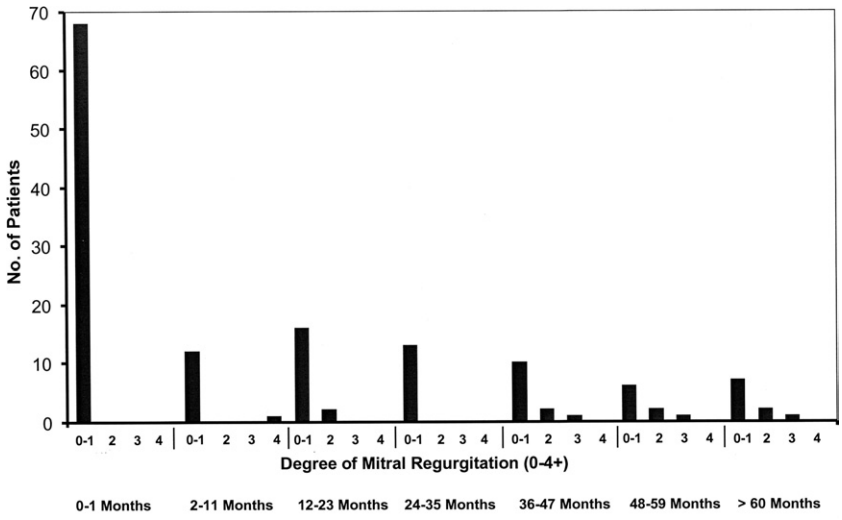

Fig 4. The degree of mitral regurgitation demonstrated on the most recent known follow-up transthoracic echocardiograms in 143 of 154 patients.

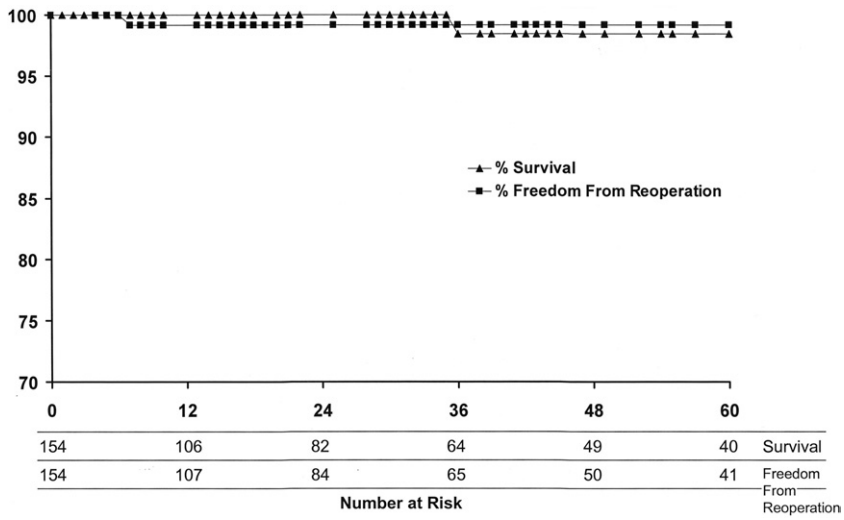

Fig 5. Kaplan-Meier analysis of survival and freedom from reoperation. (Boxes = percent freedom from reoperation; triangles = percent survival.)

anterior motion in all 11 patients. Intraoperative assessment of mitral regurgitation on the immediate postrepair transesophageal echocardiogram revealed MR ranging from 0 to 1+ in all patients. Most patients, 120 of 154 (77.9%), had a presdicharge transthoracic echocardiogram. Consistent with the postrepair intraoperative transesophageal echocardiogram, all patients continued to have 0 to 1+ MR on the predischarge transthoracic echocardiogram. The most recent known echocardiogram was evaluated in 143 of 154 patients (Fig 4). Keeping in mind that 34% (48 of 143) of those with known echocardiographic follow-up were still less than 1 year from repair, the most recent known echocardiogram was the predischarge transthoracic echocardiogram in 47.6% (68 of 143). Of the 62 patients with more than 1 year of echocardiographic follow-up, 4.8% (3 of 62) had more than 2+ mitral regurgitation. No patient who had an intended leaflet resection was converted to MV replacement or re-repair. The 30-day postoperative mortality was 0%. The 5-year freedom from reoperation for recurrent MR was 99.0%, and the 5-year survival rate was 98.5% (Fig 5).

Comment

Triangular resection with ring annuloplasty has become the procedure of choice for the surgical correction of degenerative mitral valve disease at our institution, while mitral valve replacement has become the exception. The concept of a triangular resection was suggested to us by colleagues at the Mayo Clinic [13, 14], and we subsequently added the oversized ring to prevent systolic anterior motion. This approach has lead to durable results in the context of very limited perioperative morbidity, no intraoperative mortality, and survival rates paralleling that of the general population [11, 12, 15, 16]. As the perceived dangers of mitral valve surgery are diminished, we have seen an increasing trend in earlier referral for surgery while left ventricular function is still preserved and atrial fibrillation is less common. The favorable results seen in this study should be expected as the pathologic process and patient population lend themselves to successful repair.

Repairs other than the traditional quadrangular resection with sliding annuloplasty have been criticized for increased rates of systolic anterior motion [17]. In our series, however, systolic anterior motion developed in only 7.1% of cases (11 of 154). Systolic anterior motion resolved in all cases with volume loading before the patient left the operating room and failed to produce any clinically relevant sequelae on follow-up. Grossi and colleagues [18] have also demonstrated low rates of systolic anterior motion after triangular resections. Instead of utilizing a sliding annuloplasty, which increases the complexity of the operation as well as the overall length of the suture line needed for repair, oversized rings were used to minimize left ventricular outflow obstruction. As degenerative mitral valve disease is often characterized by excessive tissue, larger annuloplasty rings minimize the effect of redundant leaflet tissue on left ventricular outflow while also normalizing leaflet coaptation. Larger annuloplasty rings have been successfully utilized by Adams and colleagues [19] in the treatment of Barlow's disease. The annuloplasty ring also corrects and prevents further annular dilation, reinforces leaflet suture lines, and thus improves upon the durability of the repair. The placement of a larger ring without leaflet resection, however, is not sufficient. The widespread use of intraoperative transesophageal echocardiography has also allowed for this physiologic repair of degenerative mitral valve disease and the prevention of clinically significant systolic anterior motion.

Much of the durability of the triangular resection lies upon the concept of a tension-free repair. As the mitral valve approximates the shape of a circle, the resection of a wedge of diseased and often excessive tissue intuitively lends itself to a simpler repair. As less "normal" tissue is removed, less tension is placed along the suture line compared with the resection of a rectangle from a circular object. Triangular resection focuses the majority of the

resected tissue to the most commonly diseased portion of the mitral valve, the leading edge, and also avoids detaching and then reattaching the leaflet to the mitral annulus. While the P2 segment often sustains the greatest stress during systole of all mitral valve segments, none of the 114 of 154 P2 resections/repairs (74.0%) failed, which implies the lack of excessive tension along the suture line used to approximate P1 and P3. By also minimizing the amount of resected leaflet tissue, the danger of creating a critical decrease in mitral valve area or left ventricular inflow is obviated [4]. The preservation of leaflet tissue and underlying chordal support achieved by triangular resections and other MV repairs (ie, artificial chords), helps maintain a more physiologic repair while still reducing the height of the diseased leaflet. When considering that the majority of reoperations for recurrent mitral regurgitation after mitral valve repair occur at a mean interval of 15.6 ± 2.5 months in a study by Gillinov and associates [20], our 5-year freedom from reoperation for recurrent MR of 99.0% is truly encouraging, as most failures would likely have manifested during the study period. Other popular repair techniques have demonstrated comparable outcomes. Deloche and colleagues [3] and Braunberger and associates [9] reported an approximately 0.4% per year risk of reoperation for patients undergoing MV repair with Carpentier techniques for nonrheumatic MV disease. In another series, artificial chord usage for degenerative anterior and posterior leaflet disease resulted in a 3-year freedom from reoperation of 91.9% and 90.7%, respectively [21].

Successful utilization of triangular resection for mitral insufficiency has also been previously reported. Spencer and colleagues [1] and Grossi and coworkers [22] at New York University have reported excellent results from triangular resections for prolapsing anterior leaflets in more than 100 patients. The 10-year freedom from reoperation after triangular resection of anterior leaflet prolapse in 32 patients was reported as 93% by Sakamoto and associates [4]. In a recent study of mitral valve repairs at the Mayo clinic, where triangular resection with ring annuloplasty was commonly used, Suri and coworkers [5] reported a risk of reoperation of 0.5% per year, 0.92% per year, and 1.64% per year for isolated posterior, bileaflet, and anterior leaflet disease, respectively. Our experience of 154 patients with isolated posterior, bileaflet, and anterior degenerative disease supports these findings.

Irrespective of the potential advantages of a triangular resection, the reality of mitral valve surgery for degenerative disease is one of many repairs achieving good results. Artificial chord implantation, chordal translocation, and flip-over techniques, while often complicated, are successfully performed. The Carpentier approach to mitral valve repair has provided patients with arguably the most durable repair for more than 2 decades. The resulting complexity of repairs has, however, unfortunately led to the underutilization of mitral valve repair for degenerative disease and the late referral of patients for MV surgery.

Despite the widely accepted benefits of mitral valve repair over replacement, the Society of Thoracic Surgeons (STS) database revealed that only approximately 40% of regurgitant mitral valves were repaired, rather than replaced in the late 1990s [2]. In this study, the authors appropriately suggested that many valves that may have been repaired with "complex" techniques were replaced as the majority of repairs were simple annuloplasties. Triangular resection with ring annuloplasty for degenerative mitral regurgitation provides the contemporary cardiac surgeon with a simple, reproducible, and teachable operation that could potentially transform mitral valve surgery into a more approachable discipline within cardiac surgery. That is true whether approached through a standard or minimally invasive approach. In a time where mitral valve replacement continues to be routinely performed, early operation for MR and its associated benefits is less of a reality for our patients, as the relatively high morbidity and mortality for mitral valve replacement often precludes timely surgical referral [8]. Earlier repair of degenerative MV disease not only improves upon the success of the repair as less of the MV apparatus is damaged, but also prevents further functional decline. Left ventricular geometry and function are preserved, and the rates of atrial fibrillation and its thromboembolic and anticoagulant-associated risks are also minimized with early repair [8]. Most importantly, anterior, posterior, and bileaflet prolapse are amenable to this approach.

In conclusion, triangular leaflet resection of the MV produces durable results and can be safely and efficiently performed with minimal morbidity and mortality. The complexity of alternative approaches to MV repair has made MV surgery an almost unreasonable endeavor for some cardiac surgeons. The approach described here should allow for the increased utilization of MV repair for degenerative disease as surgeons and cardiologists alike become more comfortable with the surgical therapies available to their patients.

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DISCUSSION

DR MICHAEL MACK (Dallas, TX): Leo, a great presentation and thank you for sending me your manuscript ahead of time. I think you have highlighted one of the major issues in cardiac surgery today in this paper, and that is the low percent of repairable valves that are actually repaired, and that one of the reasons is the fact that the techniques that we utilize are not simple, not easily teachable, and not reproducible, and that you now are making an attempt for a simplified procedure that is more adoptable by most cardiac surgeons.

Now, I know that having gone through your fellowship at the University of Virginia that you have been exposed to multiple techniques of mitral valve repair and that you have gained some expertise. My question is, going through your training and learning these techniques, how easy is this really to do and do you advise people going home and doing this, and if not, how would they learn more about the technique, and is it as easily applied to the anterior leaflet as the posterior leaflet?

The second question is, you reported on 154 cases over 7 years, but we don't have a sense of what percent of the overall mitral repairs this represents, and has that percent changed over time? I know that Friederich Mohr's group in Leipzig as they have adopted more of the artificial chord techniques, and now they are in a randomized trial, they are having trouble getting surgeons to stay with the standard resection techniques because everybody likes doing the new technique. So is the number of patients undergoing triangular resection increasing in your institution?

Third, one of the limitations of this study, I think, is the lack of echocardiographic follow-up, and as our cardiology colleagues now doing percutaneous techniques with the Evalve trial are fond of saying, that freedom from reoperation is no longer going to be an adequate surrogate for the valve being adequately repaired. The only surgical series I am aware of out there that does have long-term echocardiographic follow-up is Tirone David. Do you have any echocardiographic follow-up or are you planning on doing so?

Fourth is, as you have also alluded, this is a disease of the chords, for the most part, and not a disease of the leaflet, and this philosophy of leaflet preservation rather than resection, I think, is a laudable one. But now that you don't need to downsize anymore and, as a matter of fact, have actually upsized your rings, do you really feel there is a need for an annuloplasty ring anymore, and if so, why?

And then lastly, as we heard from Dr Naunheim this morning, one of the problems that we have in surgery is the volume of procedures done, and if you look at the average cardiac surgeon practicing, they do somewhere between 20 and 40 mitral valve procedures a year, of which half are annuloplasty alone. So that gives the average surgeon operating 10 to 20 opportunities a year to use repair techniques. So what would be your advice? Should we all adopt this technique because it is simpler, should we refer everybody to high volume centers, or should we just realize that probably neither of those are realistic and just go with a subvalvular apparatus sparing mitral valve replacement as a realistic alternative? Thank you and congratulations.

DR GAZONI: Thank you, Dr Mack. I would never use my name and expertise in the same sentence, but I will do my best to answer your questions.

While I do not advise cardiac surgeons to simply start utilizing these techniques when they go home, I encourage that we all start considering and visualizing this approach the next time we repair a patients myxomatous valve. As far as how to learn this operation, I am sure that Dr Kron would be happy to show anyone how to do this. The reality is that this approach truly simplifies mitral valve repair. While many consider complex repair techniques for degenerative mitral valve disease to be a daunting task, triangular resections with upsized rings will hopefully demystify operative repair of the mitral valve. One of the great benefits to this approach is that it can easily be applied to the anterior and posterior leaflet pathology.

Looking over our experience of triangular leaflet resections, it, by and large, is our procedure of choice. I would say that close

to 95% of our mitral valve repairs for degenerative disease during the course of this study utilized triangular resections. I can't remember the last time Dr Kron did a quadrangular resection and sliding plasty. The advent of transesophogeal echocardiograms have allowed for the increased utilization of this repair amongst others. We use this approach for virtually any patient with degenerative mitral valve disease and are able to get the patient out of the operating room with little to no mitral regurgitation, no associated mortality, and little morbidity.

In regard to the question of echocardiographic follow-up, we are currently working on collecting that data. This is, however, a difficult issue to tackle as the majority of our patients live several hours away and generally only have one follow-up visit at our institution.

In regard to the need for the placement of annuloplasty rings, we still think that it is definitely required for all of these resections. The annuloplasty ring addresses the progressive nature of degenerative mitral valve disease. Rings not only reinforce the repair but also help prevent further annular dilatation. It does not take long to put in a ring, and so I would definitely advocate its use.

As far as answering your question about the average cardiac surgeon in the community who performs about 10 to 20 mitral valve repairs, I do not think that the answer is to refer to centers that have a large volume. I think we have to have some collaborative efforts to spread the word that this is a simple and reproducible approach that every cardiac surgeon should perform. When we consider that P2 disease is most common, and the easiest to repair, the cardiac surgeon in the community should be able to tackle this operation. The take-home message is that for degenerative mitral valve disease replacement is not acceptable the vast majority of the time. As we have learned over the last decade, mitral valve replacement, even with the preservation of the subvalvular apparatus, is far from benign and we do disservice to our patients if we do not strive to find better alternatives.

DR KEVIN D. ACCOLA (Orlando, FL): I appreciate your comments. This is certainly a sound and reproducible technique for the anterior leaflet, especially when you have the isolated ruptured chordae. You mentioned the concept of downsizing the annuloplasty ring versus upsizing. Could you comment briefly on your technique with regard to sizing, as this does sometimes alter the anterior leaflet geometry.

DR GAZONI: We definitely get an idea beforehand what size ring we want to use before we actually perform the resection. Nowadays, we operate on patients at a time where annular dilatation is not as big an issue as it was several years ago. So I think that downsizing is of less importance.

DR W. RANDOLPH CHITWOOD, JR (Greenville, NC): Doctor Gazoni, I have one question and one comment. Professor Carpentier and others taught us valve function, function, function! I agree totally with your comments and those principles of functional preservation that Dr Kron has taught you. Most surgeons, when repairing mitral valves, do not think about stress-strain relationships and the elastic modulus of the chordae tendenae. These are diseased chords, and therefore your method of repair emulates the best engineered valve reconstruction that one can attain.

How do you handle the Barlow's valve with massive bileaflet prolapse? We now shorten chords on the leaflet side rattler than by papillary muscle shortening. We believe there is less stress on the individual chord than shortening the chord at the papillary head or by shortening the papillary muscle. But how do reduce the prolapse in a Barlow's valve? Do you do multiple triangular resections in these patients? Thank you for allowing me the floor for this discussion.

DR GAZONI: We have addressed Barlow's disease with multiple triangular resections. What makes Barlow's disease paradoxically more complicated yet easier to fix is the amount of redundant tissue. One of the key principles to keep in mind while we resect a large area of valvular tissues is that we must be able to bring the tissue together with little tension. The degree of tension at the end of the repair is generally the guiding and limiting factor rather than a predetermined percentage of the leaflet area or leading edge.

Anterior leaflet disease is a little bit trickier. I think all of us are fairly hesitant to take out a large amount of the anterior leaflet, but if the redundant tissue is present and needs to be resected, we go ahead and resect it. We must however keep in mind that the apex of the resection should not go more than one third the distance from the free edge to the annulus. Ultimately, this technique of triangular resections and upsized rings has really been serving us and our patients really well.