Triggers for Surgical Referral in Degenerative Mitral Valve Regurgitation
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Degenerative mitral valve disease is the most common etiology of mitral regurgitation in developed countries. Degenerative mitral valve disease should be distinguished from other valvular disease because most of the lesions caused by degenerative changes are amenable to valve repair as opposed to replacement, and successful durable repair with optimal timing can maintain the patient’s normal life expectancy. Despite dramatic surgical progress in degenerative mitral valve repair over the past few decades and detailing of surgical indications in established practice guidelines, prevailing data suggest a significant number of patients are still not referred for surgery in a timely fashion or are even denied for surgery for inappropriate reasons. This article reviews the current surgical triggers which all practicing cardiovascular specialists should be familiar with and which should prompt immediate surgical referral.  (Circ J 2013; 77: 28–34)

Key Words: Degenerative mitral valve disease; Mitral regurgitation; Surgical indications

Mitral regurgitation (MR) is the most common valvular heart disease and affects 2.5% of the general population in the United States. The etiology of MR is variable and generally classified as degenerative, ischemic, rheumatic, infective, or congenital. In developed countries, because of the reduced prevalence of the rheumatic etiology, degenerative mitral valve disease is the most common etiology of MR. In degenerative mitral valve disease, infiltrative or dysplastic tissue changes cause elongation or rupture of the mitral valve chordae, resulting in leaflet prolapse and usually associated anular dilatation. Degenerative changes are also often seen in the mitral valve leaflets. Degenerative mitral valve disease is unique compared with other valvular heart disease in several regards. It often affects otherwise relatively healthy individuals; the natural history is insidious; repair not replacement is the surgical treatment of choice; the surgical techniques are still evolving and can be technically demanding in selected complex cases; and, most importantly, the restoration of life expectancy can be expected if appropriately treated. These unique characteristics of degenerative mitral valve disease, in turn, pose specific problems, such as inconsistent referral practices among cardiologists, widely varied surgical expertise and practice, variable rate of valve replacement among institutions, and controversy over the indications for surgery, particularly in asymptomatic patients.

The aim of this article is to review the current basis for management of degenerative mitral valve disease, to help better understand the optimal management strategy for these patients.

Definition of Severe MR

The determination of MR severity is the critical first step in managing patients with degenerative mitral disease because severity denotes prognosis and dictates the management. Echocardiography is the essential tool for evaluation of MR. The diagnosis of severe MR should be based on an integrative approach, such as recommended by the American Society of Echocardiography (ASE) to allow consistent estimation of MR severity. Although 3-dimensional echocardiography, an emerging modality, shows promise with cumulative experience and evidence, 2-dimensional (2D) and Doppler transthoracic and/or transesophageal echocardiography remain the gold standard diagnostic tool for MR. There are several parameters in 2D and Doppler echocardiography to evaluate MR severity. Table 1 summarizes the ASE approach to defining the severity of MR. Each parameter has its own advantage and limitation and no single parameter can make a definite diagnosis of severe MR by itself. All parameters need to be interpreted as a group for better diagnostic accuracy. Echocardiography is also important in the evaluation of the mechanism of MR, which comprises the pathophysiologic triad of etiology, lesion, and dysfunction. Combined with history and physical examination, echocardiography can accurately determine the MR mechanism. A detailed description of the MR mechanism should be available, especially when the patient with degenerative MR is referred for surgery, because the feasibility of repair is highly dependent on the mechanism. Essentially, all degenerative mitral valves are repairable, and although this is feasible in refer
Table 1. Grading of Mitral Regurgitation Severity

| Specific signs | Mild to moderate | Moderate to severe | Severe |
|----------------|------------------|--------------------|--------|
| Small central jet <4 cm² or <20% of LA area | Signs of MR >mild, but no criteria for severe MR | Vena contracta width ≥0.7 cm with large central MR jet (area >40% of LA) or with a wall-impinging jet of any size |
| Vena contracta width <0.3 cm | | | |
| No or minimal flow convergence | | | |

Supportive signs

| Systolic dominant flow in pulmonary veins | Signs of MR >mild, but no criteria for severe MR | Dense triangular continuous-wave Doppler MR jet |
| A-wave dominant mitral inflow | | E-wave dominant mitral inflow (E >1.2 m/s) |
| Soft density continuous-wave Doppler MR signal | | |
| Normal LV size | | Enlarged LV and LA size |

Quantitative parameters

| RVol, m/beat | 30–44 | 45–59 | ≥60 |
| RF, % | 30–39 | 40–49 | ≥50 |
| ERO, mm² | 20–29 | 30–39 | ≥40 |

ERO, effective regurgitant orifice area; LA, left atrium; LV, left ventricle; MR, mitral regurgitation; RF, regurgitant fraction; RVol, regurgitant volume.

ence mitral centers,11 this can only be achieved on a population level by matching the mechanism of MR to the appropriate surgical expertise necessary to deal with the identified mechanism.12 The baseline left ventricular (LV) function and size should also be documented by echocardiography and changes from these baseline values may subsequently be used to guide the necessity and timing of surgery.

**Overview of the 2006 ACC/AHA Guidelines**

Other than echocardiographic surveillance, no specific management is recommended for less than severe degrees of MR. However, once a diagnosis of severe MR is confirmed, surgical intervention should be a considered treatment option. In the current American College of Cardiology/American Heart Association (ACC/AHA) guidelines13 (Figure), there are 5 surgical indications specified, with severe MR as a prerequisite: (1) symptoms; (2) LV dysfunction; (3) LV enlargement; (4) new onset atrial fibrillation (AF); and (5) pulmonary hypertension (PHT). Each condition by itself is considered as an agreed-on indication for surgery as either a Class I (recommended) or Class IIa (reasonable). The rationale and validity for each indication will be reviewed subsequently.

The first question in evaluating the indication for surgery is whether the patient is symptomatic or asymptomatic. The presence of symptoms related to MR is considered as a Class I indication for surgery. If the patient is asymptomatic, then the next question is whether the patient has LV dysfunction or dilatation, which are currently defined as ejection fraction (LVEF) <60% and/or LV end-systolic diameter (ESD) ≥40 mm, either of which are considered as Class I indications. If the patient is asymptomatic with a normal left ventricle, then the presence of PHT, which is defined as pulmonary artery systolic pressure (PASP) ≥50 mmHg at rest or ≥60 mmHg after exercise, or new onset AF are Class IIa indications. Besides these 5 surgical indications, there is another controversial surgical indication, which is the mere presence of severe MR. This is the only surgical indication in which there is disagreement between the 2006 ACC/AHA guidelines (Class IIa: reasonable) and the 2007 European Society of Cardiology (ESC) guidelines (Class IIb: may be considered). This is also the only indication in which both guidelines specify a clear cutoff of a successful repair rate >90%. For other indications, although the guidelines stipulate a preference for repair, a desired repair rate is not stated. Other factors such as risk stratification, local logistics, and informed patient’s preference should also be involved in the decision-making, but, notably, the ACC/AHA guidelines stipulate the importance of “surgical centers experienced in performing MV repair” and strongly encourage cardiologists to refer the asymptomatic patient to these centers if none of the previously cited 5 indications are present.

The ESC recently released revised guidelines and made some significant changes.14 The detail of these changes will be mentioned in the section on each conventional indication.

It should be emphasized that the ACC/AHA guidelines define not only the surgical indications but also the recommended surveillance before surgery. The guidelines recommend periodic surveillance, which is a combination of history, physical examination, and echocardiography. The interval is annual for moderate MR and becomes more frequent for moderate to severe MR, which is every 6–12 months with the instruction for the patient to promptly report symptoms. Although severe MR is the only recommended trigger for surgery, this close follow-up is also the guideline-recommended standard once MR with moderate or more severity is diagnosed.

**Interpretation of Landmark Studies**

The surgical indications in the guidelines are predominantly based on retrospective studies, either natural history study or surgical series, published during the period when the surgical techniques and expertise were still rapidly evolving and the guidelines too were evolving. Also, existing data demonstrate that, in real-world clinical practice, even in developed countries, the management of patients with degenerative mitral disease is far from ideal. In fact, the data still show relatively frequent valve replacement15,16 with high variability of repair.
The data also suggest suboptimal adherence to guidelines for surgical referral among cardiologists and referring physicians. Therefore, when interpreting the studies from which the guideline indications for surgery were derived, one has to be cognizant of several factors:

- Who was enrolled and excluded? (ie, etiology: degenerative vs. other, and the prevalence of the 5 guideline surgical indications at the study enrollment)
- How were patients followed during the period of “medical” management? (ie, the level of adherence to guideline-recommended follow-up)
- Were patients promptly referred? (indicated by prevalence of patients without severe symptoms and relatively preserved LV function)
- Who operated in the surgical arm? (ie, the level of surgical expertise with repair rate and durability)
- Source of studies (the majority of analysis on which guidelines are based emanate from relatively few institutions).

All these factors have a significant effect on the “natural” course of the study cohort and, without close scrutiny, the result can be potentially misleading.

Symptoms: Class I Indication

In the current ACC/AHA guidelines, symptoms (defined as New York Heart Association (NYHA) Class II, III, or IV) are a Class I indication. The NYHA functional class is subjective, but is widely used in clinical practice and research as an indicator of symptoms. The guidelines cite a study, published in 1999 to support the validity of symptoms as a surgical indicator. In that surgical study, patients with severe nonischemic (degenerative 79%, rheumatic 8%, endocarditis 8%, and others 4%) MR who underwent mitral surgery (repair in 72%) were enrolled from 1984 to 1991. The enrolled patients were divided into 2 groups based on their NYHA functional class at surgery: Class I/II or Class III/IV. The Class I/II group had
excellent survival comparable to the expected survival, whereas the Class III/IV group had worse survival than expected. The presence of preoperative NYHA Class III/IV remained an independent predictor of postoperative excess mortality in the overall population after multivariate adjustment for confounding factors such as age, LVEF and other comorbidities and continued to be so in a subgroup analysis of patients who underwent repair. These findings were subsequently validated by several other studies.

**LV Dysfunction: Class I Indication**

LVEF is currently the most conventional and widely used parameter to describe LV function but, in the setting of severe MR, LVEF does not necessarily reflect the actual LV function, which is myocardial contractile capacity. This is because LVEF is pre- and afterload-dependent and severe MR creates a favorable loading condition to help show apparently high LVEF by increasing preload with regurgitant volume and reducing afterload with backward ejection to the left atrium. In the setting of severe MR, therefore, the interpretation of LVEF is not straightforward and normal LVEF does not mean preserved myocardial contractile capacity or forward (through aortic valve) stroke volume, which are what matters. Another important limitation on LVEF is that, although the ASE recommends quantitative assessment of LVEF, it is still frequently visually estimated, making it not very clear whether the cutoff of 60% has an accurate basis. Nonetheless, LV dysfunction, defined as LVEF with a cutoff ≤60%, is currently a Class I indication.

The main criticism of the use of LVEF <60% as an indication for surgery is that once the LVEF is less than 60%, irreversible myocardial damage may have ensued and life expectancy is compromised on a population level, independent of successful mitral valve surgery. Patients with LVEF <60% have a worse long-term survival after mitral valve surgery, compared with those with normal ventricular function. Additionally, the LVEF does not normalize in many patients, despite successful mitral valve repair, up to 5 years post surgery. 

**LV Enlargement: Class I Indication**

LV enlargement, which is defined as LVESD ≥40 mm, is considered as a Class I indication. By 2006, the year in which the current ACC/AHA guidelines were issued, there were only studies with either a small cohort or mixed etiology available to support the validity of LVESD as a surgical indication. This was reflected in the discordance of cutoff value for LVESD between the US and European guidelines, ESC using 45 mm as the cutoff in its 2007 guidelines. 

As in the case of LV dysfunction, the use of LV dilatation as an indication for surgery has been recently challenged because there are data that suggest that once the LV is dilated, irreversible myocardial damage has taken place and life expectancy will be compromised regardless of subsequent mitral valve repair. The observational study by Tribouilloy et al showed an independent, strong association between LVESD ≥40 mm and worse outcomes under medical management and even after surgery after multivariate adjustment of other potential prognostic factors (age, sex, symptoms, LVEF and AF). The result was the same in a subgroup analysis of patients free of baseline Class I indication (symptoms or low LVEF). Many now argue for intervention on severe MR prior to the onset of LV dysfunction or dilatation.

Taking into account the result of that study, the 2012 recently released ESC guidelines include the range of 40–45 mm as a Class IIa indication, even in the absence of symptoms or LV dysfunction, which was not considered a surgical trigger in the previous 2007 guidelines. The Class I cutoff of 45 mm remains.

**Pulmonary Hypertension: Class IIa Indication**

PHT, defined as PASP >50 mmHg at rest or >60 mmHg at exercise, is a Class IIa indication by itself. Even in the absence of symptoms and LV dysfunction, surgery is reasonable in the presence of PHT. To support the validity of PHT as a surgical indication, the guidelines cite a study published in 1990, which dealt with 48 patients with MR and showed the association of preoperative pulmonary pressure and postoperative LV function after MV replacement, so the validity and specific cutoff of 50 mmHg has been more dependent on experts’ consensus than on direct data. A recent 2011 study further investigated PHT as a surgical indication. This observational study demonstrated that by the time the patient developed PHT, currently defined as PASP >50 mmHg, it was most likely the patient already had other surgical indications as well. This raises the question of the validity of the current cutoff of 50 mmHg.

Exercise PHT, defined as PASP >60 mmHg at exercise, is also a Class IIa indication in the North American guidelines. In Europe, exercise-induced PHT was not included in the 2007 guidelines, but is specified as a Class IIb indication in the latest 2012 guidelines. Although there are no robust data available showing the direct association of exercise PHT and adverse outcomes in patients with degenerative MR, one study investigated the incidence of exercise PHT in asymptomatic patients with degenerative MR (severe in 60%, moderate in 40%) and its effect on the subsequent occurrence of symptoms. The prevalence of exercise PHT was detected in almost half of the patients (46%) and strongly associated with the subsequent development of symptoms. A cutoff of 56 mmHg gave the best predictive power, concluding that the currently recommended cutoff of >60 mmHg was reasonable. Although that study focused on exercise PHT, it also gave an important insight to resting PHT. In the study’s cohort, the prevalence of resting PHT was only 15%. The true prevalence of resting PHT could be even lower, considering the study only enrolled the patients with measurable pulmonary artery pressures by Doppler echocardiography. The study showed that although the resting PHT was also associated with subsequent symptoms, the best predictive cutoff was 36 mmHg, much lower than the current cutoff of 50 mmHg. This finding suggests that less than severe PHT could already be an early sign of decompensation, and that the PASP rarely reaches as high as 50 mmHg without the development of symptoms, LV dysfunction, or AF. Although it is true that PHT is a common sequela of severe MR, a lower cutoff for PHT definition may be reasonable for its use as a surgical indication. In fact, another study also showed the association of PHT with a lower cutoff and subsequent occurrence of symptoms and LV dysfunction in a similar patient cohort, supporting this proposal.

**Atrial Fibrillation: Class IIa Indication**

AF is the only objective indication for surgery that is based on the presence or absence of a categorical factor. Other surgical indications are based on an arbitrary cutoff of continuous parameters (LVEF, LVESD, and PASP) or the subjective presence of symptoms. AF has been shown to be a serious complication of MR and is associated with cardiac morbidity and
Besides LA size, newer surgical indicators have been proposed to be a reasonable parameter to quantify and predict the risk even in sinus rhythm. Although still Class IIb, LA size seems for surgical indication in the 2012 European guidelines: a volume requirement (is met) Pros (especially if the requirement is met) • Potential long-term solution with prevention of cardiac events secondary to severe mitral regurgitation • Possible better preservation of life expectancy Cons (especially if the requirement is not met) • Small risk of operative mortality and morbidity • Risk of unwanted replacement with subsequent higher risk of prosthesis related events • Risk of recurrent mitral regurgitation and persistence of same risk of cardiac events associated with mitral regurgitation • ≈50% will avoid surgery in the midterm (5–10 years)

**Left Atrial Size**

The LA size is known to be related to cardiac morbidity and mortality. In recent years, there have been studies showing the association between LA size and the outcomes in patients with degenerative MR. Although LA volume as opposed to diameter has been shown to be more powerful prognostic indicator, LA diameter is more widely used in routine clinical practice and research. In a study that enrolled patients with degenerative MR in sinus rhythm at baseline, LA enlargement with LA diameter of 55 mm as the cutoff was associated with increased mortality under medical management but not after surgery, independent of Class I indication (symptoms, LVEF, and LVESD). Although patients were in sinus rhythm at enrollment, presumably subsequent AF incidence was frequent in the LA enlargement group, partly accounting for the adverse outcomes in this group. The effect of PASP was not adjusted either and the correlation of PASP and LA size was not given, so it is unclear whether LA size remained a significant predictor of outcomes after adjustment for PASP. Nonetheless, the study showed the possibility of LA size as a potential surgical indication, especially when measurable PASP is not available. As mentioned, LA size is now another trigger for surgical indication in the 2012 European guidelines: a volume index >60 ml/m² is considered as a Class Ib indication even in sinus rhythm. Although still Class Ib, LA size seems to be a reasonable parameter to quantify and predict the risk of subsequent AF before it actually occurs.

**Other Potential Surgical Indicators**

Besides LA size, newer surgical indicators have been proposed with cumulative evidence, such as B-type natriuretic peptide, exercise tolerance, and LV contraction reserve.

### Percutaneous Mitral Clip Procedure

The percutaneous mitral clip procedure is under investigation and currently not the treatment of choice for degenerative (primary) MR. In the latest 2012 ESC guidelines, this procedure may be considered (Class IIb) only for patients with symptomatic, severe secondary MR despite optimal medical therapy who are judged inoperable or at high risk for surgery.

### Prophylactic Surgery vs. Watchful Waiting

The appropriateness and timing of surgery for severe MR in patients who do not have any of the 5 guideline-defined surgical indications (symptoms, LV dysfunction, LV dilatation, AF, and PHT) remain controversial. The current ACC/AHA guidelines are in favor of prophylactic surgery for asymptomatic severe MR (Class IIa indication), whereas the European guidelines remain in favor of watchful waiting (with asymptomatic severe MR as a Class IIb indication for surgery). It is notable that despite their different positions both guidelines clearly mention the need for experienced centers with a successful repair rate of at least 90% if prophylactic surgery is considered.

Both guidelines cite 2 landmark studies for this discussion. In the first study published in 2005, 198 asymptomatic patients with severe degenerative MR were enrolled. They were free of symptoms, but not necessarily of other currently agreed-on indications, because LVEF >50% was included, 10% had AF, and PASP was 42±13 mmHg at enrollment. The subsequent follow-up was done by the patients’ personal physicians and the strategy was not clearly mentioned. Of 198, 163 (82%) had surgery during the follow-up of 5 years (unclear if prophylactic or indication-driven) and 35 (18%) were managed solely medically. Overall 5-year survival of the 198 patients was good at 85%, comparable to 86% of expected survival from the general population, but the 5-year survival of the 35 solely medically managed patients was worse at 53%, compared with the expected 78%.

In the second study published in 2006, 132 asymptomatic patients with severe degenerative MR were enrolled. The patients were free of symptoms and also other indications, reflecting the younger cohort than in the previous study. The subsequent follow-up was predefined by a valve clinic, with periodic close follow-up and referral to surgery if any 1 of the 5 surgical indications appeared. Of the 132 patients, 38 (29%) had surgery during follow-up of 8 years (all indication-driven) and 94 (71%) were managed solely medically. Overall, the
8-year survival of the 132 surgical patients was excellent at 91%, comparable to the expected survival from the general population. Among the 94 solely medically managed patients, there were 6 deaths (3 cardiac, 3 non-cardiac). Of the 3 cardiac cases, 2 were patients who met the surgical indication but refused surgery. Thus, the result of solely medically managed patients seemed excellent under a watchful waiting strategy.

Although these studies provided important information on the present discussion of management of patients free of surgical indications, the direct comparison of prophylactic surgery and watchful waiting were not allowed because the strategy of prophylactic surgery was not adopted in either study.

In 2009, another study, 56 which was unique in that it adopted a prophylactic surgery strategy and compared it with watchful waiting strategy, was published. This study enrolled 447 patients with severe degenerative MR free of any surgical indication. Unlike the previous 2 studies, the patients were assigned to 2 different strategies, seemingly based on physician and patient preferences: early prophylactic surgery (n=161) and watchful waiting (n=286). In the prophylactic surgery group, 7-year survival from cardiac death was 100%, although deaths excluded as non-cardiac included strokes and infection, which may be related to the surgery. In the watchful waiting group, of the 286, 53 (19%) had surgery during the follow-up (all indication-driven) and 233 (81%) were managed solely medically during the follow-up of 7 years. Of note, of 79 patients who met the surgical indication, 28 presented with admission to the hospital for chronic heart failure, raising the question of the intensity of the follow-up routine. Nonetheless, the overall 7-year freedom rate from cardiac death in the 286 patients in the watchful waiting group was excellent at 95% (the expected survival was not given). Among the 233 solely medically managed patients, there were 11 cardiac deaths, of which 6 were patients who met the surgical indication but refused surgery. Even though the authors focus on the superiority of early surgery, these results do also represent a good result for watchful waiting. Also, the prophylactic surgery group had an unusual absence of midterm cardiac death, raising the question as to whether these results would be replicated in other cohorts.

Prophylactic surgery is certainly a reasonable option, provided valve repair is highly predictable and durable. We would argue that the repair rate should be near 100%, higher than recommended in the guidelines, if prophylactic surgery is performed, because this patient group is otherwise relatively healthy and young and also valve replacement places them at risk of prosthesis-related complications. Medical follow-up may also have reasonable outcomes with vigilant watchful waiting, 56 but with this strategy there must be awareness that life expectancy for some patients can be compromised if they develop guideline indications. The pros and cons of each strategy are summarized in Table 2.

The decision-making process should be an integrated approach, involving the risk stratification of the patients (age, comorbidities, and capability of adhering to guideline-recommended follow-up) and the patient’s preference after being given all relevant information regarding the natural history, surgical expertise at the center, and benefits/risks of surgery.

Conclusions

The 2006 ACC/AHA guidelines specify 5 surgical indications: symptoms, LV dysfunction, LV enlargement, PHT, and new onset AF. The validity of severe MR in and of itself as a surgical indication is still controversial and other potential indicators are under investigation. These discussions are only meaningful when medical surveillance before surgery is vigilant and other currently agreed-on surgical indications are well understood and work as an actual trigger for surgery. The real-world current clinical practice, however, remains suboptimal for many patients, so all practicing cardiovascular specialists should be familiar with the current guidelines for management.

References

1. Nkomo VT, Gardin JM, Skelton TN, Gottlieber JS, Scott CG, Enriquez-Sarano M. Burden of valvular heart diseases: A population-based study. *Lancet* 2006; 368: 1005–1011.
2. Adams DH, Anyanwu AC. Seeking a higher standard for degenerative mitral valve repair: Begin with etiology. *J Thorac Cardiovasc Surg* 2008; 136: 551–556.
3. Anyanwu AC, Adams DH. Etiologic classification of degenerative mitral valve disease: Barlow’s disease and fibroelastic deficiency. *Semin Thorac Cardiovasc Surg* 2007; 19: 90–96.
4. Kainuma S, Taniguchi K, Toda K, Funatsu T, Kondoh H, Nishino M, et al. Restrictive mitral annuloplasty for functional mitral regurgitation: Acute hemodynamics and serial echocardiography. *Circ J* 2011; 75: 571–579.
5. Enriquez-Sarano M, Schaff HV, Orszulak TA, Tajik AJ, Bailey KR, Frye RL. Valve repair improves the outcome of surgery for mitral regurgitation: A multivariate analysis. *Circulation* 1995; 91: 1022–1028.
6. Enriquez-Sarano M, Avierinos JF, Messika-Zeitoun D, Detaing D, Capps M, Nkomo V, et al. Quantitative determinants of the outcome of asymptomatic mitral regurgitation. *N Engl J Med* 2005; 352: 875–883.
7. Zoghbi WA, Enriquez-Sarano M, Foster E, Grayburn PA, Kraft CD, Levine RA, et al. Recommendations for evaluation of the severity of native valvular regurgitation with two-dimensional and Doppler echocardiography. *J Am Soc Echocardiogr* 2003; 16: 777–802.
8. Chikwe J, Adams DH, Su KN, Anyanwu AC, Lin HM, Goldstone AB, et al. Can three-dimensional echocardiography accurately predict complexity of mitral valve repair? *J Cardiothorac Surg* 2012; 41: 518–524.
9. Grewal J, Mankad S, Freeman WK, Click RL, Suri RM, Abel MD, et al. Real-time three-dimensional transesophageal echocardiography in the intraoperative assessment of mitral valve disease. *J Am Soc Echocardiogr* 2009; 22: 34–41.
10. Carpentier A. Cardiac valve surgery: The “French correction”. *J Thorac Cardiovasc Surg* 1983; 86: 323–337.
11. Castillo JG, Anyanwu AC, Fuster V, Adams DH. A near 100% repair rate for mitral valve prolapse is achievable in a reference center: Implications for future guidelines. *J Thorac Cardiovasc Surg* 2012; 144: 308–312.
12. Adams DH, Anyanwu AC. The cardiologist’s role in increasing the rate of mitral valve repair in degenerative disease. *Curr Opin Cardiol* 2008; 23: 105–110.
13. Barlow RO, Carabello B, Kanu C, de Leon AC Jr, Faxon DP, Freed MD, et al. ACC/AHA 2006 guidelines for the management of patients with valvular heart disease: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (writing committee to revise the 1998 Guidelines for the Management of Patients With Valvular Heart Disease): Developed in collaboration with the Society of Cardiovascular Anesthesiologists: Endorsed by the Society for Cardiovascular Angiography and Interventions and the Society of Thoracic Surgeons. *Circulation* 2006; 114: e84–e231.
14. Saharian A, Alfieri O, Andreotti F, Antunes MJ, Baran-Esquivias G, Benzaquen H, et al. Guidelines on the management of valvular heart disease (version 2012): The Joint Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J* 2012; 33: 2451–2496.
15. Anyanwu AC, Bridgewater B, Adams DH. The lottery of mitral valve repair surgery. *Heart* 2010; 96: 1964–1967.
16. Gammie JS, Sheng S, Griffith BP, Peterson ED, Rankin JS, O’Brien SM, et al. Trends in mitral valve surgery in the United States: Results from the Society of Thoracic Surgeons Adult Cardiac Surgery Database. *Ann Thorac Surg* 2009; 87: 1431–1437; Discussion 1437–1439.
17. Gammie JS, O’Brien SM, Griffith BP, Ferguson TB, Peterson ED. Influence of hospital procedural volume on care process and mortality for patients undergoing elective surgery for mitral regurgitation. *Circulation* 2007; 115: 881–887.
18. Bach DS, Awaïs M, Gurn HS, Kohnstamm S. Failure of guideline
