Ischemic cardiomyopathy is the most common cause of heart failure in the United States. This advanced form of coronary artery disease is marked by diffuse myocardial damage, left ventricular remodeling, and often functional ischemic mitral regurgitation (MR). Whether moderate functional ischemic MR in patients with ischemic cardiomyopathy should be addressed with mitral valve repair at the time of coronary artery bypass grafting (CABG) has been debated for a decade. Arguments against concomitant mitral valve repair are that CABG alone, by decreasing ischemia and improving left ventricular function, often decreases functional ischemic MR, and adding mitral valve repair to CABG increases operative complexity and risk. Arguments favoring concomitant mitral valve repair are that mitral valve repair consistently decreases functional ischemic MR, and CABG alone does not predictably improve postoperative MR.

Myocardial viability can be determined by dobutamine stress echocardiography, positron emission tomography, or magnetic resonance imaging. The choice of imaging study is influenced primarily by institutional preference and technological availability. Penicka et al used single-photon emission computed tomography, while there is a growing tendency to use magnetic resonance imaging for preoperative assessment of patients with ischemic cardiomyopathy. Magnetic resonance imaging is a unique tool that gives the clinician a comprehensive assessment of all relevant features of ischemic cardiomyopathy: ventricular function and size, myocardial scarring, and severity of MR. A large meta-analysis has demonstrated that increased myocardial viability on noninvasive preoperative testing is strongly associated with improved survival in patients with chronic coronary artery disease and functional ischemic MR. Most prior studies on treating functional ischemic MR focused on perioperative assessment of mitral valve function with an added simple assessment of ventricular contractility. This “valvulo-centric” approach overlooked the true myocardial cause of functional ischemic MR and resulted in studies with discrepant findings.

In this issue of Circulation, Penicka and colleagues present an elegantly designed and conducted study to help solve this surgical conundrum. They demonstrate that in patients with ischemic cardiomyopathy and moderate MR, the presence of preoperative myocardial viability in the areas adjacent to the papillary muscles and absence of papillary muscle dysssynchrony were associated with a reduction in MR after isolated CABG. This observational study included 135 patients with ischemic cardiomyopathy (ejection fraction <45%) and moderate MR who underwent CABG without mitral valve repair. Preoperative echocardiographic evaluation of functional ischemic MR included measurements of severity of MR based on the width of vena contracta and the ratio of regurgitant jet to left atrial area. Measurements of mitral valve tenting and displacement of mitral coaptation were used to assess changes in mitral valve geometry caused by left ventricular remodeling. Dysssynchrony between the papillary muscles was determined by tissue Doppler imaging. Myocardial viability was assessed by single-photon emission computed tomography.

Approximately 40% of patients experienced an improvement in MR after CABG alone, having no or mild MR 1 year after surgery. The remaining 60% showed no improvement or worsening MR. The absence of preoperative papillary muscle dysssynchrony and presence of viability in myocardial segments adjacent to papillary muscles were associated with improvement in postoperative functional ischemic MR in >90% of patients. In contrast, the absence of myocardial viability and presence of significant papillary muscle dysssynchrony were associated with no improvement or worsening postoperative MR.

An important point is that the authors found that changes in postoperative MR translated into corresponding clinical outcomes. Patients with improved postoperative functional ischemic MR had better functional status and survival compared with those whose MR remained the same or worsened after surgery.

An additional important contribution of the study by Penicka and colleagues is that it shifts the focus from the mitral valve to myocardial viability and function as the primary determinants of recovery from moderate functional ischemic MR after isolated CABG. Most prior studies on treating functional ischemic MR focused on perioperative assessment of mitral valve function with an added simple assessment of ventricular contractility. This “valvulo-centric” approach overlooked the true myocardial cause of functional ischemic MR and resulted in studies with discrepant findings.

We believe that the results of this study will have a strong impact on the 3 key elements in the care of patients with ischemic cardiomyopathy and functional ischemic MR: diagnostic workup, therapeutic approaches, and interpretation of outcomes. The diagnostic workup of patients with chronic coronary artery disease and functional ischemic MR has evolved over time. Clinical evaluation, coronary angiography, and echocardiographic assessment of MR have recently been augmented by the assessment of myocardial viability. Myocardial viability can be determined by dobutamine stress echocardiography, single-photon emission computed tomography, positron emission tomography, or magnetic resonance imaging. The choice of imaging study is influenced primarily by institutional preference and technological availability. Penicka et al used single-photon emission computed tomography, but there is a growing tendency to use magnetic resonance imaging for preoperative assessment of patients with ischemic cardiomyopathy. Magnetic resonance imaging is a unique tool that gives the clinician a comprehensive assessment of all relevant features of ischemic cardiomyopathy: ventricular function and size, myocardial scarring, and severity of MR. A large meta-analysis has demonstrated that increased myocardial viability on noninvasive preoperative testing is strongly associated with improved survival in patients with chronic coronary artery disease and functional ischemic MR.
patients with ischemic cardiomyopathy and depressed left ventricular function.\textsuperscript{10} Penicka et al emphasized the importance of myocardial viability, particularly regional viability in areas adjacent to the papillary muscles. Restoration of normal papillary muscle function after revascularization of viable myocardium led to an improvement in postoperative MR. These results correspond to earlier findings indicating that the presence of scar in the region of posterior papillary muscle results in an increased incidence of recurrent MR after CABG and mitral annuloplasty.\textsuperscript{9} These studies suggest that a comprehensive evaluation of myocardial viability should be performed in patients with ischemic cardiomyopathy and MR who are being considered for surgery.

Ventricular dyssynchrony has long been recognized as a predictor of poor outcomes in patients with ischemic cardiomyopathy plus congestive heart failure.\textsuperscript{15} Dyssynchrony between papillary muscles, as determined by tissue Doppler echocardiography in the Penicka et al study, is a surrogate for advanced ischemic changes and scarring of the ventricle; therefore, the failure of dyssynchrony to improve after revascularization is not surprising.

Surgical revascularization as the sole treatment for ischemic cardiomyopathy and moderate functional ischemic MR has been advocated by many surgeons, with the assumption that improved myocardial perfusion will result in reversal of left ventricular remodeling and consequent resolution of MR.\textsuperscript{16} However, postoperative MR does not always improve with CABG alone, although the reasons for this failure have not been elucidated.\textsuperscript{8} These observations resulted in recommendations that mitral valve annuloplasty be considered for patients with moderate functional ischemic MR at the time of CABG. The article by Penicka and colleagues identifies factors that predict successful resolution of functional ischemic MR, allowing a causal therapeutic approach to ischemic cardiomyopathy. The authors recommend isolated CABG for patients with functional ischemic MR, viable myocardium, and no ventricular dyssynchrony. Surgical revascularization in these patients with a mild form of ischemic cardiomyopathy resulted in decreased MR, reversal in left ventricular remodeling, and improved survival. The absence of viability or presence of ventricular dyssynchrony is indicative of advanced-stage ischemic cardiomyopathy in which recovery from functional ischemic MR with isolated CABG is unlikely; in these patients, concomitant mitral valve repair should be considered. The value of mitral valve repair in ischemic cardiomyopathy is unclear. Initial observations that established a correlation between functional ischemic MR and worse survival among patients with ischemic cardiomyopathy led to the thought that mitral valve repair at the time of CABG may reverse the course of disease and improve outcomes.\textsuperscript{17} However, correlation does not always translate into causality. Mitral valve repair with an annuloplasty ring, which has been adopted as the preferred treatment for functional ischemic MR, has been shown to result in improved functional status without improved survival.\textsuperscript{5,7,18} Beneficial effects of restrictive mitral annuloplasty on left ventricular remodeling were observed in patients with milder forms of ischemic cardiomyopathy and preserved left ventricular dimensions.\textsuperscript{3} However, a substantial reduction in mitral orifice area in restrictive annuloplasty may result in functional mitral stenosis and worsening of functional status.\textsuperscript{19}

In summary, patients with ischemic cardiomyopathy and functional ischemic MR represent a very heterogeneous population that differs in extent of myocardial viability and function, with functional ischemic MR being primarily a reflection of the severity of ventricular dysfunction rather than its cause. Whether to revascularize the coronary arteries alone or add a mitral valve repair to correct functional ischemic MR should be guided by preoperative myocardial viability studies. Although surgical techniques for mitral valve repair continue to evolve, the extent of ischemic myocardial injury remains the main determinant of patient outcomes. A prospective randomized trial between CABG and CABG with concomitant mitral valve repair will determine the optimal treatment of patients with ischemic cardiomyopathy and moderate functional ischemic MR. The National Institutes of Health–sponsored Cardiothoracic Surgical Clinical Trials Network is currently enrolling patients in such a trial (Surgical Interventions for Moderate Ischemic Mitral Regurgitation).

Disclosures

Dr Mihaljevic is a consultant and speaker for Intuitive Surgical, St. Jude Medical and Edwards Lifesciences. Dr Gillinov is a consultant and speaker for Edwards Lifesciences and St. Jude Medical, has received honoraria from ATS Medical, and has an equity interest in Viacor Inc. He also serves as a consultant to EndoValve. Dr Sabik is a consultant and speaker for Medtronic Inc.

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