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The Mitral Regurgitation Index: An Echocardiographic Guide to Severity

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OBJECTIVES The purpose of this study was to develop a semiquantitative index of mitral regurgitation severity suitable for use in daily clinical practice and research.

BACKGROUND There is no simple method for quantification of mitral regurgitation (MR). The MR Index is a semiquantitative guide to MR severity. The MR Index is a composite of six echocardiographic variables: color Doppler regurgitant jet penetration and proximal isovelocity surface area, continuous wave Doppler characteristics of the regurgitant jet and tricuspid regurgitant jet-derived pulmonary artery pressure, pulse wave Doppler pulmonary venous flow pattern and two-dimensional echocardiographic estimation of left atrial size.

METHODS Consecutive patients (n = 103) with varying grades of MR, seen in the Adult Echocardiography Laboratory at UCSF, were analyzed retrospectively. All patients were evaluated for the six variables, each variable being scored on a four point scale from 0 to 3. The reference standards for MR were qualitative echocardiographic evaluation by an expert and quantitation of regurgitant fraction using two-dimensional and Doppler echocardiography. A subgroup of patients with low ejection fraction (EF <50%) were also analyzed.

RESULTS The MR Index increased in proportion to MR severity with a significant difference among the three grades in both normal and low EF groups ($F = 130$ and $F = 42$, respectively, $p < 0.0001$). The MR Index correlated with regurgitant fraction ($r = 0.76$, $p < 0.0001$). An MR Index ≥2.2 identified 26/29 patients with severe MR (sensitivity = 90%, specificity = 88%, PPV = 79%). No patient with severe MR had an MR Index <1.8 and no patient with mild MR had an MR Index >1.7.

CONCLUSIONS The MR Index is a simple semiquantitative estimate of MR severity, which seems to be useful in evaluating MR in patients with a low EF. (J Am Coll Cardiol 1999;33:2016–22) © 1999 by the American College of Cardiology

Echocardiography is the most commonly used noninvasive method for detection and estimation of mitral regurgitation (MR) severity. Although the echocardiographic finding of MR is ubiquitous in adults, evaluating its severity remains a clinical challenge. Numerous echocardiographic techniques, both qualitative and quantitative, have been developed. However, no single precise method is routinely used as a "reference standard" (1) and previous studies have demonstrated that existing measures of MR severity correlate poorly with clinical signs and symptoms (2,3).

Quantitative echocardiographic measures include calculation of regurgitant volume, regurgitant fraction (RF) and effective regurgitant orifice area by two-dimensional and Doppler echocardiography (4–8) and the proximal isovelocity surface area (PISA) technique, respectively (9–11). These quantitative methods are cumbersome and time consuming and, hence, infrequently used for routine clinical evaluation. Qualitative evaluation is based on a number of variables: color Doppler jet characteristics including jet entrainment, jet width and area, continuous wave (CW) Doppler intensity and character of the regurgitant jet, pulmonary venous flow pattern and left atrial (LA) dynamics (12). The qualitative nature of these variables leads to a high degree of interobserver variability that may adversely influence clinical decision making. Hence, a simple yet accurate reproducible and clinically applicable guide is desirable to identify and follow up patients with hemodynamically significant MR.

We hypothesized that the systematic application of a combination of qualitative and quantitative echocardiographic variables would provide an index of MR that would be more reproducible than a qualitative estimate alone and less time intensive than existing quantitative methods. The specific aims of this study were to develop a new "MR Index" and to test the hypotheses that the MR Index would:

1) correlate with the qualitative assessment of severity of MR; and
2) correlate with a quantitative measure of MR, in this instance the RF.

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Abbreviations and Acronyms

CW = continuous wave
EF = ejection fraction
LA = left atrium
LV = left ventricular
MR = mitral regurgitation
PISA = proximal isovelocity surface area
RF = regurgitant fraction

METHODS

We retrospectively studied 103 consecutive patients (54 men and 49 women) between the ages of 25 and 89 years with echocardiographically diagnosed native valve MR, examined and entered into the UCSF Adult Echocardiography Database between January 1994 and December 1996. Approval for this study was obtained from the Committee for Human Research at UCSF. Inclusion criteria were:

1) "isolated MR,"
2) sinus rhythm,
3) heart rate <110 bpm,
4) no more than trivial or mild aortic regurgitation, and
5) concurrent tricuspid regurgitation regardless of severity.

Exclusion criteria were:

1) trivial or trace MR,
2) associated mitral or aortic stenosis (n = 6),
3) moderate or severe aortic regurgitation (n = 4), qualitative
4) atrial fibrillation or sinus tachycardia >110 beats/min (n = 3), and
5) previous mitral valve repair surgery (n = 1).

Four patients (one with mild MR, two with moderate MR and one with severe MR) were excluded from the total of 89 patients with MR for technical reasons such as an inadequate pulmonary venous flow signal. In addition to patients with MR, ten age-matched normal subjects from the same population were also analyzed.

In our laboratory, the routine evaluation and assignment of a qualitative grade of MR is based on a number of echocardiographic and Doppler parameters (12) and are reported using standard phrases from a dictionary database as mild, mild to moderate, moderate, moderate to severe and severe. Patients were divided into three categories on the basis of the expert reader's grading of MR severity: MILD MR—included patients graded as mild MR, MODERATE MR—included patients graded as mild-moderate and moderate MR, SEVERE MR—included patients graded as moderate-severe and severe MR. As a quantitative expression of MR, RF was retrospectively calculated in all patients by two dimensional and Doppler echocardiography as described below.

The left ventricular (LV) end diastolic volume and the LV end systolic volumes were measured using the biplane method of discs using the orthogonal four and two chamber apical views and the ejection fraction (EF) was calculated as described below. Subgroup analysis by EF compared patients as those with normal or near normal EF (EF > 50%) (n = 50) with those with moderate or severely decreased EF (EF < 50%) (n = 36). The EF in the <50% group ranged from 8% to 49%. Furthermore, the 36 patients were classified into those with moderately decreased EF (EF > 30%) (n = 18) and those with severely decreased EF (EF < 30%) (n = 18). These were evenly divided as six patients in each category of mild, moderate and severe MR.

Echocardiographic study. Doppler, M mode and two-dimensional echocardiography were performed according to the established clinical laboratory practice using commercially available instruments routinely used in the Echocardiography Laboratory (Hewlett-Packard Sonos 1500 and 2500 and the Acuson XP 128, Andover, Massachusetts) with 2.5 or 3.5 MHz phased array transducers.

The Mitral Regurgitation Index. The MR Index was derived from six frequently applied echocardiographic variables. Three of the variables were significantly influenced by the severity of MR; these included jet penetration into the LA, PISA, CW regurgitant jet character and intensity. Three variables related to the compensatory changes in the heart secondary to MR were: pulmonary artery pressure by tricuspid regurgitation velocity, pulmonary venous inflow pattern and LA size. Each parameter was scored on a four point scale from 0–3 (refer to Table 1) and the total was divided by the number of variables. Thus, a grade of 3.0 represents the most extreme degree of MR and a grade of 0 represents the absence of MR.

Jet penetration was studied in the parasternal long axis and apical four and two chamber views. A jet was considered to be eccentric if it impinged on the lateral wall or the interatrial septum in any of the above views. Because this was a retrospective study, not all echocardiograms reviewed did include a magnified view with a lowered Nyquist for measurement of PISA and the radius was therefore measured in the apical four chamber view (Nyquist setting in all patients ranged between 50 and 64). The PISA radius was measured as the distance from the first alias to a point at the trailing edge of the mitral leaflets nearest the regurgitant orifice along a vector parallel to the direction of interrogation at a point in midsystole. The CW jet intensity and character were evaluated from spectral recordings obtained either in the apical four chamber view or with the standard lone CW transducer positioned at the apex.

The systolic pulmonary artery pressure was estimated as the sum of the gradient across the tricuspid valve (calculated from the modified Bernoulli equation as gradient = $4\ v^2$ where v = peak velocity) and the right atrial pressure. Right atrial pressure was estimated using the size and respiratory response of the inferior vena cava in the subcostal view as