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E-Challenge

# Ischemic Mitral Regurgitation: To Fix or Not to Fix

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IN 1968, DR GEORGE BURCH described mitral regurgitation (MR) triggered by myocardial ischemia (MI) as papillary muscle dysfunction syndrome, now known as ischemic mitral regurgitation (IMR).[1] Optimal surgical approach to management of IMR has evolved over time and still is a matter of debate. Variable opinions exist regarding the addition of mitral valve repair (MVR) in patients with moderate IMR undergoing coronary artery bypass graft (CABG).[2-4] Recurrence of MR despite repair possibly suggests irreversible remodeling of mitral valve (MV) apparatus. Several studies have used quantitative 3-dimensional (3D) imaging for assessment of the degree of valvular remodeling as a predictor of recurrence of IMR after MVR.[5-7] Thus, mitral geometric remodeling and structural abnormalities can be used to identify patients who will benefit from an intervention.

## Clinical Case

A 65-year-old woman, with a past medical history of hypertension, diabetes mellitus, and hyperlipidemia, was admitted for elective CABG. She had earlier presented to the hospital with sudden onset of shortness of breath and chest tightness. Her cardiac workup revealed mild mitral regurgitation, normal valvular structures, and biventricular function (quantitative biplane left ventricular [LV] ejection fraction was 62%, with mild symmetrical left ventricular hypertrophy and normal cavity size), on preoperative transthoracic echocardiography (TTE). Additionally, cardiac catheterization showed severe 3-vessel coronary artery disease. Specifically, she had a critical (95%) proximal left anterior descending artery lesion, 80% stenosis of the proximal right coronary artery, and 70% ostial stenosis of the first obtuse marginal artery with good distal runoff. She had an uneventful induction of general anesthesia, and the right internal jugular vein was cannulated with a triple-lumen central venous catheter according to ultrasound guidance. An X8-2T transesophageal echo (TEE) probe was used with an EPIQ ultras3ound system (Philips Medical Systems, Andover, MA) for a comprehensive TEE examination before surgery. She had a baseline systolic blood pressure (SBP) level of 120/70 mmHg, a heart rate of 60- to- 65 beats/-min (bpm), mildly depressed global systolic function, mildly thickened mitral leaflet, and a centrally directed MR jet of trace- to- mild intensity by visual qualitative assessment (Video 1).

During the left internal mammary artery harvest, her SBP increased to 140 mmHg, and moderate- to- severe hypokinesis

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Optimal interventional planning for ischemic mitral regurgitation, initially known as papillary muscle dysfunction syndrome, has been a matter of debate for decades. The primary challenge constitutes the selection of patients who will benefit from an intervention. In this E-challenge, the authors present a unique case with discrepancies in evaluation of severity of mitral valve regurgitation using qualitative visual assessment and the semiquantitative vena contracta method. Therefore, the authors have used an innovative approach involving R-wave–gated 3-dimensional imaging for quantitative valve analysis and assessment of the degree of valvular remodeling to assist in decision-making.

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of the anterior and lateral left ventricular walls along with the apical segment was noted on the TEE examination. The MR grade also increased to moderate-severe intensity by visual qualitative assessment (Video 2). Preoperative trace mitral regurgitation and intraoperative moderate-to-severe regurgitation can be compared through visual qualitative assessment (Fig 1). The surgical team was informed of this development, and the patient was administered 5 mg of metoprolol and started on nitroglycerin infusion at a rate of 0.5 mcg/kg/min. When the SBP returned to the range of 120 to 125 mmHg, there was resolution of the LV wall motion abnormalities and the severity of MR returned to baseline. The same cycle of events happened a few minutes later, with elevation of the SBP in the 140-mmHg range during opening of the pericardium, and she responded to increasing the dose of nitroglycerin to 1 mcg/kg/min. Whereas the severity of MR was judged to be moderate-severe using 2-dimensional (2D) color-flow Doppler (CFD) imaging, the vena contracta (VC) of the MR jet was 0.27 cm, which is in the range of mild intensity MR (Fig 2).

## Echocardiographic Challenge

1. Based on discordance in assessment of the severity of MR between the visual qualitative assessment and the semiquantitative VC method, what is the best approach to resolve this discordance?
2. If no significant remodeling exists on geometric analysis of the valve, should a mitral valve intervention be performed based on the dynamic mitral regurgitation?

## Clinical Course

To resolve the discordance between visual qualitative assessment and semiquantitative VC method, R-wave–gated 3D images of the mitral valve were acquired with and without CFD. Using the multiplanar reformatting, the VC was identified and again measured to be 0.3 cm. The 3D data were also accessed off-line with the 3D Cardio-View reconstruction software (TomTec Imaging Systems GmbH, Unterschleissheim, Germany) for geometric analysis of the mitral valve. Specifically, the leaflet tethering angle of the posteromedial scallop (P3) of the posterior leaflet was measured to be 21˚, the nonplanarity angle of the valve was 130˚, tenting height was 1.0 cm, and the annulus was not dilated in the anteroposterior axis (Fig 3). At this stage, cardiopulmonary bypass (CPB) was initiated after heparinization. The case was discussed with the primary cardiologist, and a decision was made to perform revascularization only and not address the dynamic MR based on the following reasons: The MR was possibly related to an acute ischemic event as it responded to anti-ischemic therapy; an increase in the MR jet area qualitatively with SBP elevation without a similar increase in the VC of the jet possibly represented an increase in the LV- to- left atrial (LA) pressure gradient and not an increase in the effective regurgitant orifice area; the lack of mitral geometric remodeling based on the parameters used to define remodeling from prior experience further signified that MR had an acute and dynamic component; and the cardiac catheterization report had demonstrated high-grade proximal stenosis of the coronary vessels, with good targets postulating likely good results with surgical revascularization alone.

The patient underwent a 3-vessel CABG, with left internal mammary artery- to left- anterior descending and 2 vein grafts to the right coronary artery and first obtuse marginal artery. She was separated from cardiopulmonary bypass with background vasopressor therapy (phenylephrine 0.5 mcg/kg/min) and with atrial pacing at a rate of 80 bpm. TEE examination revealed improved biventricular systolic function without any wall motion abnormalities and trace MR (Video 3). The patient was transferred to the intensive care unit and extubated a few hours later. She was transferred to the step-down unit the following day. She was discharged from the hospital to a rehabilitation facility on the fifth postoperative day.

## Discussion

In this specific patient, the authors integrated the information obtained from the geometric indices of mitral valvular remodeling into their clinical decision-making. The geometric parameters illustrated in the literature as predictors of recurrence of MR include anterior leaflet angle, P3 leaflet tethering

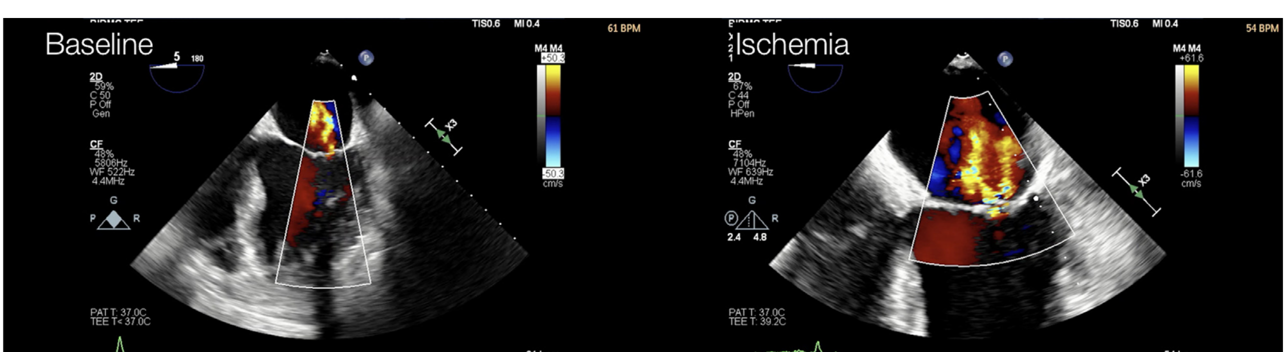


Fig. 1. Midesophageal 4-chamber views with color Doppler on the mitral valve comparing intraoperative preprocedure trace mitral regurgitation and intraoperative moderate to severe regurgitation during the left internal mammary artery (LIMA) harvest through visual qualitative assessment.

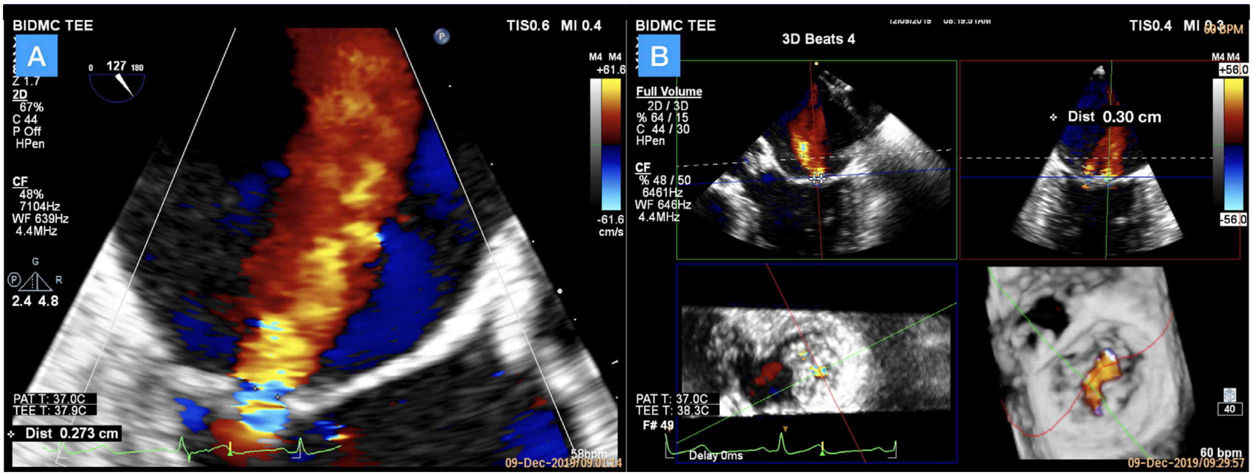


Fig. 2. (A) Midesophageal long axis view (zoom) of regurgitant mitral valve using vena contracta (VC) of a mitral regurgitation (MR) jet measured 0.27 cm to grade severity of mitral regurgitation. (B) Transesophageal echocardiogram imaging of a MR jet using 3-dimensional multiplanar reformatting to evaluate vena contracta measured 0.3 cm.

angle, leaflet tenting angle, tenting height, tenting area, anterior leaflet tethering, interpapillary shortening, and the left ventricular size and function.[8-13] However, the authors used postacquisition P3 leaflet tethering angle, nonplanarity angle, and the anteroposterior diameter parameters to assist in a management plan based on their extensive experience regarding the predictive value of these indicators.[14-16] Specifically, an optimal cutoff value of 29.9° of preoperative P3 tethering angle is a strong independent predictor of recurrence of IMR.[14]

The primary challenge encountered in decision-making is comprised of discordance in determination of severity of MR between visual qualitative assessment and semiquantitative VC method. The area of the MR jet by CFD in the LA is a velocity and not a volume map. It is determined by the LV-LA pressure gradient and the momentum of the flow. In addition, this driving pressure can also be affected by the machine settings.[16] VC is a semiquantitative method and is relatively less dependent on the loading conditions and the LV-LA driving pressure gradient, possibly leading to the difference in both measurements.[17] Although there was discordance between the qualitative and semiquantitative indices of MR severity assessment, there was absence of evidence of significant structural remodeling of the mitral valvular apparatus based on the parameters included to define remodeling status. Hence, the absence of mitral geometric remodeling was used to support the decision to avoid intervention, considering the acute nature of the MR. Resolution of the severity of IMR with anti-ischemic therapy and return to baseline grade of mild central MR specified the dynamic nature of IMR in this patient. Similarly, its reliance on volume and fluid status was appreciated by the qualitative increase in MR jet area,with systolic blood pressure (SBP) elevation without a similar increase in VC of the jet. Thus, this suggested a possibility of an increase in the left ventricle (LV)- to- left atrium (LA) pressure gradient instead of an increase in the effective regurgitant orifice area as a possible cause of dynamic IMR.

Such an innovative approach for assessment of MV geometry using R-wave–gated 3D imaging depends on the combination of 3D transesophageal echocardiography and advanced image analyses with a custom computerized valve modeling algorithm, Echo-View 5.4 (TomTec Imaging Systems GmbH, Unterschleissheim, Germany). Because this is an advanced analytical software, shortcomings of this approach are the requirement of expertise essential to operate software for intraoperative use. However, this unique application of 3D imaging

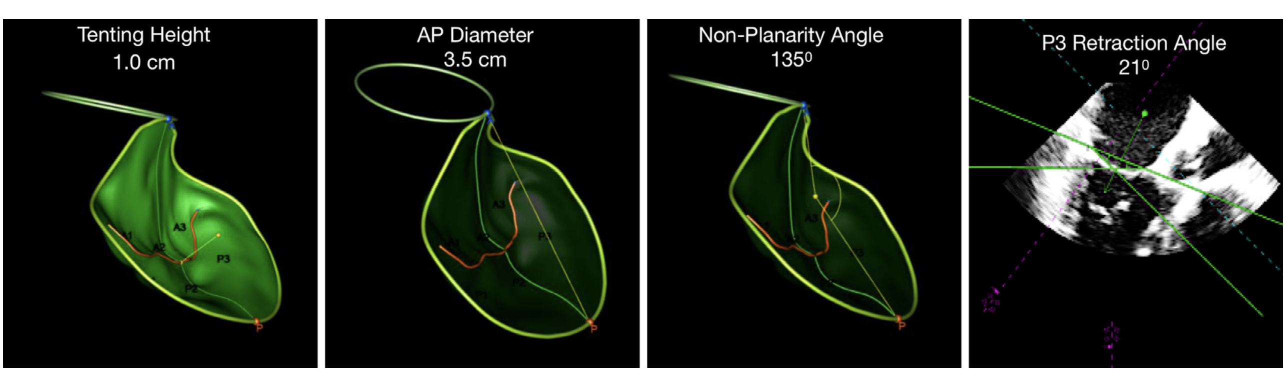


Fig. 3. A 3-dimensional reconstruction with a superimposed mitral valve (MV) model depicting various indices of MV geometry including the tenting height (1.0 cm), the anteroposterior diameter (AP) (3.5 cm), the nonplanarity angle (135°), and posteromedial scallop retraction angle (21°) (TomTec Imaging Systems GmbH, Unterschleissheim, Germany).

with quantitative analysis can play a vital role in such challenging clinical situations.

In conclusion, this methodology offers the potential of detailed in vivo quantitative 3D valve analysis, thereby assisting in tackling the clinical dilemma of performing an intervention or no intervention in patients with dynamic ischemic mitral regurgitation.

## Conflict of Interest

Authors report no conflicts of interest.

## Supplementary materials

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1053/j.jvca.2020.04.043.

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