Assessing prosthetic mitral valve regurgitation by transoesophageal echo/Doppler

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Transoesophageal echocardiography has greatly improved our ability to detect structural and regurgitant abnormalities associated with prosthetic mitral valves.

Despite advances in imaging, the assessment of a mechanical prosthetic mitral valve remains a considerable challenge, particularly when valvar regurgitation is suspected. Transthoracic imaging is well suited to assess the haemodynamics of forward flow across prosthetic mitral valves. Thus detection of prosthetic stenosis is usually accomplished without difficulty. In contrast, because of the location of the mitral valve prosthesis, the reflective characteristics of the materials used to manufacture the valve, the distance from the transducer, and the shadowing produced by the valve apparatus, detection of structural and regurgitant abnormalities of the valve is limited. Transoesophageal echocardiography (TOE) has greatly improved our ability to directly detect structural and regurgitant abnormalities associated with a prosthetic mitral valve. Studies directly comparing the efficacy of transthoracic echocardiography and TOE have established TOE as the “gold standard” for non-invasive diagnosis of prosthetic mitral valve dysfunction.

MITRAL PROSTHETIC FORWARD FLOW

Recognising the limitations of direct transthoracic imaging of prosthetic regurgitation, recent studies have focused on characteristics of mitral prosthetic forward flow as a clue to the presence of significant regurgitation. The most successful parameters take into account the fact that high volumes of flow should cross the mitral valve in a forward direction whenever significant prosthetic regurgitation is present. An analysis of 57 patients by Olmos and colleagues evaluated several variables of forward flow across a prosthetic mitral valve. The most useful parameters for detecting moderate or severe mitral insufficiency were: a peak mitral velocity greater than 1.9 m/s (sensitivity 90%, specificity 89%); a mean gradient across the prosthetic valve greater than 5 mm Hg (sensitivity 90%, specificity 70%); and a ratio > 2.5 of the time velocity integral of mitral flow divided by the time velocity integral of left ventricular outflow tract flow (sensitivity 89%, specificity 91%). When combined with a pressure half time appropriate to a non-stenotic prosthesis these parameters effectively screened out patients with only minimal amounts of mitral insufficiency. While these indices help overcome issues of shadowing they lack the ability to directly interrogate regurgitant flow, thus TOE is still necessary to define the type, location, severity, and anatomic correlates of prosthetic valve regurgitation.

TOE is exquisitely sensitive for the detection of valvar insufficiency. Indeed many cases of mild insufficiency detected by TOE are not detectable by angiography. Furthermore, all commonly manufactured low profile prosthetic valves have a built-in amount of “normal” regurgitant flow to help reduce the likelihood of valve thrombosis. Because of differences in design, each type of prosthetic valve has a characteristic signature of regurgitant flow that should be considered normal. These normal flow patterns comprise two components, the initial being the closure backflow occurring as the leaflet rapidly closes, and the more long lasting being holosystolic backflow leakage. Careful orientation of the TOE transducer to the valve and use of multiple imaging planes are important to fully differentiate pathologic regurgitation from the physiologic signature regurgitation. In general, pathologic regurgitant jets are those that are greater than 2 cm in length, holosystolic with turbulence, and of different shape from the expected signature physiologic regurgitant pattern of the valve.

Following identification of a pathologic regurgitant jet, it is important to differentiate the origin of the jet as being valvar or paravalvar. This is best done by careful multiplane imaging of the valve apparatus. Tracing the origin of the regurgitant jet as being inside or outside the sewing ring is the critical step. Indeed, the most common error made in the diagnosis of mitral prosthetic regurgitation is the failure to differentiate a paravalvar leak from a valvar leak. A recent study, comprising predominantly of TOE cases, identified an error rate for this of approximately 10%. Virtually no other types of diagnostic errors were identified in this study. The authors concluded that the failure to differentiate paravalvar from valvar insufficiency was predominately due to inadequate orientation of the angle of interrogation with the prosthetic valve plane. It appeared most important to obtain a perpendicular orientation through the centre of the valve orifice to best differentiate the pathologic from physiologic regurgitation.

SEVERITY OF MITRAL REGURGITATION

Rating the severity of prosthetic mitral regurgitation is also a considerable challenge. The volume of the regurgitant flow jet is determined by the size of the regurgitant orifice, the driving force from the pressure gradient across the
orifice, and the length of time of systole. Initial studies that
defined regurgitant severity focused on characterisation of
the colour flow jet. Methods that measured jet area or jet
length, while initially promising, were soon found to have
significant limitations because of variations in haemody-
namics, instrument settings, receiving chamber characteris-
tics, jet eccentricity, jet impingement on chamber walls, and
variability in perception by readers. This led to investigation
of other flow phenomena of regurgitation, particularly
that related to flow convergence of the regurgitant jet into the
regurgitant orifice and characterisation of the jet as it
immediately exited the orifice (assessment of the vena
contracta).1 7 Refinement of these techniques led to quanti-
tative parameters relating the width of the vena contracta to
severity, and the calculation of an effective regurgitant orifice
and effective regurgitant volume.6–9 An alternative and
indirect approach assessed flow phenomena in the pulmon-
ary veins and systole reversal of flow was recognised as
indicating severe mitral insufficiency.10

Despite such a wide array of parameters being available,
little organised information exists on their efficacy in patients
with mechanical prosthetic valves. Thus the study of Vitarelli
and colleagues in this edition of Heart is a welcome addition
to the literature.11 These authors studied 47 patients with
clinically suspected prosthetic valve dysfunction, all of whom
had various types of mechanical prosthetic valves. TOE
examinations were performed across the entire 180˚ spec-
trum of a multiplane transducer. An important aspect of this
study was the authors’ simultaneous evaluation of several
parameters of regurgitant severity: mitral regurgitant area,
diameter of the vena contracta, assessment of flow conver-
genence parameters including maximal instantaneous regur-
gitant flow and regurgitant orifice area, and the ratio of peak
systolic to peak diastolic pulmonary venous flow velocity. The
efficacy of these parameters was compared against the
standard angiographic 1+ to 4+ grading system of mitral
regurgitation.

The authors found that their echocardiographic parameters
worked quite well compared to angiography. The vena
contracta measurement showed the highest correlation and
also had the best receiver operating curve for detecting severe
valvar insufficiency. Indices derived from flow convergence
also performed very well. Consistent with previous studies,
measurements of pulmonary venous flow characteristics and
regurgitant jet area were less effective. The authors also
importantly confirmed prior data showing that the use of mul-
tiple imaging planes improved the reliability of their results.12

What should be the approach to prosthetic mitral valve
insufficiency in 2004? When prosthetic dysfunction is
suspected it still may be reasonable in many circumstances
to start with a transthoracic study. A typical comprehensive
transthoracic examination in some circumstances may
identify significant regurgitation. The primary danger is
underestimation of regurgitant severity. To reduce depend-
ence on direct imaging of the regurgitant jet, it is
worthwhile to calculate the transthoracic forward flow
parameters proposed by Olmos and colleagues.1 A
assessment of peak mitral valve velocity, mean gradient, and
the flow velocity integral ratio of mitral flow to left ventricular
outflow tract flow is a very logical first step in screening for
valvar insufficiency and utilises easily obtained data from the
routine exam. If the clinical index of suspicion is low, the
prosthetic valve flow characteristics are all within normal
ranges, and valve morphology appears normal, evaluation
may be stopped at this point. If, on the other hand, any of the
other Olmos criteria are abnormal or clinical suspicion is still
significant the patient should have a TOE. Those patients
with a high clinical suspicion for prosthetic valve insuffi-
ciency should go directly to TOE.

**TOE EXAMINATION**

The TOE examination needs to be complete and deliberate.
Careful alignment of the transducer is essential to fully
display leaflet motion as comprehensively as possible.
Multiplane imaging should be done at a minimum of every
30˚ from 0–180˚. If pathologic flow is observed over and above
the usual regurgitant signature of the valve it should be
carefully characterised in multiple planes. Vitarelli and
colleagues show that the best correlation occurs when the
maximal regurgitant jet characteristics are calculated after
evaluating multiple views.13 Localisation of the jet is also
important for the surgeon. The decision to operate and the
effectiveness of the operation can be enhanced by careful
communication of the precise location of the regurgitant jet
and whether or not it is paravalvar or valvar. To this end,
the quantification system established by Foster and colleagues
for describing the location of regurgitant leaks on both native
and prosthetic valves is of considerable value.14 This system
uses not only a full rotational examination but also
advocates further imaging at 0˚ sweeping through the valve by moving
the transducer upward and downward in the oesophagus to
show as much of the circumference of the valve plane as
possible.

For characterising regurgitant severity, use of all of the
major parameters investigated by Vitarelli and colleagues is
recommended.15 Measurement of the width of the vena
contracta, interrogation of the regurgitant jet with contin-
uous wave Doppler, flow convergence index, flow convergence
parameters and perhaps even valve regurgitant jet area can be
done quickly during the examination and calculated easily at
the conclusion of the study. The most convincing information
about regurgitant severity will occur when the conclusions
reached by measuring these multiple parameters agree with
each other.

What of the future? Three and four dimensional imaging
reconstruction is feasible for mitral regurgitant jets. Three
dimensional displays may add further important information
for the surgeon in planning the operation and localising the
source of the problem.16 Perhaps three dimensional display
may also add quantitative information. As more rapid real
time three dimensional systems become available this form of
imaging will become a practical reality. For the time being,
however, comprehensive two dimensional imaging combined
with multiple measurements of regurgitant severity is the
standard of care.

**REFERENCES**

1 Daniel LB, Grigg LE, Weisbl RD, et al. Comparison of transthoracic and
transesophageal assessment of prosthetic valve dysfunction.
Echocardiography 1990;7:83–95.
2 Bach DS. Transesophageal echocardiographic (TEE) evaluation of prosthetic
valves. Cardiol Clin 2000;18:751–71.
3 Olmos L, Salazar G, Barbetseas J, et al. Usefulness of transthoracic
echocardiography in detecting significant prosthetic mitral valve regurgitation.
Am J Cardiol 1999;83:199–205.
4 Flachskampf FA, O'Shea JP, Griffin BP, et al. Patterns of normal transvalvular
regurgitation in mechanical valve prostheses. J Am Coll Cardiol
1991;18:1493–98.
5 Faletto F, Constantin C, De Chiara F, et al. Incorrect echocardiographic
diagnosis in patients with mechanical prosthetic valve dysfunction: correlation
with surgical findings. Am J Med 2000;108:531–7.
6 Grayburn PA, Fehske W, Oman H, et al. Multiplane transesophageal
echocardiographic assessment of mitral regurgitation by Doppler color flow
mapping of the vena contracta. Am J Cardiol 1994;74:912–7.
7 Cohen GI, Davison MB, Klein AL, et al. Comparison of flow convergence
with other transthoracic echocardiographic indexes of prosthetic mitral
regurgitation. J Am Soc Echocardiogr 1992;5:620–7.
8 Tribouilloy C, Shen WF, Quere JP, et al. Assessment of severity of mitral
regurgitation by measuring regurgitant jet width at its origin with transesophageal Doppler color flow imaging. Circulation 1992;85:1248–53.
9 Thomas JD. How leaky is that mitral valve? Simplified Doppler methods to
measure regurgitant orifice area. Circulation 1997;95:548–50.
10 Klein AL, Obarski TP, Stewart WJ, et al. Transesophageal Doppler
echocardiography of pulmonary venous flow: a new marker of mitral
regurgitation severity. J Am Coll Cardiol 1991;18:518–26.
Congenital coronary artery anomaly demonstrated by three dimensional 16 slice spiral CT angiography

A 57 year old man with multiple risk factors for coronary artery disease presented with exercise related chest pain. An x ray angiogram revealed no coronary atherosclerosis but, rather, an anomalous left coronary artery course. Whether the anomalous coronary artery travelled a clinically benign course posterior to the aorta or a potentially lethal course between the aorta and pulmonary trunk, however, could not be ascertained by the two dimensional x ray angiography. Because of severe bradycardia (heart rate 47 beats per minute), causing prolonged breath-hold times, a magnetic resonance coronary angiogram was limited by extensive respiratory motion artefact and failed to clarify the route of the anomalous coronary artery. Consequently, the patient underwent coronary computed tomographic (CT) angiography. On a Siemens 16 slice CT scanner, the entire heart was scanned by using 12 x 0.75 mm collimation spiral scanning and retrospective ECG-gating technique.

The left main coronary artery had an anomalous origin from the right, anterior sinus of Valsalva originating just above the right coronary artery ostium and followed a benign, retroaortic course (black arrowhead) after which it bifurcated into the left circumflex artery and a small left anterior descending artery (lower panels A–C: Ao, aorta; GCV, great cardiac vein; LA, left atrium; LAA, left atrial appendage; LAD, left anterior descending artery; LCX, left circumflex artery; LM, left main coronary artery; LV, left ventricle; PDA, posterior descending artery; PT, pulmonary trunk; RA, right atrium; RCA, right coronary artery; RV, right ventricle; RVB, right ventricular branch). The first septal perforating artery (white arrowhead) arose just anterior to the right coronary artery ostium (upper panels A and B), consistent with the x ray angiogram. The dominant right coronary artery bifurcated into the posterior descending artery and right ventricular branch at its mid distal portion. As CT findings excluded malignant coronary anomaly, there was no need for surgical intervention.

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