Dobutamine echocardiography: a diagnostic tool comes of age

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Both the practice and indications for dobutamine stress echocardiography (DSE) have changed over the past 15 years. At first DSE was the prerogative of a few enthusiastic cardiologists working at specialized centres, but this technique has developed into a commonly used practical tool with widespread availability. In the early years DSE was used for the assessment of coronary artery disease; test results were either positive or negative. Nowadays the scope of DSE has expanded to the detection of viable myocardium in patients with heart failure, preoperative cardiac risk assessment and prognostication for late cardiac events. The introduction of technical advances such as quad-screen format, second harmonic imaging, and contrast agents have substantially improved the image quality. Thus, even in the case of patients with poor image quality and chronic pulmonary disease it is now possible to examine these patients. A recent development in DSE is the introduction of semi-quantitative stress test results to assess the severity of coronary artery disease. Myocardial ischaemia was described according to the extent (number of segments), severity (hypokinesia, akinesia, or dyskinesia), and the heart rate at which ischaemia occurred during the test (heart rate threshold). In meta-analysis studies DSE has been shown to have a sensitivity of 73% and specificity of 91% in the detection of coronary artery disease.

Despite the progress of DSE over the past decade some limitations remain. The major limitation is its subjective visual wall motion score leading to a limited reproducibility of the test, even among 'experts'.1 The assessment of wall motion score largely depends on image quality. The study of Hoffmann et al investigated the influence of technical advances (such as second harmonic imaging, leading to an improved visualisation of left ventricular wall motion and standardised reading criteria), on the reproducibility of the test for the detection of coronary artery disease, in 150 studies scored in five different centres. After the introduction of second harmonic imaging and standardised reading criteria, the kappa value increased from 0.37 to 0.50.2 Although this was considered to be a great improvement, the introduction of a genuine quantitative approach would probably make test results more robust.

Quantitative approaches for the objective assessment of wall motion are mainly based on two techniques: one uses the endocardial border motion from 2-D images with or without echo contrast, and the other uses the measurement of myocardial velocity by tissue Doppler. In this issue of the Journal Mädler et al.,3 report on a method they developed for objective assessment of coronary artery disease using myocardial Doppler velocity during DSE. The MYDISE, Myocardial Doppler in Stress Echocardiography Study was a collaboration between eight European centres. In a group of 289 subjects myocardial velocity of 11 left ventricular segments were measured during DSE. In a group of 92 subjects with a very low probability of coronary artery disease and a group of 48 with proven coronary artery disease myocardial velocity values were assessed at maximal stress. Velocities were corrected for heart rate, age and female gender. The most reproducible parameter was peak systolic velocity (in cm/s) during ejection. Myocardial velocity is reduced in the presence of ischaemia and/or scar tissue. Diagnostic models were constructed for the three different coronary artery territories, (LAD, LCX, and RCA), by sampling at selected segments correcting for age, heart rate and female gender. These models were validated in a group of 149 patients referred for chest pain, using coronary angiography as a reference. Using best cut-off points from receiver-operator curves, the sensitivity and specificity for the detection of LAD,

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LCX, and RCA disease were 80% and 80%, 91% and 80%, and 93% and 82%, respectively.

Tissue Doppler imaging has two important advantages: first, a high signal-to-noise ratio and, secondly, assessment of the longitudinal (base-apex) contraction, which contributes to half of the left ventricular ejection fraction. Instead of a simple velocity cut-off, Mäderl and colleagues chose a sophisticated approach taking into account the coronary artery territory, age, heart rate, and female gender. Using this model a high sensitivity and specificity was achieved for the detection of coronary artery disease.3

Although the tissue Doppler velocity technique has many advantages and can be used successfully for the assessment of myocardial viability,4,5 some disadvantages exist, which may hamper future widespread use.6 Because tissue Doppler velocity of a segment is measured relative to the transducer, the velocity is influenced by the motion of adjacent segments and by translation and rotation of the heart. For instance, the presence of a scar or ischaemia of a mid-ventricular segment will influence the contraction velocity at the base. The recently introduced techniques of regional myocardial strain and strain-rate imaging should overcome this limitation. Jamal and colleagues were one of the first to show the value of strain-rate imaging for the detection of stunned myocardium in a pig model. After reduction of coronary flow of the LCX, inducing stunned myocardium, the reduced contractile reserve during low-dose dobutamine infusion could be accurately assessed compared to control animals by strain-rate values.7 Both Kowalski and Davidavicus subsequently defined the feasibility of ultrasonic strain / strain-rate imaging for various forms of clinical stress testing.5,9 In a more recent study of Voigt and colleagues of the use of strain-rate for the assessment of myocardial ischaemia during DSE was shown. These data showed the progress strain-rate imaging has made over the past years for the objective assessment of myocardial viability and ischaemia.10 Nonetheless, despite the potential limitations of tissue Doppler velocity imaging, this study represents a sophisticated approach to the quantitative assessment of wall motion and future studies are warranted to further define the role of tissue Doppler velocity imaging compared to other techniques such as ultrasonic strain-rate imaging during DSE.

References