Can Contrast Dobutamine Stress Echocardiography Be Performed with Standardized Imaging Settings for Everybody?

Hélène Thibault, MD, Jonathan Timperley, MB, ChB, MRCP, Alexander Ehlgen, MD, Antoine Pariente, MD, Dana Dawson, MB, ChB, and Harald Becher, MD, PhD, FRCP,
Oxford, United Kingdom; and Bordeaux, France

Objective: **The objective was to assess a standardized imaging and contrast injection protocol for contrast-enhanced dobutamine stress echocardiography (DSE).**
Methods: **A total of 102 patients underwent DSE with tissue harmonic imaging and a standardized protocol with contrast power modulation. Contrast intensities in the left ventricular cavity and the myocardium were evaluated by a visual score and quantitative analysis.**
Results: **Of the contrast studies, 98% were diagnostic without modification of the settings. Excellent endocardial border definition was found in 93% of the segments with contrast versus 53% with tissue harmonic imaging ($P < .05$). The interobserver agreement in assessing segmental wall motion improved from 71.5% to 85.9%. There were no differences between the myocardial segments' video intensity in the four- and three-chamber views. In the two-chamber view video intensity was lower in the basal segments compared with the other segments.**
Conclusion: **Power modulation contrast imaging can be applied with a completely standardized protocol for DSE in the majority of patients with excellent endocardial border defnition.** (J Am Soc Echocardiogr 2005;18:1194-1202.)

New contrast-specific imaging modalities such as power modulation (Philips Medical Systems, Andover, MA) and CPS (Siemens Medical Solutions, Iselin, NJ) have the potential to provide simultaneous assessment of left ventricular (LV) regional wall motion[1,2] and myocardial perfusion.[3-5] However, there have been some concerns that adjustment of the machine settings, contrast dosage, and administration vary from patient to patient. In many publications, there are statements that settings are optimized individually, but recommendations regarding these are not precise.[6-8] Therefore, there are no large series using a standardized protocol of machine settings and contrast administration. To assess first LV function and then perfusion, settings may need to be altered.

When using grey scale contrast imaging, power and gain setting have a large impact on the myocardial signal. Thus by increasing or decreasing the gain at a certain depth, one can create or fill an apparent perfusion defect. This makes this method very susceptible to artifacts.

Currently, ultrasound contrast agents are licensed for improvement of endocardial border definition (EBD). Therefore in a clinical situation contrast is used to improve the assessment of LV wall motion and information on myocardial perfusion may be gained, but should be used in addition to the wall motion assessment. However, one must not reduce the quality of imaging of LV wall motion to obtain some perfusion information. Dobutamine stress echocardiography (DSE) is one of the most important clinical situations in which optimal EBD is required.[9]

Real-time power modulation is a new contrast modality that can produce almost complete suppression of tissue signals and images only the ultrasound agent. Contrast agents are pure intravascular tracers, and therefore after intravenous injection only the cavity and the intramyocardial signals are displayed. In theory the best EBD is obtained with a bright and homogeneous LV cavity and a dark myocardium. To see some contrast in the myocardium we necessarily decrease the difference in signal intensity between the myocardium and LV cavity, which may impair EBD. Individual adjustment of the ultrasound scanner and the dosage of the contrast agent have been used in contrast echocardiography to optimize EBD and myocardial contrast enhancement. To simplify the examination a completely standardized protocol was developed for DSE.

From the Department of Cardiology, The John Radcliffe Hospital, Headington, Oxford, United Kingdom (H.T., J.T., A.E., D.D., and H.B.); and Département de bio statistique, Centre Hospitalier Universitaire, Bordeaux, France (A.P.).

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Reprint requests: Harald Becher, MD, PhD, FRCP, Department of Cardiology, The John Radcliffe Hospital, Cardiac Investigation Annex, Oxford OX3 9DU, United Kingdom (E-mail: *Harald.Becher@orh.nhs.uk*).

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The aim of this study was to evaluate whether a protocol with fixed settings of contrast administration, lateral gain, time gain compensation (TGC), transmit power, frequency, and post-processing can provide high-quality images for assessment of LV function during dobutamine stress echo. Second, we evaluated how this protocol affected the homogeneity of myocardial contrast enhancement.

METHODS

We studied 102 consecutive patients who underwent DSE between December 2002 and June 2003. Seventy-eight patients were investigated for a clinical suspicion of coronary artery disease, 12 patients were referred for risk assessment before noncardiac surgery, and 12 patients were referred for assessment of myocardial viability. The contrast agents used for the study were the two licensed contrast agents in the United Kingdom: Optison, per fluorocarbon-containing albumin-coated microbubbles (Optison, Amersham, UK), and Sonovue, lipid sulphur hexafluoride microbubbles (Sonovue, Bracco International, B.V., Milan, Italy).

Power Modulation Imaging Settings

Power modulation imaging was performed using a Sonos 5500 scanner (Phillips Medical Systems) with an S3 transducer. A standardized setting was used in all patients (Table 1). The mechanical index was 0.1 (−21.5 dB), frequency 2.5 MHz. The TGC controls were placed in the middle as a straight line. The lateral gain controls were set at the bottom. The sector size was adjusted to be as narrow as possible to see the entire LV including the myocardium. The focus was positioned at the level of the mitral annulus. If there was any suspicion on an apical perfusion abnormality, additional loops were acquired with the focus moved to the apex. This default setting was the result of pilot studies and was systematically used unless endocardial borders were not clearly visible because of poor LV opacification or attenuation at greater depth. Then the transmit power was increased up to a mechanical index of 0.4, and the other settings were kept constant.

Dobutamine Stress Echocardiography

Baseline images in tissue harmonic imaging (THI) were obtained in all three apical views (four-chamber, two-chamber, and long-axis views) and parasternal views after individual adjustment of TGC and lateral gain. Contrast acquisitions were obtained in the same three apical views after either a 0.3-mL bolus of Optison or a 0.7 mL/min infusion of Sonovue. Contrast timing was dependent on the quality of the window. For patients with suboptimal resting native image, contrast acquisitions were performed at rest and intermediate and peak stress. For patients with good resting images, contrast acquisitions were performed at peak only. If there was a new regional wall motion abnormality present at peak stress then contrast acquisitions were also performed in recovery. Dobutamine was infused in 3-minute stages of 10, 20, 30, and 40 μg · kg · min, and if necessary atropine (0.3 mg bolus up to 1.2 mg) was added to achieve 85% predicted maximal heart rate for ischemia protocol. A protocol beginning at 5 μg · kg · min increasing to 10, 20 μg · kg · min was used for viability study and stopped as soon as the heart rate increased by 10 beats/min. All recordings were stored on magneto-optical disk and analyzed off-line.

Images Analysis

Analysis was performed off-line using visual analysis and Q-lab software (Phillips Medical Systems). The readers were different from the staff who acquired the studies. The readers reviewed single beat loops and were blinded for all clinical data including injection modality.

Wall motion, endocardial border delineation, and myocardial contrast signals were evaluated at peak stress on the three apical views according to the 17 LV segments according to the American Society of Echocardiography guideline (basal, mid- and distal segments of each wall, as well as apex).[10]

Analysis of Wall Motion

Each segment was scored as not analyzable (score 0), normokinetic (score 1), hypokinetic (score 2), akinetic (score 3), and dyskinetic (score 4) on both native harmonic and contrast images by two independent readers: one experienced reader (more than 2 years DSE reading) and one novice (<6 months DSE reading). The reproducibility of the segmental wall motion score was studied by comparing novice and expert readings of the complete study and on segments judged analyzable.

Analysis of Left Ventricular Opacification

Endocardial border delineation was graded in all segments using the following criteria: 0 = not seen, 1 = hardly visualized, and 2 = well delineated on the peak stress acquisition. This grading was performed on both contrast power modulation and native harmonic imaging.

A quantitative analysis was performed using the Q-Lab software (Phillips Medical Systems). Four sample volumes were placed at different depths in the middle cavity (from the apex to the mitral valve), and signal intensity (dB) on end-systolic images was measured in these regions of interest (ROI).

Analysis of Myocardial Contrast Signal Homogeneity

Only patients with a normal resting echocardiography and no inducible wall motion abnormality were included. The degree of myocardial contrast enhancement was graded on each of the 17 segments by following scoring criteria: 0 = no enhancement, 1 = mild enhancement, and 2 = bright contrast enhancement.

A quantitative analysis was also performed using the Q-Lab software with seven sample volumes positioned on each of the three apical views. At least three video intensity (VI) measures were performed on end-systolic images and averaged for each ROI.