Usefulness of Ultrasound Contrast Agent to Improve Image Quality During Real-Time Three-Dimensional Stress Echocardiography

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Dobutamine stress echocardiography is an accepted tool for the diagnosis of coronary artery disease. Some investigators have claimed that 3-dimensional imaging improves the diagnostic accuracy of dobutamine stress echocardiography. The purpose of the present investigation was to examine the role of contrast echocardiography in the improvement of segmental quality and interobserver agreement during stress real-time 3-dimensional echocardiography (RT3DE). The study comprised 36 consecutive patients with stable chest pain referred for routine stress testing. Three-dimensional images were acquired with an RT3DE system with an X4 matrix-array transducer. All available reconstructed 2-dimensional segments were graded as optimal, good, moderate, or poor. Wall motion was scored as normal, mild hypokinesia, severe hypokinesia, akinesia, or dyskinesia. At peak stress, 466 of the 612 segments (76%) could be analyzed during conventional RT3DE. With contrast-enhanced RT3DE, the number of available segments increased to 553 (90%). The image quality index during conventional RT3DE was 2.2, whereas with contrast-enhanced RT3DE, it was 3.1. With conventional RT3DE, 2 independent observers agreed on the diagnosis of myocardial ischemia in 85 of 108 coronary territories (79%, $\kappa = 0.26$). With contrast-enhanced RT3DE, agreement increased to 95 of 108 coronary territories (88%, $\kappa = 0.59$). Study agreement on myocardial ischemia was present in 26 of 36 studies (72%, $\kappa = 0.43$) with conventional RT3DE and in 32 of 36 studies (89%, $\kappa = 0.77$) with contrast-enhanced RT3DE. In conclusion, during stress RT3DE, contrast-enhanced imaging significantly decreases the number of poorly visualized myocardial segments and improves interobserver agreement for the diagnosis of myocardial ischemia. **(Am J Cardiol 2007;99:275–278)**

Dobutamine stress echocardiography is an accepted tool for the diagnosis of coronary artery disease.[1] The interpretation of echocardiographic images, however, is critically dependent on the quality of the recordings and the experience of the observer.[2] Some investigators have claimed that 3-dimensional imaging improves the diagnostic accuracy of dobutamine stress echocardiography.[3–5] However, 1 of the main limitations of 3-dimensional imaging is the inherently lower image quality compared with 2-dimensional imaging. Left ventricular (LV) opacifying contrast agents have been successfully applied during 2-dimensional dobutamine stress echocardiography to improve endocardial border delineation.[6] The use of intravenous ultrasound contrast improves endocardial border visualization, leading to a more accurate interpretation of wall motion abnormalities.[6] The purpose of the present investigation was to examine the role of contrast echocardiography in the improvement of LV segmental quality and interobserver agreement during stress real-time 3-dimensional echocardiography (RT3DE).

Methods

Patient population: The study comprised 36 consecutive patients in sinus rhythm with chest pain referred for stress testing. Baseline clinical characteristics of the patients are listed in Table 1. Beta blockers were used in 22 patients (61%). The study was approved by the institutional review board, and all patients gave informed consent.

Dobutamine–atropine stress protocol: Dobutamine was administered through a peripheral vein in 3-minute stages of 10, 20, 30, and 40 μg/kg/min. The infusion was stopped when 85% of age-predicted heart rate was reached. Otherwise, dobutamine infusion was continued and supplemented by 0.25-mg doses of atropine (to a maximal dose of 1 mg). The stress test was terminated when severe angina, shortness of breath, symptomatic decrease in systolic blood pressure (>40 mm Hg), arterial hypertension (>240/120 mm Hg), severe arrhythmias, or other serious adverse effects occurred.

Contrast examination: SonoVue (Bracco Imaging S.p.A., Milan, Italy) was used at baseline conditions, low dose, and peak stress. The contrast agent was given as a bolus of 0.5 ml with additional boluses of 0.25 ml when needed. A low

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Table 1
Clinical and demographic characteristics (n = 36)

Variable	Subjects
Age (yrs)	57 ± 13
Men	24 (67%)
Diabetes mellitus	9 (25%)
Hypertension*	18 (50%)
Hypercholesterolemia†	14 (39%)
Current smoker	4 (11%)
Previous acute myocardial infarction	10 (28%)
Previous coronary bypass surgery	2 (6%)
Previous coronary angioplasty	7 (19%)

* Defined as systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure ≥90 mm Hg and/or the use of antihypertensive medication.

† Defined as total serum cholesterol ≥230 mg/dl and/or serum triglycerides ≥200 mg/dl or the use of a lipid-lowering agent.

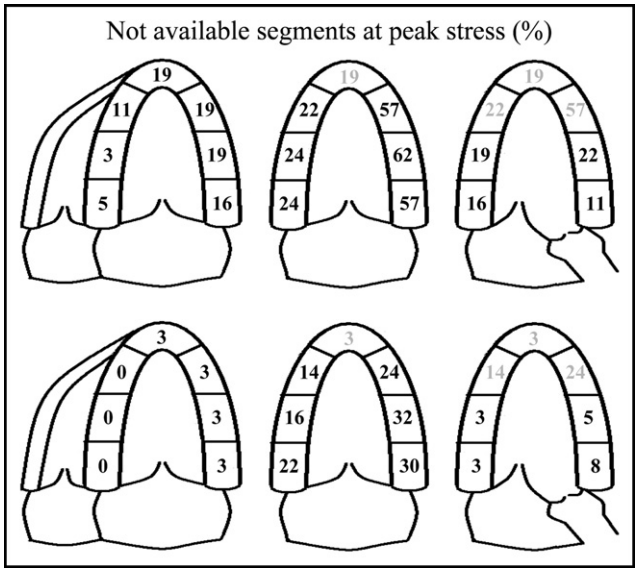

Figure 1. LV 17-segment model showing the percentage of nonvisualized segments during peak stress with conventional *(top)* and contrast-enhanced *(bottom)* 3-dimensional echocardiography.

mechanical index (0.3) was used. Care was taken to record the images at a phase when contrast flow was relatively stable, with absent or minimal swirling of contrast in the apex.

Dobutamine stress RT3DE: The RT3DE images were acquired from an apical window with a Sonos 7500 echocardiographic system (Philips Medical Systems, Best, The Netherlands) equipped with a 3-dimensional data acquisition software package. An X4 matrix-array transducer was attached to the echocardiograph. After visualizing the reference images (in the apical 4-chamber and orthogonal views), a full-volume data set of the left ventricle was acquired. With electrocardiographic gating, 4 pyramidal subvolumes of 20° × 80° were acquired during the first, third, fifth, and seventh cardiac cycles. These 4 conical subvolumes were automatically integrated into a pyramidal data set of 80° × 80° incorporating full LV volume. Regional LV wall motion was evaluated using cropped planes representative of the 4-, 2-, and 3-chamber views.

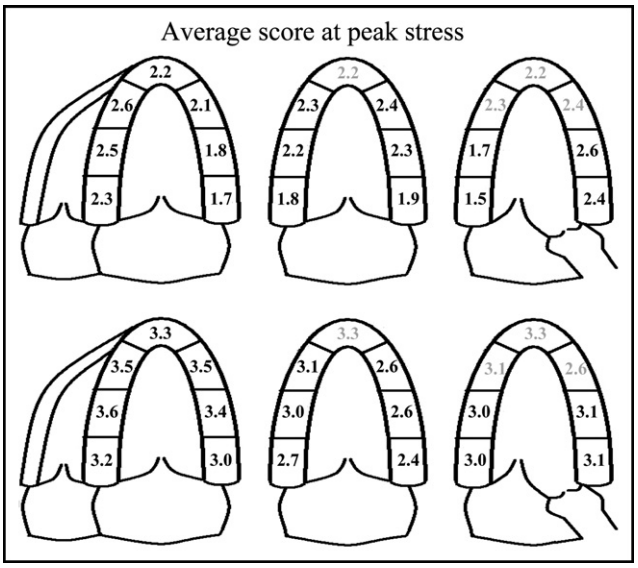

Figure 2. LV 17-segment model showing the segmental quality index in the visualized segments during peak stress with conventional *(top)* and contrast-enhanced *(bottom)* 3-dimensional echocardiography.

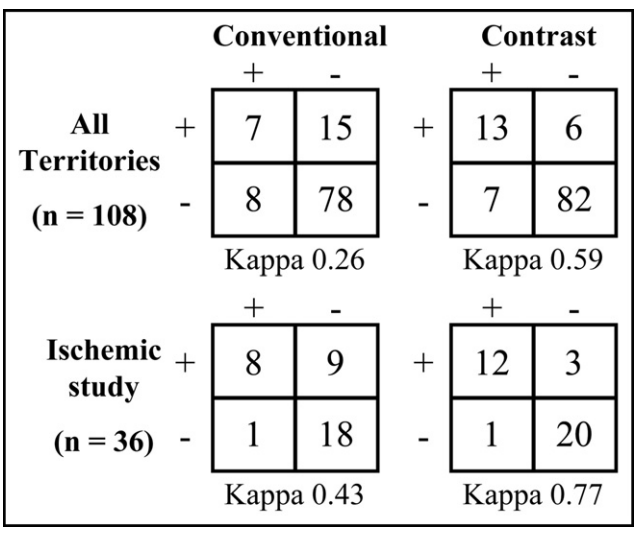

Figure 3. Interobserver agreement with conventional *(left)* and contrast-enhanced *(right)* 3-dimensional stress echocardiography for the diagnosis of myocardial ischemia for all coronary territories *(top)* and the overall study result *(bottom)*.

Off-line data analysis: The digitally stored RT3DE data set was analyzed off-line with the assistance of 4D TomTec Echoview 5.3 software (TomTec Inc., Unterschleissheim, Germany). The RT3DE data set was judged on the basis of the absence of artifacts throughout the cardiac cycle. All available reconstructed segments at peak stress were graded as optimal (4 = excellent quality without possibility to improve), good (3 = good quality without artifacts), moderate (2 = sufficient quality without artifacts or good quality with artifacts), or poor (1 = poor or moderate quality with artifacts). An image quality index was calculated for each segment by the summation of all scores in that particular segment divided by the number of analyzed segments. Wall motion was assessed using the standard 17-segment LV