Comparison of Two- and Three-Dimensional Unenhanced and Contrast-Enhanced Echocardiographies Versus Cineventriculography Versus Cardiac Magnetic Resonance for Determination of Left Ventricular Function

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Contrast enhancement has been shown to improve detection of regional wall motion abnormalities (RWMA) in 2-dimensional (2D) echocardiography. This study determined the use of contrast enhancement in the setting of 3-dimensional (3D) echocardiography for definition of left ventricular RWMA compared with 2D echocardiography, cineventriculography, and cardiac magnetic resonance (CMR). In 63 patients, unenhanced and contrast-enhanced (SonoVue; Bracco Imaging S.p.A., Milan, Italy) 2D and 3D echocardiographies, CMR, and cineventriculography were performed. Hypokinesia in ≥1 segment defined the presence of RWMA. Interreader agreement (IRA) between 2 blinded off-site readers on presence of RWMA was determined within each imaging technique. Intermethod agreement among imaging techniques was analyzed. A standard of truth for the presence of RWMA was obtained by an independent expert panel decision. IRA on presence of RWMA expressed as Cohen's κ coefficient was 0.27 for unenhanced 3D echocardiography, 0.40 for unenhanced 2D echocardiography, 0.57 for CMR, and 0.51 for cineventriculography. The use of contrast increased IRA on RWMA to 0.42 for 3D echocardiography and to 0.56 for 2D echocardiography. Agreement with CMR on RWMA increased for 3D echocardiography when contrast enhancement was used (κ 0.40 vs 0.22 for unenhanced 3D echocardiography). Similarly, agreement of 2D echocardiography with CMR on RWMA increased with contrast enhancement (κ 0.50 vs 0.32). Accuracy to detect expert panel−defined RWMA was highest for CMR (84%) followed by 2D contrast echocardiography (78%) and 3D contrast echocardiography (76%). It was lesser for 2D and 3D unenhanced echocardiographies. In conclusion, analysis of RWMA is characterized by considerable interreader variability even using high-quality imaging techniques. IRA on RWMA is lower with 3D echocardiography compared with 2D echocardiography. IRA on RWMA and accuracy to detect panel-defined RWMA improve with contrast enhancement irrespective of the 2D or 3D echocardiography use. **(Am J Cardiol 2014;113:395−401)**

The objectives of this multicenter study were to (1) determine the interreader agreement (IRA) in the definition of regional wall motion abnormalities (RWMA) for unenhanced and contrast-enhanced 3-dimensional (3D) echocardiographies compared with unenhanced and contrast-enhanced 2-dimensional (2D) echocardiographies, cineventriculography, and cardiac magnetic resonance (CMR), (2) determine the agreement between the different imaging techniques in the definition of RWMA, and (3) evaluate for each of the imaging techniques the agreement and accuracy of determined RWMA related to the standard of truth on regional left ventricular (LV) function as defined by an expert panel decision (EPD) based on clinical, electrocardiographic (ECG), angiographic, and imaging data. The design of this study allowed a direct comparison of the techniques during resting conditions on the same patients. Blinded readings using experienced independent core laboratories were performed for each imaging technique according to defined standards.

Methods

This multicenter open-label study used intrasubject comparison of 3D unenhanced and contrast-enhanced echocardiographies with 2D echocardiography, biplane cineventriculography, and CMR for determination of RWMA. Coronary angiography for suspected coronary

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See page 401 for disclosure information.

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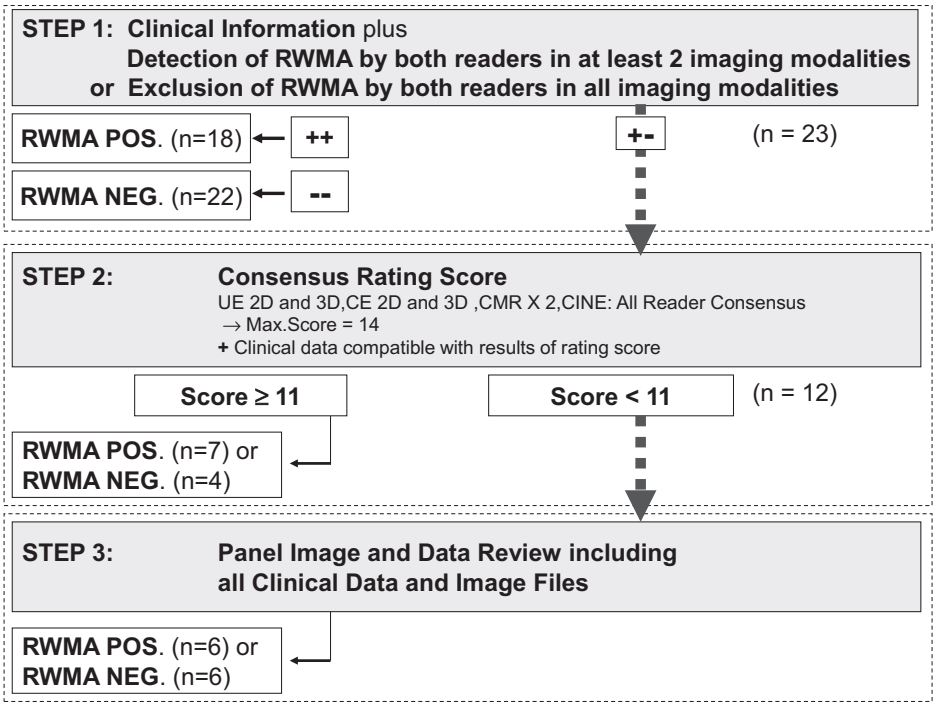

Figure 1. Three-step decision algorithm used to define the standard of truth (EPD) on the presence of RWMA. CE = contrast-enhanced echocardiography; CINE = cineventriculography; UE = unenhanced echocardiography.

Table 1
Patient baseline characteristics

Characteristic	Value, n = 63 (%)
Age (yrs)	63.8 ± 10.4
History of previous myocardial infarction	20 (32)
Previous percutaneous coronary intervention	33 (52)
Previous coronary bypass surgery	7 (11)
Significant coronary artery disease	48 (76)
Coronary stenosis in left anterior descending	35 (56)
Coronary stenosis in left circumflex branch	40 (63)
Diabetes mellitus	6 (10)
Hypertension	44 (70)
Hypercholesterolemia	21 (33)
Ejection fraction by cineventriculography	
<35%	10 (16)
35%–55%	16 (25)
>55%	37 (59)

Hypertension: blood pressure >140/90 mm Hg or medically treated; hypercholesterolemia: total cholesterol level >200 mg/dl or medically treated.

artery disease was performed in all patients. Immediate revascularization after coronary angiography was an exclusion criterion. All imaging techniques were performed within 72 hours with the patient being in stable hemodynamic conditions.

For each imaging technique, recommendations on the performance of image acquisition were defined to secure uniform and interpretable image data sets from all participating institutions. The adherence to the predefined imaging protocols of this multicenter trial by the performing physicians was monitored during the enrollment period.

The analysis of image data sets for RWMA was performed for each imaging technique by 2 independent off-site readers not affiliated to the participating centers who were unaware of the clinical data and the results of the other imaging techniques. All off-site readers had at least 5 years of experience in the evaluated imaging technique. Guidelines were defined and provided on the evaluation of regional LV function for each imaging technique to the unaffiliated off-site readers of the independent core laboratories (see Appendix). Regional wall motion of each analyzed segment was defined as either normokinetic, hypokinetic, akinetic, or dyskinetic. Whenever the regional function could not be defined because of insufficient image quality, the function was assumed to be normal. Although regional function was determined for each LV segment, the presence of an RWMA was reported on a patient basis, and a comparison of methods was performed on detection of RWMA on a patient basis. The study was conducted according to the Good Clinical Practice and in compliance with local regulatory requirements. The research protocol was approved by the applicable central and local institutional ethics committees. All patients gave written informed consent to participate in the study.

Sixty-five patients were enrolled at 4 European centers with balanced contribution. Patient enrollment was stratified at each center based on results from angiographic ventriculography to achieve a balanced distribution within 3 predefined LV ejection fraction groups (>55%, 35% to 55%, and <35%). An interpretable cineventriculography with availability of at least 2 consecutive nonextrasystolic cardiac cycles during ventriculographic contrast administration was a prerequisite for inclusion into the study. Two patients had to be excluded from the study because of