Three-Dimensional Echocardiography for the Preoperative Assessment of Patients With Left Ventricular Aneurysm

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Background. **Surgical ventricular reconstruction has been proposed as a treatment option in heart failure patients with left ventricular (LV) aneurysm. The feasibility of this procedure has some limitations, and extensive preoperative evaluation is necessary to give the correct indication. For this purpose, magnetic resonance imaging (MRI) is currently considered the gold standard, providing accurate quantification of LV shape, size, and global and regional function together with the assessment of myocardial scar and mitral regurgitation severity. The aim of this study was to evaluate the accuracy of real-time three-dimensional echocardiography (RT3DE) as a potential alternative to MRI for this evaluation.**

Methods. **A total of 52 patients with ischemic cardiomyopathy and LV aneurysm underwent a comprehensive analysis with two-dimensional echocardiography, RT3DE, and MRI.**

Results. **Excellent correlation ($r = 0.97$, $p < 0.001$) and agreement were found between RT3DE and MRI for quantification of LV volumes, ejection fraction, and sphericity index; in a segment-to-segment comparison, RT3DE was shown to be accurate also for the analysis of wall motion abnormalities (k = 0.62) and LV regional thickness (k = 0.56) as a marker of myocardial scar. In contrast, two-dimensional echocardiography significantly underestimated these variables. Furthermore, mitral regurgitant volume assessed by RT3DE showed excellent correlation ($r = 0.93$) with regurgitant volume measured by MRI, without significant bias (= −0.7 mL/beat).**

Conclusions. **In the management of heart failure patients with LV aneurysm, RT3DE provides an accurate and comprehensive assessment, including quantification of LV size, shape, global systolic function, regional wall motion, and myocardial scar together with precise evaluation of the severity of mitral regurgitation.**

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Left ventricular (LV) remodeling after acute myocardial infarction is defined as progressive LV dilation and dysfunction, accompanied by an expansion of myocardial scar [1, 2]. This process was demonstrated to be associated with a poor prognosis [3, 4], and several treatments are now available to attenuate or partially reverse this phenomenon. Particularly in the presence of a left ventricle aneurysm, surgical ventricular reconstruction (SVR) has been proposed to improve LV size, shape, wall stress, and function [5]. However, the feasibility of this procedure has some limitations, and an extensive preoperative evaluation is necessary to give the correct indication, to plan the operation, and to estimate the perioperative and postoperative mortality. In particular, accurate values of LV size, shape, and function are crucial to evaluate the impact of surgery; precise identification of LV regional dysfunction and myocardial scar site and extent is also fundamental to determine the feasibility of the procedure. In addition, reliable quantification of mitral regurgitation is important to evaluate the possibility to perform concomitant mitral valve repair [6].

Magnetic resonance imaging (MRI) is currently considered the gold standard for this comprehensive assessment, providing highly accurate and reproducible data [6]. However, this technique is not widely available and is not compatible with cardiac devices. As an alternative, conventional two-dimensional (2D) echocardiography has been applied, although with significant inaccuracy due to assumptions about LV cavity geometry. Real-time three-dimensional echocardiography (RT3DE) is now available to overcome these limitations and has been

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Abbreviations and Acronyms

EDV = end-diastolic volume
EF = ejection fraction
EROA = effective regurgitant orifice area
ESV = end-systolic volume
LV = left ventricular
LVEDV = left ventricular end-diastolic volume
LVEF = left ventricular ejection fraction
LVESV = left ventricular end-systolic volume
MRI = magnetic resonance imaging
RT3DE = real-time three-dimensional echocardiography
SI = sphericity index
SVR = surgical ventricular reconstruction
2D = two-dimensional
WMSI = wall motion score index

shown to be more accurate than 2D echocardiography for quantification of LV volumes [7]. The aim of this study was, therefore, to evaluate, in comparison with MRI, the feasibility and accuracy of RT3DE for the complex assessment of patients with LV aneurysm, including LV volumes, LV shape, LV ejection fraction, LV wall motion abnormalities, and identification of myocardial scar and quantification of the severity of mitral regurgitation.

Patients and Methods

The study population consisted of 60 consecutive patients with ischemic cardiomyopathy and LV akinetic/dyskinetic aneurysm who were referred from July 2006 to September 2008 to evaluate the possibility of SVR. The evaluation included, in the same day, conventional 2D echocardiography, RT3DE, and cardiac MRI. Using these imaging modalities, LV size and shape and LV global and regional systolic function were evaluated. The presence of a LV thrombus was also assessed. Because echocardiography can not provide a precise identification of myocardial scar, RT3DE and MRI were compared for the measure of LV regional thickness as a well-known marker of transmural scar. Finally, these two imaging modalities were compared for the assessment of mitral regurgitation severity. All the variables included in the analysis are summarized in Table 1.

All patients gave informed consent, and the protocol was approved by the Institutional Review Board.

Standard 2D Echocardiography

Patients were imaged in the left lateral decubitus position using a commercially available system (iE33; Philips Medical Systems, Bothell, WA) equipped with a 3.5-MHz transducer. The LV end-systolic volume (LVESV) and LV end-diastolic volume (LVEDV) were determined from the conventional apical two- and four-chamber views, and LV ejection fraction (LVEF) was calculated using the biplane Simpson's technique [8].

As a measure of LV shape, sphericity index (SI) was calculated by dividing LVEDV by the volume of a sphere whose diameter was derived from the major end-diastolic LV long-axis. The LV long-axis was obtained as the longest distance between the center of the mitral annulus and the endocardial apex in the four-chamber view [6, 9].

Qualitative assessment of the regional wall motion was performed according to the standard 16-segment model [10], and was graded as follows: 1 = normal; 2 = hypokinetic; 3 = akinetic; and 4 = dyskinetic. A global wall motion score index (WMSI) was calculated as the sum of each LV segment's score divided by the number of visualized segments [8].

Finally, the presence of LV thrombus, especially in the apical region, was evaluated without contrast administration, using standard and off-axis views.

Table 1. List of Measures and Imaging Modalities Included in the Study

	MRI	RT3DE	2DE
Left ventricular end-diastolic volume	X	X	X
Left ventricular end-systolic volume	X	X	X
Left ventricular ejection fraction	X	X	X
Left ventricular sphericity index	X	X	X
Left ventricular wall motion score index	X	X	X
Left ventricular thrombus detection	X	X	X
Left ventricular regional thickness	X	X	—
Mitral regurgitant volume	X	X	—

MRI= magnetic resonance imaging; RT3DE = real-time three-dimensional echocardiography; 2DE = two-dimensional echocardiography.

Real-Time 3D Echocardiography

Patients were imaged with the same system (iE33; Philips Medical Systems) equipped with an X3, fully sampled matrix transducer. Apical full-volume data sets were obtained combining, within one breath-hold, seven small real-time subvolumes to provide a larger pyramidal volume (up to 101 × 104 degrees) and to ensure a complete capture of the left ventricle. A 3D data set was considered unsuitable for analysis if more than two segments could not be visualized or if it contained visible stitch artefacts due to irregular heart rate or breathing movements. To assess the severity of mitral regurgitation, apical full-volume color Doppler data sets were also acquired with a Nyquist limit set between 30 cm/s and 50 cm/s. All 3D data sets were stored digitally, and quantitative analysis was performed offline using a semiautomated contour tracing algorithm (Q-Lab Version 6.0; Philips Medical Systems).

During postprocessing of the 3D data set, the software automatically displays the apical four- and two-chamber views and the parasternal short-axis view. After initial identification of the apex and mitral annulus with five reference points on the end-diastolic and end-systolic frames, a preconfigured ellipse is fitted to the endocardial border for each frame. A manual adjustment of the endocardial border was performed if required. A LV 3D