Editorial

Should contrast be routinely used for echocardiographic assessment of left ventricular function? A matter of appropriateness

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This editorial refers to 'Assessment of systolic left ventricular function. A multi-centre comparison of cineventriculography, cardiac magnetic resonance imaging, unenhanced and contrast enhanced echocardiography'† by R. Hoffmann et al., on page 607

Hoffmann et al.¹ present data showing that contrast-enhanced echocardiography, compared with unenhanced echocardiography, provides more accurate determination of left ventricular ejection fraction and significantly improves the correlation with cineventriculography and magnetic resonance imaging (MRI). Certainly, the most important question arising from this study is whether contrast injection should be routinely recommended for echocardiographic assessment of left ventricular function, as suggested by the study results. The authors did not discuss this question, nor did they state any clinical implications, thereby leaving the question open to public discussion. We would like to offer the following considerations.

Because most heart diseases affect the left ventricle, assessment of left ventricular volumes and function is of critical importance. Several diagnostic approaches have proved their usefulness for assessing left ventricular function, including cineventriculography, echocardiography, MRI, and radionuclide angiography. However, providing quantitative estimates of left ventricular volume, all these approaches have their limitations, and their accuracy and feasibility have been the subject of countless studies. Of the four approaches mentioned, echocardiography has become the most widely used diagnostic technique for assessment of left ventricular function, because of its unrivalled combination of cost effectiveness, clinical accessibility, accuracy, and tolerability. Cineventriculography, though the 'historic' clinical standard, is inherently limited by its invasive nature and suffers from significant inter-observer variability and limited reproducibility. MRI, in comparison, provides superior visualization of the left ventricle, making it a valuable clinical reference technique, but is yet unsuitable as a clinical standard because of its current limitations pertaining to accessibility, applicability to patients with pacemakers, and tolerability due to claustrophobia. Radionuclide angiography, though frequently used for reference in former studies, has never really challenged the other three approaches as a clinical standard because of its limited accessibility by cardiologists and limited applicability due to safety issues concerning the use of radioactive material.

A distinguishing feature of echocardiography, compared with the other three imaging modalities, is that echocardiography has undergone an evolutionary process of improvement and diversification since its clinical introduction in 1953.² Cineventriculography, MRI, and radionuclide angiography have only limited potential for technical improvement relevant to left ventricular analysis. Therefore, echocardiography has become the diagnostic imaging modality that provides the most information on left ventricular function. Beginning with limited 1D information from M-mode recording, echocardiographic analysis of left ventricular dimension and function became 2D in 1967 and 3D in 1992.³ Parallel to the inclusion of new dimensions, echocardiographic signal analysis was considerably extended to provide a broad range of information on left ventricular performance, including methods like tissue harmonic imaging, tissue Doppler, automated border detection, tissue tracking, and contrast application for left ventricular opacification.

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Why is this important for the discussion of contrast application? Although each new method has been shown to improve left ventricular analysis, the dubious prize for most methods of advanced analysis and increased information has been a concomitant increase in complexity and time effort. Therefore, after enthusiastic initial reports, subsequent clinical studies are required to define the case or situations in which a method is clinically indicated and when it is deemed unnecessary. Because of this critical understanding of the extant methods, standard echocardiography today is fortunately not three-dimensional dobutamine-stress contrast tissue-Doppler echocardiography (3DSCDE), which takes at least 1 h for a routine study. For example, 3D echocardiography has been demonstrated to provide more accurate determination of left ventricular volumes than 2D echocardiography based on geometric assumptions. However, 3D volumetry has a clinically relevant benefit only in asymmetrical ventricles, such as in the presence of aneurysms, not in symmetrical ventricles, such as in dilated cardiomyopathy. In light of the additional time required for data analysis and costly 3D equipment, agreement exists that 3D left ventricular volumetry is only appropriate in asymmetrical ventricles, or that standard application of 3D volumetry is generally inappropriate. Similar considerations are necessary with the application of contrast echocardiography, such as additional study time, costs, safety, and manpower.

Hoffmann et al. present a large, multi-centre study of 120 patients where agreement on left ventricular volumes and ejection fraction was significantly improved between contrast-enhanced echocardiography and MRI compared with unenhanced echocardiography. The results are certainly important for clinical diagnosis, especially due to the severe underestimation of end-diastolic and end-systolic volumes by unenhanced echocardiography compared with MRI ($-72.3 \pm 39.8$ mL; $-35.7 \pm 32.5$ mL). However, it must be taken into consideration that underestimation of left ventricular volumes by echocardiography is well known and, for that reason, normal values of left ventricular volumes have been defined from echocardiographic measurements. In addition, underestimation of left ventricular volumes occurs from tangential scan planes using apical long axis cross-sectional views as recently confirmed by 3D echocardiography, which is a methodological problem that cannot be overcome by contrast-enhanced echocardiography and better endocardial border detection. In addition, as shown in the study by Hoffmann et al., as in previous studies, echocardiographic underestimation of volumes has an almost insignificant effect on the determination of ejection fraction and its agreement to other methods (unenhanced echocardiography vs. MRI: 0.8 $\pm$ 10.6%; contrast-enhanced echocardiography vs. MRI: 4.6 $\pm$ 8.7%). Therefore, it is not appropriate to apply contrast to achieve better agreement with other imaging techniques or absolute values of left ventricular volumes and ejection fraction. In addition, accurate quantification of left ventricular ejection fraction has become of particular importance for therapeutic decision making, for example, regarding the implantation of automated implanted cardiac defibrillators, where a threshold of ejection fraction of $<30\%$ has recently been defined. Contrast application, however, is of important diagnostic value for the assessment of left ventricular function in all cases with insufficient endocardial border detection preventing from accurate planimetry for quantitative volumetry.

In conclusion, though the study of Hoffmann et al. clearly demonstrates improved accuracy of contrast-enhanced echocardiography compared with unenhanced echocardiography, there is no reason to recommend its standard application. This, however, may change in future applications of echocardiography, when real-time 4D data sets will be acquired routinely within seconds and multi-parametric automated analysis of left ventricular function will be performed off-line. Within this scenario, routine application of contrast for improved automated border detection could be justified. Today, however, routine clinical application of echocardiography should be restricted by a careful selection of the appropriate methods, on an individual case basis, to keep echocardiography what it is—the most practical, effective, tolerable, and accessible diagnostic method for cardiac diseases.

References