Rapid bed-side myocardial perfusion imaging: is a dream coming true?

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Online publish-ahead-of-print 2 August 2008

Getting comprehensive, spatial information about regional myocardial perfusion without any doubt is one of the most important clinical questions in cardiology. Today's imaging techniques either indirectly detect regional ischaemia based on the analysis of myocardial function (stress echocardiography and strain imaging) or try to visualize myocardial perfusion directly based on relatively complex techniques [two-dimensional (2D) myocardial contrast echo]. Both conventional 2D stress echocardiography and myocardial contrast echocardiography (MCE) sample the desired information from serially acquired 2D image planes. This way of acquisition remains time-consuming and sometimes complex.

Since the late 1990s, MCE has been an important scientific focus in clinical cardiology. After some technical, challenging, methodological approaches including triggered imaging and different generations of left-heart contrast agents, low-intensity real-time scanning allows a relatively robust visualization of regional myocardial perfusion. MCE has been demonstrated being valuable for the diagnosis of perfusion defects in acute coronary syndromes as well as in chronic coronary artery disease. Especially, for the diagnosis of chronic ischaemic heart disease, MCE is usually combined with pharmacological stress tests (mainly adenosine/dipyridamole but also dobutamine). However, 2D MCE still remains challenging with regard to technical equipment, contrast application, and examiner experience, and therefore is far from being established in all cardiology centres.

On the other hand, real-time 3D echocardiography has become a mobile, fast, and relatively inexpensive commercially available tool for precise and reproducible cardiac imaging over the last 5–6 years. Image quality as well as ease of use has improved over that period, too. The acquisition of a complete pyramidal volume data set (the so-called ‘full volume’ mode) decreases the number of acquired heart beats to only four and shortens the scanning time significantly.

Obviously, a combination of new modalities such as contrast and stress testing, strain imaging and stress, stress and 3D, strain and 3D or contrast and 3D will open a variety of interesting and promising approaches. The combination of real-time 3D echocardiography and stress testing has been identified as a potentially helpful clinical tool for a better and faster diagnosis of ischaemic heart disease. There are several advantages of real-time 3D imaging during stress testing besides a shorter scanning time. There is no need to change the transducer position during apical scanning once the echo window is found. This makes acquisition easier and faster for both the beginner and the expert echocardiographer. Moreover, the narrow time window at peak stress can be used much more effectively.

However, despite all enthusiasm, some limitations have to be mentioned. Image quality using matrix array transducers still is worse than with high-end 2D equipment. This is not only due to the technological constraints of a matrix transducer but also to the mechanical limitation of a relatively large probe footprint that interferes with narrow intercostal spaces. Additionally, the limited sector width (maximum about 80°) may not be wide enough to cover the complete left ventricle in the ultrasound sector, especially in patients with apical aneurysm or dilated ventricles. Last but not least, temporal resolution at present is limited to about 40–50 ms. This limitation clearly influences the sensitivity of the test during peak stress and remains unsatisfactory. Although the limitations still prevent from a widespread use, physical and pharmacological 3D stress echo studies—in a majority combined with contrast enhancement for left ventricular opacification—have been published by several groups over the last years.

In this issue of European Journal of Echocardiography, Bhan et al. report on a comparative study a combination of even three techniques (stress, contrast, and 3D) vs. conventional 2D MCE as gold standard. The combination of three modalities is challenging and remains difficult. Still inherent problems like shadowing due to contrast application itself,
rib and lung artefacts causing reduced image quality may interfere significantly with the ability to perform 3D MCE. There are difficulties in the definition of myocardial segments in the 3D data set for wall motion and perfusion analysis—a problem still unsolved and waiting for a semi-automatic software-based solution. Nevertheless, as one of the first groups, Bhan et al. were able to demonstrate not only the feasibility of such a highly complex combination in the clinical setting but also that pathological findings can be identified with a good agreement to 2D echocardiography. Thus, it obviously works. However, still some of the above-mentioned limitations will prevent many centres from performing 3D MCE during stress testing on a routine basis. A very important and necessary improvement will be the quantification of myocardial contrast enhancement to avoid subjectivity and examiner dependency.

At the end of the road after some modifications, 3D MCE will most likely be robust enough to allow bed-side perfusion imaging even in acute coronary syndromes without the need of expensive hardware or time-consuming acquisition.

References