Flash-phase images to detect coronary artery stenosis: a novel finding during contrast-echocardiography

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Flash-replenishment sequences are commonly used during contrast stress-echocardiography to detect regions subtended by significant coronary artery disease, which show slower replenishment compared with normal regions at peak stress. We have discovered that the images obtained during the first part of the sequence, made by a series of high mechanical index (MI) impulses (called ‘flash’ impulses), can in fact portend substantial information on myocardial perfusion independently by the analysis of the following replenishment phase. We describe this novel finding in a paradigmatic case. Flash-replenishment sequences are commonly used during contrast stress-echocardiography to detect regions subtended by significant coronary artery disease, which show slower replenishment compared with normal regions at peak stress. We have discovered that the images obtained during the first part of the sequence, made by a series of high-MI impulses (called ‘flash’ impulses), can in fact portend substantial information on myocardial perfusion independently by the analysis of the following replenishment phase. We describe this novel finding in a paradigmatic case.

Keywords

Echocardiography • Contrast • SonoVue • Myocardial perfusion • Flash-replenishment

‘Flash-replenishment’ sequences are commonly used during contrast stress-echocardiography to detect myocardial regions with reduced blood flow reserve, potentially subtended by significant coronary artery stenosis. Following the administration of a vasodilatory stressor abnormal myocardial regions demonstrate slow replenishment rate, after microbubbles have been destroyed by means of repetitive high mechanical index (MI) impulses.1,2 The sequence of impulses used to destroy the microbubbles in the myocardium is normally considered only for its efficiency to obtain good myocardial ‘blackening’, a pre-requisite for subsequent reliable analysis of the replenishment phase.

On the contrary, we have repeatedly observed that the images obtained during the ‘flash’ part of the sequence (usually neglected) may portend information regarding the potential presence of a coronary stenosis, independently by the analysis of the replenishment phase.

Images in Figure 1 were obtained during flash-replenishment dipyridamole-echocardiography (0.84 mg/kg/6 min) and continuous infusion of SonoVue® (0.8 mL/min/4 min) in a patient studied for chest pain of undetermined origin. The visual analysis of the replenishment phase after dipyridamole was only borderline for the presence of perfusion abnormalities in the apex, but the specific analysis of the flash phase was instead diagnostic, delineating a clear perfusion defect in the apical septum after few high MI flash impulses (bottom row) (see also Supplementary data, Video S1 for the complete flash replenishment sequence).

Figure 1A (top left) shows the coronary angiography with mild circumflex artery disease and an intermediate severity stenosis of the left anterior descending artery (LAD), identified as the culprit lesion for the inducible perfusion abnormality.

The analysis of the flash phase may indeed present advantages compared with standard low-MI analysis of the replenishment phase, high-MI ultrasound being technically less dependent on...
the quality of acoustic windows for visualization of difficult segments, such as deeper anterior and lateral ones. This is well demonstrated in Figure 2.

Figure 2 shows the same study as in Figure 1, but in a two-chamber view. The pre-flash low-MI frame (Figure 2A) clearly shows low-signal from the mid- and basal anterior segments, while during the high-MI flash impulses these segments become well discernible (Figure 2B and C); it is possible to exclude that the low signal detected in those segments when low-MI is used (Figure 2A) represents a true perfusion defect, since related video-intensity curve during flash-phase is flat (yellow line), differently from the true positive apical region (blue line) where the curve shows a quick drop after few flash impulses (Figure 2D), similarly to what happened in the apical septal segment in Figure 1. The false-positive hypoperfusion of the basal and mid anterior segments was indeed an artefact due to low ultrasound penetration, a frequent problem of low-MI imaging techniques (see Supplementary data, Video S3).

The pathophysiology of this newly reported sign of abnormal perfusion detectable during the flash phase is probably dependent on the reduced myocardial blood flow reserve in regions subtended by significant coronary stenosis (peak myocardial blood volume, velocity and flow being reduced in the hypoperfused myocardium compared with normal territories. As the lower myocardial blood flow in the replenishment phase shows a slower rate of replenishment, similarly, in the flash phase, it may appear as a
faster rate of microbubbles destruction by high-MI repetitive impulses; in fact, the lower blood flow into the myocardium facilitates the more rapid destruction of microbubbles.

There are three reasons for missing the display of a perfusion defect: not enough contrast, saturation (too much contrast), or low ultrasound penetration. During the first part of the flash there is saturation of the signals (every pixel is at or close to the upper range of the dynamic range of the system) and therefore it is unlikely to display a perfusion defect. Later during the flash some contrast has been destroyed and now the pixel intensity better correlates with the amount of contrast in the myocardium. Tissue harmonics are still significantly present, potentially obscuring the perfusion defect; only when tissue harmonics are not overwhelming the signal amplitude can fall within the dynamic range and a perfusion defect can be detected in the late flash phase. During the replenishment phase, the tissue harmonics are suppressed by the use of contrast-specific low power imaging. This facilitates the detection of a perfusion defect, making this type of analysis during the replenishment phase the standard way to assess myocardial perfusion, unless there is insufficient ultrasound penetration, which is not rare with low-MI imaging.

**Supplementary data**

Supplementary data are available at *European Journal of Echocardiography* online.

**References**
