


Case series of mobile structures detected vividly by using superb microvascular imaging

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Background

Superb microvascular imaging (SMI) is a new imaging technique that can reveal low-velocity blood flow without use of a contrast agent. SMI is based on an original algorithm and effectively removes tissue motion artifacts (clutter motion) from the background, thereby preserving visibility of low-velocity blood flow. SMI is expected to be useful for the evaluation of heart diseases, as well as blood vessels.

Case summary

Here, we report three cases in which a mobile structure in the heart or a blood vessel was detected easily by strong enhancement on SMI. In the heart, the entire mass was strongly enhanced by colour-SMI and had the appearance of 'a fire ball'. In the abdominal aorta and carotid artery, SMI captured a strongly enhanced echo image of a mass and revealed hyperechoic mobile plaque. It was hard to detect with the conventional echocardiography.

Discussion

It is important to detect mobile intravascular and intracardiac structures as they are risk factors of thrombosis. Echo images are often strongly affected by the skill of the examiner, the patient's body habitus, and the presence of intestinal gas; thus, it is often difficult to detect a small mass with conventional echocardiography. With the use of SMI, even small mobile structures can be displayed at high intensity in comparison with the surrounding blood flow. Therefore, the non-invasive SMI was useful for the detection of mobile intravascular and intracardiac structures. Our findings of the current report may lead to new developments in SMI for imaging in the cardiac region.

Keywords

Superb micro-vascular imaging • Mobile structures • Fireball sign • Motion artefact • Case report

ESC curriculum

2.1 Imaging modalities • 2.2 Echocardiography • 6.8 Cardiac tumours

Learning points

- Superb micro-vascular imaging (SMI) allows the identification of small mobile structures that are more intense than the surrounding blood flow and appear larger than on real image.
- The entire mobile structure is strongly enhanced on SMI and shown as a hyperechoic mass.
- The motion artefact seen on SMI may be used in the diagnosis of small mobile structures and could aid in prevention of thrombotic events.

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Introduction

Superb microvascular imaging (SMI) is a new imaging technique that can reveal low-velocity blood flow without use of a contrast agent. Developed by Canon Medical Systems and approved for clinical use in 2014, SMI has been reported to be useful for the evaluation of ulcerated plaques and neoplastic vessels within the carotid artery, as well as for imaging of low-velocity blood flow in the liver, thyroid gland, mammary gland, and in tumours.^{1–3} SMI is also useful as a convex probe and may be a helpful tool for assessment of heart disease. Mobile structures in the heart or blood vessels are risk factors for systemic thrombosis;^{4–6} therefore, it is important to be able to detect these structures with high sensitivity. This report describes three cases in which a mobile structure in the heart or a blood vessel was detected easily by strong enhancement on SMI.

Timeline

Organs	Characteristics
Heart	A pedunculated apical mass measuring 10×10mm was found incidentally in a 70-year-old man with chest pain who was undergoing echocardiography to confirm a diagnosis of ischaemic cardiomyopathy. The mass was isoechoic and had smooth margins when using conventional B-mode imaging. However, on colour SMI, the entire mass was strongly enhanced and had the appearance like 'a fire ball'. The mass was surgically resected to prevent thrombosis and the patient was diagnosed with papillary fibroelastoma.
Abdominal aorta	A 70-year-old man with an ischaemic toe was referred to our hospital. Doppler ultrasound of the lower limbs showed normal Doppler waveforms. The abdominal aorta was also assessed to rule out pathology. Conventional sonography showed no stenosis or dilatation of the aorta. It however detected diffuse plaque without mobility in the abdominal aorta. SMI revealed hyperechoic mobile plaque measuring 3×2 mm; this image was less enhanced, and the mobility of the plaque was hard to detect by the B-mode visualization. The image was clarified only in systole, which showed its hypermobility. The patient was subsequently diagnosed with cholesterol emboli due to mobile plaque.
Carotid artery	An 87-year-old man with arteriosclerosis obliterans was investigated for carotid artery stenosis during screening for vascular disease. SMI revealed a strongly enhanced echo image in the left internal carotid artery, which appeared more vivid on SMI than on the M-mode imaging. The mobility of the mass was shown only in systole. Therefore, the diagnosis was a mobile plaque measuring 4×2 mm that could not be detected by conventional colour Doppler echocardiography.

Case presentations

Case 1

The patient was a 70-year-old man with a history of angina pectoris and exertional chest pain in whom echocardiography using an i6SX1 probe (Aplio i900; Canon Medical Systems, Odawara, Japan) was performed to evaluate left ventricular wall motion and confirm a diagnosis of ischaemic cardiomyopathy. A pedunculated apical mass measuring 10×10 mm was incidentally found on echocardiography, in the absence of regional wall motion abnormalities or left ventricular dysfunction. The mass was isoechoic and had smooth margins when using conventional B-mode. However, unlike on conventional B-mode imaging, the entire mass was strongly enhanced by colour-SMI and had the appearance of 'a fire ball' (Figure 1; see Supplementary material online, Figure S1). The mass was surgically resected to prevent thrombosis and the patient was diagnosed with papillary fibroelastoma.

Case 2

A 70-year-old man with an ischaemic toe was referred to our hospital. Ankle-brachial pressure index was unremarkable (right 1.13, left 1.03). Ultrasound Doppler of the lower limbs showed normal Doppler waveforms. Abdominal aorta was also assessed to rule out pathology. Conventional sonography using an i8CX1 probe showed no stenosis or dilatation of the aorta. It however detected diffuse plaque without mobility in the abdominal aorta (Aplio i900; Canon Medical Systems, Odawara, Japan). SMI revealed hyperechoic mobile plaque of 3×2 mm; this image was less enhanced, and the mobility of the plaque was hard to detect under the B-mode visualization (Figure 2) (see Supplementary material online, Figure S2A, B). The image was clarified only in systole, which showed its hypermobility. The patient was subsequently diagnosed with cholesterol emboli due to mobile plaque.

Case 3

The patient was an 87-year-old man with arteriosclerosis obliterans who was screened for vascular disease using carotid ultrasound with an i11LX3 probe (Aplio i900; Canon Medical Systems, Odawara, Japan). Conventional sonography showed no stenosis or dilatation but did reveal diffuse calcified plaque in both carotid arteries. The acoustic shadow from the calcified plaque interfered with detailed observation of characteristics of the plaque. However, SMI captured a strongly enhanced echo image of a mass in the left internal carotid artery that was more vivid than an M-mode image (Figure 3; see Supplementary material online, Figure S3). The mobile mass was shown only in systole. The patient was diagnosed with a mobile plaque measuring 4×2 mm even though it could not be detected by conventional colour Doppler echocardiography (see Supplementary material online, Figure S4).

Discussion

SMI is a new blood flow imaging technique that is based on an original algorithm and effectively removes tissue motion artefacts (clutter motion) from the background, thereby preserving visibility of low-velocity blood flow.⁷ Conventional colour Doppler techniques cannot separate low-velocity flow signals from overlaying clutter motion, which mainly contains low-frequency components,⁸ because both blood flow and clutter motion are removed by the wall filter when visualizing blood flow with high resolution.⁹ Therefore, the ability to visualize low-velocity blood flow in tiny vessels is lost. However, SMI can distinguish between tissue motion and low-velocity blood flow and allows the analysis of clutter motion.¹⁰ This results in a high frame rate and a high-resolution ultrasound image of low-velocity blood flow, which only

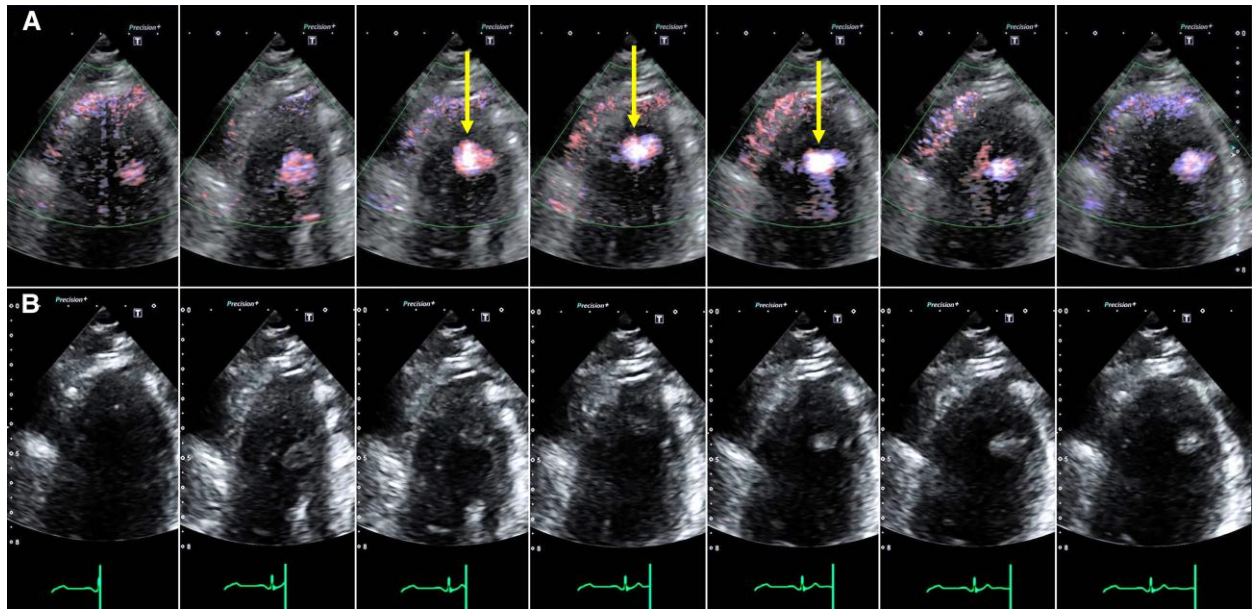


Figure 1 Sequential images of a mobile mass in the left ventricle. (A) Colour superb micro-vascular imaging mode (upper line) shows a strongly enhanced mobile mass that moves like 'a fireball'. (B) The mobile mass shown by the B-mode.

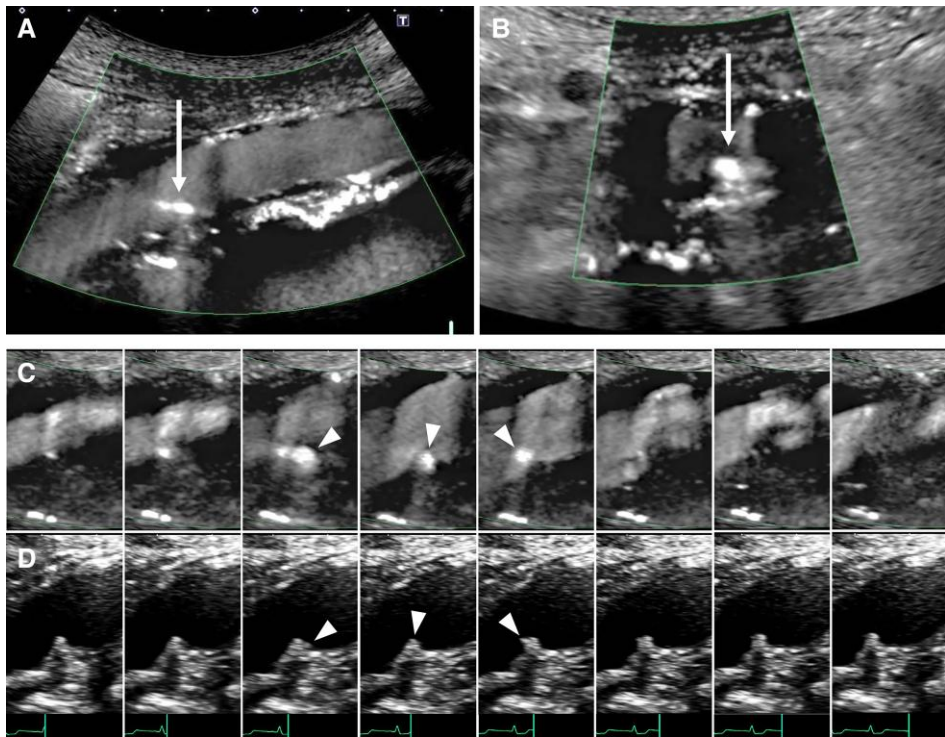


Figure 2 A strongly enhanced mobile plaque in the abdominal aorta shown by superb micro-vascular imaging mode (arrow). (A) Long-axis and (B) short-axis image. Sequential images show a strongly enhanced mobile plaque in the abdominal aorta (head arrow). (C) Superb micro-vascular imaging mode (upper line) and (D) the B-mode (lower line).

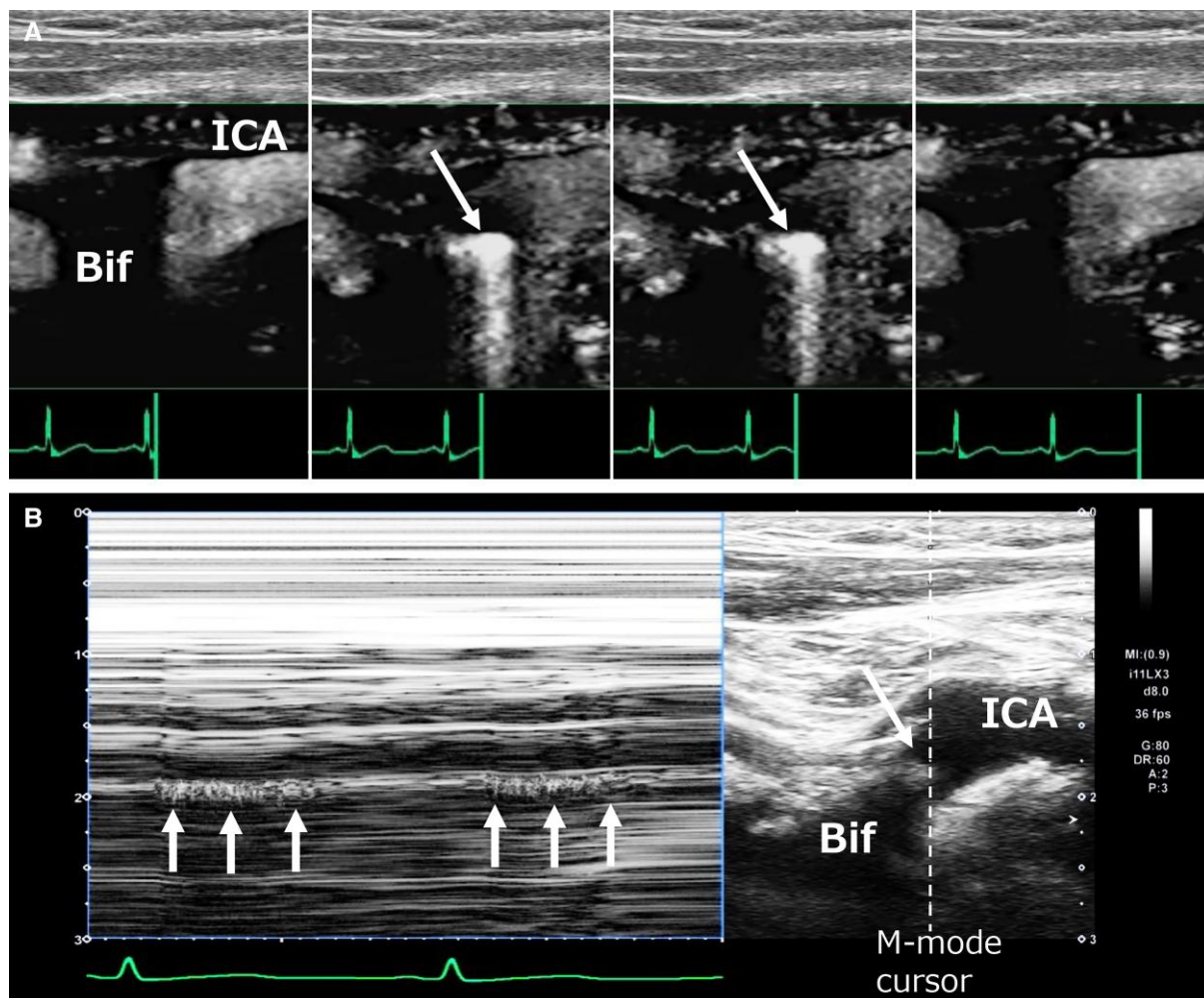


Figure 3 (A) Sequential images of a strongly enhanced mobile plaque (arrow) in the carotid artery obtained in superb micro-vascular imaging mode. (B) M-mode image of the plaque obtained during systole (arrows). ICA = internal carotid artery, Bif = bifurcation.

reduces motion artefacts, unlike conventional colour Doppler techniques.¹¹

Mobile intravascular or intracardiac structures such as plaque, thrombosis, mass, and vegetation move with blood flow depending on the cardiac cycle. Conversely, because the motion of mobile structures is more rapid than that of the surrounding tissues, SMI can detect mobile structures without being eliminated by the original algorithm. Moreover, a mobile structure is displayed with an intensity that is higher than that of the surrounding blood flow because it has a stronger reflection intensity. Therefore, the 'fireball sign' is a motion artefact phenomenon seen on SMI analysis, that is, a clutter motion with hypermobility that is not eliminated by the original SMI algorithm. A previous report has also described a B-flow 'winker' phenomenon, whereby B-flow imaging revealed a high-intensity mobile plaque within the carotid artery.¹² We have now identified an interesting artefact phenomenon when using SMI whereby a mobile structure can be displayed with high intensity (similar to the findings on B-flow imaging); we have named this phenomenon the 'fireball sign' because it moves like a fireball.

It is important to detect mobile intravascular and intracardiac mobile structures because they are risk factors for thrombosis.⁵ To our knowledge, there have been no previous reports on the ability of SMI to provide more vivid image of a strongly enhanced intravascular or

intracardiac mass than conventional B-mode. Echo images are often affected by the skill of the examiner, the patient's body habitus, and the presence of intestinal gas. Moreover, even with conventional echocardiography, which has high temporal and spatial resolution, it is often difficult to detect a small mass <2 mm accurately (diagnostic sensitivity is 61.9% for transthoracic echocardiography, and 76.6% for transoesophageal echocardiography).¹³ The sensitivity for detecting a mobile vegetation was reported to be lower with conventional transthoracic echocardiography than with transoesophageal echocardiography (60% vs. >90%) in patients with infectious endocarditis;¹⁴ therefore, conventional transthoracic echocardiography is sometimes insufficient for accurate detection of small mobile structures.

As indicated in this report, a small mobile plaque within an area containing diffuse plaque in the abdominal aorta is hard to detect on the conventional B-mode images but appears as a strongly enhanced echo image on SMI. With the use of SMI, even small mobile structures can be displayed at high intensity in comparison with the surrounding blood flow; the images can also be larger than the real image. Therefore, SMI may be useful for diagnosis of small mobile structures and aid in the prevention of thrombotic events. Computed tomography and magnetic resonance imaging have low temporal and spatial resolution; therefore, it is difficult to detect small mobile structures using

these modalities. Moreover, transoesophageal echocardiography is invasive. In this series, the non-invasive SMI was useful for the detection of mobile intravascular and intracardiac structures. Our findings of the current report may lead to new developments in SMI for imaging in the cardiac region.

Lead author biography



Yutaka Demura, MS, was born in Fukui, Japan, in 1983 and a medical sonographer in the Japan society of ultrasonic medicine. He is a chief of Biomedical Laboratory Scientist at National Cerebral and Cardiovascular Center, Osaka, Japan. His interests in clinical research including adult cardiac echocardiography and cardiovascular ultrasonography.

Supplementary material

[Supplementary material](#) is available at *European Heart Journal – Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as [Supplementary data](#).

Consent: The authors confirm that informed consent for submission and publication of this case report including images and associated text have been obtained from the patient in line with COPE guidance.

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Conflict of interest: None declared.

Data availability

The datasets generated and/or analyzed during the present study are available from the corresponding author upon reasonable request.

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