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CASE REPORT
Coronary heart disease

A case report of a coronary myocardial bridge with impaired full-cycle ratio during dobutamine challenge

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Background A myocardial bridge (MB) is a coronary variant in which an epicardial coronary artery tunnels through the myocardial band. Although MBs have been reported to cause ischaemia, physiological assessment of an MB has not been fully established.

Case summary We encountered a case with exertional chest pain who underwent coronary angiography showing an MB at the mid-left anterior descending artery with systolic compression. Optical coherence tomography showed an MB defined as a homogeneous intermediate intensity surrounding the epicardial artery. The full-cycle ratio, defined as the lowest ratio of distal coronary pressure (P_d) to aortic pressure (P_a) during the entire cardiac cycle, measured 0.89 at rest and 0.73 with intravenous dobutamine of 20 μg/kg/min with a distinctive waveform pattern (early diastolic P_d drop) during a dobutamine challenge. Metoprolol succinate dosage was increased. The patient has been free from chest pain for 7 months after the discharge.

Discussion Optical coherence tomography may contribute to anatomical detections of MBs. Because a systolic compression of the MB and release of the vascular lumen during early diastole leads to an early steep pressure loss, early diastolic P_d drop should be one of the specific haemodynamic characteristics of MBs. On the other hand, in a severe atherosclerotic stenosis, P_d drop is typically observed in late diastole, which could be differentiated from that of MBs. Because full-cycle ratio reflects the whole cardiac cycle including early diastole, this might be more useful than other physiological indices for detection of MB-related ischaemia induced by a dobutamine challenge.

Keywords Case report • Full-cycle ratio • Myocardial bridge • Optical coherence tomography

Learning points

- Full-cycle ratio might be useful for detection of early diastolic drop of distal coronary pressure which is unique for myocardial bridge (MB)-related ischaemia induced by a dobutamine challenge.
- Optical coherence tomography may contribute to anatomical detections of MBs.

Introduction

A myocardial bridge (MB) is a coronary variant in which an epicardial coronary artery tunnels through the myocardial band. Although it is often considered benign, MBs have been reported to cause ischaemia in some patients.[1] Escaned *et al.*[2] highlighted the importance of

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diastolic fractional flow reserve (FFR) during a dobutamine challenge to assess the physiological significance of an MB because overshooting systolic pressure could cause an error for the assessment of mean FFR; however, the distinct pressure wave pattern during early diastole due to an MB compared with an atherosclerotic fixed stenosis has not been well described. Herein, we report a case with stable effort angina without angiographic significant stenosis but rather an MB.AQ

Timeline

Initial presentation	A 72-year-old man started suffering from exertional chest pain. The chest pain was persistent despite the medication of aspirin and calcium channel blocker.
5 months later	Stress test with single-photon emission computed tomography was performed and showed a small sized anteroseptal wall ischaemia.
6 months later	Echocardiography was performed and showed normal left ventricular systolic function.
7 months later	Cardiac catheterization was performed and diagnosed as a myocardial bridge. Beta-blocker has been increased.
14 month later	He has been free from symptoms during follow-up.

Case presentation

A 72-year-old man with exertional chest pain lasting 5 months was referred to our hospital. He had hypertension and hyperlipidaemia without prior cardiovascular history. A stress test with single-photon emission computed tomography 2 months before the catheterization showed a small sized anteroseptal wall ischaemia. An echocardiography 1 month before the catheterization showed normal left ventricular systolic function. Given his persistent symptom despite the medication of aspirin and calcium channel blocker, he underwent coronary angiography. Coronary angiography showed a systolic compression at the mid-left anterior descending artery (LAD) without any other significant stenosis (*Figure 1*, *Supplementary material online, Video S1*). Optical coherence tomography (OCT) corresponding to the angiographic squeezing showed an MB defined as a homogeneous intermediate intensity band (similar to the intensity of media of which major composition is smooth muscle cell) above the epicardial artery (i.e. perivascular side); the minimal lumen area measured 2.15 mm^2 (*Figure 2*, *Supplementary material, S2*). The depth and length of the intramyocardial tract of the LAD were 0.39 mm and 16.8 mm, respectively, indicating the superficial type.[3,4] Full-cycle ratio, defined as the lowest ratio of distal coronary pressure (P_d) to aortic pressure (P_a) during the entire cardiac cycle, was measured with a dobutamine challenge with a pressure sensor located distal to the MB. The full-cycle ratio at rest and then inotropic stimulation by intravenous dobutamine of 5, 10, and 20 μg/kg/min were 0.89, 0.90, 0.86, and 0.73, respectively (*Figure 3*). Compared with the waveform of atherosclerotic stenosis, which typically shows the lowest ratio in late diastole, the lowest ratio in this case was observed in early diastole. Chest discomfort was induced by dobutamine of 10 μg/kg/min and increased along with heart rate as the dosage of dobutamine increased. With dobutamine of 20 μg/kg/min, full-cycle ratio pullback showed a significant pressure step-up at the site of MB (*Figure 4*). The cut-off value of full-cycle ratio to correlate with ischaemia at rest has been reported to be 0.89.[5] Because dobutamine incudes hyperaemia,[6] the value of 0.73 (<0.80) at 20 μg/kg/min of dobutamine was considered significant ischaemia. Metoprolol succinate dosage was increased from 50 mg/day to 100 mg/day and has not been further increased because of a bradycardia. The patient has been free from chest pain for 7 months after the discharge.

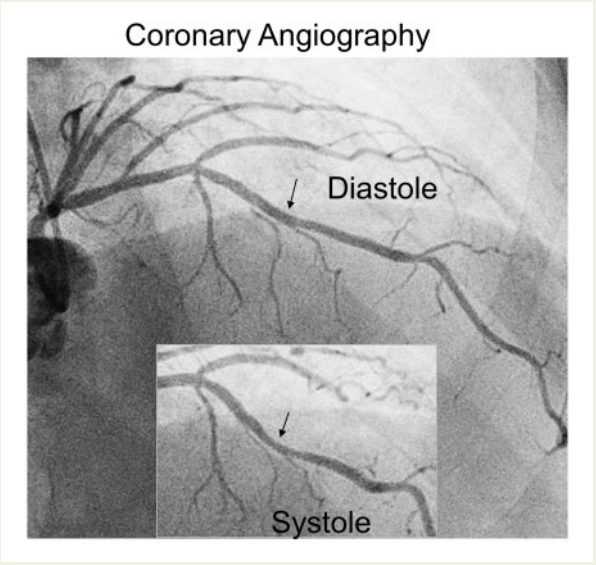

Figure 1 Coronary angiography showed a systolic compression at the mid segment of left anterior descending artery.

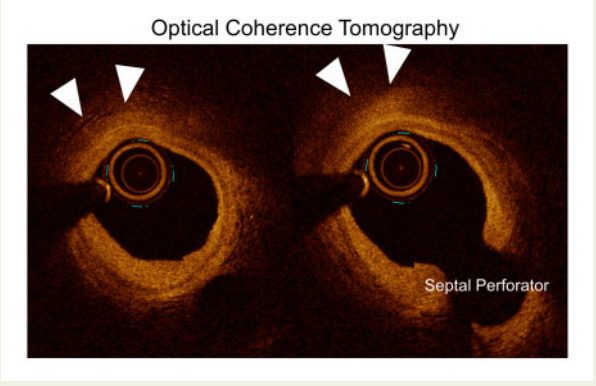

Figure 2 Optical coherence tomography showed a myocardial bridge (white arrowheads) on the epicardial artery (opposite the site of the septal perforator, i.e. pericardial site).

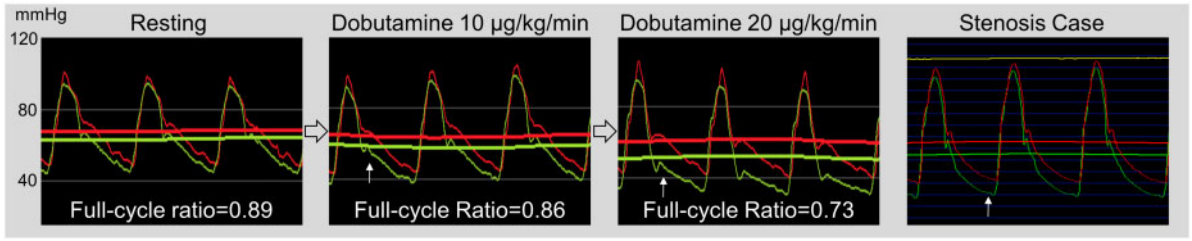

Figure 3 Full-cycle ratio measured 0.89 at rest. During a dobutamine challenge, full-cycle ratio decreased gradually and measured 0.73 at 20 μg/kg/min. The P_d drop in the myocardial bridge started in early diastole (left, white arrows). As a reference, P_d drop in significant atherosclerotic stenosis is usually observed only in late diastole (right, white arrow).

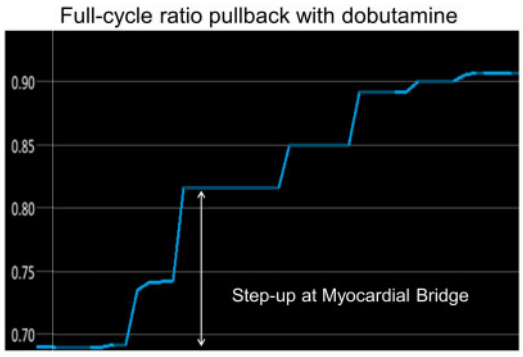

Figure 4 Full-cycle ratio pullback showed a significant step-up at the myocardial bridge.

Discussion

Although the traditional *in vivo* detection of an MB has been made with coronary angiography showing the characteristic 'milking effect',[7] MB can be underdiagnosed in patients with little systolic compression. Intravascular ultrasound is more sensitive than angiography to diagnose MB, with a prevalence of 20–25% in the LAD.[8] Though there have been few studies using OCT to identify MBs,[9] OCT with higher resolution should be able to detect MB with higher sensitivity compared to coronary angiography and with similar sensitivity compared to intravascular ultrasound, especially when the MB shows little systolic compression. In a coronary computed tomography angiographic (CCTA) study, Konen *et al.*[3] identified 30.5% of intramuscular segments in 118 patients, in which 72% were located in LAD. The length of intramuscular segment measured 23 ± 9 mm with depth ranging from 0.1 to 5.6 mm. The superficial and short MB detected by OCT in the present study caused a symptom and a distal P_d drop by dobutamine challenge. Although OCT clearly enables us to identify the presence of MB, CCTA would be an additional reliable tool to understand the anatomical patterns of its intramuscular segment.

For a severe coronary stenosis, a typical resting waveform has been reported as 'diastolic dipping', exhibiting a P_d down-sloping in late diastole.[10] The present case exhibited an early diastolic P_d drop and down-sloping in entire diastole induced by a dobutamine challenge, although the P_d pattern at rest was similar to the typical stenosis pattern (i.e. P_a and P_d are parallel after the dicrotic notch) (*Figure 3*).[10] Ge *et al.*[11] described a 'fingertip' phenomenon, indicating a steep rise in the flow velocity in early diastole followed by a sharp deceleration and subsequent plateau in the MB using a Doppler flow wire, which was explained by the systolic compression of the MB and release of the vascular lumen during early diastole. Similarly, early P_d drop should reflect the early steep pressure loss due to an enlargement of the lumen in the MB during early diastole. Because such dynamic lumen change does not occur in atherosclerotic stenosis, we can differentiate the contribution on ischaemia between by an MB vs. by a fixed stenosis using a different wave pattern (early vs. late diastolic P_d drop). Recently, Tarantini *et al.*[12] demonstrated the haemodynamic evaluation of MBs by using FFR and instantaneous wave-free ratio (iFR) at rest and after a dobutamine challenge. While median FFR did not significantly change after a dobutamine challenge, median iFR dropped significantly, suggesting the favourable utility of iFR compared with FFR. They characterized intracoronary pressure recordings across the MB during dobutamine challenge as a ventricularization and an overshooting of maximal P_d over P_a induced by systolic compression in 80% of patients. Full-cycle ratio reflects the whole cardiac cycle including early diastole, while iFR reflects only the wave-free period not including the first 25% of diastolic phase. Thus, full-cycle ratio might be more useful than other indices for detection of MB-related ischaemia induced by a dobutamine challenge. Further large-scale studies are warranted to establish the best physiological assessment of MBs.

Lead author biography

Eisuke Usui graduated from Tokyo Medical and Dental University and completed the MD course in 2010. After his cardiovascular interventional fellowship at Department of Cardiovascular Medicine, Tsuchiura Kyodo General Hospital, he is currently working as a intravascular imaging fellow at Cardiovascular Research Foundation and Columbia University Irving Medical Center in New York, NY, USA.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

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

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

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