

# Intraoperative coronary angiography and fractional flow reserve measurement with dobutamine infusion in supra-arterial myotomy for a myocardial bridge: a case report

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## Background

A myocardial bridge (MB) is a congenital coronary anomaly, wherein the epicardial coronary artery tunnels through the myocardial band. Treatment is indicated when clinical symptoms occur, and  $\beta$ -blockers are the first choice of treatment. Symptomatic patients refractory to medical therapy are considered for other options, including stent placement, coronary artery bypass grafting, or surgical supra-arterial myotomy. Supra-arterial myotomy is effective; however, the symptoms might persist if myocardial resection is inadequately performed.

## Case summary

We encountered a patient experiencing exertional chest pain. Coronary angiography revealed a MB at the mid-left anterior descending artery with systolic compression. The patient's fractional flow reserves (FFRs) were 0.93 at rest and 0.72 with intravenous administration of 50  $\mu$ g/kg/min dobutamine. The symptoms were refractory to drugs, and supra-arterial myotomy was performed with intraoperative coronary artery angiography, which revealed the milking effect of the residual myocardium; therefore, additional myocardial resection was performed. Postoperative coronary artery angiography showed no systolic compression, and the postoperative FFRs were 0.88 at rest and 0.92 with intravenous administration of dobutamine 50  $\mu$ g/kg/min.

## Discussion

Although surgical supra-arterial myotomy is safe and effective, inadequate myocardial resection might cause symptom recurrence. Intraoperative coronary artery angiography during the surgery can indicate whether additional resection is required. Objective assessment of ischaemia might be useful in cases with a MB, which can cause asymptomatic myocardial ischaemia and sudden cardiac death. FFRs before surgery can help in evaluating the need for surgery and for confirming the therapeutic effect and subsequent treatment.

## Keywords

Case report • Myocardial bridge • Surgical supra-arterial myotomy • Intraoperative coronary artery angiography • Fractional flow reserve

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## Learning points

- Intraoperative coronary angiography is useful in determining the endpoint of supra-arterial myotomy and can probably improve the quality of surgery.
- Fractional flow reserve (FFR) before surgery is useful for evaluation of the surgical indication and FFR after surgery is useful for confirming the therapeutic effect and subsequent treatment.

## Introduction

A myocardial bridge (MB) is a congenital coronary anomaly in which the epicardial coronary artery tunnels through the myocardial band. Although it is often considered benign, MBs are sometimes associated with silent ischaemia, stable angina, acute coronary syndrome, Takotsubo cardiomyopathy, arrhythmia, and sudden cardiac death in some patients<sup>1</sup>. The first choice of treatment is medications, including  $\beta$ -blockers or calcium channel antagonists. Symptomatic patients refractory to medical therapy are considered for further options, including stent placement, coronary artery bypass grafting (CABG), or surgical supra-arterial myotomy.<sup>2,3</sup> While Boyd et al.<sup>4</sup> and Rezayat et al.<sup>5</sup> reported surgical supra-arterial myotomy as safe and effective, some patients require reoperation for symptom recurrence. Although further verification is necessary, exercise stress echocardiography, myocardial perfusion imaging, and fractional flow reserves (FFRs) assessment can be used to evaluate functional ischaemia in cases with MB<sup>6</sup>. FFR is a standard established method for assessing functional ischaemia in cases with coronary artery stenosis<sup>7</sup>. It is defined as the ratio of the mean distal coronary artery pressure to the mean aortic pressure measured during maximal hyperaemia. However, Hakeem et al.<sup>8</sup> reported that FFR measurement with adenosine infusion might underestimate the significance of stenosis in patients with MB. FFR measurement using high-dose dobutamine infusion is an alternative method for evaluating ischaemia in patients with MB because dobutamine increases the heart rate and myocardial contraction, which reduces the vascular cavity. Herein, we report a case where myocardial resection was performed along with intraoperative coronary angiography (CAG). In addition, the change in FFR was measured using high-dose dobutamine infusion.

## Timeline

|                      |   |
|----------------------|---|
| Initial presentation | A 40-year-old man with exertional chest pain for 6 months visited our hospital. His Canadian Cardiovascular Society (CCS) functional classification was 2. He had no medical history. |
| 1 week later         | Coronary computed tomography revealed myocardial bridge (MB). Fractional flow reserve (FFR) after inotropic stimulation with intravenous dobutamine                                   |

Continued

50  $\mu\text{g/kg/min}$  was 0.72, which indicated significant ischaemia.

He was started on  $\beta$ -blocker and calcium-channel antagonist.

His symptoms did not improve with the medicines and he had adverse effects due to medications.

2 months later

We performed a supra-arterial myotomy with intraoperative coronary angiography for MB refractory to medication.

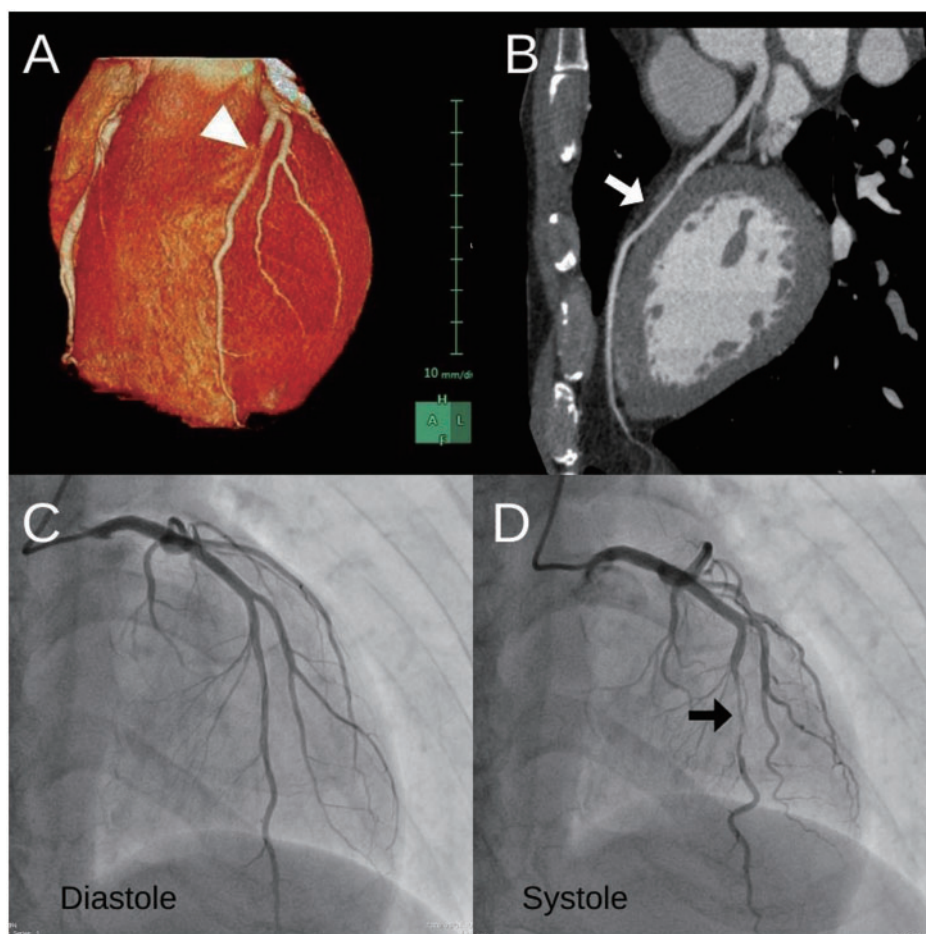
His CCS improved to 1. He did not require any medicines after the supra-arterial myotomy.

3 months later

FFR after inotropic stimulation with intravenous dobutamine of 50  $\mu\text{g/kg/min}$  was 0.92, which showed an improvement in functional ischaemia

## Case presentation

A 40-year-old man with exertional chest pain for 6 months visited our hospital. He had no habit of exercising; however, his job was car maintenance, which required manual labour. He complained of chest pain during work, and his Canadian Cardiovascular Society (CCS) functional classification was 2. He had no relevant medical history. Coronary computed tomography revealed an MB at the mid-left anterior descending artery (LAD) (Figure 1A and B). The depth and length of the MB were 3.5 mm and 35 mm, respectively, indicating a deep type.<sup>2</sup> CAG revealed systolic compression at the mid-LAD without any other significant stenosis (Figure 1C and D; Video 1). Measurement of FFRs with dobutamine stimulation was performed to assess ischaemia. We gradually increased the dose of dobutamine from 10 to 50  $\mu\text{g/kg/min}$  by 10  $\mu\text{g/kg/min}$  every 3 min. We measured FFRs at each stage and judged positive with FFRs less than 0.75. FFRs at rest and after inotropic stimulation with intravenous dobutamine of 20 and 50  $\mu\text{g/kg/min}$  were 0.93, 0.86, and 0.72, respectively (Figure 2A–C). The pressure waveform showed a rapid pressure drop in the early diastolic phase, which is characteristic of MB. Although he received  $\beta$ -blockers and calcium channel antagonists (bisoprolol 5 mg and diltiazem 100 mg), his symptoms during work did not improve. Moreover, the medications caused dizziness. Hence, our team suggested surgery. Two months later, we performed a supra-arterial myotomy. Before the thoracotomy, a 4-Fr sheath was inserted into the right femoral artery, and off-pump supra-arterial myotomy was performed with a small thoracotomy in the 4th intercostal space on the left side. Myocardial resection was performed after identifying the position of the coronary artery being squeezed using epicardial echocardiography, which also helped avoid perforation of the right ventricle by confirming the distance to the right ventricular cavity. Intraoperative CAG was performed by a cardiologist through a 4-Fr sheath placed in the right femoral artery after the surgeon exposed the anterior surface of the LAD (Figure 3A), and the systolic milking effect persisted on the distal side (Figure 4A and B); hence, the residual myocardial tissue was excised (Figure 3B). CAG was performed again, and the milking effect was no longer seen (Figure 4C and D, Video 2).



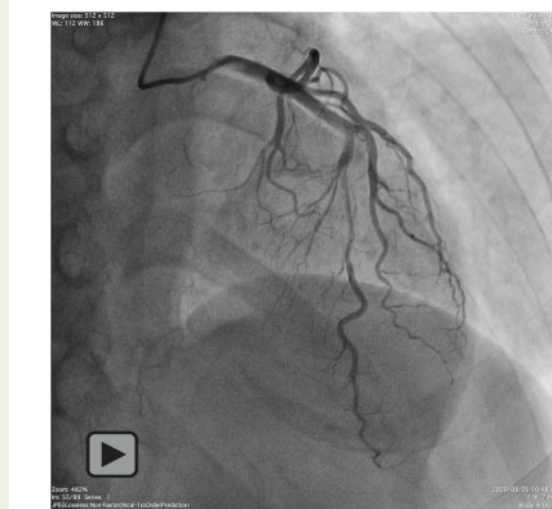
**Figure 1** (A and B) Coronary computed tomography showing a myocardial bridge at the mid-left anterior descending artery (white arrow, white arrowhead). (C and D) Coronary angiogram showing a systolic compression at the mid-left anterior descending artery (black arrow).

No systolic compression was observed in the follow-up CAG ([Figure 5](#), [Video 3](#)) 1 month after the surgery. FFRs at rest and after inotropic stimulation with intravenous dobutamine of 20 and 50  $\mu\text{g/kg/min}$  were 0.88, 0.92, and 0.92, respectively ([Figure 2D–F](#)). The patient was asymptomatic for the next 2 months after discharge. His CCS improved to 1. He did not receive any medicines after the supra-arterial myotomy.

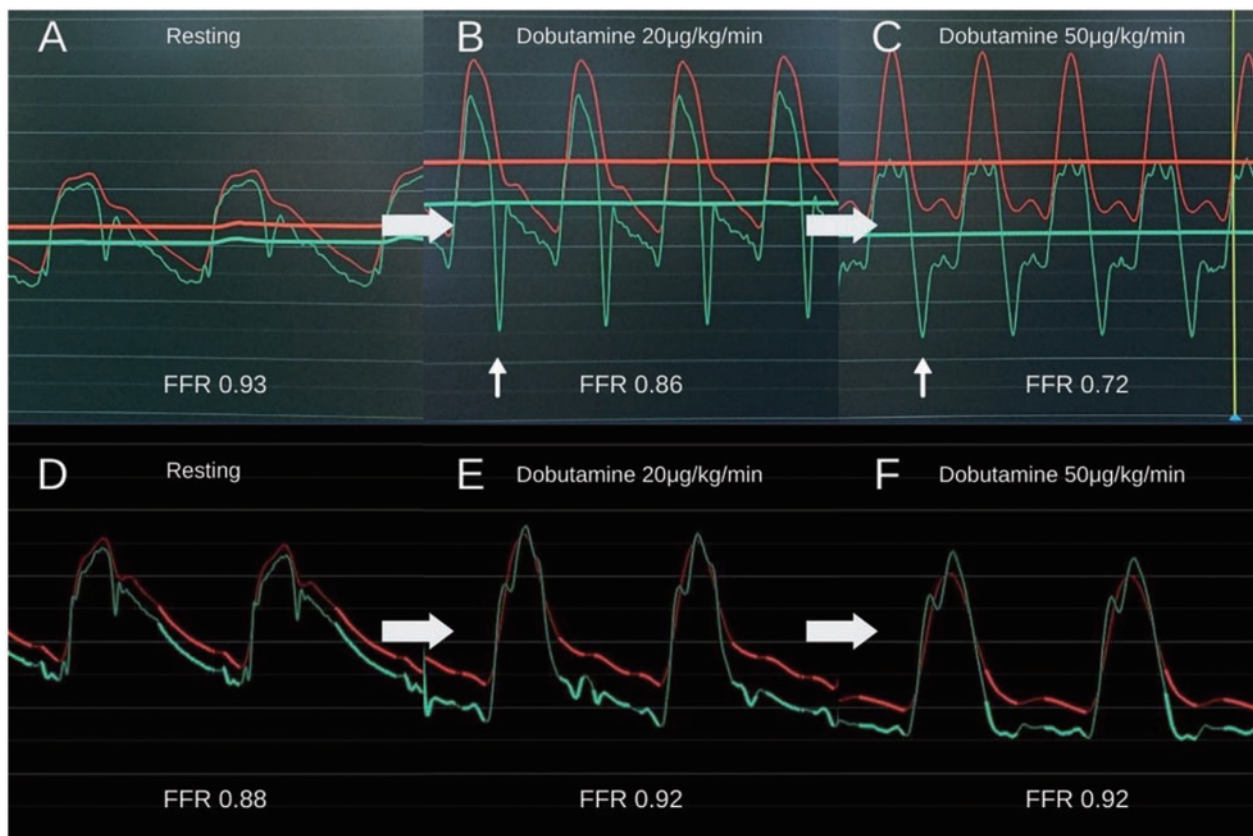
## Discussion

This case underscores the following: first, intraoperative CAG is useful in determining the endpoint of supra-arterial myotomy, possibly improving the outcomes of the surgery. Second, improvement in functional ischaemia can be confirmed by postoperative FFR assessment.

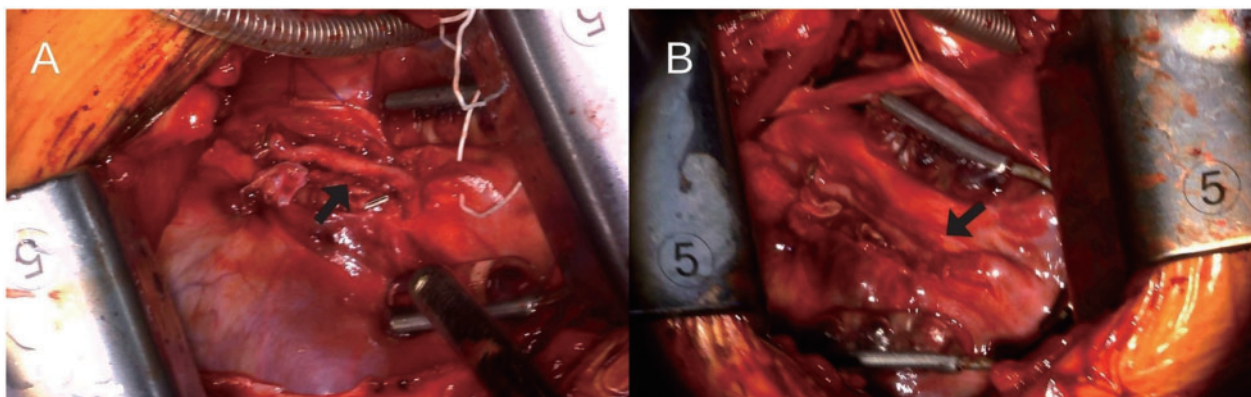
While supra-arterial myotomy for MB has been shown to be safe and effective,<sup>4</sup> it has associated complications, such as right ventricular rupture, aneurysm, and bleeding. Moreover, there are reports of recurrent angina, and inadequate myocardial resection might cause persistence of the milking effect, resulting in symptom recurrence.



**Video 1** Coronary angiogram showing a systolic compression at the mid-left anterior descending artery.



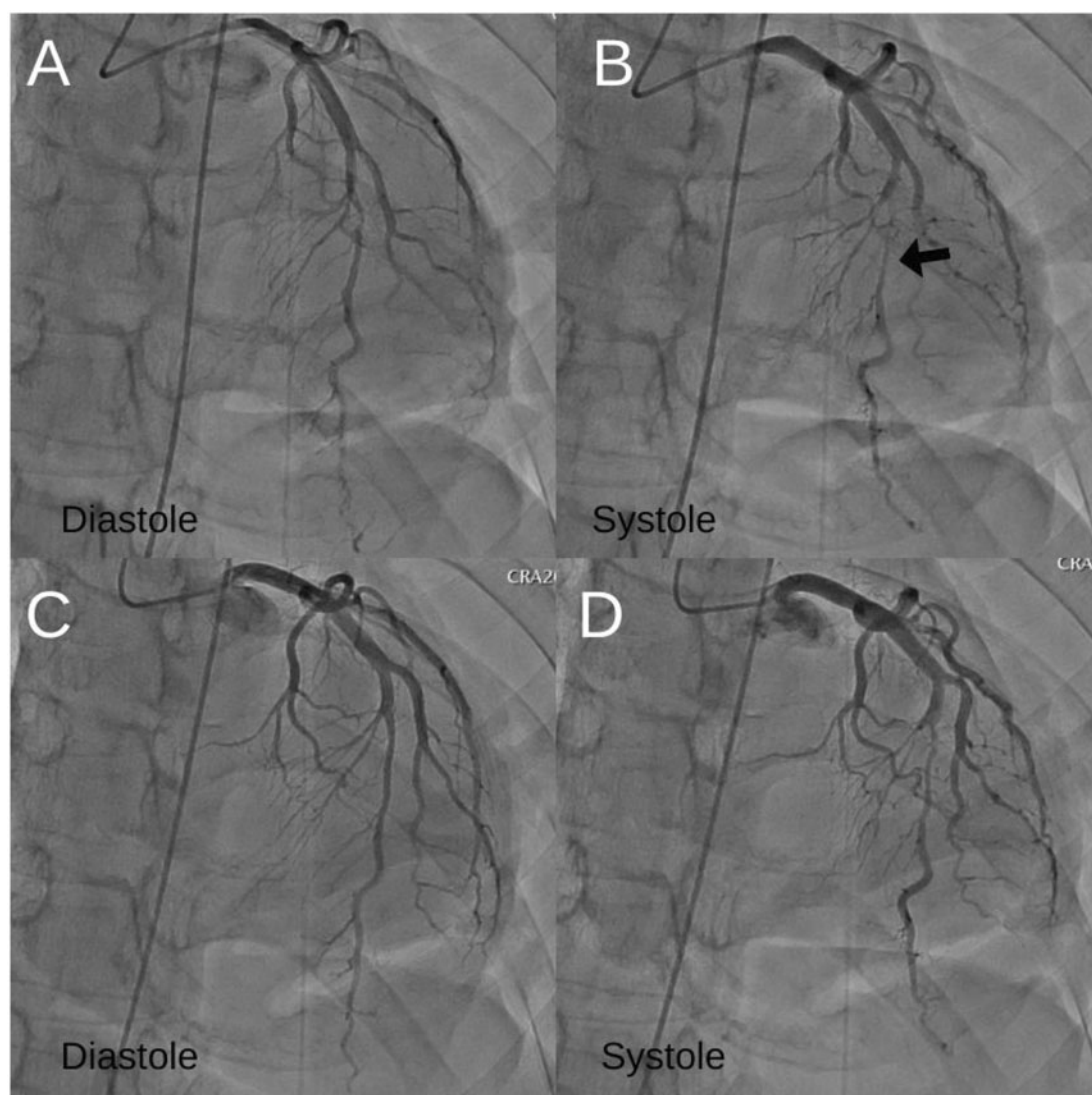
**Figure 2** (A–C) Preoperative fractional flow reserves at rest and after inotropic stimulation with intravenous dobutamine of 20 and 50  $\mu\text{g/kg/min}$  were 0.93, 0.86, and 0.72, respectively. The white arrows show a rapid pressure drop in the early diastolic phase characteristic of myocardial bridge. (D–F) Postoperative fractional flow reserves at rest and after inotropic stimulation by intravenous dobutamine of 20 and 50  $\mu\text{g/kg/min}$  are 0.88, 0.92, and 0.92, respectively.



**Figure 3** (A) The anterior surface of the left anterior descending artery is exposed (black arrow). (B) We performed an additional myocardial resection at the site of the black arrow.

Boyd et al.<sup>4</sup> reported a case wherein a repeat supra-arterial myotomy was required because of inadequate myocardial resection. Rezayat et al.<sup>5</sup> also reported about a patient requiring CABG after surgical

myotomy. These cases might be probably due to inadequate myocardial resection. In our case, the residual milking effect was identified on intraoperative CAG, and additional myotomy was performed



**Figure 4** (A and B) Intraoperative coronary angiography after exposing the left anterior descending artery showing the systolic milking effect persisting on the distal side (black arrow). (C and D) Intraoperative coronary angiography after additional myotomy does not show the milking effect.

immediately. Although intraoperative CAG has not been reported during supra-arterial myotomy for MB, Mack<sup>9</sup> and Zhao *et al.*<sup>10</sup> reported the usefulness of intraoperative CAG during CABG. It helps the surgeons during the surgery to determine whether additional resection is required.

There are few reports about an objective evaluation of the improvement in functional ischaemia during surgery. Hill *et al.*<sup>11</sup> increased the heart rate to 150 beats per minute by atrial pacing and recorded the intraoperative coronary flow before and after supra-arterial myotomy. They reported that supra-arterial myotomy reduced the lag between end-systolic blood flow and the onset of diastolic coronary blood flow and increased the total coronary flow during surgery. In this case, we objectively assessed the improvement in ischaemia by FFR measurement with dobutamine before and after surgery. We confirmed improvement in FFR and disappearance of the dip in the early diastolic phase, which is characteristic of MB

(Figure 2B and C). FFR is an established standard method for assessing functional ischaemia in coronary artery stenosis. However, Hakeem *et al.*<sup>8</sup> reported that FFR measurement with adenosine infusion might underestimate the significance of stenosis in cases with MB. FFR measurement using high-dose dobutamine infusion is an alternative method for evaluating ischaemia in cases with MB because dobutamine increases myocardial contraction in the coronary arteries and compresses the vascular cavity. However, Tarantini *et al.*<sup>1</sup> reported that FFR might underestimate the significance of stenosis in MB due to systolic overshooting of the distal region. This might result in an artificial increase in the mean pressure. Although the new resting indices, such as instantaneous wave-free ratio, might be better than FFR for assessing MB-related myocardial ischaemia, the significance of resting ischaemia in cases with MB is still unclear. In this study, effective supra-arterial myotomy was shown to improve physiological ischaemia. This is useful in patients with MB, which can cause

asymptomatic myocardial ischaemia and sudden cardiac death. Furthermore, based on the results of FFR measurement, it was concluded that postoperative medication was not required.

In summary, intraoperative CAG in a hybrid operating room can be used to set the criteria for the termination of supra-arterial myotomy, which can improve the quality of surgery, and effective supra-arterial myotomy improves functional ischaemia. FFR before surgery is useful for evaluation of the surgical indication, and FFR after surgery

is useful for confirming the therapeutic effect and subsequent treatment.

## Lead author biography



cardiology.

Shuichiro Yamauchi is graduated from Oita University and completed the MD course in 2013. After his cardiological fellowship at Beppu Medical Centre and Oita Medical Centre, he is currently working as a cardiologist at Department of Cardiology, The Sakakibara Heart Institute of Okayama in Japan. His academic interests include structure heart disease and interventional

## Supplementary material

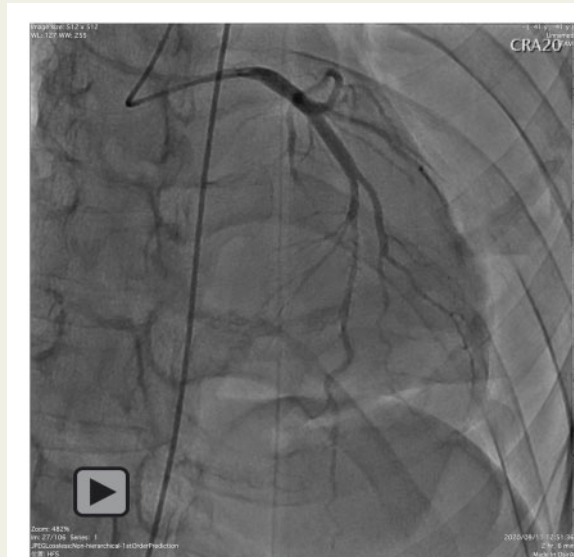
[Supplementary material](#) is available at *European Heart Journal - Case Reports* online.

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

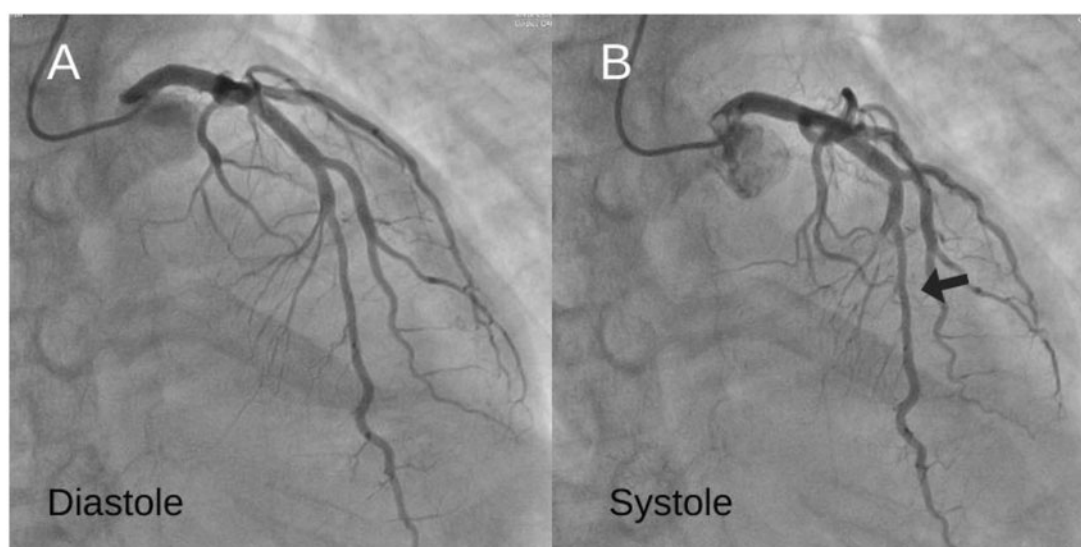
**Consent:** The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

**Conflict of interest:** None declared.

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**Video 2** Intraoperative coronary angiography after exposing the left anterior descending artery showing that systolic milking effect persists.



**Figure 5** Systolic compression remains absent in the coronary angiography 1 month after surgery. The black arrow indicates the site where the supra-arterial myotomy was performed.

