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How should I treat a patient with critical stenosis of a bifurcation of the left main coronary artery with an acute angulation between the left main artery and the left circumflex artery?

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CASE SUMMARY

BACKGROUND: A 49-year-old male with a history of coronary bypass surgery three months before presented with typical anginal chest pain on exertion. Coronary angiography showed a critical stenosis at the bifurcation of the left main coronary artery and diffuse stenosis in the left internal mammary artery graft.

INVESTIGATION: Physical examination, electrocardiogram, exercise testing, coronary angiography.

DIAGNOSIS: Left main artery stenosis post coronary bypass surgery with internal mammary artery graft failure.

MANAGEMENT: Stenting of the stenosis using a new wiring technique.

KEYWORDS: acute angulation, bifurcation, left main coronary artery

PRESENTATION OF THE CASE

A 49-year-old male with a history of prior coronary bypass graft surgery three months before came back with typical anginal chest pain on exertion. His angina was classified as grade III according to the Canadian Cardiovascular Society grading system. The risk factor for coronary artery disease in this patient was smoking. However, he had stopped smoking after the bypass surgery. An exercise stress test showed a positive result with horizontal ST depression in II, III, aVF, V4, V5, and V6 at low workload. His medications included aspirin 325 mg daily, simvastatin 20 mg daily, and atenolol 50 mg daily. Coronary angiography showed a 95% stenosis at the trifurcation of the left main coronary artery (LMCA) involving the ostium of the left anterior descending artery (LAD), the left circumflex artery (LCX), and the ramus intermedius (RI). The angulation between the left main artery and the left circumflex artery was nearly 90 degrees **(Figure 1, Moving image 1)**. The internal mammary artery was diffusely diseased without antegrade flow into the LAD **(Figure 2, Moving image 2)**. The saphenous grafts to the diagonal branch and the posterior descending artery were patent. Graft to the LCX was not found. He declined re-operation. His healthcare payment did not cover rotational atherectomy.

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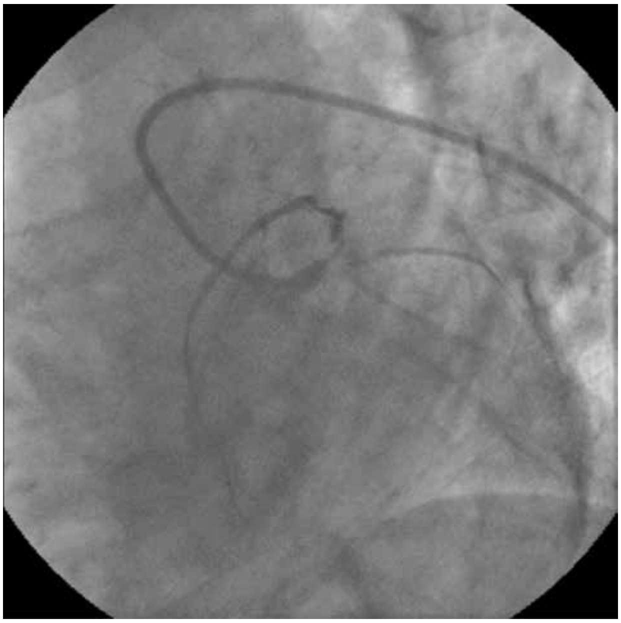

Figure 1. *Coronary angiogram showing a 95% stenosis at the trifurcation of LMCA involving the ostium of the LAD, the LCX, and the RI with angulation between the LMCA and the LCX of nearly 90 degrees.*

Figure 2. *The diffusely diseased internal mammary artery without antegrade flow into the LAD.*

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How would I treat?

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The present case is one of three-vessel disease (3-VD) with a severely obstructive lesion involving a left main coronary artery (LMCA) trifurcation. This latter lesion is particularly complex as the disease involves the distal LMCA and the ostium of the three branches, classifying this trifurcation as "true" or "1,1,1,1", according to the Medina classification. In addition, the angle A ("Approach") between the LMCA and the left circumflex (LCX) is quite unfavourable, being superior to 70°, which is associated with more difficult side branch access. Primarily, this patient was correctly referred to coronary artery bypass grafting (CABG) in view of the diffuse 3-VD and LMCA disease, high anatomical complexity, young age and low surgical risk, as in these conditions surgery has been demonstrated to be more beneficial than percutaneous coronary intervention (PCI)[1]. Despite the technical failure of the surgery, probably due to stealing flow from the mammary artery to a residual collateral ramus, a re-operation is still a treatment option, considering that the estimated CABG operative mortality rate remains reasonably low at <2%, as assessed by the logistic EuroSCORE II. On the other hand, PCI with drug-eluting stents would be a viable, less invasive alternative strategy. Indeed, when the SYNTAX score is intermediate (>22 and <33), as in the present patient, PCI and CABG have similar overall five-year outcomes[2]. In addition, several registries, although small, have shown the feasibility and high procedural success rate of PCI for LMCA trifurcation, with good long-term safety results, despite a relatively high rate of target lesion revascularisation, especially in true trifurcations, suggesting the need for an optimal stenting technique[3,4]. Thus, the collegial assessment by the local Heart Team would be appropriate for decision making in this case, but the patient's refusal of the surgical approach has driven the choice for PCI. In particular, this is a very complex PCI that should be performed in centres with the prompt availability of intensive care and surgical back-up. Moreover, the complexity of the lesion requires precise planning of the materials and PCI technique, and would make it reasonable to use ventricular assistance with the Impella® system (Abiomed, Danvers, MA, USA) or intra-aortic balloon pumping before starting the procedure.

PCI strategy

An 8 Fr left XB (Cordis, Johnson & Johnson, Warren, NJ, USA) is the guiding catheter of choice. Firstly, we would perform the wiring of all three branches, preferably by using a spring coil, floppy, extra support guidewire for the left anterior descending artery (LAD) and polymeric tapered guidewires – with a large radius of tip curvature – for the ramus intermedius (RI) and LCX. After that, we would plan to predilate first only the LAD with a non-compliant 2.0-2.5/20 mm balloon and then the RI and LCX in a kissing fashion with low-profile, short and small balloons (1.5-2.0/15 mm). In case of LCX difficult access, a 7 Fr GuideLiner® (Vascular Solutions Inc., Minneapolis, MN, USA) or the anchor technique would be attempted. A progressive increasing of balloon sizes would be used for predilation in the three branches, based on the appearance of the lesions after each step. Intravascular ultrasound (IVUS) would be performed before stent implantation, to assess vessel diameter and calcium distribution, in order to guide further possible debulking strategies. Regarding the optimal stenting strategy in such a complex case, there is no clear evidence or standardisation, with the best technique being the one that fits the specific anatomy best. While a two-stent technique on the LAD and LCX plus balloon on the RI could be considered, in view of the large plaque burden involving the whole bifurcation, which is a distribution pattern associated with worse outcomes[5], we would opt for a three-stent technique, starting with stenting the LCX and RI by a TAP technique and then a stent on the LMCA-LAD crushing the LCX stenting. We would perform the following post-dilatation sequence: proximal optimisation technique (POT) on the LMCA, distal recrossing of the LCX stent, kissing balloon of the LMCA-LCX and final POT on the LMCA. Post-stenting IVUS or OCT would be performed in order to guide further strategies to optimise stent apposition and expansion, by achieving minimal lumen areas of at least 5 mm^2 in the LCX and RI, 6 mm^2 in the LAD ostium, 7 mm^2 at the polygon of confluence and 8 mm^2 in the LMCA[6].

Conflict of interest statement

The authors have no conflicts of interest to declare.

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How would I treat?

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This is a very interesting and educational case with different important issues to highlight. A young man with multivessel disease and a complex trifurcation lesion at the distal left main (LM), left anterior descending artery (LAD), ramus intermedius (RI) and left circumflex artery (LCX). Bypass surgery was the first option for myocardial revascularisation which he underwent three months before. It is not clear from the two angiographic images presented (obtained after surgery) what the SYNTAX score was and what the left ventricular function was in this patient prior to surgery. Vessel size seems almost small and run-off is not optimal, which had probably contributed to an early occlusion of the LIMA. Also, a depressed left ventricular function might have played an important role.

The second important issue is what is the best option for this patient - re-CABG or PCI? Re-operation is always associated with higher risk, particularly if other grafts are still patent, as in this patient. Consequently, PCI should be considered as the first option, despite the fact that the LM trifurcation lesion in this case is very complex and challenging.

As in any complex lesion, it is very important to plan the procedure carefully before starting. In this case, I would plan a two-stent technique for the LM-LAD–RI bifurcation and only POBA for the LCX to avoid excessive stent overlapping at the carina which might predispose to stent thrombosis and in-stent restenosis. I would choose a 7 Fr guiding catheter. Then I would place three wires in all the trifurcation branches. I would predilate with a kissing balloon from the LM to RI and the LM to LAD with 2.5×15 mm semi-compliant balloons. In the event of any compromise to the LCX, I would also predilate the LCX with a 1.5 mm semi-compliant balloon. Then I would proceed to stenting the RI, simultaneously keeping a 2.5×15 mm balloon in the LM to LAD with a minimal protrusion of the stent from the RI to LM. After deployment of the stent in the RI, I would retrieve the delivery balloon catheter into the LM a bit, and perform a kissing balloon inflation. Then I would completely retrieve the delivery balloon and then at high pressure inflate the balloon still *in situ* from the LM to LAD. Then I would place the second stent covering the whole LM to proximal LAD and jailing both wires in the RI and LCX. I would recross two wires through the LM-LAD stent into the RI and into the LCX. Firstly I would dilate the stent strut towards the LCX and then towards the RI, followed by a second kissing balloon inflation LM-LAD and LM-RI, and finally POT inflation with a short 4.0×8 mm balloon in the LM (this approach can be defined as the DK reverse TAP approach). IVUS guidance, if available, is recommended since it might positively impact on the clinical outcome. In case of any compromise of the LCX ostium, I would perform another dilatation of the LM-LCX with (maximum) 2.0×12 mm balloon followed by a DEB 2.5×18 mm at nominal pressure.

The approach described above offers some advantages over the classic mini-crush or DK crush, since it avoids any overlapping of three layers of struts and makes the procedure easier, particularly in a complex anatomy such as in our case with a full coverage of the carina, despite the SB angulation.

Conflict of interest statement

The author has no conflicts of interest to declare.

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How did I treat?

ACTUAL TREATMENT AND MANAGEMENT OF THE CASE

Percutaneous coronary intervention was selected as the treatment strategy according to the patient's decision. The LAD was wired using the HI-TORQUE Whisper guidewire (Abbott Vascular, Santa Clara, CA, USA). However, attempts to wire in the LCX were unsuccessful. A 2.5×15 mm balloon was then inflated at 2 atm at the bifurcation of the LMCA in an attempt to assist wiring in the LCX, but the wire still could not be passed into the LCX. The same 2.5×15 mm balloon was inflated again in the LAD beyond the lesion and was pulled back against the plaque towards the guiding catheter to change the angulation between the LMCA and the LCX **(Moving image 3)**. The wire could then be passed into the RI branch. The kissing balloon technique was performed in the LAD and RI using a 2.5×15 mm balloon in the LAD and a 2.0×15 mm balloon in the RI, both of which were at nominal pressure. However, the wire still could not be passed into the LCX due to the angulation between the RI and the LCX. The same 2.0×15 mm balloon was inflated again in the RI and was pulled back towards the guiding catheter to reduce the RI-LCX angle **(Moving image 4)**. The wire was then passed into the LCX. The kissing balloon technique was performed using two 2.5×15 mm balloons in the LAD and the LCX, both of which were at 8 atm. The mid-LAD lesion was corrected by placement of a 3×23 mm XIENCE V® drug-eluting stent (DES) (Abbott Vascular). The T-stenting technique was selected for correction of the LMCA lesion using a 2.5×12 mm XIENCE V DES in the proximal LCX and a 3.5×23 mm XIENCE V DES in the LM-LAD junction. Proximal optimisation of the LM-LAD stent was carried out by a 4×8 mm balloon at 12 atm. TIMI 3 flow was achieved in all branches **(Moving image 5)**.

Various techniques for wiring a side branch artery with a nearly acute angle take-off had been considered before the pull-back balloon technique. Kawasaki et al developed the reverse guidewire technique[7], and Suzuki et al combined that technique with a Crusade catheter (Kaneka Medix Corp., Tokyo, Japan)[8]. However, neither of the aforementioned techniques would have helped to pass a wire into the LCX in our case because the severe stenosis in the proximal LAD beyond the LCX ostium would have precluded the bent tip of a wire going into the LCX. Inflating a balloon at the LAD ostium to direct a wire into the LCX might have led to plaque shifting from the ostium of the LAD towards the ostium of the LCX. Colombo and Stankovic suggested other methods, including gradual predilation in the main branch or the use of the Venture™ wire control system (St. Jude Medical, St. Paul, MN, USA)[9]. The former was attempted unsuccessfully earlier as mentioned. To date, the Venture wire control system is not available in Thailand. Rotational atherectomy could have removed the atherosclerotic plaque and helped to pass the wire into the LCX. However, the patient's healthcare payment did not cover that procedure.

I invented the pull-back balloon-assisted wiring technique for a bifurcation lesion with difficult angulation in 2008 and named it the "Plaque-plowing technique" in an oral presentation at EuroPCR 2013. The principle of this technique is to avoid an unfavourable direction of the snowplough phenomenon when an angioplasty balloon is inflated on an atherosclerotic plaque, especially a plaque with an overhanging edge near the bifurcation. Instead of inflating a balloon directly on the plaque, a balloon is inflated beyond the plaque and pulled back to move the plaque out of the side branch ostium. This technique has been performed in five cases with such lesions when the wires were not able to be passed into side branches due to the acute angulation between the side branch and the proximal main vessel. The technique was successful in these five cases without complication in any patient. Nevertheless, it has never been attempted more than once in a single lesion. This case demonstrates that the principle is applicable even in a complex trifurcation lesion **(Figure 3-Figure 7)**. The main advantage of this technique is its simplicity. An additional device such as a Crusade catheter is not required. The manipulation of a wire as in the reverse wire technique is also unnecessary. Theoretical disadvantages of the Plaque-plowing technique include distal embolisation and coronary artery dissection. However, such complications have not yet been demonstrated in any patients.

Conflict of interest statement

The author has no conflicts of interest to declare.

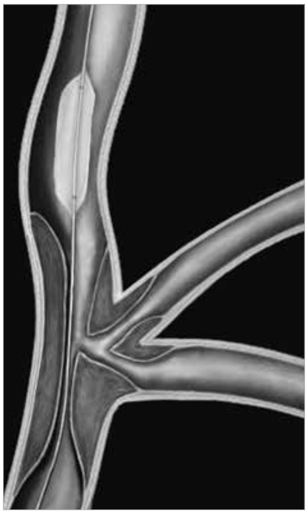

Figure 3. *Balloon inflated beyond LAD plaque.*

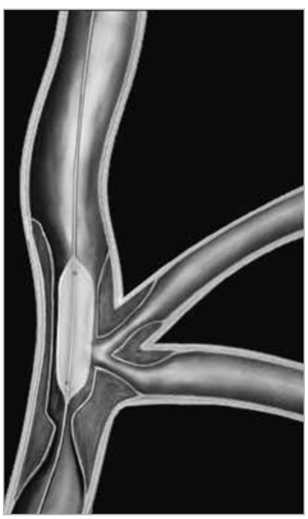

Figure 4. *Balloon pulled back towards a guiding catheter thus widening the angulation between the LMCA and the RI.*

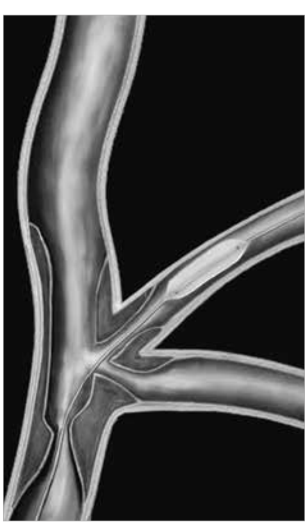

Figure 5. *Balloon inflated in the RI.*

Figure 6. *Balloon pulled back from the RI towards a guiding catheter, resulting in the widening of the angulation between the LMCA and the LCX.*

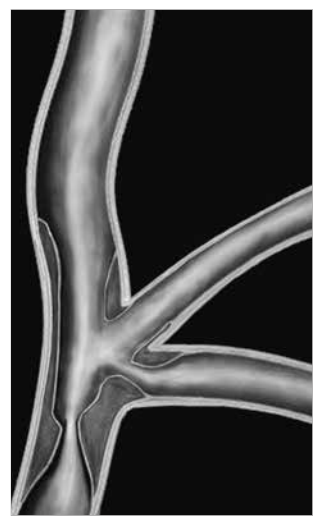

Figure 7. *Schematic drawing of the lesion after two balloon pullbacks had been performed.*

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Supplementary data

Moving image 1. Coronary angiogram showing a 95% stenosis at the trifurcation of LMCA involving the ostium of the LAD, the LCX, and the RI branch with angulation between the LMCA and the LCX of nearly 90 degrees.

Moving image 2. The diffusely diseased internal mammary artery without antegrade flow into the LAD.

Moving image 3. Balloon inflated again in the LAD beyond the lesion and pulled back against the plaque towards the guiding catheter in an attempt to change the angulation between the LMCA and the LCX.

Moving image 4. Balloon inflated again in the RI and pulled back towards the guiding catheter in an attempt to reduce the RI-LCX angle.

Moving image 5. Final angiogram showing TIMI 3 flow in all branches with no dissection demonstrated.