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Partially Protected Left Main Stenting in a Patient with Complete Obstruction of Left Internal Mammary Graft

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ABSTRACT

We present a 59-year-old patient with a previous history of coronary artery bypass grafting (CABG) for left main and mid-left anterior descending (LAD) coronary artery disease with the use of left internal mammary artery (LIMA) and a radial graft six years ago. He performed a treadmill stress test which documented extensive ischemia in V2-V6 precordial leads with significant blood pressure drop. Coronary angiogram revealed complete obstruction of the LIMA and patent radial graft. The patient preferred percutaneous intervention (PCI) to CABG as a revascularization strategy. The procedure was guided by intravascular ultrasound. We implanted two drug eluting stents, the first one in the mid-LAD overlapped with the second one which covered the vessel up to the ostium of the left main. Significant plaque shift to the ostium of the left circumflex was treated with a kissing balloon technique.

KEY WORDS: *left main coronary artery, percutaneous coronary intervention, intravascular ultrasound, complete obstruction of left internal mammary artery*

CASE PRESENTATION

A 59 years old man, ex-smoker, with a history of hypertension, hyperlipidemia, and coronary artery bypass grafting (CABG), presented in our department for a treadmill stress test. Six years earlier, he had been diagnosed with left main coronary artery disease and a concomitant 70% stenosis in the mid-left anterior descending (LAD) coronary artery and was treated with CABG with the use of left internal mammary graft (LIMA) to the LAD and a radial artery graft to the obtuse marginal branch of the left circumflex. A dobutamine stress echocardiography test was negative for myocardial ischemia three years ago. The patient had his blood pressure well controlled after a recent modification of his antihypertensive medication. He was recently advised to have a treadmill stress test to assess blood pressure response during exercise.

He performed a full treadmill exercise test up to the 4th stage of the Bruce protocol without developing any symptoms but with a hypertensive response since his arterial blood pressure was measured 165/110mmHg at that point. However, at 10 min into the test he started complaining of dizziness which necessitated the discontinuation of the test. His blood pressure was measured at 97/60 mmHg and he developed marked ST segment depression on leads V2-V6 ECG (Fig. 1) without any angina. He was started on fluids intravenously, but 11 minutes later his blood pressure was remaining low (70/50 mmHg) despite the complete resolution of the ECG changes. Blood pressure was restored to normal 30 minutes later. Based on this test result, he was advised to

ABBREVIATIONS
CABG= coronary artery bypass grafting
IVUS= intravascular ultrasound
LAD= left anterior descending (coronary artery)
LCx= left circumflex (coronary artery)
LIMA= left internal mammary artery
LMCA= left main coronary artery
PCI= percutaneous coronary intervention
SVG= saphenous vein graft

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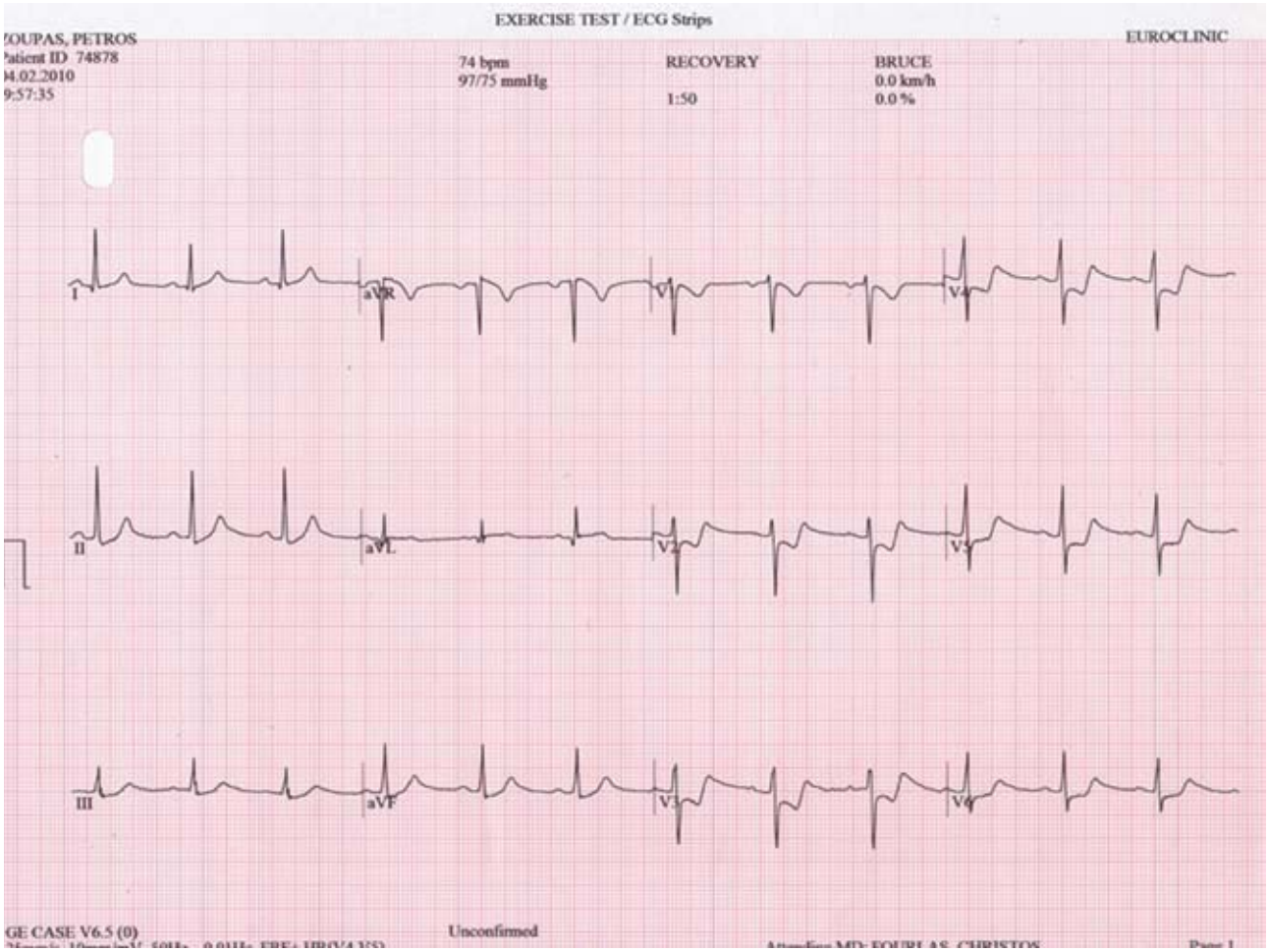

FIGURE 1. Marked ST segment depression from V2 to V6 ECG leads with a significant drop of arterial blood pressure 97/60 mmHg took place during a treadmill stress test on the first minute of recovery.

have a coronary angiogram on an urgent basis.

CORONARY ANGIOGRAPHY

The patient agreed and he was taken to the cath lab within the next one hour. The coronary angiogram showed distal left main stenosis of 60-70% extending in the proximal LAD, a 70% stenosis at the mid LAD (small vessel with vessel diameter 2 mm as measured by quantitative coronary angiography) (Fig. 2A), a 50% stenosis at the proximal segment of the left circumflex (LCx) (Fig. 2B), a patent radial graft anastomosed at the obtuse marginal (Fig. 2D), and complete absence of the LIMA (even after a contrast infusion with a pigtail catheter in the left subclavian artery) (Fig. 2C). We had a lot of difficulties to accomplish the procedure because of repeated "ventricularisation" of blood pressure when the catheter was inserted into the left main stem. Since left main and LAD seemed to be small in diameter, we performed an intravascular ultrasound (IVUS) run (Atlantis, Boston Scientific 40 MHz) using a motorized pullback system (0.5 mm/sec) in the LAD in order to determine the real size of the LAD and the left main and the real degree of stenosis. We defined the vessel size as the distance from media to media. At the mid part of LAD, the vessel was almost 3 mm in diameter and 3-3.5 mm in its proximal part (Fig. 3A and 3B, respectively). The most stenosed area lumen was measured at 2.4 cm^2 in the mid part with encroachment of the IVUS catheter and 3.3 cm^2 at the ostium (Fig. 3A and 3B, respectively). Left main was almost 4-4.5mm in diameter and the most stenosed area lumen area was 3.6 cm^2 at its distal part (Fig. 3C). Syntax score was 22, whereas logistic Euroscore was 4.46%. The patient was advised to consider redo CABG vs PCI of the left main and LAD and had extensive discussions with both interventional cardiologist and cardiac surgeon. The patient finally opted for the PCI procedure, which was performed 3 days later.

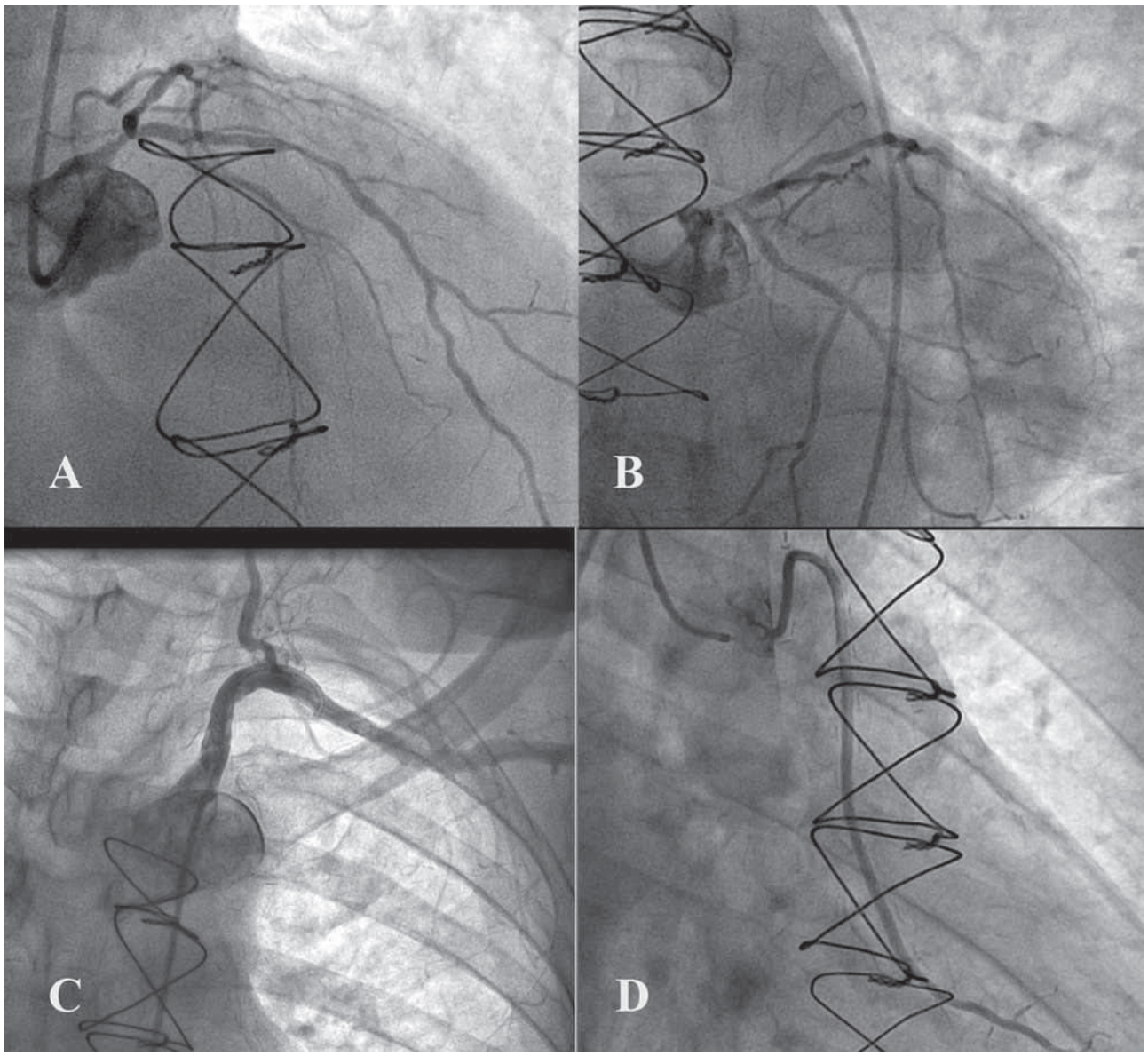

FIGURE 2. Coronary angiogram findings. **A**: Distal left main stenosis 60-70% extending in the proximal LAD, and a 70% stenosis at the mid LAD, **B**: A 50% stenosis at the proximal of LCx, **C**: Complete absence of left internal mammary artery (even after an infusion with a pigtail catheter in left subclavian artery) **D**: Patent radial graft anastomosed at the obtuse marginal.

PCI PROCEDURE

An EBU 3.5 6F guiding catheter was employed and the LAD and LCx were wired with BMW guidewires (Boston scientific). After predilating the lesion in the mid LAD (Riujin 2.5x15 mm, 12 atm), a stent (Promus, Boston Scientific 3.0x20 mm, 20 atm) was implanted with a very good result (Fig. 4A). Then another stent (Promus, Boston Scientific 3.5×28 mm, 20 atm) was implanted at the proximal LAD in order to cover from the proximal part of the previous implanted stent, with a 1mm overlapping area, to the ostium of the left main. The stent was inflated at 20 atm, while keeping the wire of the LCx jailed (Figure 4B). The result was very good but significant plaque shift towards the ostium of LCx occurred, causing a 70-80% stenosis with TIMI III flow. The LCx was re-wired with an ACS Whisper wire (Boston Scientific) and the ostial lesion was dilated with a balloon Riujin 3.0×15 mm resulting in a 10% residual stenosis. Then kissing ballooning was performed at the distal part of the left main using the prior Riujin 3x15mm balloon in the LAD and a new Riujin 2.0x15mm balloon in

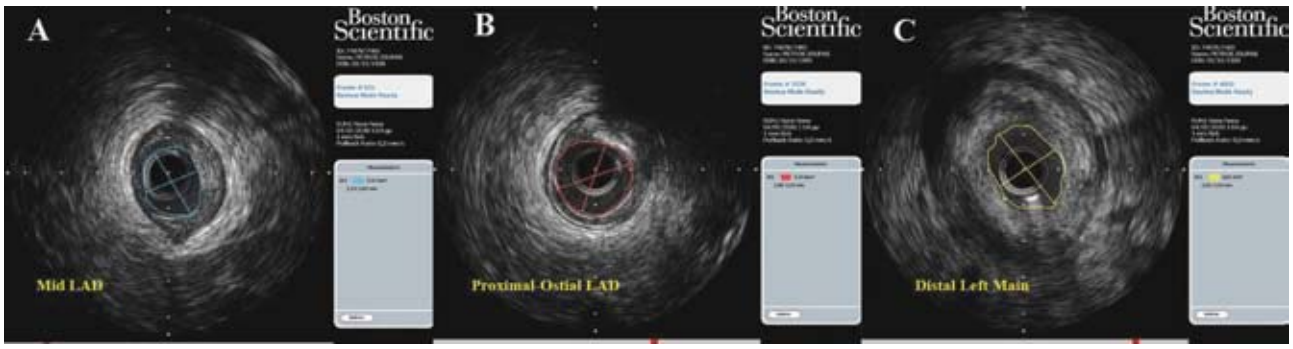

FIGURE 3. IVUS run in LAD. **A:** At the mid part of LAD, the vessel was almost 3mm in diameter and the most stenosed area lumen was measured 2.4 cm^2. **B**: At the ostial LAD the vessel was 3-3.5 mm in diameter and the lumen area was 3.3 cm^2. **C**: Left main was almost 4-4.5mm in diameter and the most stenosed lumen area was 3.6 cm^2 in its distal part.

the LCx, both inflated up to 12 atm (Fig. 4C). The procedure was concluded with post-dilating with non compliant balloons both the distal stent (Durastar 3.0x10mm, 20 atm) including the overlapping region, and the stent at the left main (Durastar 3.5x10mm, 20 atm), achieving a very good final result (Fig. 4D) which was checked with a final IVUS run. Tirofiban was infused during and after the procedure. We applied a closure device (Angioseal) and the patient was sitting at his chair comfortably 3 hours later. His post-procedural course was uneventful, and the patient remained at the hospital one more day before being discharged.

DISCUSSION

We present this case in order to emphasize mainly three issues that may arise in patients with an obstructed LIMA after CABG. Firstly, although usage of LIMA is an outstanding method of surgical revasularization, graft failure can occur and the size of the recipient vessel is a significant predictor of LIMA obstruction. Secondly, left main stenting in cases of LIMA obstruction represents a very good alternative, although many issues must be taken into account. Thirdly, IVUS can offer significant aid in cases of left main stenting.

The use of the LIMA graft and other arterial grafts has been an evolution in surgical revascularization in patients with coronary artery disease since LIMA has better long term patency rates as compared to saphenous vein grafts (SVGs). In the Veterans Affairs Cooperative Study Group[1,2] patency at 10 years was 61% for SVGs in 1,074 patients compared with 85% for LIMA grafts in 457 patients. If a vein graft was patent at 1 week, the 6-year patency rate was 76% and the 10-year patency rate was 68%. On the other hand, if a LIMA graft was patent at 1 week, the 6-year and the 10-year patency rates were 90% and 88%, respectively. Thus, the 10-year patency of LIMA grafts was found to be better than SVGs. However, the 10-year patency for SVGs was found better and the 10-year patency for LIMA grafts worse than expected. This finding underlines the fact that although LIMA grafting is a very reliable and efficient technique of CABG, it does not ensure a 100% patency rate. It is known that vessel size is the "Achilles' heel" of PCI, since it affects the outcome after coronary artery stenting with both bare metal stents and drug eluting stents (DES). The smaller the vessel the greater the restenosis rate both in bare metal[3] and DES[4]. However, it is noteworthy that in the latter study the best long-term predictors of graft patency were grafting into the LAD and grafting into a vessel that is >2.0 mm in diameter. In vessels >2.0 mm the 10-year patency was 88%, versus 55% in vessels with diameters <2.0 mm. For SVGs to the LAD, the 10-year patency was 90% for vessels >2.0 mm versus 52% for vessels <2.0 mm. For the LIMA, the 10-year patency was 100% for vessels >2.0 mm versus 82% for vessels <2.0 mm. Moreover in an older study[5], it has been shown that the diameter of the recipient vessel by angiographic measurement affects in-hospital mortality. It has been shown that vessel diameter is inversely associated with perioperative mortality related to CABG: 15.8% for 1.0-mm vessels, 4.6% for 1.5- to 2.0-mm vessels, and 1.5% for 2.5- to 3.5-mm vessels. In the case we present the angiographic diameter of the mid LAD anastomosed with the LIMA was <2 mm and this might be the cause of LIMA obstruction 6 years after the initial CABG operation. Thus, from this point of view, the small size of the recipient vessel constitutes a real problem not only for PCI but also for CABG.

Regarding the management of this patient, it could not obviously be based only on medical therapy, because he had a significantly diseased partially protected left main and LAD associated with the development of hemodynamic instability during the treadmill stress test. In this case significant amount of myocardium was at risk and the prognosis was expected to be poor. Several observational studies[6-8] initially demonstrated that patients with medically treated left main coronary artery

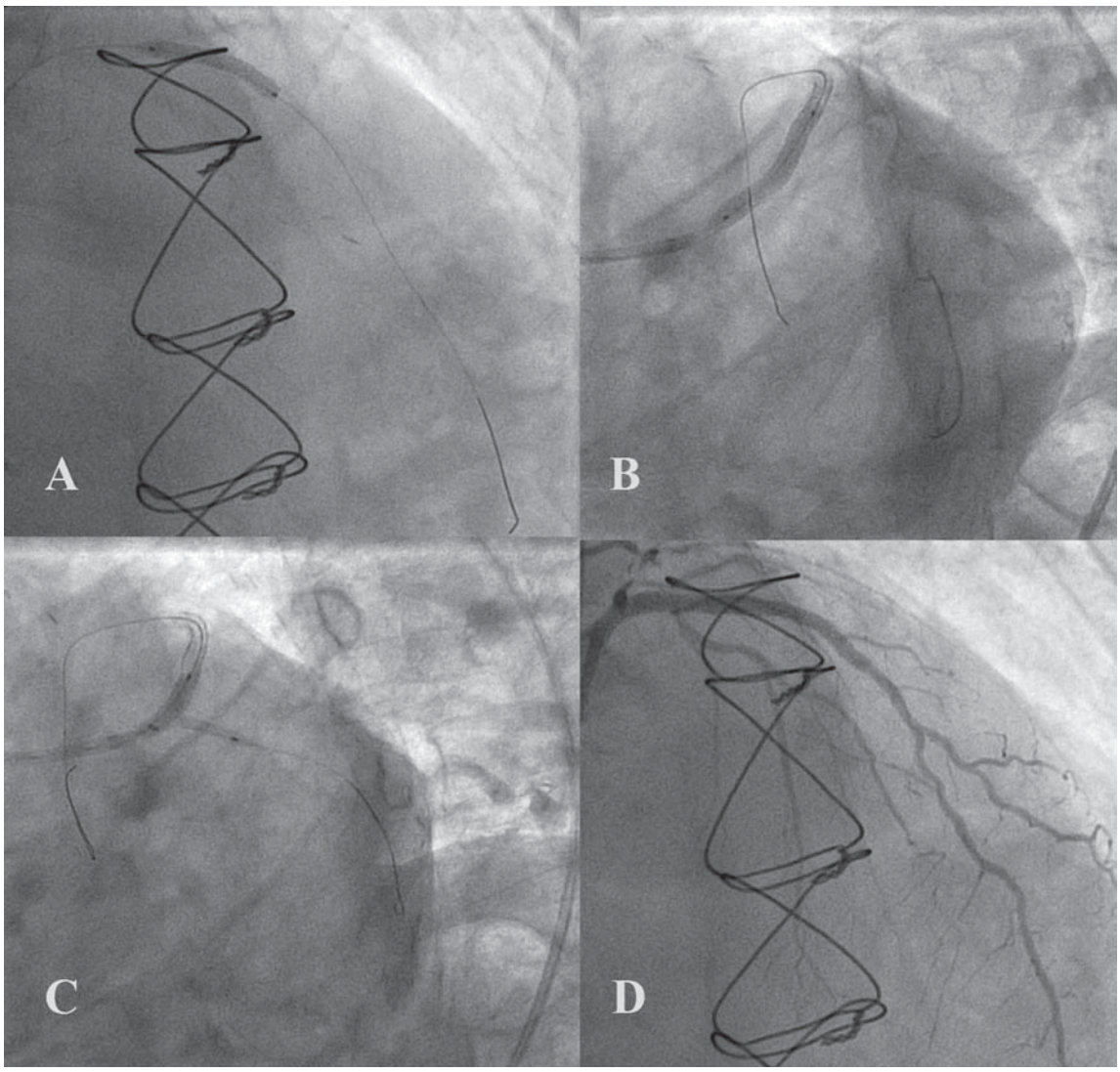

FIGURE 4. A: Stent implantation at mid LAD.**B**: Left main stenting. **C**: Kissing balloon inflation. **D**: Final result.

disease have 3-year survival rates of approximately 50%. Controlled trials comparing CABG with medical therapy[1,9,10] alone were initially performed in patients with stable angina and showed that surgical revascularization provided survival benefit to patients with >50% left main stenosis. In the Coronary Artery Surgery study[10], which included 1492 patients with left main disease, the 3-year survival rate was 91% for the surgical group and 69% for the medically-treated group. However, it should be reminded that in this cohort survival benefits were not observed in patients with mild-to-intermediate left main stenosis <60%, and normal left ventricular ejection fraction, since these patients had 3-year survival rate of >88%. From another point of view, this patient could be considered to belong in this group of patients, as the stenosis in the left main was angiographiaclly estimated to be around 60% and the ejection fraction of the left ventricle was normal. So it seems that the clinical "coin" has very often two faces. However, in all these studies the evaluation of the percentage of stenosed vessel lumen was based on quantitative coronary angiography, and not on IVUS data. It has been demonstrated and widely accepted that area lumen <4 cm^2 for the LAD and <5.9cm^2 for the left main - just as in the present case- are considered cut off points that define significant stenosis and predict poor long term outcome.

Practice guidelines regarding managing of patients with either graft failure of a previous CABG or protected left main stenting have not been published. Accordingly, in cases like the one presented herein, decision making is based on clinical considerations and on extrapolations from other guidelines, as we have no evidence-based data. In the published guidelines

for the management of patients with stable angina by ACC/AHA[11], it is recommended that repeat CABG should be performed in patients with multiple saphenous vein graft stenoses, with high-risk criteria on noninvasive testing, especially when there is significant stenosis of a graft supplying the LAD. PCI may be appropriate for focal saphenous vein graft lesions or multiple stenoses in poor candidates for reoperative surgery (class IIB, level of evidence C). Only one observational study presented data comparing medical and surgical treatment of patients with a history of CABG. That study showed that patients with late (>5 years after operation) stenoses in saphenous vein grafts had a better survival rate with reoperation than initial medical management, particularly if a stenotic vein graft supplied the LAD[12]. Patients with early (<5 years after operation) stenoses in vein grafts did not appear to have a better survival rate with reoperation, although their symptom status improved. Patients with multiple vein grafts with late stenoses or late stenoses in an LAD vein graft should have reoperation in the absence of major contraindications to surgery. Despite improvement in the procedure-related complications of PCI for vein graft stenoses by the use of coronary stents, stenting has not significantly decreased the incidence of restenosis in vein grafts[13] and is not an equivalent form of revascularization for patients with late vein-graft stenoses. The case we present is actually stenting of a partially protected left main, almost equivalent to diseased LAD with significant ostial stenosis. According to the guidelines for the management of patients with stable angina by ACC/AHA, PCI or CABG is recommended for patients with one-vessel disease with significant proximal LAD (class IIA, level of evidence C). In our case CABG and PCI are clearly equivalent alternatives.

However, although this is a case of a partially protected left main it should be kept in mind that left main is always a challenging revascularization target and PCI may be associated with a lot of technical difficulties. Moreover, it seems to make sense that long term prognosis regarding target lesion (TLR) or target vessel revascularization (TVR) after PCI in the left main must be unaffected by its protection status. Significant left main coronary artery (LMCA) disease has been found in 3% to 5% of all patients who undergo coronary angiography and in 10% to 30% of patients who undergo bypass surgery. Critical LMCA stenosis puts patients at high risk of cardiovascular events because of the extent of jeopardized myocardium and concomitant multivessel coronary artery disease. Once CABG became the standard of care for left main disease, a distinction between "protected"—by at least 1 patent bypass graft to the left coronary artery—and "unprotected left main"— no patent bypass graft to the left coronary artery—was made. In the 1980s, early attempts at balloon angioplasty of unprotected left main stenoses were associated with poor early outcomes because of coronary dissection, abrupt closure, and restenosis. Mortality rates as high as 30% at 1 year were reported[14-16] In the 1990s, bare metal stents were introduced and soon used to treat LMCA disease. Several small registries found a low rate of procedural complications, but the repeat revascularization rates of 20% to 30% because of restenosis were considered unacceptable[17-19]. Early bare metal stent registries for LMCA also found high mortality rates, particularly in high-risk patients, such as patients with acute coronary syndromes and poor left ventricular function. Importantly, high-risk subgroups often presented with late sudden death after stenting. In the early 2000s, the introduction of drug-eluting stents (DES), with the promise of significantly reduced rates of restenosis[20], raised the possibility of improved late outcomes in this challenging patient group.

Clinical outcomes after treatment of unprotected LMCA disease with either the sirolimus-eluting stent or the paclitaxel-eluting stent from >20 small registries have been published. Results reported in these registries vary widely[21-24]. Cardiac mortality 6 to 12 months after the procedure ranges from 0% to 11%. Target lesion revascularization (TLR) or TVR rates range from 2% to 38%. This wide variation in clinical outcome appears largely because of variation in both patient selection and procedural technique. The first large-scale randomized comparison of CABG versus DES for unprotected LMCA was the SYNTAX[25] (The SYNergy between percutaneous coronary intervention with TAXus and cardiac surgery) trial. This large trial contained a prespecified subgroup of 705 randomized unprotected left main patients. At 1-year follow-up, the combined safety end point of death, myocardial infarction, and stroke was nonsignificantly higher in CABG patients (7% versus 9.2%; p=0.29). Although the repeat revascularization rate was statistically worse in stent patients (12% versus 6.7%; *P*=0.002), these differences were modest.

In the present case intravascular ultrasound examination helped us to choose the stents according to the most appropriate dimension, and to decide about the strategy that we should follow for PCI in the left main artery. Since the conventional coronary angiogram is only a 'lumenogram' providing information on lumen size but offering little insight into lesion or plaque characteristics, exact evaluation of LMCA disease is sometimes difficult because of peculiar anatomic and hemodynamic factors such as large size, a short normal reference segment, overlapping of major vessels, streaming of contrast agent, and varied angulations. IVUS assessment before the procedure can not only detect significant stenosis but can also select the appropriate diameter and length of the stent [26]. Additionally, IVUS can be very helpful in optimally expanding the stent, with or without post-stent balloon dilatation to avoid under- or overstretch of the stent diameter[27]. Therefore, it seems that guidance by IVUS during LMCA stenting is of critical importance as compared with the use of IVUS in PCI treatment of other coronary lesions. It has been demonstrated[28] that elective stenting with IVUS guidance, especially in the case of drug-eluting stent placement, may reduce the long-term mortality rate for unprotected LMCA stenosis when

compared with conventional angiography guidance.

REFERENCES

1. Takaro T, Hultgren HN, Lipton MJ, et al. The VA cooperative randomized study of surgery for coronary arterial occlusive disease II. Subgroup with significant left main lesions. *Circulation* 1976;54:III107–III117.
2. Steven Goldman, Karen Zadina, Thomas Moritz, et al. Long-Term Patency of SaphenousVein and Left Internal Mammary Artery Grafts After Coronary Artery Bypass SurgeryResults From a Department of Veterans Affairs Cooperative Study. *JACC* 2004;44:11:2149–56.
3. Shpend Elezi, Adnan Kastrati, Franz-Josef Neumann, et al. Vessel Size and Long-Term Outcome After Coronary Stent Placement. *Circulation* 1998;98;1875-1880.
4. Shpend Elezi, Alban Dibra, Julinda Mehilli, et al. Vessel Size and Outcome After Coronary Drug-Eluting Stent Placement Results From a Large Cohort of Patients Treated With Sirolimus- or Paclitaxel-Eluting Stents.
5. Nancy J. O'Connor, Jeremy R. Morton, John D. Birkmeyer, et al. Effect of Coronary Artery Diameter in Patients Undergoing Coronary Bypass Surgery. *Circulation* 1996;93:652-655.
6. Lim JS, Proudfit WL, Sones FM. Left main coronary arterial obstruction: Long-term follow-up of 141 nonsurgical cases. *Am J Cardiol* 1975;36:131–135.
7. Campeau L CF, Crochet D, Petitclerc R. Left main coronary artery stenosis: the influence of aortocoronary bypass surgery on survival. *Circulation* 1978;57:1111–1115.
8. Conley MJ, Ely RL, Kisslo J, Lee KL, et al. The prognostic spectrum of left main stenosis. *Circulation* 1978;57:947–952.
9. Group ECSS. Long-term results of prospective randomized study of coronary artery bypass surgery in stable angina pectoris. *Lancet* 1982;320:1173–1180.
10. Chaitman BR, Fisher LD, Bourassa MG, et al. Effect of coronary bypass surgery on survival patterns in subsets of patients with left main coronary artery disease. Report of the Collaborative Study in Coronary Artery Surgery (CASS.) *Am J Cardiol* 1981;48:765–777.
11. ACC/AHA 2002 Guideline Update for the Management of Patients With Chronic Stable Angina. A Report of the American College of Cardiology/American Heart AssociationTask Force on Practice Guidelines (Committee to Update the 1999. Guidelines for the Management of Patients With Chronic Stable Angina). *J Am Coll Cardiol* 2003;41:159-68.
12. Lytle BW, Loop FD, Taylor PC, et al. The effect of coronary reoperation on the survival of patients with stenoses in saphenous vein bypass grafts to coronary arteries. *J Thorac Cardiovasc Surg* 1993;105:605-612.
13. Savage MP, Douglas JS Jr, Fischman DL, et al. Stent placement compared with balloon angioplasty for obstructed coronary bypass grafts. Saphenous Vein De Novo Trial Investigators. *N Engl J Med* 1997;337:740-7.
14. O'Keefe JH Jr, Hartzler GO, Rutherford BD, et al. Left main coronary angioplasty: early and late results of 127 acute and elective procedures. *Am J Cardiol* 1989;64:144–147.
15. Stertzer SH, Myler RK, Insel H, et al. Percutaneous transluminal coronary angioplasty in left main stem coronary stenosis: a five-year appraisal. *Int J Cardiol* 1985;9:149–159.
16. Tommaso CL, Vogel JH, Vogel RA. Coronary angioplasty in high-risk patients with left main coronary stenosis: results from the National Registry of Elective Supported Angioplasty. *Cathet Cardiovasc Diagn* 1992;25:169–173.
17. Takagi T, Stankovic G, Finci L, et al. Results and long-term predictors of adverse clinical events after elective percutaneous interventions on unprotected left main coronary artery. *Circulation* 2002;106:698–702.
18. Park SJ, Hong MK, Lee CW, et al Elective stenting of unprotected left main coronary artery stenosis: effect of debulking before stenting and intravascular ultrasound guidance. *J Am Coll Cardiol* 2001;38:1054–1060.
19. Silvestri M, Barragan P, Sainsous J, et al. Unprotected left main coronary artery stenting: immediate and medium-term outcomes of 140 elective procedures. *J Am Coll Cardiol* 2000; 35:1543–1550.
20. Stone GW, Ellis SG, Cox DA, et al.TAXUS-IV Investigators. A polymer-based, paclitaxel-eluting stent in patients with coronary artery disease. *N Engl J Med* 2004;350:221–231.
21. Chieffo A, Park SJ, Valgimigli M, et al. Favorable long-term outcome after drug-eluting stent implantation in non-bifurcation lesions that involve unprotected left main coronary artery: a multicenter registry. *Circulation* 2007;116:158–162.
22. Valgimigli M, van Mieghem CA, Ong AT, et al. Short- and long-term clinical outcome after drug-eluting stent implantation for the percutaneous treatment of left main coronary artery disease:insights from the Rapamycin-Eluting and Taxus Stent Evaluated At Rotterdam Cardiology Hospital registries (RESEARCH and T-SEARCH). *Circulation* 2005;111:1383–1389.
23. Erglis A, Narbute I, Kumsars I, et al. A randomized comparison of paclitaxel-eluting stents versus bare-metal stents for treatment of unprotected left main coronary artery stenosis. *J Am Coll Cardiol* 2007;50:491–497.
24. Chieffo A, Morici N, Maisano F, et al. Percutaneous treatment with drug-eluting stent implantation versus bypass surgery for unprotected left main stenosis: a single-center experience. *Circulation* 2006;113:2542–2547.
25. Serruys PW, Morice M-C, Kappetein AP, et al for the SYNTAX Investigators. PCI versus CABG for severe coronary artery disease. *N Engl J Med* 2009:360:10:961-72.
26. Nissen SE, Yock P. Intravascular ultrasound: novel pathophysiological insights and current clinical applications. *Circulation* 2001;103:604–616.
27. Mintz GS. Features and parameters of drug-eluting stent deployment discoverable by intravascular ultrasound. *Am J Cardiol* 2007;100(supplement 2):S26–S35.
28. Seung-Jung Park, Young-Hak Kim, Duk-Woo Park, et al. Impact of intravascular ultrasound guidance on long-term mortality in stenting for unprotected left main coronary artery stenosis. *Circ Cardiovasc Intervent* 2009;2:167-177.