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Left main disease management strategy: Indications and revascularization methods in particular groups of subjects

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Abstract

Surgical revascularization with coronary artery by-pass grafting is still recommended in vast majority of patients with unprotected left main disease. The aim of the paper was to analyze optimal treatment of left main disease in selected groups of patients, on the basis of current guidelines and information gained from literature data. We focused on data in relation to treatment of elderly patients, diabetics and those hemodynamically unstable. Additionally we discussed the issue of anti-platelet therapy and informed consent. As far as efficacy of treatment is concerned, not only method of revascularization but also general condition of the patient, the factors influencing peri-operative risk and optimal pharmacotherapy should be taken into account. Therefore establishment of the heart team is crucial when choosing the most suitable method of invasive treatment of left main disease. (Cardiol J 2012; 19, 4: 347–354)

Key words: left main disease, cardiac surgery, percutaneous coronary intervention, revascularization

Introduction

Surgical revascularization with vascular grafts is recommended for vast majority of patients with unprotected significant left main coronary artery stenosis (ULMS) which is also called unprotected left main disease (ULMD). Then surgery is indicated for the treatment of symptoms and for better prognosis. Technical progress in interventional cardiology and cardiac surgery, implementation of new generation of anti-proliferative drug eluting stents (DES) and correct monitoring of anti-platelet therapy lead to deeper analysis of the problem. Today, best treatment strategy is chosen not only on the basis of coronarography result but also assessment of the overall cardiovascular risk, co-morbid conditions and estimation of long term prognosis.

The aim of this article was to discuss the best ULMD strategy among particular group of patients, according to latest recommendations and researches' findings.

Methods

This review article was carried out as an descriptive epidemiological study. Data from Medline database published till June 2011 were retrospectively analyzed. Key words used for searching were as follows: left main, left main disease, treatment, coronary surgery, percutaneous coronary intervention (PCI), and combination of the aforementioned. English papers were included only.

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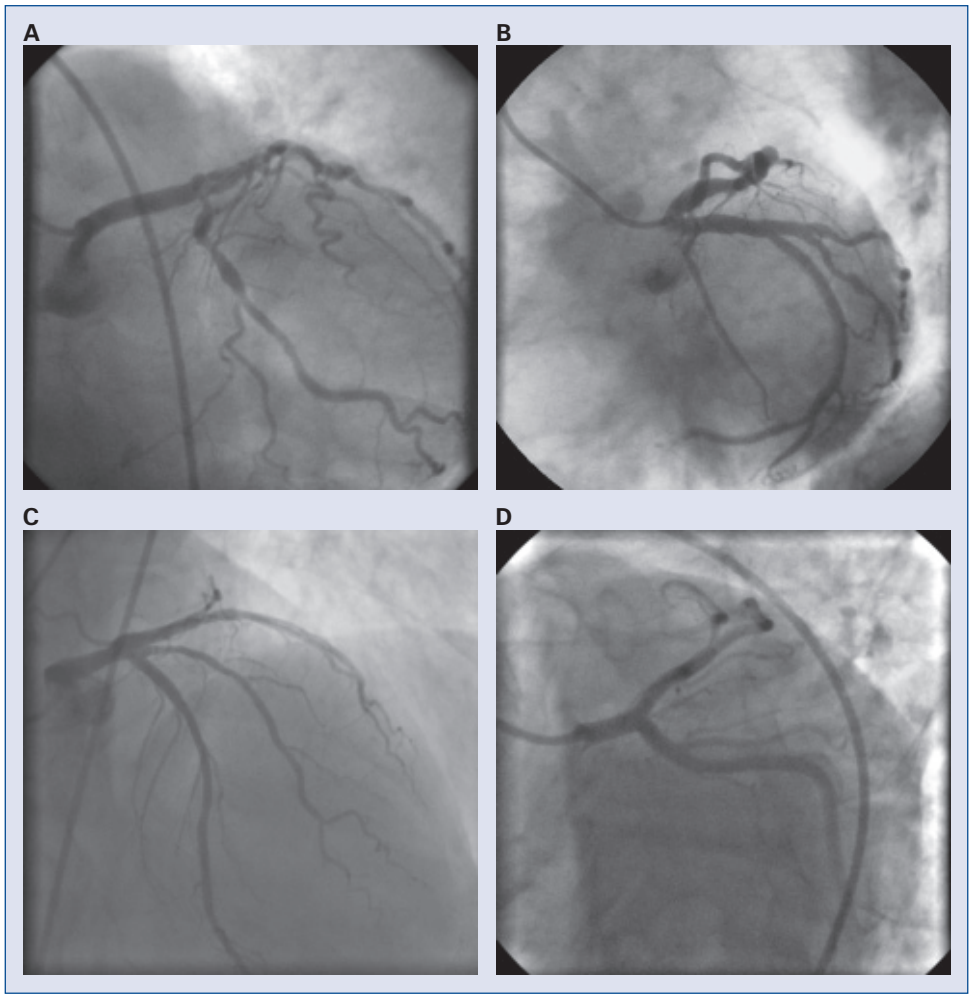

Figure 1. Morphology of left main; **A.** Long left main; **B.** Short left main; **C.** Trifurcation of left main with intermediate artery; **D.** Bifurcation of left main.

Coronary artery anatomy

Left main coronary artery (LM, LMCA) arising from the left sinus of Valsalva is a first branch of the aorta. Usually its diameter is 3.5–4.5 mm and length is 10–14 mm, and it braches into left anterior descent artery (LAD) and circumflex artery (Cx) (Fig. 1). Among 22% of population additional artery arises at the bifurcation of the LM artery, forming a trifurcation; third artery is called intermediate artery (IM) [1]. It is estimated that 0.4% of population lacks LM and both arteries arise from separates origins of the aorta [2]. LM varies in length and shape. In the Zein's research based on angio-computed tomography with 3D reconstruction four types of LM were distinguished: biconcave shape, tapering morphology, complex morphology and funnel type [3]. Ellipsoid shape in cross section of ostial, medial and distal part of LM was found in 94%, 73% and 77% of patients, respectively [3].

Significant left main stenosis

Significant LMCA stenosis (LMS) which is also called left main disease (LMD) is defined as a reduction of at least 50% in the luminal diameter of the LMCA. LMD is diagnosed in approximately 4–6% of patients undergoing coronarography and among 1/3 of patients referred to coronary artery by-pass grafting (CABG). Stenosis is located ostially, medially or in the bifurcated part in 29%, 19%, 54% of subjects, respectively (Fig. 2). LMD is rarely presented as an isolated lesion (which concerns 6–8% of coronary patients) but usually (in 70–90%) coexists with multivessel disease. LMD is more often related to the proximal than the distal part, frequently placed in the bifurcation and in more than 50% of cases that are heavily calcified [4]. Among patients suffering from diffuse atherosclerotic artery disease LMD is present in 5–9% of the cases. Isolated LMD is then described in 0.5–1% of those

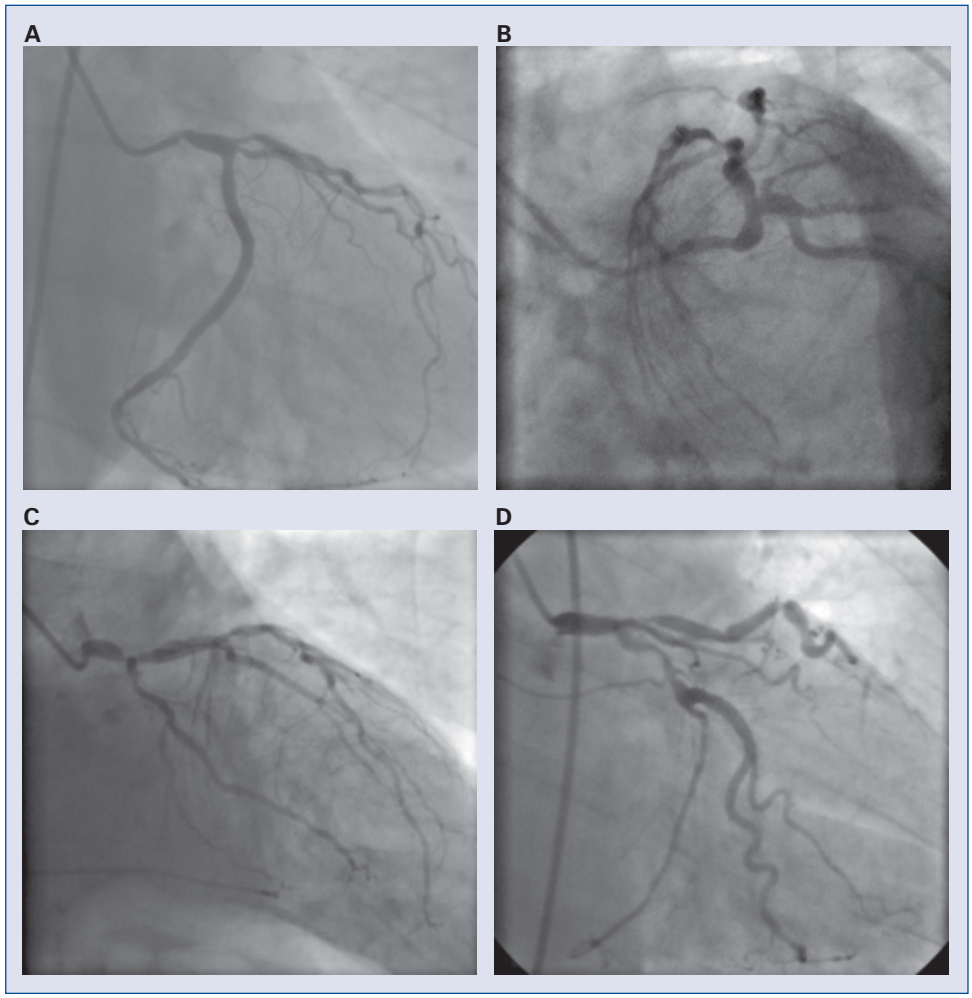

Figure 2. Left main disease; **A.** Ostial lesion; **B.** Mid-shaft lesion; **C.** Distal lesion; **D.** Lesion located at bifurcation.

subjects [5]. Unprotected LMCA refers to the vessel without any previous intervention, namely without previous by-pass grafting or stenting history.

Current guidelines of left main disease treatment

According to the European Society of Cardiology (ESC) guidelines from 2006 and American Heart Association/American College of Cardiology (AHA/ACC) guidelines from 2009, ULMD was an absolute indication for surgical revascularization, regardless of other arteriosclerotic lesions, both to alleviate the symptoms (I A) and prognosis improvement (I A). The guidelines recommended LMCA angioplasty only in the condition when surgery is not manageable (II b/C), and for the rest of the cases as alternative revascularization method with a III B class recommendation [6–8].

This approach was based on randomized trials results, in which pharmacological vs. invasive treatment (namely balloon angioplasty and bare metal stent [BMS] implantation techniques) were compared. Based on those data, CABG was superior for successful treatment for symptoms of angina pectoris. CABG is a well documented and save procedure with low prevalence of complications and development of less invasive techniques helps to reduce time of hospitalization and costs [9, 10]. Furthermore, it should be kept in mind that left internal mammary artery used as an arterial graft is patent in the 90% of subjects in a 10-year follow-up, along with survival and angina symptoms remission [11].

ESC and AHA/ACC guidelines were rather skeptic for the use of percutaneous interventions as methods of treatment of coronary patients. Despite attempt to balloon angioplasty followed by BMS implantation this approach was abandoned

in ULMD due to unacceptable high risk of restenosis [12].

DES implantation may be risky due to acute stent thrombosis which can result in sudden cardiac dead in 40% of the patients, if occurred [13–15]. Therefore DES long-term safeness was been recently investigated. It was especially important to assess the risk of late stent thrombosis, which may have catastrophic implications in patients treated for ULMD. According to a multicenter registry of 731 individuals who underwent PCI with DES implantation the risk of thrombosis was 0.95% after 30 months [16]. Similar results were published by Meliga et al. [17] who described the 3-year risk ratio of 0.6%, 1.1% and 44% for definite, probable and possible thrombus formation, respectively. Percutaneous revascularization is also believed to be superior in patients with high risk of operation (e.g. porcelain aorta), patients with contradictions to operation who do not profit from surgery or when CABG is not available and emergency revascularization is necessary [8].

Despite those above-mentioned concerns, Food and Drug Administration (FDA) estimate that 60% of DES are used off-label mainly for LMD revascularization which is associated with higher early and late stent thrombosis (with annual incidence of 1–5%) as well as with higher risk of myocardial infarction (MI) and cardiac death [18].

In 2010 ESC Working Group and European Association for Cardio-thoracic Surgery released up-to-date guidelines in which recommendations for treatment of stable coronary disease and acute coronary syndromes (ACS) are presented [19]. In stable patients LM stenosis (isolated or with bi- or trivessel disease) with low peri-operative risk of death and patient eligibility for either CABG or PCI, CABG is strongly indicated (I/A). PCI may be considered in the case of significant contradictions to cardiac surgery or patients preferences (IIb/B). Among patients classified to high risk (SYNTAX score ≥ 33) with LMD and multivessel disease, PCI is not recommended (III/B) [19].

It is worth to notice that those recommendations were modified based on SYNTAX results and new comparisons between CABG and PCI with antiproliferative DES [20–22]. It has been documented that the risk of death and major adverse cardiac and cerebro-vascular events (MACCE) is greatest in patients with the highest SYNTAX score. Moreover, in patients with the most advanced lesions (third tertile, i.e. SYNTAX score > 33 points) death and MACCE occurred significantly more frequently in PCI than CABG group (for MACCE after 1 year: 23% vs. 10.9%, and after 2 years: 28.2% vs. 15.4%, after 3 years: 34.1% vs. 19.5% ($p < 0.001$ for all). In addition, after 3 years of observation, the difference in MACCE between PCI and CABG in patients with a SYNTAX score of 23–32 points (second tertile) was also statistically significant (27.4% vs. 18.9%, $p = 0.02$).

Compared to the previous ESC guidelines (saying that ULMD stenting should only be considered if no other revascularization treatment is possible) the current recommendations and researches indicate that by favorable anatomical conditions LMCA stenting procedure can be performed successfully in patients with stable coronary artery disease (CAD). Early and late outcomes are not worse, moreover, in selected groups of patients (SYNTAX score < 23 points) can be superior to surgical treatment [6, 19, 23].

Also updated ACCF/AHA guidelines suggest that PCI is only an alternative method of revascularization in carefully selected patients, particularly to improve survival (Ia/C) [24, 25]. Controversies include possibility of treating lesions located distally in bifurcation or trifurcation which are suitable for cardiologist with a grater degree of experience and expertise [24]. Use of a Heart Team approach has been recommended in cases in which the choice of revascularization is not straightforward, including all ULMD and complex CAD cases [24, 25]. Calculation of the Society of Thoracic Surgeons and SYNTAX scores which is reasonable in patients with ULMD and complex CAD, is a class IIa recommendation [25]. In the treatment of patients with STEMI, when possible, the interventional cardiologist and cardiac surgeon should decide together on the optimal form of revascularization for these subjects, although it is recognized that these patients are usually critically ill and therefore not amenable to a prolonged deliberation or discussion of treatment options [24, 25]. Therefore one ought to be cautious choosing treatment of ULMD with PCI (IIa/C) [25].

Effect of a clinical profile of patients on prognosis

No useful algorithm which would facilitate the selection of type of revascularization on the basis of baseline cardiovascular risk and estimated prognosis has been established yet. Rademacher et al. [26] analyzed the usefulness of risk stratification according to EuroSCORE algorithm in patients with ULMD undergoing PCI. They found that EuroSCORE is useless in estimating the risk of 30-day complications but it can be useful for the evalua-

tion of a long-term death risk. The risk of death in a 9-month follow-up was almost 3-fold higher in patients with EuroSCORE > 5 (28.8%) patients compared to those with lower EuroSCORE (10.3%). Studies that assessed treatment with PCI or CABG revealed that EuroSCORE may be an independent predictor of MACCE but plays a minor role in determining optimal treatment strategy [26, 27]. White et al. [28] in a cohort of patients undergoing PCI ULMD or CABG showed that a 30-month survival without occurrence of an adverse endpoint (MACCE) was significantly worse in patients with the highest baseline risk estimated by the Parsonnet scale (i.e. > 15 points), while the overall mortality was significantly higher in patients undergoing PCI with a high risk of Ellis classification (category IV).

The Society of Thoracic Surgeons (STS) scale allows to estimate peri-operative risk of such complications as mortality, stroke, kidney failure, prolonged mechanical ventilation or infection accurately. It was verified only among surgical patients but could become a useful diagnostic tool to choose the appropriate method of revascularization, if verified in PCI LMD group [29].

Left main disease revascularization in particular groups of patient

On the basis of a 20-year follow-up of patients with critical LMS undergoing CABG surgery at the Cleveland Clinic in the years 1971–1998, it has been proven that the survival was 72% but was significantly lower in patients with reduced ejection fraction (< 60%), diabetes, hypertension, peripheral atherosclerosis, smoking habit, and with elevated levels of triglycerides [30]. Risk for repeated revascularization was 39% and was significantly greater in younger patients, those with elevated levels of triglycerides and incomplete CABG revascularization.

Diabetics

Diabetes is an equivalent of coronary heart disease and worsens prognosis in patients with ischemic heart disease, regardless of the type of treatment. Patients with diabetes undergoing CABG have a greater risk of MACCE (particularly restenosis) compared with those without diabetes [31–33]. In addition, those patients have more advanced changes in coronary vessels (higher SYNTAX score) and in case of ULMD they are often placed in the vessel's distal segment. Kim et al. [32] demonstrated that the risk of repeated revascularization in diabetic patients undergoing PCI is almost 6-folds higher than in the CABG group (respectively: 11.2% and 2%). Also, Hlatky et al. [34] in their meta-analysis confirmed that for diabetic patients CABG is superior to PCI in terms of survival and the incidence of repeated revascularization. The mortality in a 5-year follow-up was higher in the PCI group (20%) than in the CABG group (12.3%) with odds ratio 0.7 (95% CI 0.56–0.87). Additionally, in a 3-year observation, Meliga et al. [35] showed that in diabetic patients undergoing PCI of ULMD with DES MACCE incidence was higher compared to non-diabetic control group (36.6% vs. 22.4%, respectively). More information are provided by the results of a 6-year follow-up of the Stent or Surgery Trial, which documented that the risk of repeated revascularization is more than 5-folds higher in diabetic patients undergoing PCI compared with CABG (hazard ratio — HR of 5.25) [36]. Similar effect was observed for mortality rates (HR = 3.11). In the cited study, however, only 1% of patients had LMD. Data from the 1-year SYNTAX follow-up of diabetic patients with LMD and/or 3-vessel disease showed higher risk of MACCE among those treated with PCI compared with CABG (14.2% vs. 26%, $p = 0.003$) and significantly higher rate of repeated revascularization (11.1% vs. 4.1%, $p < 0.001$) [37]. Mortality among diabetic individuals compared to those without diabetes was significantly higher, regardless of the revascularization method: for PCI they were 8.4% and 3.0%, respectively, and for CABG: 6.4% vs. 2.6%. Moreover, among diabetic LMD patients mortality was higher for those treated with PCI than CABG (13.5% vs. 4.1%, $p = 0.04$).

Elderly

In the light of available data it can be assumed that the use of DES or CABG as a treatment for ULMD in the elderly is comparable according to survival. The results of a 2-year follow-up with a study group of people aged at least 75 years demonstrated similar mortality between CABG and DES groups (CABG: 17%, DES: 18%), even after taking into account confounding effect of co-morbidities [38]. In this study, statistically significant direct predictors of death were: ACS (HR = 2.33), peripheral vascular disease (HR = 3.05), low ejection fraction (HR = 0.96) and the risk estimated by EuroSCORE algorithm (HR = 1.26 per point increase) or the Parsonnet's scale (HR = 1.08 per point increase). It is worth to notice that the use of DES was associated with 8-folds higher risk of repeat revascularization in a DES group (CABG: 3%, DES: 25%).

Additional results were published by Rhodes-Cabaua et al. [39] who observed no difference in the incidence of cardiac death (CABG: 30.3%, PCI: 34.9%) and the overall MACCE incidence (CABG: 35.2%, PCI: 43.3%) in a 2-year follow-up of 249 patients aged ≥ 80 years with ULMD. In this work, the only predictor of MACCE was EuroSCORE, regardless of the revascularization type (HR = 1.17 per point increase).

Hemodynamically unstable patients/in cardiogenic shock

Interesting data come from results of a 8-year observation of patients with ACS and ULMD in the GRACE study [40]. Both, the 30-day and 6-month mortality were significantly higher in patients undergoing PCI compared to surgical revascularization: for a 30-day follow-up: 11% vs. 5.4% and in a 6-month observation: 5.4% vs. 1.6%. Also the 6-month incidence of MI was 7-folds higher (4.8% and 0.7%), and repeated revascularization was 2-folds more frequent (23% and 11.1%) in the ULMD group after PCI compared to CABG.

In 164 patients with LMD presenting symptoms of shock in the course of MI the benefit of surgical revascularization compared with PCI was also demonstrated [41]. Despite similar clinical profile (gender, age, co-morbidities, hemodynamic parameters), a 30-day survival in CABG group was 54%, while in the PCI group it was only 14%. The benefit was clear despite the significant time discrepancies between onset of MI/cardiogenic shock and revascularization, which was longer for surgical patients. Those surgical patients may also benefit from longer use of intra-aortic balloon counter-pulsation if only there are no contraindications and risk of complications is low. The authors also conclude that patients undergoing CABG benefited from full revascularization, which was achieved in 95% of patients. Moreover, favorable prognosis may come from use of cardioplegia and cardiac protection during cardiopulmonary bypass. That's why CABG is superior to PCI in unstable patients with ULMD.

Important results come from Failure in Left Main Study (FAILS) study that examined the incidence of adverse events among 70 patients undergoing CABG or PCI due to in-stent restenosis in LMCA [42]. Interestingly, MACCE occurred in 14.3% of CABG patients and in 25.4% of those after PCI with DES, and in 50% of patients receiving pharmacotherapy only. Death from any cause occurred in 5.1% patients after PCI, but no death was noticed after CABG. A new restenosis with the need of target vessel revascularization occurred in 14.3% of patients after CABG and 22% of patients after PCI even if all patients received anti-platelet treatment after ULMD revascularization.

Appropriate anti-platelet treatment undoubtedly has impact on successful PCI treatment of ULMD [43, 44]. According to current standards, anti-platelet therapy in patients undergoing PCI should remain double with acetylsalicylic acid (ASA) (COX-2 inhibitor) and adenosine receptor antagonist, and its duration is not clearly specified [44]. After BMS implantation the treatment should last at least 3 months (in the case of ACS — 12 months) and after DES implantation a mandatory period of treatment is 12 months. Those patients who underwent surgical revascularization, even in the case of LMD, in order to maintain the by-pass patency are only obliged to receive ASA (150 mg indefinitely). The additional use of adenosine receptor antagonist is rather limited and with unproven efficacy. Time frames presented above, however, are not so obvious in patients with PCI of ULMD. Lifelong use of double anti-platelet therapy is postulated due to high risk of restenosis (especially in BMS) and late thrombosis (especially in DES).

For those reasons, the use of such a radical pharmacotherapy is not in doubt. Palmerini et al. [45] in a cohort of patients after PCI-LMD showed that most adverse events occurred in patients who had used dual therapy for less than 6 months and the risk of death due to acute cardiac events were more than 4-folds higher during the first 90 days after discontinuation of clopidogrel, compared with the later period of discontinuation. But on the other hand, Chieffo et al. [16] demonstrated that the use of dual anti-platelet therapy does not necessarily prevent the occurrence of stent thrombosis; at the time of the incident all subjects received ASA and clopidogrel, according to the recommendations. In the study, determinants of thrombosis were as follows: unstable angina (OR = 3.25), low ejection fraction (OR = 1.26) and EuroSCORE (OR = 1.18 per point increase). In patients receiving dual anti-platelet therapy after DES implantation, Park et al. [46] found no benefit from the treatment lasting over 12 months. Additionally, it is revealed that prolonged use of two agents significantly increases the risk of bleeding, including gastrointestinal hemorrhage and concomitant use of certain proton pump inhibitors (especially omeprazole) may alleviate the desired anti-aggregative effect [47, 48]. Dual therapy may also be a problem for patients with bleeding diathesis. Complex anti-platelet therapy, especially in a 12-month period (or even longer) also

generates significant costs (due to limited reimbursement of clopidogrel), and at the same time may impair cooperation between doctor and patient (i.e. patient compliance and persistence). It is also worth to mention a study of Migliorini et al. [49] who assessed the impact of high residual platelet activity (HRPR) on prognosis in patients with ULMD undergoing PCI with a loading dose of 600 mg of clopidogrel. They found that the presence of high residual activity after PCI increased risk of death due to infarction in a 3-year follow-up (HRPR: 28.3% and LRPR: 8%) and increased risk of stent thrombosis (HRPR: 16% and LRPR: 4.2%). In the face of the presented data and due to the absence of clear standards, one logical option is to optimize therapy by use of regularly repeated platelets resistance tests [50].

Informed patient consent

An important point in choosing ULMD treatment strategy is to obtain conscious informed consent of the patient. First of all, one must inform the patient that the recommended method of revascularization is a surgical technique because we have strong evidence of its long-term effectiveness and safety. Undeniably, one need to explain to the patient the risks of both methods of treatment, including trauma of procedures, risk of death and other cardiac (MI, restenosis, the need of re-intervention) and non-cardiac (bleeding, renal failure, vascular problems, stroke) complications. CABG which is more invasive treatment, should be contrasted with its documented long-term benefits, what might be difficult to explain to a patient. Patients should also realize several facts: the background of the coronary heart disease, the fact that revascularization with the use of CABG or PCI is only the treatment of symptoms, he must receive a live-long pharmacological treatment (ASA, clopidogrel, statin, beta-blocker, ACE inhibitor etc.) and lifestyle modification. It is reasonable to remind the patient the need of coronary angiography in future (preferably with intravascular ultrasound), especially after PCI [44]. In light of current data, non-invasive angio-computed tomography can be performed alternatively [43, 51].

Summary

Coronary artery by-pass surgery remains the gold standard of treatment of patients with unprotected LMD. PCI may be considered in a vast minority of individuals. However considering aforementioned data, it should be emphasized that the long-term effectiveness and safety of the revascularization procedure is determined not only by the method but also by baseline cardiovascular risk, general condition of the patient, co-existing morbidity. The latter may increase the risk of complications even if optimal pharmacotherapy is applied. Therefore establishment of the heart team is crucial when choosing the most suitable method of invasive treatment of LMD.

Conflict of interest: none declared

References

1. Cadermartiri F, La Grutta L, Malago R et al. Prevalence of anatomical variants and coronary anomalies in 543 consecutive patients studied with 64-slice CT coronary angiography. Eur Radiol, 2008; 18: 781–791.
2. Topaz O, DiSciasio G, Cowley MJ et al. Absent left main coronary artery: angiographic findings in 83 patients with separate ostia of the left anterior descending and circumflex arteries at the left aortic sinus. Am Heart J, 1991; 122: 447–452.
3. Zeina A R, Resenschein U, Barmeir E. Dimensions and anatomic variations of left main coronary artery in normal population: Multidetector computed tomography assessment. Coron Artery Dis, 2007; 18: 477–482.
4. Ragosta M, Dee S, Sarembock IJ et al. Prevalence of unfavorable angiographic characteristics for percutaneous intervention in patients with unprotected left main coronary artery disease. Catheter Cardiovasc Interv, 2006; 68: 357–362.
5. Thompson R. Isolated coronary ostial stenosis in women. J Am Coll Cardiol, 1986; 7: 997–1003.
6. Fox K, Garcia MA. Guidelines on management of stable angina: executive summary. The task force on the management of stable angina pectoris of the European Society of Cardiology. Eur Heart J, 2006; 27: 1341–1381.
7. Gibons R J, Abrams J, Chatterjee K et al. ACC/AHA 2002 guideline update for the management of patients with chronic stable angina. www.acc.org/clinical/guidelines/stable/.
8. Patel MR, Dehmer GJ, Hirshfeld JW et al. ACCF/SCAI/AATS/ /AHA/ASNC 2009 Appropriateness criteria for coronary revascularization. J Am Coll Cardiol, 2009; 53: 530–553.
9. Rao C, Aziz O, Panesar S et al. Cost effectiveness analysis of minimally invasive internal thoracic artery bypass versus percutaneous revascularisation for isolated lesion of the anterior descending artery. BMJ, 2007; 334:621–627.
10. Aziz O, Rao C, Oanesar S et al. Meta-analysis of minimally invasive internal thoracicartery bypass versus percutaneous revascularisation for isolated lesion of the left anterior descending artery. BMJ, 2007; 334, 617–623.
11. Goy JJ, Jaufmann U, Hurni M et al. 10-year follow-up of a prospective, randomized trial comparing bare-metal stenting with internal mammary grafting for proximal, isolated de novo left anterior coronary artery stenosis: the SIMA (Stenting versus Internal Mammary Artery grafting) Trial. J Am Coll Cardiol, 2008; 52: 815–817.
12. Topol E J, Leya F, Pinkerton CA et al. A comparison of directional atherectomy with coronary angioplasty in patients with coronary artery disease. The CAVEAT Study Group. N Engl J Med, 1993; 329: 221–227.
13. Shemin RJ. Coronary artery bypass grafting versus stenting for unprotected left main coronary artery disease: where lies the body of proof? Circulation, 2008; 118: 2326–2329.
14. Garg P, Mauri I. The conundrum of late and very late stent thrombosis following drug-eluting stent implantation. Curr Opin Cardiol, 2007; 22: 565–571.
15. Taggart DP. Coronary artery bypass graft vs. percutaneous coronary angioplasty; CABG on the rebound? Curr Opin Cardiol, 2007; 22: 517–523.

16. Chieffo A, Park SJ, Meliga E et al. Late and very late stent thrombosis following drug-eluting stent implantation in unprotected left main coronary artery: A multicentre registry. Eur Heart J, 2008; 29: 2108–2115.
17. Meliga E, Garcia-Garcia HM, Valgimigli M et al. Longest available clinical outcomes after drug-eluting stent implantation for unprotected left main coronary artery disease: The DELFT (Drug Eluting stent for LeFT main) registry. J Am Coll Cardiol, 2008; 51: 2212–2219.
18. Farb A, Boam AB. Stent thrombosis redux: The FDA perspective. N Engl J Med, 2007; 356: 984–987.
19. Wijns W, Kolh P, Danchin N et al. Guidelines on myocardial revascularization. The task force on myocardial revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). Eur Heart J, 2010; 31: 2501–2555
20. Kappetein P. The SYNTAX trial: Three-year outcome. www.syntaxscore.com. 2010.
21. Serruys PW, Morice MC, Kappetein AP et al. Percutaneous coronary intervention versus coronary-artery bypass grafting for severe coronary artery disease. N Engl J Med, 2009; 360: 961–972.
22. Capodanno D, Capranzano P, Di Salvo ME et al. Usefulness of SYNTAX Score to select patients with left main coronary artery disease to be treated with coronary artery bypass graft. J Am Coll Cardiol Interv, 2009; 2: 731–738.
23. Min SY, Park DW, Yun SC et al. Major predictors of long-term clinical outcomes after coronary revascularization in patients with unprotected left main coronary disease: analysis from the MAINCOMPARE study. Circ Cardiovasc Interv, 2010; 3: 127–133.
24. Hillis LD, Smith PK, Anderson JL et al. 2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery. A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. Developed in collaboration with the American Association for Thoracic Surgery, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons. J Am Coll Cardiol, 2011; 58: e123–e210.
25. Levine GN, Bates ER, Blankenship JC et al. 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention. A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. J Am Coll Cardiol, 2011; 58: e44–e122.
26. Rademacher W, Knape A, Schumm J et al. Acute and long-term outcome of unprotected left main coronary angioplasty compared to the anticipated surgical risk. Interact Thorac Cardiovasc Surg, 2008; 7: 871–877.
27. Rodes-Cabau J, Deblois J, Bertrand OF et al. Nonrandomized comparison of coronary artery bypass surgery and percutaneous coronary intervention for the treatment of unprotected left main coronary artery disease in octogenarians. Circulation, 2008; 118: 2374–2381.
28. White AJ, Kedia G, Mirocha JM et al. Comparison of coronary artery bypass surgery and percutaneous drug-eluting stent implantation for treatment of left main coronary artery stenosis. J Am Coll Cardiol Cardiovasc Interv, 2008; 1: 236–45.
29. Shahian DM, O'Brien SM, Filardo G et al. The Society of Thoracic Surgeons. 2008 cardiac surgery risk models. Part 1: Coronary artery bypass grafting surgery. Ann Thorac Surg, 2009; 88: S2–S22.
30. Sabik JF 3rd, Blackstone EH, Firstenberg M, Lytle BW. A benchmark for evaluating innovative treatment of left main coronary disease. Circulation, 2007; 116 (suppl.): I232–I239.
31. Group BARI 2D Study. A randomized trial of therapies for type 2 diabetes and coronary artery disease. N Eng J Med, 2009; 360: 2503–2515.
32. Kim WJ, Park DW, Yun SC et al. Impact of diabetes mellitus on the treatment effect of percutaneous or surgical revascularization for patients with unprotected left main coronary artery disease: A subgroup analysis of the MAIN-COMPARE study. J Am Coll Cardiol Interv, 2009; 2: 956–963.
33. Kim LJ, King SB III, Kent K et al. Factors related to the selection of surgical versus percutaneous revascularization in diabetic patients with multivessel coronary artery disease in the BARI 2D (Bypass Angioplasty Revascularization Investigation in Type 2 Diabetes) trial. J Am Coll Cardiol Interv, 2009; 2: 384–392.
34. Hlatky MA, Boothroyd DB, Bravata DM et al. Coronary artery bypass surgery compared with percutaneous coronary interventions for multivessel disease: A collaborative analysis of individual patient data from ten randomised trials. Lancet, 2009; 373: 1190–1197.
35. Meliga E, Garcia-Garcia HM, Valgimigli M et al. Diabetic patients treated for unprotected left main coronary artery disease with drug eluting stents: a 3-year clinical outcome study. The diabetes and drug eluting stent for LeFT main registry (D-DELFT). EuroIntervention, 2008; 4: 77–83.
36. Investigators Stent or Surgery Trial. Coronary artery bypass surgery versus percutaneous coronary intervention with stent implantation in patients with multivessel coronary artery disease (the Stent or Surgery trial): A randomised controlled trial. Lancet, 2002; 360: 965–970.
37. Banning AP, Westaby S, Morice AC et al. Diabetic and nondiabetic patients with left main and/or 3-vessel coronary artery disease. J Am Coll Cardiol, 2010; 55: 1067–1075.
38. Palmerini T, Barlocco F, Santarelli A et al. A comparison between coronary artery bypass grafting surgery and drug eluting stent for the treatment of unprotected left main coronary artery disease in elderly patients (aged > or =75 years). Eur Heart J, 2007; 28: 2714–2719.
39. Rodes-Cabau J, DeBlois J, Bretrand OF et al. Nonrandomized comparison of coronary artery bypass surgery and percutaneous coronary intervention for the treatment of unprotected left main coronary artery disease in octogenarians. Circulation, 2008; 118: 2374–2381.
40. Montalescot G, Brieger D, Eagle KA et al. GRACE Investigators: Unprotected left main revascularization in patients with acute coronary syndromes. Eur Heart J, 2009; 30: 2308–2317.
41. Lee MS, Tseng CH, Barker CM et al. Outcome after surgery and percutaneous pntervention for cardiogenic shock and left main disease. Ann Thorac Surg, 2008; 86: 29–34.
42. Sheiban I, Sillano D, Biondi-Zoccai G et al. Incidence and management of restenosis after treatment of unprotected left main disease with drug-eluting stents 70 restenotic cases from a cohort of 718 patients: FAILS (Failure in Left Main Study). J Am Coll Cardiol, 2009; 54: 1131–1136.
43. Anderson JL, Adams CD, Antman EM et al. ACC/AHA 2007 Guidelines for the Management of Patients With Unstable Angina/Non-ST-Elevation Myocardial Infarction. J Am Coll Cardiol, 2007; 50: e1–e157.
44. Smith SC Jr, Allen J, Blair SN et al. AHA/ACC guidelines for secondary prevention for patients with coronary and other atherosclerotic vascular disease: 2006 update endorsed by the National Heart, Lung, and Blood Institute. J Am Coll Cardiol, 2006; 47: 2130–2139.
45. Palmerini T, Sangiorgi D, Marzocchi A et al. Ostial and midshaft lesions vs. bifurcation lesions in 1111 patients with unprotected left main coronary artery stenosis treated with drug-eluting stents: results of the survey from the Italian Society of Invasive Cardiology. Eur Heart J, 2009; 30: 2087–2094.
46. Park SJ, Park DW, Kim YH et al. Duration of dual antiplatelet therapy after implantation of drug-eluting stents. N Engl J Med, 2010; 362: 1374–1382.
47. Bhatt DL, Fox KA, Hacke W et al. CHARISMA Investigators. Clopidogrel and aspirin versus aspirin alone for the prevention of atherothrombotic events. N Eng J Med, 2006; 354: 1706–1717.
48. Gilard M, Arnaud B, Cornily JC et al. Influence of omeprazole on the antiplatelet action of clopidogrel association with aspirin. J Am Coll Cardiol, 2008; 51: 256–260.
49. Migliorini A, Valenti R, Marcucci R et al. High residual platelet reactivity after clopidogrel loading and long-term clinical outcome after drug-eluting stenting for unprotected left main coronary disease. Circulation, 2009; 120: 2214–2221.
50. Wilczyński M, Bochenek T, Goral J et al. Bridging by eptifibatide on patients with acute stent thrombosis, requiring urgent surgical revascularization: Report of 2 cases. Kardiol Pol, 2009; 67: 1313–1316.
51. Achenbach S. Computed tomography coronary angiography. J Am Coll Cardiol, 2006; 48: 1919–1928.