

Hybrid coronary revascularization in multivessel coronary artery disease: what is the real role of the technique?

Revascularização híbrida na doença coronária multiarterial: qual é o verdadeiro papel da técnica?

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ABSTRACT – The best treatment option for patients with complex multivessel coronary artery disease remains uncertain. In association with optimal medical therapy, coronary artery bypass graft surgery and percutaneous coronary intervention have been compared over the past decades. Hybrid coronary revascularization applies the best of both strategies, aiming at complete revascularization and lower rates of major adverse cardiovascular events. The technique comprises the use of left internal mammary artery connected to the left anterior descending artery, combining off pump and minimally invasive direct coronary artery bypass with percutaneous coronary intervention to right coronary artery and circumflex artery territories. This review aims to analyze the indications, patient selection, technical aspects, available data in the literature and perspectives of this interesting revascularization strategy.

Keywords: Coronary artery disease; Percutaneous coronary intervention/methods; Myocardial revascularization

RESUMO – A melhor opção de tratamento para pacientes com doença coronária multiarterial complexa continua incerta. Em associação com ótimos tratamentos clínicos, a cirurgia de revascularização do miocárdio e a intervenção coronária percutânea têm sido comparadas ao longo das últimas décadas. A revascularização coronariana híbrida aplica o melhor das duas estratégias, visando à completa revascularização e a menores taxas de eventos cardiovasculares adversos maiores. A técnica consiste no uso de uma ponte da artéria mamária interna esquerda para a artéria descendente anterior, combinando revascularização miocárdica com cirurgia minimamente invasiva, sem circulação extracorpórea, com intervenção coronária percutânea, para os territórios das artérias coronária direita e circunflexa. Esta revisão pretende analisar as indicações, a seleção de pacientes, os aspectos técnicos, os dados disponíveis na literatura e as perspectivas desta interessante estratégia de revascularização.

Descritores: Doença das artéria coronariana; Intervenção coronária percutânea/métodos; Revascularização miocárdica

BACKGROUND

The best treatment option for patients with complex multivessel coronary artery disease (MVD) remains uncertain. In association with optimal medical therapy, coronary artery bypass graft surgery (CABG) and percutaneous coronary intervention (PCI) have been compared over the past decades. But many important individual variables, such as angiographic complexity, diabetes, left ventricle function, age and surgical risk stratification, usually make physicians and patients individualize the final decision for each case, despite all data available in guidelines and trials.

CABG remains as the main treatment option for patients with complex MVD, according to the SYNTAX trial,¹ with better long-term outcomes regarding death, acute myocardial infarction (MI) and target lesion revascularization (TLR). However, surgery is usually more related to higher morbidity and stroke rates, as well as longer hospital stay. On the other hand, PCI can bring the patient back to its normal life earlier,

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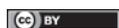
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but higher incidence of TLR and stent thrombosis, leading to acute MI, have been observed in the long-term clinical follow-up.

Hybrid coronary revascularization (HCR) plays an important role in this scenario. It was initially described by Angelini et al.² and Mack et al.³, in 1996 and 1997, respectively, and introduced in the American Heart Association/American College of Cardiology (AHA/ACC) updated guidelines for coronary artery bypass grafting surgery, in 2011.⁴ By definition, the technique comprises the use of left internal mammary artery (LIMA) connected to the left anterior descending artery (LAD), combining off pump and minimally invasive direct coronary artery bypass (MIDCAB) with percutaneous coronary intervention (PCI) to right coronary artery and circumflex territories. The surgical approach may include robotic-assisted procedures, small left thoracotomy and partial sternotomy.

WHY HYBRID? THE RATIONALE OF THE METHOD

The rationale of the method is very interesting, applying the best of both worlds, aiming at complete revascularization and lower rates of major adverse cardiovascular events (MACE) through:

- Long-term proved efficacy of LIMA-LAD (patency of approximately 98%, in 10 years),⁵⁻⁷ without the potential problems of prolonged cardiopulmonary bypass and sternotomy incision.
- Percutaneous coronary intervention with second generation drug eluting stents, which proved to be more safe and effective when compared with the first approved devices,^{8,9} and probably have better or equal results when compared to saphenous vein grafts.¹⁰ The latter present higher atherosclerotic degeneration rates and probability of long-term failure, with graft occlusion rates of roughly 20% in the first year, 30% at 10 years, and nearly 70% at 15 years.¹⁰⁻¹⁵

PATIENT SELECTION

Ideally, the candidates for HCR should be evaluated and treated by the institutional Heart Team. Clinically this patient should be at a clinical high risk stratification profile for conventional CABG with mid-sternotomy on pump, and have no contraindications to prolonged dual antiplatelet therapy (DAPT). From the angiographic point of view, a complete revascularization must always be the final goal. Usually the patient should have a complex lesion at the proximal segment of the LAD (chronic total occlusions, very tortuous and calcified anatomy) and good distal anatomy feasible to LIMA-LAD graft, associated with right (RCA) and left coronary artery (LCX) amenable to PCI.

CURRENT APPLICATION AND TECHNICAL ISSUES

Controversially the technique appears not to be commonly used at daily practice, with an incidence of only 0.48% of the current revascularization procedures in the United States.¹⁶ There are different reasons for such low applicability, but apparently it is mainly due to requirement of specialized training and of the specific learning curve of surgeons on minimally invasive approaches; moreover, there is little practical interaction among interventional cardiologists and cardiac surgeons.

Other important aspects of the HCR that can limit its use are where and how the procedures are performed. Regular operating rooms, cath labs or hybrid rooms (HR), and one-time or staged procedures (first, surgery or PCI?) have been discussed in many published studies and none of the techniques proved to be superior to the others. The AHA/ACC guidelines recommend the surgical step first.

The most attractive approach appears to be a one-time procedure, with surgery followed by PCI, at a HR. The potential benefits and disadvantages of each method are listed in table 1.

Table 1. Technical aspects of hybrid coronary revascularization strategy

HCR method	Advantages	Disadvantages
1 stop	PCI for high-risk non-LAD lesions can be performed with a protected LAD LIMA-LAD patency can be checked by angiography Possibility of making new grafts in case of stent failure Lower hospitalization period and cost Patient satisfaction	Hybrid room availability Higher bleeding risk Risk of contrast induced nephrotoxicity Higher risk of stent thrombosis caused by inflammatory response to surgery Dependent on a very close interaction between interventional cardiologists and cardiac surgeons
2 stops: MIDCAB first, and PCI second	DAPT can be used without risk of bleeding during the surgical act Angiographic validation of the LIMA-LAD graft	Risk of ischemic events at RCA and LCX territories during LAD grafting Higher cost Longer period of hospitalization
2 stops: PCI first, and MIDCAB second	Useful in cases of acute coronary syndromes when the culprit lesion is not on LAD Grafts can be done in case of PCI failure	Higher bleeding risk during the following surgical act Higher risk of stent thrombosis caused by inflammatory response to surgery

HCR: hybrid coronary revascularization; PCI: percutaneous coronary intervention; LAD: left anterior descending artery; LIMA: left internal mammary artery; DAPT: dual antiplatelet therapy; RCA: right coronary artery; LCX: left circumflex coronary artery.

CURRENT EVIDENCE

Many publications from single centers have reported experiences of approximately 3,500 patients,¹⁷ and most of them with matched cohorts compared to conventional CABG.

The first dedicated meta-analysis¹⁶ was published in 2014, and did not show any significantly statistical differences regarding hard endpoints (death, myocardial infarction or repeat revascularization) at 1-year clinical follow-up. In 2015, Panoulas et al.¹⁸ published interesting data showing that one-stage HCR procedure was the most frequent strategy, with a mean age of approximately 60 years, majority of the patients being male, with diabetes and normal left ventricle ejection fraction. The clinical risk stratification scores (EuroSCORE and Society of Thoracic Surgeons – STS) were low, and the angiographic profile (SYNTAX Score) was intermediate to high, varying from 22.3 to 33.5. The mortality rates differed widely in all studies, going from zero to 22.3% at the highest SYNTAX Score group.¹⁷

Only two studies^{19,20} reported angiographic follow-up, with binary in-stent restenosis and thrombosis rates of 9% to 13% and 2.2% to 3.7%, respectively, using first generation drug eluting stents. At 3-year follow-up, patients submitted to HCR had higher TLR rates compared with conventional CABG. Comparing long-term survival and major adverse cardiovascular events (5 years) of patients undergoing HCR or CABG, by means of the propensity score matching, similar mortality rates were observed. There are controversial data when stratifying the population according to the SYNTAX Score. Shen et al.²¹ demonstrated no difference between both strategies regarding MACE, when the score was higher than 30. On the other hand, Leache et al.¹⁷ demonstrated that conventional CABG is preferred in 30-day follow-up in patients with SYNTAX Score >32, related to survival (100% vs. 77%; $p=0.003$) and MACE (5% vs. 30%; $p=0.015$).

The POLMIDES (Prospective Randomized Pilot Study Evaluating the Safety and Efficacy of Hybrid Revascularization in Multivessel Coronary Artery Disease)²² was the first randomized clinical trial published comparing 200 consecutive patients submitted to HCR (MIDCAB and PCI with second generation DES) vs. CABG. There was no difference in 1-year follow up considering all-cause mortality (CABG 2.9% vs. HCR 2.0%; $p=NS$) and MACE-free survival rates (CABG 92.2% vs. HCR 89.9%; $p=0.54$).

CONCLUSIONS AND PERSPECTIVES

As stated by Gosev and Diegeler,^{23,24} the clinical benefits of hybrid coronary revascularization over classical coronary artery bypass surgery have not been proved in any publication. It appears to be feasible in a specifically subgroup of patients, but there are several issues to be clarified.

In association with the POLMIDES, the MERGING (Myocardial Hybrid Revascularization Versus Coronary artery Bypass Grafting for Complex Triple-vessel Disease; NCT02226900) study is another prospective randomized clinical trial with complex multivessel coronary artery patients, which compares HCR (two-stage procedure and second generation drug eluting stents) and CABG. The enrollment phase has been concluded and the 1-year clinical follow-up results are expected to be published in 2019.

Unless the overall patient outcomes, logistic and financial implications of HCR would be better than for conventional CABG alone in the long-term, HCR will continue to play a limited role in coronary revascularization.

SOURCE OF FINANCING

None.

CONFLICTS OF INTEREST

The authors declare there are no conflicts of interest.

CONTRIBUTION OF AUTHORS

Conception and design of the study: VBCE and PALN; data collection: VBCE and PALN; data interpretation: VBCE and PALN; text writing: VBCE and PALN; approval of the final version to be published: VBCE and PALN.

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