

# Revascularization Options

## Coronary Artery Bypass Surgery and Percutaneous Coronary Intervention



A. Pieter Kappetein, MD, PhD<sup>a,\*</sup>,  
Nicolas M. van Mieghem, MD<sup>b</sup>, Stuart J. Head, PhD<sup>a</sup>

### KEYWORDS

- Coronary artery bypass grafting • Percutaneous coronary intervention • Three-vessel disease
- Left main disease • SYNTAX score • Revascularization

### KEY POINTS

- The SYNTAX score is an independent predictor of adverse events of patients undergoing percutaneous coronary intervention (PCI).
- Comorbidities play an important role in predicting the clinical outcome after coronary artery bypass grafting (CABG).
- Decision making regarding the best mode of revascularization (PCI or CABG) should take place in a multidisciplinary heart team discussion, with a noninterventional/clinical cardiologist, interventional cardiologist, and cardiovascular surgeon.

### INTRODUCTION

Coronary artery disease (CAD) is the leading cause of death globally. Revascularization with coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI) are options for patients presenting with angina pectoris on optimal medical therapy. However, the choice of the most appropriate revascularization modality is controversial in some patient groups. The first saphenous vein bypass from the ascending aorta to the anterior descending coronary artery was performed in the 1960s by Kolesov and Favaloro.<sup>1</sup> This was the start of CABG, whereas PCI was first performed in 1977 by Dr Grüntzig, who opened a coronary lesion in the left anterior descending artery with a distensible balloon. During the last decade both technologies have undergone major

advances. PCI started with balloon angioplasty followed by bare metal stents (BMS) and later with drug eluting stents (DES). Together with antiplatelet and antithrombotic treatments, the outcome of PCI has improved by reducing adverse events, in particular repeat revascularization. CABG has also progressed with the use of more arterial grafts, improvements in cardiopulmonary bypass, myocardial protection, improved perioperative care, and optimizing medical treatment after surgery.<sup>2</sup> However, randomized studies have never been able to show that off-pump CABG techniques optimize outcome compared with on-pump techniques.<sup>3,4</sup>

In the United States approximately 3700 individuals per million adults undergo revascularization with PCI, whereas 1100 per million adults undergo

<sup>a</sup> Department of Cardiothoracic Surgery, Thoraxcenter Erasmus MC, PO Box 2040, Rotterdam 3000 CA, The Netherlands; <sup>b</sup> Department of Cardiology, Thoraxcenter Erasmus MC, PO Box 2040, Rotterdam 3000 CA, The Netherlands

\* Corresponding author. Department of Thoracic Surgery, Erasmus Medical Center, Room BD 569, PO Box 2040, Rotterdam 3000 CA, The Netherlands.

E-mail address: [a.kappetein@erasmusmc.nl](mailto:a.kappetein@erasmusmc.nl)

CABG. The number of patients undergoing CABG is decreasing, whereas the number of PCI procedures has remained constant.<sup>5</sup>

Randomized trials have attempted to determine which of the techniques is superior. Special subgroups of patients, including those with unprotected left main disease, multivessel disease, diabetes mellitus, and left ventricular dysfunction have been studied.

## CLINICAL TRIALS COMPARING CABG VERSUS PCI

Over the past 2 decades, almost 30 randomized controlled trials have investigated CABG versus PCI. At first, CABG was compared with balloon angioplasty, then with BMS, and most recently with DES. The Synergy Between Percutaneous Coronary Intervention With Taxus and Cardiac Surgery (SYNTAX) trial is one of the most important trials that randomized patients to CABG or PCI with DES.<sup>6</sup> The SYNTAX trial was an all-comers trial for patients with either left main disease or 3-vessel CAD. Participants deemed suitable for both CABG and PCI with paclitaxel-eluting stents by a heart team (surgeon and interventional cardiologist) were eligible for randomization. A total of 1800 patients were enrolled in the randomized arm and if patients could not be randomized they were enrolled in a CABG-ineligible PCI registry ( $n = 198$ ) or PCI-ineligible CABG registry ( $n = 1077$ ).<sup>7</sup> The primary end point of the study was major adverse cardiac and cerebrovascular events (MACCE) and the hypothesis was that PCI would be noninferior to CABG at 1 year. However, MACCE was significantly lower following CABG compared with PCI (12.4% vs 17.8%;  $P = .002$ ) and the primary hypothesis was rejected. Patients in the CABG group had more strokes compared with patients undergoing PCI, whereas patients in the PCI group had a higher rate of repeat revascularization.<sup>6</sup> After 5 years of follow-up MACCE were 26.9% in the CABG group and 37.3% in the PCI group ( $P < .0001$ ). Compared with CABG, PCI had significantly higher rates of myocardial infarction (9.7% vs 3.8%;  $P < .0001$ ) and repeat revascularization (13.7% vs 25.9%;  $P < .0001$ ). Rates of all-cause death (11.4% in the CABG group vs 13.9% in the PCI group;  $P = .10$ ) and stroke (3.7% vs 2.4%;  $P = .09$ ) were not significantly different between groups.<sup>8</sup>

An important tool derived from the SYNTAX study was the SYNTAX score, an anatomic scoring system, based on the coronary angiogram, which quantifies lesion complexity. The SYNTAX score was created with preexisting classifications, which included the American Heart Association (AHA)

classification of coronary artery tree segments modified for the Arterial Revascularization Therapy Study (ARTS), the Leaman score, the American College of Cardiology (ACC)/AHA lesion classification system, the total occlusion classification system, the Duke and International Classification for Patient Safety (ICPS) classification system for bifurcation lesions, and a consensus opinion from experts.<sup>9</sup> The SYNTAX score was designed to quantify the complexity of left main or 3-vessel disease. Using the online calculator (<http://www.syntaxscore.com>) it is possible to determine each patient's SYNTAX score (Fig. 1). The SYNTAX score proved to be an independent predictor of MACCE in patients undergoing PCI but not CABG. The 5-year results of the SYNTAX study showed that, in patients with intermediate (22–32) or high ( $\geq 33$ ) SYNTAX scores, MACCE was significantly increased with PCI (intermediate score, 25.8% of the CABG group vs 36.0% of the PCI group,  $P = .008$ ; high score, 26.8% vs 44.0%,  $P < .0001$ ). However, the drawback to this score is that it does not take into consideration the comorbidities of the patient. For this reason, the SYNTAX II score has been developed as a decision-making tool that combines the SYNTAX score with various clinical factors.

The Future Revascularization Evaluation in Patients with Diabetes Mellitus: Optimal Management of Multivessel Disease (FREEDOM) trial compared PCI with CABG in patients with diabetes and multivessel coronary disease and the composite primary 5-year end point of death, stroke, or myocardial infarction occurred less frequently in the CABG group than in the PCI group (18.7% vs 26.6%;  $P = .005$ ). Stroke rates were significantly higher in the CABG group than in the PCI group (5.2% vs 2.4%;  $P = .03$ ).<sup>10</sup> The results of the diabetic population of the SYNTAX study also favored CABG in most patients: 5-year rates were significantly higher for PCI versus CABG for MACCE (PCI 46.5% vs CABG 29.0%;  $P < .001$ ) and repeat revascularization (PCI 35.3% vs CABG 14.6%;  $P < .001$ ).

The decision to undertake CABG or PCI should be made collaboratively (the so-called heart team approach) by cardiac surgeons and cardiologists<sup>11</sup> from an assessment of an individual patient's coronary disease pattern, comorbidities, and risk of complications.

## MULTIVESSEL DISEASE

Most (70%) coronary revascularizations concern patients with multivessel disease. After the start of CABG it became clear that the treatment was successful in relieving angina. It was more difficult

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