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CURRENT OPINION

The year in cardiology 2018: coronary interventions

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Preamble

Percutaneous coronary intervention research emphasizes appropriate patient and lesion selection, as well as optimal, tailored procedural technique, and pharmacotherapy. The current review summarizes the new clinically relevant evidence in this field from selected studies published in 2018.

Introduction

The field of percutaneous coronary intervention (PCI) continues to evolve with improved devices and treatment strategies. Percutaneous coronary intervention research emphasizes appropriate patient and lesion selection as well as the technical aspects of the procedure. Increasing evidence of the usefulness of physiological assessment and intracoronary imaging supports its further integration into optimal daily practice. Improved acute and long-term safety with individualized pharmacotherapy and prevention of acute kidney injury are actively pursued. This manuscript summarizes selected data from the most important PCI studies published in 2018 (*Take home figure*).

New guidelines and recommendations

In 2018, the 3rd edition of the joint European Society of Cardiology (ESC) and European Association for Cardio-Thoracic Surgery (EACTS) guidelines on myocardial revascularization provided updated recommendations[1] as compared with the 2014 edition (*Figure 1*). The key messages include the need to achieve complete revascularization in multivessel coronary artery disease (MVD) in patients with acute (ACS) and chronic (CCS) coronary syndromes. The SYNTAX (Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery) score is strongly recommended to gauge the anatomical complexity of coronary artery disease (CAD). Both anatomical complexity and presence of diabetes mellitus are proposed as the main determinants of the relative benefits of PCI and coronary artery bypass grafting (CABG), as illustrated in *Figure 2*. In line with the previous recommendations, Heart Team consultation is encouraged to select the best revascularization strategy in complex cases. Combined angiographic and physiological guidance provides the best outcomes while sparing unnecessary stent implantation. The radial artery (RA) approach and drug-eluting stent (DES) implantation are considered preferred practice by default.[1]

The 4th Universal Definition of Myocardial Infarction (MI)[2] introduced new concepts including differentiating MI from myocardial injury. The document underlines the value of cardiac magnetic resonance (CMR) for imaging confirmation of myocardial injury and reviews clinical scenarios associated with myocardial injury vs. infarction.

The Academic Research Consortium-2 (ARC-2) consensus document[3] provided standardized endpoint definitions for PCI trials. Academic Research Consortium-2 encourages the use of device-oriented and patient-oriented composite endpoints in clinical trials to provide additional statistical power to detect potentially meaningful differences between investigational treatments.

Revascularization for chronic coronary syndromes: medical only, percutaneous coronary intervention, and coronary artery bypass grafting

In most patients with CCS, myocardial revascularization primarily aims to decrease symptoms compared with guideline-

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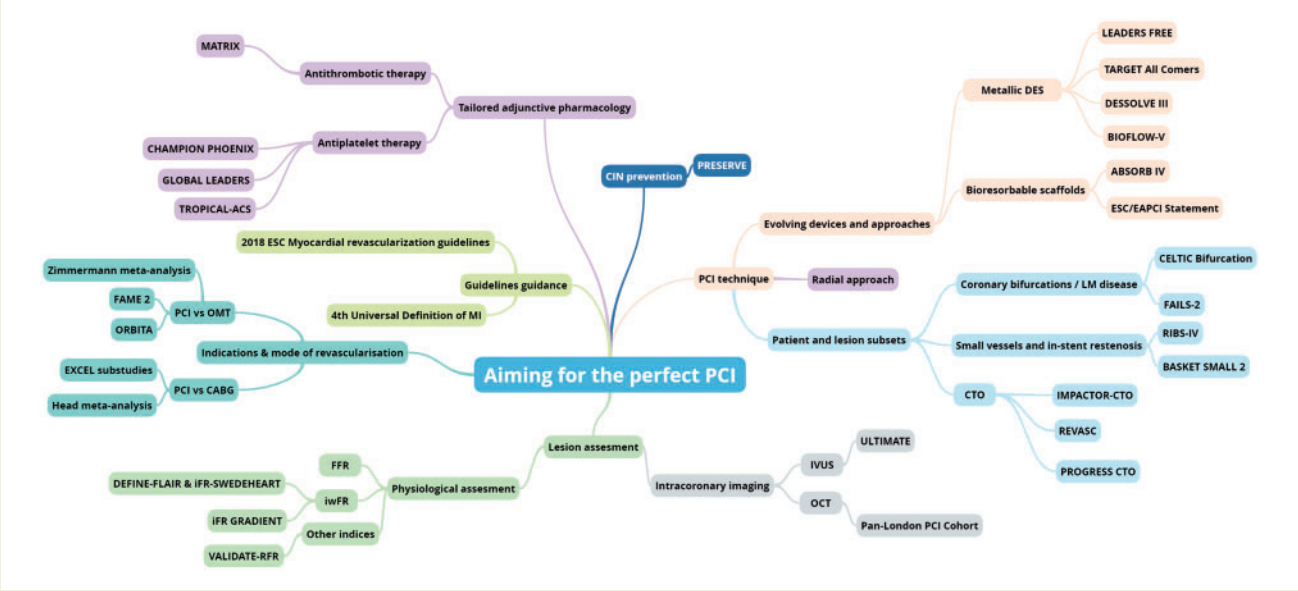


Take home figure A few of the important trials performed in 2018 that may guide contemporary practice are shown. This representation is by no means meant to be all-inclusive. CABG, coronary artery bypass grafting; CIN, contrast-induced nephropathy; CTO, chronic total occlusion; DES, drug-eluting stent; FFR, fractional flow reserve; IVUS, intravascular ultrasound; iwFR, instantaneous wave-free ratio; MI, myocardial infarction; OCT, optical coherence tomography; OMT, optimal medical therapy; PCI, percutaneous coronary interventions.

recommended optimal medical therapy (OMT). The sham-controlled ORBITA (The Objective Randomised Blinded Investigation with Optimal Medical Therapy of Angioplasty in Stable Angina) study[4] evaluated the incremental effect of PCI over optimal pharmacotherapy on exercise tolerance in patients with CCS due to single-vessel disease and preserved left ventricular function. After 6 weeks of pharmacotherapy optimization, 200 patients with mild-moderate symptoms were randomly assigned to either PCI (105 patients) or placebo (95 patients). At 6 weeks post-randomization no significant between-group difference in exercise time improvement was observed (16.6 s, 95% CI 8.9–42.0; $P = 0.20$). However, inducible ischaemia was more effectively reduced by PCI than OMT alone, and more patients were angina-free after PCI. The ORBITA was valuable in emphasizing the importance of the placebo effect in PCI studies.[4] In contrast to ORBITA, the unblinded FAME 2 (The Fractional Flow Reserve vs. Angiography for Multivessel Evaluation) study[5] demonstrated in 888 patients with at least one haemodynamically significant coronary stenosis [fractional flow reserve (FFR) ≤0.80] a reduction in the 5-year rate of death, MI, or urgent revascularization with PCI compared with OMT (13.9% vs. 27.0%; $P < 0.001$), which included a reduction in spontaneous MI (8.1% vs. 12.0%, hazard ratio 0.66, 95% CI 0.43–1.00; $P = 0.049$). A patient level meta-analysis [from FAME 2, DANAMI 3 PRIMULTI (The Primary PCI in Patients With ST-Elevation Myocardial Infarction and Multivessel Disease: Treatment of Culprit Lesion Only or Complete Revascularization) and COMPARE-ACUTE (The Fractional Flow Reserve Guided Primary Multivessel Percutaneous Coronary Intervention to Improve Guideline Indexed Actual Standard of Care for Treatment of ST-elevation Myocardial Infarction in Patients with Multivessel Coronary Disease)] compared the composite of cardiac mortality and MI at a median time of 35 months between groups randomized to FFR-guided PCI vs. medical therapy.[6] The hazard ratio was 0.72 (95% CI 0.54–0.96) significantly in favour of PCI ($P = 0.02$). The difference between groups was driven by a reduced risk in MI (NNT of 18 to prevent 1 event at 5 years).

The optimal treatment strategy (PCI vs. CABG) in patients with MVD and left main disease (LMD) continues to be controversial. The current guidelines recommend the anatomical complexity and presence of diabetes mellitus as the main determinants to guide this decision (*Figure 3*).[1,7] An individual-patient-data meta-analysis of 11 518 patients with MVD or LMD from 11 randomized trials comparing PCI and CABG supports this recommendation.[8] In MVD patients, 5-year mortality was higher after PCI compared with CABG in those with diabetes (15.5% vs. 10.0%; $P = 0.0004$), but not in those without diabetes (8.7% vs. 8.0%; $P = 0.49$). Higher SYNTAX scores also correlated with better outcomes after CABG in MVD patients. In patients with LMD, 5-year all-cause mortality was similar between PCI and CABG (10.7% vs. 10.5%; $P = 0.52$), regardless of diabetes status and SYNTAX score.

Several substudies from the EXCEL (The Evaluation of XIENCE vs. Coronary Artery Bypass Surgery for Effectiveness of Left Main Revascularization) trial demonstrated counter-balancing benefits of PCI vs. CABG in LMD, with PCI reducing peri-procedural adverse events including large MI, acute renal failure, and new onset of atrial fibrillation but CABG reducing late MI and repeat revascularization.[9–11] After 3-year follow-up, a similar improvement in quality of life was noted for PCI and CABG, although a greater early benefit was seen for PCI.[12]

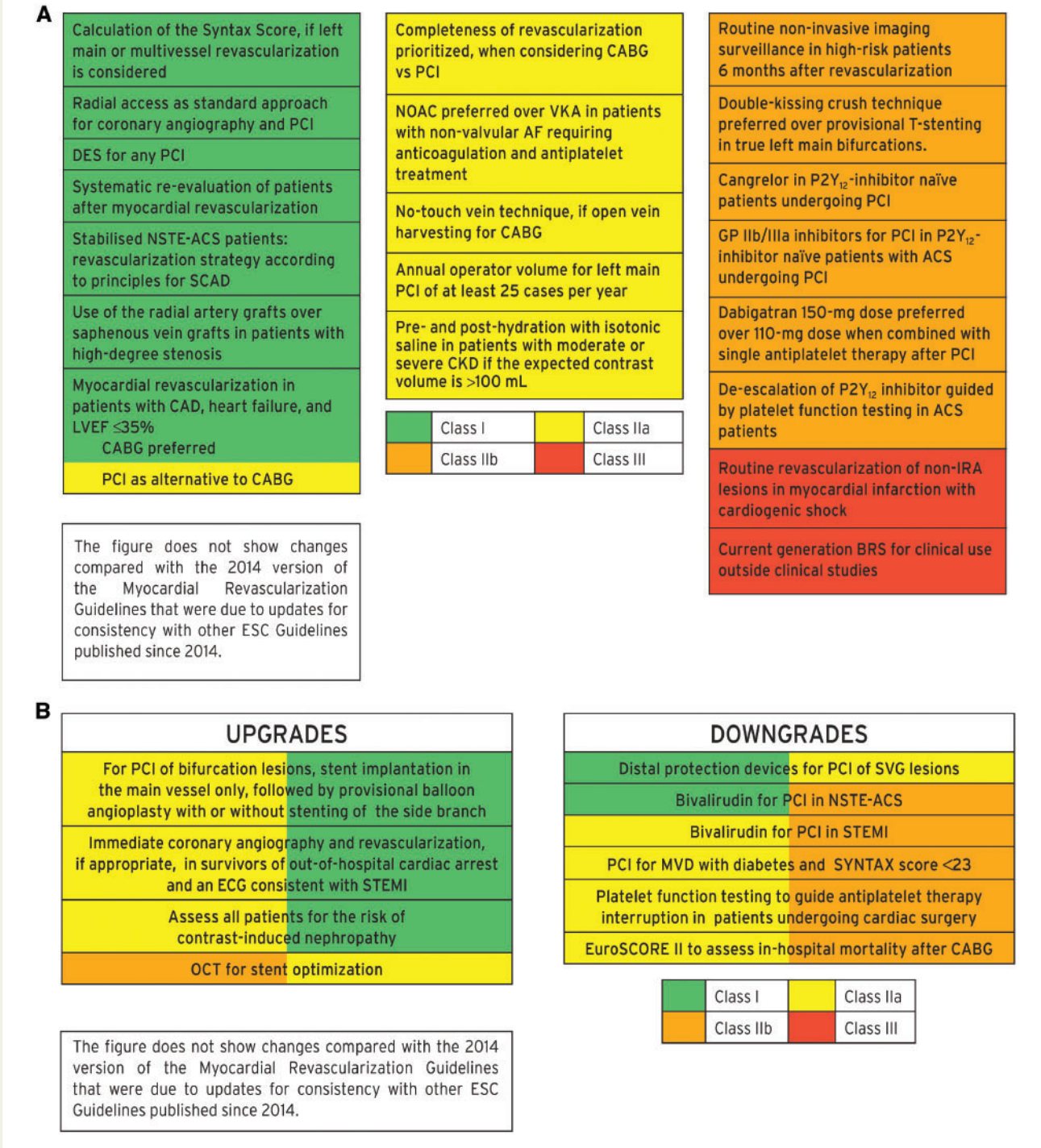
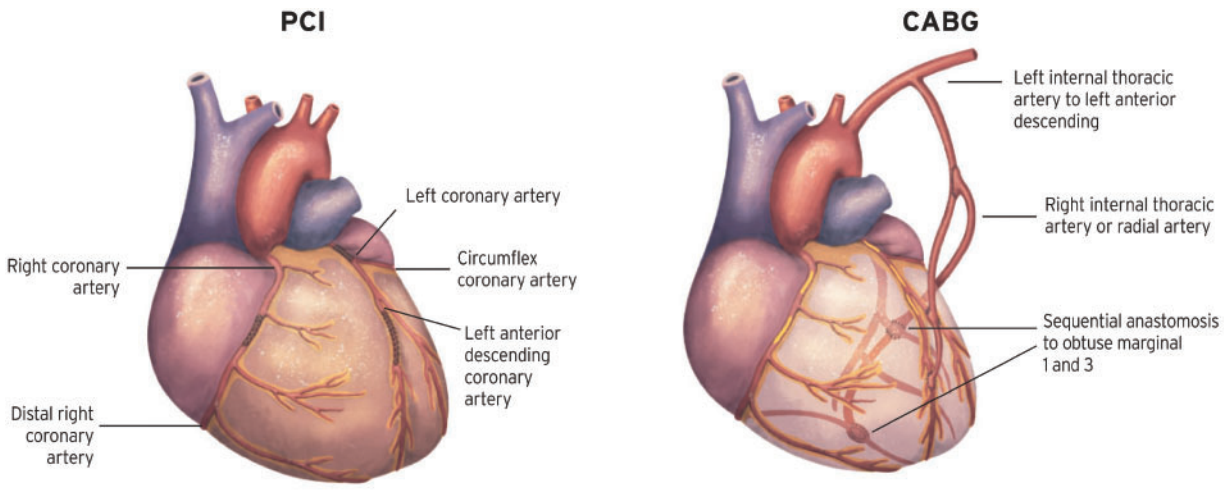


Figure 1 What is new in the 2018 European Society of Cardiology/European Association for Cardio-Thoracic Surgery Guidelines on myocardial revascularization? New recommendations (*A*) and changes in the class of recommendation (*B*). Reproduced after Neumann *et al.*[1] with permission from the *European Heart Journal*. CABG, coronary artery bypass grafting; MVD, multivessel coronary artery disease; NSTE-ACS, non-ST-elevation acute coronary syndromes; OCT, optical coherence tomography; PCI, percutaneous coronary interventions; STEMI, ST-elevation myocardial infarction; SVG, saphenous vein grafts.



FAVOURS PCI
Clinical characteristics
Presence of severe co-morbidity (not adequately reflected by scores)
Advanced age/frailty/reduced life expectancy
Restricted mobility and conditions that affect the rehabilitation process
Anatomical and technical aspects
MVD with SYNTAX score 0–22
Anatomy likely resulting in incomplete revascularization with CABG due to poor quality or missing conduits
Severe chest deformation or scoliosis
Sequelae of chest radiation
Porcelain aorta[a]

FAVOURS CABG
Clinical characteristics
Diabetes
Reduced LV function (EF ≤35%)
Contraindication to DAPT
Recurrent diffuse in-stent restenosis
Anatomical and technical aspects
MVD with SYNTAX score ≥23
Anatomy likely resulting in incomplete revascularization with PCI
Severely calcified coronary artery lesions limiting lesion expansion
Need for concomitant interventions
Ascending aortic pathology with indication for surgery
Concomitant cardiac surgery

Figure 2 Aspects to be considered by the Heart Team for decision-making between percutaneous coronary intervention and coronary artery bypass grafting among patients with stable multivessel and/or left main coronary artery disease. Reproduced after Neumann *et al.*[1] with permission from the *European Heart Journal*. CABG, coronary artery bypass grafting; Cx, circumflex; DAPT, dual antiplatelet therapy; EF, ejection fraction; LAD, left anterior descending coronary artery; LIMA, left internal mammary artery; LV, left ventricular; MVD, multivessel coronary artery disease; PCI, percutaneous coronary intervention; PDA, posterior descending artery; RA, radial artery; RIMA, right internal mammary artery; SYNTAX, Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery. [a]Consider no-touch off-pump CABG in case of porcelain aorta.

Invasive diagnostic tools

Pressure-derived fractional flow reserve

Coronary pressure-derived FFR has been the standard of care for the functional assessment of lesion severity in patients with intermediate-grade stenosis without evidence of ischaemia in non-invasive testing (Class I, level A recommendation), or in those with MVD (Class IIa, level B recommendation).[1] The resting instantaneous wave-free ratio (iwFR) has been introduced as a non-hyperaemic alternative to FFR. A recent pooled analysis of the DEFINE-FLAIR (The Functional Lesion Assessment of Intermediate Stenosis to Guide Revascularisation) and iFR-SWEDEHEART (The Instantaneous Wave-free Ratio vs. Fractional Flow Reserve in Patients with Stable Angina Pectoris or Acute Coronary Syndrome) trials[13] demonstrated the safety of deferral of revascularization with both iwFR and FFR. The iFR GRADIENT (The Single instantaneous wave-Free Ratio Pullback Pre-Angioplasty Predicts Haemodynamic Outcome Without Wedge Pressure in Human Coronary Artery Disease) registry tested the accuracy of iwFR pullback measurements to predict post-PCI physiological outcomes.[14] This technique was particularly useful in intermediate tandem and/or diffuse lesions as iwFR pullback accurately predicted post-PCI iwFR physiological gains (virtual PCI). Compared with angiography alone, availability of iwFR pullback altered revascularization procedural planning in nearly one-third of

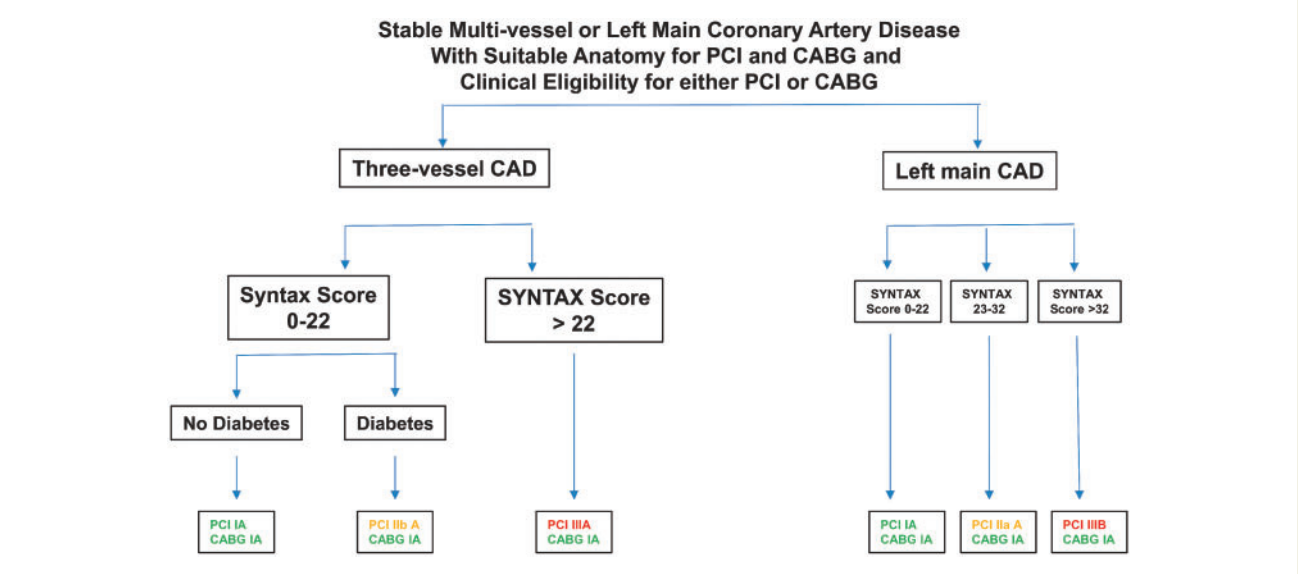


Figure 3 Algorithm to guide the choice of revascularization procedure across major categories in patients with multivessel or left main coronary artery disease. Class recommendations correspond to the 2018 European Society of Cardiology/European Association for Cardio-Thoracic Surgery Guidelines on myocardial revascularization. Reproduced after Windecker *et al.*[7] with permission from the *European Heart Journal*. CABG, coronary artery bypass grafting; CAD, coronary artery disease; PCI, percutaneous coronary intervention.

patients. The updated guidelines support the usage of iwFR to assess the haemodynamic relevance of intermediate-grade stenosis (class I, level A recommendation).[1]

A study from Van't Veer *et al.*[15] has suggested that other diastolic resting indexes are identical to iwFR, both numerically and with respect to their agreement with FFR. The new resting full-cycle ratio (RFR) index is based on unbiased identification of the lowest distal coronary pressure to aortic pressure ratio (Pd/Pa), independent of the electrocardiogram, landmark identification, and timing within the cardiac cycle. In the VALIDATE-RFR (The Validation of a Novel Non-hyperaemic Index of Coronary Artery Stenosis Severity: the Resting Full-cycle Ratio) study,[16] RFR was diagnostically equivalent to iwFR.

Recently, methods to estimate the FFR from conventional angiography without the use of a pressure wire have been shown to have excellent diagnostic accuracy. A large meta-analysis of 13 studies comprising 1842 vessels revealed that the accuracy of angiography-derived FFR for the detection of haemodynamically significant lesions was comparable to pressure wire-measured FFR.[17] The FAST-FFR (The FFR_{angio} Accuracy vs. Standard FFR) trial adds another 301 patients/319 lesions to the collective of data, and uses the Cathworks software. It has confirmed the robustness of the calculated QFR vs. invasively measured FFR.[18] Clinical outcome trials of angiography-derived FFR vs. invasive FFR or iwFR are thus warranted.

Intravascular ultrasound and optical coherence tomography

A consensus document from the European Association of Percutaneous Cardiovascular Interventions (EAPCI) strongly encourages the use of intravascular ultrasound (IVUS) or optical coherence tomography (OCT) during more complex PCI procedures especially for planning procedural strategy and optimizing stent sizing (*Figure 4*).[19] According to ESC myocardial revascularization guidelines, IVUS or OCT should be considered in selected patients to optimize stent during PCI (class IIa, level B recommendation).[1] In the multicenter ULTIMATE (The Intravascular Ultrasound Guided Drug Eluting Stents Implantation in 'All-Comers' Coronary Lesions) trial ($n = 1448$ randomized 'all-comer' patients), IVUS-guided DES implantation significantly improved 1-year clinical outcomes, compared with angiography guidance.[20] Similarly to IVUS, the use of OCT should be considered in selected patients to optimize coronary stent implantation (Class IIa, level B recommendation).[1,19] Data from the Pan-London PCI Cohort registry[21] suggested that OCT-guided PCI is associated with improved procedural and long-term outcomes, including survival, compared with angiography-guided PCI.

Non-invasive imaging

Computational algorithms allow hyperaemic FFR values to be estimated based on coronary computed tomography angiography (FFR_{CT}). In the ADVANCE (The Assessing Diagnostic Value of Non-invasive FFR_{CT} in Coronary Care) registry[22] of 5083 patients with symptoms of CAD, FFR_{CT} modified treatment recommendation in two-thirds of patients compared with computed tomography (CT) alone and was associated with performance of fewer negative angiograms, predicted revascularization, and identified those at low risk for adverse events through 90 days. A substudy from the SYNTAX II study demonstrated the potential utility of detecting functionally significant lesions in patients with 3-vessel CAD and calculation of the "functional" SYNTAX Score.[23] Results achieved with FFR_{CT} were comparable to those achieved during the standard invasive pressure

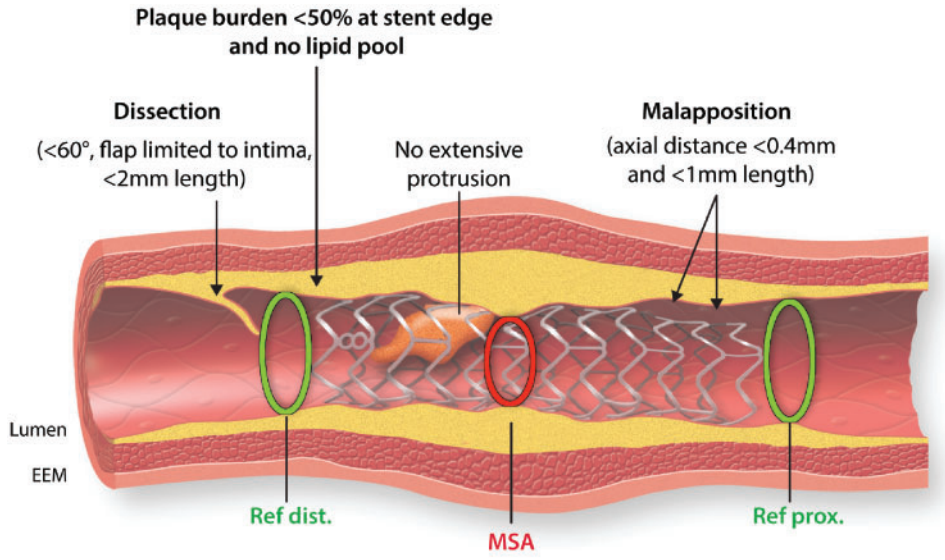


Figure 4 Criteria to assess optimal result of stent implantation using intravascular imaging. Reproduced after Raber *et al.*[19] with permission from the *European Heart Journal*. EEM, external elastic membrane; IVUS, intravascular ultrasound; MSA, minimum stent area; OCT, optical coherence tomography.

wire assessment. In the SYNTAX III REVOLUTION (The Randomized Study Investigating the Use of CT Scan and Angiography of the Heart to Help the Doctors Decide Which Method is the Best to Improve Blood Supply to the Heart in Patients With Complex Coronary Artery Disease) trial, in patients with left main or three-vessel CAD, the heart team selection of PCI vs. CABG based on FFR_{CT} showed high agreement with the decision reached from conventional coronary angiography.[24] Large-scale randomized trials evaluating FFR_{CT} are in the planning stages.

Patient and lesion subsets

Coronary bifurcations/left main disease

The treatment of coronary bifurcations is still a challenge for interventional cardiologists. Although a simplified approach with the provisional strategy is generally preferred, in selected cases a two-stent strategy is required.[25] The CELTIC Bifurcation Study (The Randomized Multicentre Trial to Compare Outcomes for Patients With Ischaemic Heart Disease and Bifurcation Coronary Artery Lesions Who Are Treated with Xience or Synergy Stents) indicated that outcomes of complex two-stent techniques such as culotte for Medina 1, 1, 1 lesions with contemporary everolimus-eluting stents may be associated with excellent outcomes at 9 months.[26]

Keeping bifurcation treatment as simple as possible also applies to the treatment of the LM bifurcation.[25] Most studies have demonstrated worse outcomes of two-stent strategies compared with a provisional one-stent strategy.[27,28] However, the FAILS-2 (The Failure in Left Main Study With 2nd Generation Stents—Cardiogroup III Study) registry confirmed that long-term outcomes of different two-stent techniques including T-stenting, mini-crush, and culotte techniques using new generation DES for LM bifurcation might be similar.[29] Intravascular ultrasound might be particularly useful before, during, and after LM PCI for which its routine use is recommended by the European Bifurcation Club.[25,30]

Treatment of chronic total occlusions

The large, multicentre PROGRESS CTO (The Prospective Global Registry for the Study of Chronic Total Occlusion Intervention) registry[31] demonstrated that contemporary techniques of recanalization of chronic total occlusions (CTOs) are highly effective with technical and procedural success rates of 87% and 85%, respectively. In this registry, CTO PCI was associated with a relatively low risk of major in-hospital complications (3%). To achieve these success rates the use of advanced techniques (retrograde or antegrade dissection re-entry) was frequently required.[31] In a randomized trial, the dissection and re-entry catheter system (Cross Boss and Stingray) was not more successful than standard wire escalation for antegrade crossing of CTOs.[32] Despite the high technical success rate, definitive data demonstrating the clinical value of PCI vs. OMT for CTOs are still lacking. The randomized EuroCTO study[33] reported greater

improvement in quality of life and reduction of angina at 12-month follow-up with CTO PCI compared with OMT, but no significant differences in clinical events. In the small randomized IMPACTOR-CTO (The Impact on Inducible Myocardial ischaemia of Percutaneous Coronary Intervention vs. Optimal Medical Therapy in Patients with Right Coronary Artery Chronic Total Occlusion) study,[34] inducible myocardial ischaemia burden assessed with adenosine stress CMR was significantly reduced after RCA PCI compared with OMT. Patients treated with PCI also reported an improvement in the quality of life. Conversely, segmental wall thickening was not improved after CTO PCI in the REVASC (The Recovery of Left Ventricular Function after Stent Implantation in Chronic Total Occlusion of Coronary Arteries) trial.[35] Given the conflicting results from prior randomized trials, further studies are required to demonstrate which patients may benefit from CTO PCI.

Small vessels and in-stent restenosis

The optimal treatments for lesions in small coronary arteries and in-stent restenosis (ISR) remain a matter of debate. The BASKET SMALL 2 (The Basel Stent Kosten Effektivitäts Trial Drug Eluting Balloons vs. Drug Eluting Stents in Small Vessel Interventions) trial,[36] the largest study to date (758 randomized patients) comparing drug-eluting balloons (DEB) and DES for the treatment of small coronary vessels (<3 mm in diameter) reported that DEB was non-inferior to DES regarding the composite endpoint of cardiac death, non-fatal MI, and target-vessel revascularization at 12 months.[36] Thus, the use of DEB for such an indication might be considered. Conversely, 3-year follow-up from the RIBS-IV (The Restenosis Intra-Stent of Drug-Eluting Stents: Drug-Eluting Balloon vs. Everolimus-Eluting Stent) randomized trial of DES-ISR lesions showed a lower composite rate of cardiac death, MI, or target-lesion revascularization (TLR) with everolimus-eluting stents compared with DEB.[37]

Evolving devices and approaches

Metallic drug-eluting stents

Despite excellent results with contemporary DES advanced designs continue to be introduced to further eliminate stent thrombosis and restenosis, to reduce dependency on long-term dual antiplatelet therapy (DAPT), and to improve lifelong prognosis. Thinner stent struts may be beneficial by accelerating endothelialization and reducing neointimal growth. A recent meta-analysis of 10 randomized trials reported lower rates of target-lesion failure (TLF) at 1 year with newer generation ultra-thin strut DES (≤65 μm) compared with contemporary thicker strut 2nd-generation DES, driven by fewer MI and stent thrombosis events.[38] These effects were consistent across three types of ultra-thin strut DES and with different DES comparators. The 2-year results of BIOFLOW-V (The Prospective Randomized Multicenter Study to Assess the SaFety and Effectiveness of the Orsiro SiroLimus Eluting Coronary Stent System in the Treatment of Subjects with up to Three De Novo or Restenotic Coronary Artery Lesions) trial confirm reduced TLF (7.5% vs. 11.9%; $P = 0.015$), target-vessel-related MI (5.3% vs. 9.5%; $P = 0.01$), and TLR (2.6% vs. 4.9%; $P = 0.04$) with ultrathin bioerodable polymer sirolimus-eluting stent (Orsiro), vs. thin (81 μm strut thickness) durable polymer everolimus-eluting stent.[39] In another study, among 2488 patients randomized to the Resolute Onyx stent (81 μm strut thickness) vs. the Orsiro stent (65 μm strut thickness), the 1-year rates of TLF were similar, and stent thrombosis was lower with the thicker strut device.[40] Moreover, 5-year rates of TLF were comparable in two randomized trials comparing ultra-thin strut DES to contemporary durable polymer everolimus-eluting stents.[41,42] The Firehawk stent is a thin-strut DES with the lowest drug and bioresorbable polymer load of all DES on the market. The TARGET All Comers (The Targeted Therapy With a Localised Abluminal Groove, Low-dose Sirolimus eluting, Biodegradable Polymer Coronary Stent) trial confirms non-inferiority of Firehawk stent vs. the Xience stent in all comers population in terms of TLF at 12 months and in-stent late lumen loss at 13 months.[43] Another new device is the MiStent, a thin-strut DES with the longest residency time for drug due to its crystalline formulation. As a result, the drug remains present several months after the polymer has biodegraded. In the DESSOLVE III (The DES With Sirolimus and a Bioabsorbable Polymer for the Treatment of Patients With De Novo Lesion in the Native Coronary Arteries) trial, the MiStent was non-inferior to the Xience stent at 1 year.[44] A recent study from Guagliumi *et al.*[45] suggested that a similar healing response at 3 months and a low incidence of neoatherosclerosis at 18 months in patients treated with biodegradable polymer everolimus-eluting stents vs. durable polymer zotarolimus-eluting stents. Thus, if there is a significant difference in clinical outcomes between current DES by thinning stent struts approximately 15–20 μm, the magnitude of the difference is likely to be small.

Eliminating the DES polymer coating may theoretically provide more uniform drug delivery and obviate adverse polymer reactions, resulting in more rapid healing. Such devices have also been proposed to shorten DAPT duration. Conversely, controlling drug dosage and release kinetics is more difficult without a polymer. In the LEADERS FREE (The Prospective Randomized Comparison of the BioFreedom Biolimus A9 Drug-Coated Stent vs. the Gazelle Bare-Metal Stent in Patients at High Bleeding Risk) trial,[46] the use of polymer-free biolimus-coated Biofreedom stents in patients at high risk of bleeding resulted in a marginal reduction in the 2-year rate of clinically driven TLR with similar rates of the composite endpoint of cardiac death, MI, or stent thrombosis compared with bare-metal stents, despite treatment with DAPT for only 1 month in both groups. These results were consistent in patients with diabetes mellitus,[46] ACS,[47] and in those undergoing complex PCI.[48] Numerous ongoing randomized trials and registry studies are examining the safety and efficacy of other durable stent types constructed with durable polymers and bioabsorbable polymers as well as novel polymer-free DES in patients at high-bleeding risk treated with an abbreviated DAPT duration.

Bioresorbable scaffolds

Bioabsorbable scaffolds (BRS) were introduced to overcome limitations arising from a permanent coronary metallic DES, including very late restenosis, thrombosis, side-branch jailing, and more. However, randomized trials and large observational studies demonstrated increased rates of device thrombosis and TLF within 30 days and 3 years with the 1st generation Absorb BRS, prior to the time of its complete bioresorption.[49,50] The higher rate of adverse outcomes with this device have been attributed to its thick struts (157 μm),

suboptimal mechanical characteristics and poor implantation technique, especially use in very small vessels. One-year results from the large-scale ABSORB IV trial demonstrated at an intermediate time point that more cautious lesion selection and more stringent technique may decrease the risk of ischaemic events for this BRS, although BRS still did not perform quite as good as metallic DES.[51] Due to inferior intermediate-term outcomes of Absorb compared with conventional metallic DES, the Task Force of the ESC and EAPCI does not recommend use of BRS outside of carefully controlled studies.[52] Investigations with novel polymer- and metal-based BRS with improved properties are ongoing.

Vascular access

Radial artery access is accepted as the preferred approach for coronary angiography and PCI in many patients.[1] A modified technique of coronary access via the left distal RA at the anatomical snuffbox has been shown to be feasible and potentially more comfortable for both operators and patients, especially when left RA access was preferred.[53,54]

Adjunctive pharmacology

The optimal duration of DAPT after PCI continues to be an area of intense interest. The large-scale GLOBAL LEADERS (The Comparative Effectiveness of 1 Month of Ticagrelor Plus Aspirin Followed by Ticagrelor Monotherapy vs. a Current-day Intensive Dual Antiplatelet Therapy in All-comers Patients Undergoing Percutaneous Coronary Intervention with Bivalirudin and BioMatrix Family Drug-eluting Stent Use) trial[55] in patients with stable CAD or ACS undergoing PCI compared a strategy of DAPT (75–100 mg aspirin daily plus 90 mg ticagrelor twice daily) for 1 month, followed by 23 months of ticagrelor monotherapy, vs. standard DAPT for 12 months [75–100 mg aspirin daily plus either 75 mg clopidogrel daily (for patients with stable CAD) or 90 mg ticagrelor twice daily (for patients with ACS)], followed by aspirin monotherapy for 12 months. Ticagrelor monotherapy was not superior to standard therapy for the prevention of all-cause mortality or new Q-wave MI 24 months after PCI (3.8% vs. 4.4%, respectively, $P = 0.07$). Stent thrombosis and major bleeding rates were not significantly different between the groups. Another approach to optimize the risk to benefit ratio of DAPT is to guide therapy based on platelet function testing. In the TROPICAL-ACS (The Testing Responsiveness To Platelet Inhibition On Chronic Antiplatelet Treatment For Acute Coronary Syndromes) study,[56] guided de-escalation of antiplatelet treatment from prasugrel to clopidogrel based on platelet function testing was non-inferior to standard treatment with prasugrel at 1 year after PCI for the combined endpoint of cardiovascular death, MI, stroke, or BARC type bleeding ≥2. Concerning peri-procedural treatment, there is growing evidence for the use of the potent intravenous $P2Y_{12}$ inhibitor cangrelor in selected patients during PCI not previously pre-treated with an oral agent. A recent analysis from the CHAMPION PHOENIX (The Cangrelor vs. Standard Therapy to Achieve Optimal Management of Platelet Inhibition) trial reported that an increasing benefit of cangrelor compared with clopidogrel loading at the time of PCI in patients with complex coronary anatomy.[57]

Regarding antithrombin use during PCI, recent European guidelines have downgraded the class recommendation for bivalirudin for both ST-segment elevation MI (from Class IIa to Class IIb) and non-ST-segment elevation ACS (from Class I to Class IIb).[1] In 2018, long-term follow-up data of the MATRIX (The Minimizing Adverse Haemorrhagic Events by Transradial Access Site and Systemic Implementation of Angiox) trial[58] were published showing no superiority of bivalirudin over unfractionated heparin for the reduction of major adverse cardiovascular events or net adverse clinical events. Bivalirudin was associated with a 32% reduction in BARC three or five non-CABG-related major bleeding, suggesting that it may be useful in patients at increased procedural bleeding risk, in which case a 2–4 h post-PCI infusion of bivalirudin at the PCI dose should be considered to mitigate the potential increased risk of stent thrombosis with this short half-life agent.

Contrast-induced nephropathy protection

The risk of contrast-induced nephropathy (CIN) should always be assessed before coronary angiography and PCI. Adequate hydration remains the mainstay of CIN prevention.[1] In the PRESERVE (The Prevention of Serious Adverse Events Following Angiography) trial,[59] among patients at high risk for renal complications who were undergoing angiography, there was no benefit of intravenous sodium bicarbonate over intravenous sodium chloride or of oral acetylcysteine over placebo for the prevention of death, need for dialysis, or persistent decline in kidney function at 90 days in patients at high risk for renal complications who were undergoing angiography.[59]

Conclusions

Numerous studies from the last year have greatly expanded the evidence-base in interventional cardiology, affecting treatment recommendations and clinical practice. These studies have emphasized the multidisciplinary approach which is required to optimize outcomes for patients with CAD, beginning with best practices for non-invasive diagnosis and foundational medical therapy, to selection of PCI vs. CABG vs. conservative care, to a novel use of interventional devices, drugs and imaging, to post-PCI management. Superimposed on these advances, major progress in chronic cardiovascular pharmacotherapy (e.g. lipid-lowering with PCSK9 inhibitors, anti-inflammatory therapy, new antithrombotic drugs) promises to further alter the natural history and prognosis of patients with ACS and CCS both before and after revascularization.

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