Consensus on the use of intravascular imaging methods (IVUS and OCT) in percutaneous coronary interventions. Intravascular Imaging Consensus

Consenso sobre la utilización de métodos de imagen intravascular (IVUS y OCT) en las intervenciones coronarias percutáneas. Consenso de imagen intravascular

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INTRODUCTION

Over the past several decades, intravascular imaging methods such as intravascular ultrasound (IVUS) and optical coherence tomography (OCT) have become essential tools for guiding and optimizing coronary interventional cardiology procedures. Through detailed assessment of vessel dimensions, vascular structure, and atherosclerotic plaque morphology, several limitations of conventional coronary angiography have been overcome, increasing procedural accuracy and safety, and providing substantial clinical benefits.

The accumulation of robust scientific evidence from randomized clinical trials and international multicenter registries has consistently shown that the systematic use of intravascular imaging is associated with a significant reduction in major adverse cardiovascular events (MACE), primarily driven by a decrease in the incidence of stent thrombosis (ST) and in-stent restenosis (ISR)[1-6].

However, despite the extensive evidence supporting the implementation of these technologies, their adoption in contemporary clinical practice in our region remains low, with substantial variability between hospitals and operators. Reasons for this underutilization include limited training for interventional cardiologists, the perception that these technologies increase procedural duration, and funding-related issues.

From an economic point of view, it is important to consider that an absolute reduction of 1.5–2% in the target lesion revascularization (TLR) rate, at an approximate cost of USD 1000 per catheter, translates into a cost of approximately USD 100,000 to prevent two additional revascularization procedures for every 100 patients. This analysis underscores the need for rational patient selection[7].

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In this context, the Argentine College of Interventional Cardiologists (CACI) has prioritized the updating and harmonization of national recommendations on the use of IVUS and OCT, with the aim of promoting rational, cost-effective, evidence-based adoption tailored to the healthcare realities of our region.

CONSENSUS RATIONALE AND OBJECTIVES

The coexistence of various technical documents and partial recommendations regarding the use of intravascular imaging methods has created a need to harmonize diagnostic criteria, clinical indications, and optimization parameters. In this regard, this document is a comprehensive and unified update of previous consensus statements developed by CACI, incorporating the new scientific evidence available through 2026 and the most recent international methodological standards.

MAIN OBJECTIVES

- To unify criteria for the use, indication, and optimization of IVUS- and OCT-guided coronary cardiovascular interventional procedures.
- To adapt international guideline recommendations to everyday clinical practice in our region.
- To promote continuing education and the incorporation of these technologies into interventional cardiology training and accreditation programs.

METHODOLOGY

The development of this consensus was coordinated by CACI, with the participation of a multidisciplinary panel of experts on interventional cardiology, cardiovascular imaging, clinical cardiology, and scientific methodology.

Evidence selection

A structured search was conducted in MEDLINE (PubMed), Scopus, Embase, and the Cochrane Library using the terms “intravascular ultrasound”, “optical coherence tomography”, “percutaneous coronary intervention”, “outcomes”,

and "guidelines" on articles published between January 2015 and March 2026. Evidence from randomized clinical trials, meta-analyses, and international consensus documents was prioritized.

DEGREE OF RECOMMENDATION AND LEVEL OF EVIDENCE

The recommendations included in this document were developed in accordance with the ACC/AHA (American College of Cardiology/American Heart Association) classification system, which has been widely adopted by leading international scientific societies, including the European Society of Cardiology (ESC)[8].

This system classifies each recommendation based on two independent dimensions: (1) the Class of Recommendation (COR), expressed as Classes I, IIa, IIb, and III, which reflects the magnitude of benefit in proportion to risk; and (2) the Level of Evidence (LOE), expressed as Levels A, B-R, B-NR, C-LD, and C-EO, which indicates the quality and strength of the data supporting the recommendation.

It is important to clarify that, in this consensus, a Class I recommendation means that an intervention "is recommended" or "is indicated/useful/effective". In sections where the most appropriate Class I wording is "is recommended"—rather than "should be performed"—, this will be explicitly stated in the text, so that the decision not to use imaging in every procedure is not necessarily interpreted as an inadequate standard of care.

CONSENSUS PROCESS

Recommendations were discussed and validated using a modified Delphi methodology, involving three consecutive rounds of consultation with a panel of national and international experts (Likert scale, 1–9; consensus defined as agreement ≥80%). The final text was reviewed and approved by all panel members[9].

SCOPE OF THIS CONSENSUS

This document focuses on the clinical, technical, and procedural use of IVUS and OCT to optimize percutaneous coronary interventional procedures. It does not address in depth their use in structural, peripheral, or experimental research settings, except where the evidence has direct implications for clinical interventional practice.

GLOSSARY OF TERMS

In order to standardize concepts and definitions—thereby facilitating future reporting tasks and collaborative research among different centers across the country—a glossary is provided below.

- IVUS: intravascular ultrasound | OCT: optical coherence tomography | PCI/ATC: percutaneous coronary intervention.
- LMCA: left main coronary artery | MACE: major adverse cardiovascular events | TVF: target vessel failure.
- TLR: target lesion revascularization | MLA: Minimum lumen area | EEL: external elastic lamina.
- FFR: fractional flow reserve | iFR: instantaneous wave-free ratio | TCFA: thin-cap fibroatheroma.
- NIRS: Near infra-red spectroscopy | LCBImax: maximum lipid core burden index.
- ACS: acute coronary syndrome | DES: drug-eluting stent | ISR: in-stent restenosis | ST: stent thrombosis | CTO: chronic total occlusion.
- CHIP: complex high-risk indicated procedures.

For the purposes of this consensus, a complex lesion is defined as one meeting at least one of the following cri-

TABLE 1. Class (strength) of recommendation

Class 1 (Strong)	**Benefit >>> Risk**
• Is recommended • Is indicated/useful/effective/beneficial • Should be performed/administered/other Comparative effectiveness: • Strategy A is recommended/indicated in preference to strategy B • Treatment A should be chosen over treatment B	
Class 2a (Moderate)	**Benefit >> Risk**
• Is reasonable • Can be useful/effective/beneficial Comparative effectiveness: • Strategy A is probably recommended/indicated in preference to strategy B • Es razonable elegir el tratamiento A sobre el tratamiento B	
Class 2b (Weak).	**Benefit > Risk**
• May/might be reasonable • May/might be considered • Usefulness/effectiveness is unknown/uncertain or not well established	
Class 3 (No benefit)	**Benefit = Risk**
• Is not recommended • Is not indicated/useful/effective/beneficial • Should not be performed/administered	
Clase 3 (Harm)	**Risk > Benefit**
• Potentially harmful • Causes harm • Associated with excess morbidity/mortality • Should not be performed/administered	

TABLE 2. Level (quality) of evidence

Level A	
• High-quality evidence from ≥1 randomized clinical trial (RCT) • Meta-analyses of high-quality RCTs • One or more RCTs corroborated by high-quality registry studies	
Level B-R	**(Randomized)**
• Moderate-quality evidence from ≥1 RCTs • Meta-analyses of moderate-quality RCTs	
Level B-NR	**(Non Randomized)**
• Moderate-quality evidence from ≥1 well-designed observational studies or registry studies • Meta-analyses of such studies	
Level C-LD	**(Limited data)**
• Randomized or non-randomized observational studies with limitations • Meta-analyses of such studies	
Level C-EO	**(Expert opinion)**
• Consensus of expert opinion based on clinical experience	

teria, in accordance with the inclusion criteria of the RENOVATE-COMPLEX-PCI[10] trial: severe angiographic coronary calcification, an ostial lesion in a major epicardial artery, a true bifurcation with a side branch ≥2.5 mm according to the Medina classification, unprotected left main coronary artery disease, CTO, ISR, a long lesion with an expected stent length ≥38 mm, or multivessel PCI involving simultaneous treatment of two or more major epicardial arteries or requiring three or more planned stents. In addition, pursuant to the IVUS-CHIP[11] trial, angiographically long lesions extending >28 mm and procedures requiring mechanical circulatory support are also included in the aforementioned criteria. It should be noted that the 2024 ESC guidelines do not provide an equivalent comprehensive definition, but rather identify left main coronary artery disease, true bifurcations, and long lesions as prototypical scenarios for which intracoronary imaging carries a Class I, Level A recommendation[12]. This explicit definition is essential in this consensus, given the particularly important role of intravascular imaging in this patient subgroup, both for proper procedural planning and final outcome optimization.

REGIONAL PERSPECTIVE

The adoption of intravascular imaging methods in Latin America has historically been constrained by technological availability, economic limitations, and healthcare coverage policies. In this regard, this document also aims to establish a methodological reference that can be adapted to different healthcare settings, helping to reduce variability between public and private institutions and promoting standardized, cost-effective clinical practice.

TECHNICAL ASPECTS OF INTRAVASCULAR IMAGING METHODS

Intravascular ultrasound

IVUS is a tool based on the emission of ultrasound waves that enables real-time characterization of vascular structures. Such waves and their differential reflection by tissues generate grayscale cross-sectional images of the examined vessel. Structures with high proportions of fibrous tissue and calcium appear hyperechoic and lipid-rich areas appear hypoechoic.

There are two main configurations: (1) solid-state systems, which use multiple transducer elements arranged in a circular configuration; and (2) mechanical systems, which use a single rotating transducer. Both designs are available in monorail or over-the-wire configurations, with automatic pullback preferred. Current-generation systems operate at frequencies of 20–60 MHz, with a spatial resolution of approximately 70 μm and tissue penetration of 5–6 mm.

IVUS can be complemented by additional technologies. Near infra-red spectroscopy (NIRS), available in our country through the Makoto® IVUS+NIRS system (Infraredx, Inc., Bedford, MA, USA), enables quantification of lipid burden through the maximum lipid core burden index (LCBImax), thus expanding the characterization of vulnerable plaque in contemporary clinical practice[13]. In this regard, the PROSPECT II study demonstrated that non-culprit plaque with an LCBImax ≥400 and a minimum lumen area (MLA) of <4.0 mm² is associated with a higher risk of future events[14].

It is important to emphasize that IVUS has greater potential for detecting the external elastic lamina (EEL) in clinical practice, particularly in vessels with severe calcification. As a recommendation, when a segment is used as reference for measurements, at least 50% of its EEL should be visible.

Optical coherence tomography

OCT uses near infra-red light that is emitted and received through a rotating optical fiber coupled to an imaging lens. The system digitally converts the reflected optical signal into high-resolution cross-sectional and three-dimensional images, thus enabling precise visualization of vascular microarchitecture and atherosclerotic plaque morphology.

Unlike IVUS, OCT offers higher spatial resolution (an axial resolution of 10–20 μm and a lateral resolution of 20–90 μm), although its tissue penetration is lower (1–2 mm).

Image acquisition requires a blood-free field, achieved through the injection of contrast medium or saline solution, which may limit its use in ostial stenoses, large-caliber vessels, or critical stenoses.

Current platforms incorporate simultaneous co-registration with angiography. Hybrid IVUS-OCT systems are under development **(Table 3)**.

INDICATIONS FOR THE USE OF INTRAVASCULAR IMAGING

Several studies have shown that both IVUS and OCT provide valuable information to guide therapeutic decision-making, particularly in left main coronary artery (LMCA) disease or complex coronary anatomy[15-18]. In this regard, intravascular imaging methods have substantially improved vascular structure assessment and increased stenting precision.

> *For the aforementioned reasons, this consensus assigns a Class I recommendation, with Level A evidence, to the use of intravascular imaging for stenting optimization in LMCA stenosis or complex lesions at centers with low-to-moderate experience in using these methods, and a Class II recommendation, with Level A evidence, for the treatment of complex lesions at high-volume centers with operators experienced in intravascular imaging.*

This recommendation is maintained despite the methodological limitations of recently published studies (OPTIMAL and IVUS-CHIP), which are discussed in the specific section at the end of this document. It should be noted that both trials consistently confirmed a reduction in stent thrombosis with IVUS guidance, thereby preserving the mechanistic value of this tool regardless of its results for the composite endpoints.

Thus, intravascular imaging is highly useful during the procedural stages detailed below.

Pre-intervention assessment: characterization of plaque composition, identification of reference segments, and determination of necessary preparation tools.

Stent selection: determination of optimal stent diameter and length, avoiding geographic miss and dissection.

Post-implantation optimization: assessment for underexpan-

TABLE 3. Comparison between both intravascular imaging methods.

Parameter	IVUS	OCT
Energy source	Ultrasound	Near infra-red light
Wavelength (μm)	35–80	1.3
Resolution (μm)	40–200 (axial); 200–300 (lateral)	15–20 (axial); 20–40 (lateral)
Maximum scanning diameter (mm)	15	7
Tissue penetration (mm)	10	1–2.5
Blood clearance	Not required	Required
Advantages	More favorable imaging in larger vessels (e.g., left main coronary artery)	Can measure and characterize calcium thickness
Disadvantages	Can measure and characterize calcium thickness	Does not enable accurate assessment of residual plaque burden at stent edges

IVUS: intravascular ultrasound. OCT: optical coherence tomography.

sion, malapposition, edge dissection, or edge hematoma, and identification of the failure mechanism in previously implanted stents.

IMPACT ON THE DECISION-MAKING PROCESS: THE LIGHTLAB INITIATIVE AND THE OCTIVUS STUDY

The LightLab Initiative showed that a standardized OCT workflow using the MLD MAX algorithm changed operator clinical decision-making in 86% of the lesions assessed in 925 patients across 16 centers in the United States. Most changes occurred during the pre-PCI assessment, in lesion morphology (45%), plaque preparation strategy (27%), stent diameter (37%), and stent length (36%). These changes were consistent regardless of the operator's previous level of experience with OCT[19]. These findings reinforce the value of intravascular imaging as an active decision-making tool, beyond its benefits in long-term clinical endpoints. Additionally, the OCTIVUS Study, the first large-scale randomized study to compare OCT versus IVUS in complex PCI (n=2008), demonstrated the non-inferiority of OCT to IVUS for target vessel failure (TVF) at 12 months (5.1% vs. 4.1%; hazard ratio [HR] 1.24; 95% confidence interval [CI]: 0.85–1.82), supporting their interchangeability in centers experienced in both techniques[20].

PRE-INTERVENTION ASSESSMENT

Intravascular imaging methods are useful for accurately characterizing atherosclerotic plaque composition, identifying vascular reference segments and stent landing zones, and selecting optimal stent length and diameter for implantation[21-22].

Image acquisition should be performed after intracoronary nitroglycerin administration, beginning at least 20 mm distal to the stenotic area[23].

In cases of critical stenosis in which the intravascular imaging catheter cannot advance beyond the obstruction, predilation may be performed using a low-profile coronary balloon at low pressure. Alternatively, in cases of marked lesion calcification, plaque preparation techniques (intravascular lithotripsy, cutting balloons, or atherectomy) may be used to facilitate catheter advancement and subsequent image acquisition[24].

Even when stent implantation is not required, intravascular imaging methods can identify features of vulnerability in plaque that is not significant from an angiographic or physiological standpoint, but which may be at risk of rupture during follow-up and may be associated with adverse clinical events, potentially warranting intensification of medical therapy[25-26].

IVUS and OCT are also useful in a setting of myocardial infarction with non-obstructive coronary arteries (MINOCA), Takotsubo syndrome, myocarditis, spontaneous coronary artery dissection (SCAD), cardiac allograft vasculopathy (CAV), and other etiologies, facilitating their accurate characterization and enabling targeted treatment. In cases of suspected SCAD, particular caution should be exercised when performing intravascular imaging because of the risk of hydraulic propagation of the dissection during intracoronary manipulation, especially given the contrast injections required for OCT. That notwithstanding, the benefit of establishing an etiological diagnosis may be substantial in determining the treatment strategy. Likewise, in a clinical setting of acute coronary syndrome (ACS), intravascular imaging methods (either OCT or high-definition IVUS) enable the differentiation between plaque erosion and plaque rupture, which could facilitate future personalized therapeutic strategies, including medical therapy alone without stent implantation in selected cases.

In the context of MINOCA, the PROMISE study, a prospective, multicenter, randomized study, showed that an OCT-guided stratified approach enabled the identification of the underlying etiological mechanism in a greater proportion of cases and was associated with more targeted treatment, with potential clinical benefits[27]. Similarly, the use of IVUS or OCT is an established indication for CAV assessment, since angiography significantly underestimates the extent of disease in this setting.

Substantial evidence supports the accuracy of intravascular imaging methods in identifying features of atherosclerotic plaque vulnerability, such as thin-cap fibroatheroma (TCFA; cap thickness <65–75 μm), high lipid burden, a minimum lumen area (MLA) <4.0 mm^2, plaque burden ≥70%, macrophage infiltration, and high lipid core burden. Whether identified individually or in combination, these features make it possible to detect atherosclerotic plaque at high risk of rupture, which may lead to an increased incidence of adverse cardiovascular events[28-35]. In this context, NIRS enables quantification of lipid core burden through the maximum lipid core burden index (LCBImax). In relation to it, the PROSPECT II study showed that non-culprit plaque with an LCBImax ≥400 and an MLA <4.0 mm^2 carries a higher risk of causing future events and may warrant intensification of medical therapy14. Pre-intervention assessment also helps clarify complex anatomical findings, such as ambiguous aorto-ostial coronary stenoses, coronary dissections, intramural hematomas, aneurysmal vascular disease, and diffuse graft vasculopathy in transplant recipients[36-40].

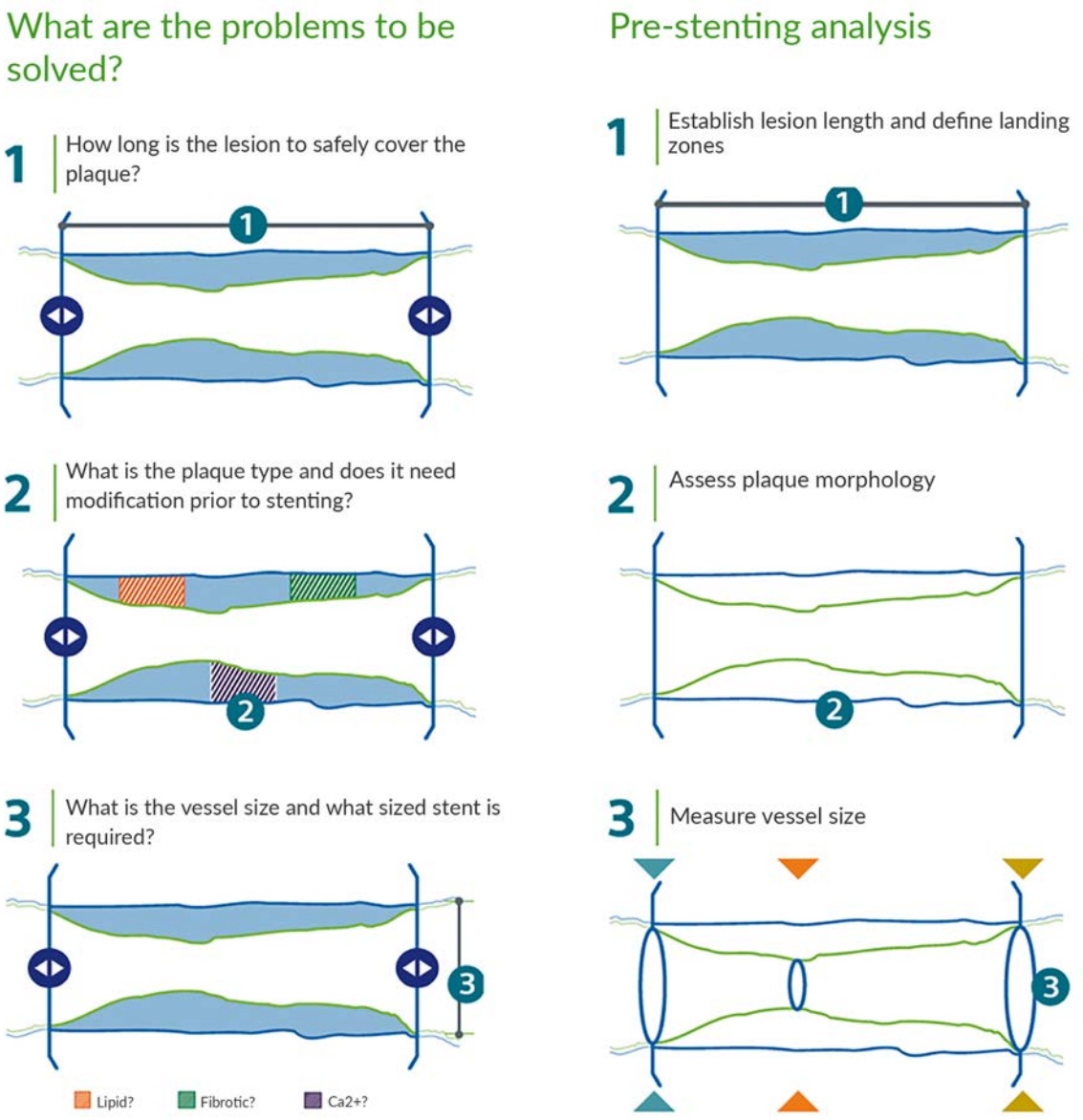

Figure 1. *IVUS123™ algorithm for the assessment of atherosclerotic coronary artery disease before stent implantation.*

For the aforementioned reasons, this consensus assigns a Class I recommendation, with Level A evidence, to performing intravascular imaging before a coronary interventional procedure, with the aim of achieving better characterization of vascular architecture and atherosclerotic plaque in order to establish an accurate etiological diagnosis and provide targeted treatment.

OPTIMIZATION DURING THE INTERVENTIONAL PROCEDURE

Before stent implantation

Algorithms have been developed for accurate characterization of atherosclerotic plaque with the aim of optimizing stent implantation. The IVUS123™ algorithm proposes a sequential assessment of plaque length, safe stent landing zones, plaque composition, and vessel dimensions (**Figure 1**). This algorithm was developed as part of Boston Scientific's educational approach, together with its AVVIGO™/ALA™ (Automated Lesion Assessment) software. With it, we can systematically and objectively determine atherosclerotic plaque length, identify safe landing zones for the stent to be implanted, characterize atherosclerotic plaque composition to determine whether targeted plaque preparation techniques are required, and establish vessel dimensions in the segments proximal and distal to the plaque, with the aim of avoiding geographic miss during stent implantation.

In this regard, this document assigns a Class I recommendation, with Level A evidence, to the use of intravascular imaging to characterize atherosclerotic disease and determine target vessel dimensions.

Stent selection

Several studies have shown that stent underexpansion is one of the main predictors of MACE during follow-up[41-44]. In

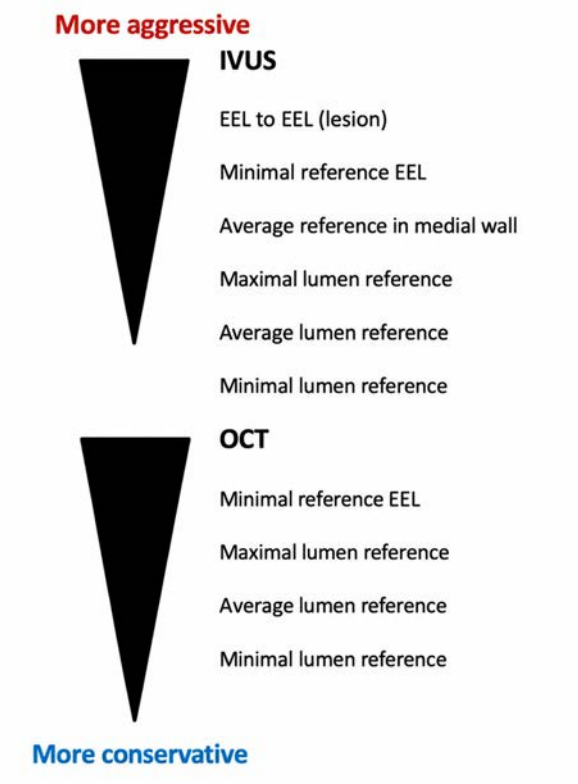

Figure 2.

this sense, various strategies have been proposed for stent diameter selection, taking into account the vascular architecture data provided by intravascular imaging methods and considering the following:

- the average lumen diameters of the proximal and distal reference segments,
- the reference maximal lumen diameter (proximal or distal), or
- the minimal EEL area as determined by IVUS or OCT.

More aggressive approaches, applicable only with IVUS (not with OCT), are based on a media-to-media measurement at the site of the minimal lumen diameter.

From a practical standpoint, the use of the distal lumen reference (whether based on the EEL or the lumen itself) is a straightforward and safe strategy, followed by post-dilation of the mid- and proximal part of the stent **(Figure 2)**.

Moreover, when using a lumen-based approach, the OPINION Study recommended selecting stent diameter using the mean lumen diameter, rounding up to the next 0.25-mm increment[45]. In contrast, when applying an EEL-based approach, it is advisable to use the mean EEL diameter (derived from two orthogonal measurements, or from a single measurement when EEL visibility is limited to approximately 180°), rounding the stent diameter down to the nearest 0.25-mm46. Long stenoses with marked variations in diameter (for example, lesions extending from the mid-segment of the left anterior descending artery to the left main coronary artery) are an important exception to this strategy. In these cases, the identification of stent underexpansion should take into account both differences in vessel diameter and the presence of side branch origins[47] **(Table 4)**.

TABLE 4. Stent sizing with intravascular imaging methods.

• The benefit of imaging-guided angioplasty does not seem to depend strictly on the algorithm used for stent sizing using IVUS or OCT.
• From a practical point of view, using the distal luminal diameter as a reference can be a safe and simple approach, with subsequent optimization of the mid- and proximal stent segments.
• Specifically, the mean distal luminal diameter rounded up (0–0.25 mm), for example, 3.76 → 4.0 mm, or the mean vessel area diameter (EEL measurement in 2 orthogonal axes) rounded down to the nearest 0.25 mm multiple of the stent size (for example, 3.76 → 3.5 mm) can be used.
• When using OCT, the EEL reference strategy is still feasible, although more challenging than a lumen-based approach for routine clinical practice.
• Correct stent landing zone selection is crucial, as a residual plaque burden of <50% and, in particular, the presence of lipid-rich tissue at the stent edge are associated with subsequent restenosis.
• Angiography co-registration with IVUS or OCT is useful for determining stent length and enables accurate placement.

IVUS: intravascular ultrasound. OCT: optical coherence tomography. EEL: external elastic lamina.

Regarding the selection of appropriate stent length, incomplete lesion coverage has consistently been identified as one of the predictors of stent failure (ST, ISR), as well as of MACE during follow-up[48,49]. In this regard, it is clinically important to avoid selecting stent landing zones in areas with a residual plaque burden >50%, paying particular attention to lipid-rich atherosclerotic plaque, which has been associated with a higher incidence of edge restenosis after implantation of newer-generation drug-eluting stents (DES)[41,50-51]. Similarly, co-registration of intravascular imaging with angiography is an essential tool for facilitating accurate stent length selection and optimizing implantation.

This consensus document assigns a Class I recommendation, with Level A evidence, to the use of intravascular imaging to objectively assess vessel dimensions, both in terms of diameter and total length of the affected vessel, in order to select the appropriate stent for implantation, maximize clinical benefit, and reduce the likelihood of periprocedural vascular complications.

Post-stenting optimization

Several studies have proposed a series of optimization criteria for both IVUS and OCT aimed at reducing the incidence of adverse clinical events after stenting, during follow-up **(Figure 3).**

Among these, the ULTIMATE study included the following: (1) a minimum stent area >5.0 mm^2 or 90% of the minimal lumen area (MLA) of the distal reference segment; (2) a plaque burden <50% within 5 mm proximal or distal to the stent edge; and (3) the absence of edge dissection involving the media and extending >3 mm^2. In contrast, a simplified algorithm known as MLD-MAX has recently been proposed for pre- and post-intervention assessment using OCT. Pre-procedural assessment using this algorithm evaluates atherosclerotic plaque morphology, lesion length, and vessel diameter, while post-procedural assessment identifies the presence or absence of medial dissection and evaluates stent apposition and expansion[52] **(Figure 4).**

All stent sizing criteria must be interpreted in consideration of modality-specific differences in lumen detection and vessel measurement. In this regard, despite the diversity of optimization criteria applied in clinical studies, the

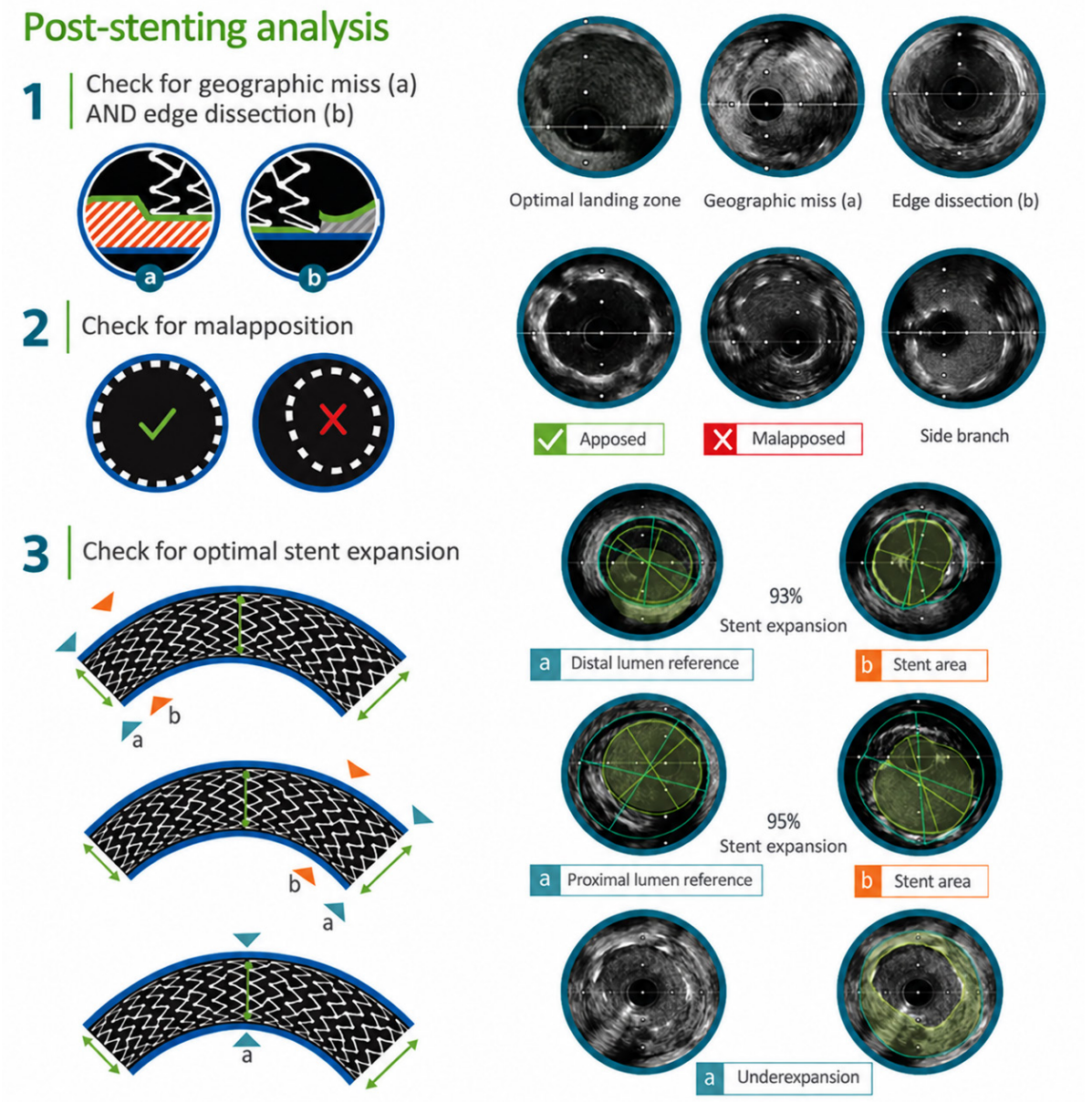

Figure 3.

benefits of intravascular imaging-guided PCI have been shown to be robust and consistent across different clinical settings **(Table 5).**

While studies directly comparing OCT-guided PCI with conventional angiography or IVUS-guided PCI are limited, the available evidence suggests that OCT is superior to angiography and equivalent to IVUS for guiding percutaneous coronary intervention[53-58]. In this regard, the benefit is likely not attributable to a specific imaging modality—IVUS or OCT—but rather to the greater quantity and quality of diagnostic information provided by both techniques compared with angiography alone. To date, no study has shown that the enhanced capabilities offered by OCT for the detection of stent edge dissections, tissue prolapse, intraluminal thrombus, or stent malapposition are associated with better prediction of adverse clinical events during follow-up compared with IVUS[58,59].

This consensus assigns a Class I recommendation, with Level A evidence, to the use of intravascular imaging methods to optimize stent implantation, ensure correct positioning, and rule out periprocedural vascular complications, which are associated with worse clinical outcomes.

STENT FAILURE MECHANISMS

Despite advancements in stent technologies and optimization strategies for percutaneous coronary revascularization, stent failure or ISR—which is angiographically defined as significant in-stent stenosis (a >50% reduction in luminal diameter)—continues to be a clinically relevant condition with a non-negligible prevalence, constituting a significant therapeutic challenge[60,61]. In relation to it, a classification of stent failure mechanisms has been proposed and

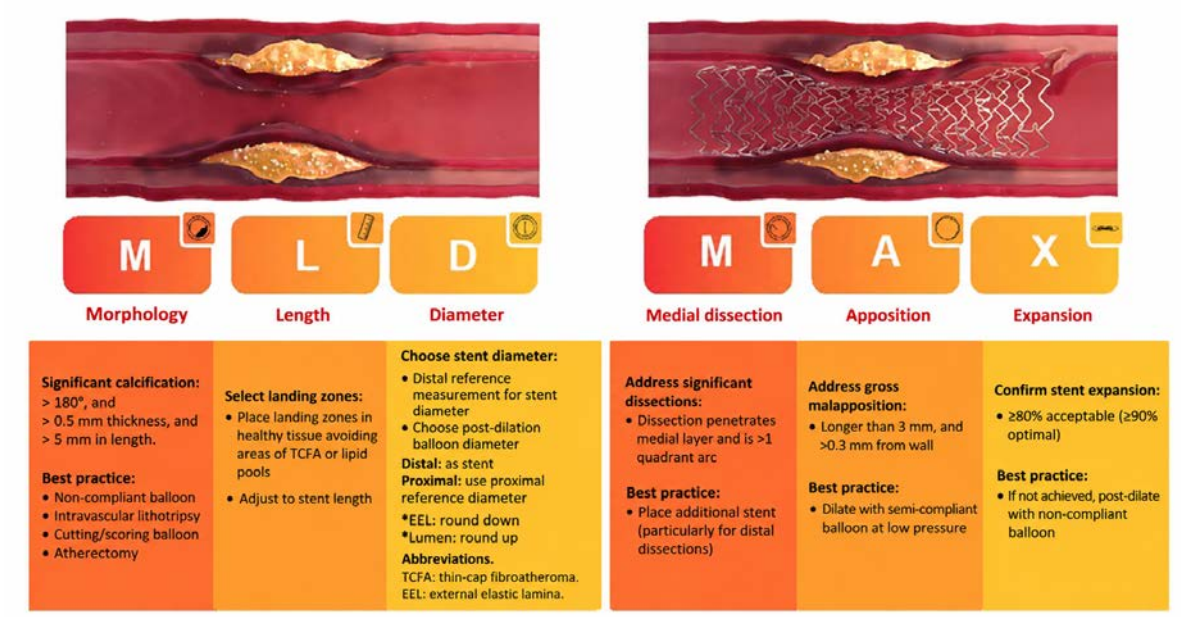

Figura 4. *TCFA: thin-cap fibroatheroma. EEL: external elastic lamina..*

TABLE 5. Criteria for correct stent optimization using intravascular imaging methods.

• A relative stent expansion >80% (MSA divided by the mean reference luminal area) should be achieved in routine clinical practice.
• An MSA >5.5 mm^2 by IVUS and >4.5 mm^2 by OCT should be achieved in all lesions except those in the left main coronary artery.
• The clinical relevance of acute malapposition remains uncertain. However, extensive malapposition should be avoided and corrected, if anatomically feasible, after stenting. Early strut coverage may be favored by complete apposition.
• Acute malapposition <0.4 mm with longitudinal extension <1 mm should not be corrected, as spontaneous neointimal integration is anticipated. This cutoff point requires prospective validation
• Late malapposition is a well-established cause of late and very late stent thrombosis.
• Tissue prolapse in ACS, compared with stable CAD, is associated with poorer outcomes, probably due to differences in the composition of the protruding tissue.
• Extensive dissections detected by IVUS or OCT are independent predictors of MACE.Residual plaque burden, wide lateral extension (>60°), longitudinal extension (>2 mm), involvement of deep layers (media or adventitia), and distal location relative to the stent all increase the risk of adverse events. .
• Stent edge hematoma can be detected by IVUS or OCT in the event of residual stenosis at the stent edge detected by angiography.

MSA: minimum stent area. IVUS: intravascular ultrasound. OCT: optical coherence tomography. ACS: acute coronary syndrome. CAD: coronary atherosclerotic disease. MACE: major adverse cardiac events.

is now widely adopted, allowing for their etiologies to be grouped into two major pathophysiological categories. This distinction facilitates an understanding of the underlying mechanisms while enabling an individualized therapeutic approach[62] **(Table 6).**

Although ISR is an angiographic diagnosis, intravascular imaging techniques offer greater sensitivity both for its characterization and for understanding its underlying pathophysiological mechanisms. In this regard, IVUS and OCT differ substantially in their ability to identify the various stent failure mechanisms, something that is directly related to the intrinsic characteristics of each modality, particularly regarding resolution and tissue penetration depth[53, 63] **(Table 7).**

This consensus document recommends the use of intravascular imaging methods in cases of stent failure, with a Class IIa recommendation and Level A evidence, to establish an etiological diagnosis of the failure mechanism and characterize it precisely in order to guide targeted treatment.

Since stent failure is very frequently caused by unrecognized underexpansion, the use of intravascular imaging in this setting could be upgraded to a Class I recommendation in future updates as more specific evidence emerges.

DETERMINING STENOSIS SIGNIFICANCE

Coronary lesions outside the left main coronary artery

To date, robust evidence has shown that intravascular physiology-based methods, such as the determination of coronary fractional flow reserve (FFR) as a hyperemic index and instantaneous wave-free ratio (iFR) as a reference non-hyperemic index, are highly safe and effective methods to determine the functional severity of coronary stenoses[64-66].

Conversely, among the anatomical parameters quantified using intravascular imaging methods, the MLA is the parameter that correlates best with the presence of ischemia confirmed by intravascular physiology-based methods. In this regard, IVUS-derived MLA cutoff values range from 2.1 to 4.4 mm^2 and are generally lower in studies involving Asian populations than in patients from Western cohorts. Combining parameters (for example, MLA with plaque burden or lesion length), adjusting for vessel size, or incorporating tissue characterization technologies have not been shown to be superior to using MLA alone. Unlike IVUS, OCT-derived MLA cutoff values range from 1.6 to 2.4 mm^2, although the number of available studies is half of that available for IVUS. Meta-analyses suggest an IVUS-derived 2.8–2.9-mm^2 MLA cutoff (3.0 mm^2 in Western populations and 2.7 mm^2 in Asian patients) and an OCT-derived 2.0-mm^2 MLA cutoff[69-71]. It is

TABLE 6. Stent failure mechanisms.

I	Mechanical	Underexpansion (Type I A)	High-pressure balloon
		Stent fracture (Type I B))	DES
II	Biological	Hiperplasia intimal (Tipo II A)	Balloon, DCB, DES y VBT
		Non-calcified neoatherosclerosis (Type II B)	DCB y DES
		Calcified neoatherosclerosis (Type II C)	Balón *scoring*, ELCA y AR
III	Mixed pattern: combined mechanical and biological machanisms		Balón de alta presión con DCB, DES o VBT
IV	Chronic total occlusion		DCB o DES, VBT for multiple layers, MRS if necessary
V	>2 stent layers		Balloon, DCB, VBT y CRM

DES: drug-eluting stents. DCB: drug-coated balloons. VBT: vascular brachytherapy. ELCA: excimer laser coronary atherectomy. RA: rotational ablation. MRS: myocardial revascularization surgery.

TABLE 7. Benefits of each method according to the clinical-anatomical scenario.

	IVUS	OCT
Assessment of LMCA lesion severity	+++	+
Assessment of de novo lesion characteristics		
• Thin-cap fibroatheroma	–	+++
• Thrombus	+	+++
• Plaque rupture	++	+++
• Calcified nodule	+	+++
• Dissection	++	+++
• Positive remodeling	+++	+
• Plaque burden	+++	+
• Aorto-ostial disease	+++	–
Stent optimization		
• Expansion	++	+++
• Apposition	++	+++
Stent failure		
• Neointimal hyperplasia	+	++
• Underexpansion	++	+++
• Malapposition	++	+++
Renal failure	+++	+

IVUS: intravascular ultrasound. OCT: optical coherence tomography. LMCA: left main coronary artery.

worth emphasizing that most intravascular imaging studies show that MLA has a high negative predictive value but a low positive predictive value for the determination of a therapeutic strategy (PCI versus deferral of invasive treatment) outside the left main coronary artery (LMCA). This means that any anatomically significant stenosis identified by intravascular imaging does not necessarily correspond to functionally significant ischemia. Therefore, integration with physiological assessment methods is strongly recommended in this setting.

Three randomized clinical trials—DEFER, FAME, and FAME-2—provided the basis for a Class I recommendation for the use of FFR to assess the severity of coronary lesions outside the LMCA[64-66]. However, the strength of such recommendation has been called into question by recent trials with neutral results—FLOWER-MI, FUTURE, and FAME-3[72-74]. Furthermore, the FORZA study demonstrated equivalence between an OCT-guided strategy and an FFR-guided strategy, although its methodological limitations (single-center study conducted in 2020; comparison of PCI guidance versus decision to defer intervention) warrant caution in its interpretation[75].

Left main coronary artery lesions

An accurate assessment of angiographic significance of LMCA lesions is associated with low interobserver agreement, with agreement rates as low as 30%, particularly in stenoses involving the ostium. In Western countries, an IVUS-derived <6 mm² MLA is the parameter that correlates best with ischemia, whereas two studies involving Korean populations suggested that an MLA >4.5–4.8 mm² would be sufficient to rule out the need for revascularization[76-77]. The lower cutoff values observed in Asian populations compared with Western populations have been attributed to smaller cardiac mass in Asian patients, as well as to the observation that a normal, non-atherosclerotic LMCA in this population has 75% of the cross-sectional area observed in Western patients[78]. In this regard, a meta-analysis comparing IVUS-guided deferral of LMCA revascularization with FFR-based assessment showed equivalent clinical outcomes at 30 months[79].

To date, the available evidence on LMCA PCI has been supplemented by the OPTIVUS-Complex PCI study[80] and the INFINITE meta-analysis, which analyzed 11 randomized studies comparing IVUS versus angiography for LMCA interventions[81]. However, the OPTIMAL study—the largest randomized trial specifically designed for this indication—did not demonstrate the superiority of IVUS guidance over angiography in patients with unprotected LMCA disease at a median follow-up of 2.9 years (HR 1.11; 95% CI: 0.87–1.42; P=0.40). This finding affects the recommendation for this subgroup and is discussed in detail in a dedicated section at the end of this document[82].

Assessment of the left main coronary artery (LMCA) using OCT has two main limitations: the large vessel caliber combined with the limited tissue penetration shown by this method, and the need to clear blood from the lumen, which particularly affects visualization of the aorto-ostial junction. It is worth emphasizing that, to date, there are no correlation studies or long-term follow-up studies using OCT in this setting. Nevertheless, OCT can be used to assess the mid or distal segment of the LMCA, a common location for high-risk atherosclerotic plaque.

Intravascular imaging should be acquired from both the anterior descending artery and the circumflex artery up to the aorto-ostial junction, in order to determine the MLA (using the lower value obtained from the two pullbacks), as well as to assess the presence of disease at the ostia of both coronary arteries. LMCA disease typically extends into the anterior descending artery in approximately 90% of patients, with variable involvement of the circumflex artery, regardless of Medina classification. In this regard, isolated ostial disease in the anterior descending artery (Medina 0,1,0) or the circumflex artery (Medina 0,0,1) almost always implies distal LMCA involvement when assessed using intravascular imaging[83].

It should be noted that an LMCA whose diameter is smaller than that of the largest distal coronary vessel, or that does not comply with Murray's law, should not be considered ana-

TABLE 8. Specific clinical scenarios favoring IVUS or OCT.

Scenario	Preferred method	Justification
ACS culprit lesion	OCT	OCT easily detects and differentiates between red thrombus and white thrombus, and it can identify erosion.
Suspected SCAD	IVUS	Contrast flushing required by OCT could expand the dissection.
Aorto-ostial lesions	IVUS	Clearing blood from the aorto-ostial junction is a difficult task.
LMCA PTCA	IVUS	OCT provides scarce data; OCT ostium assessment is difficult to achieve.
Chronic total occlusion	IVUS	Contrast flushing required by OCT could expand a dissection.
Stent failure	OCT	OCT enables strut coverage assessment and neoatherosclerosis detection.
Chronic kidney disease	IVUS	Contrast flushing required by OCT could worsen kidney disease.

ACS: acute coronary syndrome. OCT: optical coherence tomography. SCAD: spontaneous coronary artery dissection. IVUS: intravascular ultrasound. PTCA: percutaneous transluminal coronary angioplasty. LMCA: left main coronary artery

tomically small but rather diffusely diseased, without an angiographically normal reference segment84.

SITUATIONS IN WHICH ONE METHOD IS SUPERIOR TO THE OTHER

In the vast majority of PCI procedures involving stent implantation, both IVUS and OCT can be used safely, effectively, and interchangeably, with comparable outcomes over short- and intermediate-term follow-up. However, there are specific scenarios in which one modality may be preferable to the other, either for clinical reasons or because there is a greater body of evidence for that modality[85] **(Table 8).**

It is worth considering that IVUS has greater EEL detection power in clinical practice, which is particularly relevant in severely calcified vessels where OCT may not adequately visualize the EEL. This technical difference may influence the choice of imaging modality in individual cases, without implying overall clinical superiority of IVUS.

NEW RANDOMIZED CLINICAL TRIALS AND THEIR IMPACT ON THE RECOMMENDATIONS IN THIS CONSENSUS

In March 2026, two highly relevant trials were simultaneously published in the New England Journal of Medicine: the IVUS-CHIP study, which included 2020 patients undergoing complex-lesion PCI, and the OPTIMAL study, which included 806 patients with unprotected LMCA disease. Both trials yielded neutral results—IVUS-CHIP: HR 1.25; P=0.08; OPTIMAL: HR 1.11; P=0.40—, although both consistently showed a significant reduction in definite stent thrombosis with IVUS guidance, a finding that preserves the mechanistic value of this tool regardless of the results for the composite endpoints.

These results do not invalidate the use of IVUS; rather, they may be explained by a combination of concurrent methodological limitations. First, the participating operators, who had extensive prior experience with intracoronary imaging and routinely used IVUS in 50–100% of their cases, had so thoroughly internalized its principles that they also applied them in the angiography arm, effectively creating an "IVUS without IVUS" control arm. Post-dilation rates in the angiography group reached 84–96%, figures substantially higher than those observed in previous positive trials, such as ULTIMATE (57%) and RENOVATE (75%), thereby eliminating the procedural separation between the groups. Second, the predefined stent optimization criteria were achieved in only 48% of lesions in IVUS-CHIP, and IVUS findings prompted additional corrective maneuvers in only 29% of cases in OPTIMAL, thus switching IVUS from an active decision-making tool to a passive observational modality. Third, pre-stent IVUS—which accounts for its greatest mechanistic value in guiding lesion preparation and stent selection—was performed in only 63–65% of patients in both trials, limiting its potential in a substantial proportion of cases. Furthermore, while 45.8% of patients in IVUS-CHIP had severe calcification, rotational atherectomy was used in only 6.5% and intravascular lithotripsy in 10.6% of cases: without appropriate plaque-preparation tools, IVUS can document underexpansion, but it cannot correct it. Finally, both trials based their power calculations on a 35% relative risk reduction (HR 0.65), derived from observational data from the first-generation drug-eluting stent era. In a contemporary setting, 15–20% constitutes a more realistic treatment effect, which would require 4000-6000 patients to achieve adequate statistical power, leaving both studies likely underpowered to detect true clinical benefit.

In a Latin American setting, where adoption remains low and operator experience is heterogeneous, the recommendations of this consensus remain fully valid: IVUS and OCT continue to be essential tools for LMCA disease assessment, complex lesions, stent failure management, and any clinical scenario in which imaging actively influences decision-making processes.

CONCLUSIONS

To date, there is a substantial body of scientific evidence establishing intravascular imaging methods as fundamental tools for optimizing coronary interventional procedures. Their use is consistently associated with a reduction in adverse clinical events during follow-up, supporting their systematic incorporation into contemporary interventional practice.

The accuracy with which these technologies characterize coronary vascular architecture allows for a detailed identification of atherosclerotic plaque morphology and a precise determination of target vessel dimensions. This level of information enables a targeted therapeutic approach, facilitating the selection of the optimal plaque preparation strategy as well as the appropriate choice of stent size.

In addition, intravascular imaging helps identify the etiology of the index coronary event in cases where no angiographically significant stenoses are observed, providing valuable information about alternative mechanisms, such as plaque rupture or erosion. Furthermore, it has shown an adequate ability to assess stenosis severity in both the left main coronary artery and other epicardial vessels. In certain clinical settings, intravascular imaging offers distinct advantages due to its technological features and its ability to guide decisions more precisely than angiography alone.

For the aforementioned reasons, current evidence makes it

necessary to consider intravascular imaging as part of the quality standard in contemporary angioplasty, particularly in complex or high-risk lesions, where its omission may compromise clinical outcomes.

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