# Lesion assessment in 2022: Beyond the angiogram

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# From the guidelines

- Coronary angiography remains the default method to define coronary anatomy and characterize the severity of coronary arterial stenoses.
- A visually estimated diameter stenosis severity of ≥70% for non–left main disease and ≥50% for left main disease has been used to define significant stenosis and to guide revascularization strategy.
- Although the length of a lesion may contribute to physiological lesion severity (ie, a longer moderate lesion may result in more ischemia than a focal severe lesion), there are no standard cutoffs for lesion length used to classify a severe stenosis.
- An angiographically intermediate coronary stenosis is defined as a diameter stenosis severity of 40% to 69%, and generally warrants additional investigation to assess physiological significance.

**Type A**

- Discrete
- Concentric
- Readily accessible
- Smooth Contour
- Little or no calcification
- Non ostial
- No major side branch involved
- Absence of thrombus

**Type B**

- Tubular
- Eccentric
- Moderate tortuosity
- Moderately angulated (45 – $90^0$)
- Irregular contour
- Moderate – heavy calcification
- Total occlusion (< 3 months)
- Ostial
- Bifurcation lesion
- Thrombus present

Note: $B_1$ = characteristic only; $B_2$ = 2 or more characteristics

**Type C**

- Diffuse
- Excessive Tortuosity
- Extremely angulated
- Total occlusion (> 3 months)
- Inability to protect major side branch
- Degenerated vein graft

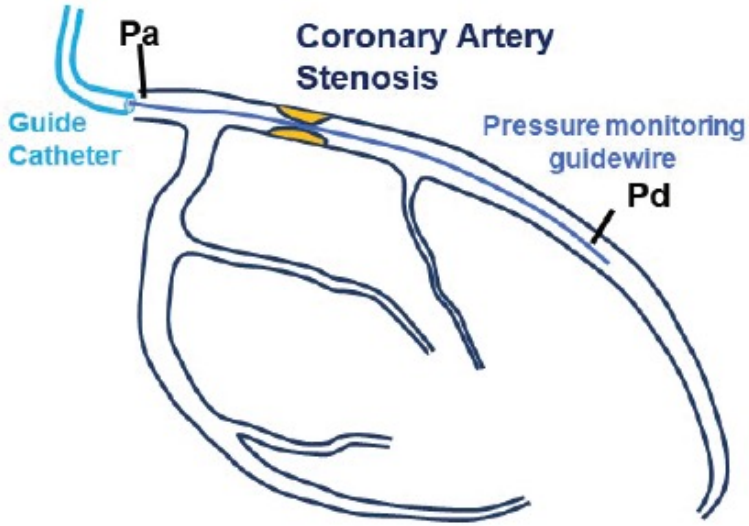
**Recommendations for the Use of Coronary Physiology to Guide Revascularization With PCI**

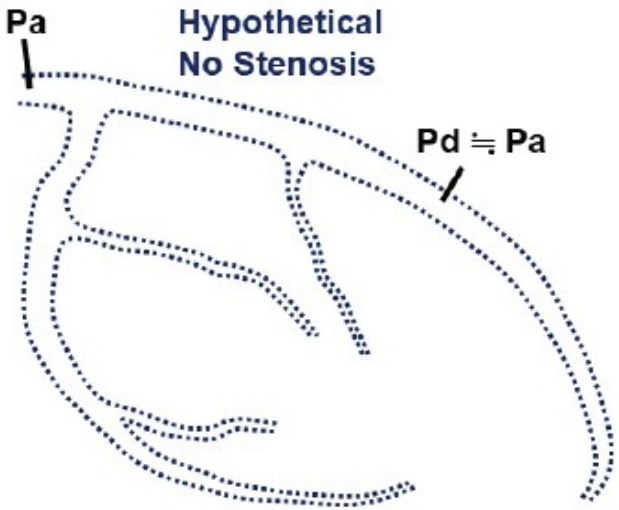
**Referenced studies that support the recommendations are summarized in Online Data Supplement 5.**

| COR | LOE | Recommendations |
|---|---|---|
| 1 | A | 1. In patients with angina or an anginal equivalent, undocumented ischemia, and angiographically intermediate stenoses, the use of fractional flow reserve (FFR) or instantaneous wave-free ratio (iFR) is recommended to guide the decision to proceed with PCI.[1-6] |
| 3: No benefit | B-R | 2. In stable patients with angiographically intermediate stenoses and FFR >0.80 or iFR >0.89, PCI should not be performed.[7-10] |

# Physiology

- FFR and iFR are 2 of the most commonly used physiological methods of assessing lesion significance.
- FFR is defined as the ratio of maximal blood flow in a region distal to a lesion compared with the normal maximal blood flow of an artery.
- iFR, an index of lesion severity, is the instantaneous wave-free ratio (in diastole) of coronary pressure distal to the coronary lesion (Pd) to the aortic pressure (Pa)



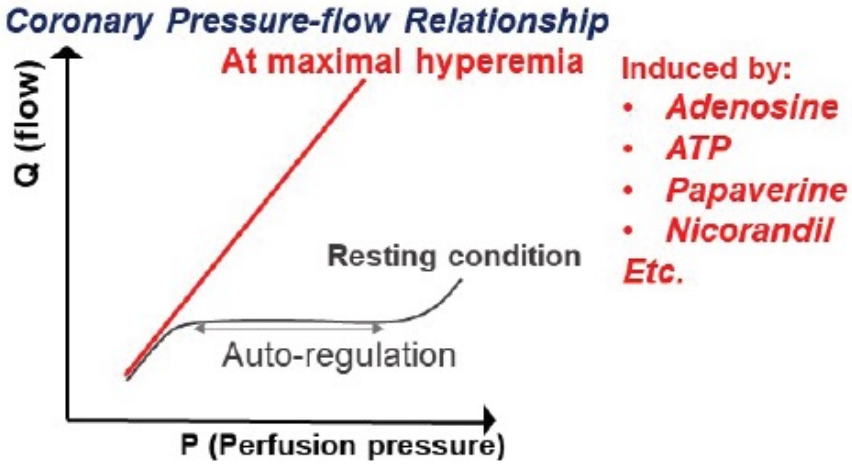




$$FFR = \frac{\text{Maximum Myocardial Flow (stenosis)}}{\text{Maximum Myocardial Flow (hypothetical no stenosis)}}$$

$$\approx \frac{(Pd - Pv) / \cancel{\text{Resistance}}}{(Pa - PV) / \cancel{\text{Resistance}}} \quad \text{at hyperemia}$$

*Assuming that Pv is close to zero*

$$\approx \frac{Pd}{Pa} \quad \text{at hyperemia}$$

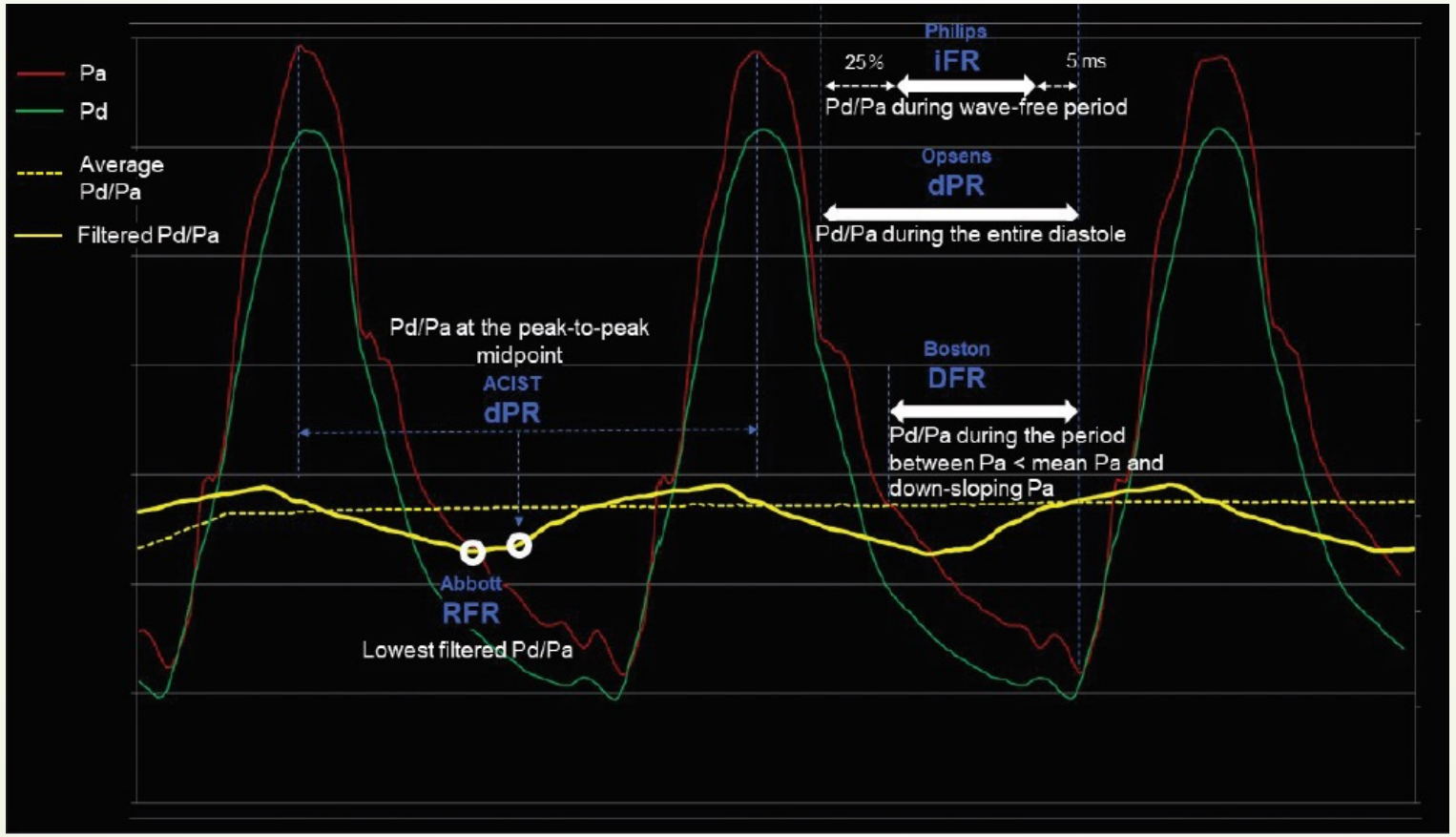


# Data

| TABLE 1. FFR AND iFR PIVOTAL TRIALS | | | | | |
|---|---|---|---|---|---|
| | DEFER[10-12] | FAME[4,13-15] | FAME2[5,16,17] | iFR-SWEDEHEART[18] | DEFINE-FLAIR[19] |
| N | 325 | 1,005 | 1,220 | 2,037 | 2,492 |
| Enrollment year | 1997-1998 | 2006-2007 | 2010-2012 | 2014-2015 | 2014-2015 |
| Patient | Stable patients referred for elective PCI | Stable angina, unstable angina, or NSTEMI | Stable or stabilized patients with angina or silent ischemia | Stable angina, unstable angina, or NSTEMI (nonculprit) | Stable angina or ACS (nonculprit lesion) |
| Lesion | A single de novo stenosis (> 50% DS) | Multivessel disease (> 50% DS) | Single- or multi-vessel disease (> 50% DS) | Single- or multi-vessel disease (40%-80% DS) | Single- or multi-vessel disease (40%-70% DS) |
| Primary comparison | Deferral of PCI (n = 91) vs performance of PCI (n = 90) in patients with FFR ≥ 0.75 | FFR-guided (n = 509) vs angiography-guided PCI (n = 496) | FFR-guided PCI plus MT (n = 447) vs MT alone (n = 441) in patients with a lesion with an FFR ≤ 0.8 | FFR-guided (n = 1,018) vs iFR-guided revascularization (n = 1,019) | FFR-guided (n = 1,250) vs iFR-guided revascularization (n = 1,242) |
| Primary endpoint | Death, MI, repeat revascularization at 2 years | Death, MI, or repeat revascularization at 1 year | Death, MI, or urgent revascularization at 2 years | Death, MI, or unplanned revascularization at 1 year (noninferiority) | Death, MI, or unplanned revascularization at 1 year (noninferiority) |
| Findings | Similar event-free survival between the deferral and performance groups (89% vs 83%) at 2 years | Lower events in the FFR-guided PCI (13.2% vs 18.3%; $P = .02$) at 1 year | Lower rate of primary endpoints in the PCI (8.1% vs 19.5%; $P < .001$) at 2 years | Similar event rate between FFR vs iFR guidance (6.1% vs 6.7%; $P = .53$; $P = .007$ for noninferiority) | Similar event rate between FFR vs iFR guidance (7% vs 6.8%; $P = .78$; $P < .001$ for noninferiority) |
| Long-term follow-up | 5 and 15 years | 5 years | 5 years | Ongoing | Ongoing |

Abbreviations: ACS, acute coronary syndrome; DS, diameter stenosis; iFR, instantaneous wave-free ratio; FFR, fractional flow reserve; MI, myocardial infarction; MT, medical therapy; NSTEMI, non–ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention.

# Non hyperemic indices

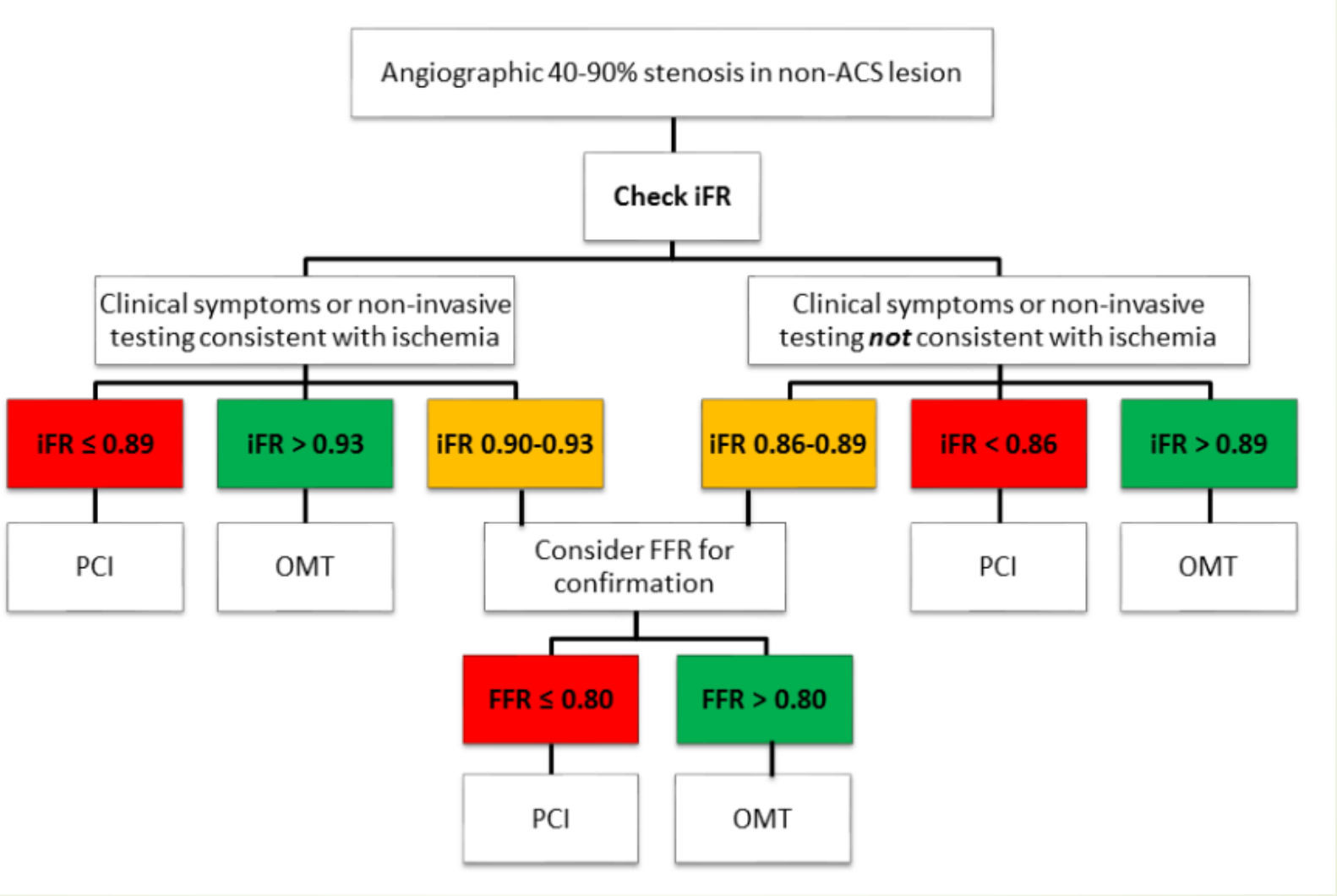


# There are a few…

| TABLE 2. FFR, RESTING Pd/Pa, AND OTHER NHPRs | | | | |
|---|---|---|---|---|
| Pressure Index | Company | Hyperemia | Cutoff | Calculation of the Index |
| FFR | All | Required | ≤ 0.80 | Average Pd/Pa during the entire cardiac cycle at hyperemia (typically averaged over 3 beats) |
| Resting Pd/Pa | All | NHPR | ≤ 0.91 | Average Pd/Pa during the entire cardiac cycle (typically averaged over 3 beats) |
| RFR | Abbott | NHPR | ≤ 0.89 | Instant lowest filtered Pd/Pa ratio during the entire cardiac cycle (over 5 beats) |
| iFR | Philips | NHPR | ≤ 0.89 | Average Pd/Pa during wave-free period (over 5 beats) |
| DFR | Boston Scientific Corporation | NHPR | ≤ 0.89 | Average Pd/Pa during the period between Pa < mean Pa and down-sloping Pa (over 5 beats) |
| dPR | Acist | NHPR | ≤ 0.89 | Instant Pd/Pa at the peak-to-peak midpoint (over 5 beats) |
| | Opsens Medical | NHPR | ≤ 0.89 | Average Pd/Pa during the entire diastole (over 5 beats) |

Abbreviations: DFR, diastolic hyperemia-free ratio; dPR, diastolic pressure ratio; FFR, fractional flow reserve; iFR, instantaneous wave-free ratio; NHPR, nonhyperemic pressure ratio; Pa, aortic pressure; Pd, distal coronary artery pressure; RFR, resting full-cycle ratio.

# The grey zone



# IVUS

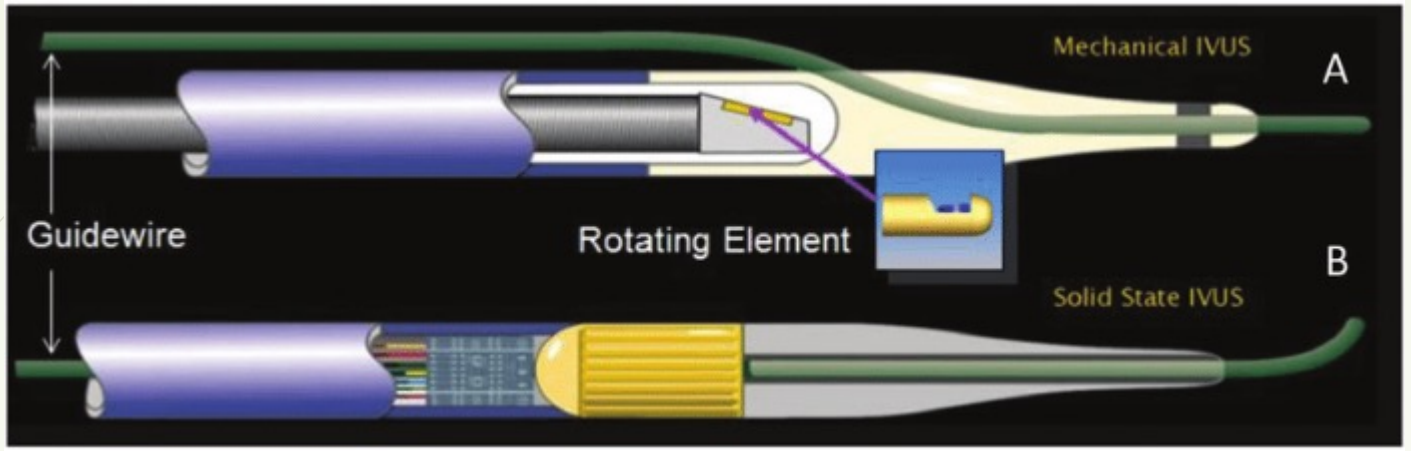
| Recommendation for Intravascular Ultrasound to Assess Lesion Severity<br>Referenced studies that support the recommendation are summarized in Online Data Supplement 6. | | |
|---|---|---|
| **COR** | **LOE** | **Recommendation** |
| **2a** | **B-NR** | 1. In patients with intermediate stenosis of the left main artery, intravascular ultrasound (IVUS) is reasonable to help define lesion severity.[1-5] |

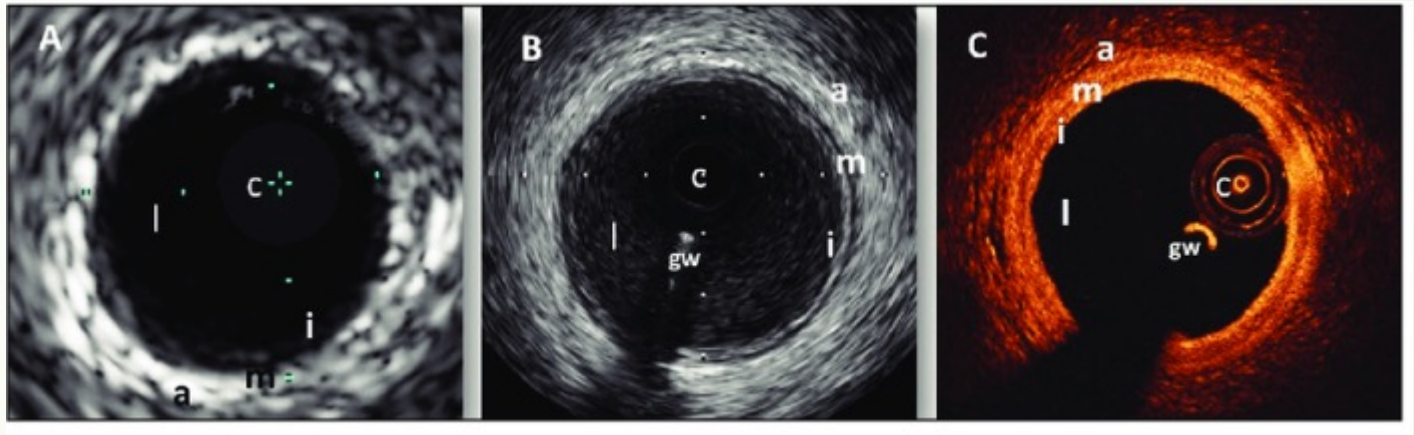
# IVUS

- IVUS can offer important anatomic information beyond what is seen on coronary angiography.
- IVUS is particularly useful in lesions involving the left main artery where there may be limitations in coronary angiography due to overlapping vessels or foreshortening.
- IVUS offers significantly greater spatial resolution than angiography alone (IVUS axial resolution is 100 to 150 μm, and coronary angiography axial resolution is 300 μm). Detailed cross-sectional images provide accurate evaluation of lesion characteristics, including lumen dimensions, lesion length, plaque morphology and location, thrombus, dissection, and stent apposition and expansion.
- Additionally, minimal lumen area on IVUS has been shown to correlate with physiological indices.

# Cutoffs!

- In the case of indeterminate left main disease, studies have shown that IVUS evaluation with deferral of intervention for a minimum lumen area of ≥6 to 7.5 $mm^2$ is safe,
- although a smaller cutoff (4.5–4.8 $mm^2$) may be more appropriate in patients of Asian descent.


Mechanical IVUS
A
Guidewire
Rotating Element
B
Solid State IVUS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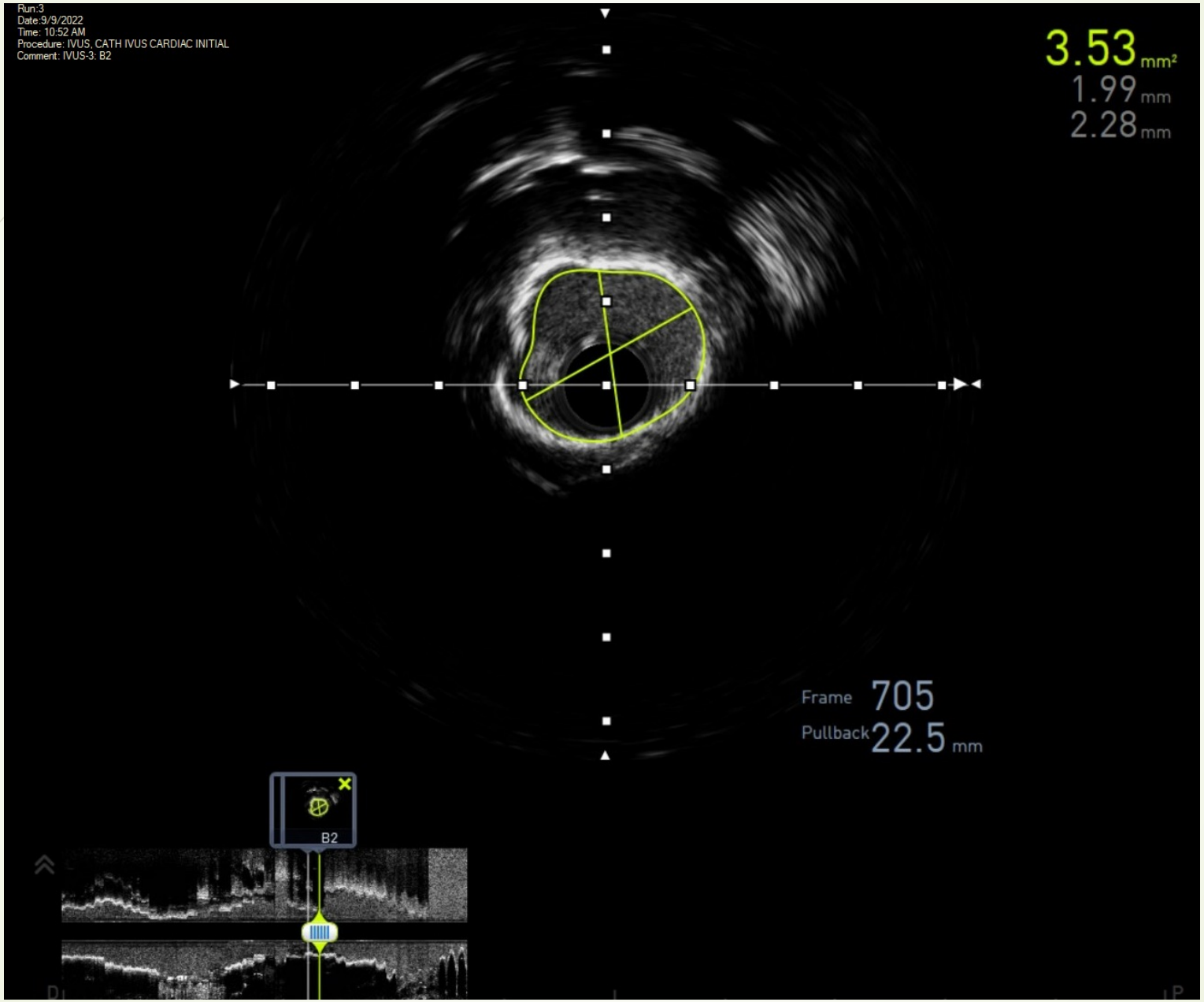
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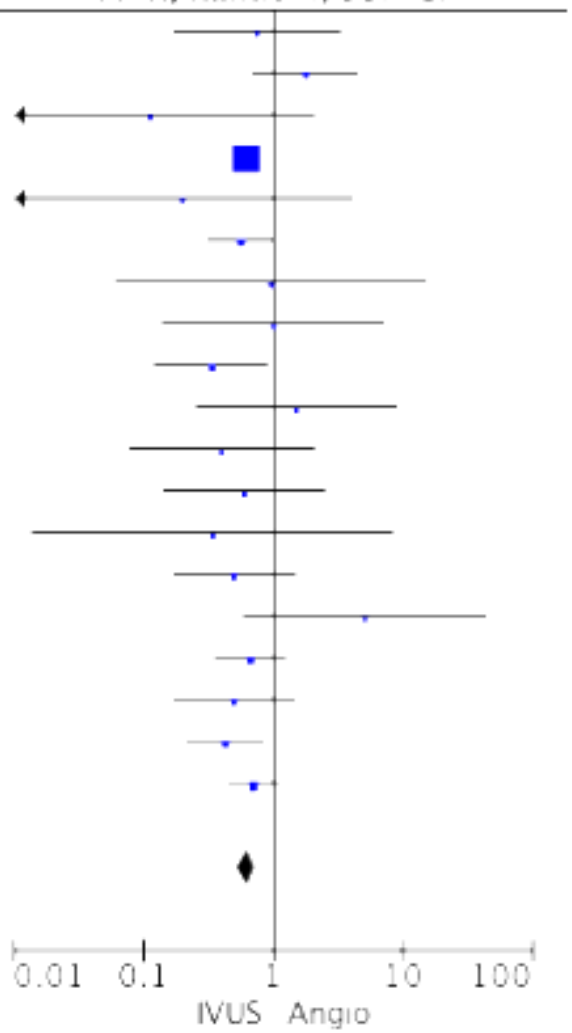
3.53 mm²
1.99 mm
2.28 mm
Frame 705
Pullback 22.5 mm
B2

| Study or Subgroup | IVUS Events | IVUS Total | Angio Events | Angio Total | Weight | Risk Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| AIR-CTO 2015 | 3 | 115 | 4 | 115 | 1.1% | 0.75 [0.17, 3.28] |
| AVID 2009 | 12 | 395 | 7 | 406 | 2.9% | 1.76 [0.70, 4.43] |
| CHEN et al 2012 | 0 | 123 | 4 | 123 | 0.3% | 0.11 [0.01, 2.04] |
| Choi et al | 98 | 1647 | 416 | 4331 | 53.6% | 0.62 [0.50, 0.77] |
| CTO-IVUS 2015 | 0 | 201 | 2 | 201 | 0.3% | 0.20 [0.01, 4.14] |
| De la Torre Hernandez 2014 | 17 | 505 | 30 | 505 | 7.2% | 0.57 [0.32, 1.01] |
| DIPOL 2007 | 1 | 83 | 1 | 80 | 0.3% | 0.96 [0.06, 15.15] |
| EXELLENT 2013 | 2 | 463 | 2 | 463 | 0.6% | 1.00 [0.14, 7.07] |
| Gao et al 2014 | 5 | 291 | 15 | 291 | 2.4% | 0.33 [0.12, 0.91] |
| HOME DES IVUS 2010 | 3 | 105 | 2 | 105 | 0.8% | 1.50 [0.26, 8.79] |
| Hong et al 2014 | 2 | 201 | 5 | 201 | 0.9% | 0.40 [0.08, 2.04] |
| IVUS-XPL 2015 | 3 | 700 | 5 | 700 | 1.2% | 0.60 [0.14, 2.50] |
| Kim et al 2013 | 0 | 269 | 1 | 274 | 0.2% | 0.34 [0.01, 8.30] |
| MATRIX 2011 | 5 | 548 | 10 | 548 | 2.1% | 0.50 [0.17, 1.45] |
| OPTICUS 2001 | 5 | 273 | 1 | 275 | 0.5% | 5.04 [0.59, 42.83] |
| Roy et al 2008 | 16 | 884 | 24 | 884 | 6.2% | 0.67 [0.36, 1.25] |
| Ultimate 2018 | 5 | 724 | 10 | 724 | 2.1% | 0.50 [0.17, 1.46] |
| Wakabayashi et al 2012 | 12 | 637 | 28 | 637 | 5.4% | 0.43 [0.22, 0.84] |
| Witzenbichler et al 2014 | 27 | 3349 | 60 | 5234 | 11.9% | 0.70 [0.45, 1.11] |
| **Total (95% CI)** | | **11513** | | **16097** | **100.0%** | **0.63 [0.54, 0.73]** |
| Total events | 216 | | 627 | | | |

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 15.65$, df = 18 (P = 0.62); $I^2 = 0\%$

Test for overall effect: Z = 5.91 (P < 0.00001)




Download figure | Download PowerPoint

RESEARCH SUMMARY

# Fractional Flow Reserve or Intravascular Ultrasonography to Guide PCI

Koo B-K et al. DOI: 10.1056/NEJMoa2201546

## CLINICAL PROBLEM

Fractional flow reserve (FFR) and intravascular ultrasonography (IVUS) are the two most common tools used as adjuncts to coronary angiography for guiding decision making regarding percutaneous coronary intervention (PCI). A head-to-head comparison of the two approaches with respect to clinical outcomes is needed.

## CLINICAL TRIAL

**Design:** A multinational, prospective, randomized, open-label trial examined whether FFR guidance would be noninferior to IVUS guidance in patients with intermediate coronary stenosis.

**Intervention:** 1682 adults with intermediate stenosis (40–70%) in a target vessel ≥2.5 mm by visual estimation on coronary angiography were assigned to FFR guidance or IVUS guidance. In the FFR group, PCI was performed if the FFR was ≤0.80; in the IVUS group, PCI was performed if the minimal lumen area was ≤3 mm² or ≤4 mm² with a plaque burden of >70%. The primary outcome was a composite of death from any cause, myocardial infarction, or any revascularization at 24 months.

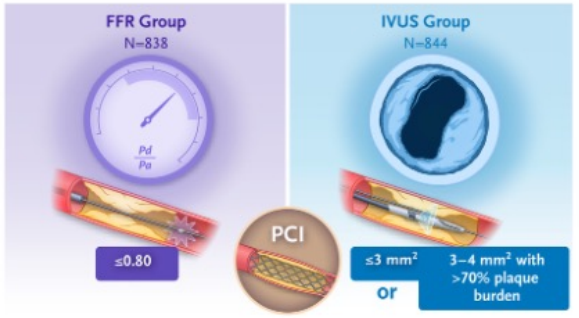
## RESULTS

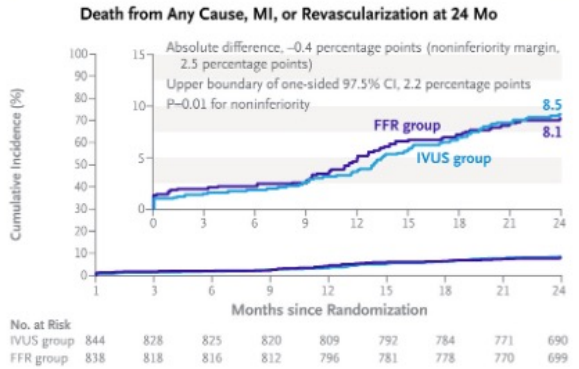
FFR guidance was found to be noninferior to IVUS guidance with respect to the primary composite outcome. The FFR group had a lower incidence of target-vessel PCI during the index procedure.

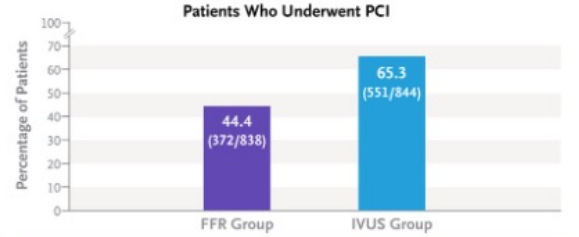
## LIMITATIONS AND REMAINING QUESTIONS

- The study included low-risk patients with a mean SYNTAX score of <10, indicating low anatomical complexity of the coronary lesions, so the findings may not apply to higher-risk patients.
- Operating physicians were aware of the assigned treatment; this could have influenced the frequency of revascularization during follow-up.

**Links: Full Article | NEJM Quick Take | Editorial**



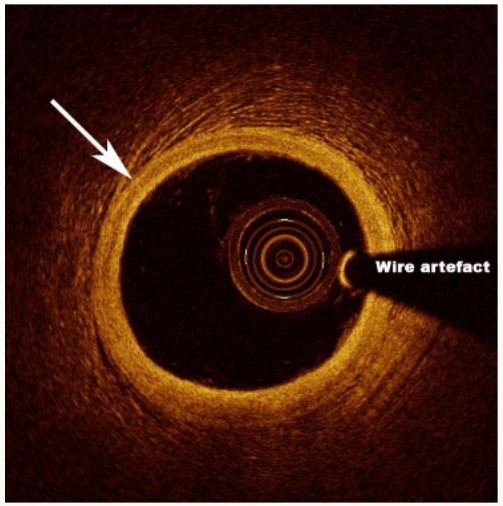




## CONCLUSIONS

Among patients with intermediate coronary stenosis, FFR guidance was noninferior to IVUS guidance with respect to a composite of death, myocardial infarction, or revascularization at 24 months, with a lower frequency of stent implantation during the index procedure.

# The other guy OCT

- Optical coherence tomography is an intravascular imaging modality akin to intravascular ultrasound. It utilizes light waves instead of sound waves for image acquisition and consequently provides a quantum leap in coaxial resolution.
- (that wording is from the manufacturer if you cant guess.)
- Light waves near infrared range (1,300 nm wavelength) are projected around the imaged structure and the reflected backscattered light signals form the images for analysis.

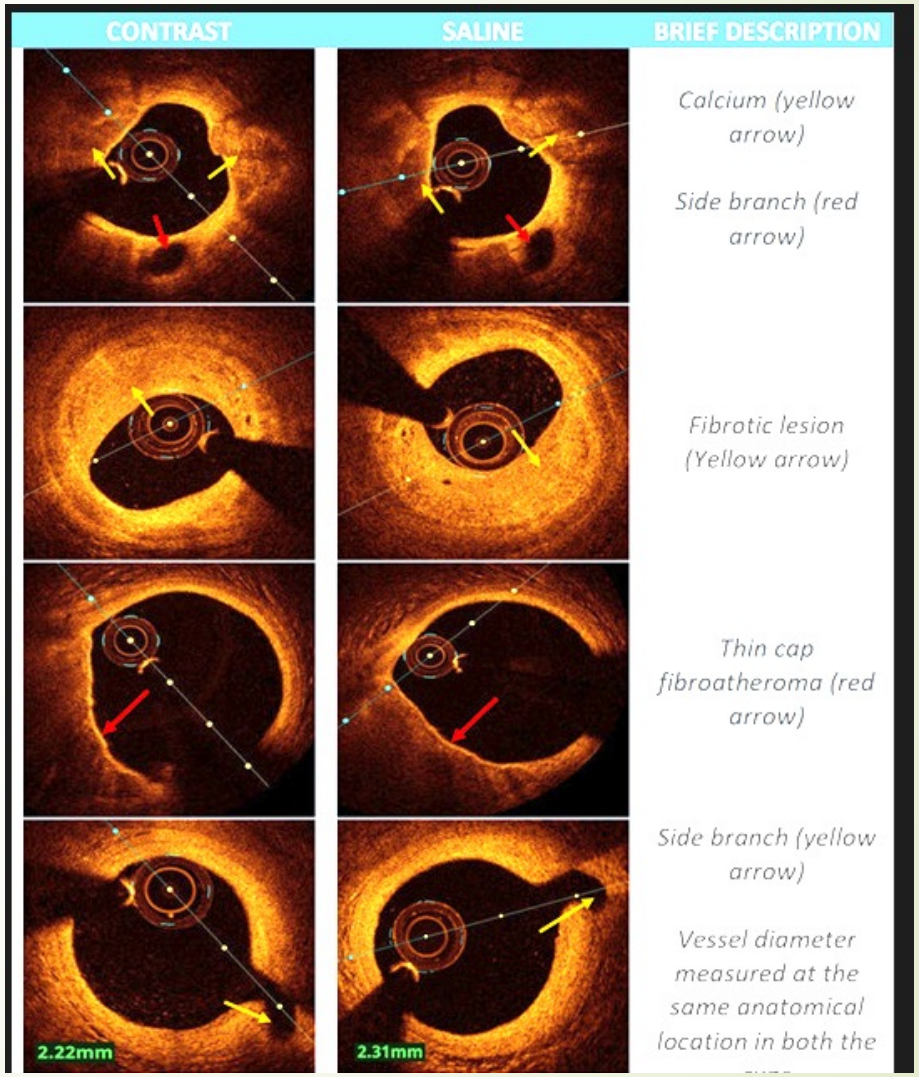


# When do I use it then?

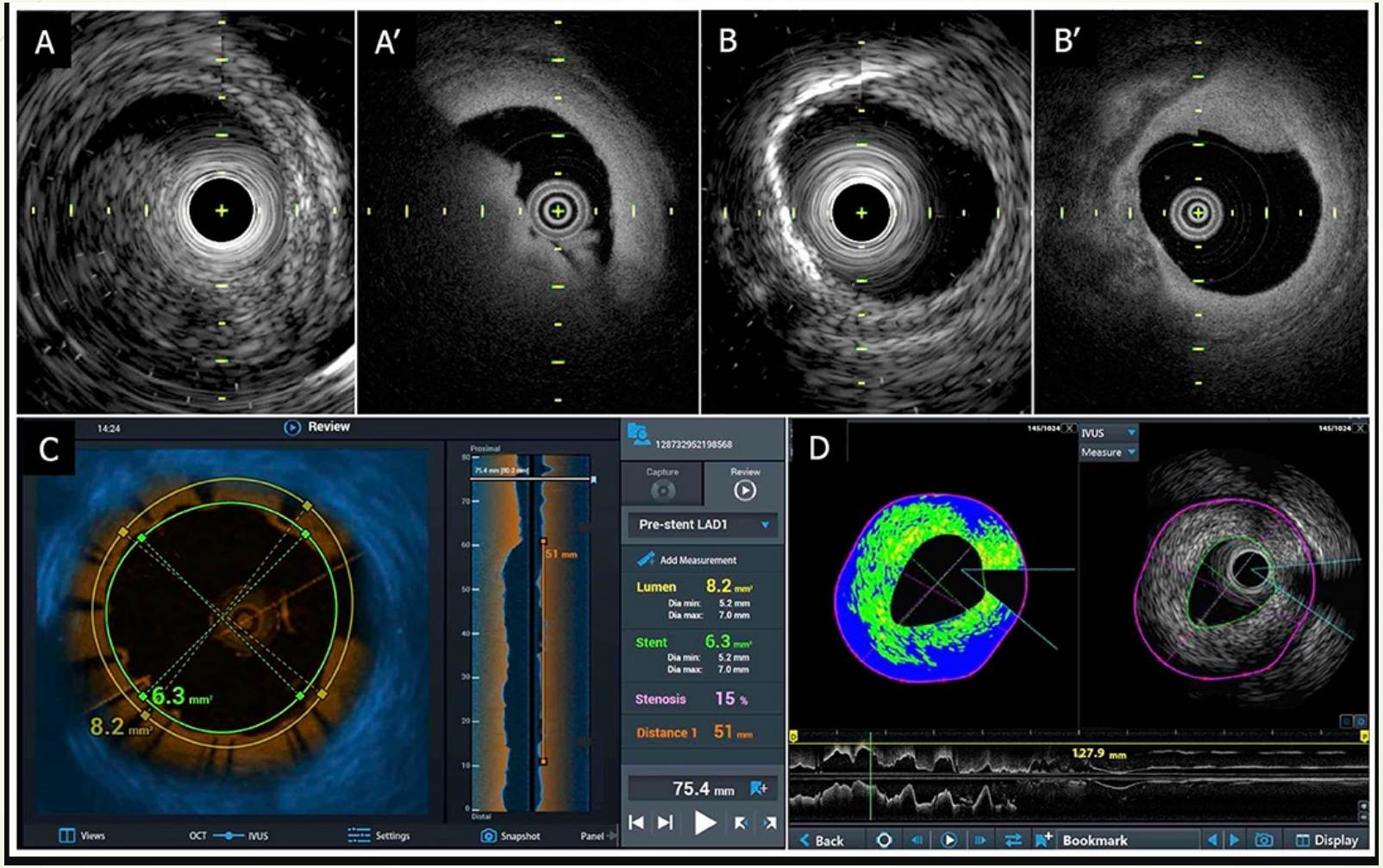
**Comparison of Intravascular Imaging Systems**

| Lesion Type | IVUS | OCT |
|---|---|---|
| Ostial left main | ++ | - |
| Neointimal hyperplasia | + | ++ |
| Calcified | ++ | + |
| Thrombus | + | ++ |
| Stent apposition | + | ++ |
| Dissection | + | ++ |
| Thin-capped atheroma | - | ++ |
| Vessel diameter >5.0 mm | ++ | + |

++ excellent lesion assessment,
+ good lesion assessment,
- difficult lesion assessment



# The future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Stent 6.3 mm²
Dia min: 5.2 mm
Dia max: 7.0 mm
Stenosis 15 %
Distance 1 51 mm
75.4 mm
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8.2 mm²
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Views
OCT
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127.9 mm
Back
Bookmark
Display