
ICPS

# Resténose intra-stent: Comprendre pour mieux traiter

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# ISR is a multifaceted problem

**Lesion-related factors:**

- Long/diffuse lesion
- Calcified lesion
- Small Vessel
- Bifurcation

**Patient-related factors:**

- Diabetes
- Poorly controlled risk factors
- Chronic renal failure

**ISR**

**Stent-related factors:**

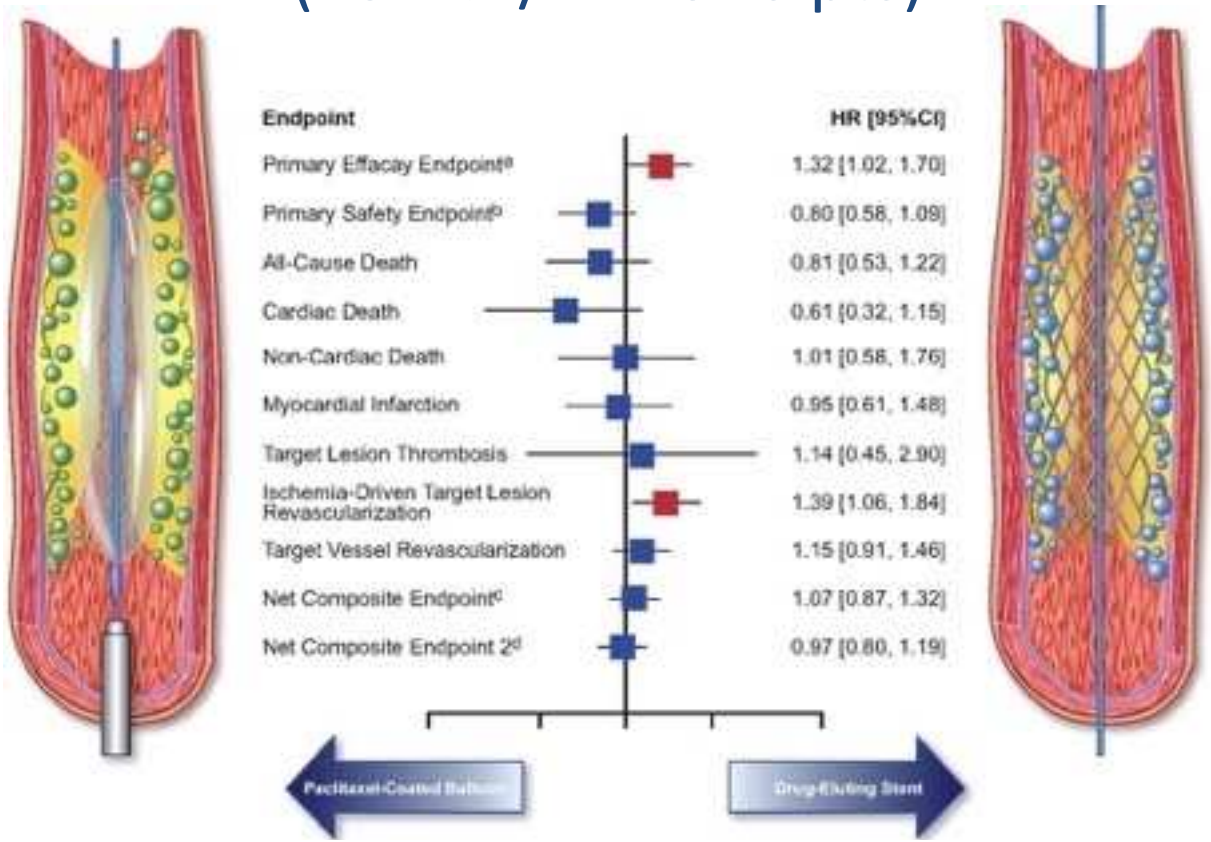
- Bare metal stent
- Thick struts
- Durable polymer (?)

**PCI-related factors:**

- Underexpansion
- Multiple layers
- Initial overstretch
- Stent fracture / Compression
- Residual plaque burden
- Geographical Miss

# DCB vs. DES for ISR : The DAEDALUS meta analysis

## (10 RCT/ n=1976 pts)




 **Giaccopo D et al. European Heart Journal (2020) 41, 3715–3728 .**

# The ISR continuous Spectrum

**Mechanical trigger**:
- Overstretch
- Underexpansion
- Fracture…

**Local Inflammation**

**NIH**

**Neoatherosclerosis**

**Non cardiac promotting factors** :
- Diabetes
- Chronic renal failure

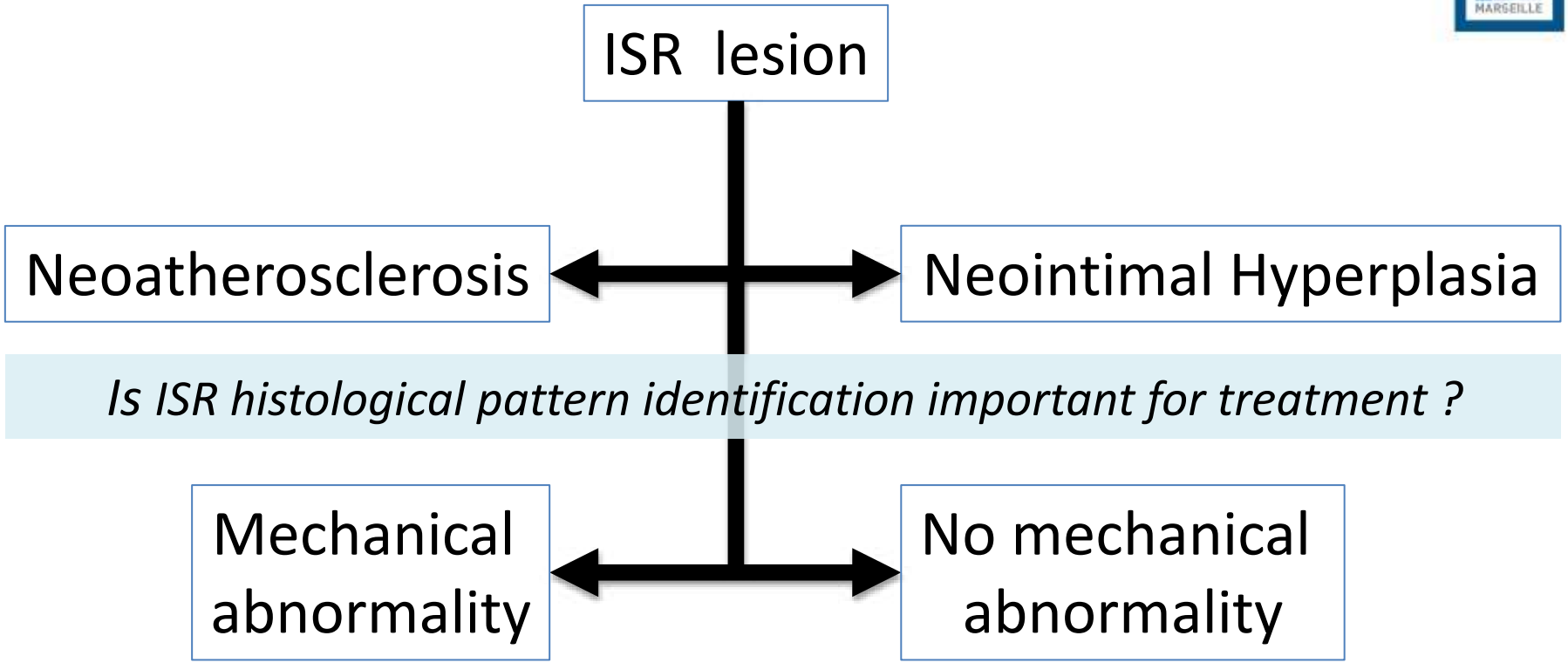
**On going CV risk factors** :
- Diabetes, dylipidemia, smoking…

0 1 3 6 12 24 **Months post PCI**

# Waksman ISR classification

| Type | Definition | | Treatment options |
|---|---|---|---|
| I | **Mechanical** | Underexpansion (I A) | High Pressure ballon |
| | | Stent Fracture (I B) | DES |
| II | **Biologic** | Intimal hyperplasia ( II A ) | POBA, DCB, DES , VBT |
| | | Neoatherosclerosis non calcified (II B ) | DCB or DES |
| | | Neoatherosclerosis , calcified ( II C ) | Scoring/ RA/ ELCA |
| III | **Mixed pattern:** ***combined mechanical and biologic etiology*** | | High Pressure ballon + DCB/DES or VBT |
| IV | **Chronic total occlusion** | | DCB or DES, Brachytherapy or CABG |
| V | **≥ 2 layers of stent** | | POBA, DCB, VBT or CABG |

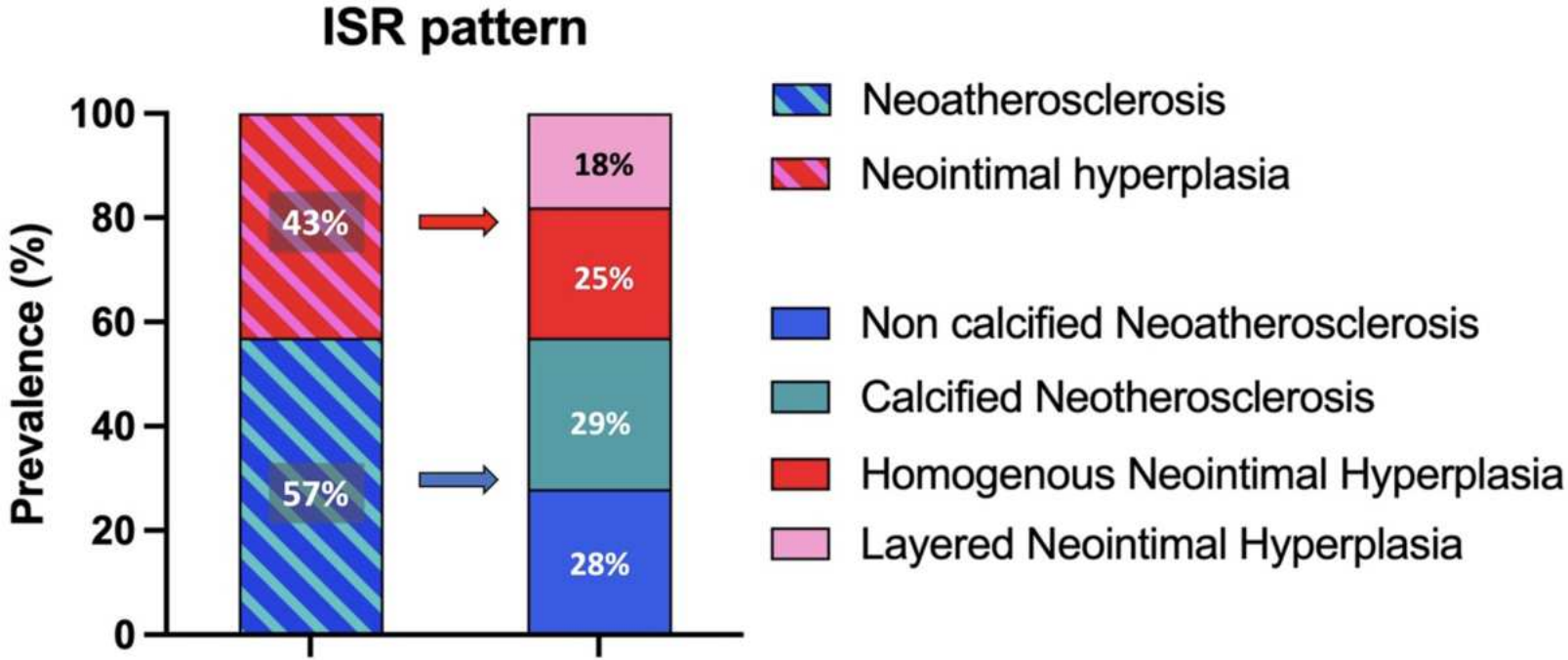
Schlofmitz E et al. Circulation: Cardiovascular Interventions. 2019;12:e007023




*Is underlying mechanical abnormality analysis important for treatment ?*

# OCT ANALYSIS : ISR pattern

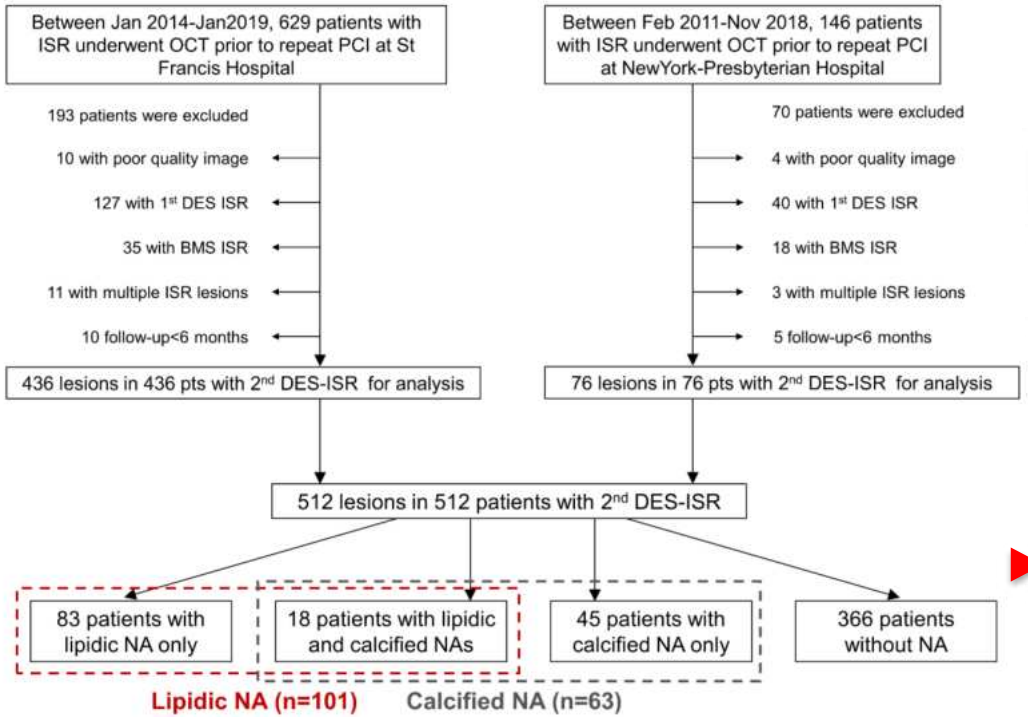
## N=297 all comers ISR patients with OCT analysis



# DES vs.DCB for Neoatherosclerosis-related ISR

| | DES | DCB |
|---|---|---|
| **PROS** | ➢ Better scaffolding<br>➢ Reliable drug delivery<br>➢ Limited risk of IS dissection | ➢ No additional layer of struts<br>➢ Simple /safe<br>➢ Safe to use in bifurcation |
| **CONS** | ➢ Add an additional layer of struts<br>➢ Risk of underexpansion<br>➢ Careful lesion preparation is mandatory | ➢ Designed for NIH treatment<br>➢ Risk of dissection /Incomplete scaffolding<br>➢ Profile/ Deliverability<br>➢ Non predictable drug transfer<br>➢ Impact on calcifications ? |

# Neoatherosclerosis-related ISR : PCI results



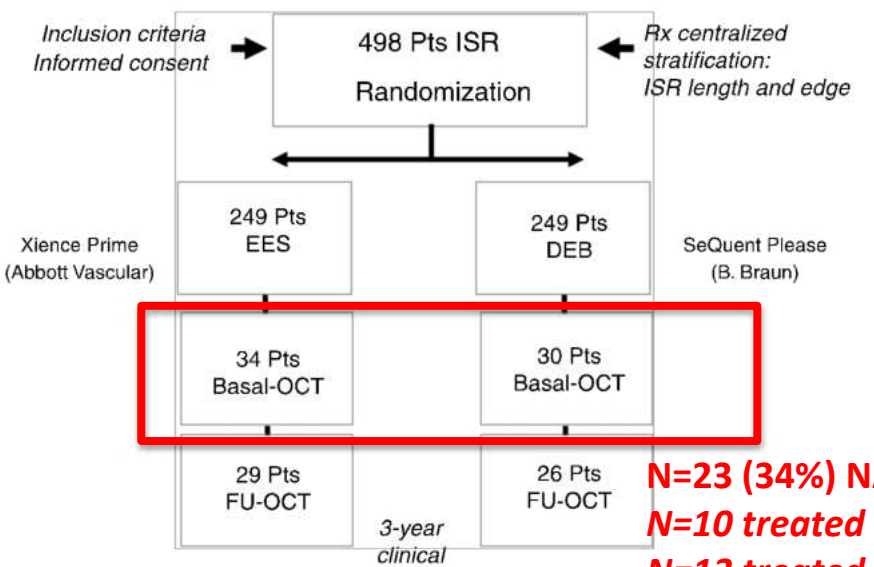

**Clinical and morphological factors associated with 3-y TLF**

| | Hazard ratio (95% CI) | *P* value |
|---|---|---|
| Lipidic neoatherosclerosis | 2.05 (1.36–3.09) | <0.001 |
| Calcified neoatherosclerosis | 0.98 (0.51–1.89) | 0.95 |
| Time from stent implantation to ISR, y | 0.90 (0.82–0.98) | 0.02 |
| Age, y | 0.99 (0.97–1.01) | 0.19 |
| Female sex | 1.56 (1.06–2.30) | 0.03 |
| eGFR<60 mL/(min·1.73m²) | 1.47 (0.99–2.17) | 0.052 |
| Diabetes | 1.29 (0.89––1.87) | 0.18 |
| LDL cholesterol, per 10 mg/dL | 0.98 (0.93–1.03) | 0.46 |
| New DES implantation vs balloon angioplasty | 0.92 (0.62–1.37) | 0.69 |
| Final QCA minimum lumen diameter, mm | 0.49 (0.32–0.74) | <0.001 |



**CHEN Z. et al.** *Circ Cardiovasc Interv.* 2022;15:e011693

# Neoatherosclerosis-related ISR & TRT in RIBS-IV & RIBS-V trials




*64 Pts: 100% clinical data available at 1, 2, and 3 years.*

**N=23 (34%) NA lesions**

***N=10 treated with DCB***

***N=13 treated with EES***

| | EES (n=13) | DCB (n=10) | p |
|---|---|---|---|
| **Restenosis** | 33 % | 11 % | ns |
| **MACE 1 y** | 7.7% | 10% | ns |
| **MACE 3 y** | 7.7% | 10% | ns |

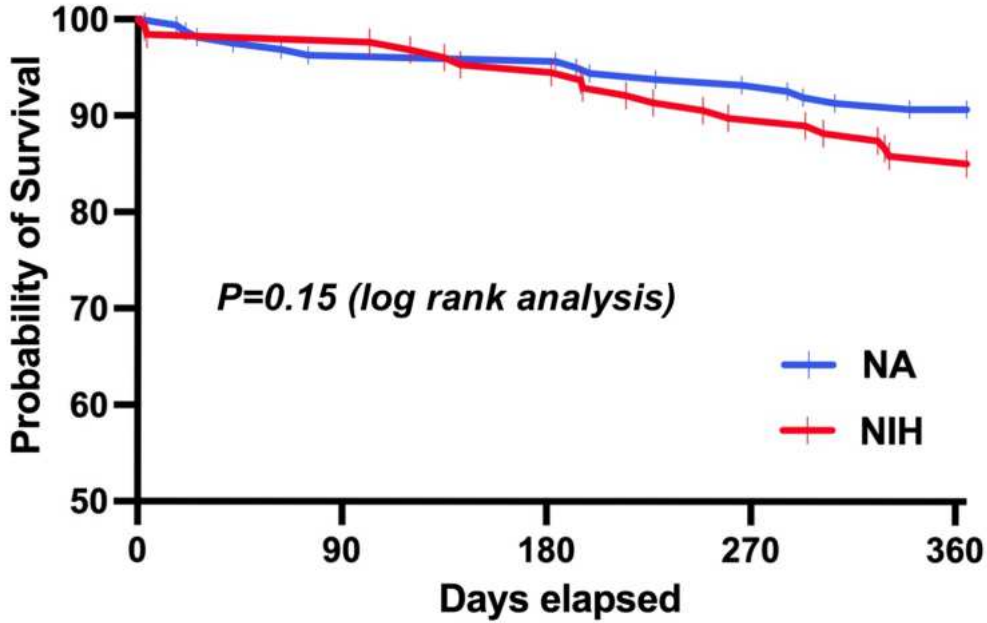


**GONZALO N . et al.** Revista Española de Cardiología . 2021;74 (5): 427-

# Initial ISR pattern & TVF incidence after ISR PCI

**1 year F-U**
*289 patients*

***42 MACE (14.5%)***
***32 TVF (11%)***
**27 TVR (9.3%)**
**5 deaths (1.7%)**

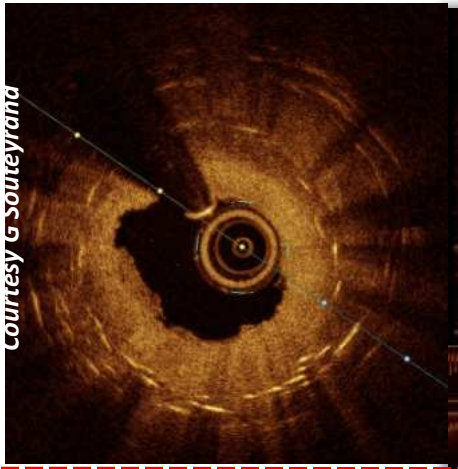


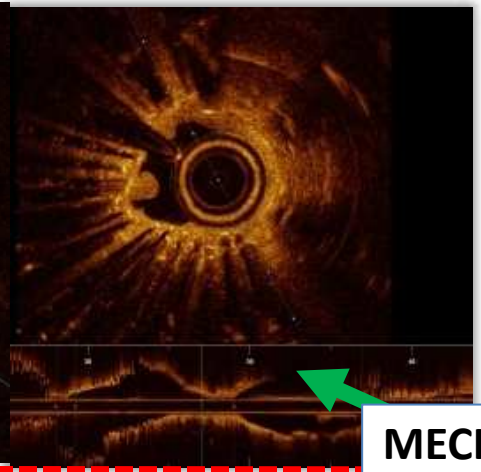

*Number at risk*

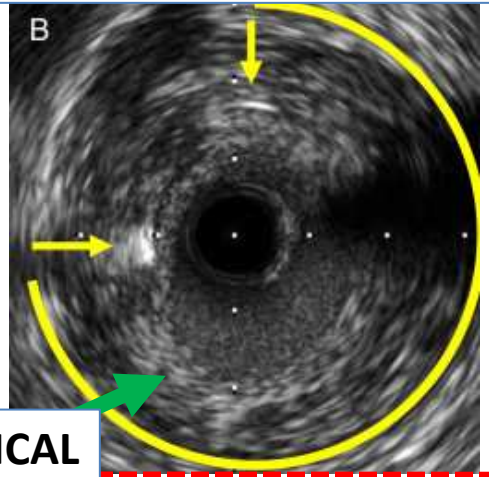
| | | | | | |
|---|---|---|---|---|---|
| NIH | 127 | 125 | 121 | 115 | 110 |
| NA | 161 | 155 | 154 | 151 | 147 |

UNDEREXPANSION / MULTIPLE STENT LAYERS

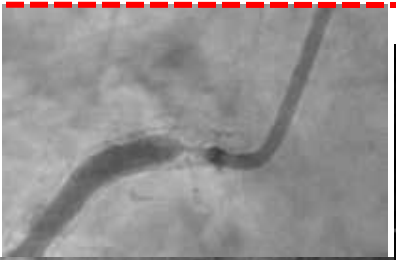
STENT FRACTURE

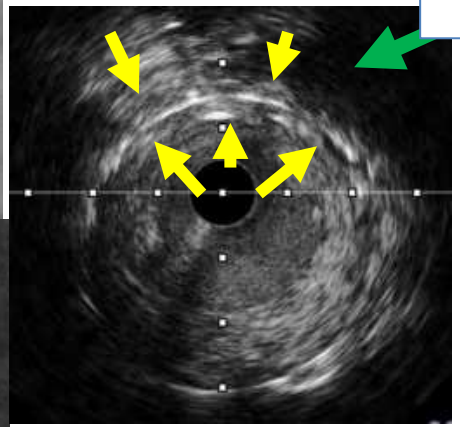


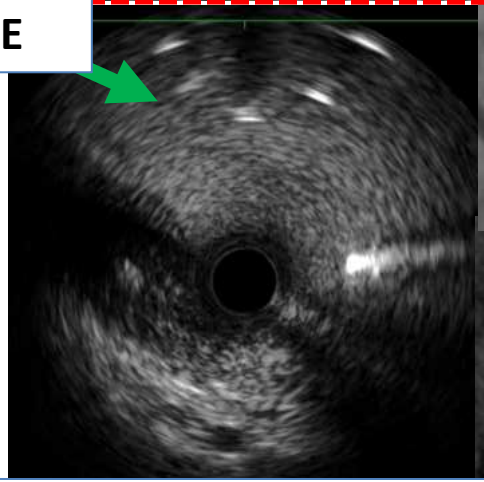



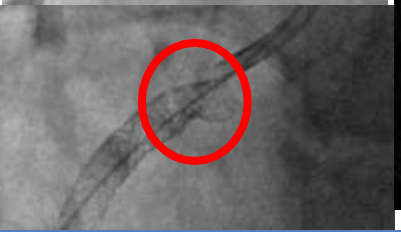



MECHANICAL FAILURE





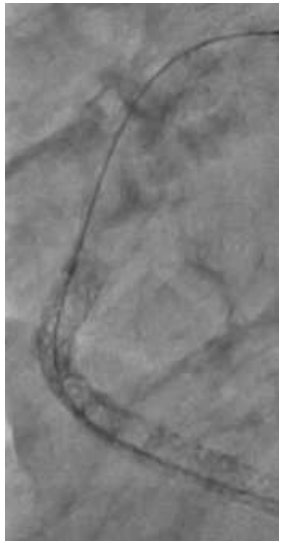


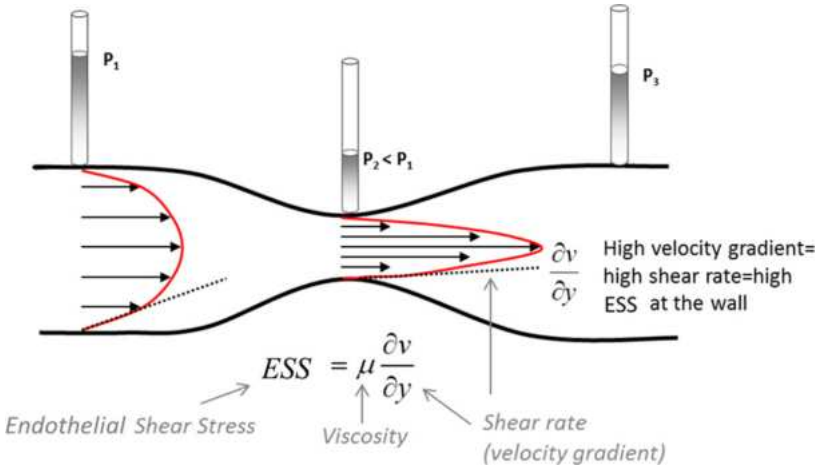


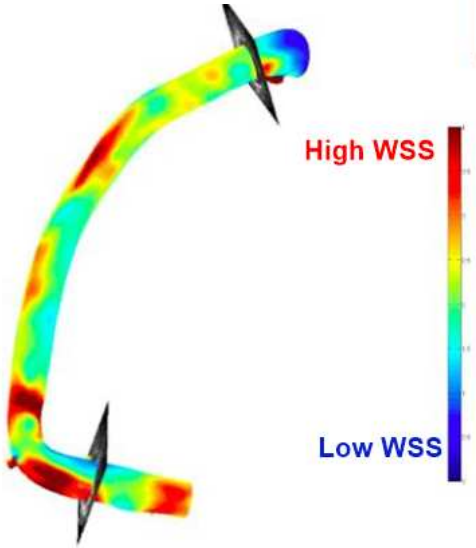
LONGITUDINAL COMPRESSION

STENT CRUSH

# Stent undexpansion & local hemodynamics





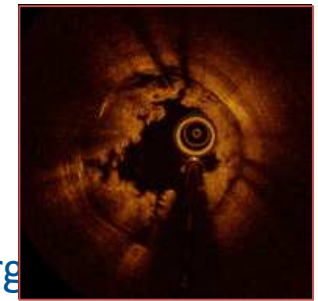



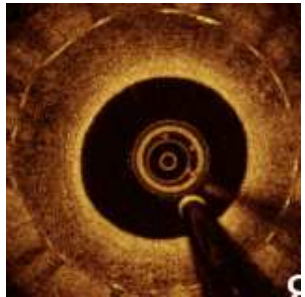

**Local platelet agreggation**

**High shear rate / stress**

**Smooth muscle cells proliferation**

**Prothrombotic state**





**Neointimal proliferation**

# Final MSA & TVF incidence after ISR PCI

**1 year F-U**
*289 patients*

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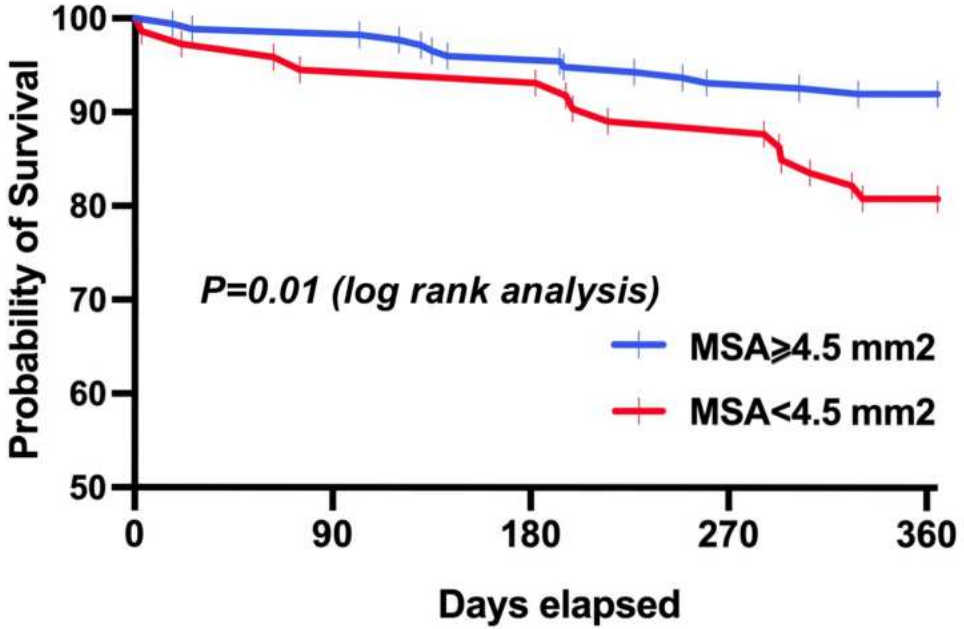
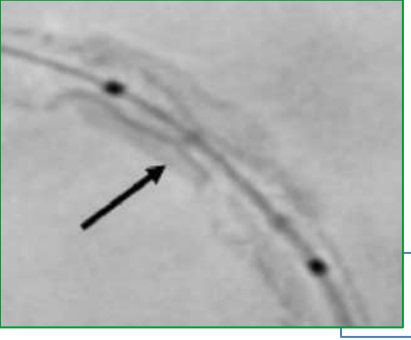



| *Number at risk* | | | | | |
|---|---|---|---|---|---|
| MSA<4.5 mm2 | 73 | 69 | 68 | 65 | 59 |
| MSA≥4.5 mm2 | 175 | 173 | 169 | 165 | 163 |



# OPTIONS FOR UNDEREXPANDED STENTS

Stent under expansion

↓

NC Balloon/ Cutting balloon / Ultra high pressure NCB — Safety: +++ Efficacy:++

↓

Intravascular lithotripsy — Safety: +++ Efficacy: +++

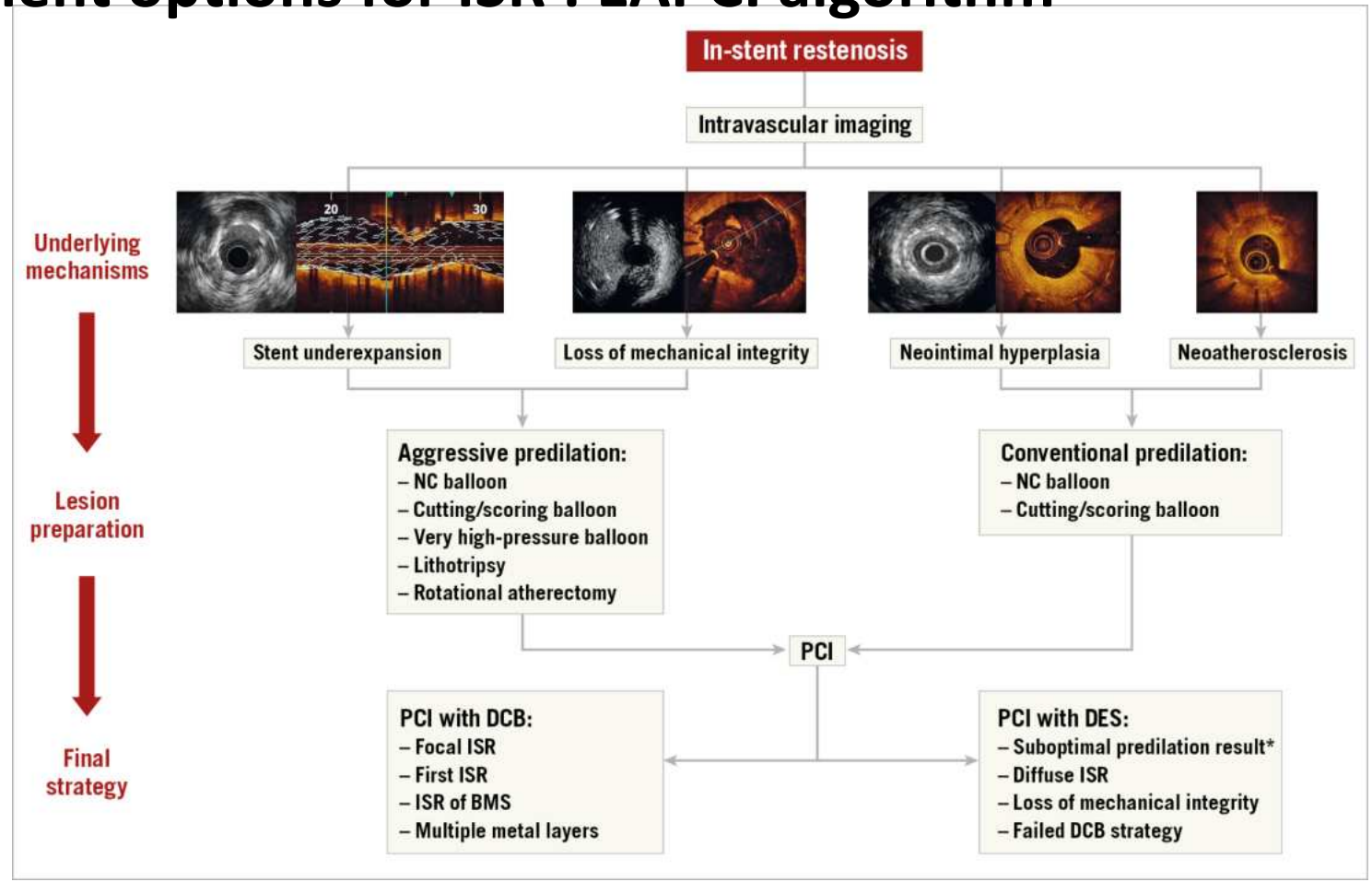
↓

Rotablator / « Stent ablation » — Safety: + Efficacy: +

↓

Laser atherectomy-assisted expansion — Safety: + Efficiacy: +

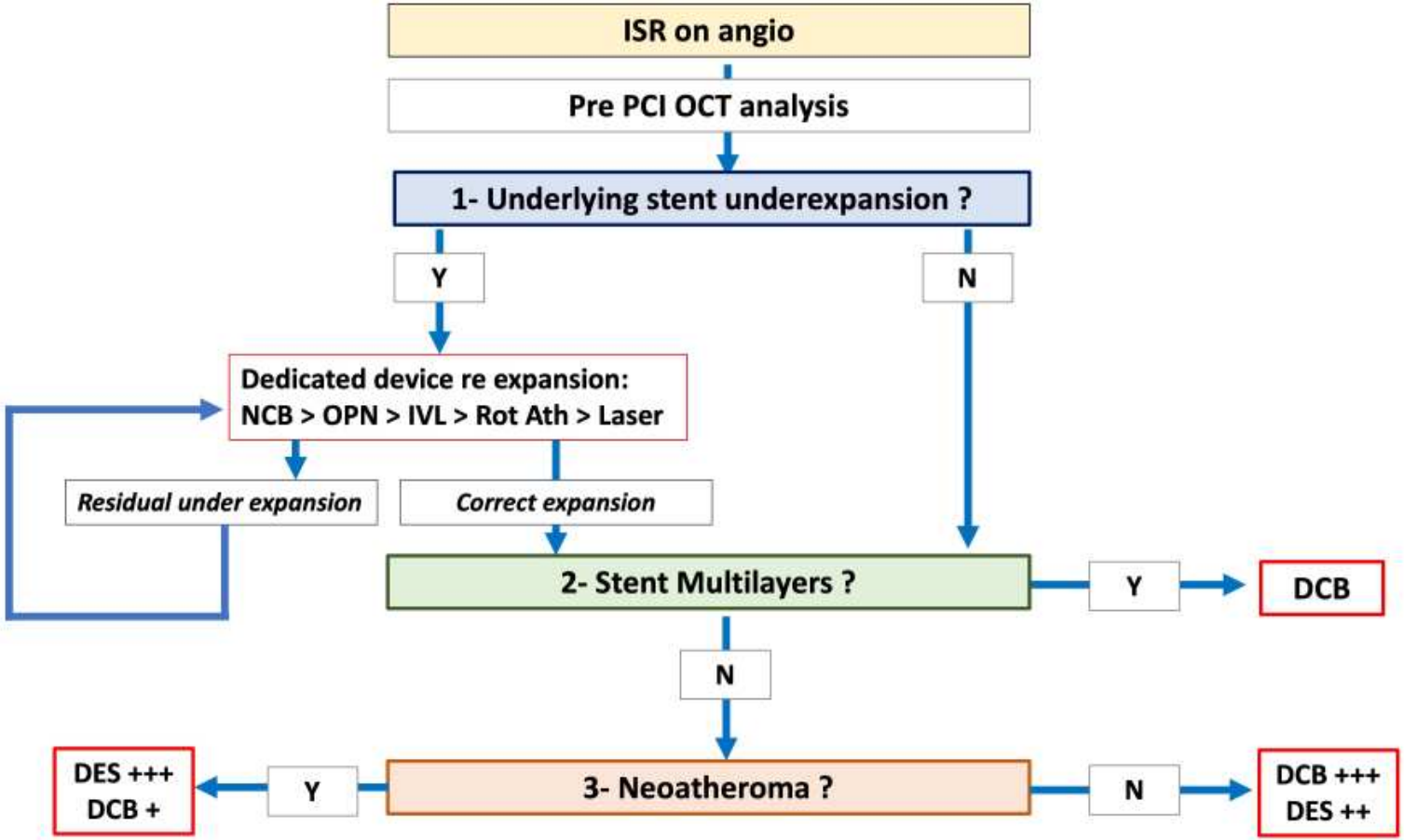
# Treatment options for ISR : EAPCI algorithm






Stefanini GG et al. EuroIntervention 2020;16:e875-e890

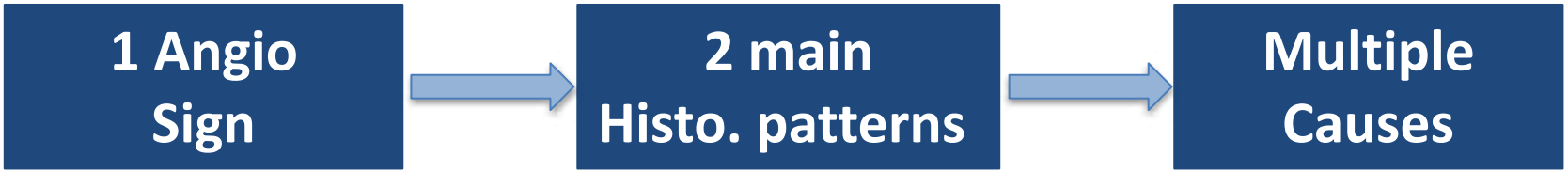
# Treatment options for ISR : RESTO algorithm






N. Amabile & G. Souteyrand / 2023

# Conclusions : Intra Stent Restenosis

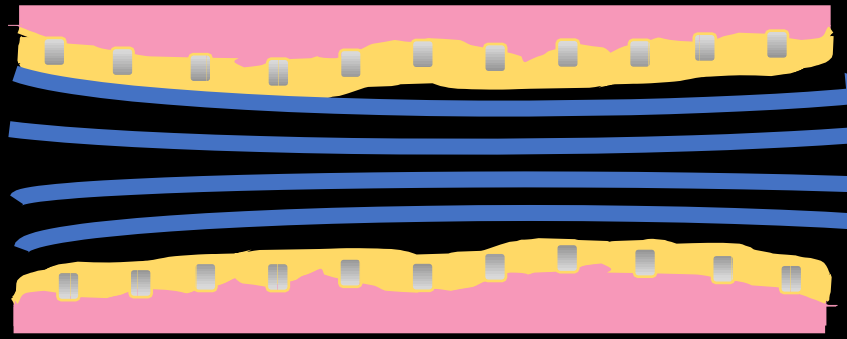



- Identification+ correction of underlying mechanical causes and associated risk factors are key points to prevent recurrence

- Intracoronary imaging could be pivotal to propose the best treatment

- Whether tailored management strategies based on ICI analysis is superior to angio remains to be assessed in future trials

## Adequately expanded stent

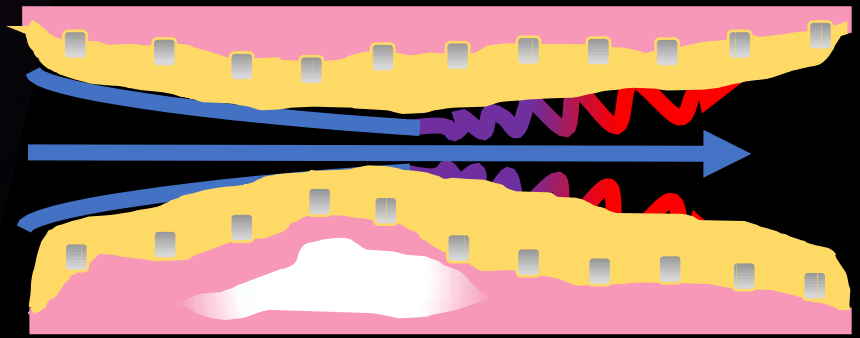


Laminar flow

Adequate Shear stress

Normal healing

## Underexpanded stent

Turbulent flow

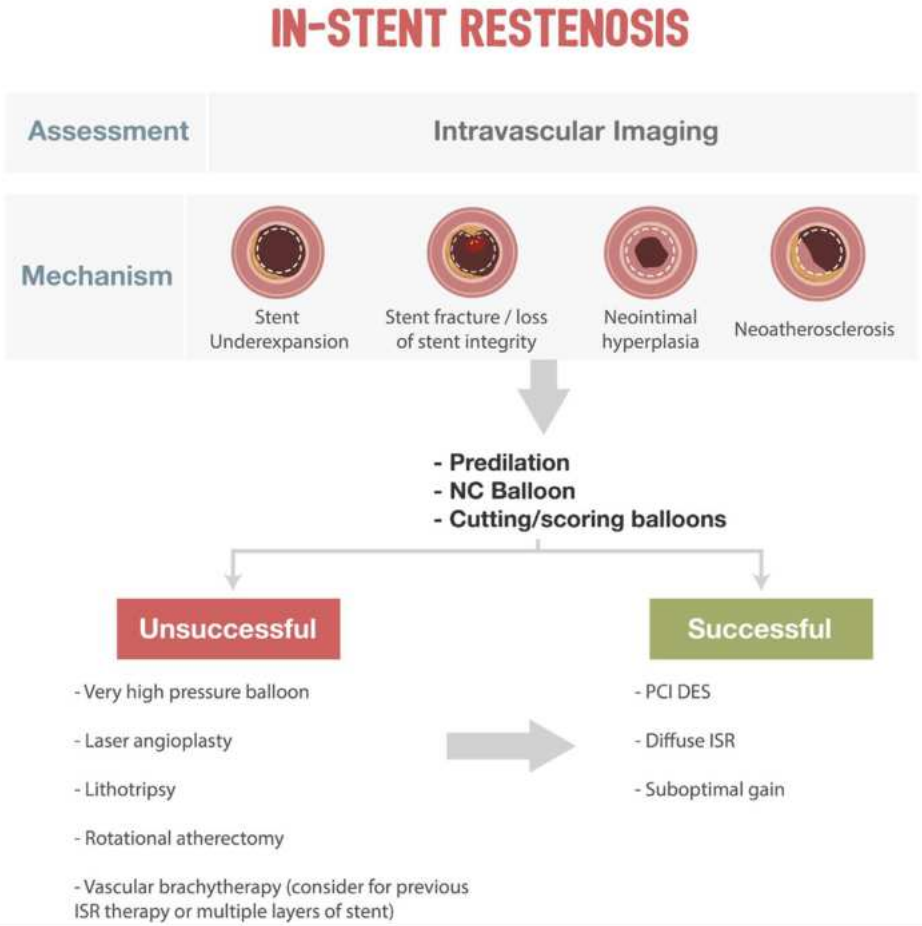
Modified shear stress

↗ ISR risk




**Alfonso et al. EuroIntervention 2022;18:e103-e123.**

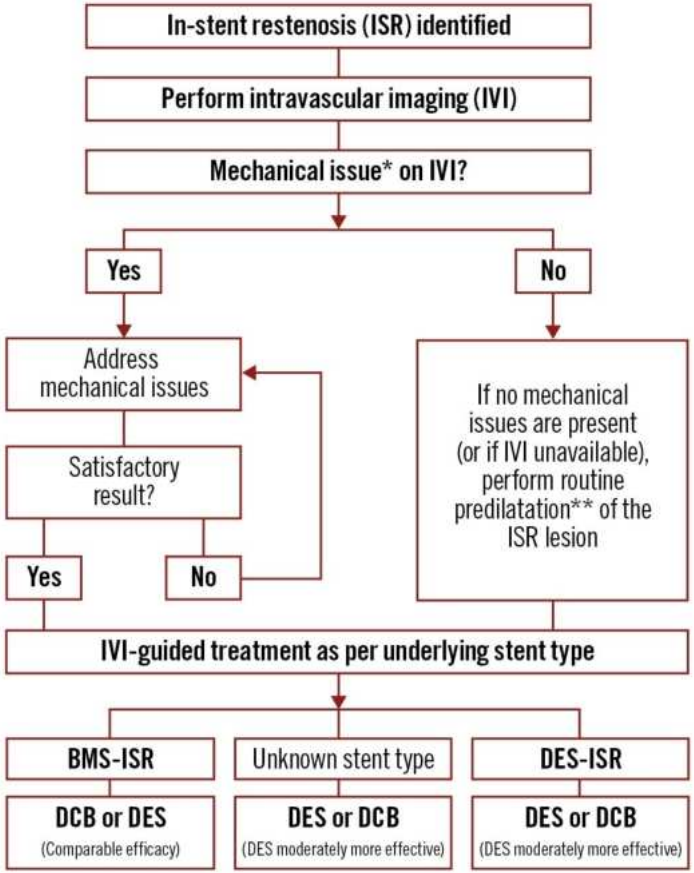
# Treatment options for ISR : SCAI algorithm






Klein LW et al. JSCAI 2023

# Treatment options for ISR : Alfonso algorithm






Alfonso et al. EuroIntervention 2022;18:e103-e123.