

Coronary Calcified Nodules – A Classification

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Disclosure Statement of Financial Interest

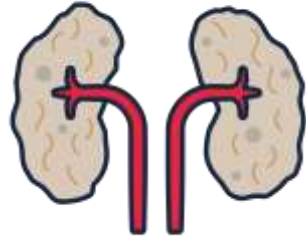
Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

Affiliation/Financial Relationship	Company
Institutional Support	Abbott, Philips, Boston Scientific, Abiomed, ACIST Medical, Shockwave
Consulting Fees/Honoraria	Abbott, Philips, Boston Scientific, Abiomed, ACIST Medical, Shockwave, Neovasc, Zoll, Novo Nordisk
Equity	Xenter, Covanos
Other	Executive Director, Optimizing PCI (OPCI)

Patient population at highest risk



Age



Renal failure

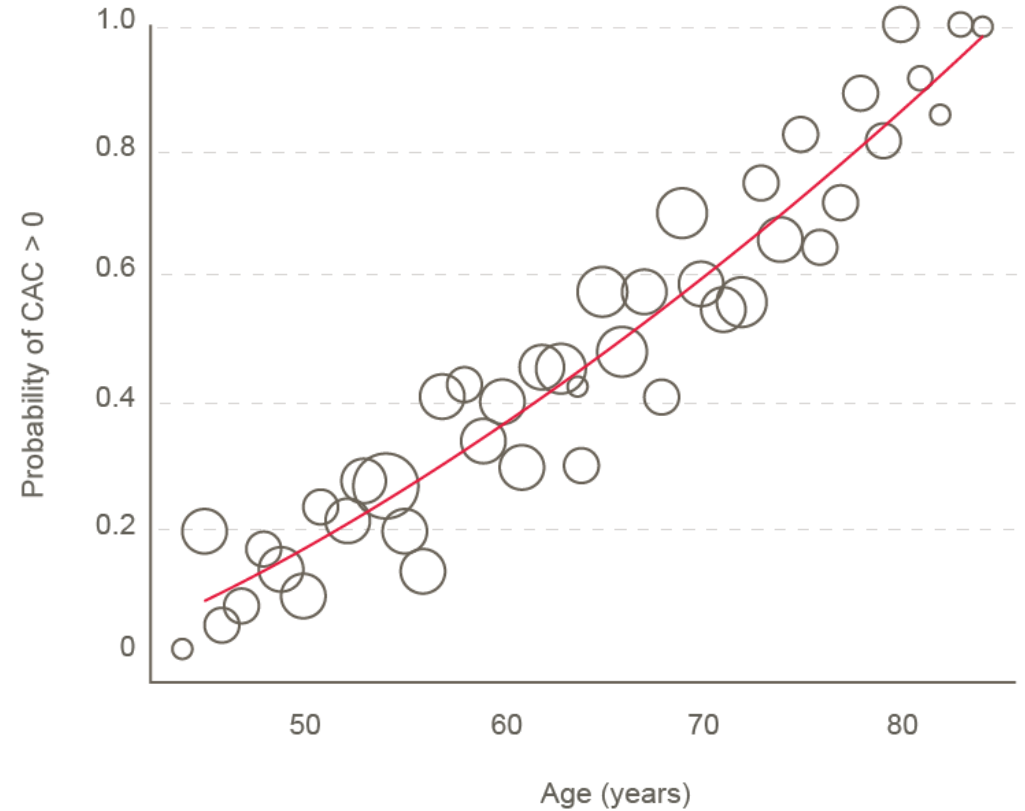


Diabetes



Sex

White (n=1308)

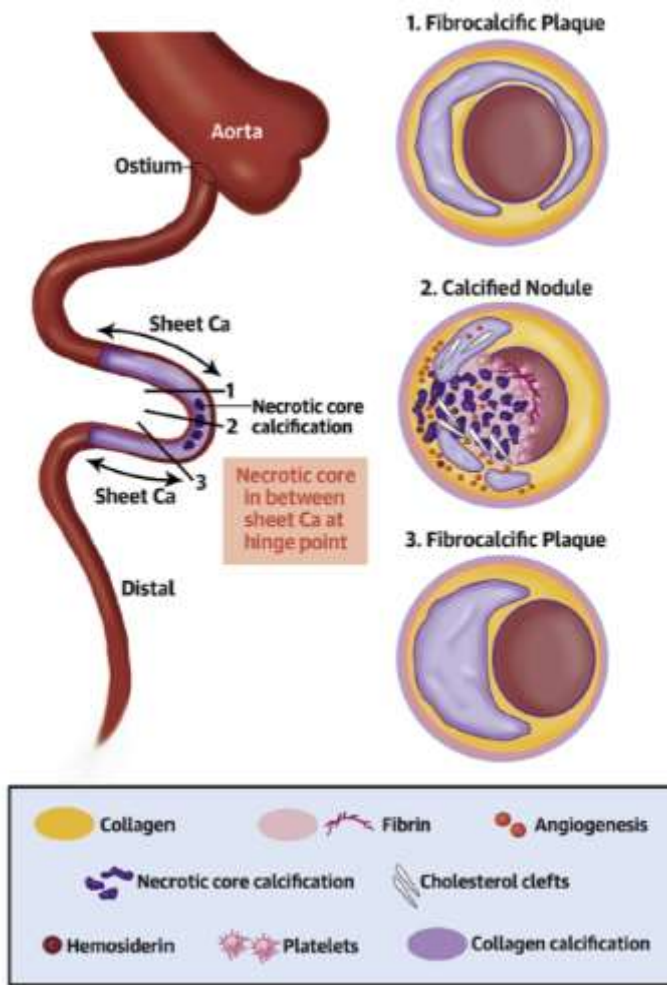
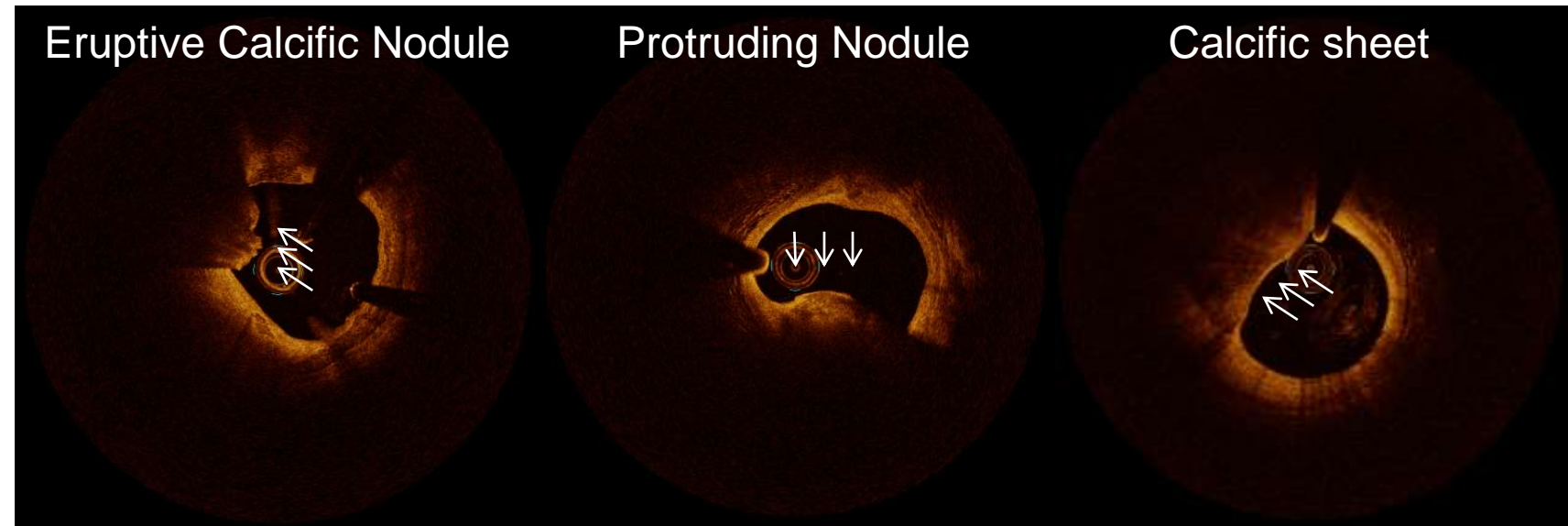


McClelland et al. Circulation. 2006;113:30-37.

Calcified Nodules - Types

Calcium nodule (CN)

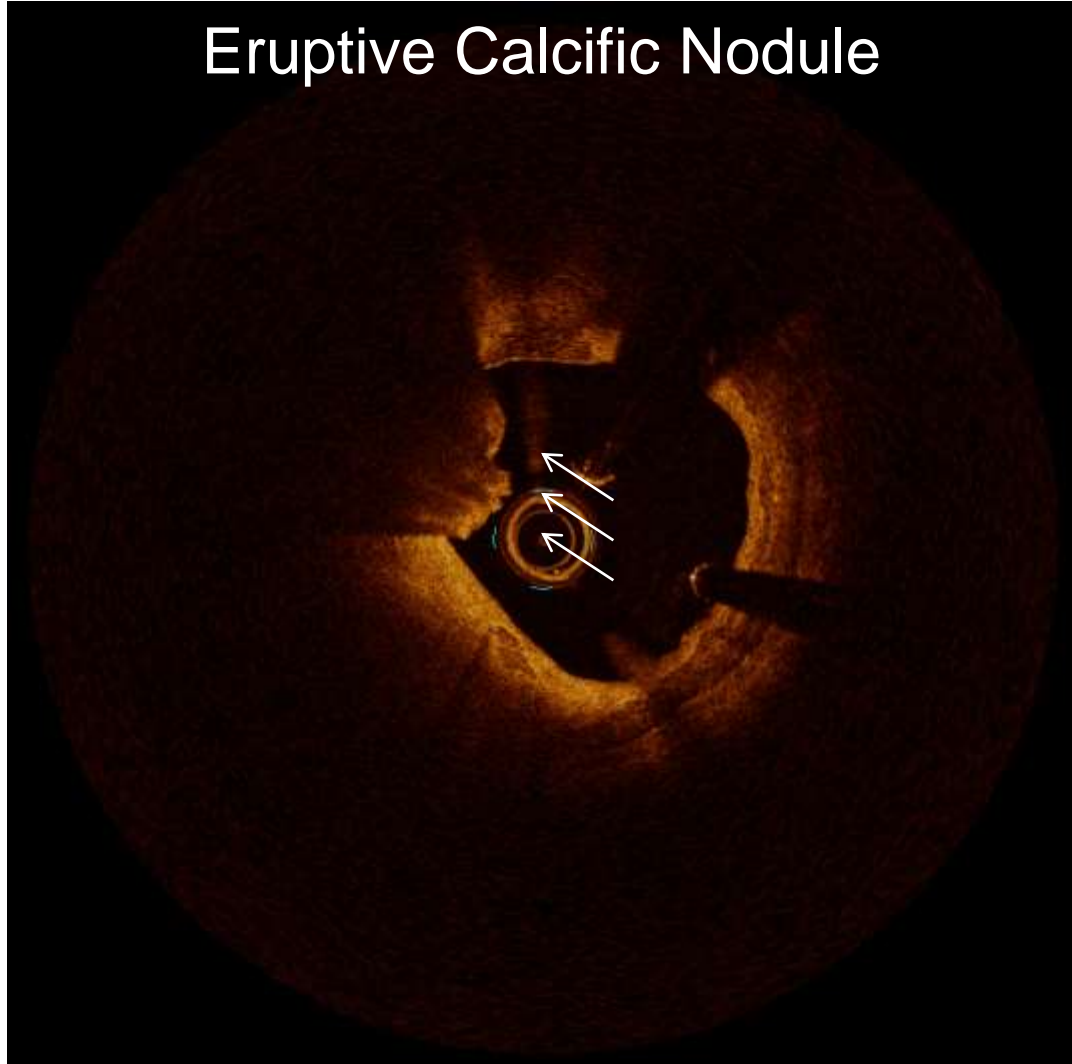
- **Eruptive CN:** Accumulation of small calcium fragments with **irregular surface** and adjacent proximal or distal deep sheet calcification
- **Nodular calcification (Non-eruptive):** Calcium fragment with **smooth thick** fibrous cap with adjacent proximal or distal deep sheet calcification



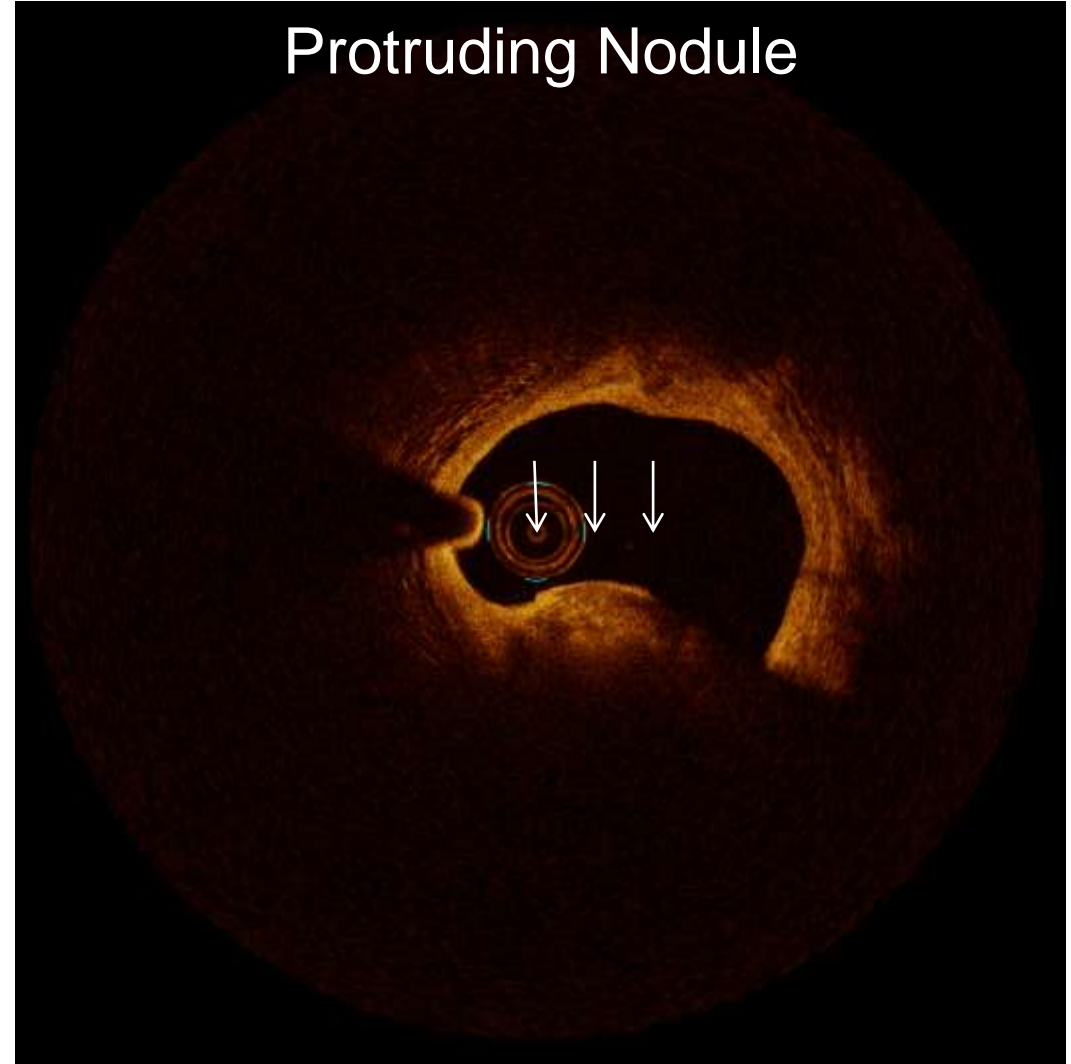
Torii, S. et al. J Am Coll Cardiol. 2021;77:1599-611. Lee, T. et al. J Am Coll Cardiol. 2017;10:883-91. Ali et al. EuroIntervention 2021;17:e105-e123.

Clinically Relevant Calcified Nodules

Eruptive Calcific Nodule

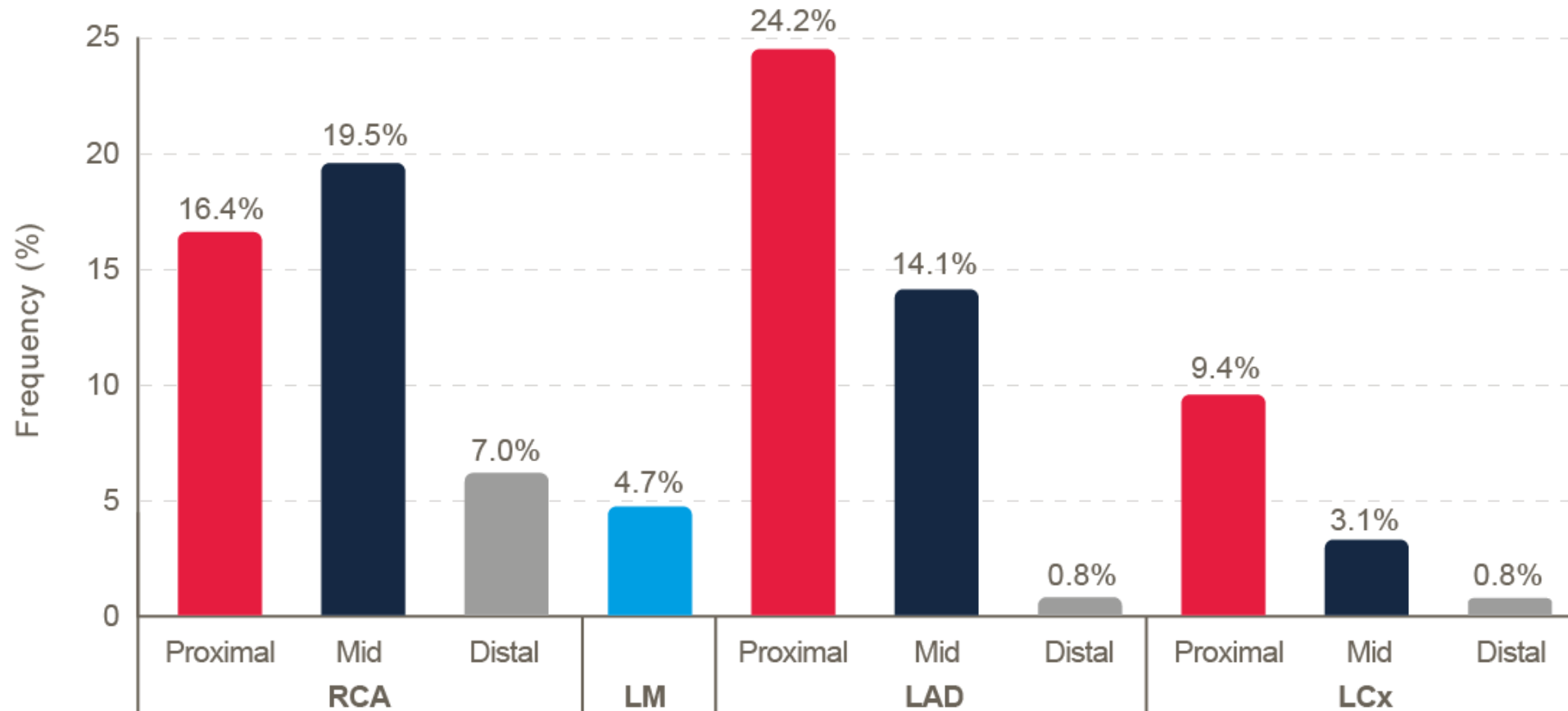


Protruding Nodule



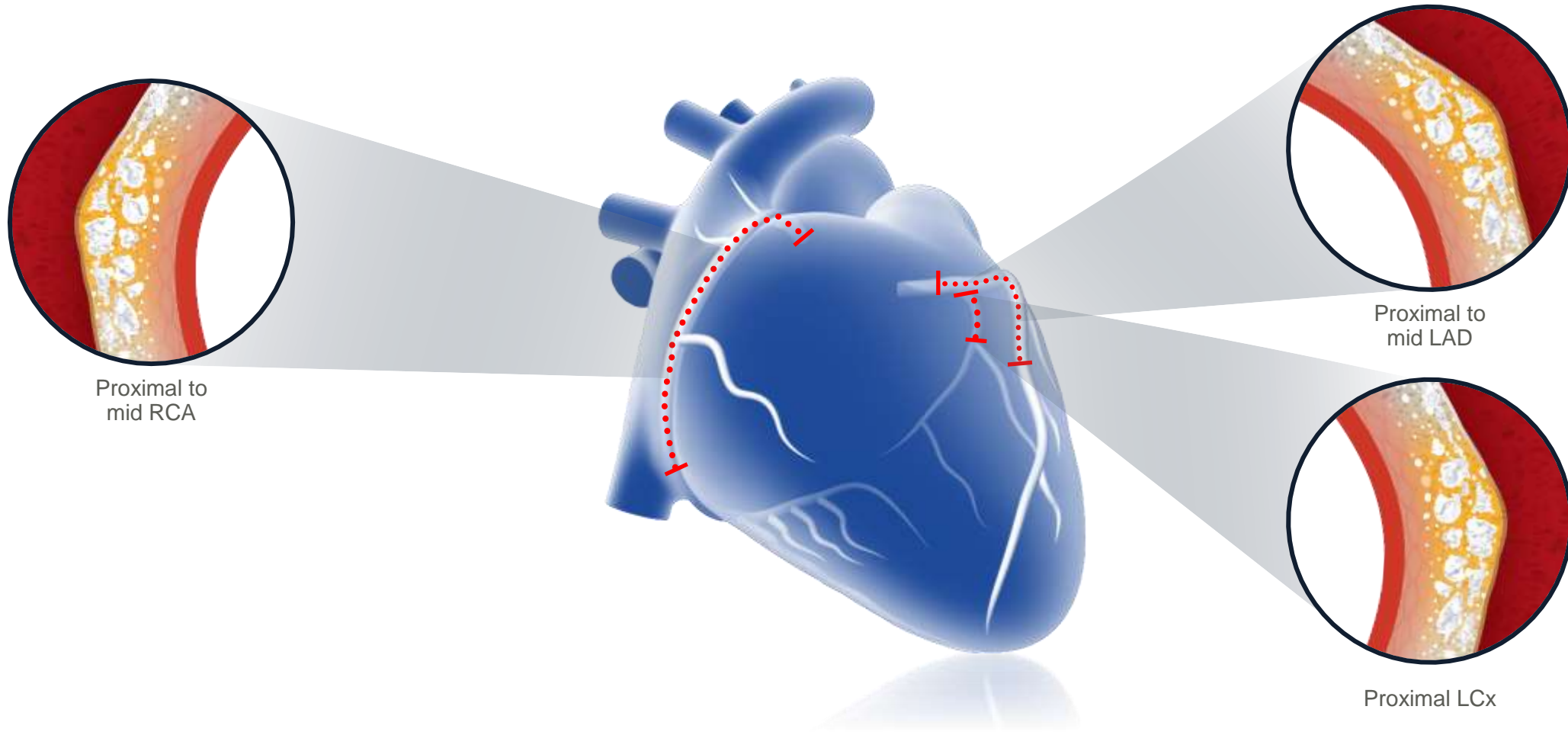
Ali et al. EuroIntervention 2021;17:e105-e123.

Calcified Nodules - Distribution



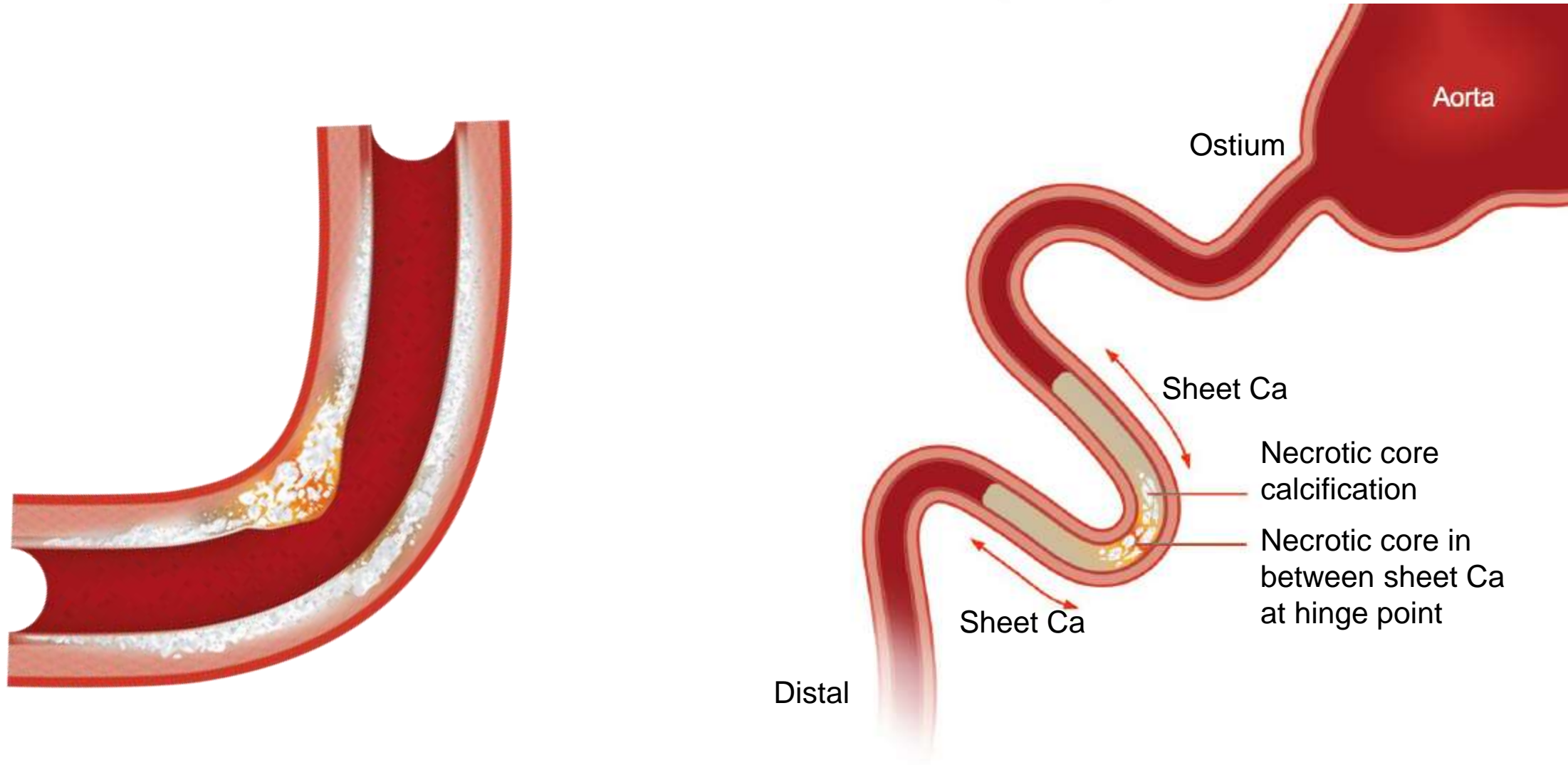
Morofuji T, et al. Catheter Cardiovasc Interv. 2021 Jan 1;97(1):10-19.

Calcified Nodules - Located at areas of torsional stress



1) Virmani R, et al. Arterioscler Thrombosis Vasc Biol 2000;20:1262-1275. 2) Mori H, et al. JACC Cardiovasc Imaging. 2018 Jan;11(1):127-142.
3) Torii S, et al. J Am Coll Cardiol. 2021 Apr 6;77(13):1599-1611.

Calcified nodules: Located within sites of dense calcium



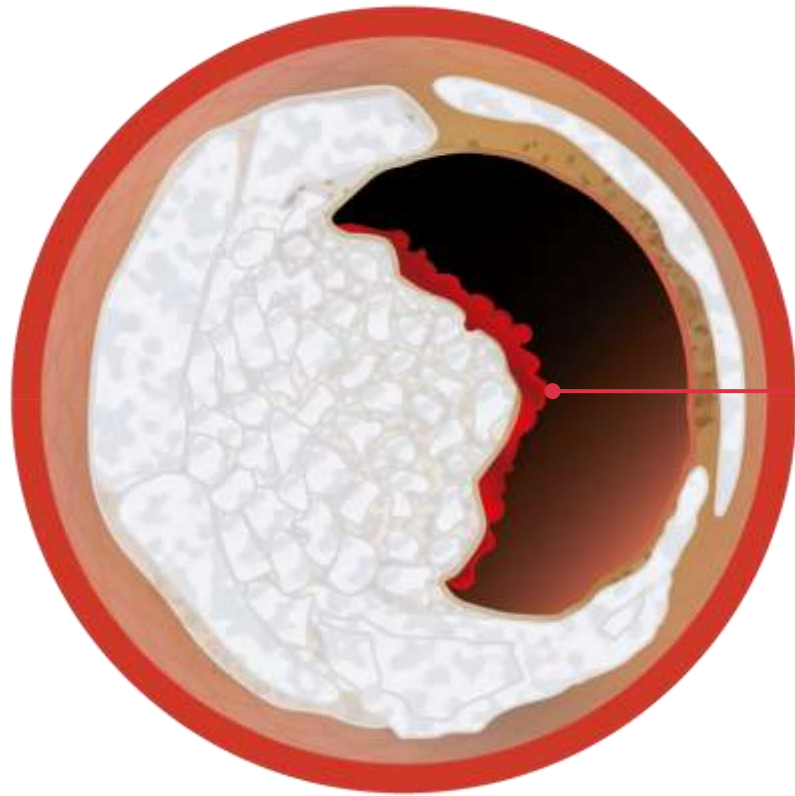
1)Virmani R, et al. Arterioscler Thrombosis Vasc Biol 2000;20:1262-1275. 2) Mori H, et al. JACC Cardiovasc Imaging. 2018 Jan;11(1):127-142.
3) Torii S, et al. J Am Coll Cardiol. 2021 Apr 6;77(13):1599-1611.

Rules of calcified nodules

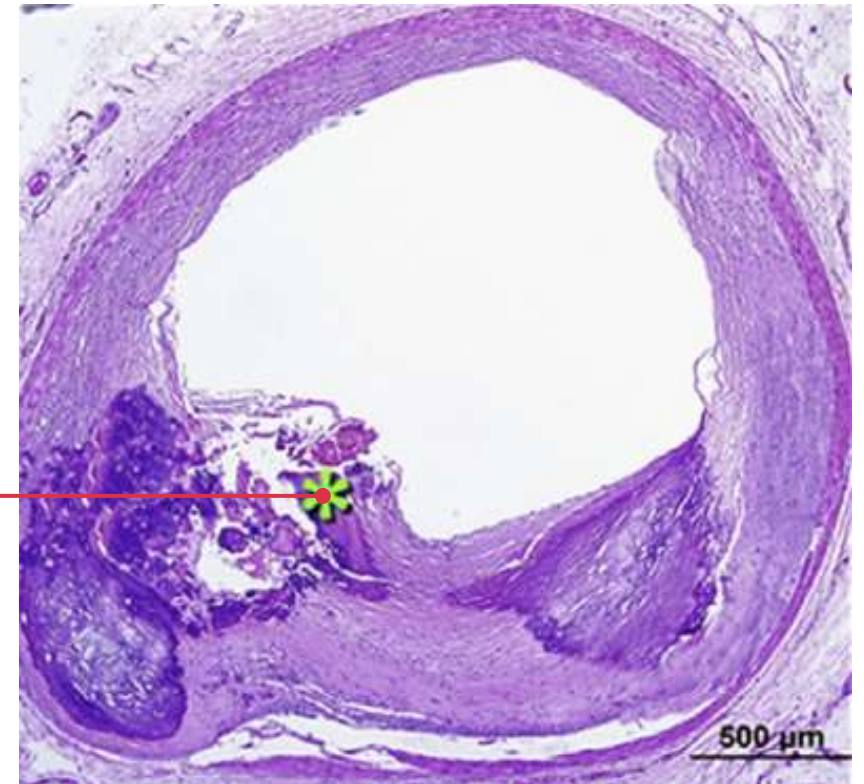
Occur more commonly:

1. In sites of severe calcium
2. At sites of torsional stress

Eruptive Calcified Nodule – Unstable (5% ACS)

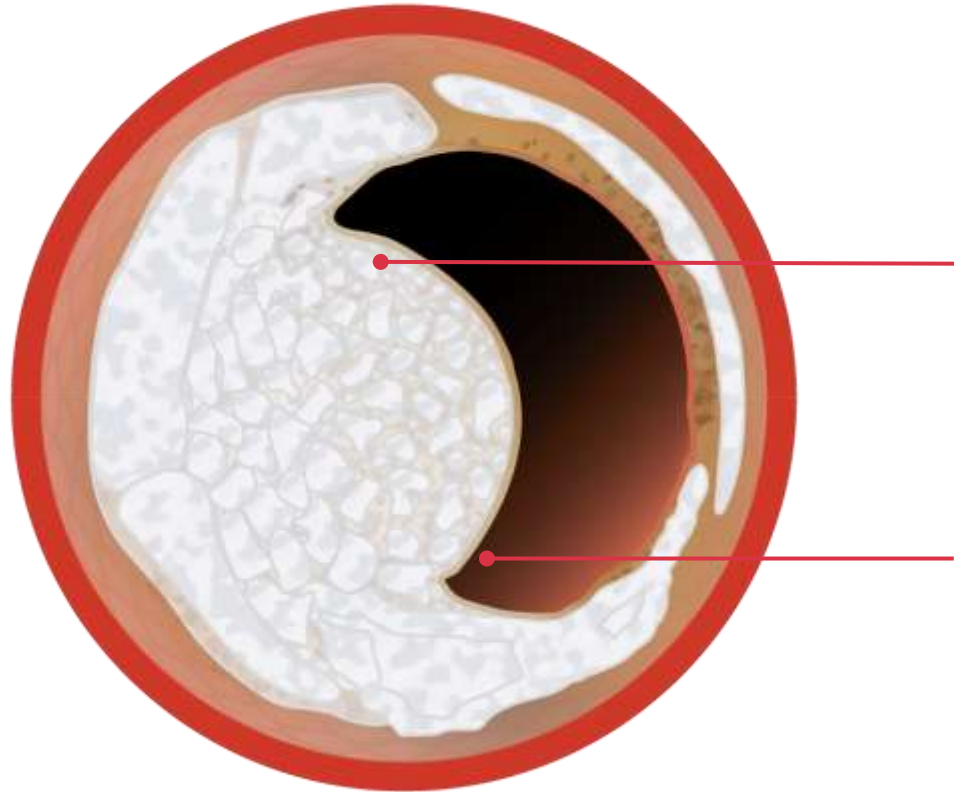


Thrombus



Protruding Calcified Nodule – Stable

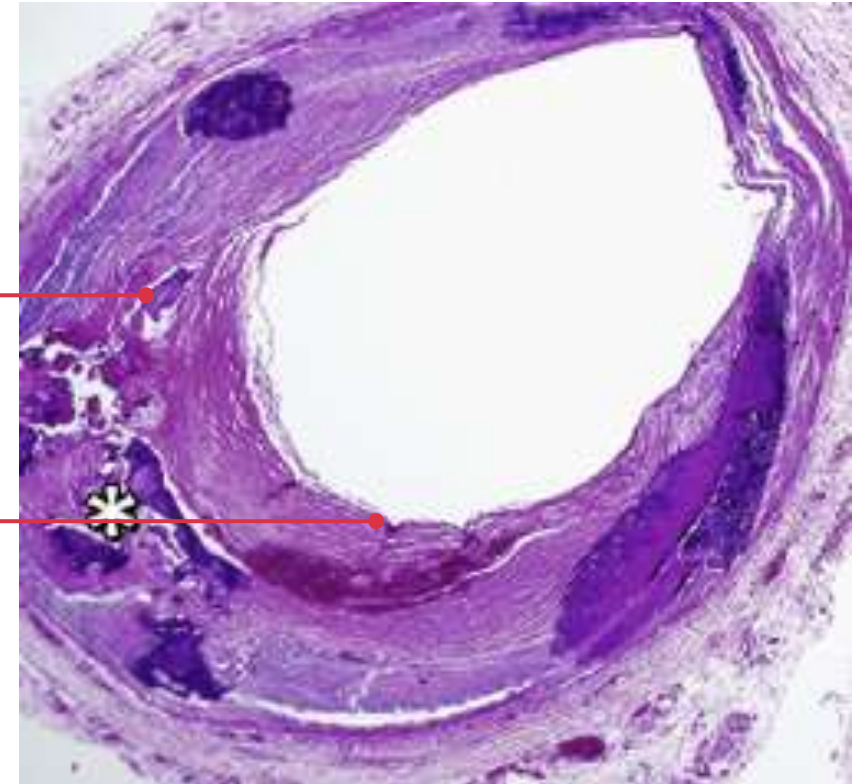
Nodular calcium



Calcified fragments

Fibrous cap

Histological example

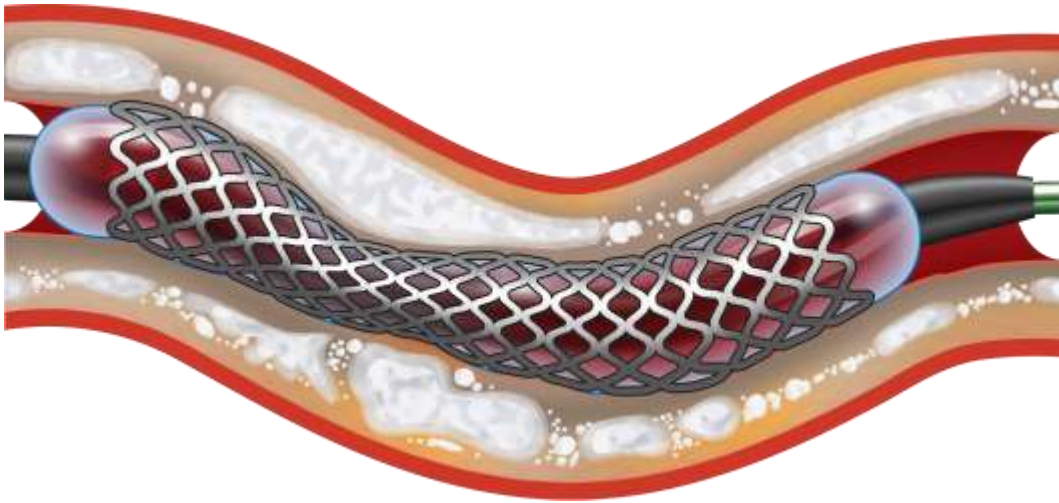


Rules of calcified nodules

1. Eruptive CN are active
2. Protruding CN are passive

Calcific Nodules

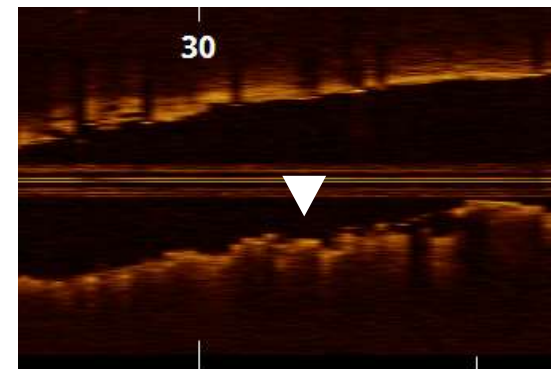
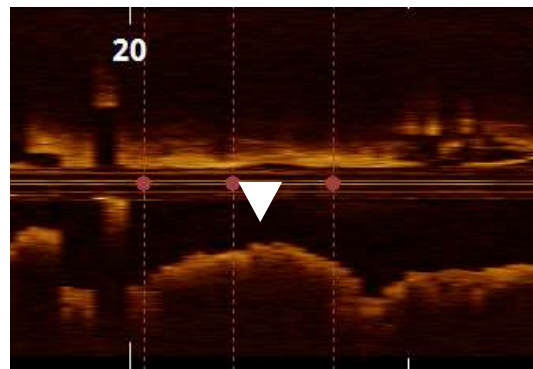
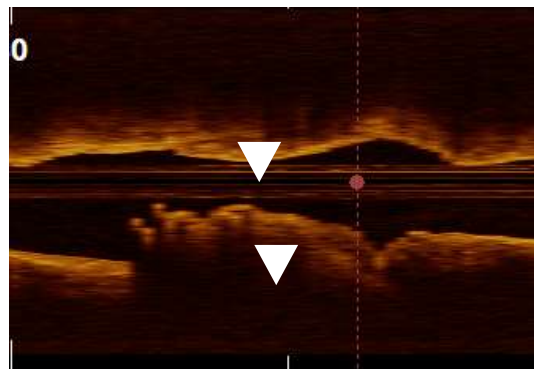
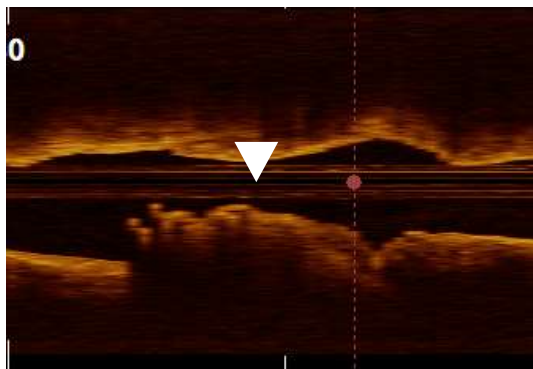
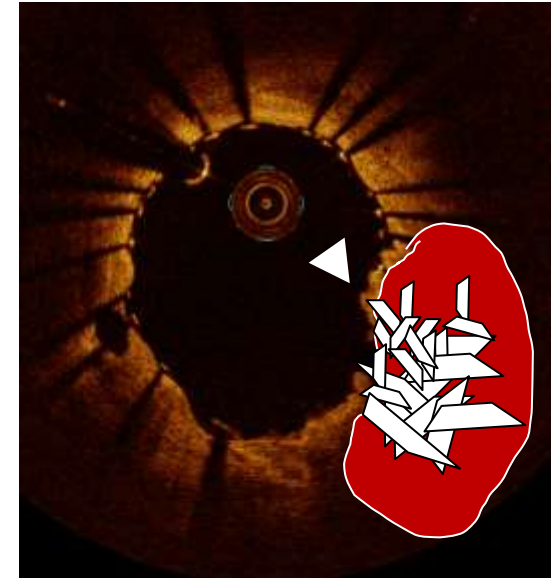
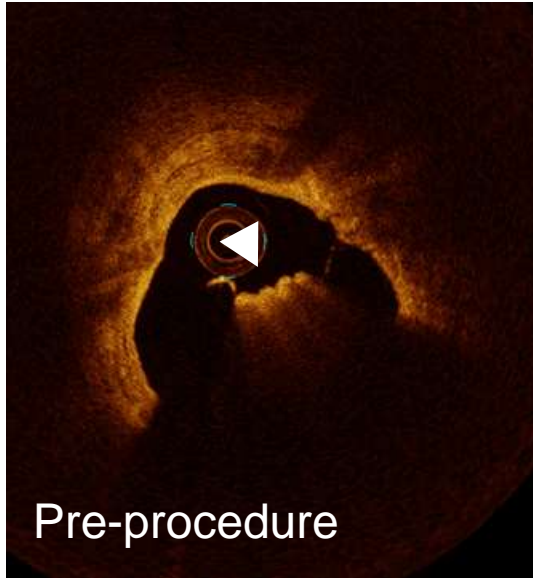
Principles of therapy - Angiography



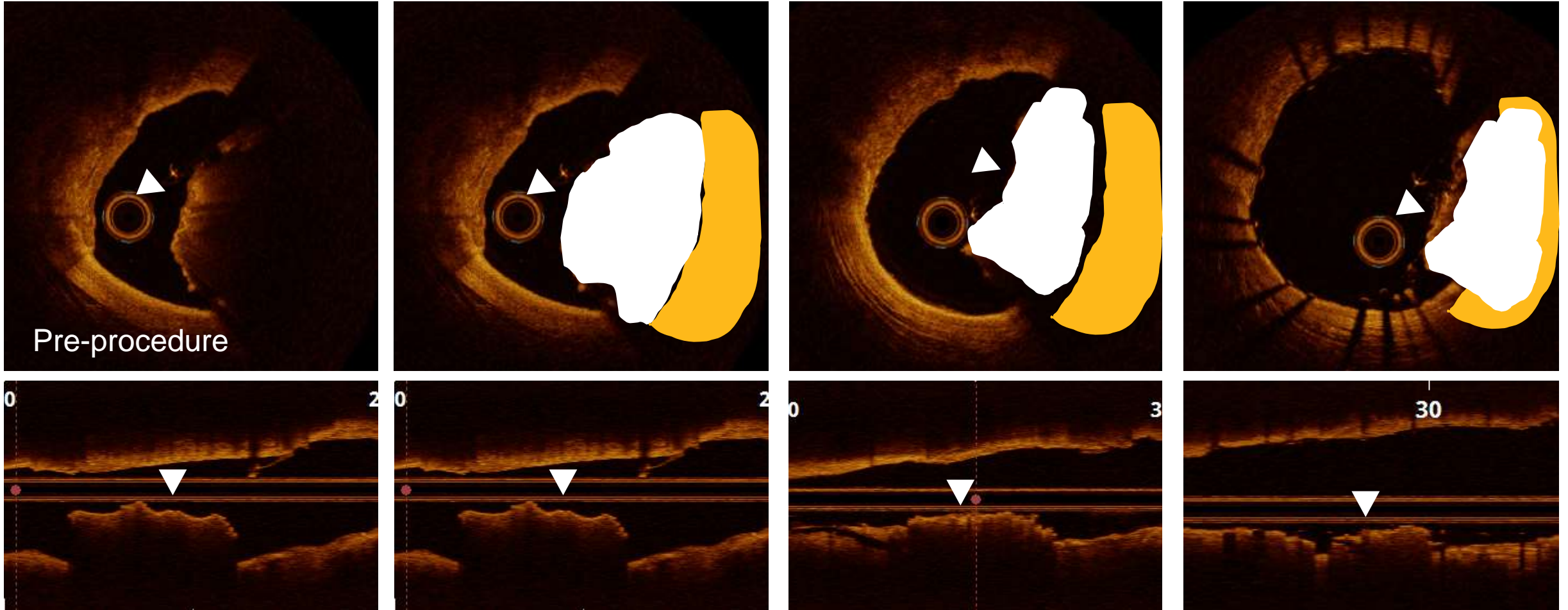
Nodular calcium is
heterogenous in response

Look the same, but behave different

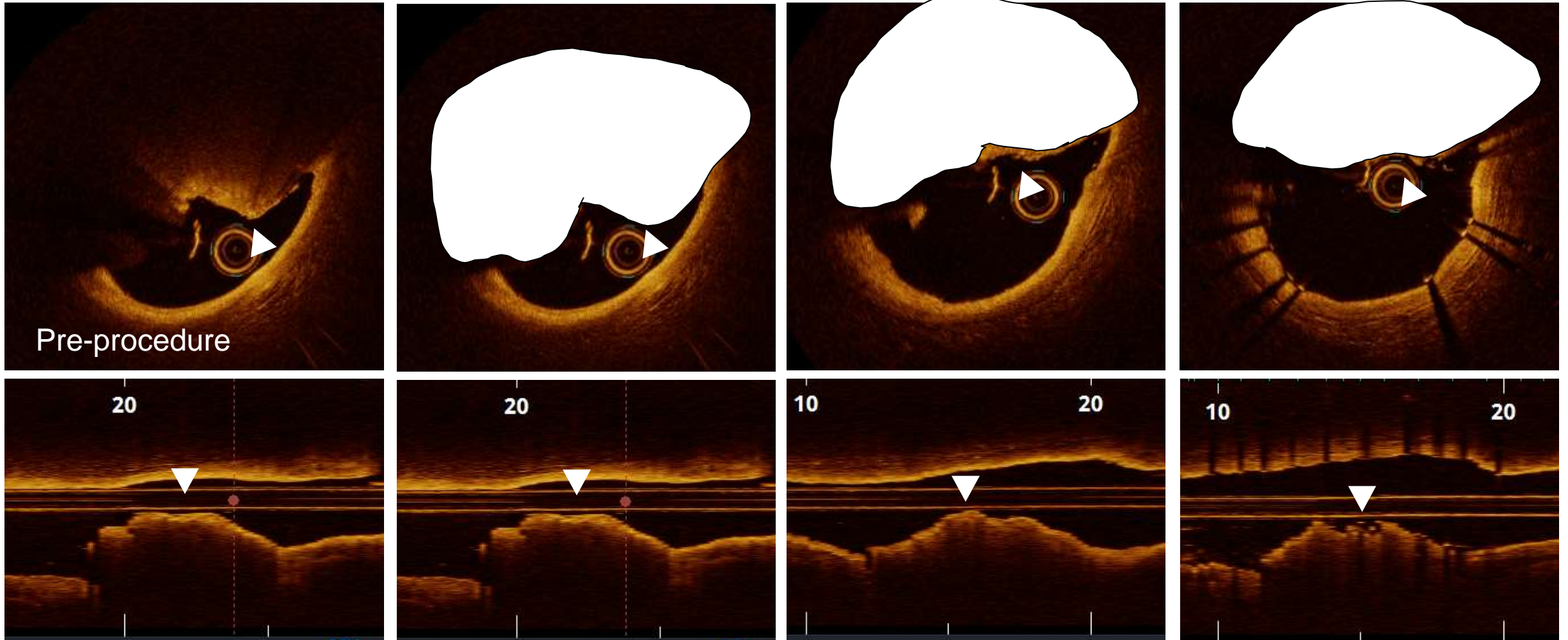
Eruptive Calcified Nodule: Deformable



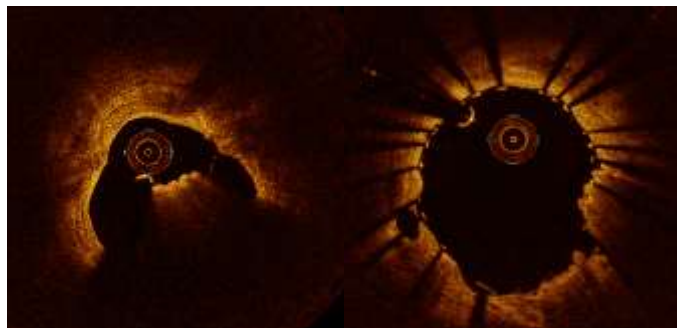
Protruding Calcified Nodule: Deformable



Protruding Calcified Nodule: Non-Deformable



Patterns of Stent Expansion

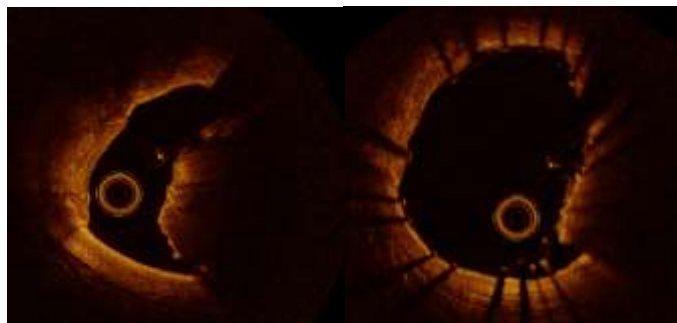


Concentric expansion

Deformed eruptive calcified nodule

34%

Glass in a Pillow



Concentric expansion

Deformed nodular calcification

43%

Marble in a Pillow



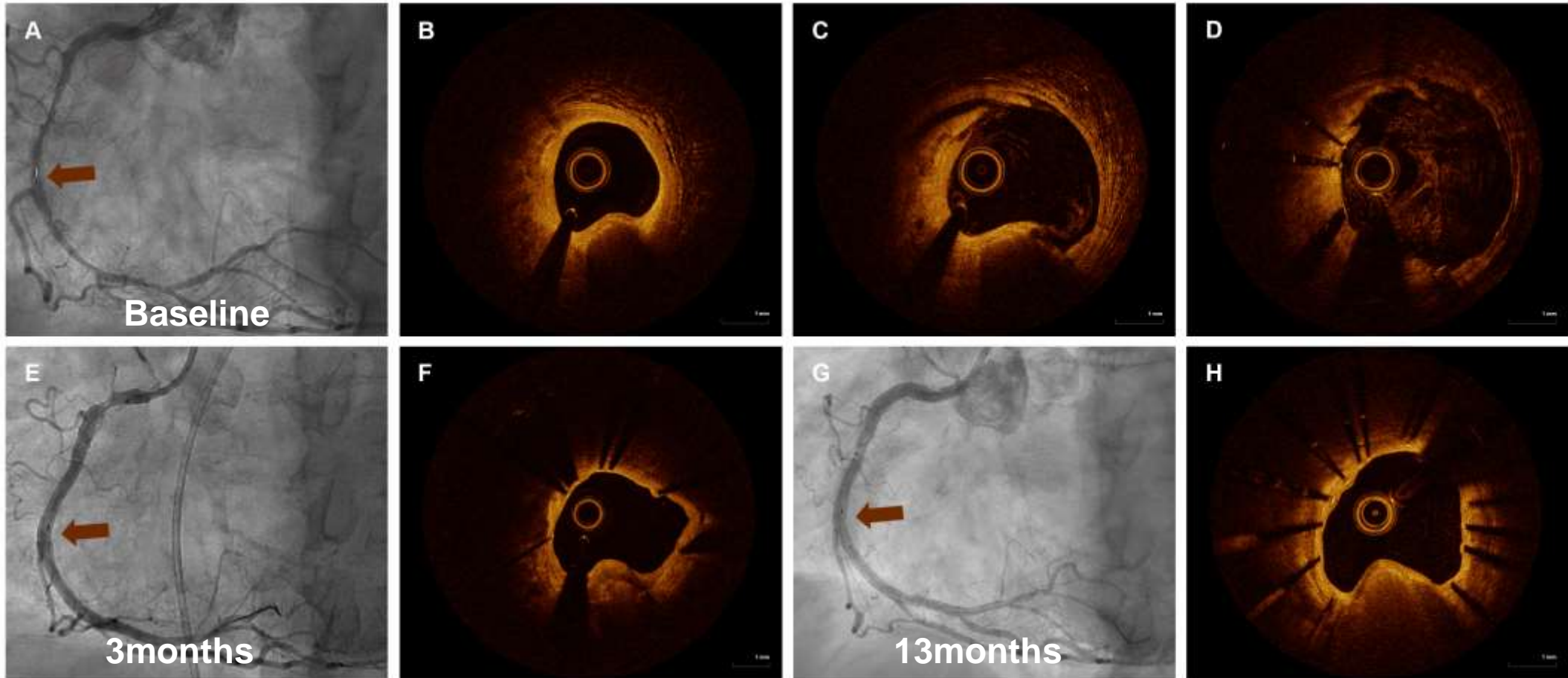
Eccentric expansion

Non-deformed nodular calcification

23%

Marble on Rock

Calcified Nodule: Natural History



Calcified Nodule: Natural History

Eruptive-CN

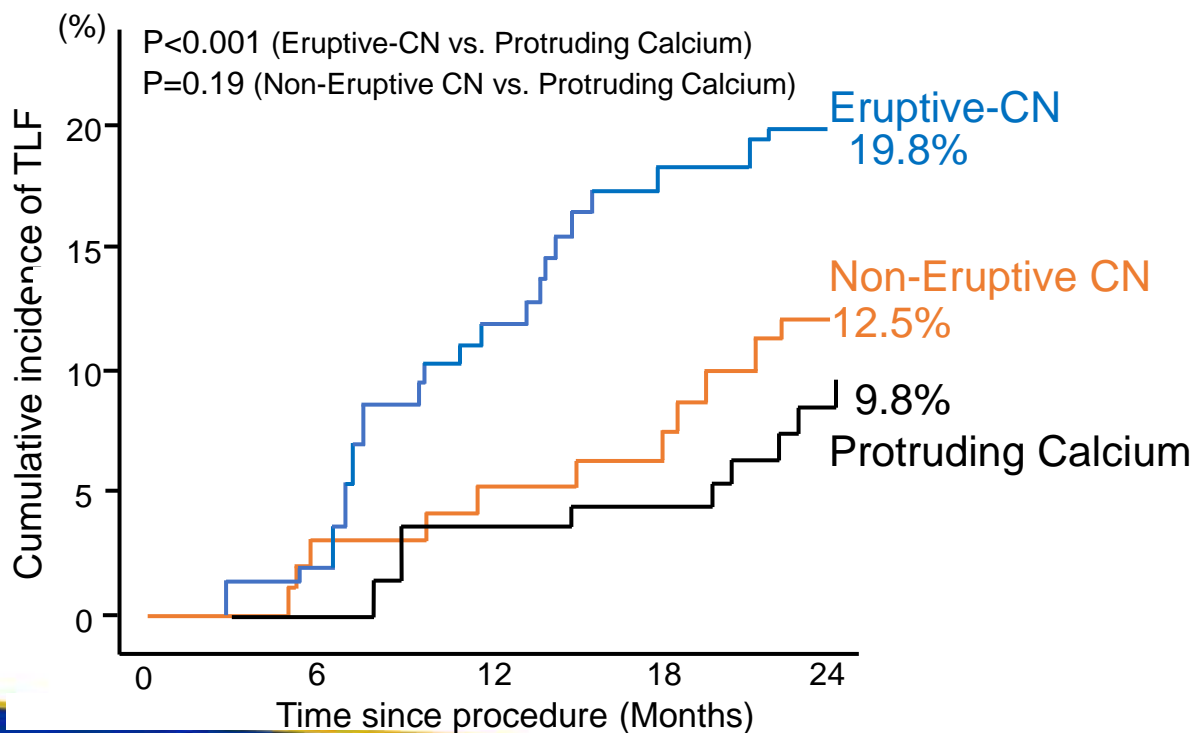
Non-Eruptive CN

Protruding Calcium



Comparison between CN and Protruding Calcium

	Eruptive-CN (N=126)	Non-Eruptive CN (N=104)	Protruding-Calcium (N=154)	P value
Age (years)	71 ± 9	73 ± 8	69 ± 10	0.051
Angiographic radiolucent mass	33.3 %	37.5 %	5.2 %	<0.001
Mid RCA location	26.1 %	16.3 %	7.2 %	<0.001
Δ Angle in lesion (°)	9.4 ± 7.6	9.0 ± 6.2	7.5 ± 4.5	0.04
Max-calcium arc (°)	247 ± 82	233 ± 80	205 ± 82	<0.001
Stent expansion (%)	89.2 ± 18.7	81.5 ± 18.9	89.7 ± 13.1	<0.001



Factors Associated with 2-year Target Lesion Failure in Multivariable Cox Proportional Hazard Model

	Hazard Ratio (95% CI)	P value
Eruptive-CN vs. Protruding Calcium (reference)	2.58 (1.18, 5.53)	0.01
Non-Eruptive CN vs. Protruding Calcium (reference)	1.38 (0.56, 3.35)	0.47
Circumference of CN or Protruding Calcium (mm)	1.61 (1.04, 1.91)	0.02
Stent area at CN or Protruding Calcium site (mm ²)	0.83 (0.71, 0.96)	0.01
Δ Angle in lesion (per 10°)	0.97 (0.92, 1.04)	0.51
Diabetes mellitus	1.86 (0.99, 3.48)	0.06
Age (per 10 years)	0.98 (0.94, 1.01)	0.27
Hemodialysis	1.33 (0.45, 3.87)	0.59

CI=confidence interval; CN=calcified nodule

Rules of calcified nodules

1. Eruptive CN are deformable by PCI
2. Protruding CN may or may not be deformable
3. TVF is greater in eruptive CN but prognosis overall sub-optimal