



ČESKÁ ASOCIACE  
INTERVENČNÍ KARDIOLOGIE



## Invazivní zobrazovací techniky v intervenční kardiologii

T. Kovárník

II. interní klinika VFN a 1. LF UK v Praze

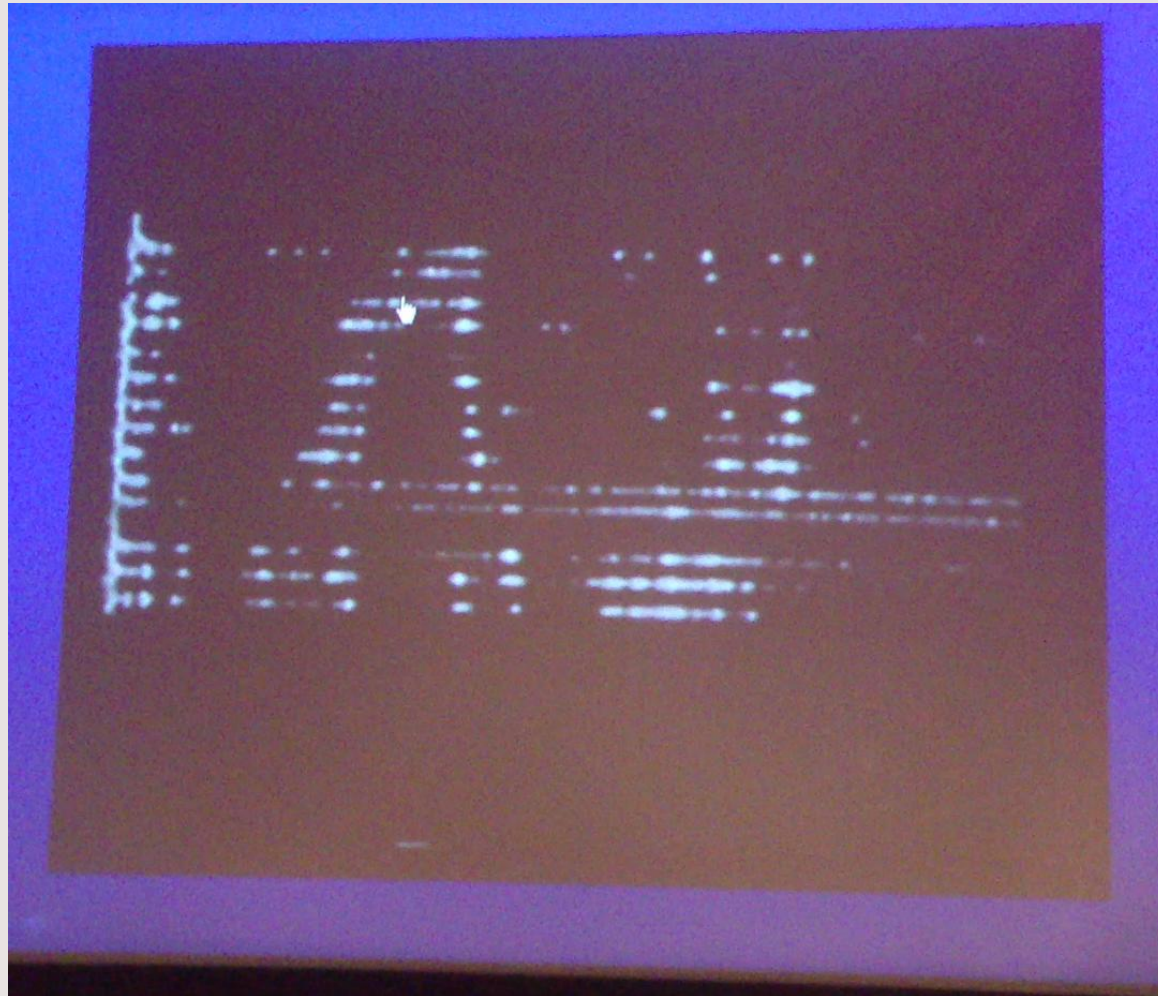
resilience





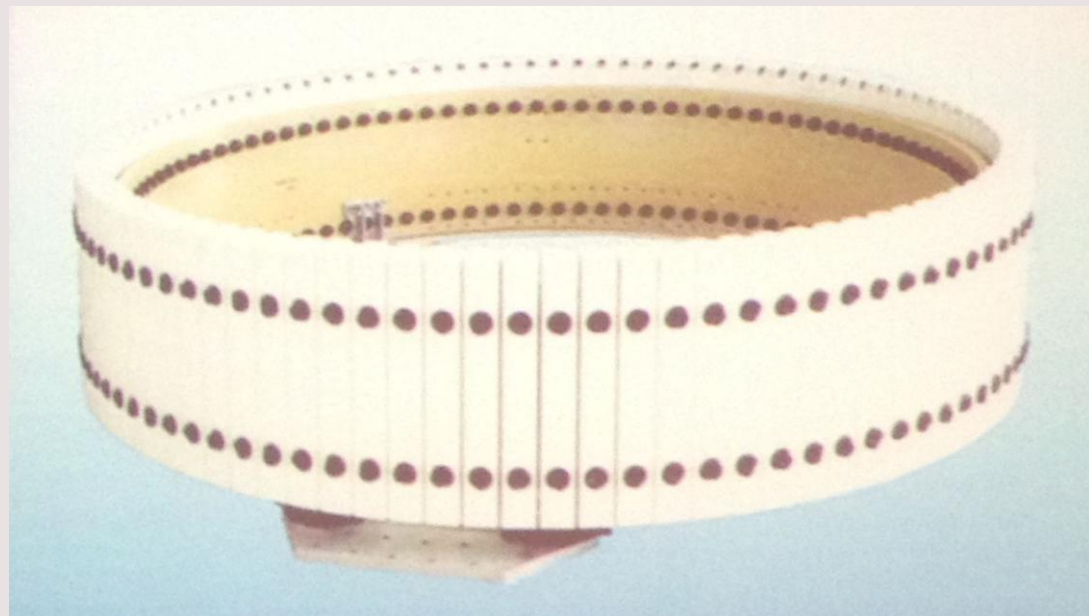
# První 2D echokardiografické vyšetření, rok 1972

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# Původ intravaskulárního ultrazvuku

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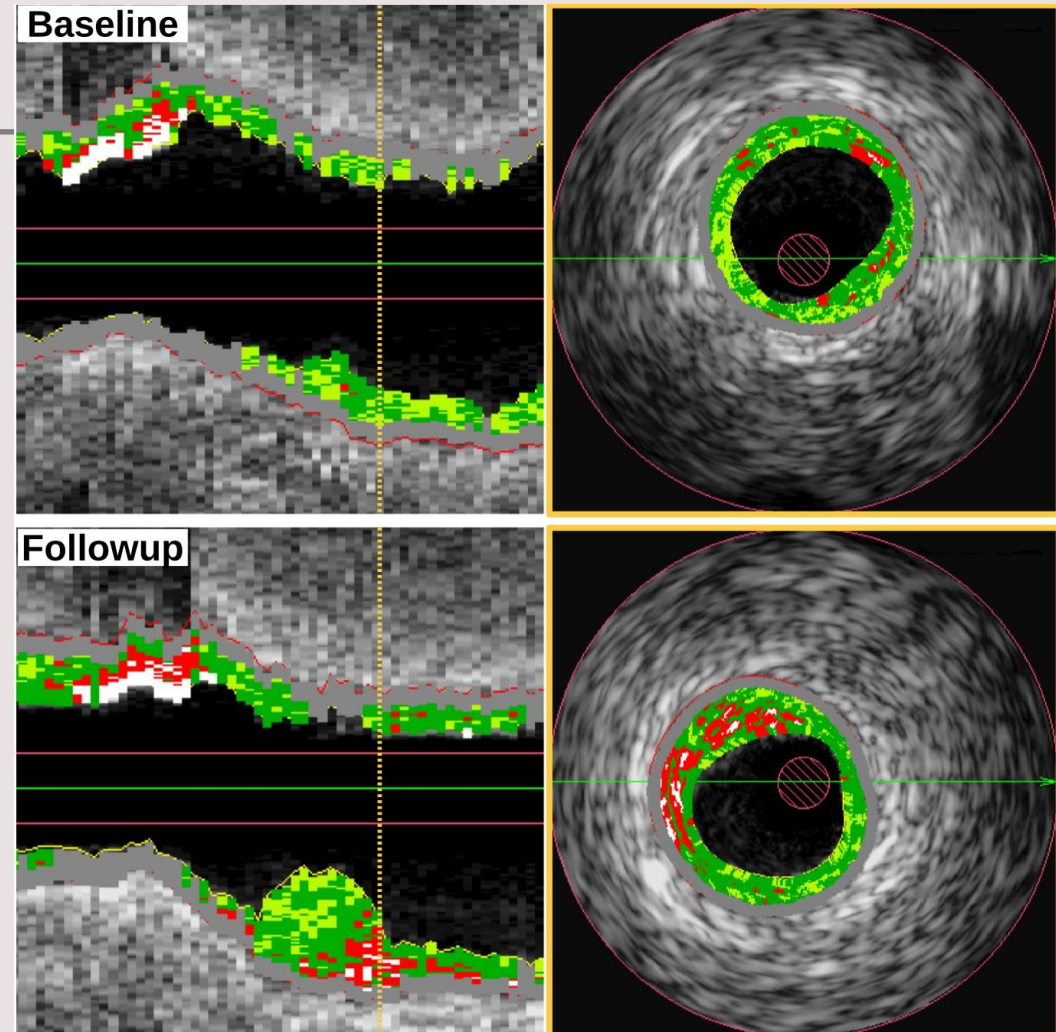
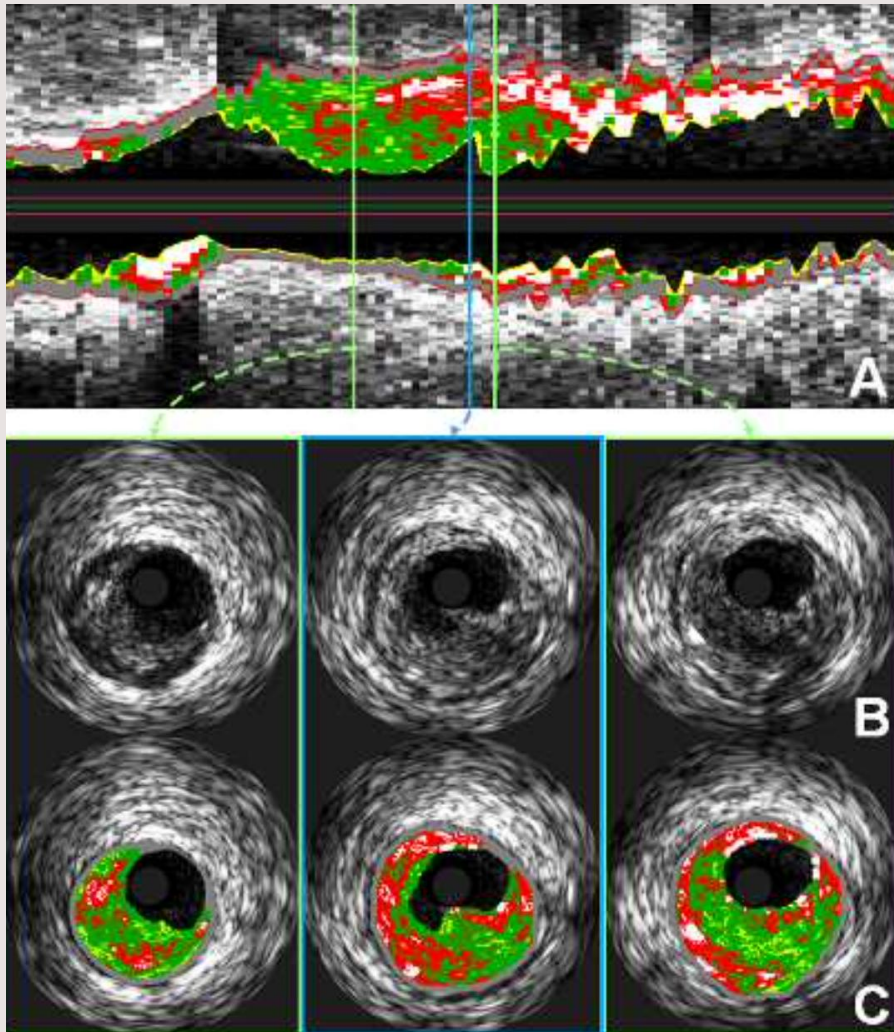


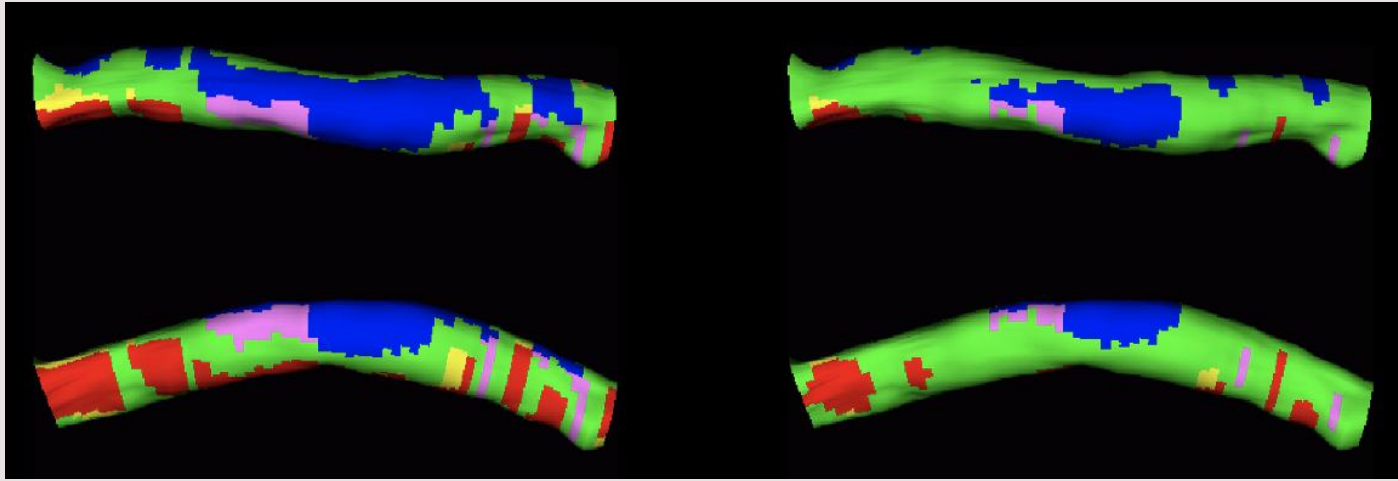
3 metry



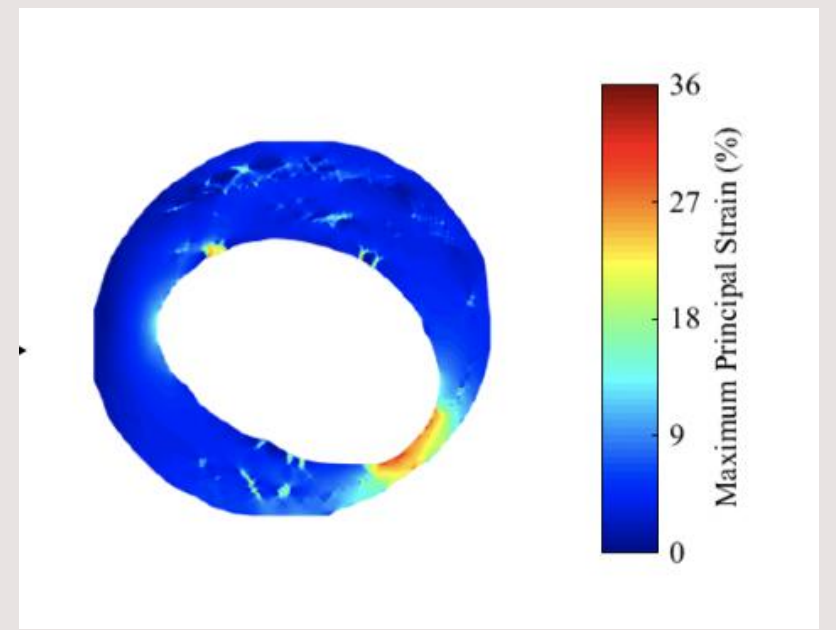


# IVUS-VH: virtual histology

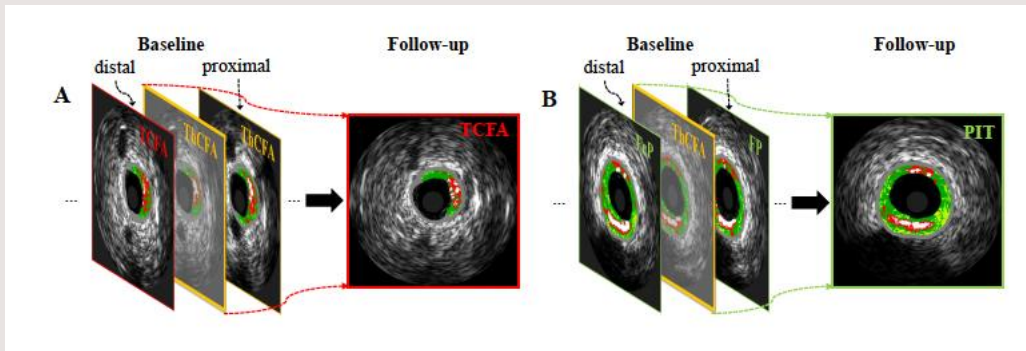




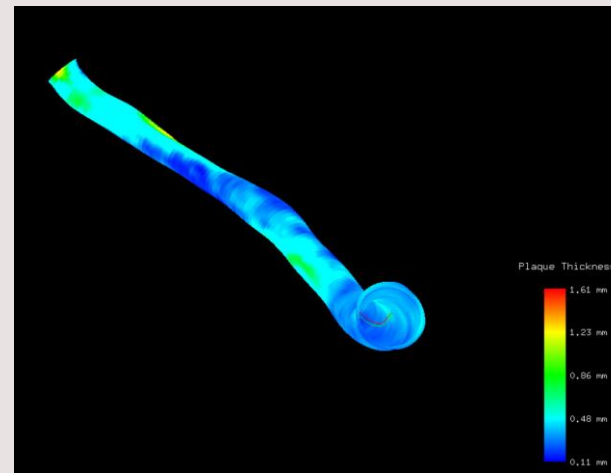
Shear stress



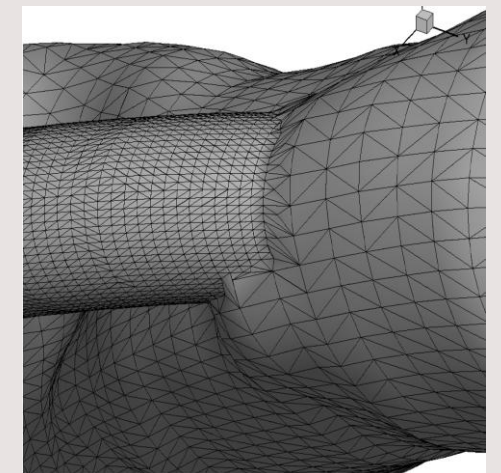
Napětí v plátu



3D hodnocení rozsahu TCFAs



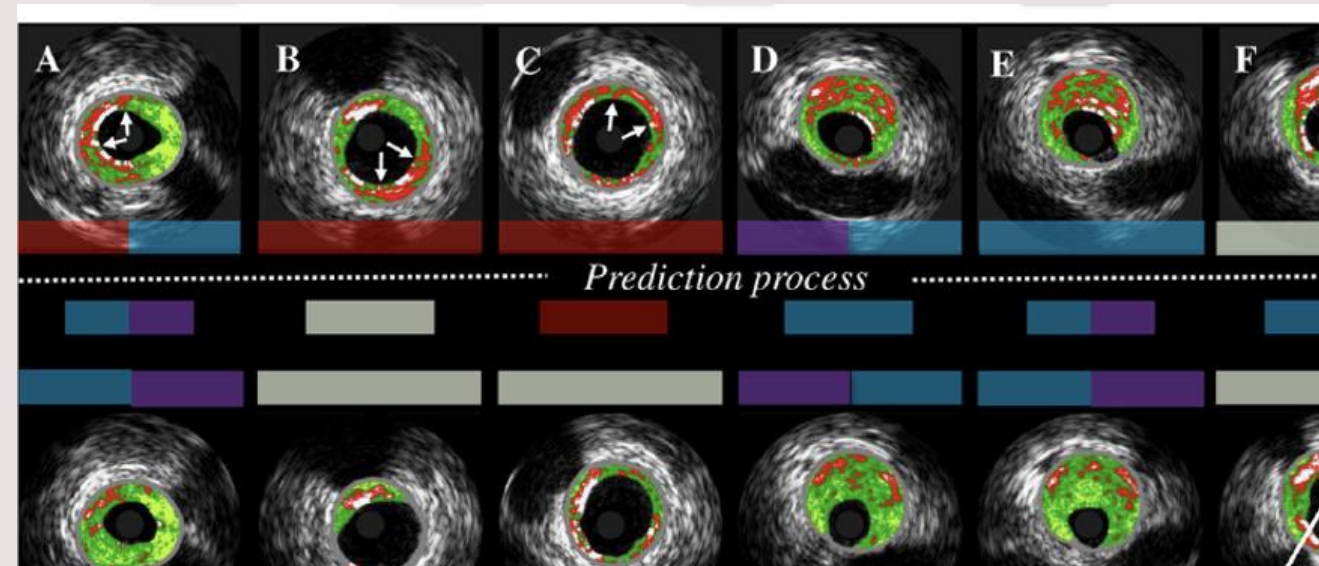
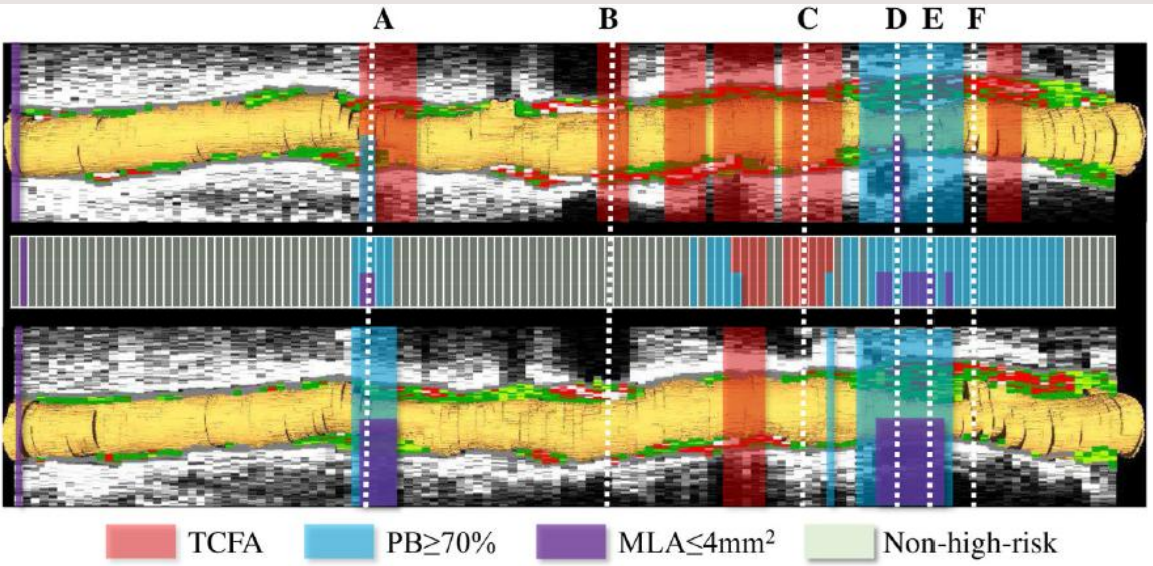
3D hodnocení lipidové tkáně s



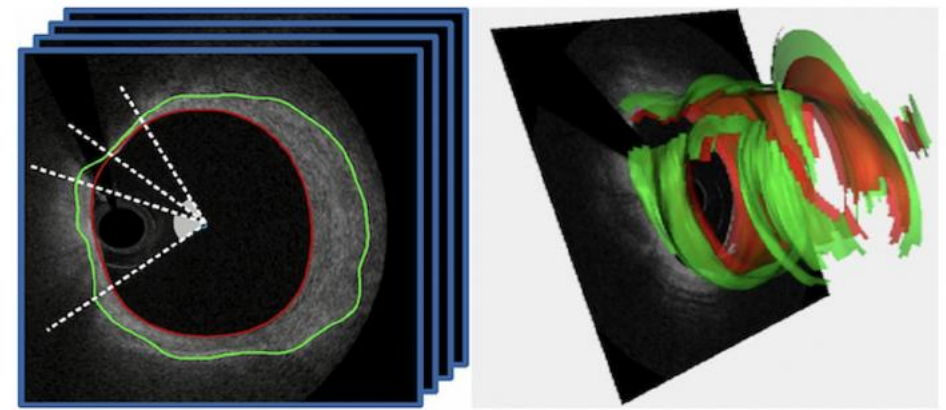
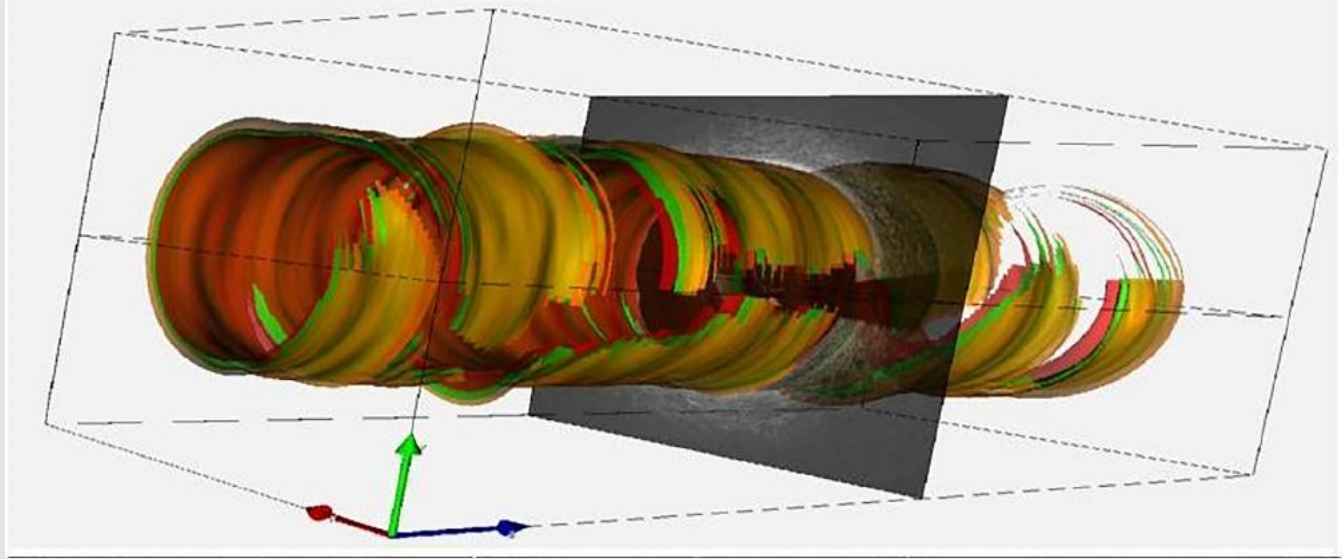
3D hodnocení bifurkací



# Artificial intelligence (AI)

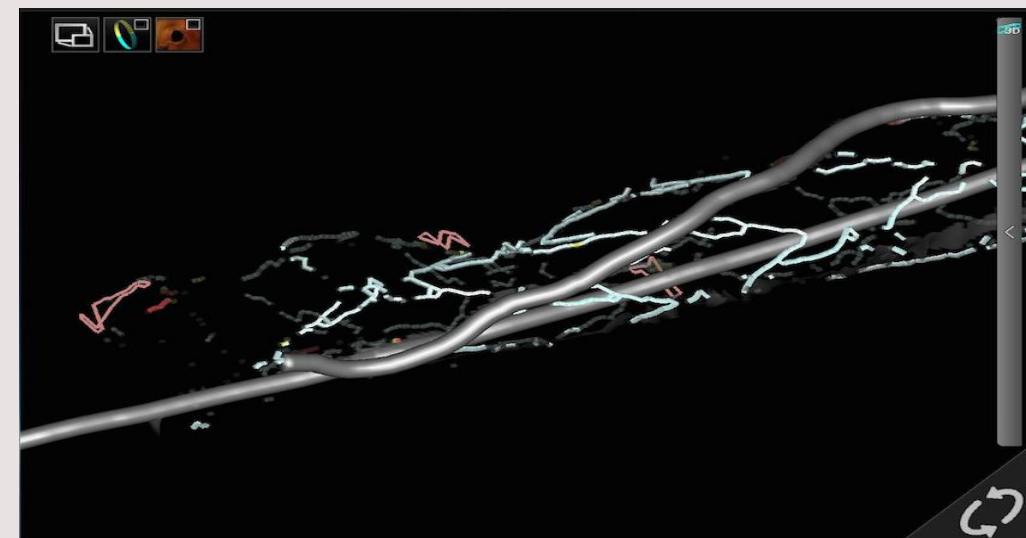
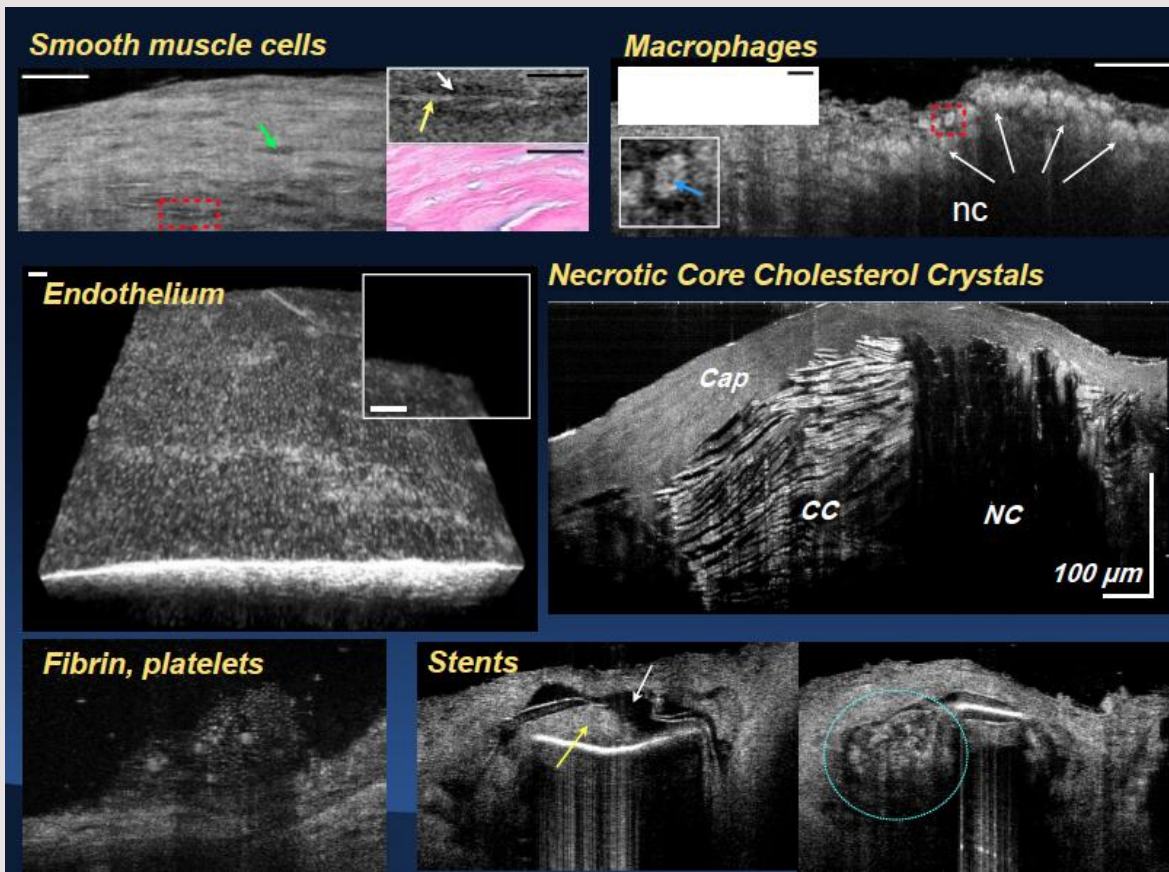
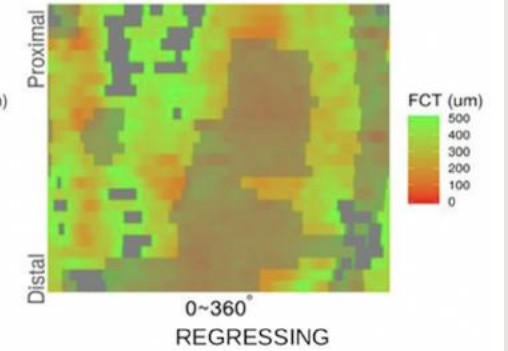
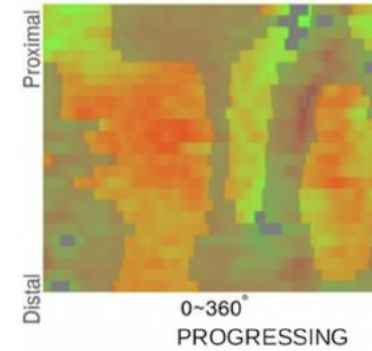






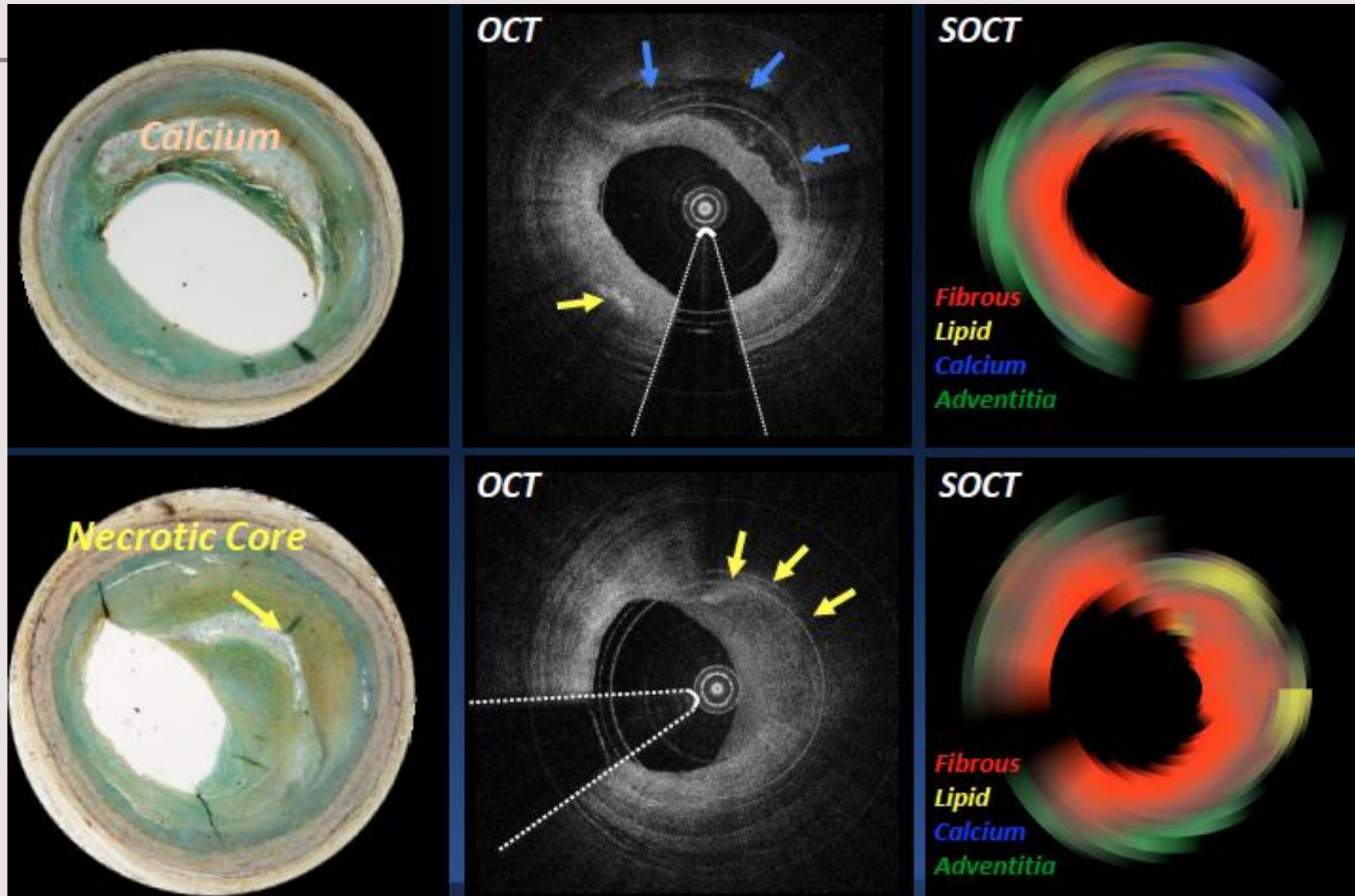
PROGRESSING

REGRESSING





# Spectral-OCT in vitro

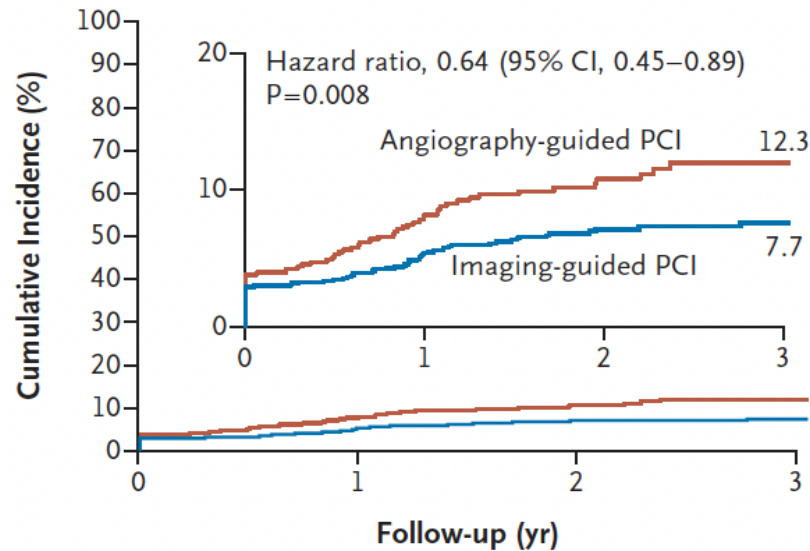


ORIGINAL ARTICLE

# Intravascular Imaging–Guided or Angiography-Guided Complex PCI

J.M. Lee, K.H. Choi, Y.B. Song, J.-Y. Lee, S.-J. Lee, S.Y. Lee, S.M. Kim, K.H. Yun, J.Y. Cho, C.J. Kim, H.-S. Ahn, C.-W. Nam, H.-J. Yoon, Y.H. Park, W.S. Lee, J.-O. Jeong, P.S. Song, J.-H. Doh, S.-H. Jo, C.-H. Yoon, M.G. Kang, J.-S. Koh, K.Y. Lee, Y.-H. Lim, Y.-H. Cho, J.-M. Cho, W.J. Jang, K.-J. Chun, D. Hong, T.K. Park, J.H. Yang, S.-H. Choi, H.-C. Gwon, and J.-Y. Hahn, for the RENOVATE-COMPLEX-PCI Investigators\*

## A Target-Vessel Failure



### No. at Risk

Angiography-guided PCI	547	496	280	120
Imaging-guided PCI	1092	1023	591	255

Subgroup	Intravascular Imaging-Guided PCI no. of events/total no. of patients (cumulative incidence, %)	Angiography-Guided PCI no. of events/total no. of patients (cumulative incidence, %)	Hazard Ratio (95% CI)
Overall	76/1092 (7.7)	60/547 (12.3)	0.64 (0.45–0.89)
Type of imaging devices			
Intravascular ultrasonography	59/800 (8.0)	60/547 (12.3)	0.66 (0.46–0.95)
Optical coherence tomography	15/278 (5.8)	60/547 (12.3)	0.47 (0.27–0.83)
Type of complex coronary lesions			
True bifurcation	23/233 (10.3)	13/126 (11.8)	0.97 (0.49–1.93)
Chronic total occlusion	9/220 (5.0)	13/99 (14)	0.30 (0.13–0.71)
Unprotected left main coronary artery disease	9/138 (6.8)	11/54 (25)	0.31 (0.13–0.76)
Diffuse long coronary-artery lesion	36/617 (6.5)	31/281 (11.9)	0.52 (0.32–0.83)
Multivessel PCI involving ≥2 major coronary arteries	36/409 (9.5)	22/213 (11.7)	0.84 (0.50–1.44)
Lesion necessitating use of ≥3 stents	16/208 (8.1)	6/97 (6)	1.24 (0.49–3.18)
Lesion with in-stent restenosis	22/158 (15.6)	12/78 (17)	0.90 (0.45–1.82)
Severely calcified lesion	11/157 (7.3)	11/74 (17)	0.46 (0.20–1.06)
Ostial lesions of major coronary artery	8/182 (4.4)	9/69 (16)	0.33 (0.13–0.85)
Initial presentation			
Stable ischemic heart disease	25/532 (5.0)	27/275 (10.4)	0.46 (0.27–0.80)
Acute coronary syndrome	51/560 (10.4)	33/272 (14.6)	0.74 (0.48–1.15)
Age			
<65 yr	36/517 (7.8)	23/238 (10.6)	0.72 (0.42–1.21)
≥65 yr	40/575 (7.4)	37/309 (13.6)	0.57 (0.36–0.88)
Sex			
Male	66/869 (8.3)	46/431 (11.7)	0.70 (0.48–1.02)
Female	10/223 (5.2)	14/116 (14.5)	0.35 (0.16–0.80)
Diabetes mellitus			
Yes	45/394 (12.9)	26/223 (12.3)	0.97 (0.60–1.57)
No	31/698 (4.7)	34/324 (12.2)	0.41 (0.25–0.67)
Chronic kidney disease			
Yes	22/203 (13.3)	19/93 (23)	0.51 (0.27–0.93)
No	54/889 (6.4)	41/454 (9.9)	0.66 (0.44–0.99)
Left ventricular ejection fraction			
<50%	22/210 (12.0)	12/84 (15)	0.72 (0.35–1.45)
≥50%	54/882 (6.7)	48/463 (11.8)	0.58 (0.39–0.85)

0.10 1.00 10.00

← Intravascular Imaging-Guided PCI Better | Angiography-Guided PCI Better →



**ORIGINAL ARTICLE**

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# Intravascular Ultrasound–Derived Calcium Score to Predict Stent Expansion in Severely Calcified Lesions

Mingyou Zhang<sup>id</sup>, MD; Mitsuaki Matsumura<sup>id</sup>, BS; Eisuke Usui, MD; Masahiko Noguchi, MD; Tatsuhiro Fujimura, MD, PhD; Khady N. Fall<sup>id</sup>, MD, MPH; Zixuan Zhang<sup>id</sup>, MS; Tamim M. Nazif<sup>id</sup>, MD; Sahil A. Parikh<sup>id</sup>, MD; LeRoy E. Rabbani<sup>id</sup>, MD; Ajay J. Kirtane<sup>id</sup>, MD, SM; Michael B. Collins, MD; Martin B. Leon, MD; Jeffrey W. Moses<sup>id</sup>, MD; Dimitri Karpaliotis, MD, PhD; Ziad A. Ali<sup>id</sup>, MD, DPhil; Gary S. Mintz, MD; Akiko Maehara<sup>id</sup>, MD

Angiographic Calcium?

Yes

IVUS: Maximum Superficial Calcium >270°?

Yes

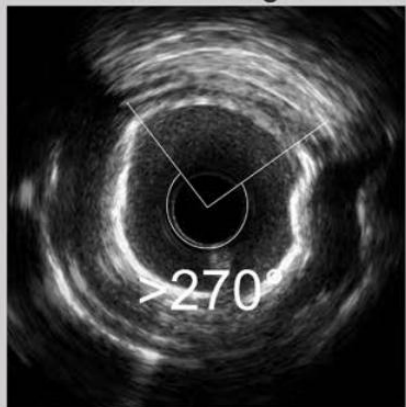
### IVUS Calcium Score

Calcium >270°  
in ≥5mm length?

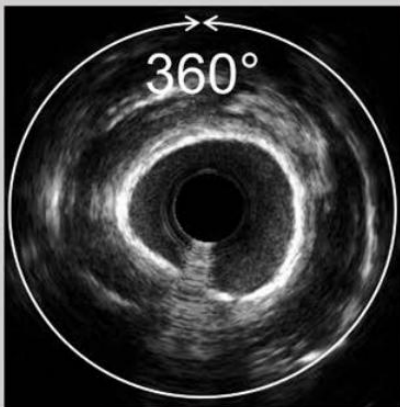
360° of calcium?

Calcified nodule?

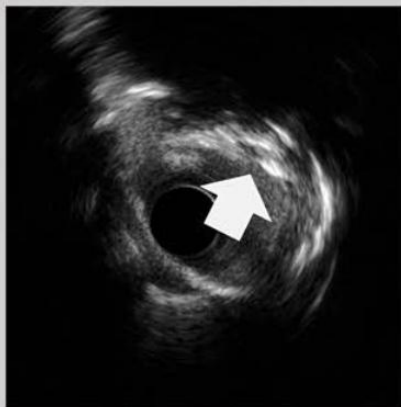
Vessel diameter <3.5 mm?



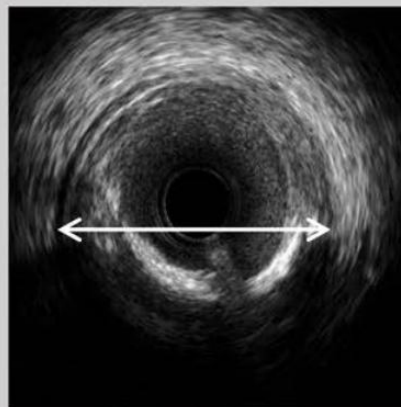
Yes =1, No=0



Yes =1, No=0



Yes =1, No=0




Yes =1, No=0

IVUS Calcium Score = 2, 3, 4 ? If yes, consider atherectomy

Variable	Group B (validation cohort)	
	Regression coefficient (95% CI)	P value
Calcium score	-8.1 (-10.5 to -5.7)	<0.0001
Lesion length by QCA, mm	-0.05 (-0.28 to 0.18)	0.66
Maximum balloon pressure, atm	-0.41 (-1.00 to 0.17)	0.17
Maximum device size/artery ratio	-8.3 (-23.4 to 6.7)	0.28



# Zero contrast optical coherence tomography-guided percutaneous coronary intervention in patients with non-ST segment elevation myocardial infarction and chronic kidney disease

Zheng-Yu Liu MD<sup>1,2</sup>  | Zi-hui Yin BD<sup>3</sup> | Cheng-Yang Liang MD<sup>4</sup> | Jing He MD<sup>1,2</sup> |  
Chang-Lu Wang MD<sup>1,2</sup> | Xiang Peng MD<sup>1,2</sup> | Yu Zhang BD<sup>1,2</sup> |  
Zhao-Fen Zheng MD<sup>1,2</sup> | Hong-Wei Pan MD<sup>1,2</sup>



European Heart Journal (2016) **37**, 3090–3095  
doi:10.1093/eurheartj/ehw078

**EHJ BRIEF COMMUNICATION**

*Interventional cardiology*

## Imaging- and physiology-guided percutaneous coronary intervention without contrast administration in advanced renal failure: a feasibility, safety, and outcome study

Ziad A. Ali<sup>1,2\*</sup>, Keyvan Karimi Galoughi<sup>1</sup>, Tamim Nazif<sup>1,2</sup>, Akiko Maehara<sup>1,2</sup>, Mark A. Hardy<sup>3</sup>, David J. Cohen<sup>4</sup>, Lloyd E. Ratner<sup>3</sup>, Michael B. Collins<sup>1,2</sup>, Jeffrey W. Moses<sup>1,2</sup>, Ajay J. Kirtane<sup>1,2</sup>, Gregg W. Stone<sup>1,2</sup>, Dimitri Karmaliotis<sup>1,2</sup>,

# Intravascular Ultrasound Analysis of Intraplaque Versus Subintimal Tracking in Percutaneous Intervention for Coronary Chronic Total Occlusions and Association With Procedural Outcomes



Lei Song, MD,<sup>a,b,c</sup> Akiko Maehara, MD,<sup>a,b</sup> Matthew T. Finn, MD,<sup>b</sup> Sanjog Kalra, MD, MSc,<sup>b</sup> Jeffrey W. Moses, MD,<sup>a,b</sup> Manish A. Parikh, MD,<sup>a,b</sup> Ajay J. Kirtane, MD, SM,<sup>a,b</sup> Michael B. Collins, MD,<sup>b</sup> Tamim M. Nazif, MD,<sup>a,b</sup> Khady N. Fall, MD, MPH,<sup>b</sup> Raja Hatem, MD,<sup>b</sup> Ming Liao, MA,<sup>b</sup> Tiffany Kim, BA,<sup>b</sup> Philip Green, MD,<sup>b</sup> Ziad A. Ali, MD, DPHIL,<sup>a,b</sup> Candido Batres, MD,<sup>b</sup> Martin B. Leon, MD,<sup>a,b</sup> Gary S. Mintz, MD,<sup>a</sup> Dimitri Karpaliotis, MD, PhD<sup>a,b</sup>

- identifikace místa okluze
- směřování vodiče do místa uzávěru
- subendoteliální rekanalizace
- identifikace falešného lumen
- určení velikosti a délky stentů
- kontrola efektu intervence

[www.icj.ir](http://www.icj.ir)

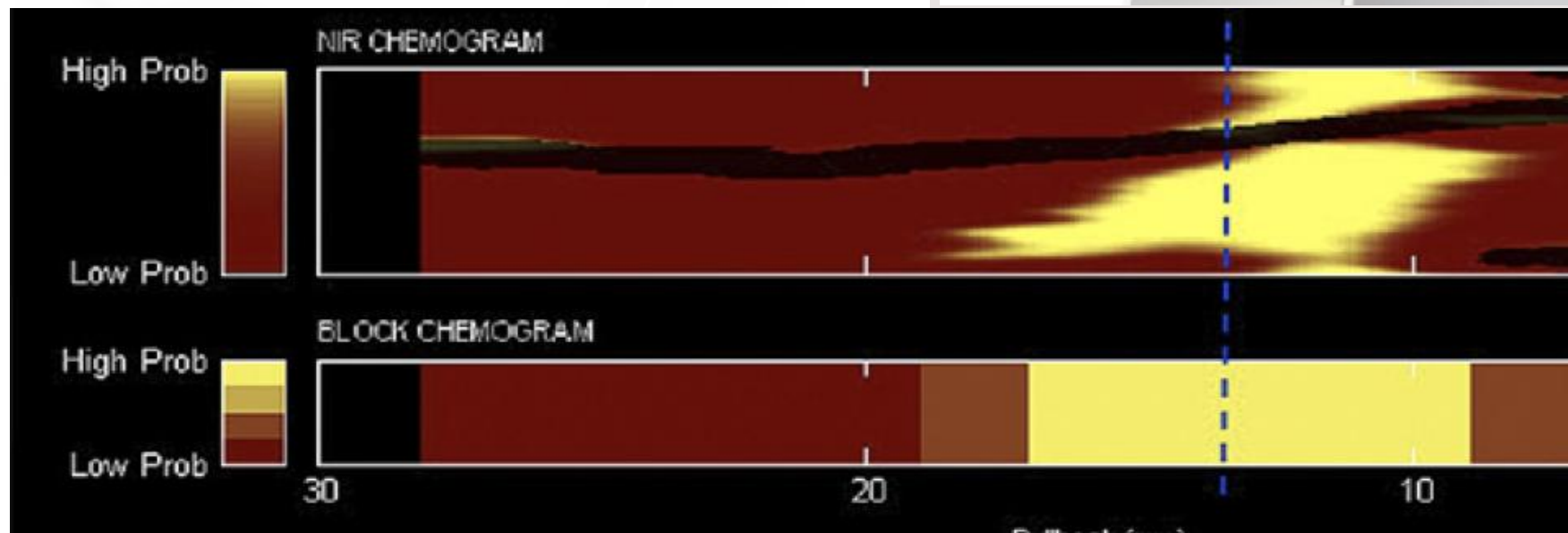
Original Article

## Intravascular Ultrasound in Percutaneous Coronary Intervention for Chronic Total Occlusion

*M Mohandes, J Guarinos, J Sans, A Bardaji*

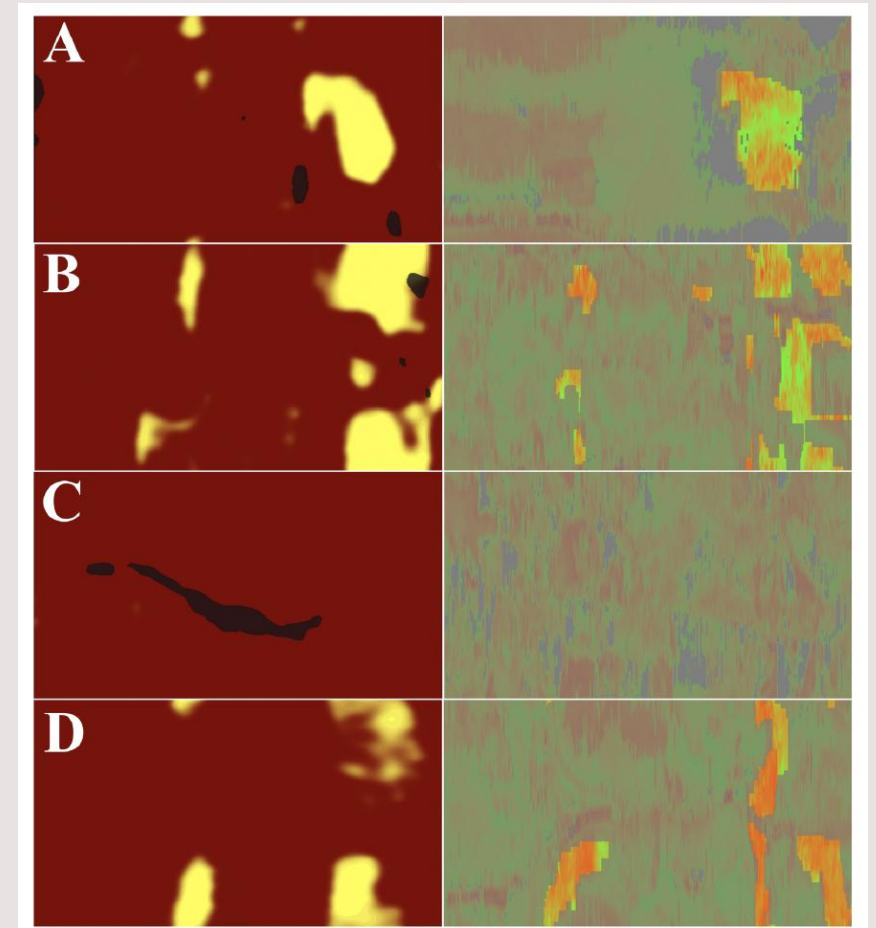
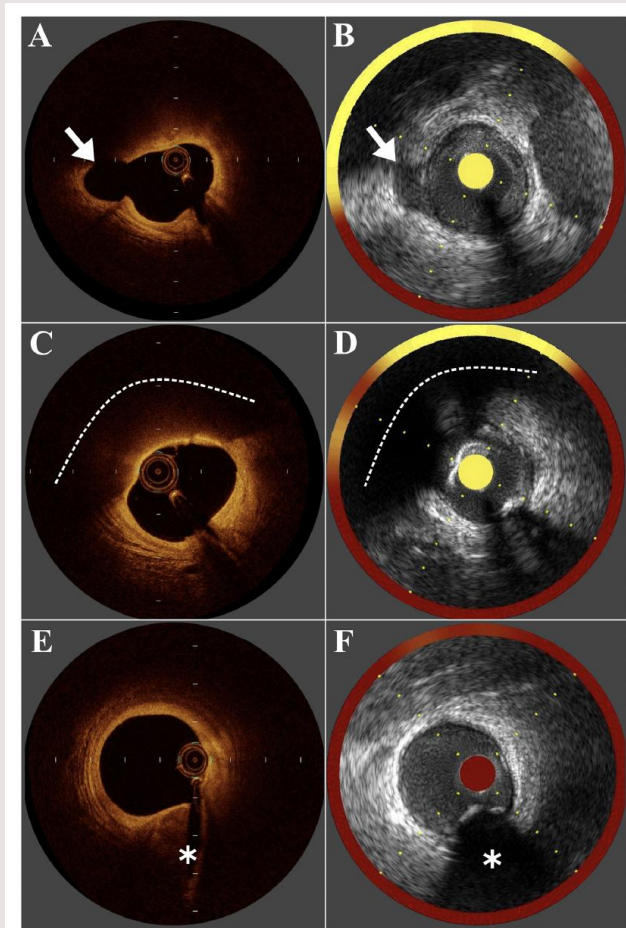


# NIRS konsole Makoto



# The accuracy of detailed analysis of optical coherence tomography in detection of plaque lipid content: dual-imaging study with optical coherence tomography and near-infrared spectroscopy

Karel Kopriva, Zhi Chen, Martin Mates, Frantisek Holy, Barbora Stekla, Michaela Vesela, Jan Pudil, Martin Chval, Andreas Wahle, Milan Sonka & Tomas Kovarnik





# Indikace použití zobrazovacích metod

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Hodnocení hemodynamické významnosti léze (pouze u kmene ACS)

Nejasný angiografický nále

Analýza bifurkačních lézí a stenóz kmene

Vedení intervencí

- LM / bifurkace

- CTO

- SCAD

Diagnostika komplikací

Redukce množství kontrastu



ESC

European Society  
of Cardiology

European Heart Journal (2018) 00, 1–96

doi:10.1093/eurheartj/ehy394

ESC/EACTS GUIDELINES

# 2018 ESC/EACTS Guidelines on myocardial revascularization

## Recommendations on functional testing and intravascular imaging for lesion assessment

Recommendations	Class <sup>a</sup>	Level <sup>b</sup>
When evidence of ischaemia is not available, FFR or iwFR are recommended to assess the haemodynamic relevance of intermediate-grade stenosis. <sup>15,17,18,39</sup>	I	A
FFR-guided PCI should be considered in patients with multivessel disease undergoing PCI. <sup>29,31</sup>	IIa	B
IVUS should be considered to assess the severity of unprotected left main lesions. <sup>35–37</sup>	IIa	B

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FFR = fractional flow reserve; iwFR = instantaneous wave-free ratio; IVUS = intravascular ultrasound; PCI = percutaneous coronary intervention.

<sup>a</sup>Class of recommendation.

<sup>b</sup>Level of evidence.

## Recommendations on intravascular imaging for procedural optimization

Recommendations	Class <sup>a</sup>	Level <sup>b</sup>
IVUS or OCT should be considered in selected patients to optimize stent implantation. <sup>603,612,651–653</sup>	IIa	B
IVUS should be considered to optimize treatment of unprotected left main lesions. <sup>35</sup>	IIa	B

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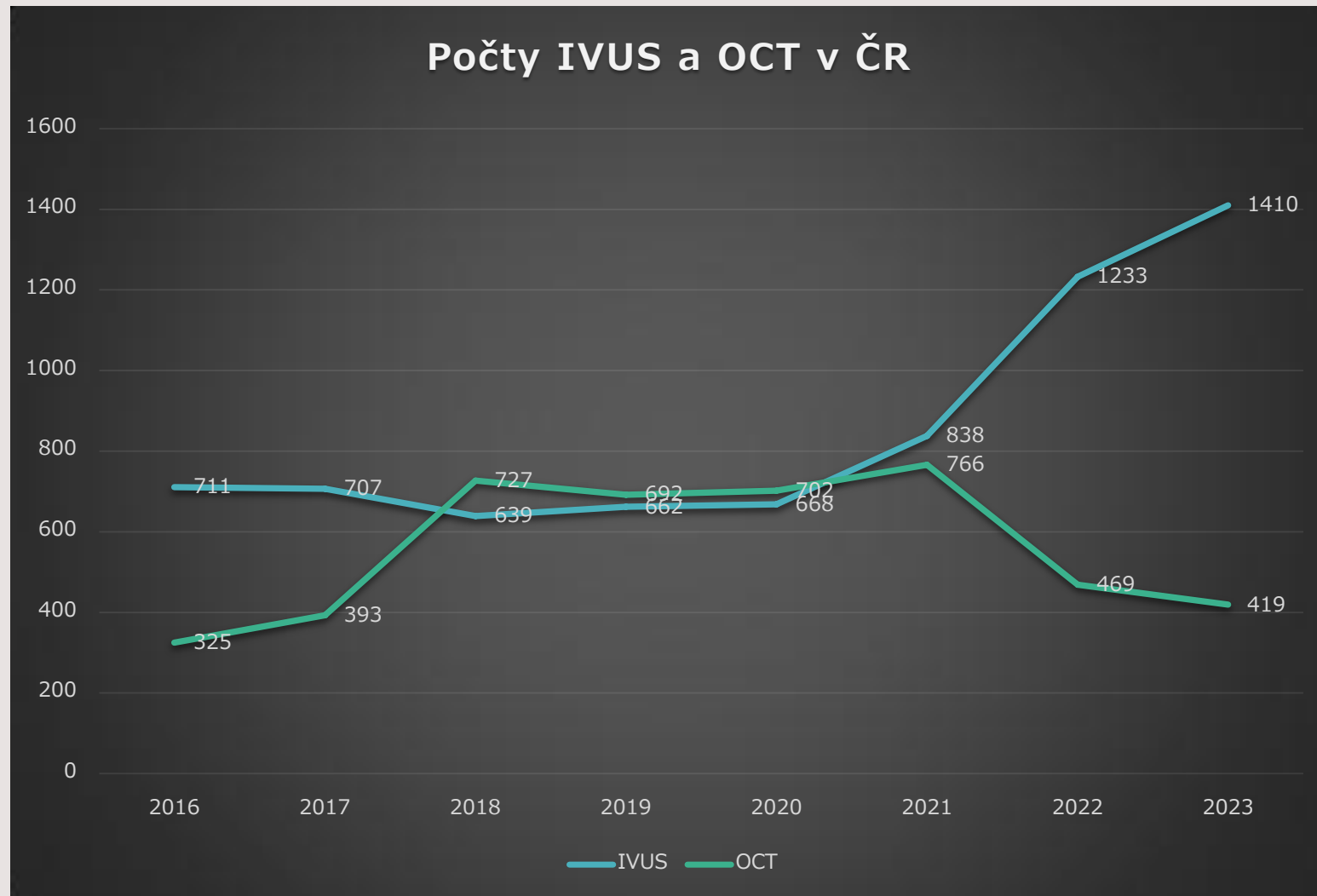
IVUS = intravascular ultrasound; OCT = optical coherence tomography.

<sup>a</sup>Class of recommendation.

<sup>b</sup>Level of evidence.



# Počty IVUS a OCT výkonů v ČR



# Postup při provádění IVUS vyšetření

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Definovat jasný cíl vyšetření

Zavést IVUS sondu dostatečně za místo léze

Klidný, pomalý, kontinuální pullback i v při manuálního vyšetření

Vyšetřovat až do ostia koronární tepny

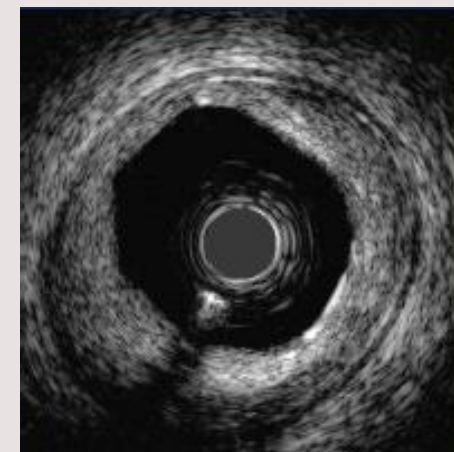
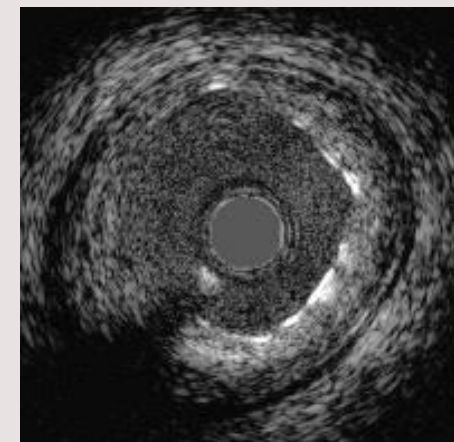
U vysoko frekvenčních sond je možno tepnu propláchnout fyziologickým roztokem ke zvýšení kontrastu mezi krví a lumen

Při vyšetřování kmene dislokovat guiding katétr do aorty

Rozměry měřit v end-dia stole – teoretický požadavek

Rutinně podávat NTG před vyšetřením

Strukturovaný popis vyšetření





# Jaký IVUS přístroj zvolit

## Volcano Philips

- Katétra Eagle eye Platinum 20MHz
- Katétra Revolution 45 MHz
- Katétra PV 0.018 – periferní tepny a žíly, 20 MHz
- Katétra PV 0.35 – zobrazení aorty, 10 MHz

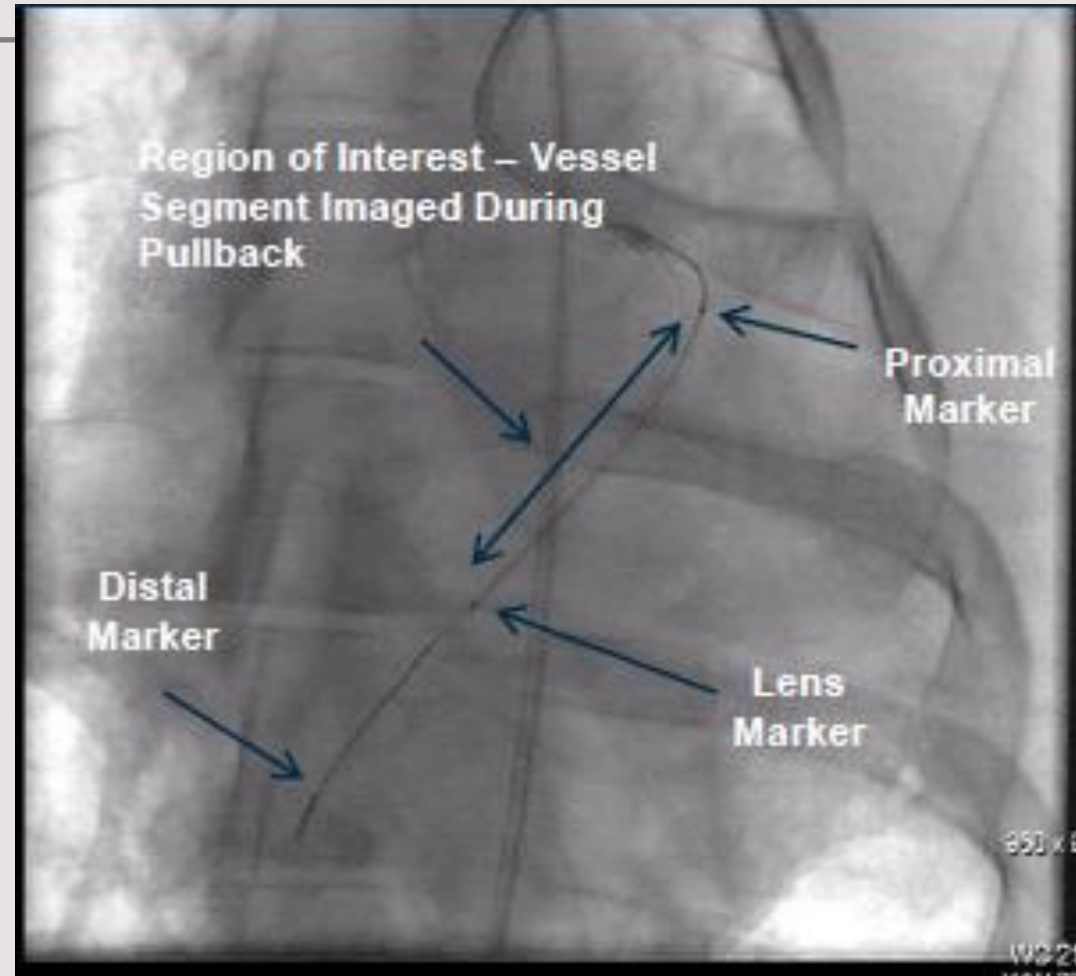
## Kodama IVUS, ACIST Medical

- Dvoufrekvenční katétra 40 a 60MHz
- Volba upravených typů zobrazení

## Polaris IVUS – Boston Scientific

- Katétra Opticross HD 60 MHz
- Katétra Opticross 18, 30 MHz
- Katétra Atlantis 40 MHz
- Katétra iCross. 40 MHz

# Příprava OCT vyšetření



# Aplikace kontrastní látky

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Dostatečná intubace guiding katétru

Preferenčně automatická aplikace kontrastu

ACS rychlost 4 ml/sec, množství 16ml

ACD rychlost 3 ml/sec, množství 12ml

Tlakový limit 300 psi

Větší tepny: rychlost 4 ml/sec, množství 20ml

Na konzoli zvolit “enable” a pro aplikaci použít manuální nebo automatický mód

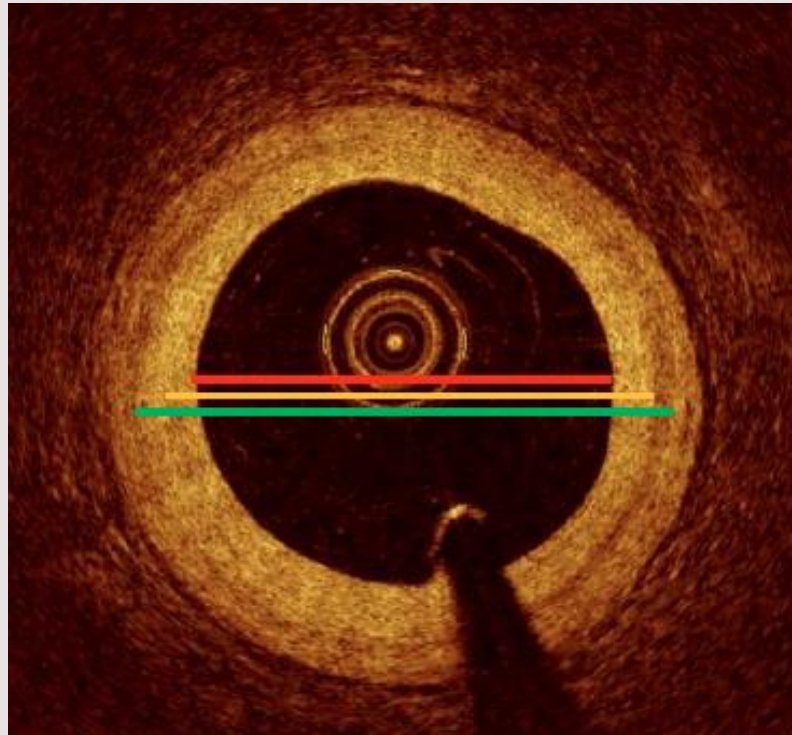


# Určení velikosti stentu

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## Co měřit

- Lumen-lumen
- Media-media

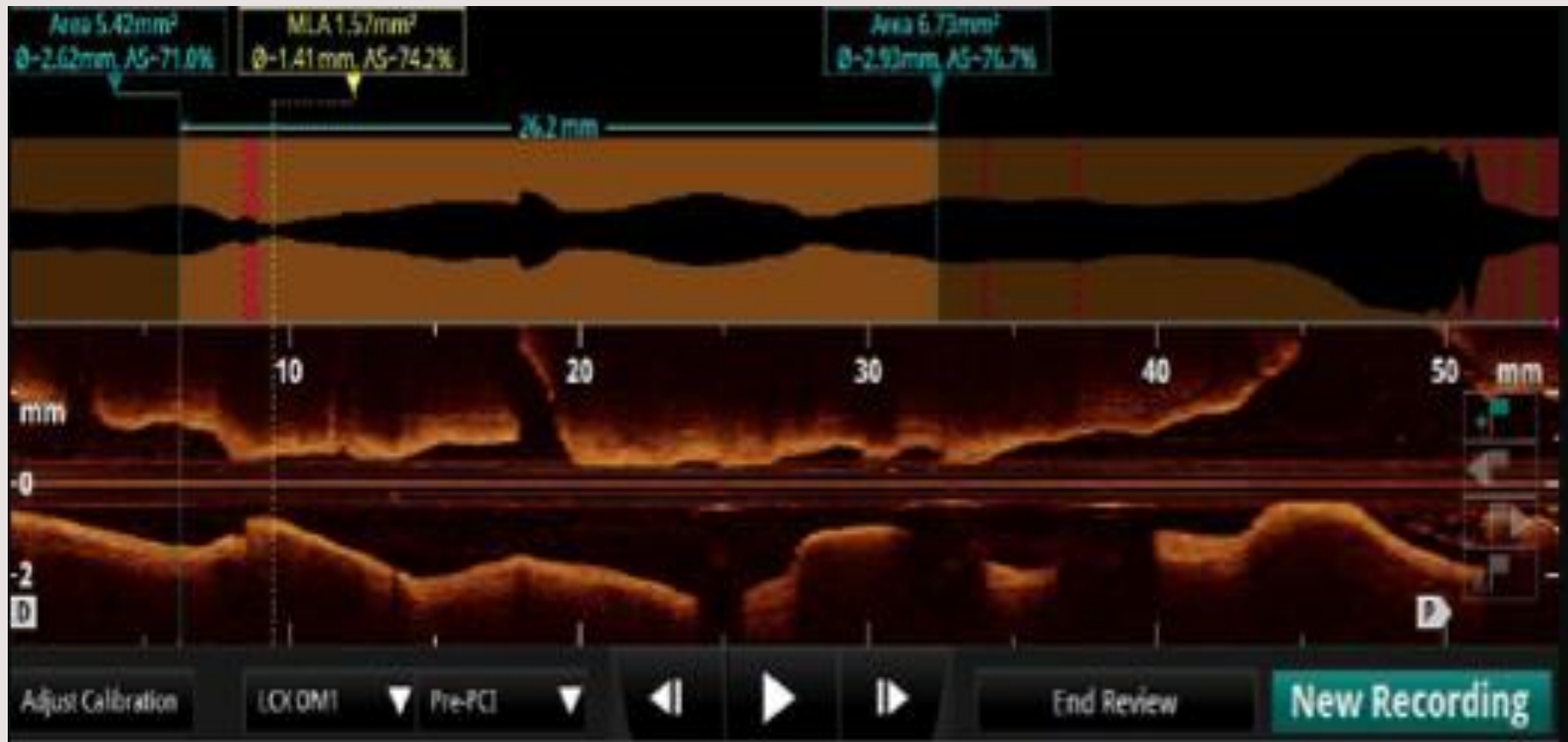


## Kde měřit

- Distal. ref. segment
- Průměrný ref. segment

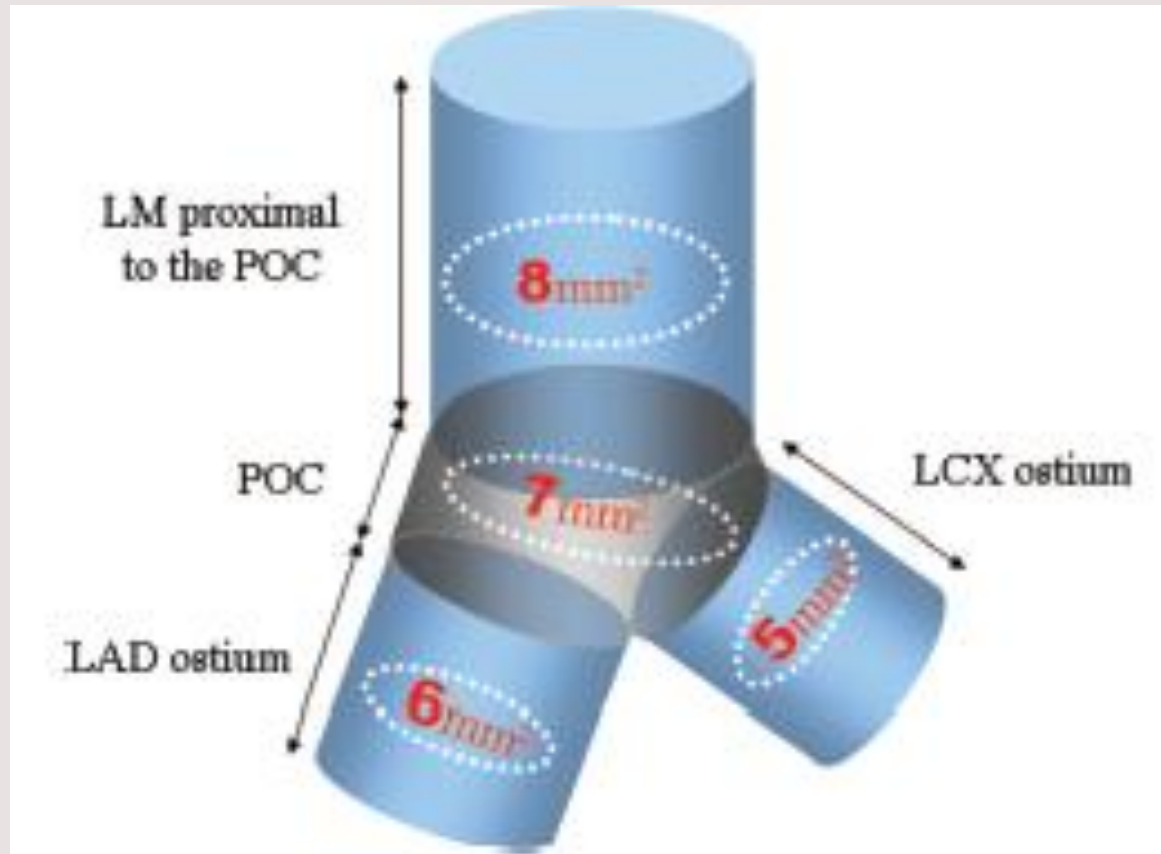
# Určení délky stentu

## - aplikace "lumen profile" -



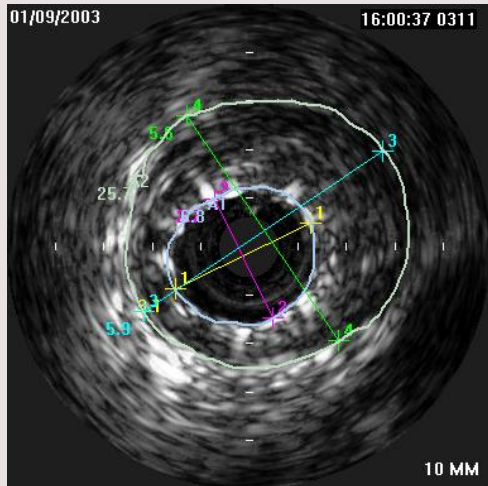
# Doporučené cílové plochy ve stentu u PCI LM

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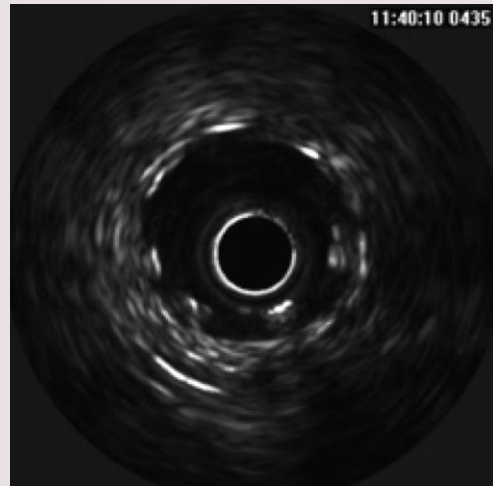


# Malexpanze vs. malapozice stentu



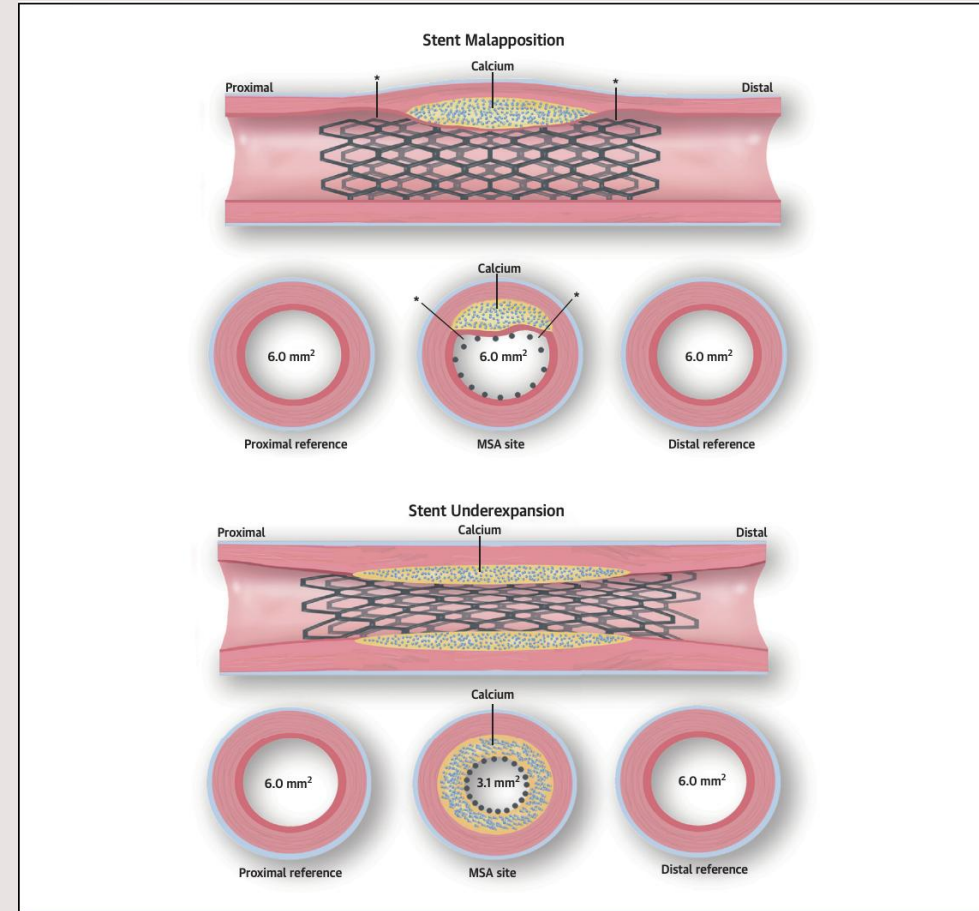
## Expanze

- plocha ve stentu ve srovnání s plochou lumen v referenčním segmentu
- nedostatečnou expanzi stentu je třeba řešit vysokotlakou postdilatací

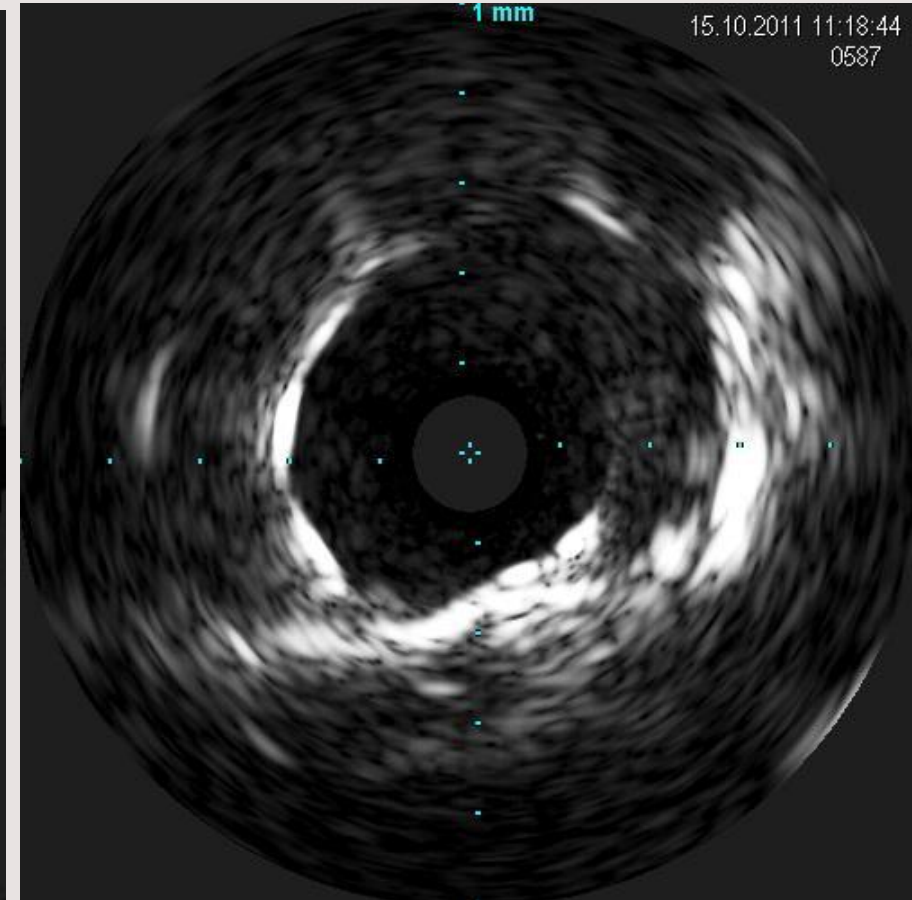
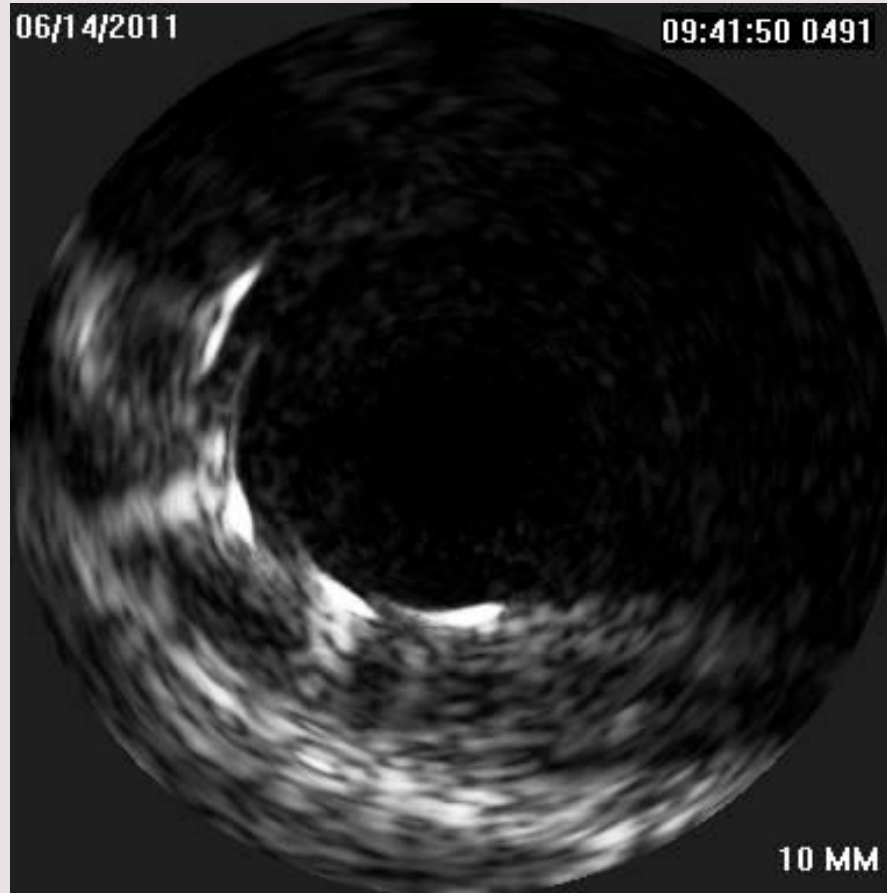


## Apozice

- kontakt vzpěr stentu s cévní stěnou
- neadekvátní apozici je třeba řešit dilatací větším balónem za použití nominálního tlaku



# Správná pozice stentu v ostiu ACS



# Diagnostika komplikací

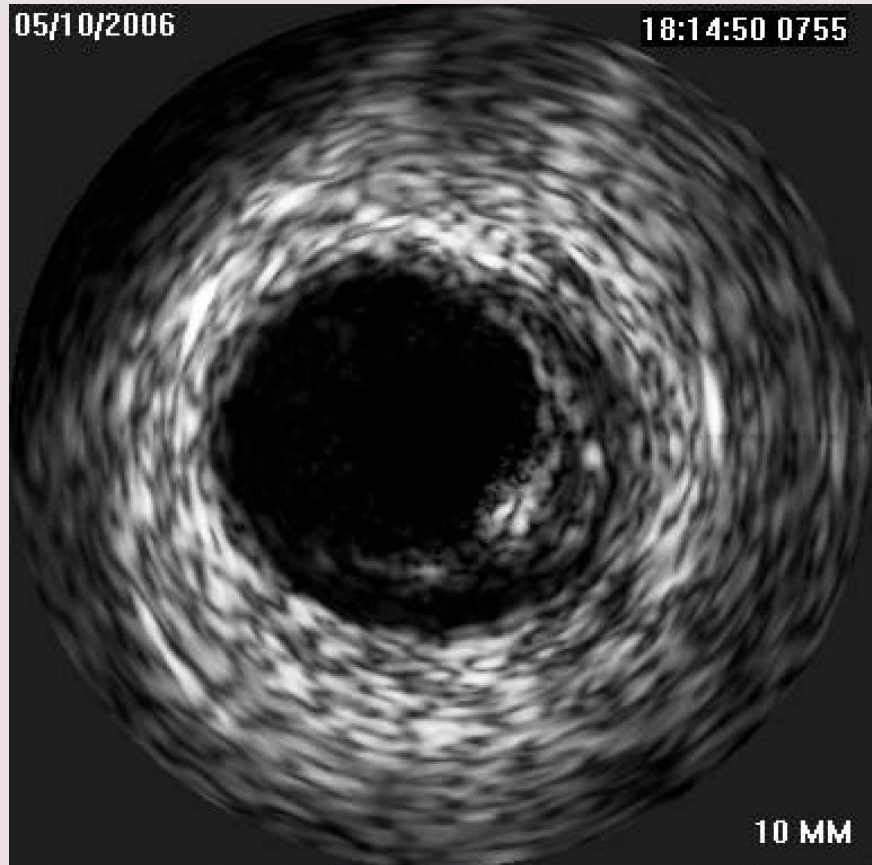
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# Příklady komplikací po balónkové dilataci

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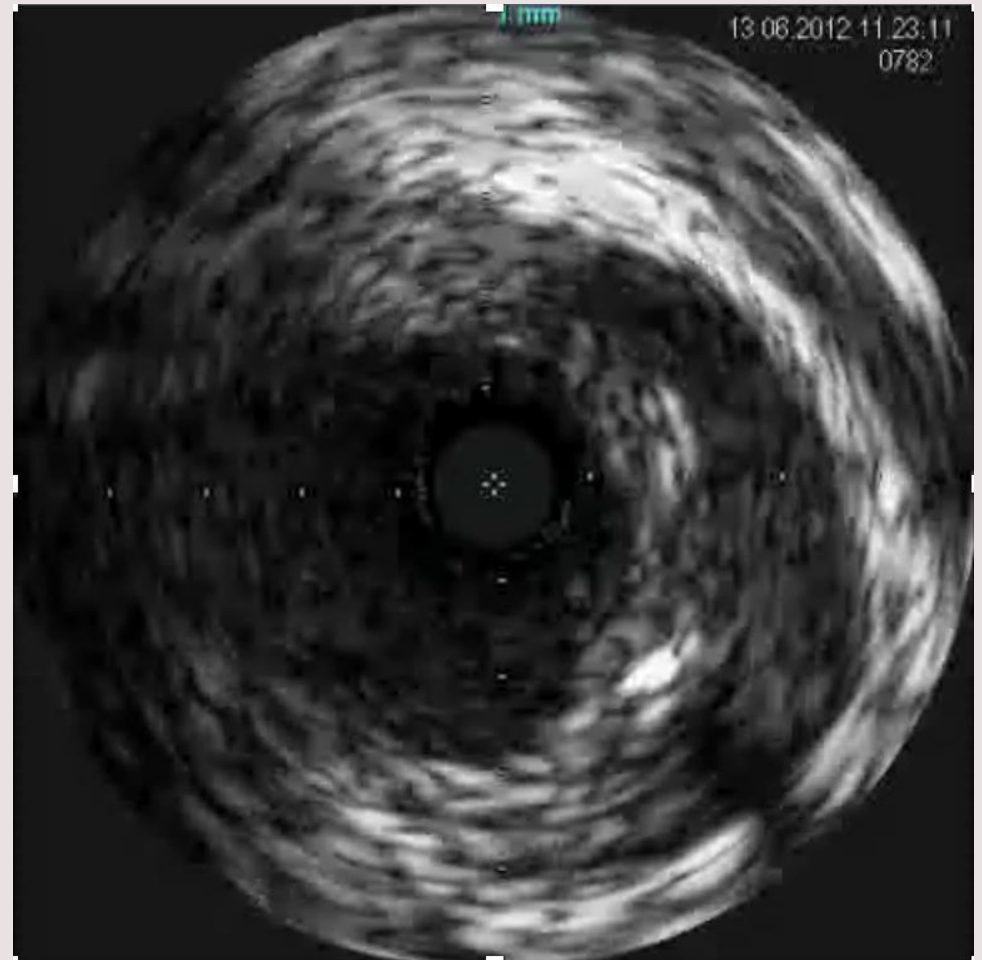
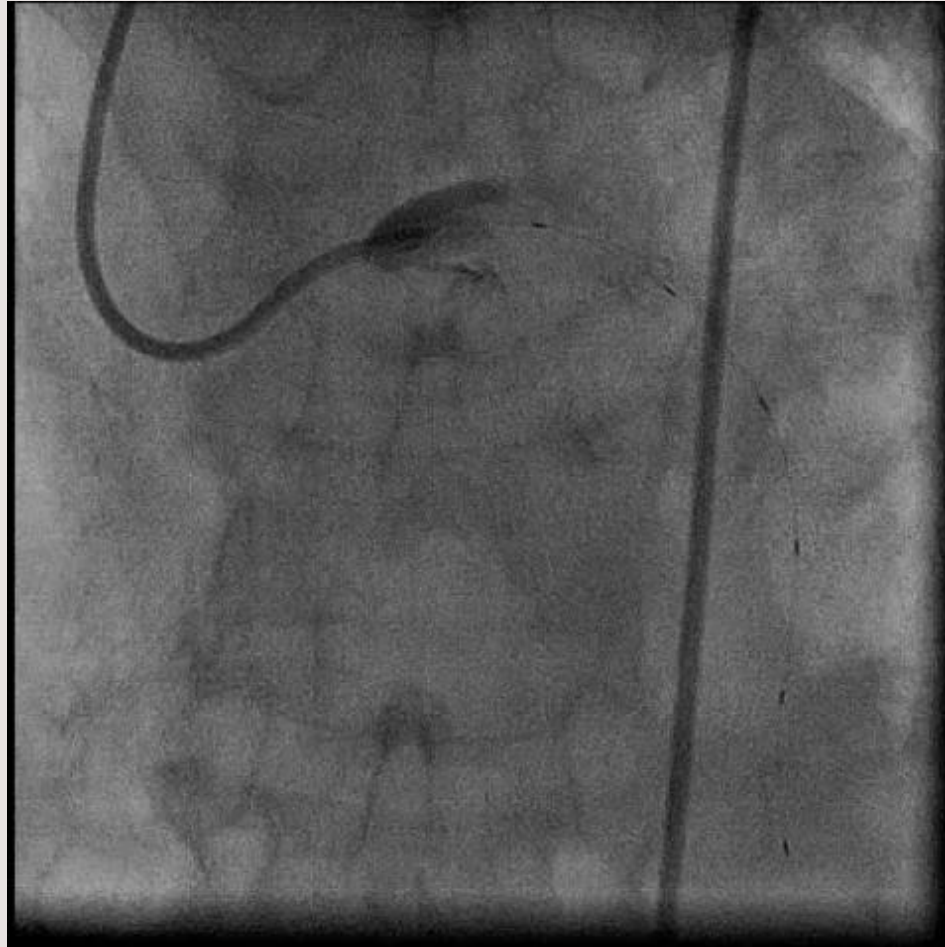


Disekce



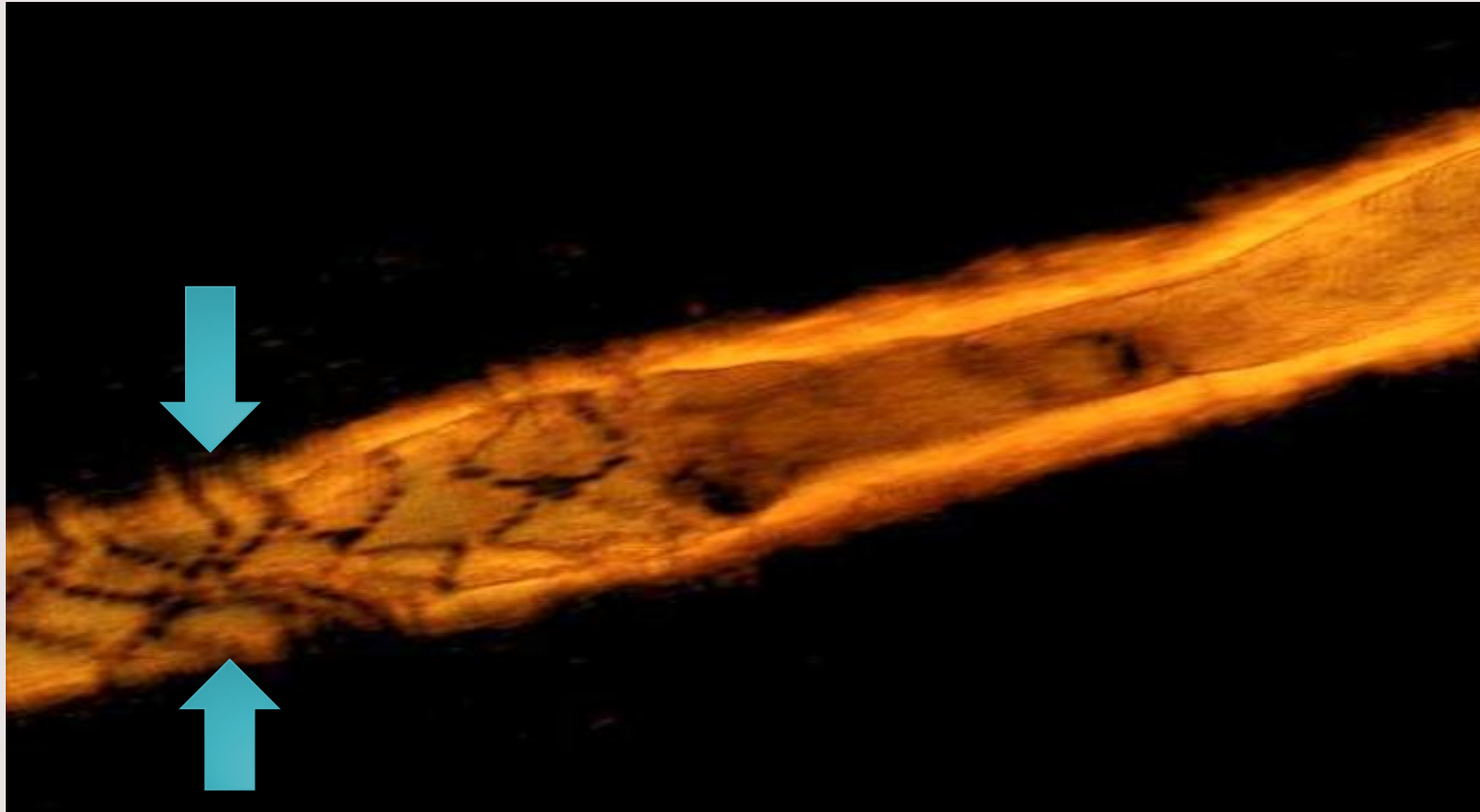
Intramurální hematom

# IVUS u ostiálních disekcí



# Nedostatečná expanze stentu

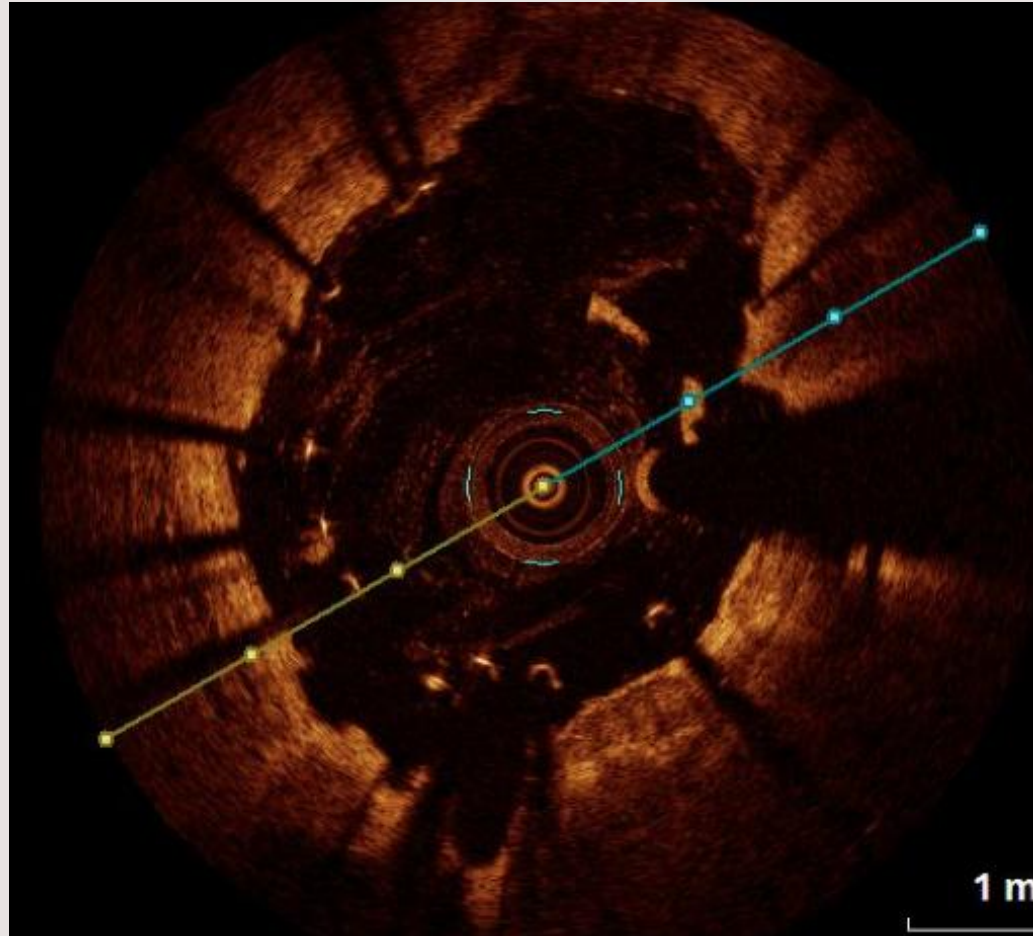
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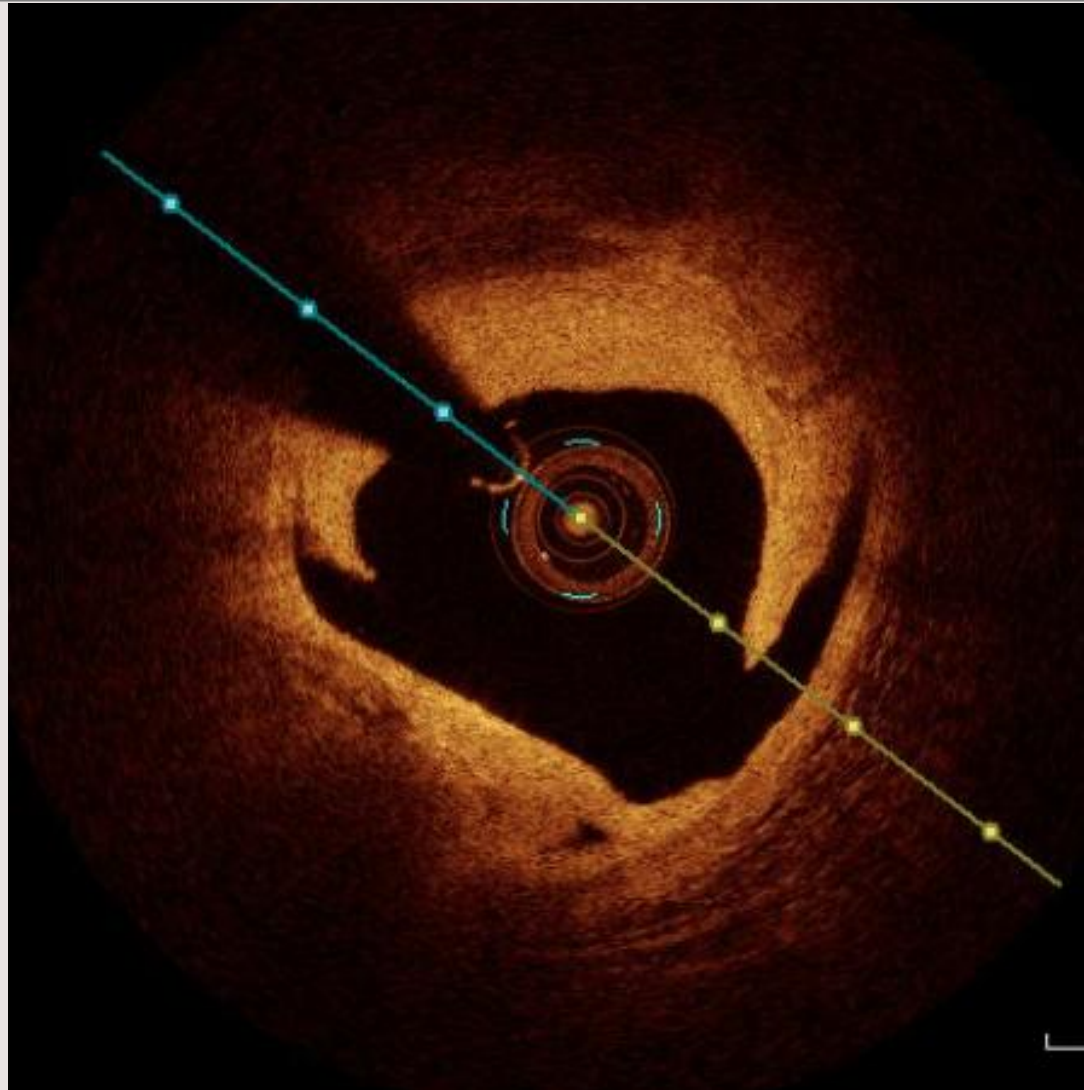
# Nedostatečná apozice stentu

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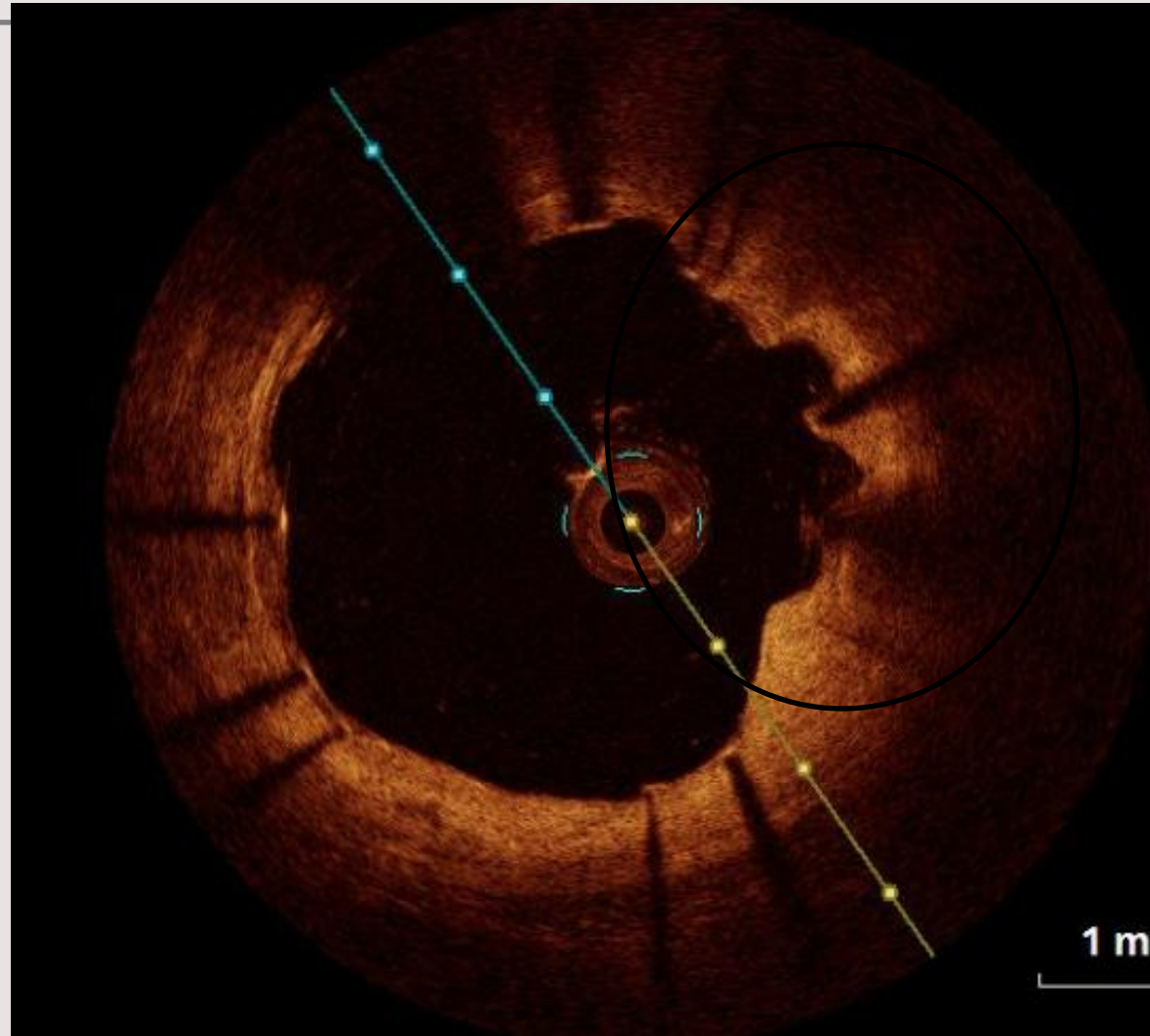


# Edge disekce

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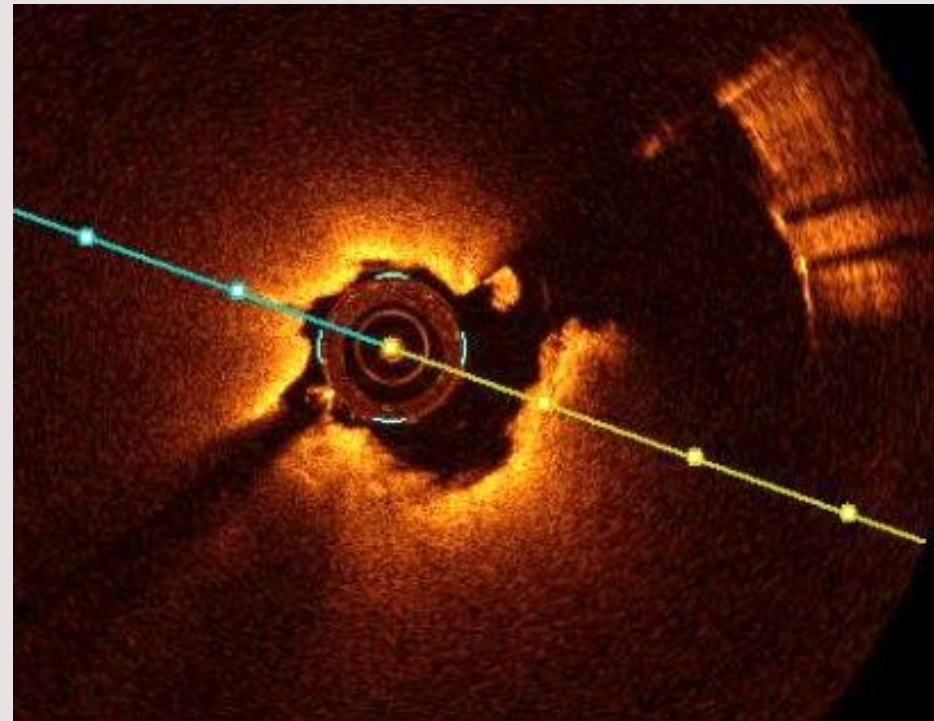
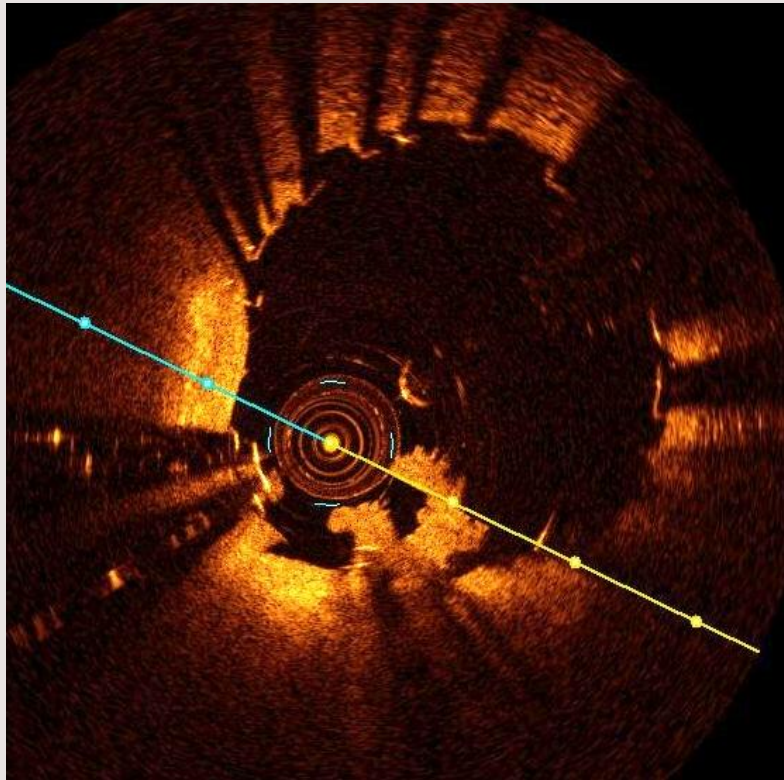
# Evaginace cévní stěny





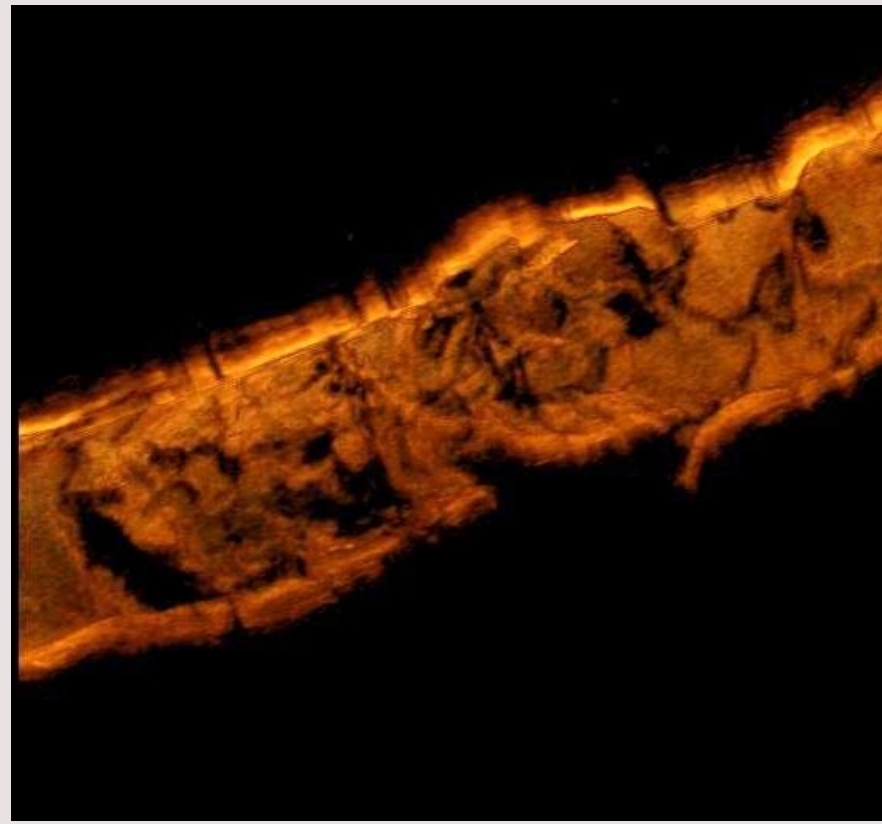
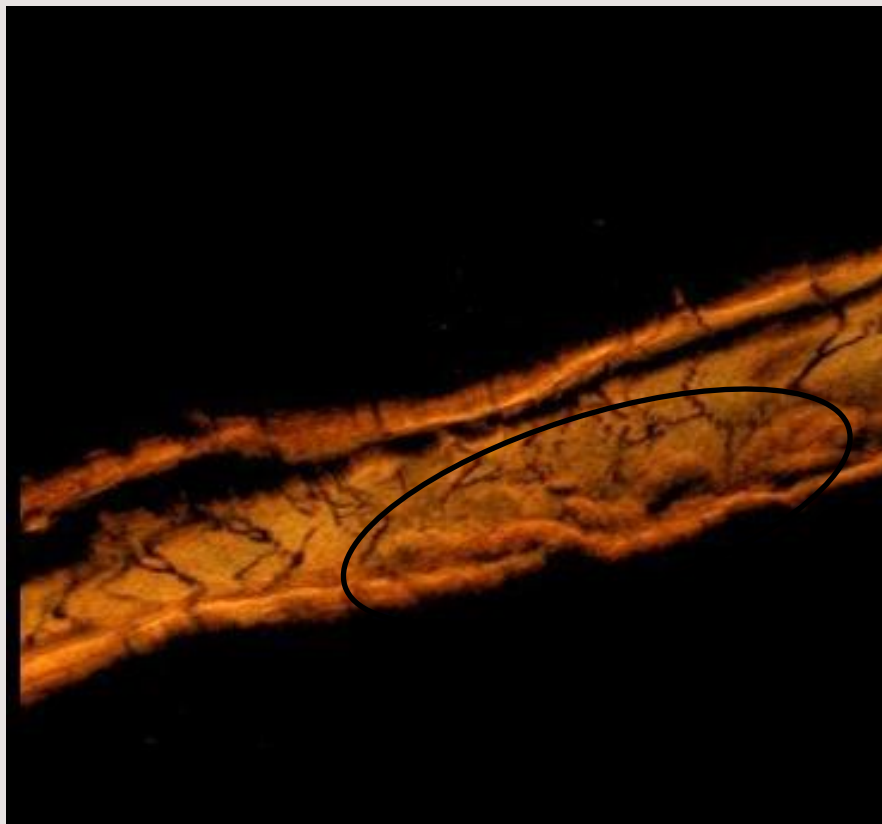
# In stent trombóza

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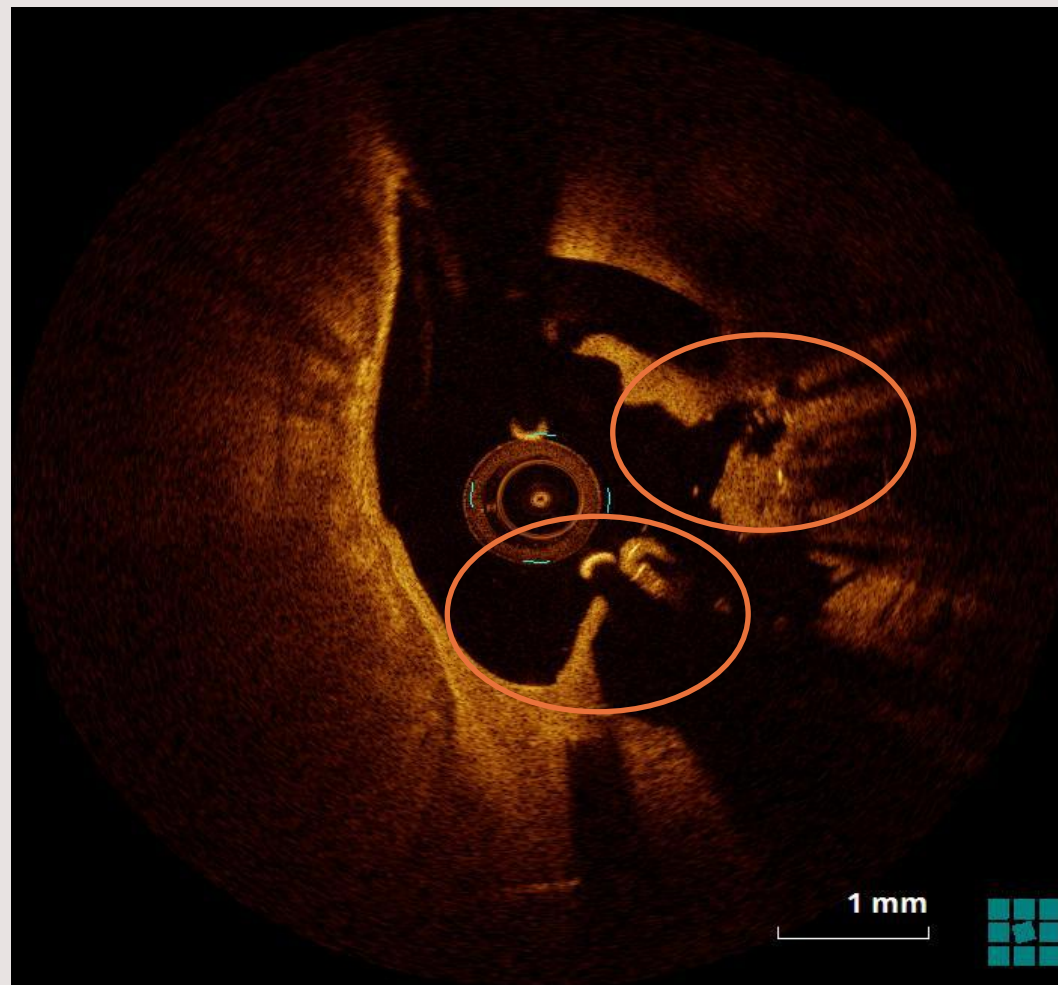
# Trombóza ve stentu

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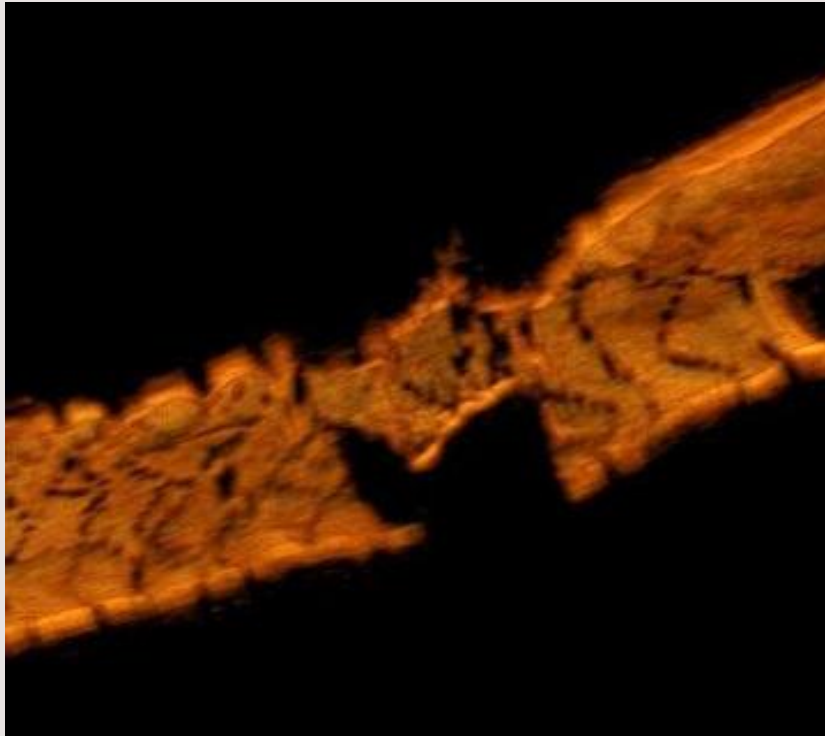
# Deformace stentu balónkovou dilatací

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# Deformace stentu kalcifikovaným plátem

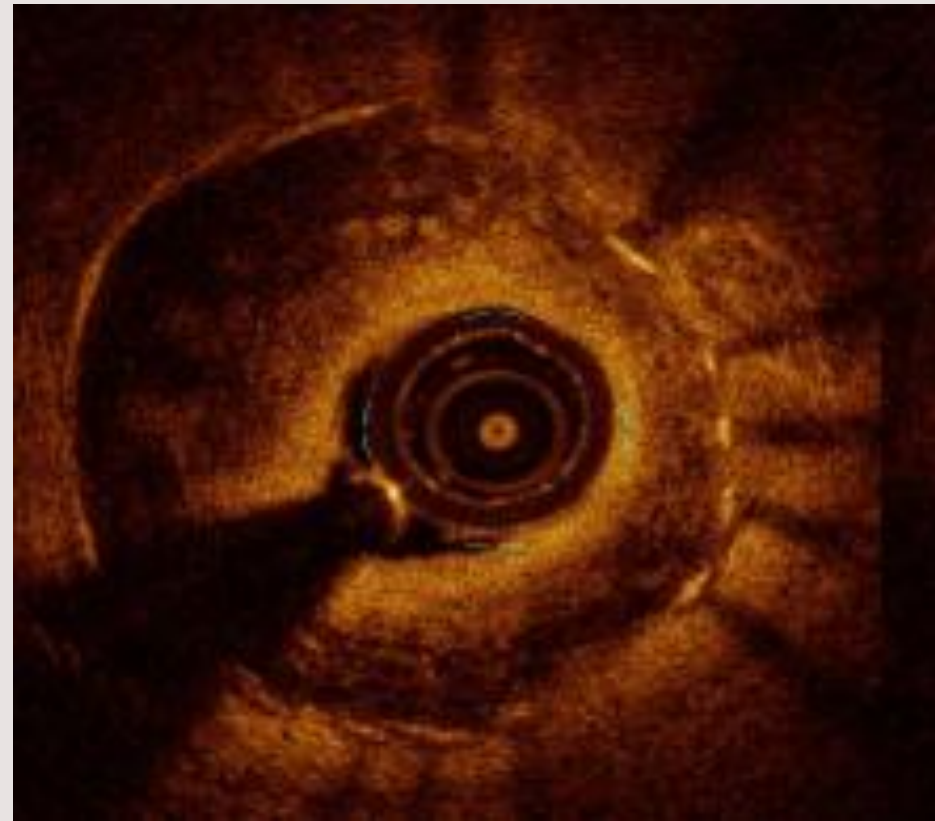
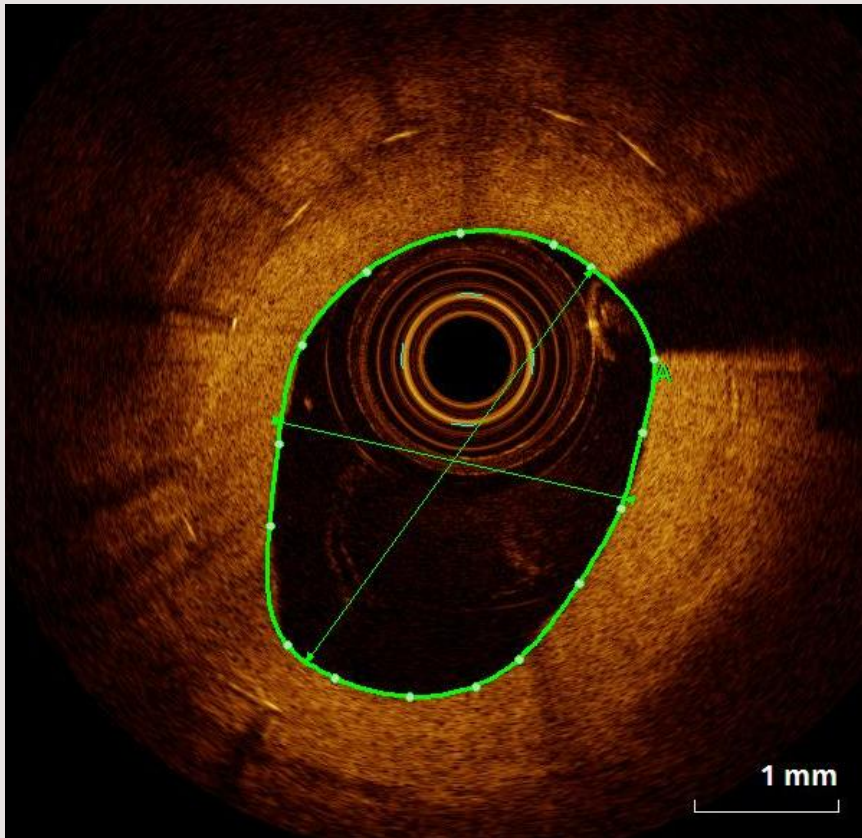
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# In stent restenóza vs. neoateroskleróza

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# Závěry

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- 1/ Zobrazovací metody jsou v intervenční kardiologii doporučovány stále častěji
- 2/ Důvodem je zlepšení diagnostiky angiograficky nejasných lézí a dále určení strategie komplexních lézí
- 3/ Vedení PCI pomocí zobrazovacích metod je zvláště přínosné u PCI kmene ACS, bifurkací, kalcifikovaných lézí a chronických uzávěrů
- 4/ Zvyšuje se počet PCI vedených zobrazovacími metodami pro redukci kontrastu
- 5/ Postavení IVUS a OCT je ekvivalentní až na specifické situace (ostia, komplikace ve stentu, BVS)
- 6/ K hodnocení získaného obrazu se stále častěji používá umělá inteligence
- 7/ V katlabu by měl být vždy jeden člen týmu, který se této problematice věnuje více a který ideálně spolupracuje s klinickým inženýrem

