# Histopathological View of Bifurcation lesions

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# Disclosure

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

**Employment in industry: No**

**Honorarium: Amgen; Abbott Vascular; Biosensors; Boston Scientific; Celonova; Cook Medical; CSI; Lutonix Bard; Sinomed; Terumo Corporation.**

**Institutional grant/research support: R01 HL141425 Leducq Foundation Grant; 480 Biomedical; 4C Medical; 4Tech; Abbott; Accumedical; Amgen; Biosensors; Boston Scientific; Cardiac Implants; Celonova; Claret; Concept Medical; Cook; CSI; DuNing; Edwards; Emboline; Endotronix; Envision Scientific; Lutonix/Bard; Gateway; Lifetech; Limflo; MedAlliance; Medtronic; Mercator; Merill; Microport; Microvention; Mitraalign; Mitra assist; NAMSA; Nanova; Neovasc; NIPRO; Novogate; Occulotech; Orbus Neich; Phenox; Profusa; Protembis; Qool; Recor; Senseonics; Shockwave; Sinomed; Spectranetics; Surmodics; Symic; Vesper; W.L. Gore; Xeltis.**

**Owner of a healthcare company: No**

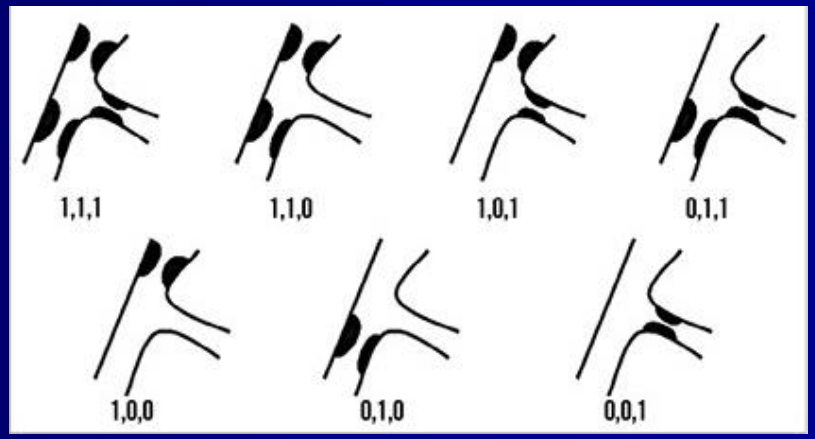
**Stockholder of a healthcare company: No**

# Background

## Bifurcation Lesions

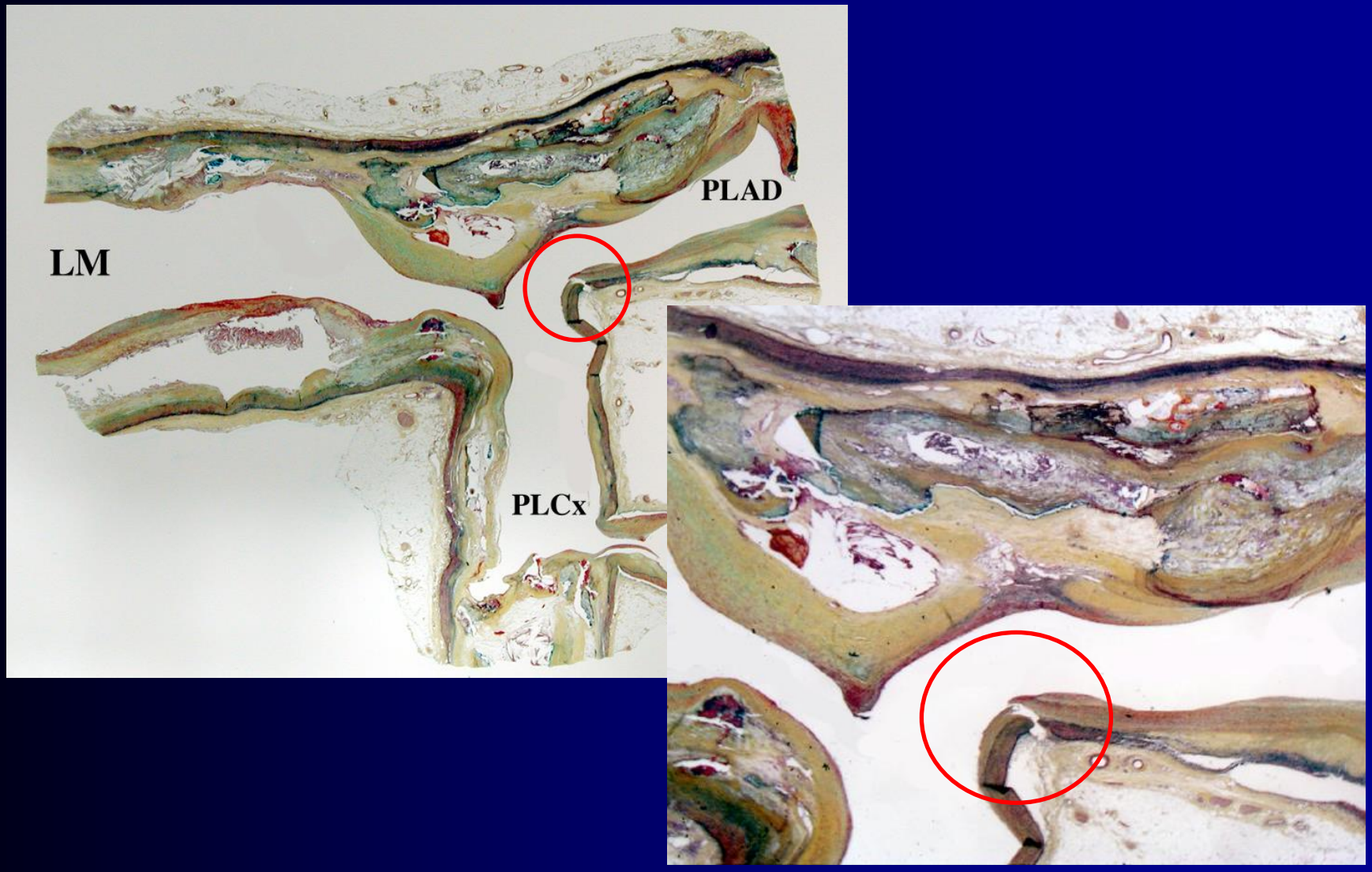
- Defined as coronary artery narrowing occurring adjacent to, and/or involving a significant side branch (usually >2 mm) that you don't want to lose
- Account for nearly 20% of coronary lesions requiring PCI
- Associated with worse clinical outcomes compared with non-bifurcation PCI

## Medina Classification




Medina A, Suarez de Lezo J, Pan M. [A new classification of coronary bifurcation lesions]. Rev Esp Cardiol. 2006;59:183

# PLAQUE FORMATION IN BIFURCATIONS



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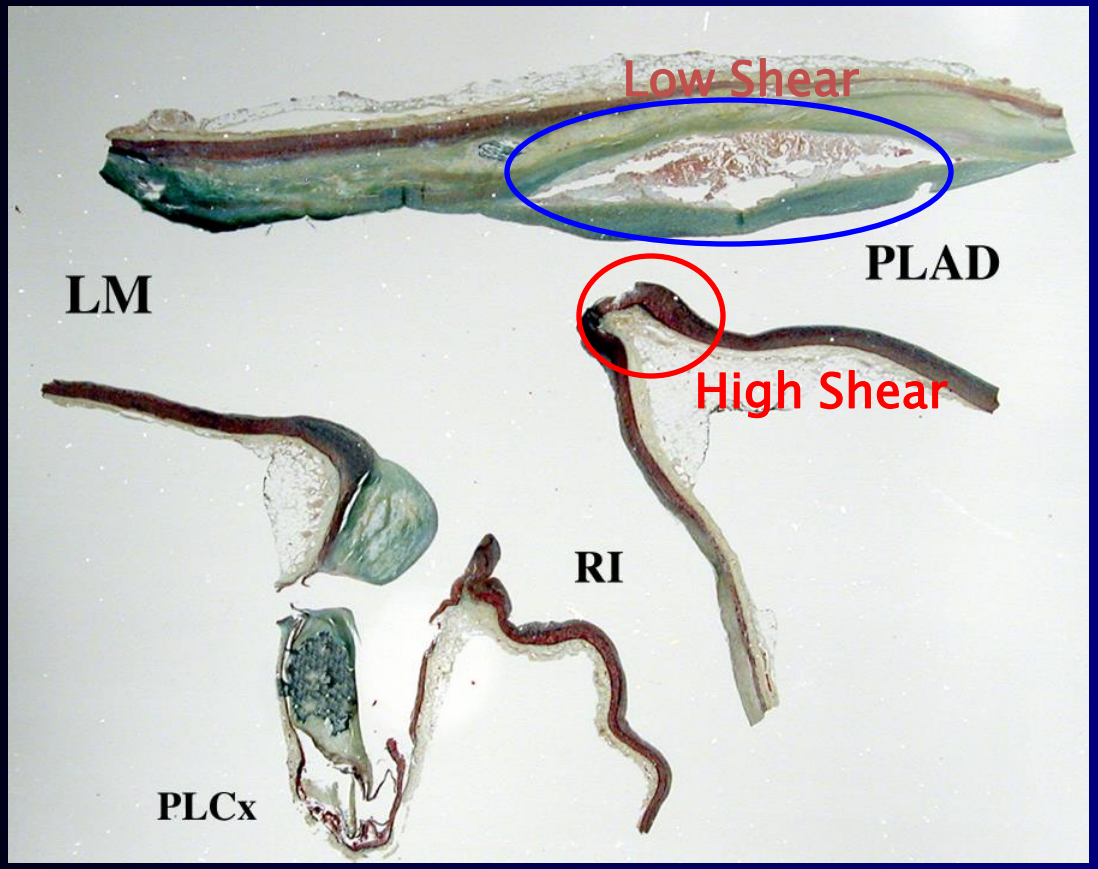
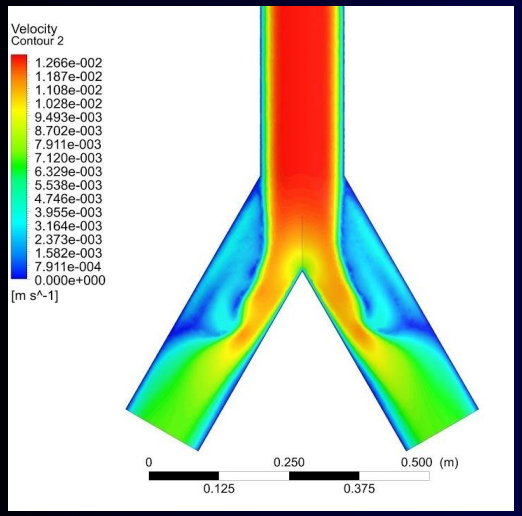
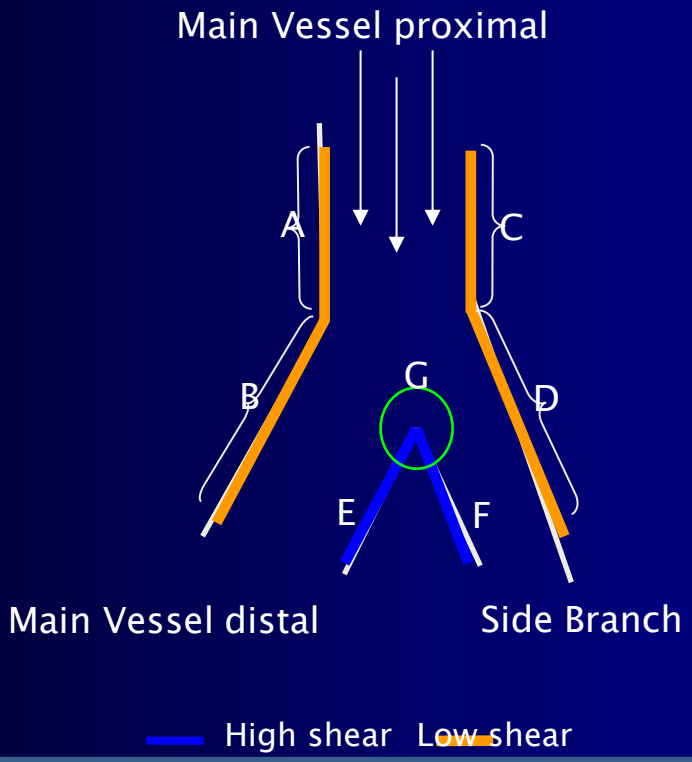
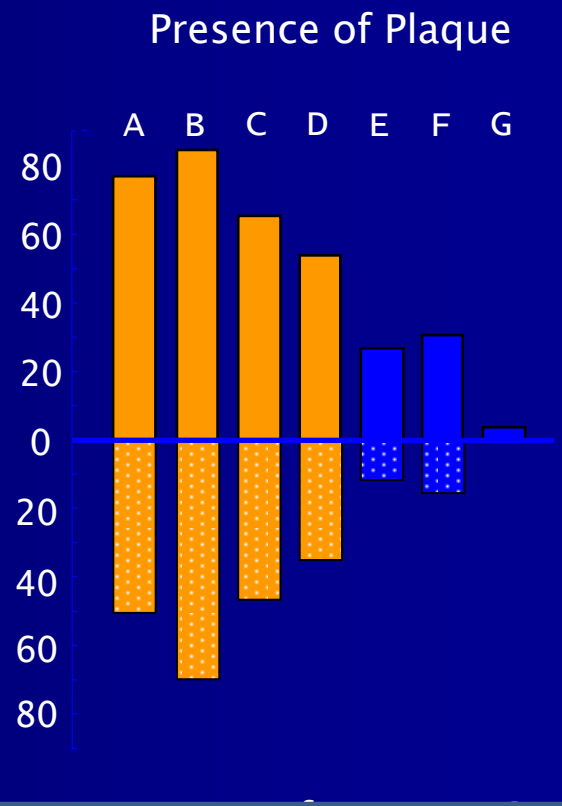



# Plaque Formation in Bifurcations

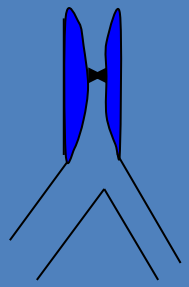


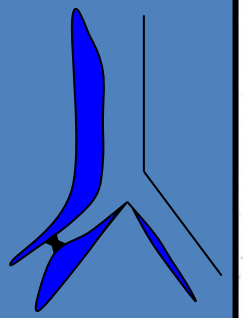

**Greater atherosclerotic plaque burden occurs at low-shear regions of bifurcations**

# Histopathological classification of bifurcation lesions



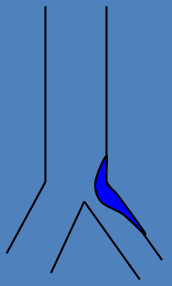
A only


A only

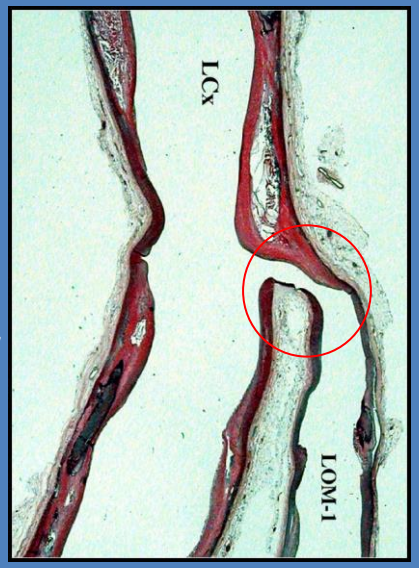


B only


B only

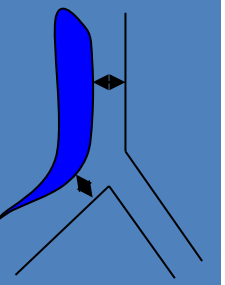


C only

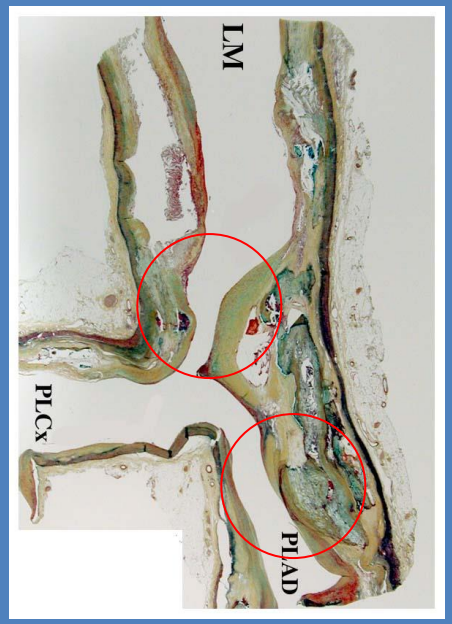



C only

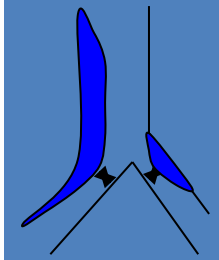
# Histopathological classification of bifurcation lesions



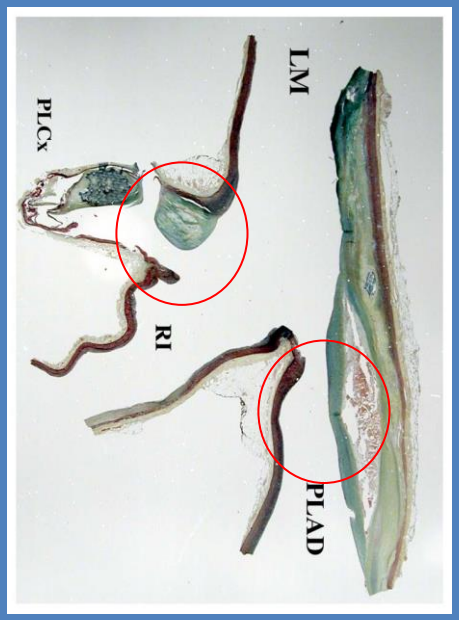
A+B



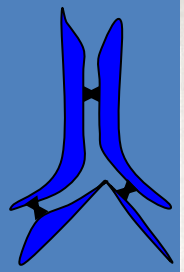

A+B



B+C



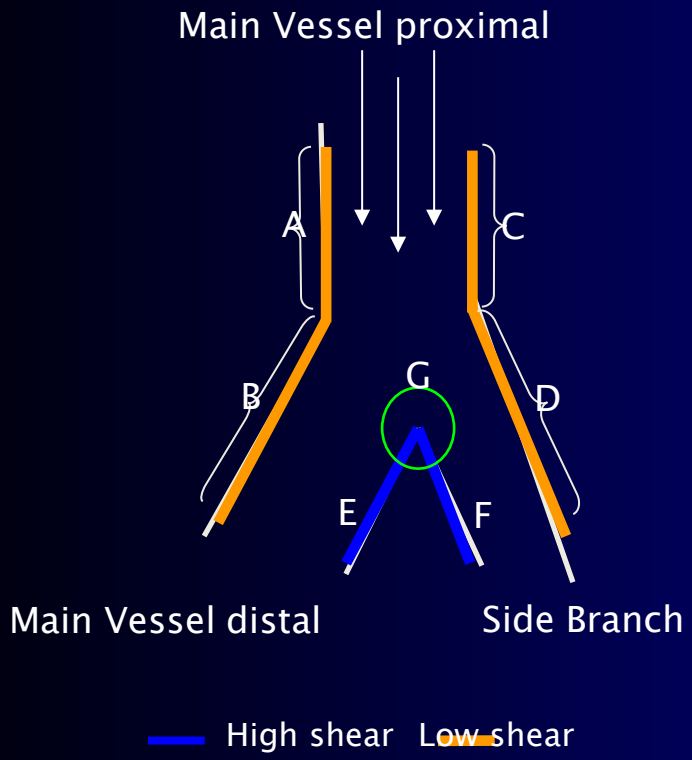

B+C

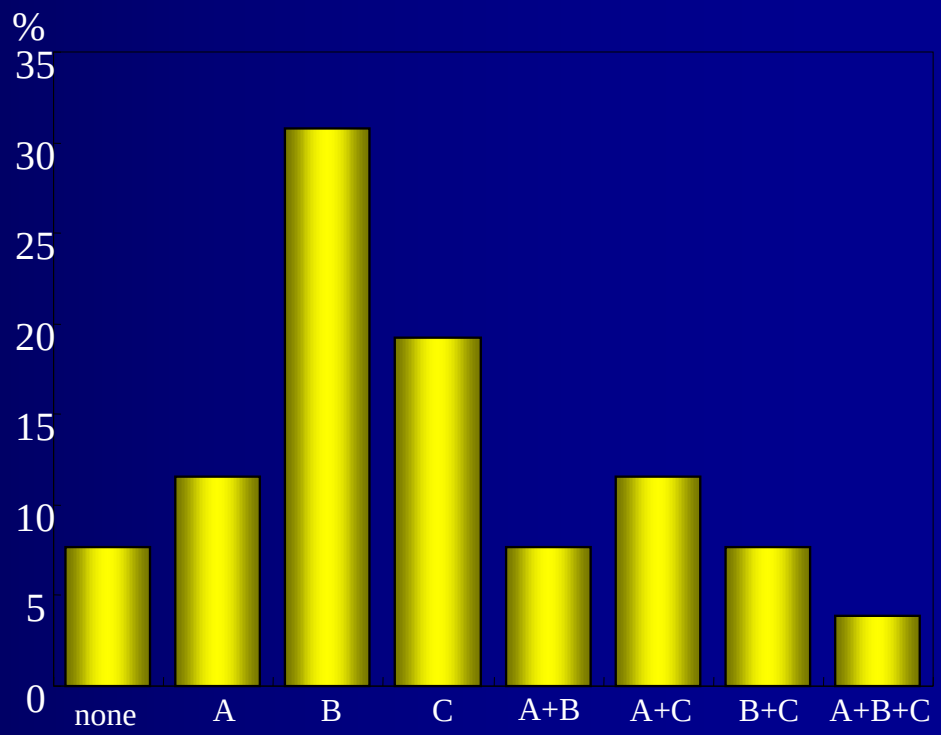


A+B+C

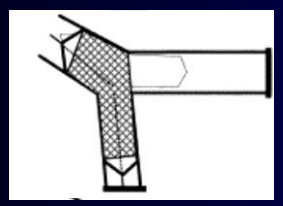

A+B+C

# Prevalence of Plaque distribution in bifurcation lesions

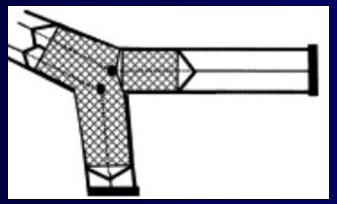


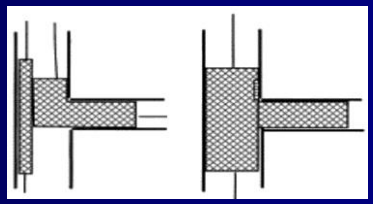
# BIFURCATION TREATMENT STRATEGIES



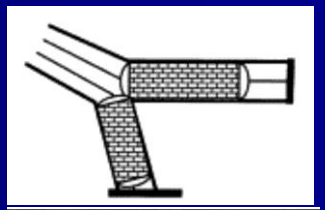
1 stent



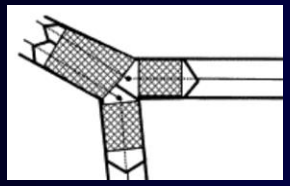
T stent



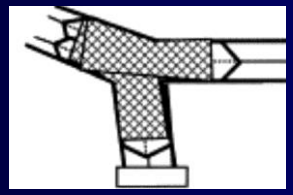
Crush stent



V stent



Y stent



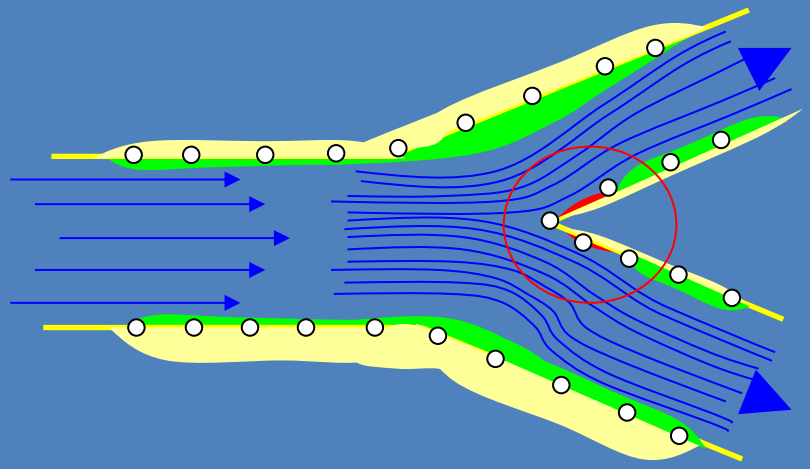
Culottes

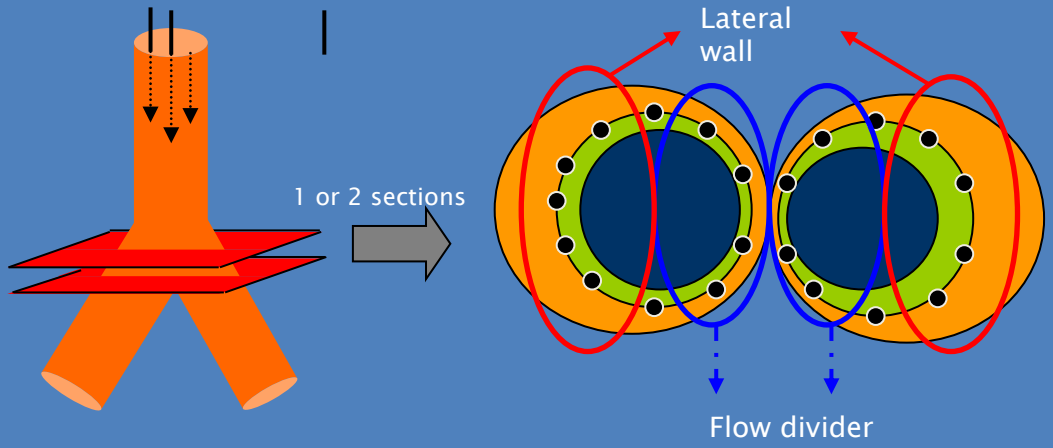
# OUTCOME OF PCI IN BIFURCATIONS

## ANALYSIS OF THE CVPATH COHORT

| Stent type | DES (n=14) | BMS (n=20) |
|---|---|---|
| Restenosis | | |
| MV (%) | 1 (7) | 6 (30) |
| SB (%) | 2 (14) | 5 (25) |
| Thrombosis (total) | | |
| MV (%) | 10 (71) | 8 (40) |
| SB (%) | 6 (43) | 6 (30) |
| Thrombosis ≥ 30 days | | |
| MV (%) | 7 (88) | 5 (25) |
| SB (%) | 3 (38) | 2 (10) |
| Stent related death | 10 (71) | 8 (40) |
| Procedure related death | 1 (7) | 2 (10) |

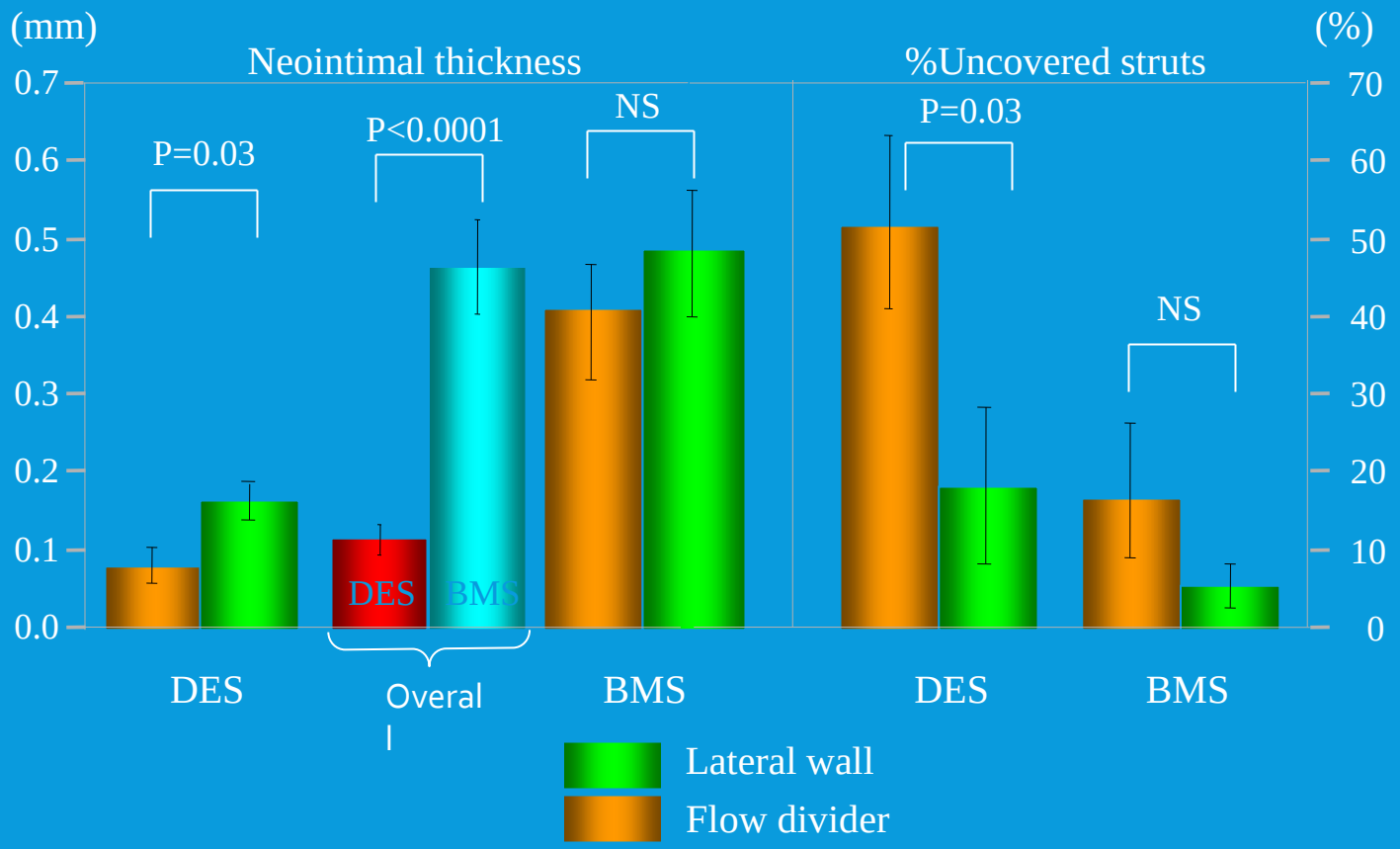
# PATHOPHYSIOLOGY OF PCI IN BIFURCATIONS





# OUTCOME OF PCI IN BIFURCATIONS

## ANALYSIS OF THE CVPATH COHORT



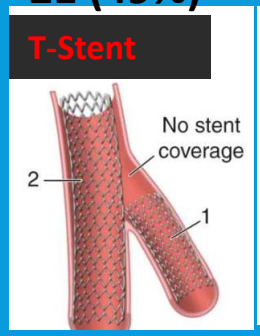
# Bifurcation Stenting with 2 stent techniques from CVPath Stent Registry (2005 to 2018)

**Type of Techniques**

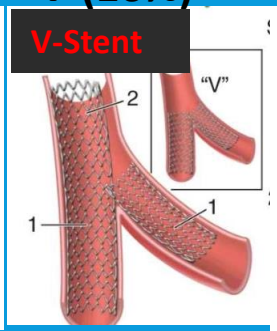
**Mean Age: 65 yrs, Male: 73%**

n=43

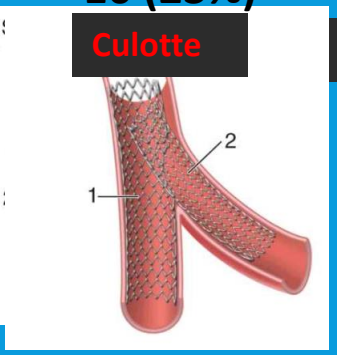
**21 (49%)** — **T-Stent**



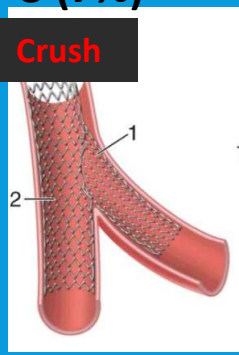

**7 (16%)** — **V-Stent**




**10 (23%)** — **Culotte**



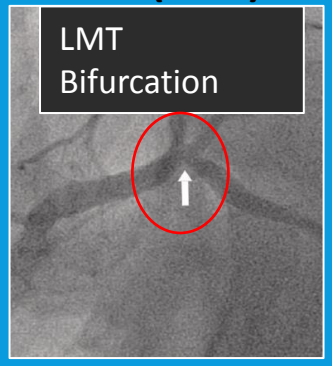

**3 (7%)** — **Crush**



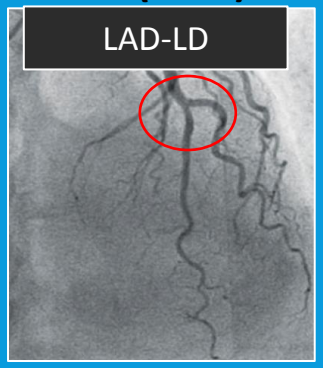

**2 (4%)** — **Kissing**


**Location**

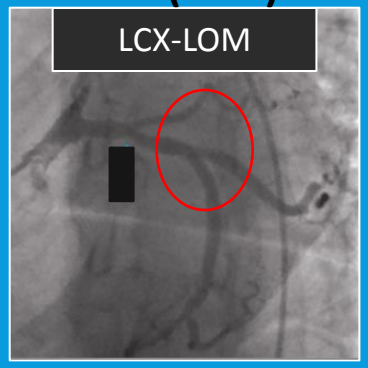
**17 (40%)** — LMT Bifurcation



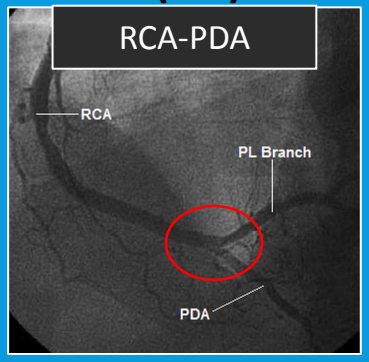
**15 (35%)** — LAD-LD



**10 (23%)** — LCX-LOM



**1 (2%)** — RCA-PDA



## Stent Failure in Bifurcation stenting Stratified by Duration

| Duration of stent implantation (days) | | 0-30 | 31-360 | 361- |
|---|---|---|---|---|
| N=43 | | 13 (30%) | 16 (37%) | 14 (33%) |
| Stent failure mode | | | | |
| Stent thrombosis | 16 (37%) | 6 (14%) | 4 (9%) | 6 (14%) |
| Restenosis | 2 (4%) | 0 | 1 (2%) | 1 (2%) |

## Causes of thrombosis

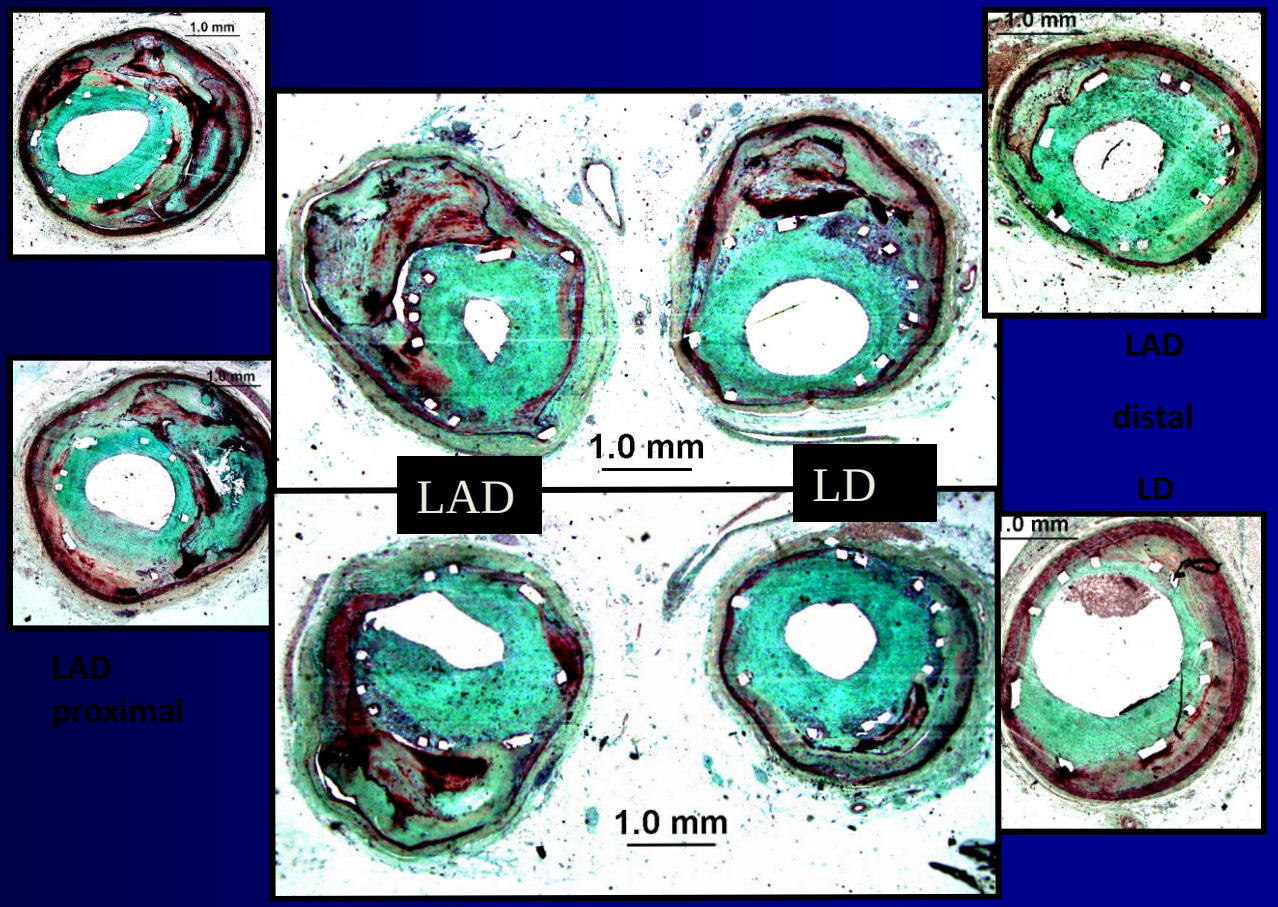
| Causes of thrombosis | Total n=16 |
|---|---|
| Uncovered struts | 6 (38%) |
| Malapposition | 4 (25%) |
| Hypersensitivity | 2 (13%) |
| Medial injury with dissection | 1 (6%) |
| Protrusion of NC | 1 (6%) |
| 2 stent technique | 1 (6%) |
| Unknown | 1 (6%) |

## Stent Failure divided by type of stents

| Type | n=43 | Event | ST | Restenosis |
|---|---|---|---|---|
| T-Stent | 21 (49%) | 7 (33%) | 6 (29%) | 1 (5%) |
| V-Stent | 7 (16%) | 2 (29%) | 2 (29) | 0 (0%) |
| Culotte | 10 (23%) | 5 (50%) | 4 (40%) | 1 (10%) |
| Crush Stent | 3 (7%) | 2 (67%) | 2 (67%) | 0 (0%) |
| Kissing stent | 2 (5%) | 2 (100%) | 2 (100%) | 0 (0%) |

# COMPLICATIONS OF PCI IN BIFURCATIONS

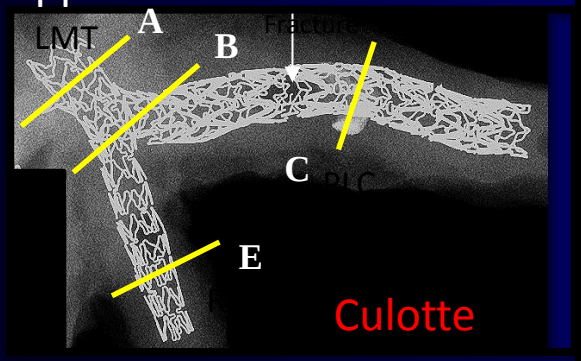
## RESTENOSIS

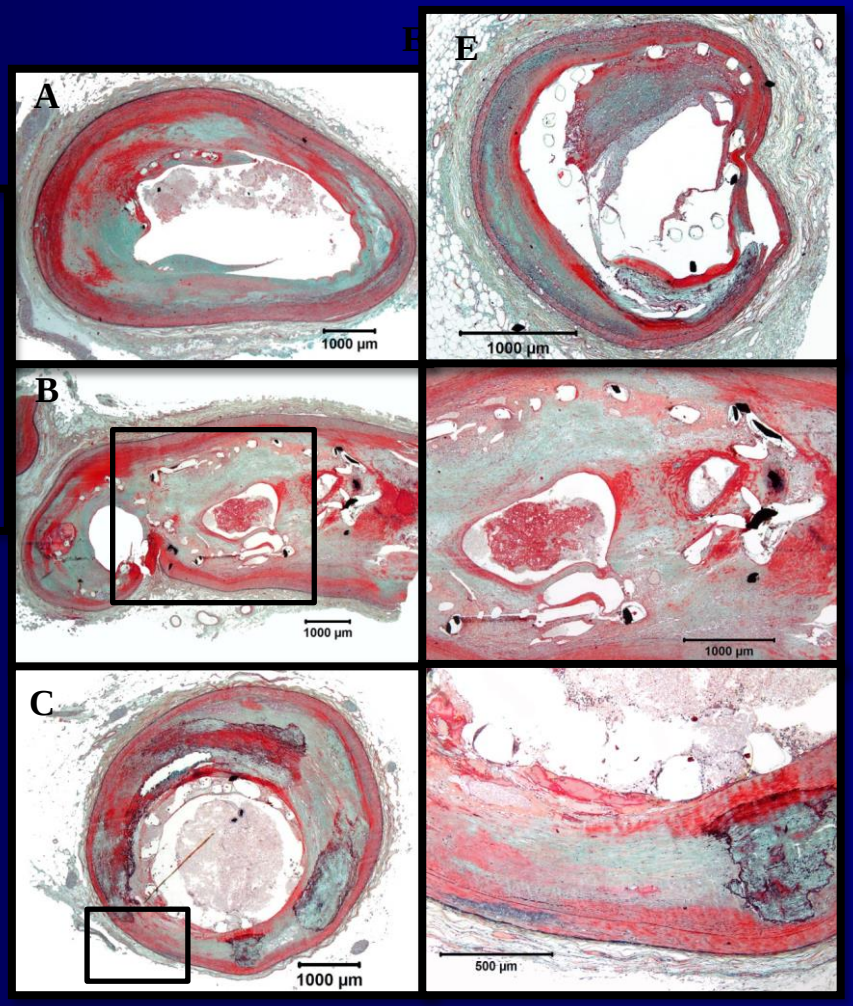



69M with stent implantation in LAD/LD. 4 months after the PCI, he underwent CABG due to restenosis of LAD and LD. He died from complications of CABG.

# Restenosis in distal main vessel

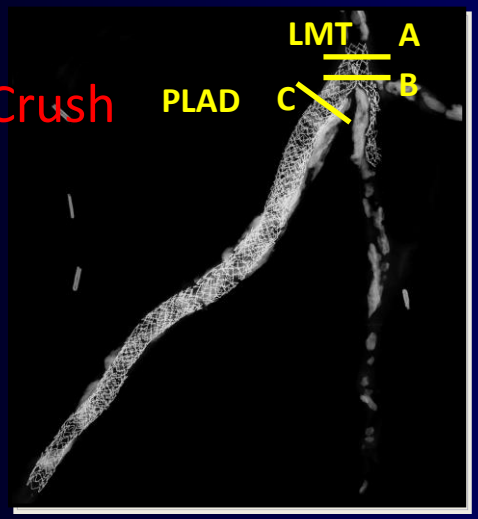
60-yrs-old M
Xience 1 year LMT to RI
PLC 3 year Vision and Cypher
Overlapped

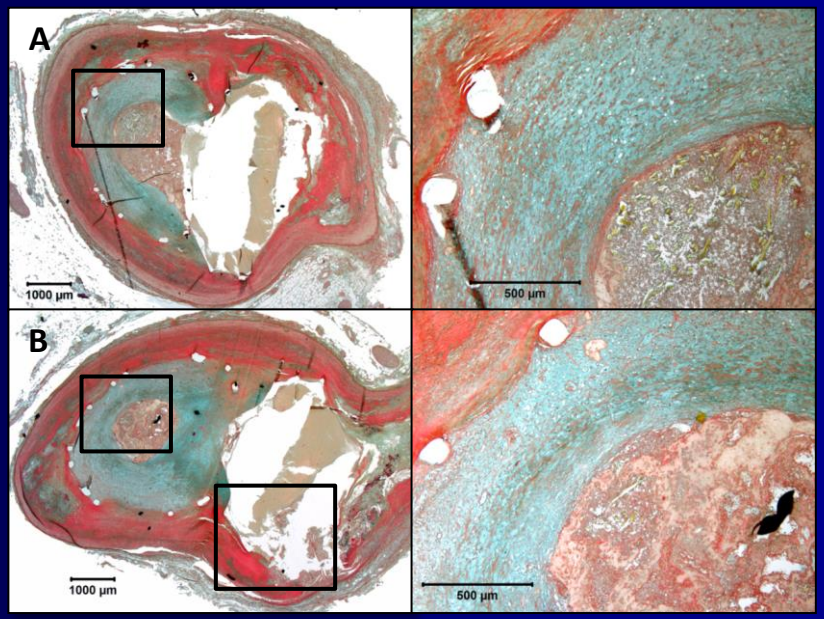


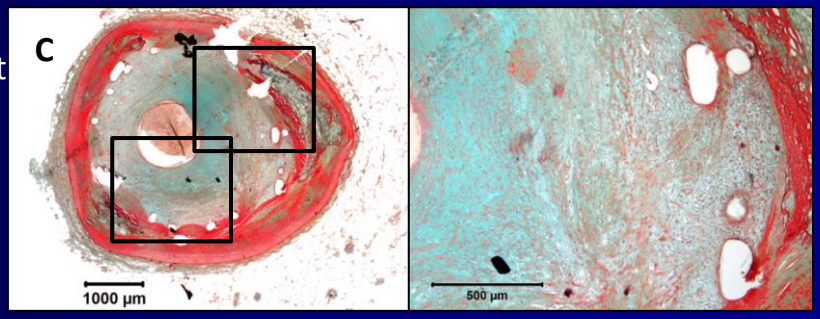
# Restenosis in distal main vessel

Xience LMT-RI 5 days
Xience LAD 1.5 years

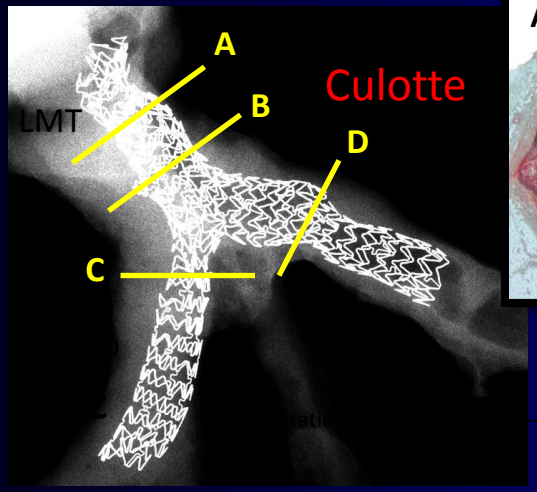


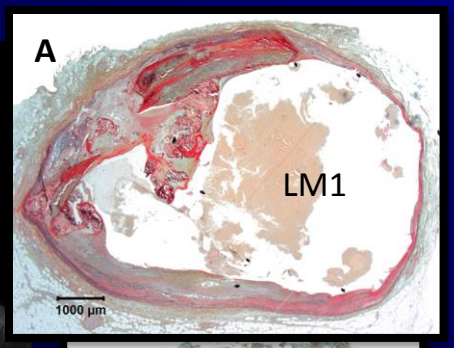



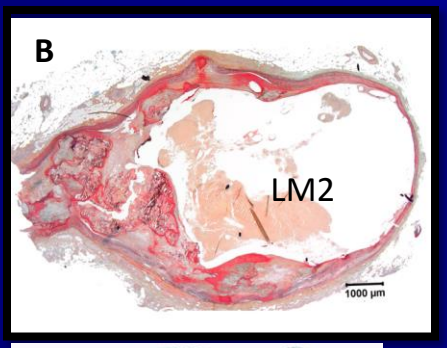

76-yrs old M, with HT, CABGx3 3 months ago with continuous CP, 5 days prior to death had stent procedure and had witnessed arrest

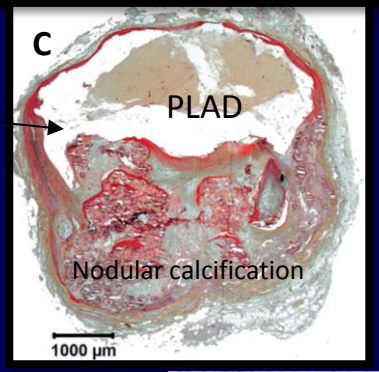


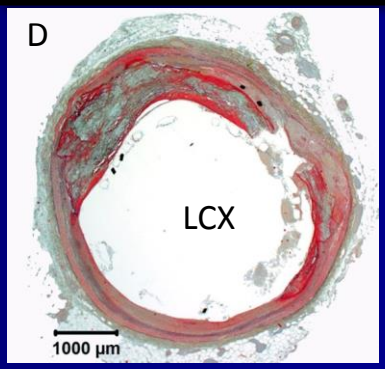
# Stent thrombosis related to Uncovered struts



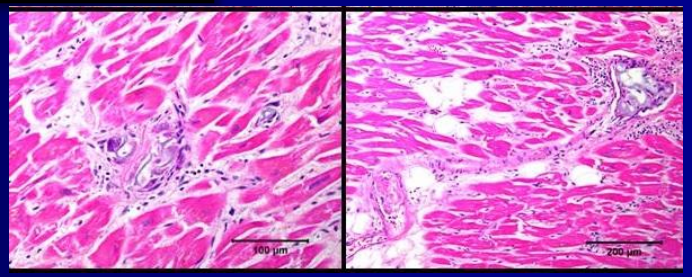



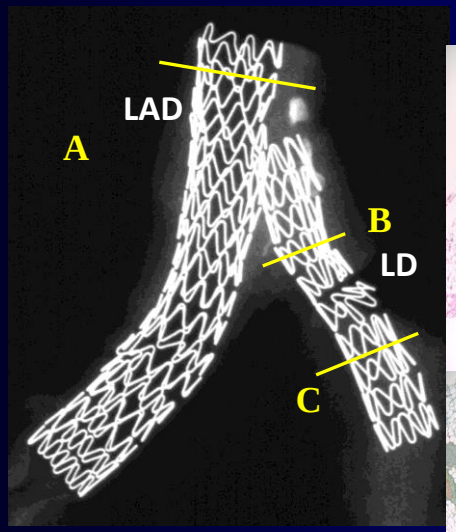

LMT-LCX Xience 18 days
LMT-LAD Xience 18 days

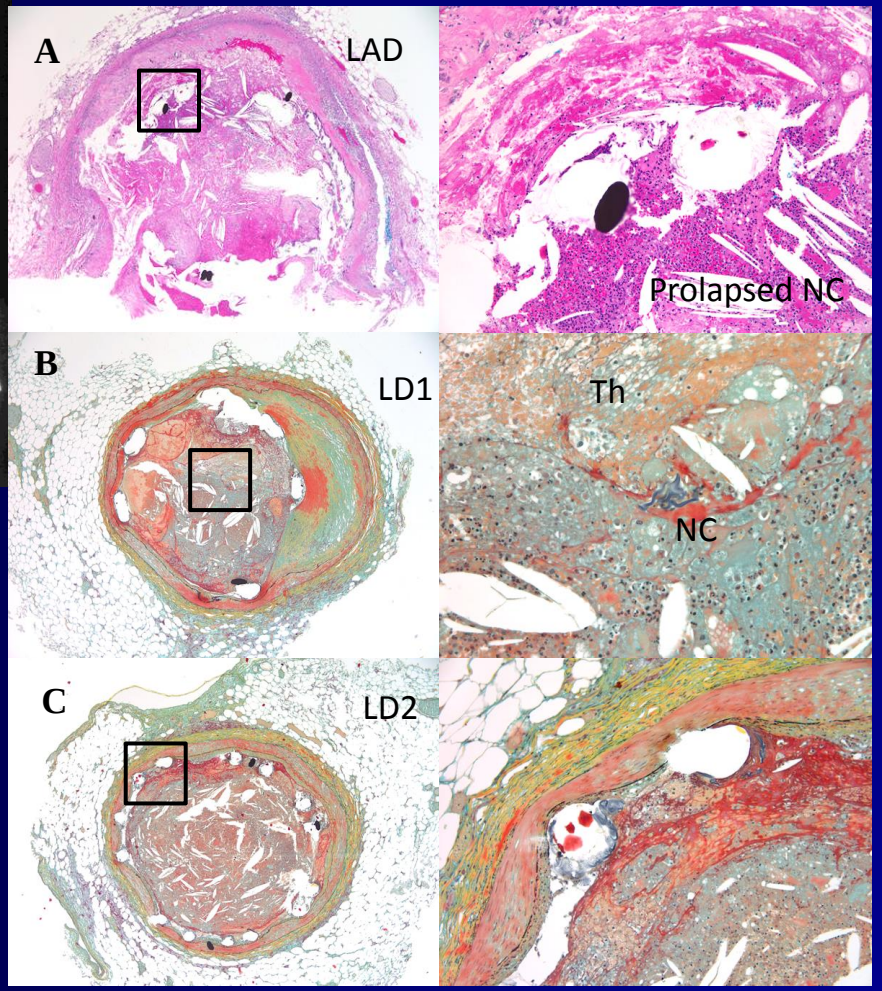
73-yrs-old obese F, SLE with renal involvement, CRF, steroid myopathy, dyslipidemia, CAD and Paraoxysmal Afib, admitted with NSEMI 17 days before death, stents in LM, LAD and LCX, died from multiorgan failure.



Atherectomy debris, in myocardium

# Stent Thrombosis Related to Protrusion of Necrotic Core



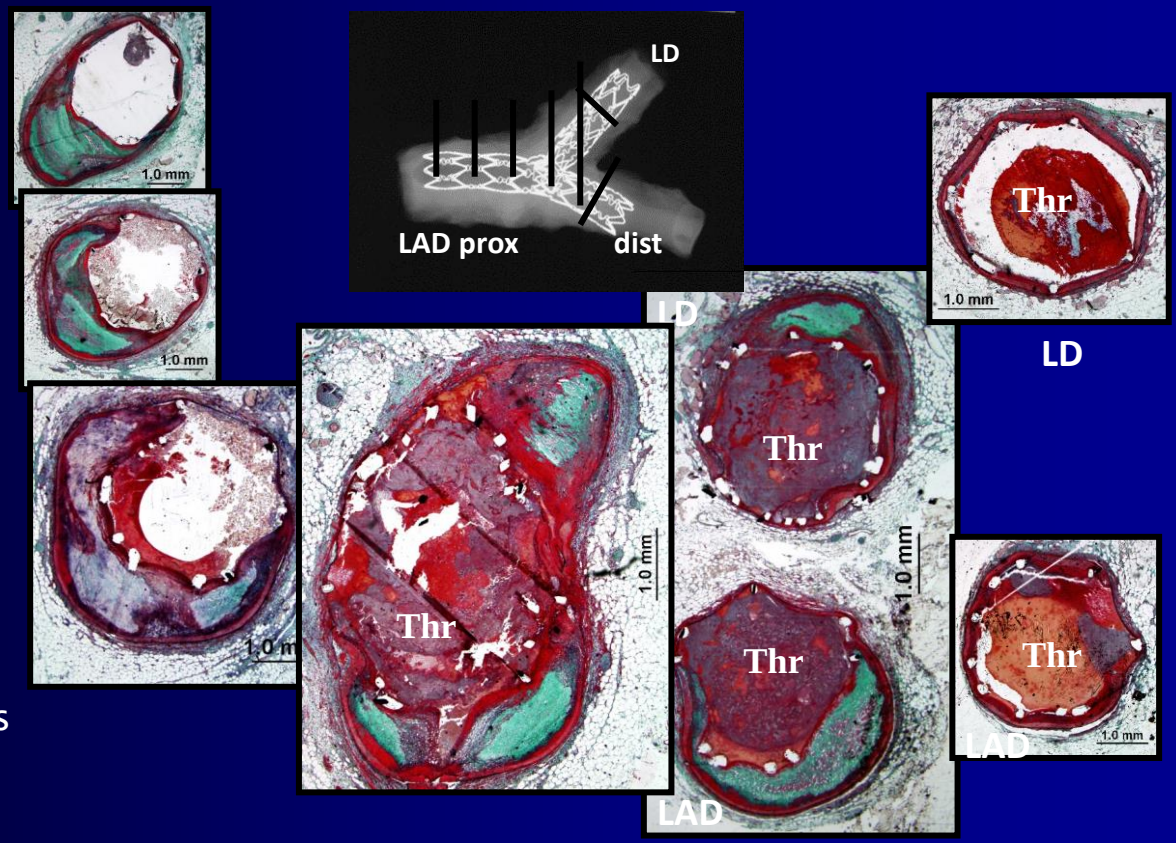




**Endeavor LAD and LD**
**4 days prior to death**
**Etiology for stenting was AMI**

66-yrs-old-WM, presented with CP(NSTEMI), implanted two stents LAD , died 4 days later at home.

# COMPLICATIONS OF PCI IN BIFURCATIONS

## SUBACUTE THROMBOSIS



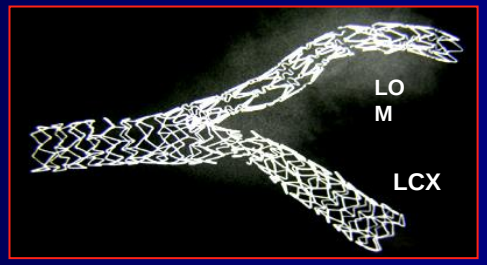

37 years old female, history of hyperlipidemia and smoking.

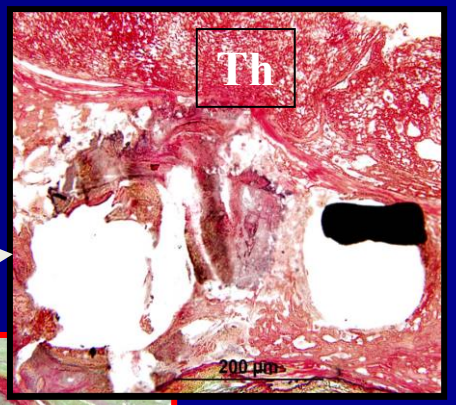
Stent implantation in LAD/LD was performed for CAD.

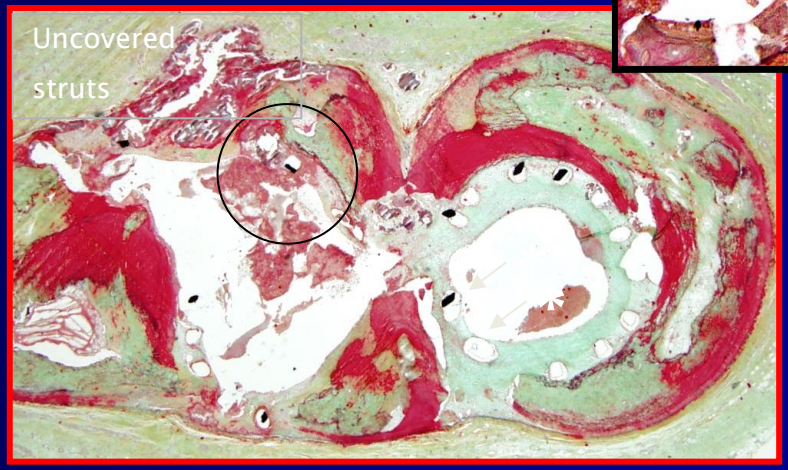
7days after the procedure, she died suddenly.

# COMPLICATIONS OF PCI IN BIFURCATIONS

## LATE STENT THROMBOSIS




68 Female. End-stage renal disease on hemodialysis

Jan. 05: PCI of LCX /LOM followed by DES.

<u>Oct. 05:</u> Presented with non-ST elevation MI (9-months)

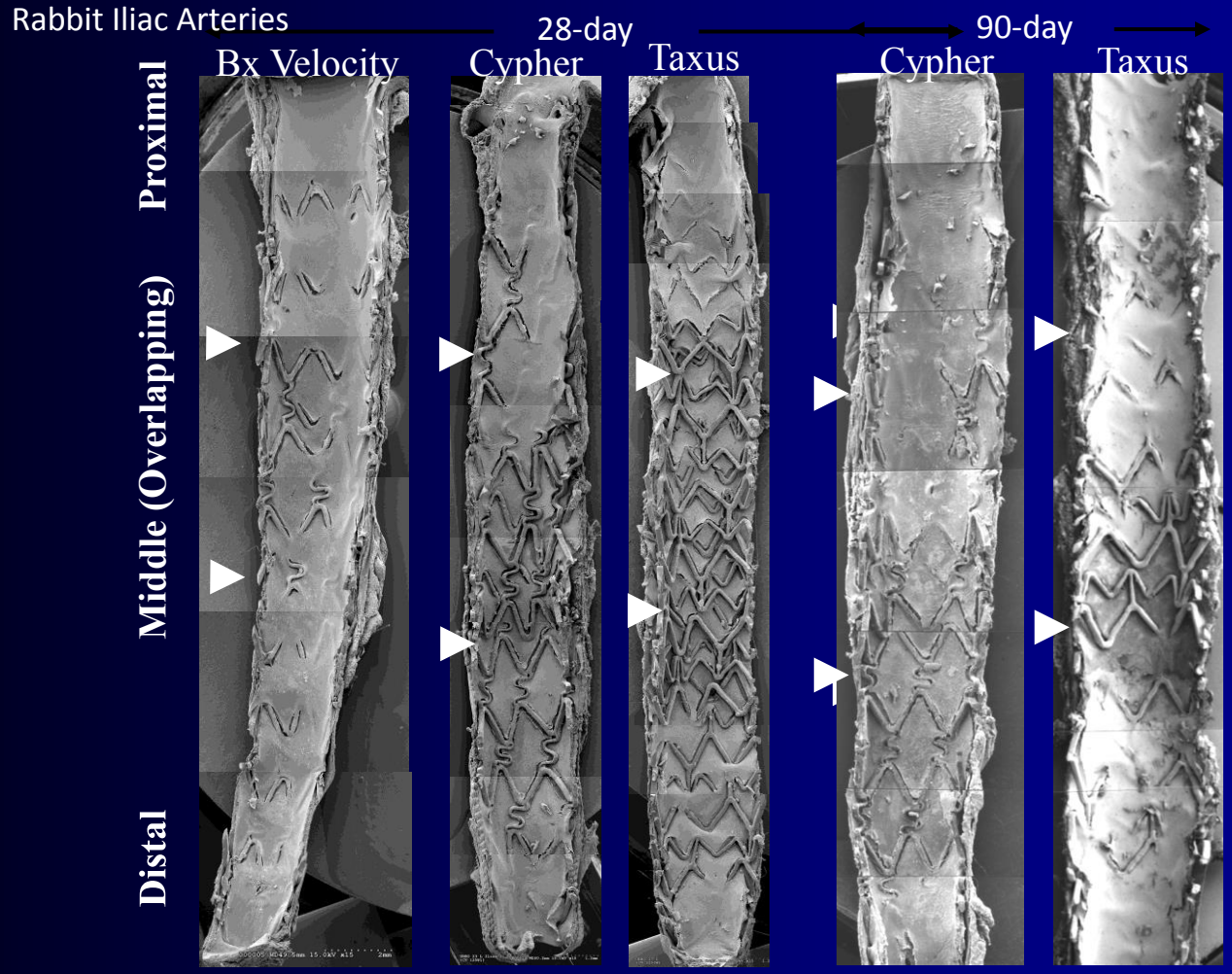
Angiography showed severe narrowing of LCX. The LCX was opened with balloon angioplasty. But the patient died shortly thereafter.

* Thin neointima

# Culotte/Crush stent techniques shows overlapping stent configuration in the main vessel

Therefore, overlapping stent site more likely to show delayed healing and greater neointimal thickness

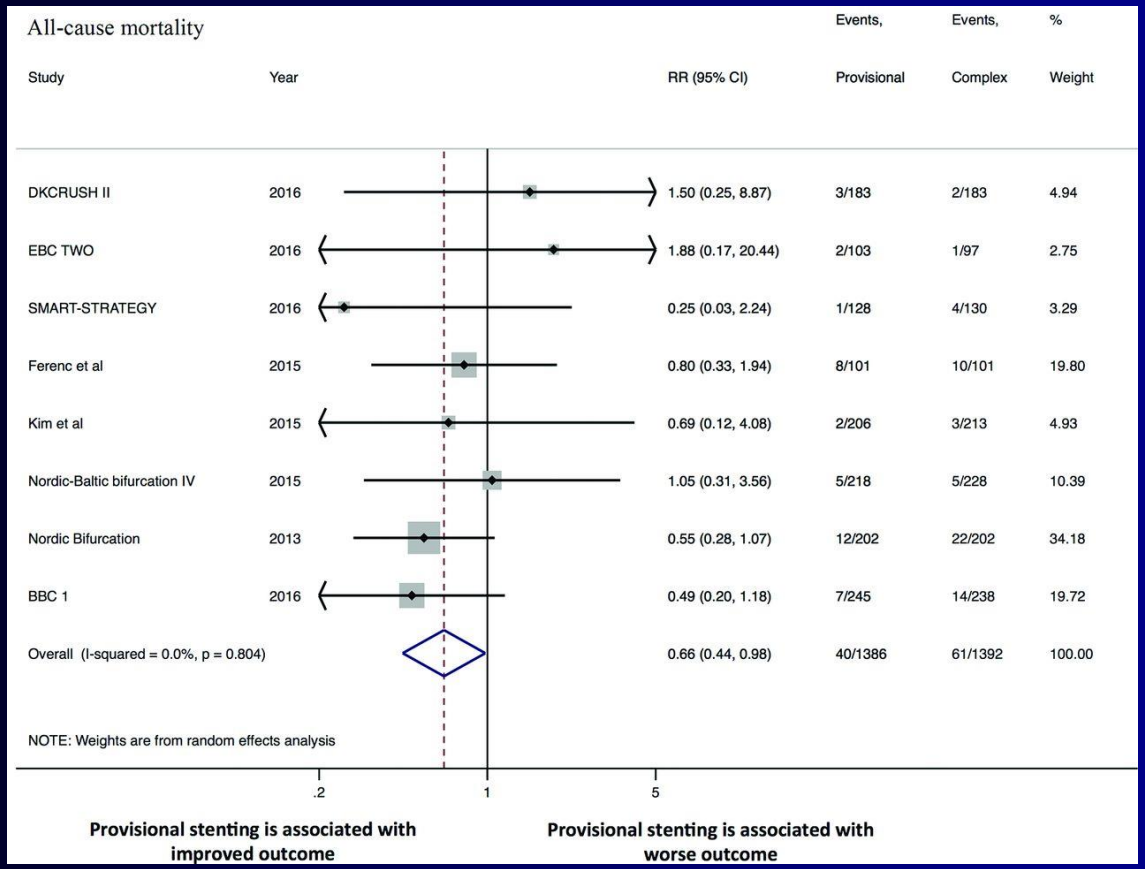
# Delayed healing at sites of overlapping stents




Sakamoto et al. Expert Rev Med Devices. 2018 Sep;15(9):665-682.

# BIFURCATION TREATMENT STRATEGIES

**Provisional vs. Two-stent technique**



# Conclusion

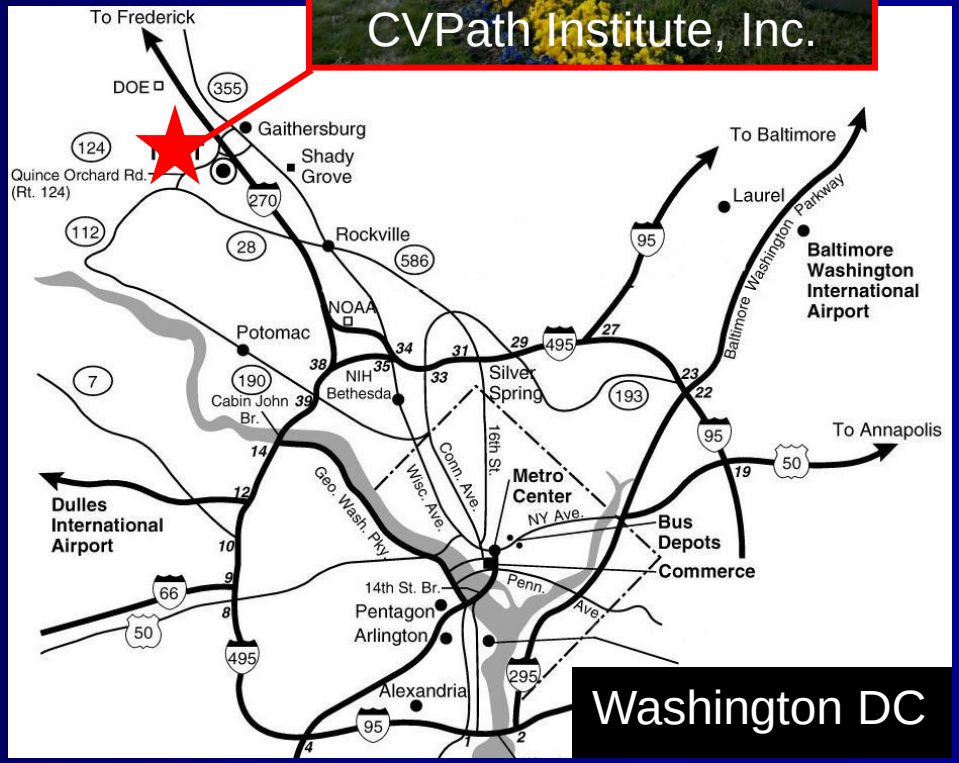
- The development of atherosclerotic plaques in bifurcations is closely related to shear stress
- Plaque burden is higher in low shear areas
- PCI in bifurcation lesions is associated with a higher complication rate as compared to non-bifurcated lesions
- Stent implantation may change the vessel geometry and thus alter the shear stress
- Rigid stents might straighten the artery leading to an expansion of low shear areas which might contribute to restenosis
- On the other hand, flow disturbance is the primary cause of delayed arterial healing in bifurcation lesions following DES implantation
- Refinements in stent geometry might overcome these issues

# Acknowledgments


## CVPath Institute

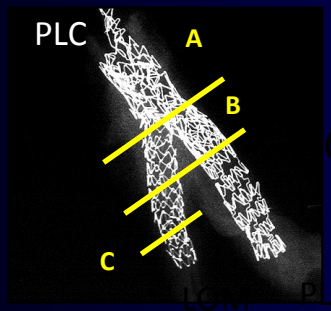
Hiroyuki Jinnouchi, MD
Atsushi Sakamoto, MD
Sho Torii, MD
Yu Sato, MD
Anne Cornelissen, MD
Salome Kuntz, MD
Qi Cheng, MD
Maria Romero, MD
Robert Kutz, MS
Abebe Atiso, HT
Jinky Beyer
Lila Adams, HT
Frank D Kolodgie, PhD
Aloke V. Finn, MD



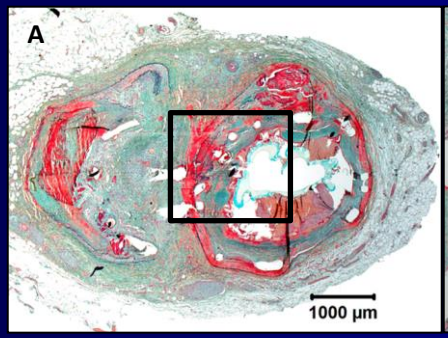


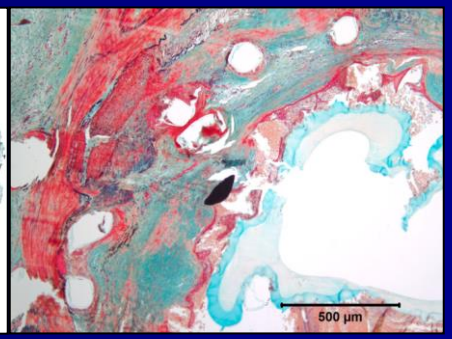
# CTO in a side branch

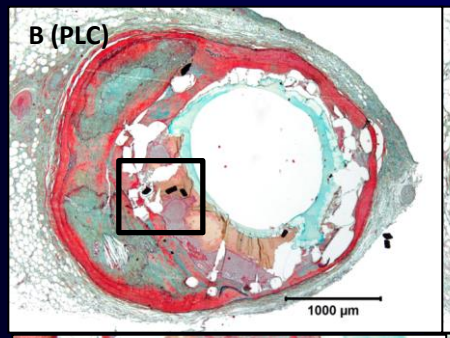
71—yrs old M with HT, remote CABG: CP, Inf MI
Xience PLC 5 days
Promus LOM 1 years

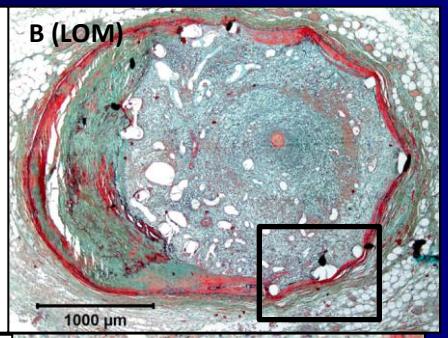


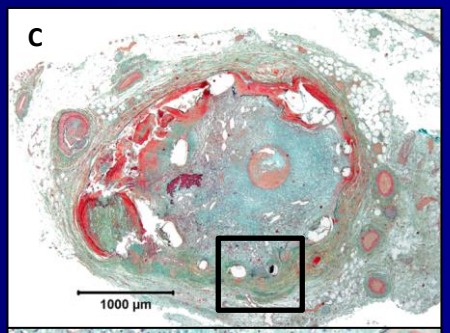

Culotte

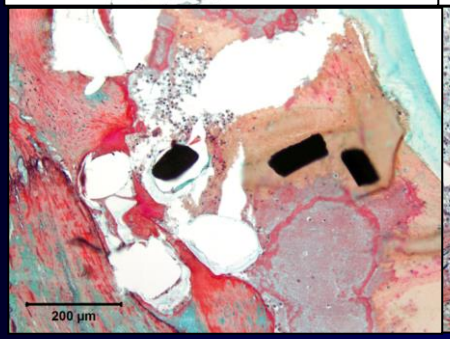


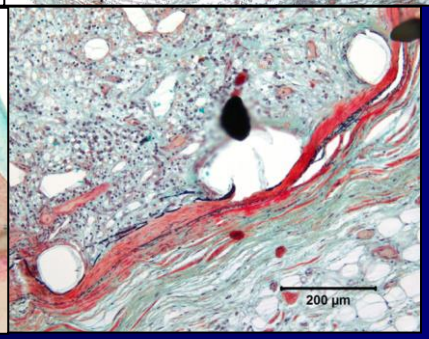



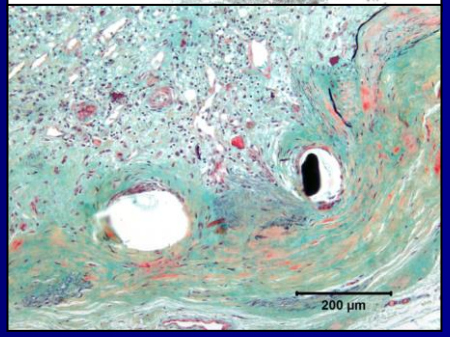



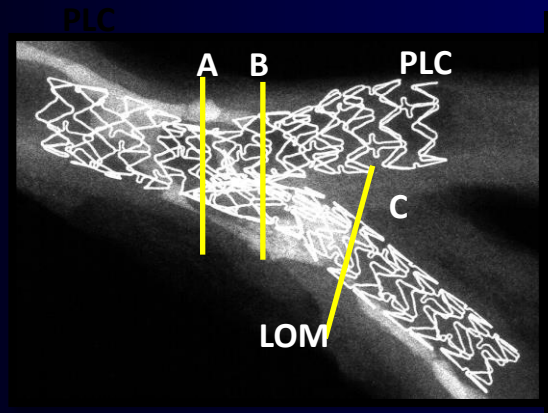



# Stent thrombosis related to Malapposition




Crush

PLC-F

PLC Xience 1 days

LOM Xience 1 days

73-yrs-old M, CAD post LAD stenting 8-yrs prior to presenting with atypical chest pain, died 1 day post stenting of PLC/LOM.