

PCI Techniques

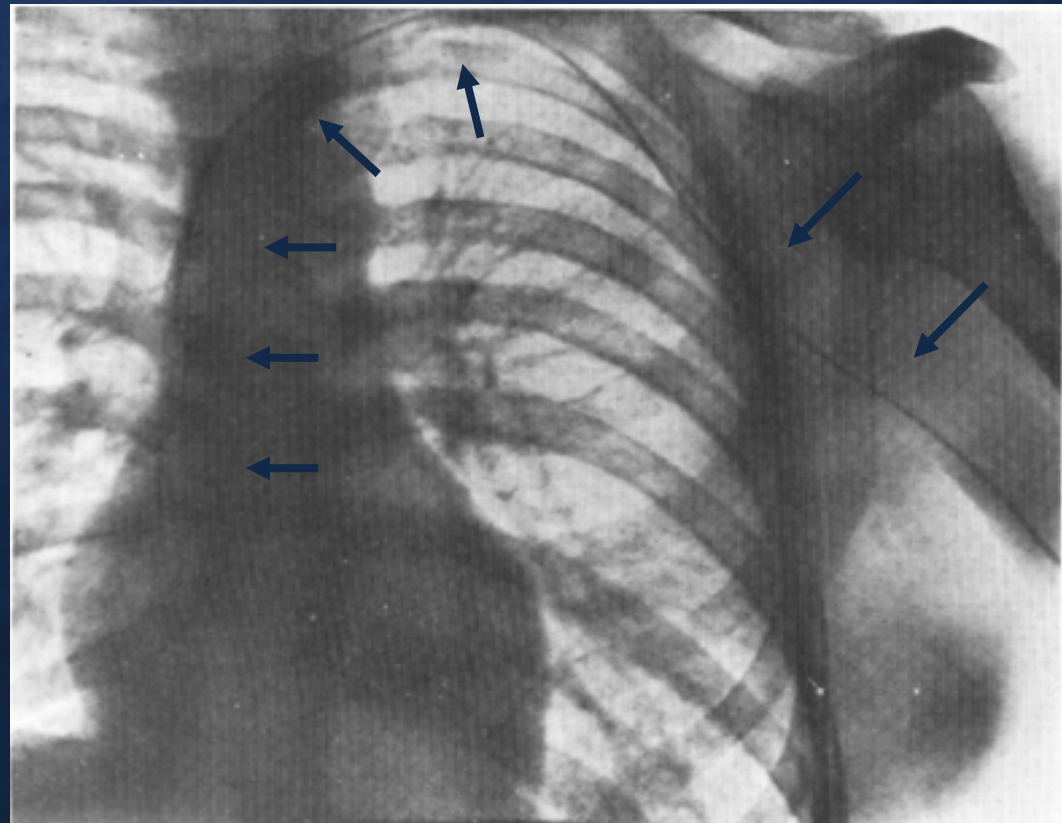
From Balloon to DES

Hyeon-Cheol Gwon

Sungkyunkwan University School of Medicine
Cardiac and Vascular Center, Samsung Medical Center

First Human Catheterization

- 1929 Werner Forssmann



First Coronary Angiography

- 1958 Mason Sones
 - Sone technique: brachial artery cut-down for CAG



First Human Coronary Angioplasty

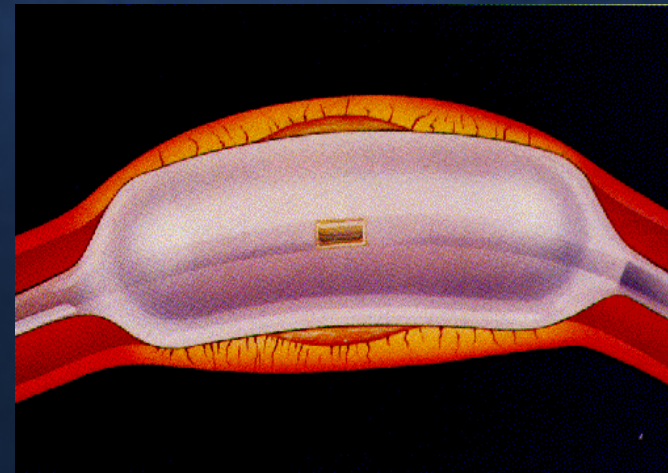
- 1977 Andreas Roland Gruentzig
 - First human coronary balloon angioplasty



Restenosis

The Beginning of Long Journey

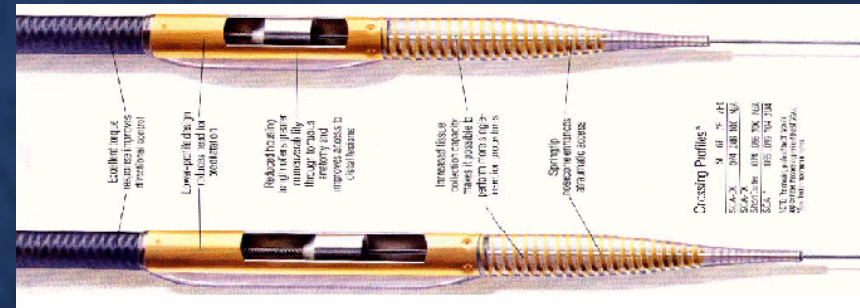
- Restenosis rate of balloon angioplasty
 - Simple lesion 30%
 - Complex lesion 40%
- Mechanism of restenosis
 - Acute recoil
 - Negative remodeling
 - Neo-intimal proliferation



→ **New devices: Atherectomy, Stent, Drug delivery**

Atherectomy Devices

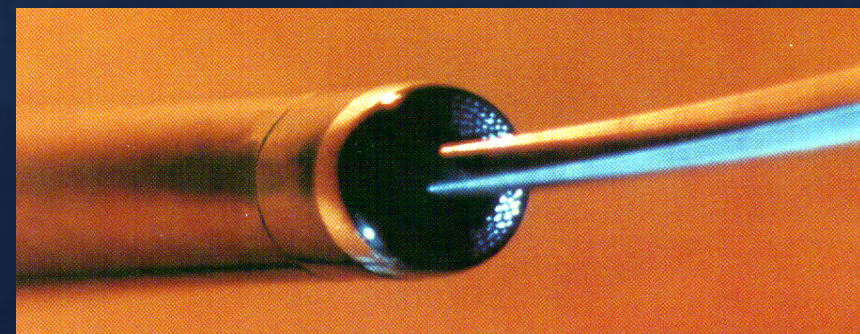
Directional coronary
atherectomy (DCA)



Rotational atherectomy



Excimer laser coronary
angioplasty (ELCA)



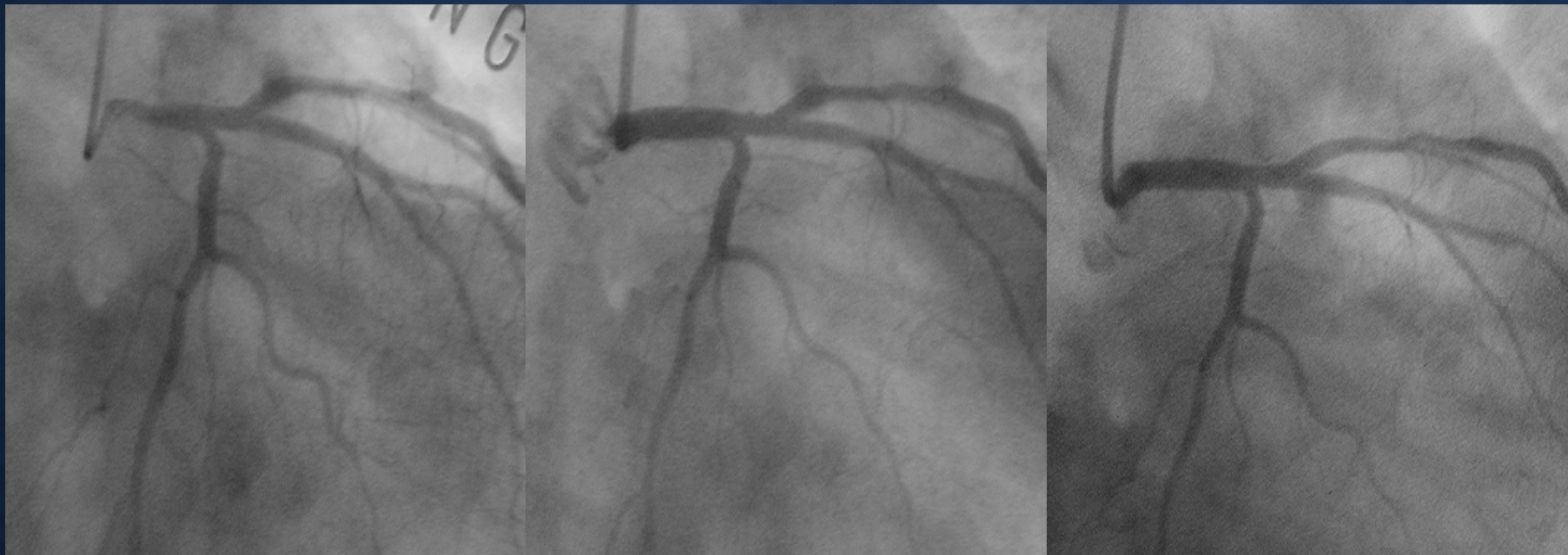
Directional Atherectomy

- Balloon versus Optimal Atherectomy Trial (BOAT)
 - Aggressive debulking with IVUS guidance

	PTCA	DCA
Residual stenosis (%)	18	15
Success rate (%)	87	93*
Inhospital death, MI, CABG (%)	2.8	3.3
Inhospital NonQMI / QMI(%)	2.8	3.3
6 mo restenosis rate (%)	40	32*
6 mo TLR (%)	18	15

DCA for Left Main DES ISR

M/55 Stable angina

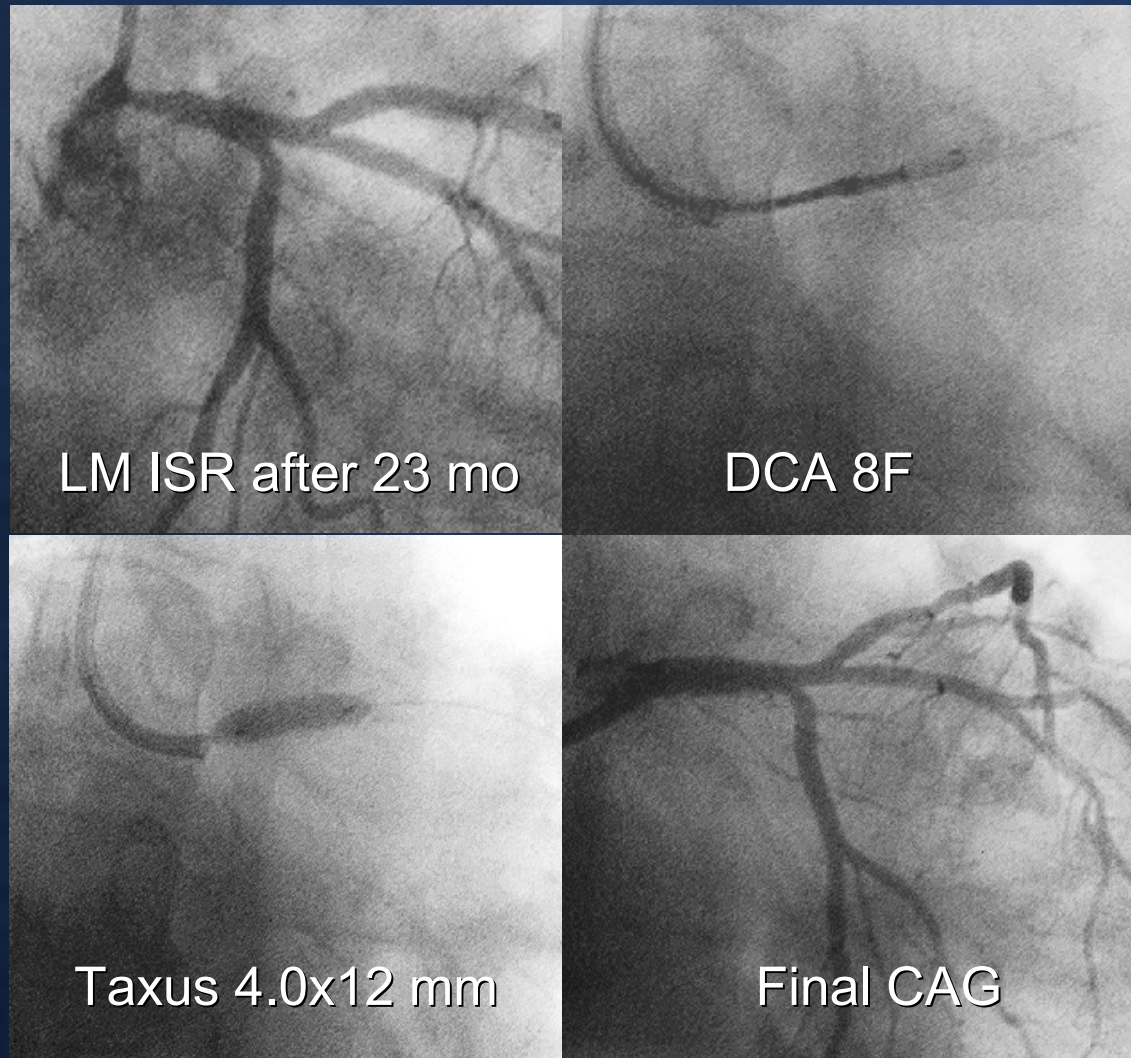


Baseline CAG

Post PCI
Cypher 3.5x18 mm

9-mo FU CAG

DCA for Left Main DES ISR



Advent of Stent Era

Stent Thrombosis

1991 First report of stent in human

Subacute thrombosis = 24 %

→ Aggressive systemic anticoagulation

Subacute thrombosis = 5 - 20 %

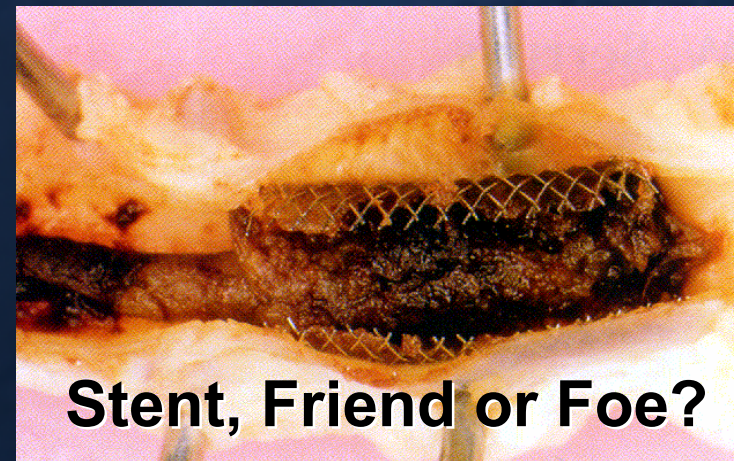
Bleeding complication > 15 %

→ Improvement to < 2%

New stent design

High pressure expansion

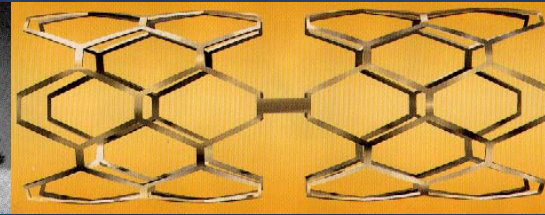
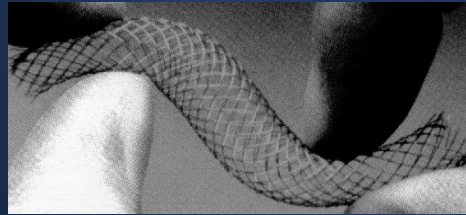
Dual antiplatelet



Stent, Friend or Foe?

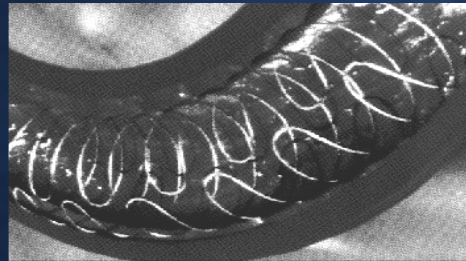
Bare Metal Stent

Wallstent



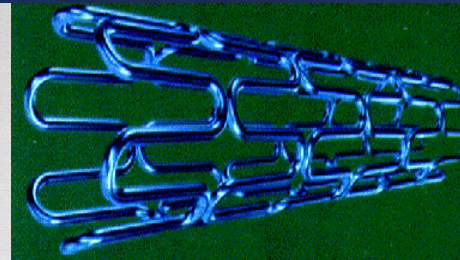
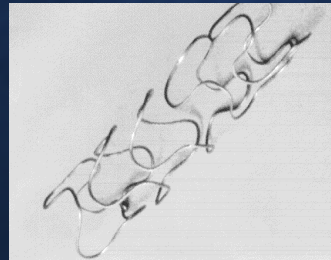
JJ stent

**Gianturco
- Roubin**



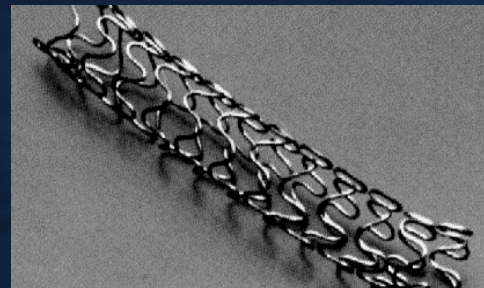
Multilink

Wiktor



Micro GFX

Cordis

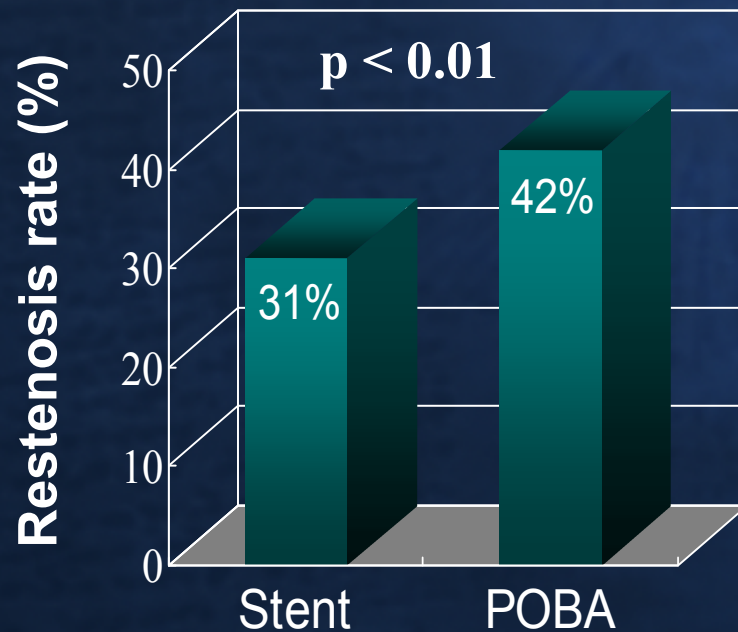


NIR

After all, I am your friend.

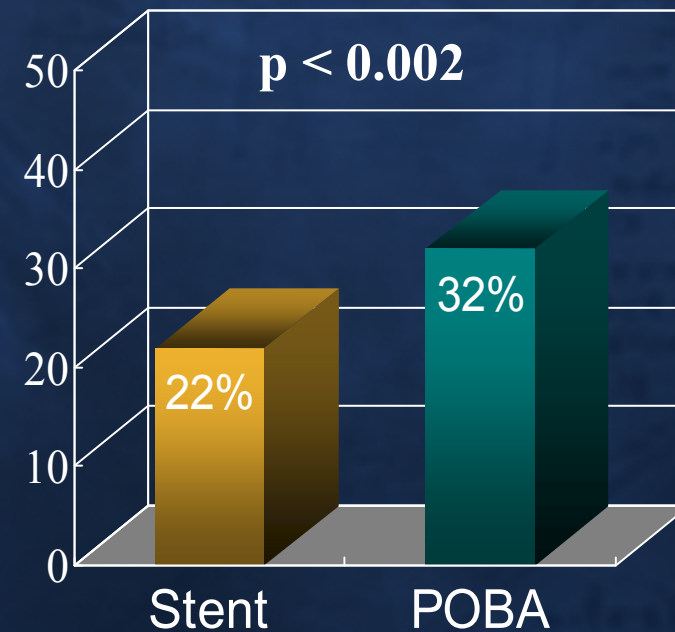
STRESS

Fischman NEJM 1994



BENESTENT

Serruys P NEJM 1993

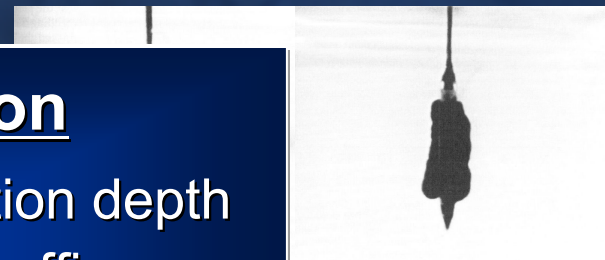


Stable or unstable angina, > 3.0 mm

Local Drug Delivery

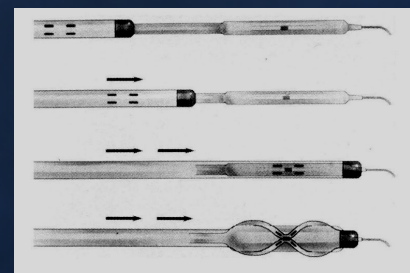
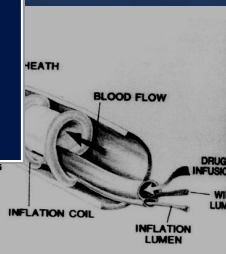
Right concept, Wrong technique

- Local drug delivery catheter
 - Double balloon
 - Micro-porous balloon
 - Hydrogel
 - Dispatch
 - InfusaSite
- List of tested drugs
 - Antiplatelet
 - Antithrombin
 - Thrombolytic
 - Calcium blocking agent
 - Steroid
 - Antiproliferative agents
 - Growth factor inhibitor
 - Antisense oligonucleotide



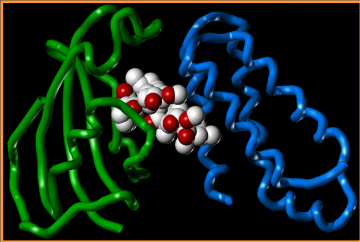
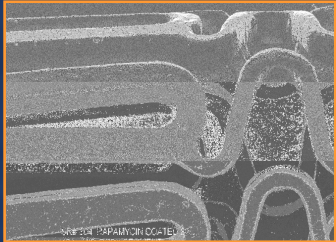
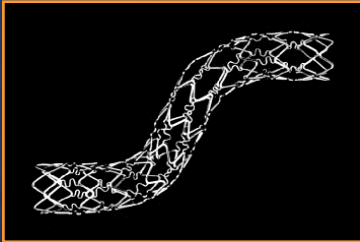
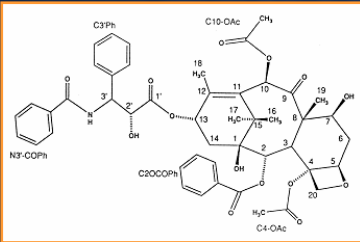
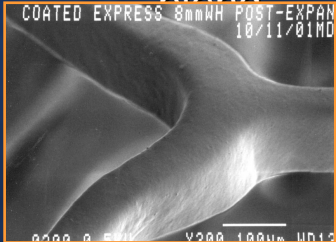
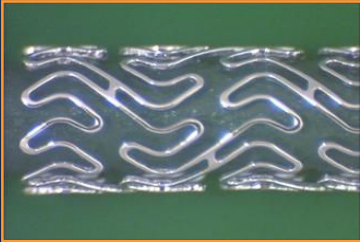
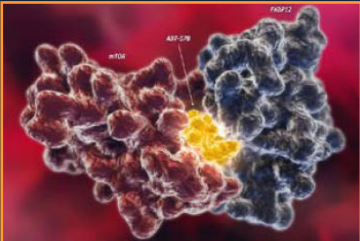
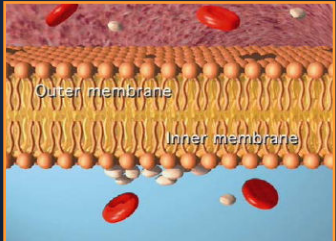

Limitation

Shallow penetration depth
Low delivery efficacy
Short intramural retention



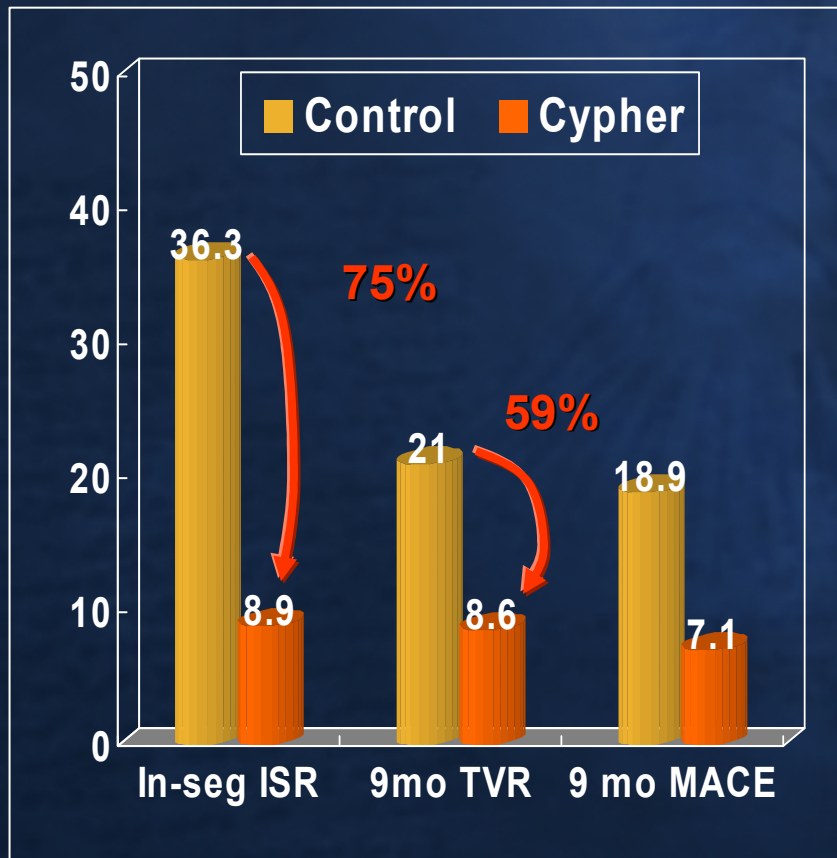
Drug-Eluting Stent

Local drug delivery: Dream comes true

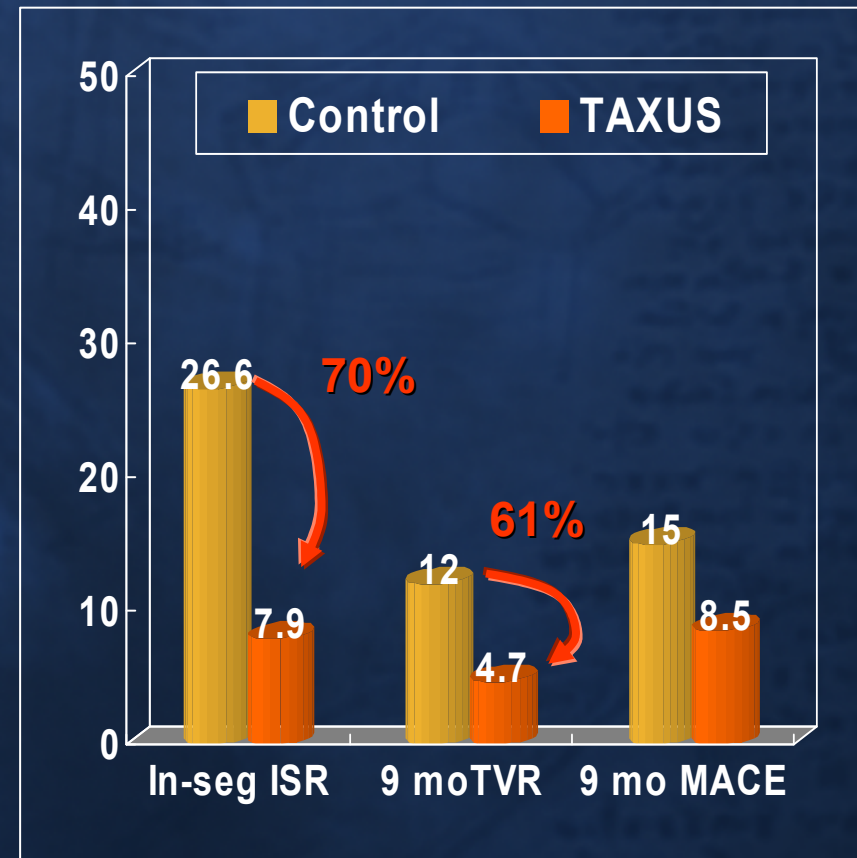
	Drug	Polymer	Stent
Cypher			
	Sirolimus	PEVA + PBMA	BX Velocity
TAXUS			
	Paclitaxel	Polyolefin derivative	Liberté
Endeavor			
	Zotarolimus	Phosphorylcholine	Driver

SIRIUS and TAXUS IV

The end of restenosis



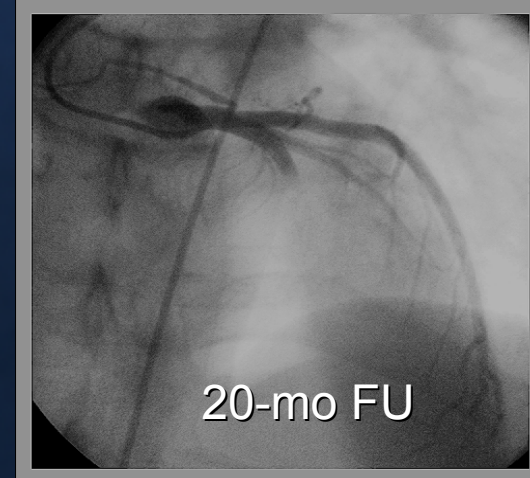
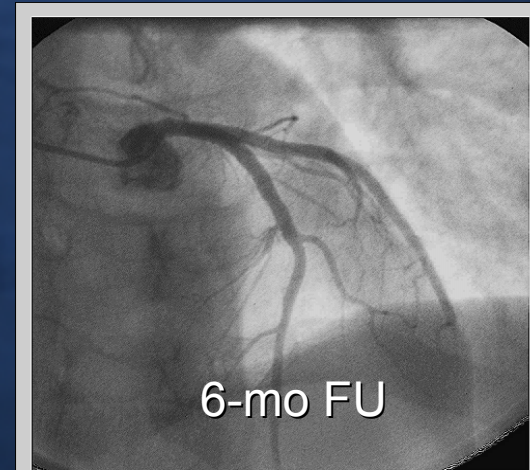
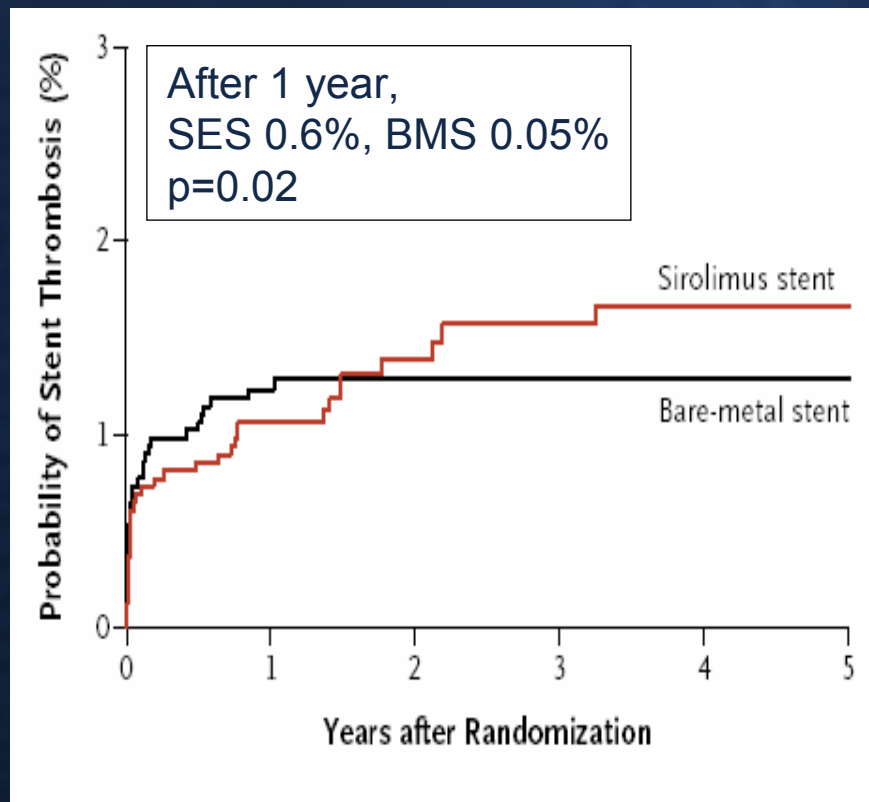
SIRIUS



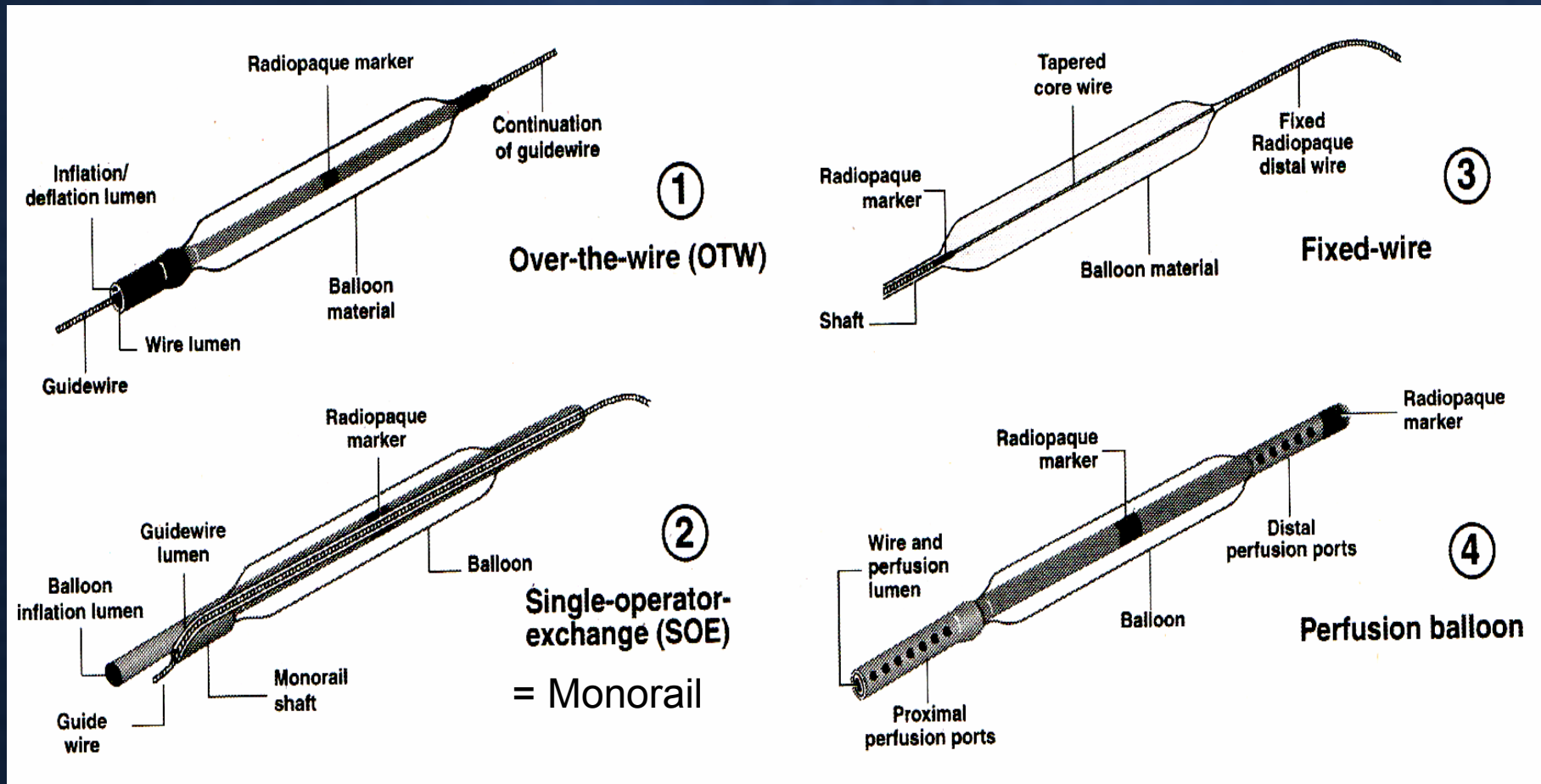
TAXUS IV

Drug-Eluting Stent

- Late stent thrombosis

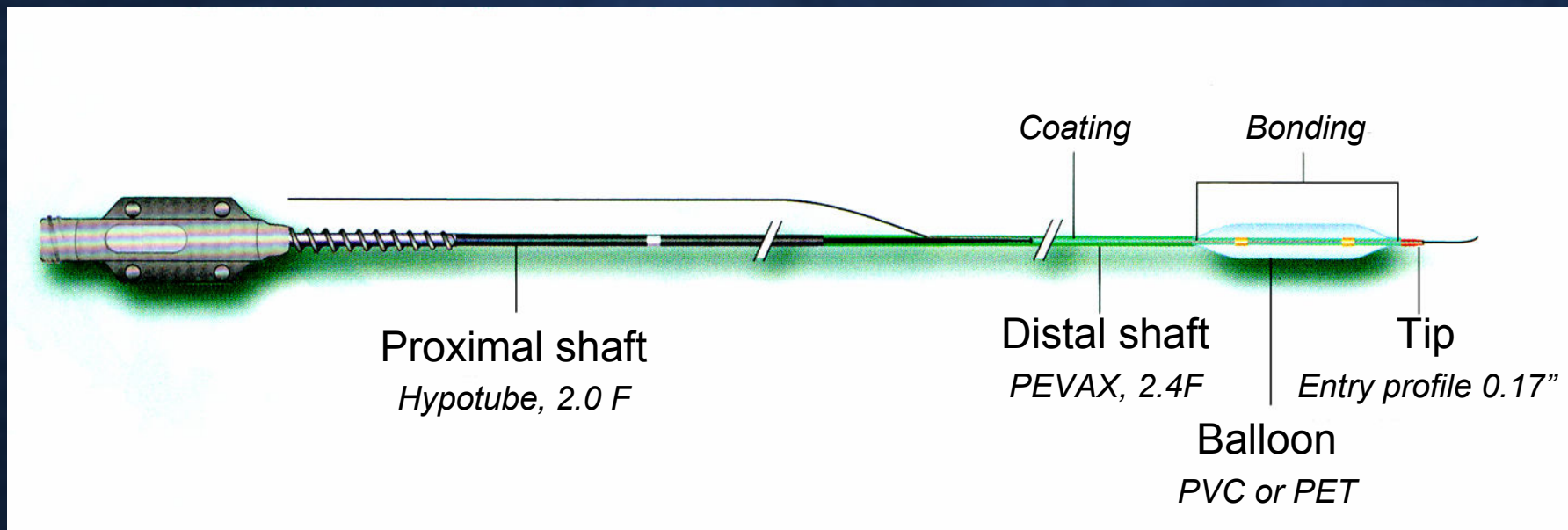


Type of Balloon

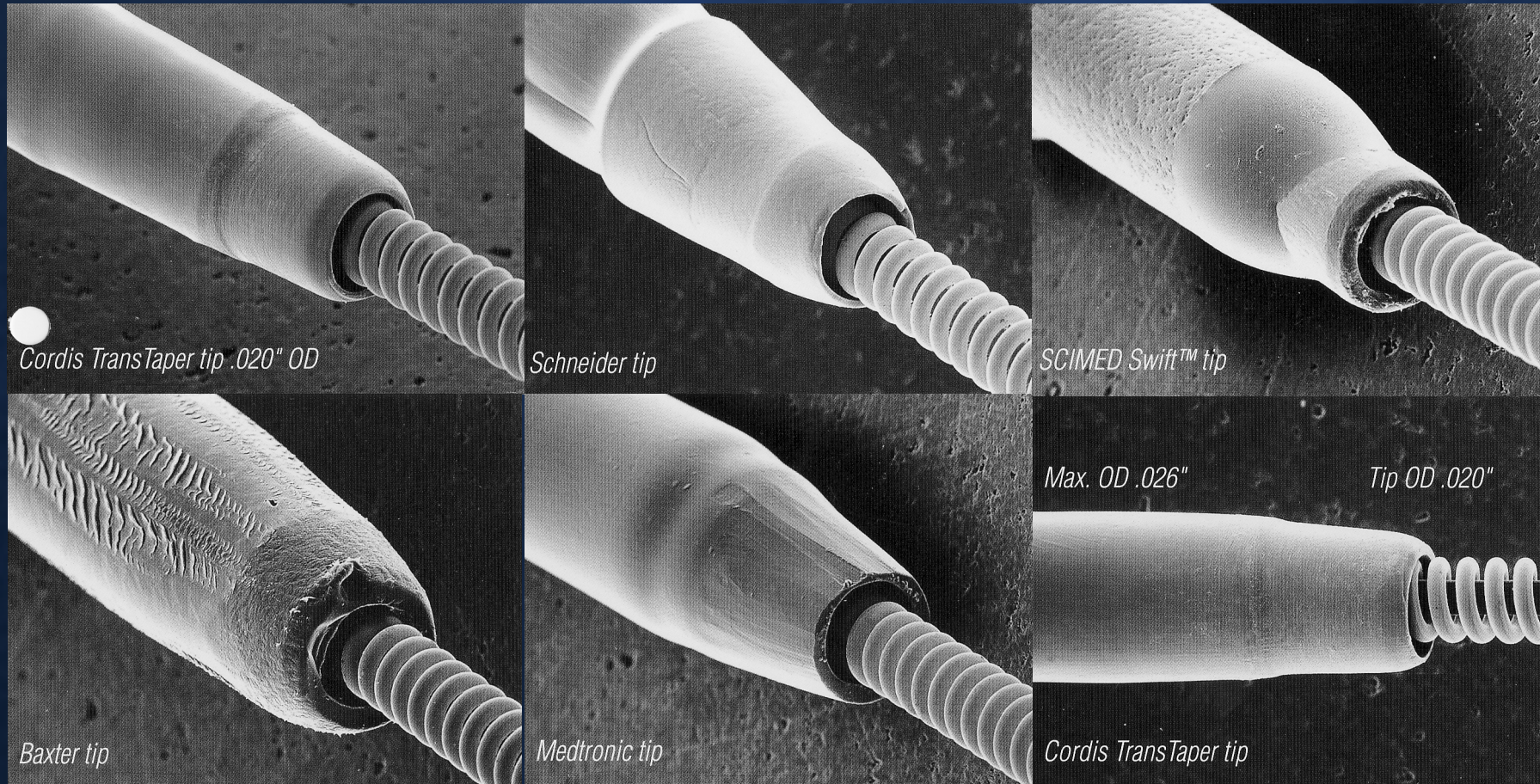


Structure of Balloon

- Proximal shaft – Distal shaft – Balloon – Tip
- Balloon profile
 - Lesion entry profile = tip profile
 - Crossing profile = balloon profile



Balloon Tip Profile



Characteristics of Balloon

- Compliance
 - Compliant
 - Semi-compliant
 - Non-compliant
- Pressure response
 - Nominal pressure
 - Rated burst pressure
 - Mean burst pressure
- Creep

MONORAIL systems $\updownarrow 3.0$ mm $\leftarrow 12$ mm

ATM - kPa PRESSURE	3.0 mm Balloon
3.0 - 304	2.68
4.0 - 405	2.71
5.0 - 507	2.75
6.0 - 608	2.79
7.0 - 709	2.82
8.0 - 811	2.86
9.0 - 912	2.89
10.0 - 1013	2.93
11.0 - 1115	2.96
12.0 - 1216	NOMINAL 3.00
13.0 - 1317	3.01
14.0 - 1419	3.03
15.0 - 1520	3.05
16.0 - 1621	3.07
17.0 - 1723	3.08
18.0 - 1824	3.10*
19.0 - 1925	3.12
20.0 - 2026	3.14**
21.0 - 2128	3.15
22.0 - 2229	3.18

PTCA Dilatation Catheter
PTCA-dilatationskateter; PTCA-dilatatiekatheter;
Cathéter de dilatation pour PTCA;
PTCA-Dilatationskatheter; Καθετήρας Διεύρυνσης
PTCA; Catetere dilatatore per PTCA;
Catéter de dilatación PTCA; Cateter de Dilatação
para PTCA; PTCA dilatationskateter;
PTCA拡張カテーテル

3.0 mm **20** mm

IP(atm)
Inflation Pressure
拡張圧

4	2.65
5	2.75
6	2.87
7	2.94
8	Nominal 3.00
9	3.06
10	3.10
11	3.15
12	3.18
13	3.23
14	Rated 3.27
15	3.32
16	3.36
17	3.40
18	3.46

GCID 0.056" (1.42 mm)
Minimum Guide Catheter I.D.
小径ガイドカテーテル内径 (0.36 mm)

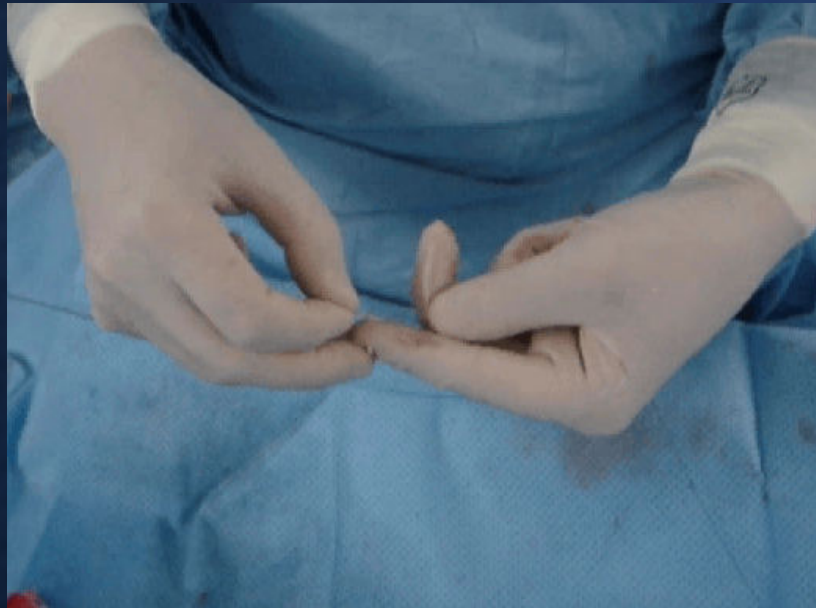
SPR3020X
LOT 0000408719
2009-01
BALLOON
Ballon Diameter:
バルーン径

Balloon Deliverability

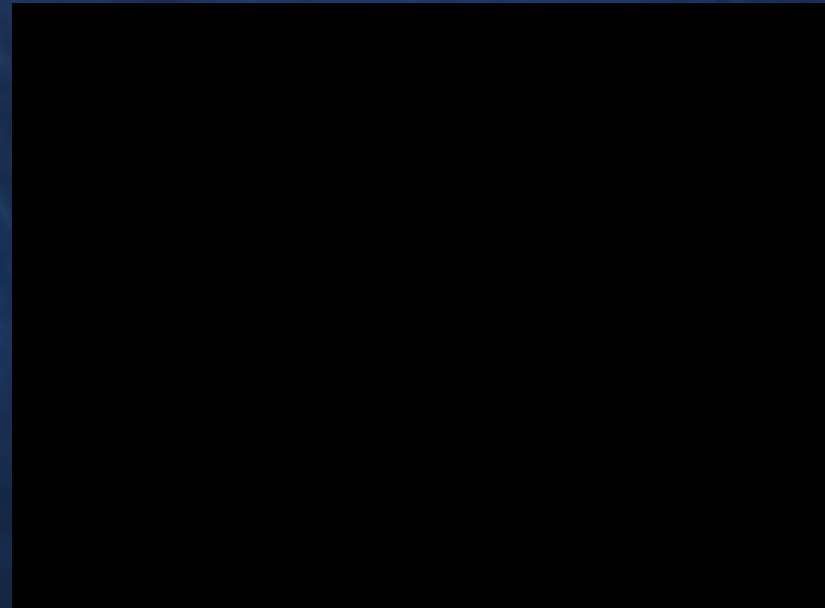
- Deliverability
 - Trackability – To the lesion
 - Crossibility – Through the lesion
- Factors for deliverability
 - Tip: tip profile, tip softness
 - Balloon profile
 - Coating
 - Transition from proximal to distal shaft
 - Stiffness of shaft

Balloon Techniques

- Insertion and removal of SOE balloon



Balloon insertion



Balloon removal

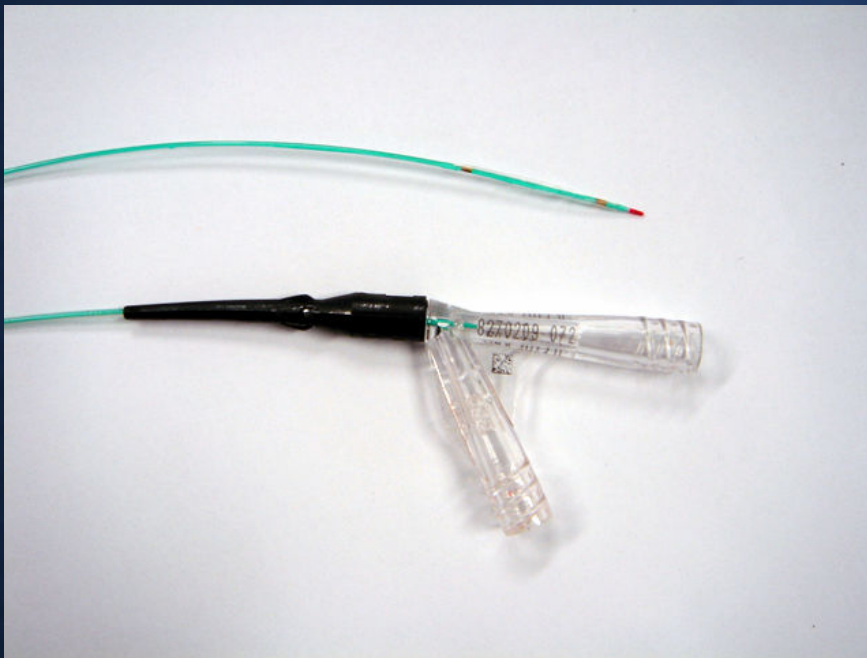
Balloon Techniques

- Assistant: holding the wire and balloon

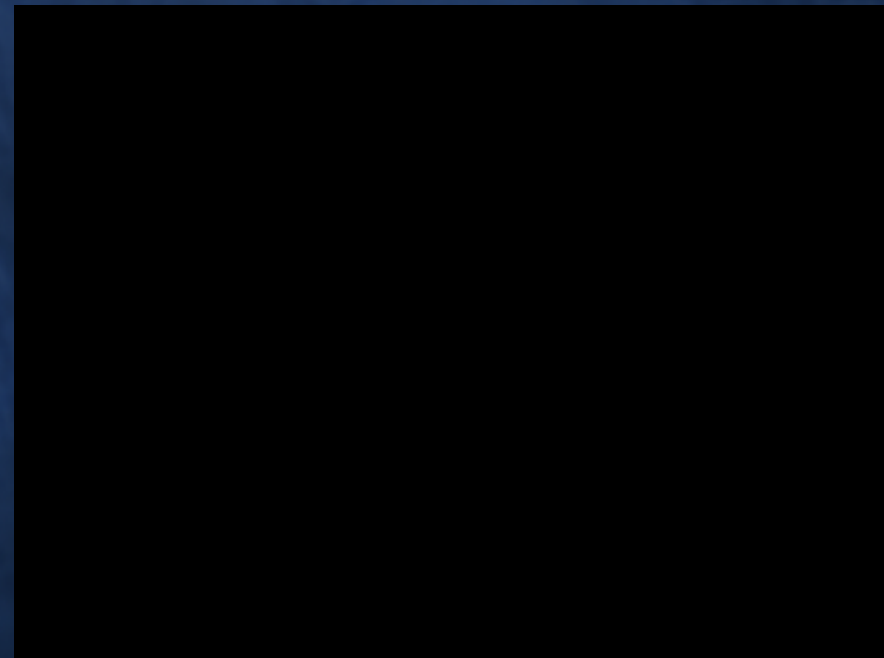


Balloon Techniques

- Insertion and removal of OTW balloon



Over-the-wire balloon



Nanto technique

When Difficult to Insert Balloon or Stent

1. Guiding catheter technique

- Stronger curve, larger caliber
- Alignment to the artery
- Deep throating technique

2. Guidewire technique

- Stiff guidewire
- Buddy wire technique

3. Balloon technique

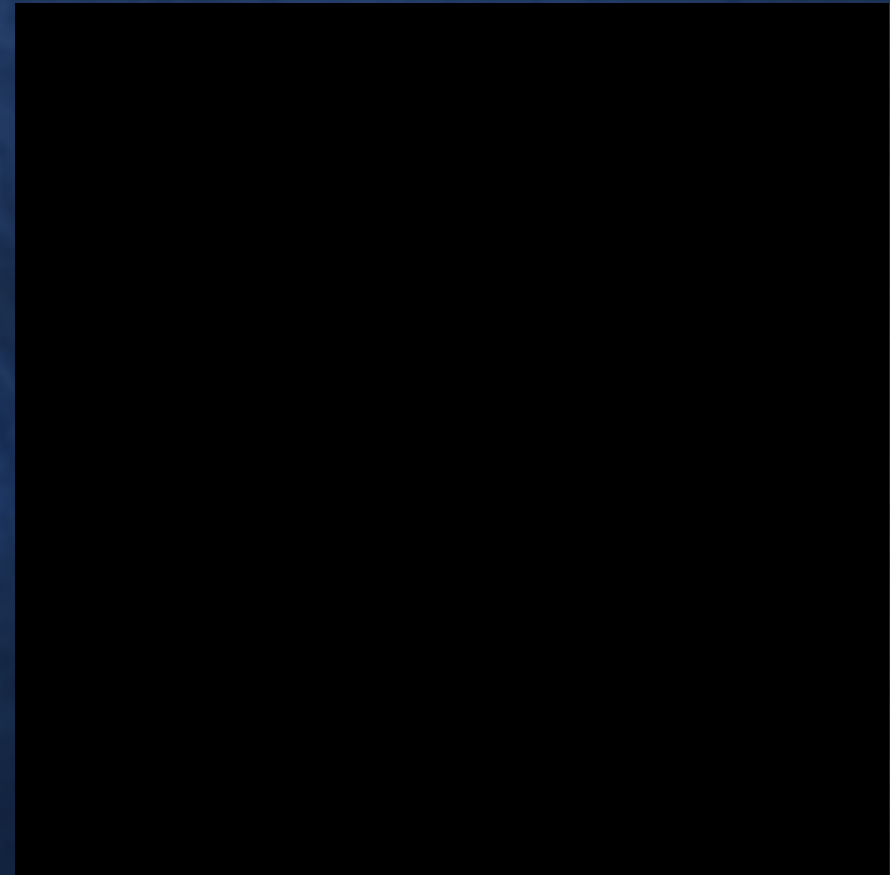
- Smaller balloon: 1.25 – 1.5 mm
- Buddy balloon technique
- Anchor balloon technique

How to Cannulate XB curve

1. Guiding catheter technique

LCA cannulation with
XB curve

Use hard-end of
0.0035" guidewire



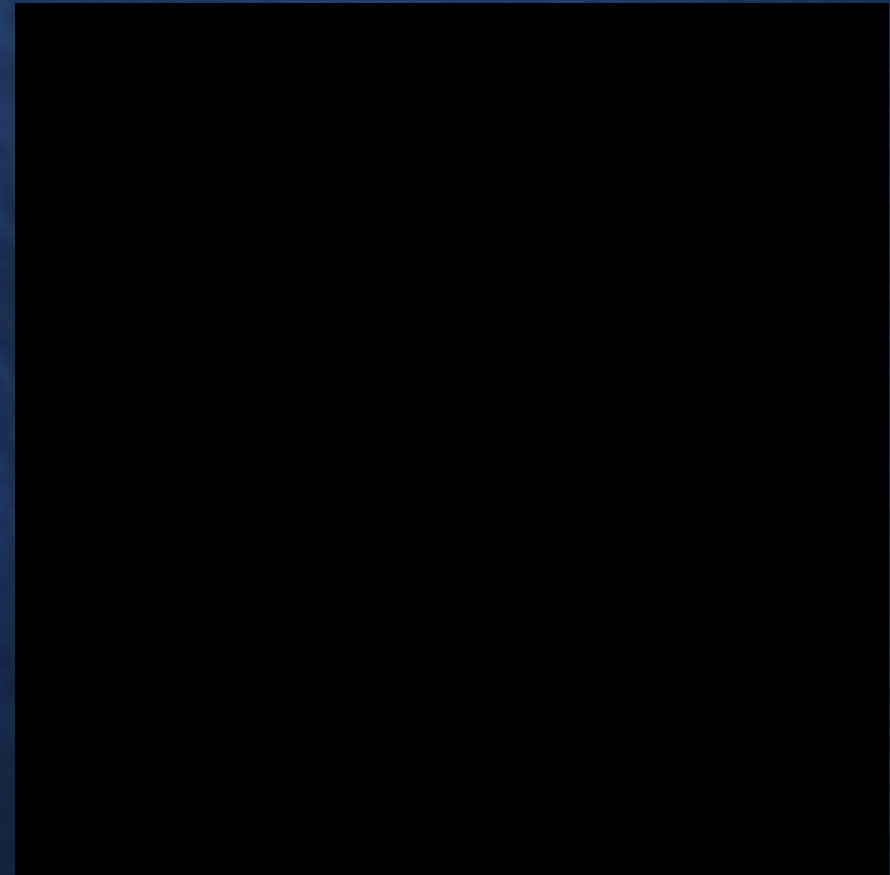
How to Cannulate XB curve

1. Guiding catheter technique

RCA cannulation with
XB curve

Step 1

Extend the curve
with hard-end of
wire

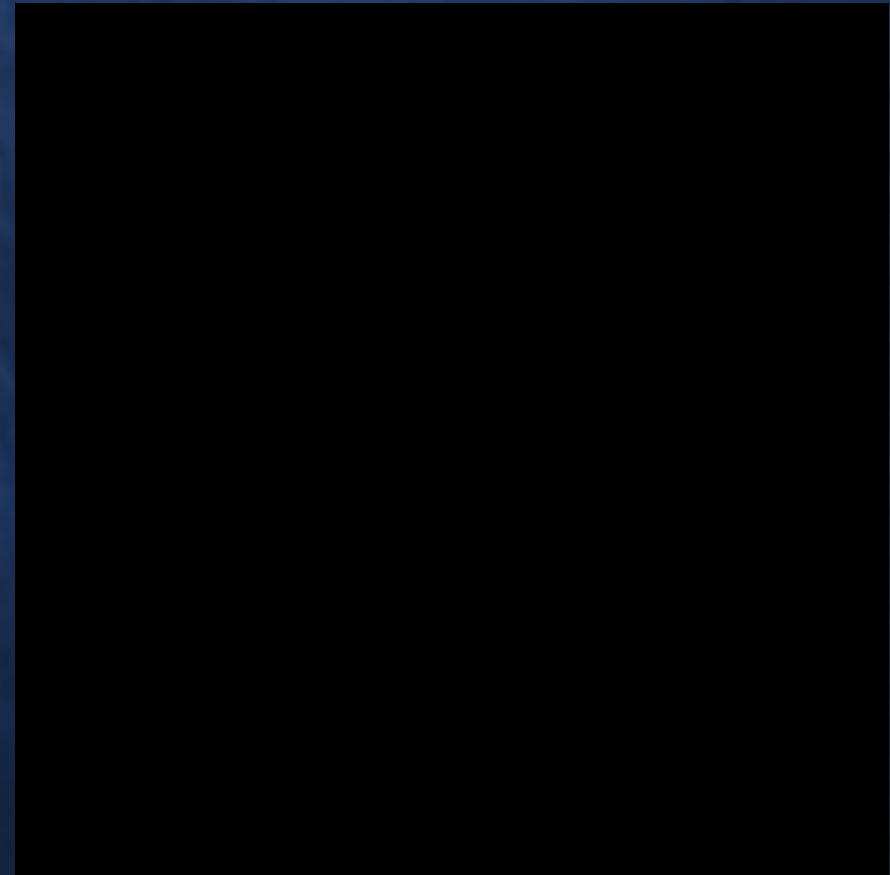


How to Cannulate XB curve

1. Guiding catheter technique

RCA cannulation with
XB curve

Step 2
Cannulation



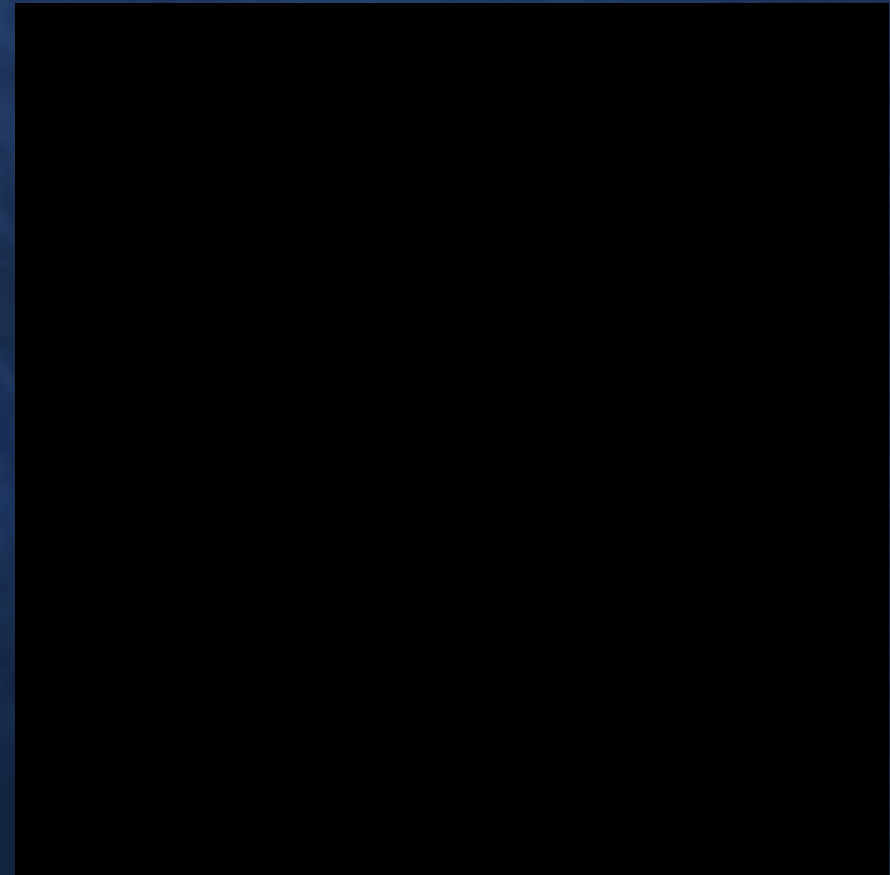
How to Cannulate XB curve

1. Guiding catheter technique

RCA cannulation with
XB curve

Step 3

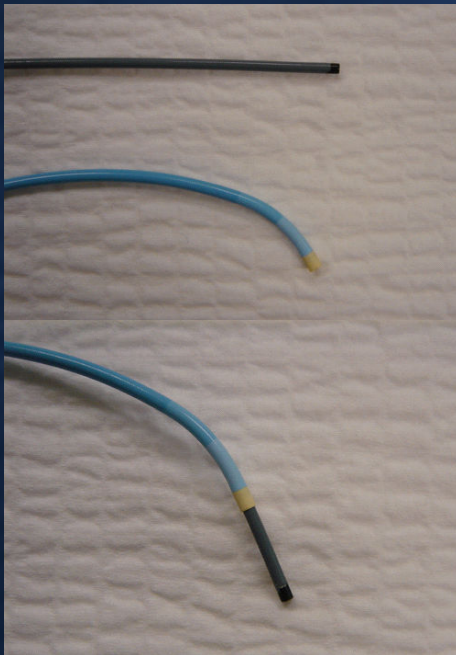
Adjust curve



When Difficult to Insert Balloon or Stent

1. Guiding catheter technique

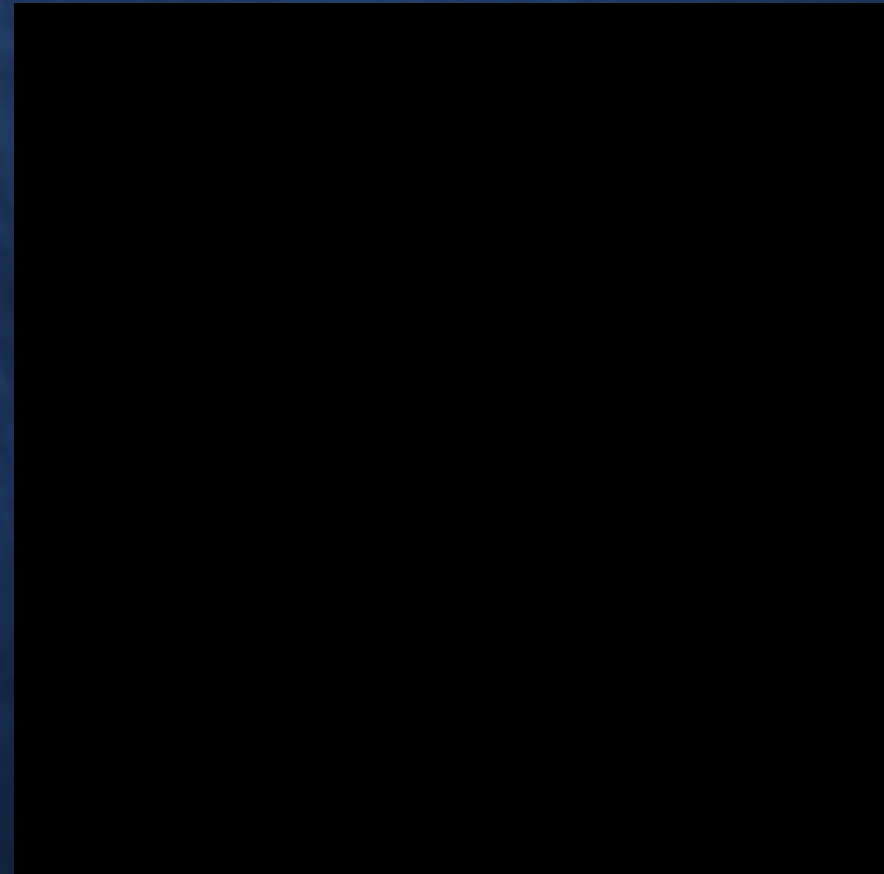
- Mother-and –child catheter technique



5F

6F

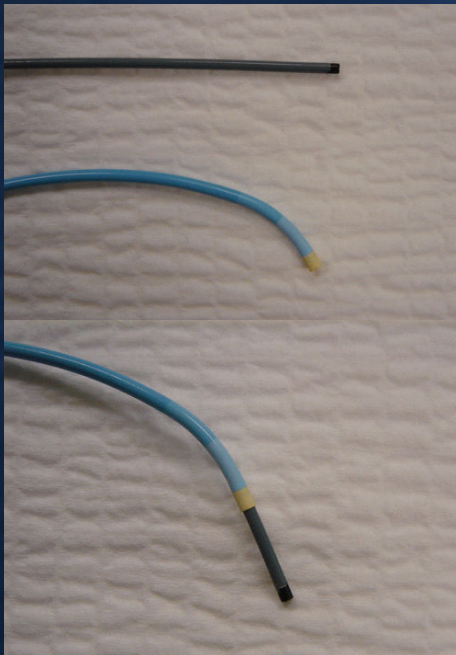
5 in 6F



When Difficult to Insert Balloon or Stent

1. Guiding catheter technique

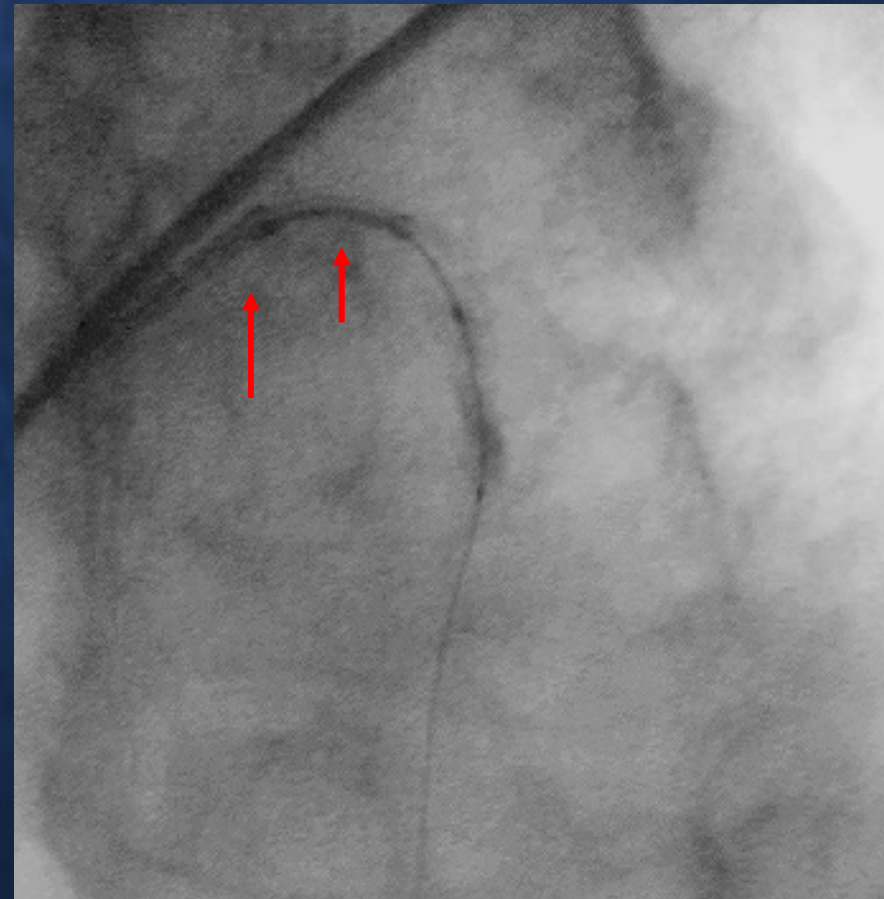
- Mother-and –child catheter technique



5F

6F

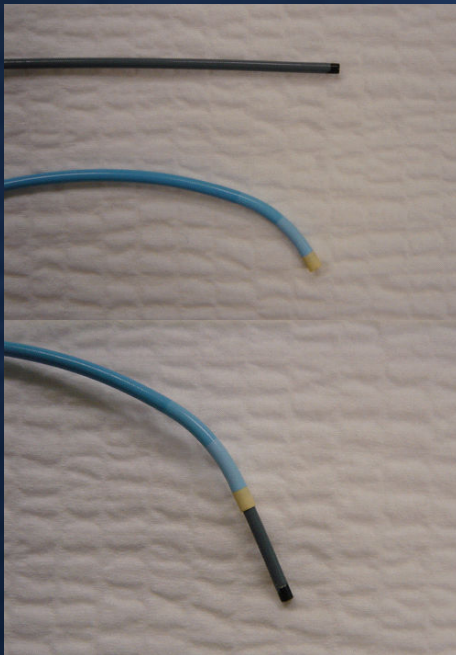
5 in 6F



When Difficult to Insert Balloon or Stent

1. Guiding catheter technique

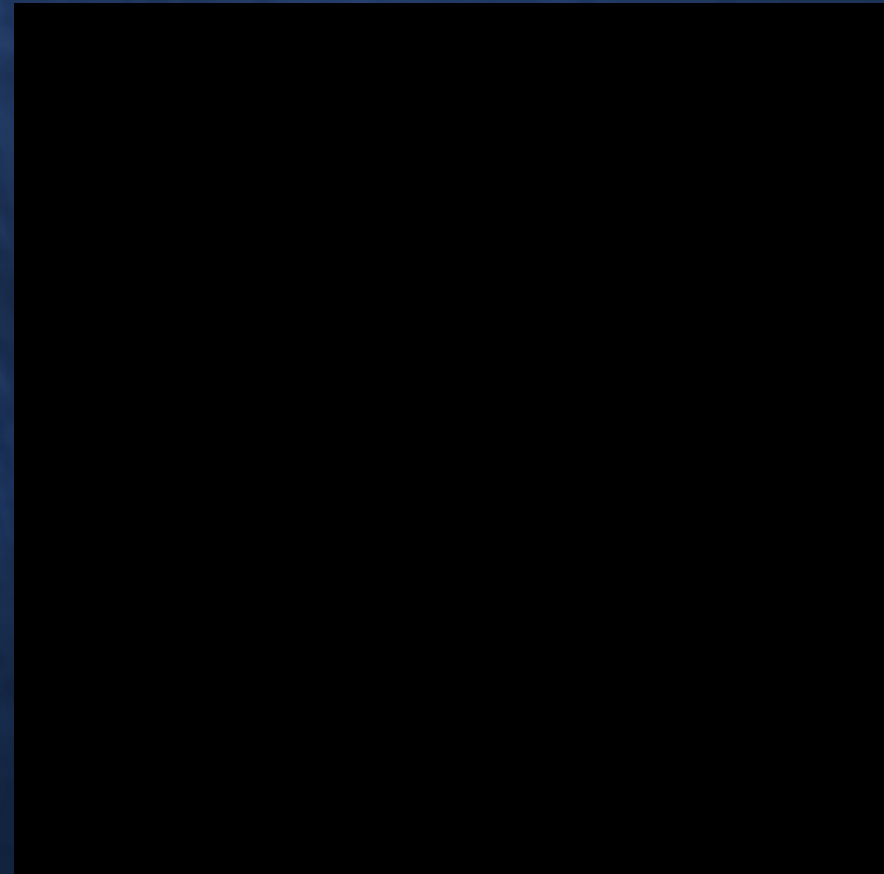
- Mother-and –child catheter technique



5F

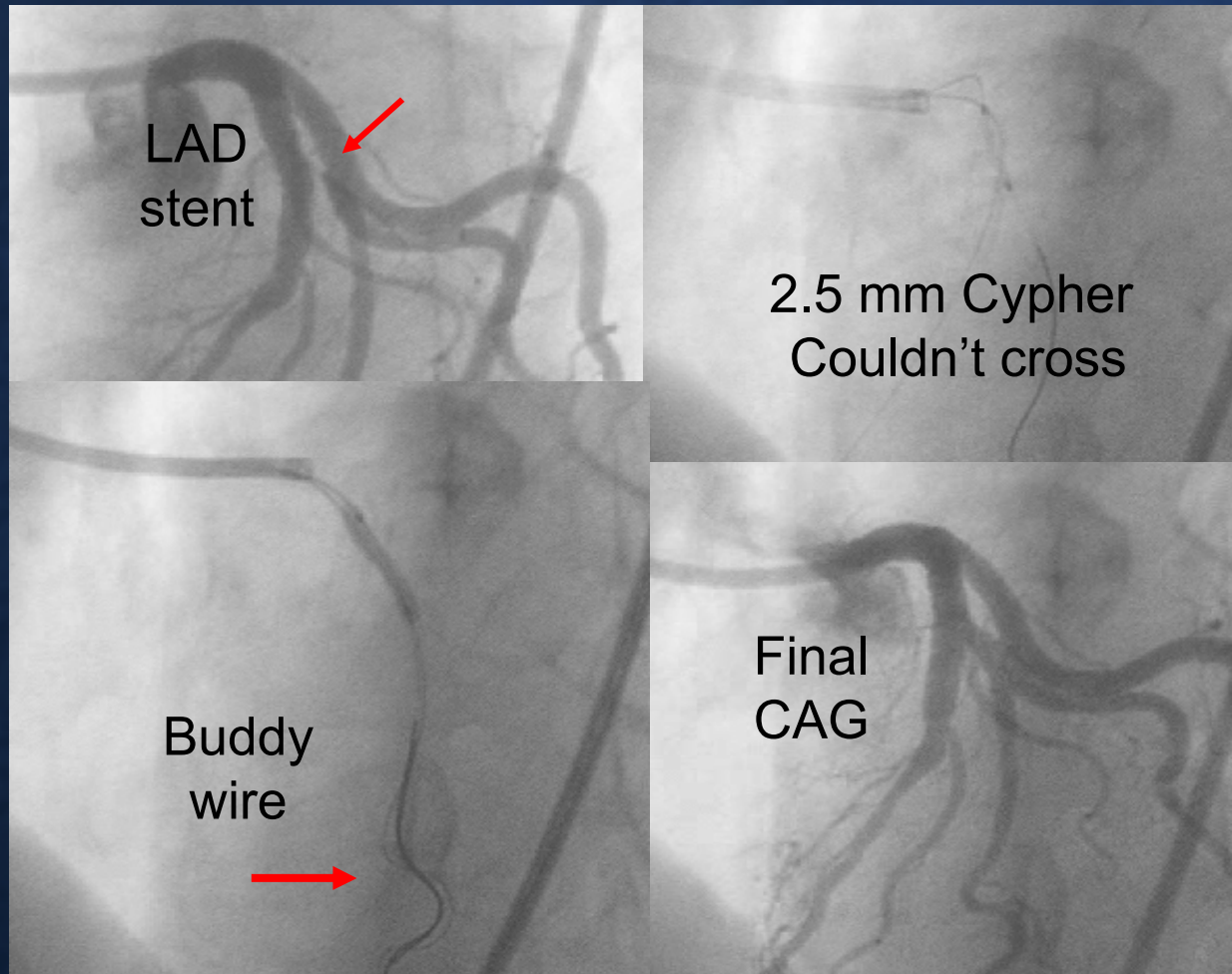
6F

5 in 6F



When Difficult to Insert Balloon or Stent

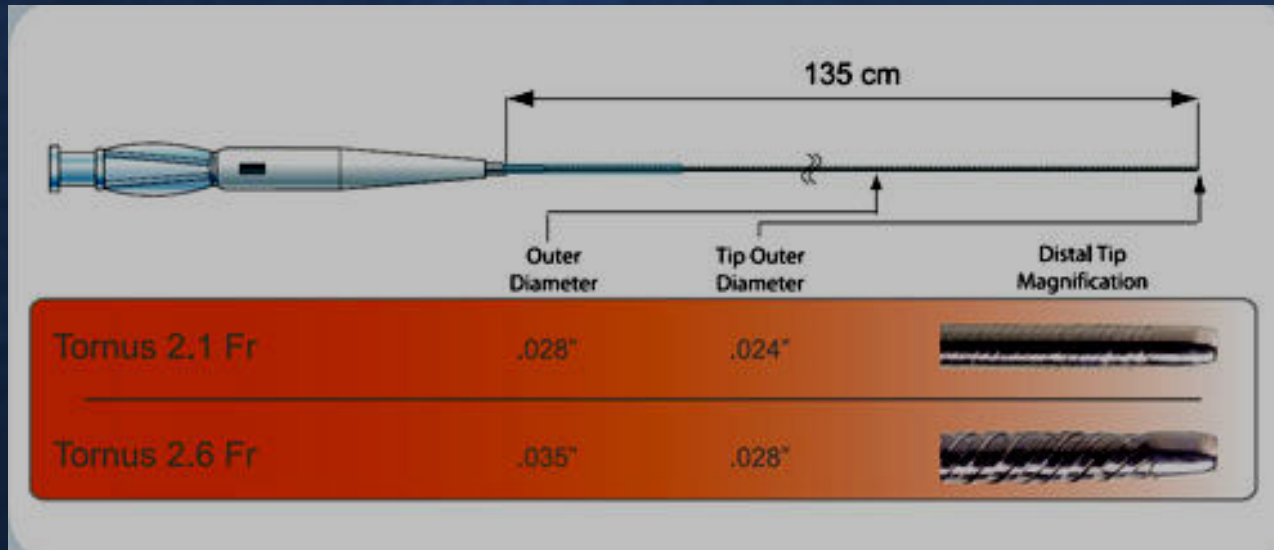
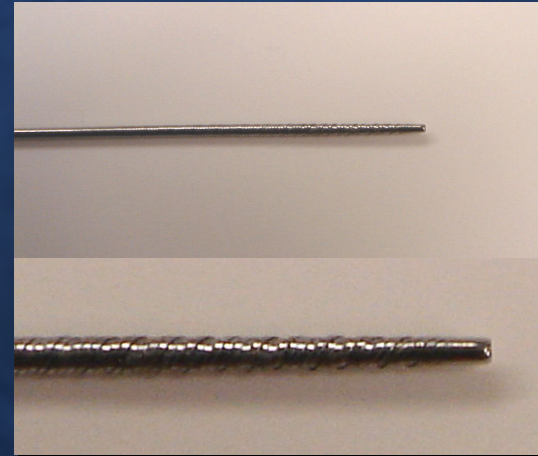
2. Guidewire technique: Buddy wire technique



When Difficult to Insert Balloon or Stent

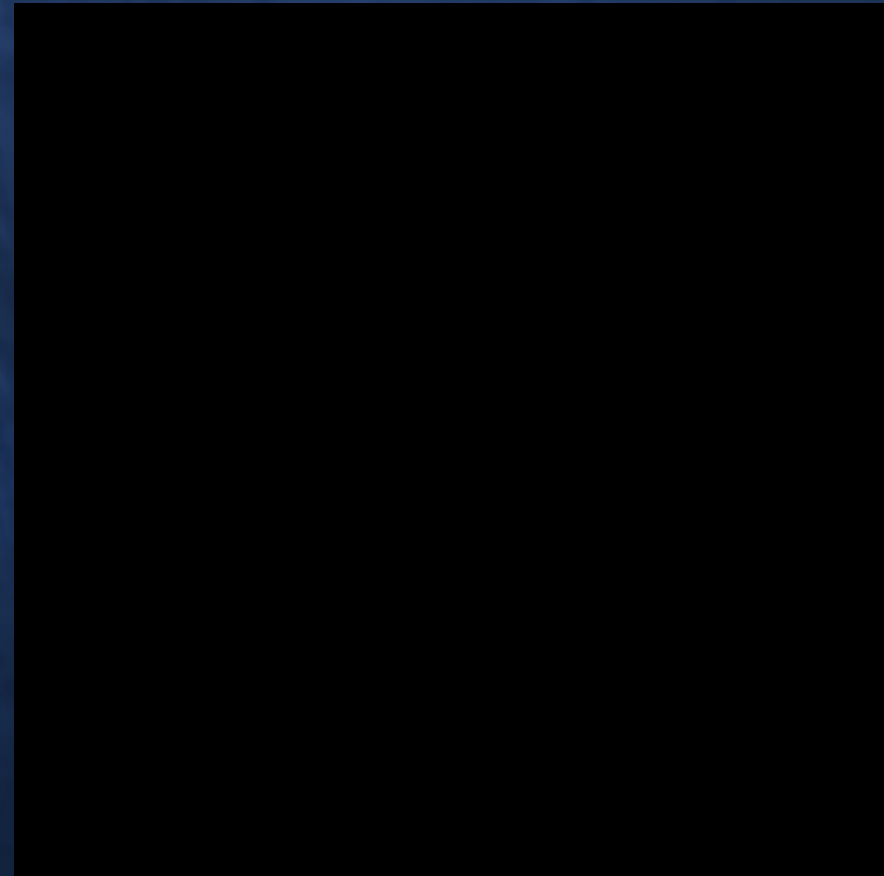
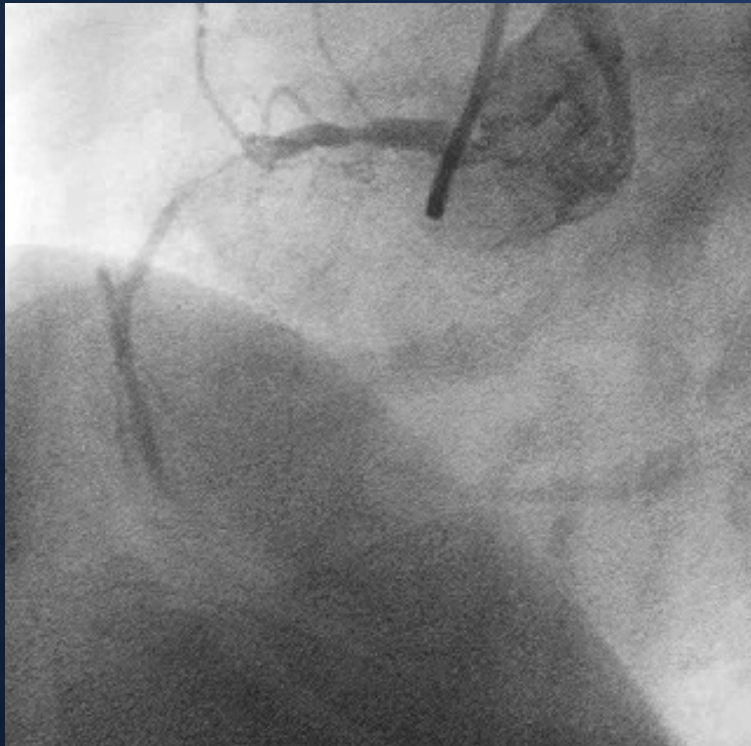
Other devices

- Tornus® catheter



When Difficult to Insert Balloon or Stent

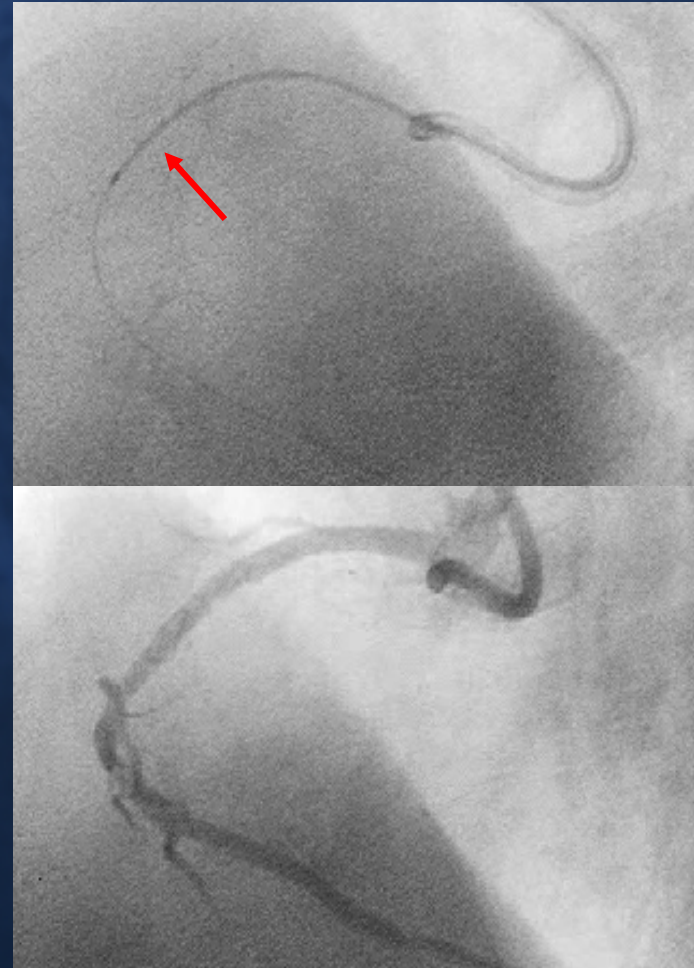
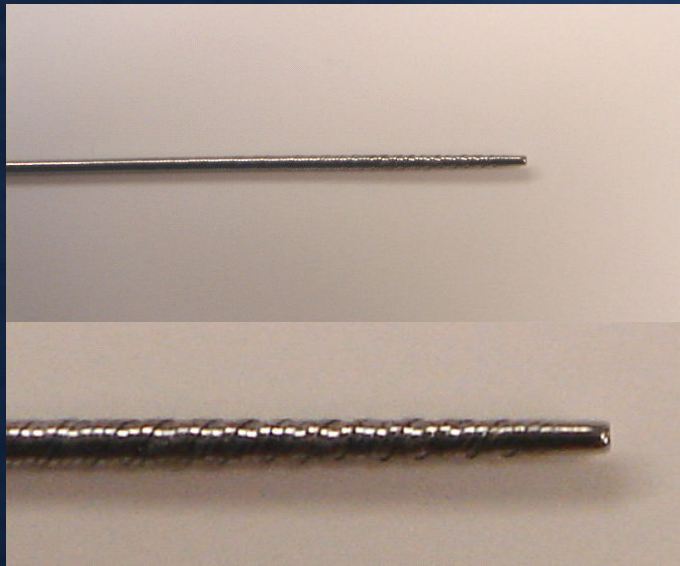
Other devices



When Difficult to Insert Balloon or Stent

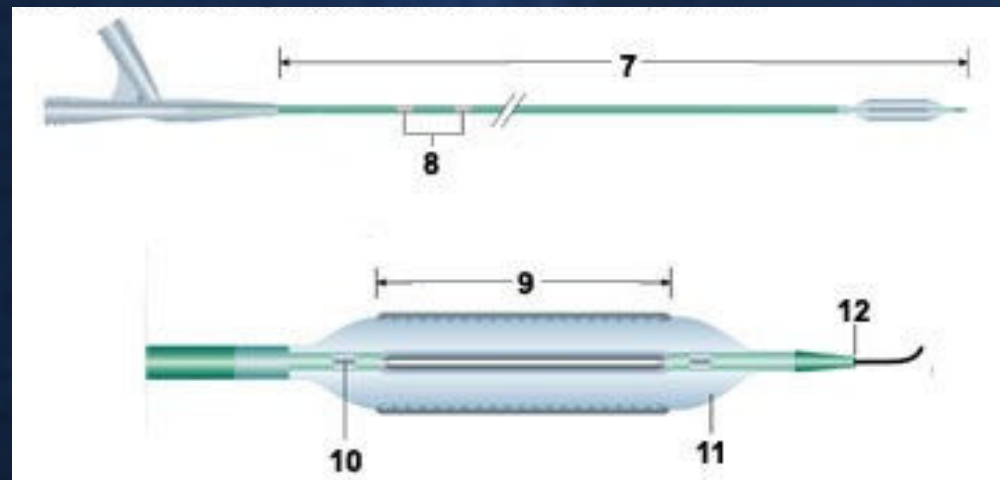
Other devices

Tornus®



When Difficult to Dilate

- High pressure inflation of non-compliant balloon
- Cutting balloon
- Focused ballooning
- Rotablator



Stent Characteristics

Characteristics	Determinants
Deliverability	Profile, shaft coating, flexibility
Flexibility	Strut thickness, stent design
Conformability	Strut thickness, stent design
Radial strength	Strut thickness, stent design
Fore-shortening	Stent design
Stent recoil	Strut material, stent design
Metal-to-surface area	Stent design
Radioapicity	Strut material and thickness, stent design
Bio-compatibility	Material, coating, metal-to-surface area

Strut Thickness and Restenosis

ISAR-STEREO I & II

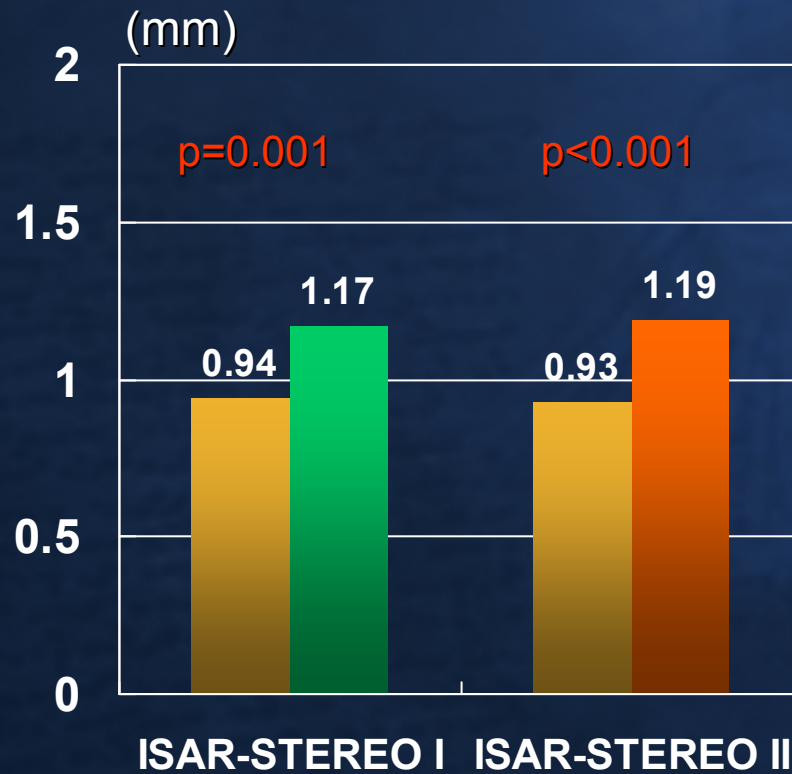
Group	ISAR-STEREO I		ISAR-STEREO II	
	Rx Multi-Link	Multi-Link Duet	Rx Multi-Link	Bx Velocity
N	326	325	309	302
Strut thickness	50 um	140 um	50 um	140 um
Morphology				

Kastrati Circulation 2001

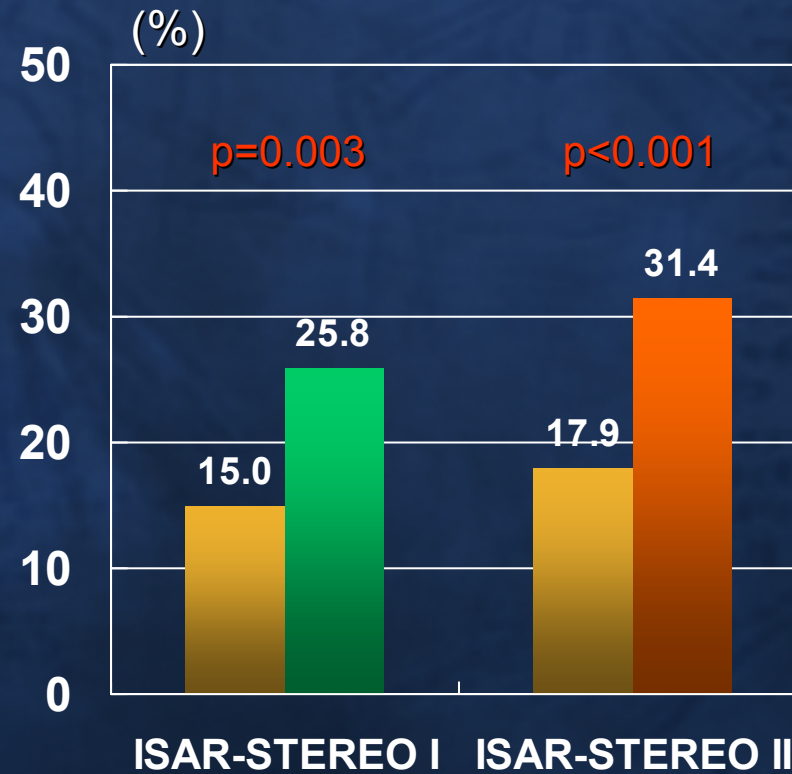
Pache JACC 2001

ISAR-STEREO I&II

Late Loss



Restenosis rate



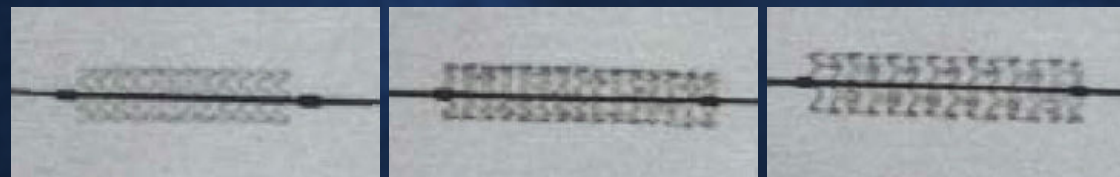
Rx Multi-Link (50 um) Multi-Link Duet (140 um) Bx Velocity (140 um)

Stent strut thickness

• Bx Velocity	140 um	SS
• Sonic	140 um	SS
• Express-2	132 um	SS
• S660	127 um	SS
• S7	119 um	SS
• ML Penta	122 um	SS
• ML Pixel	99 um	SS
• Driver	91 um	CoNi
• ML VISION	81 um	CoCr

Why Cobalt Alloy?

- **Stronger** material than stainless steel
 - UTS: Co-Cr 161 ksi vs. SS 94 ksi
 - Thinner struts with same radial force
- **Higher radiopacity** compared to stainless steel



Stent	Multi-Link	ML VISION	ML PENTA
Strut thickness	56 um	81 um	122 um

CoCr

Stent Technique

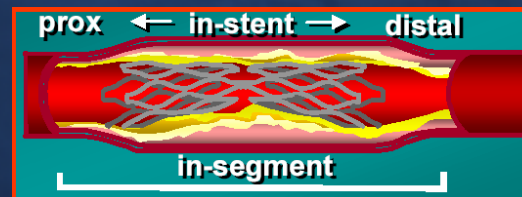
The larger , the better

- Stent apposition and expansion
 - Related to stent thrombosis as well as restenosis
 - Step-up and step-down
 - Post-dilation for instent residual stenosis



Geographic Miss

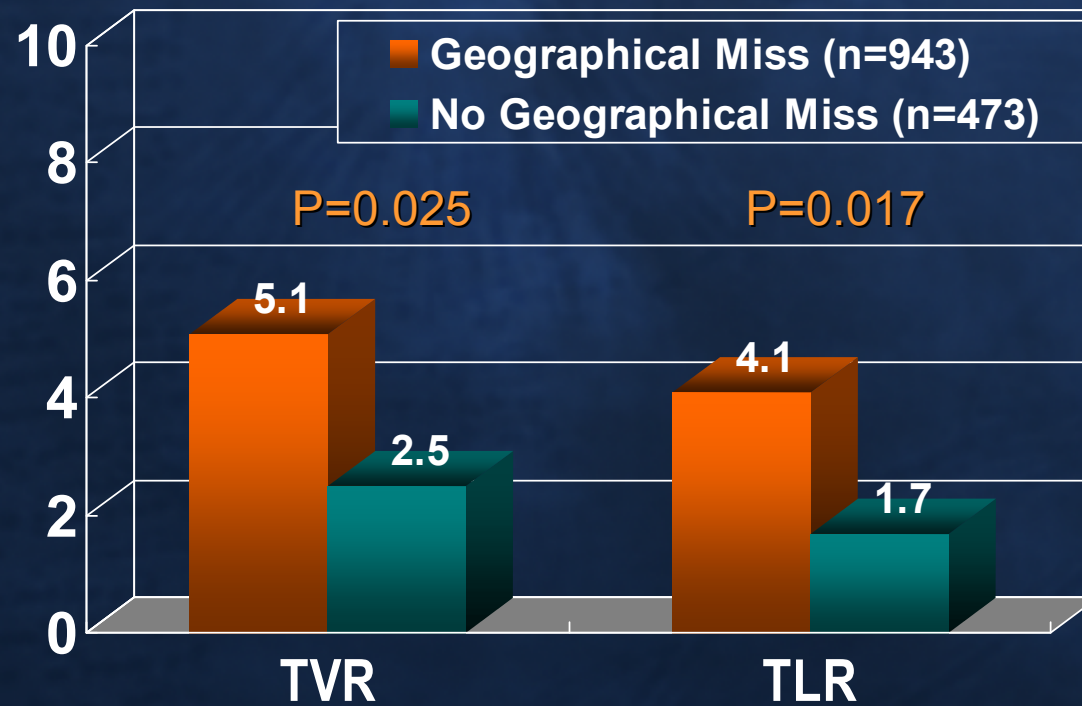
- SIRIUS study



	Sirolimus (%) N=533	Control (%) N=525	P-value
In-stent	3.2	35.4	<0.001
Proximal margin	5.8	8.1	0.285
Distal margin	2.0	7.2	0.002
In-segment	8.9	36.3	<0.001

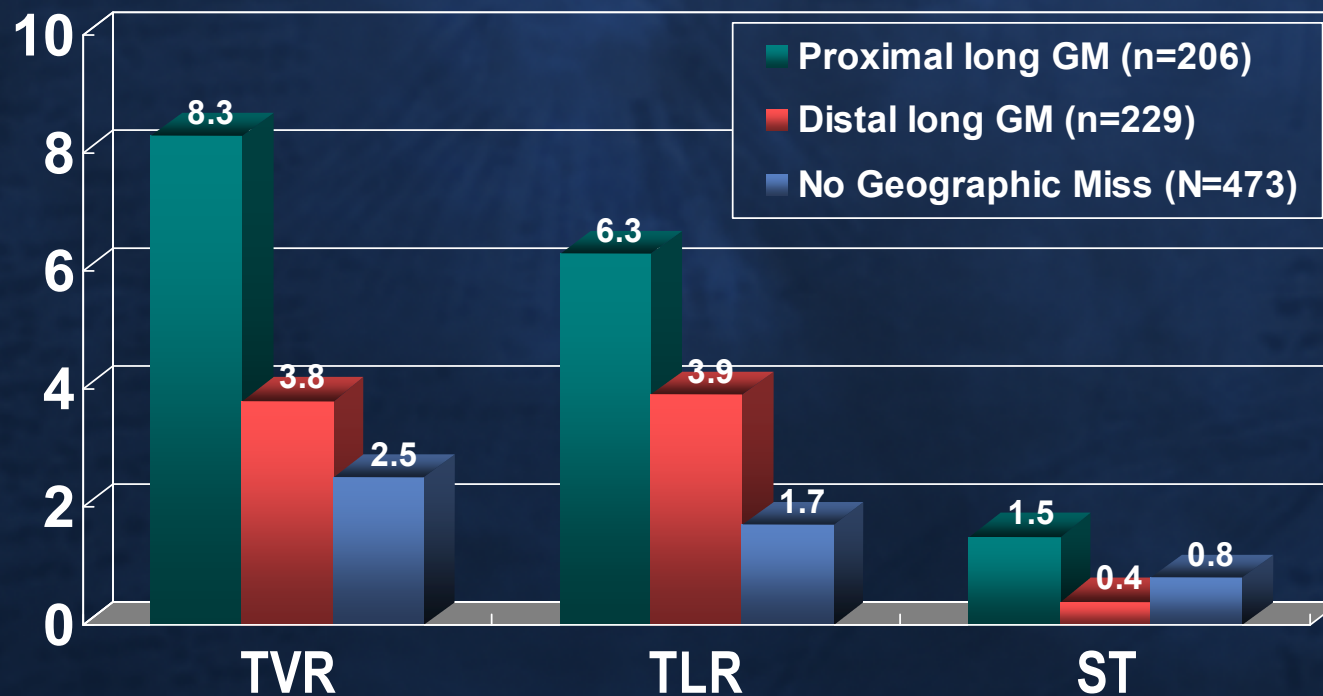
Geographic Miss

- S.T.L.L.R
 - 1-year outcome after DES implantation



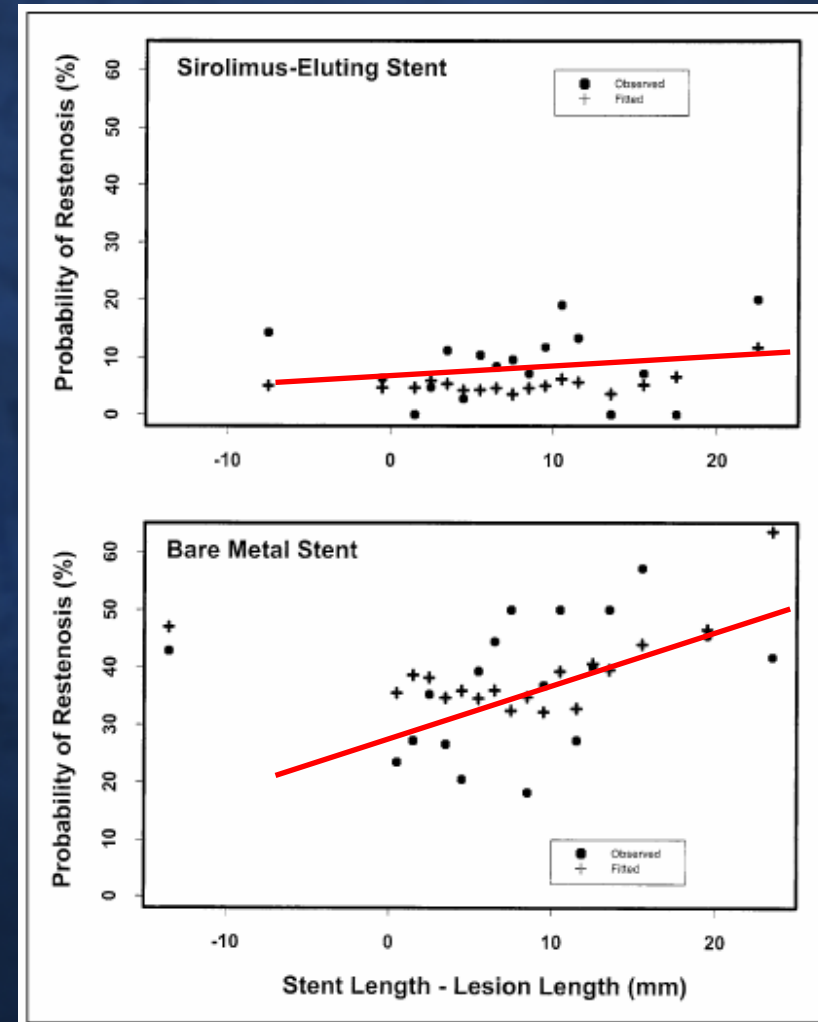
Geographic Miss

- S.T.L.L.R
 - 1-year outcome after DES implantation



The longer, the better? No!

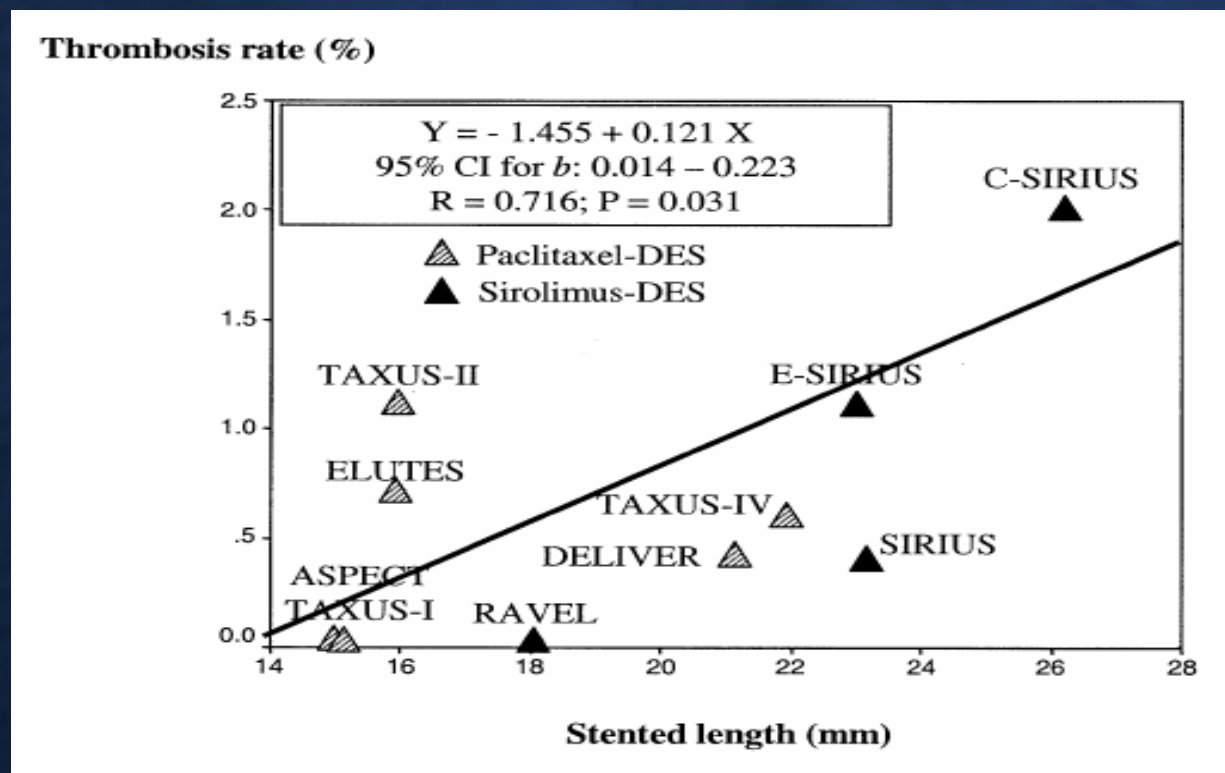
- SIRIUS study (Mauri. AJC 2005)
 - Stent-to lesion length ratio is still a unfavorable factor for long-term outcome in this era of DES



The longer, the better? No!

Increased risk of stent thrombosis

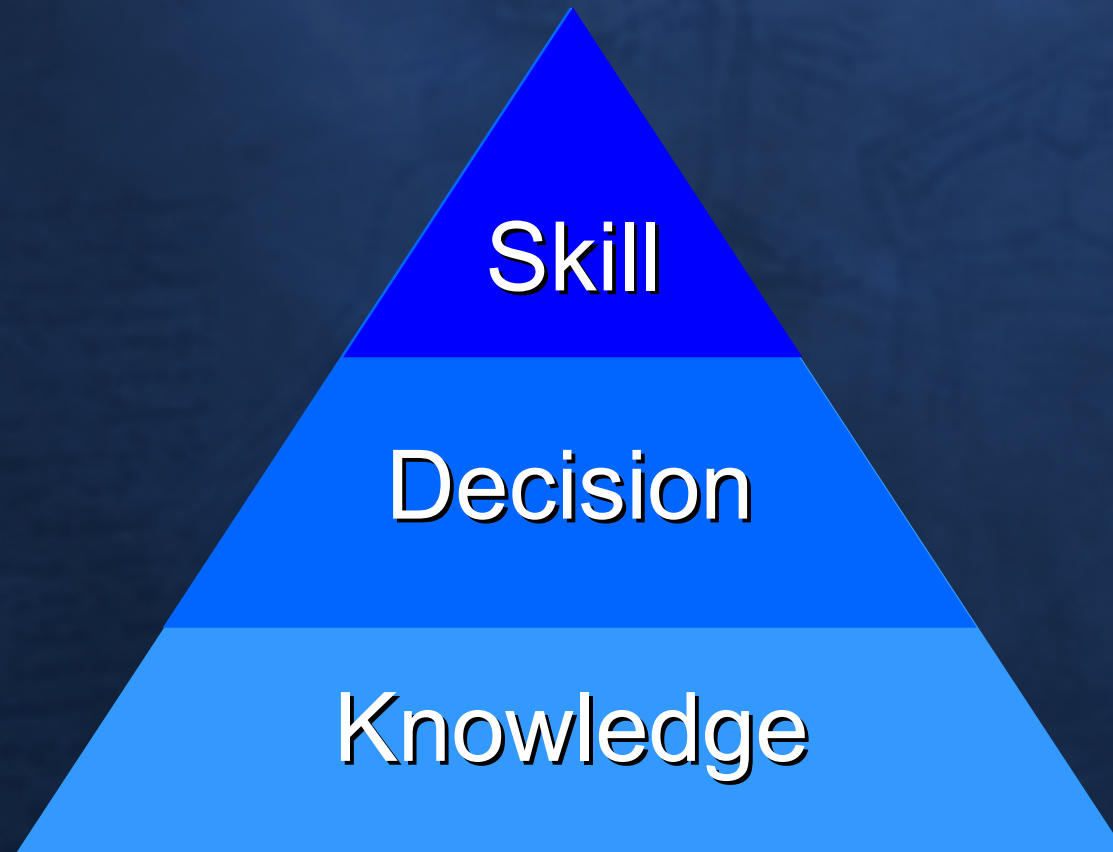
- Drug eluting stent (Moreno JACC 2005)



Summary

- History of PCI: from balloon to DES
- Balloon types
- Balloon structure
- Balloon characteristics
- Balloon technique
- Stent characteristics
- Stent technique

Conclusion



Thank you for your attention