
Coronary stenting in bifurcation lesions

Apr 2006

Bifurcation lesions

Lesioni complesse

Alta incidenza di complicazioni :

- In fase acuta: 5-15% di IMA periprocedurali
- A distanza: alta ristenosi :

con BMS 40-60%

con DES : > 20% su ramo secondario

Lesioni frequenti

Oltre 20% dei trattamenti PCI sono su biforcazioni

Dispositivi e tecniche ancora in evoluzione

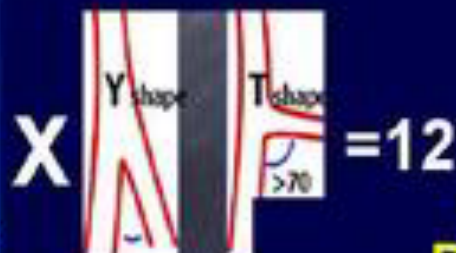
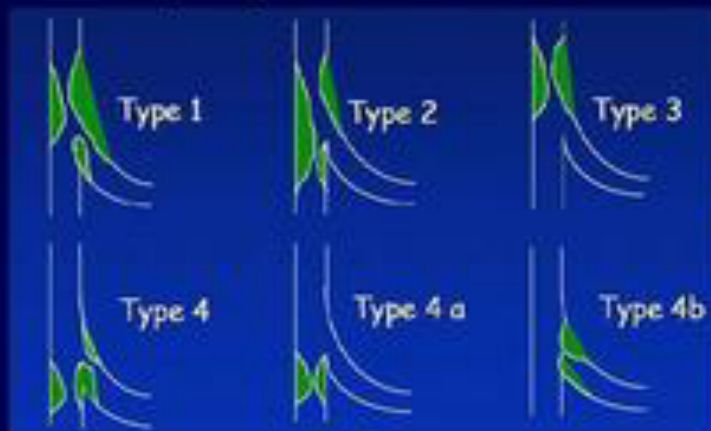
Bifurcation definition

Ramo principale



Lefevre classification:

- many types
- angulation changes during the procedure
- plaque shift is common and unpredictable



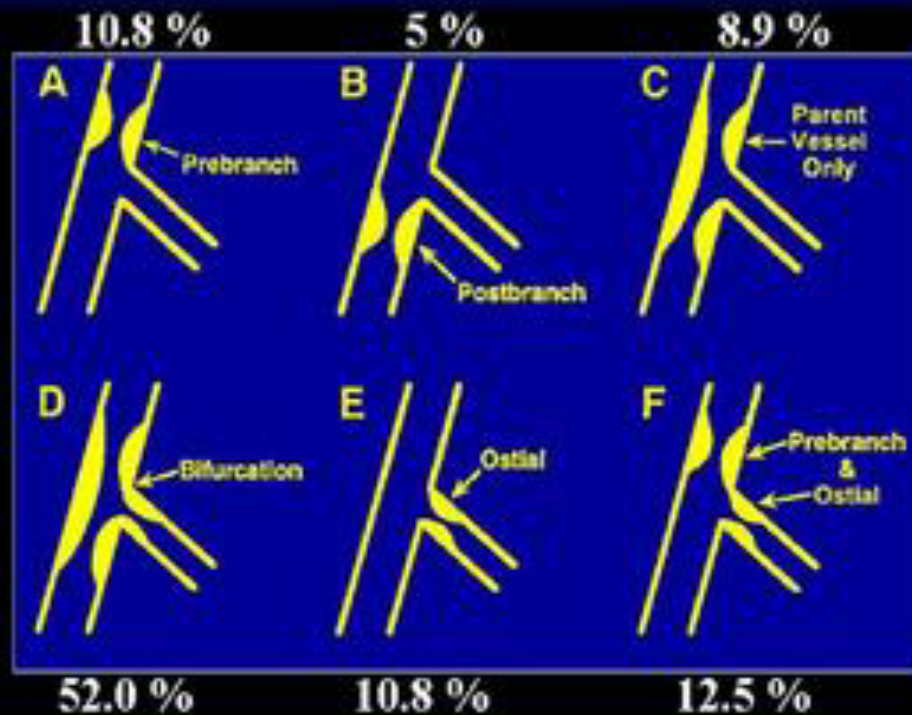
$\times = 12$

DUKE CLASSIFICATION

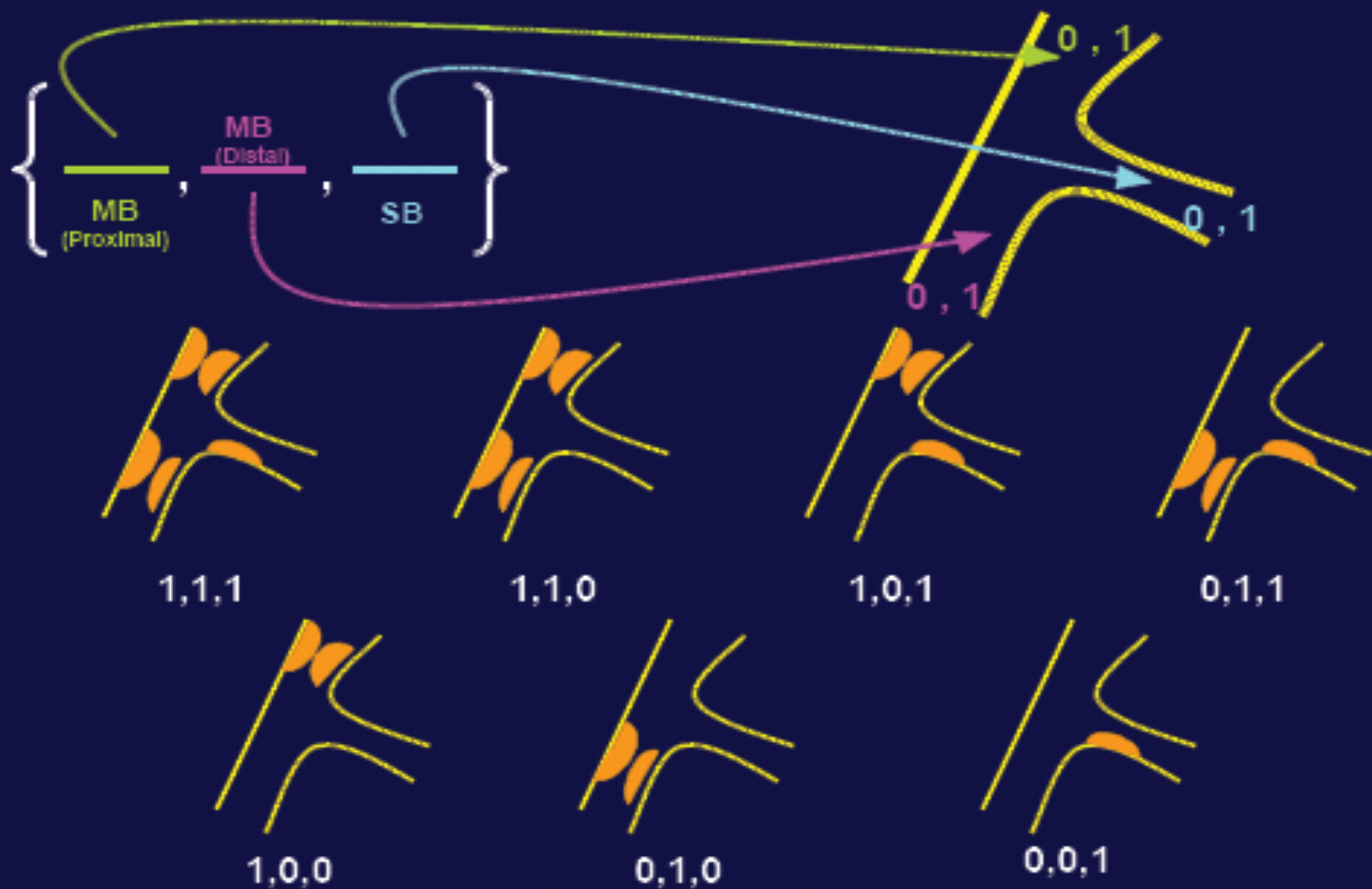


\times

$= 30$



Medina classification



Lefevre classification: angiographic pattern



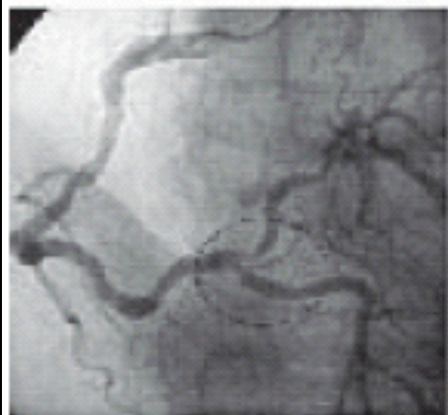
Case 4a. Type 1



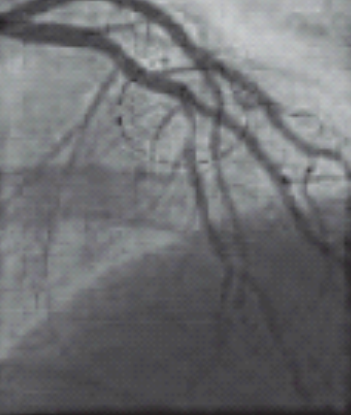
Case 4b. Type 2



Case 4c. Type 3



Case 4d. Type 4



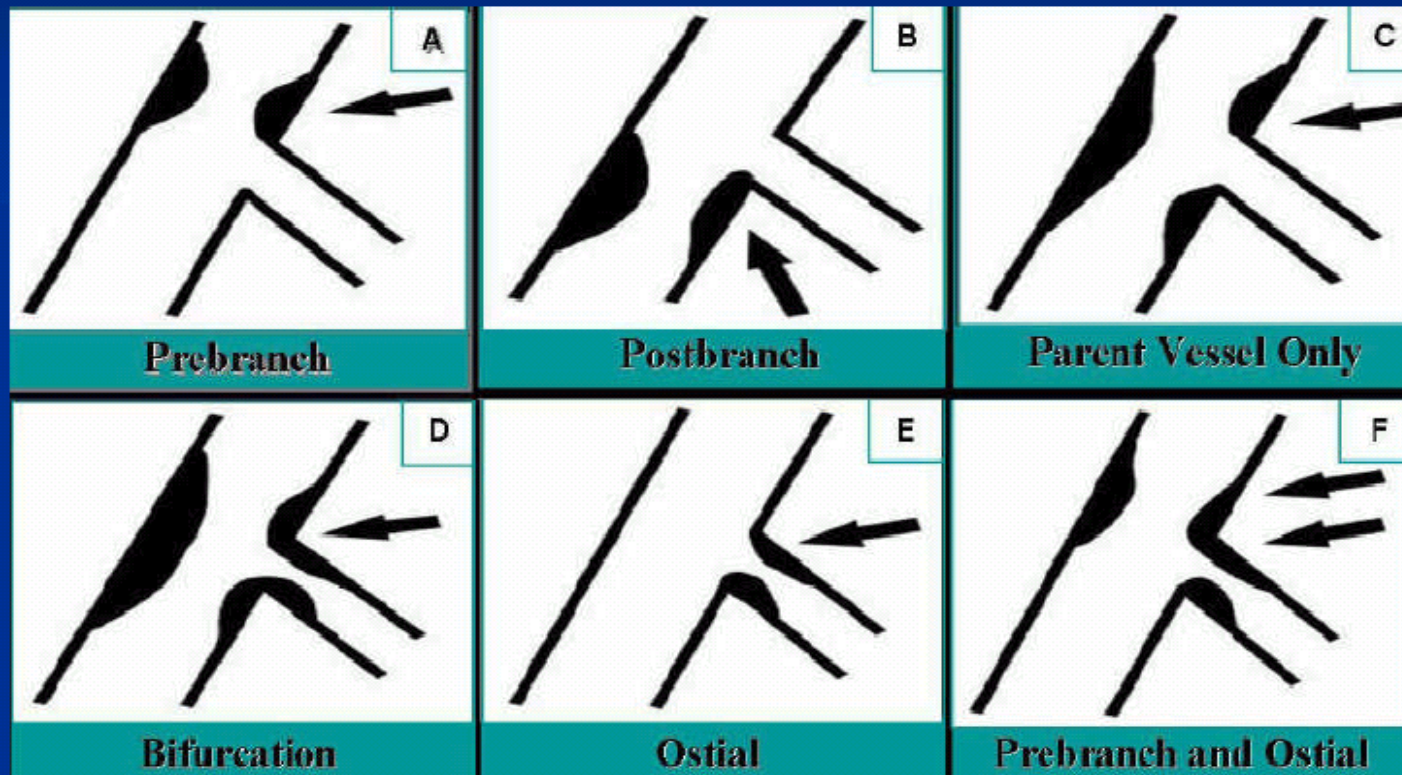
Case 4e. Type 4a



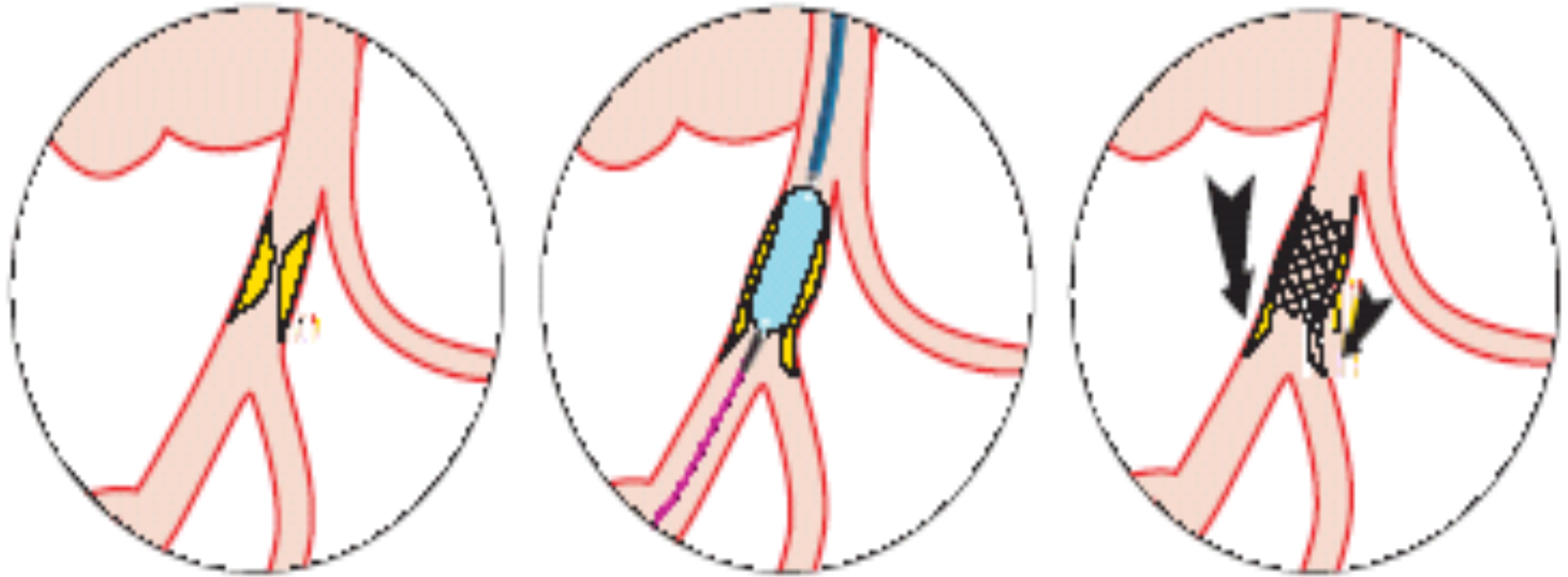
Case 4f. Type 4b



Bifurcation Classification



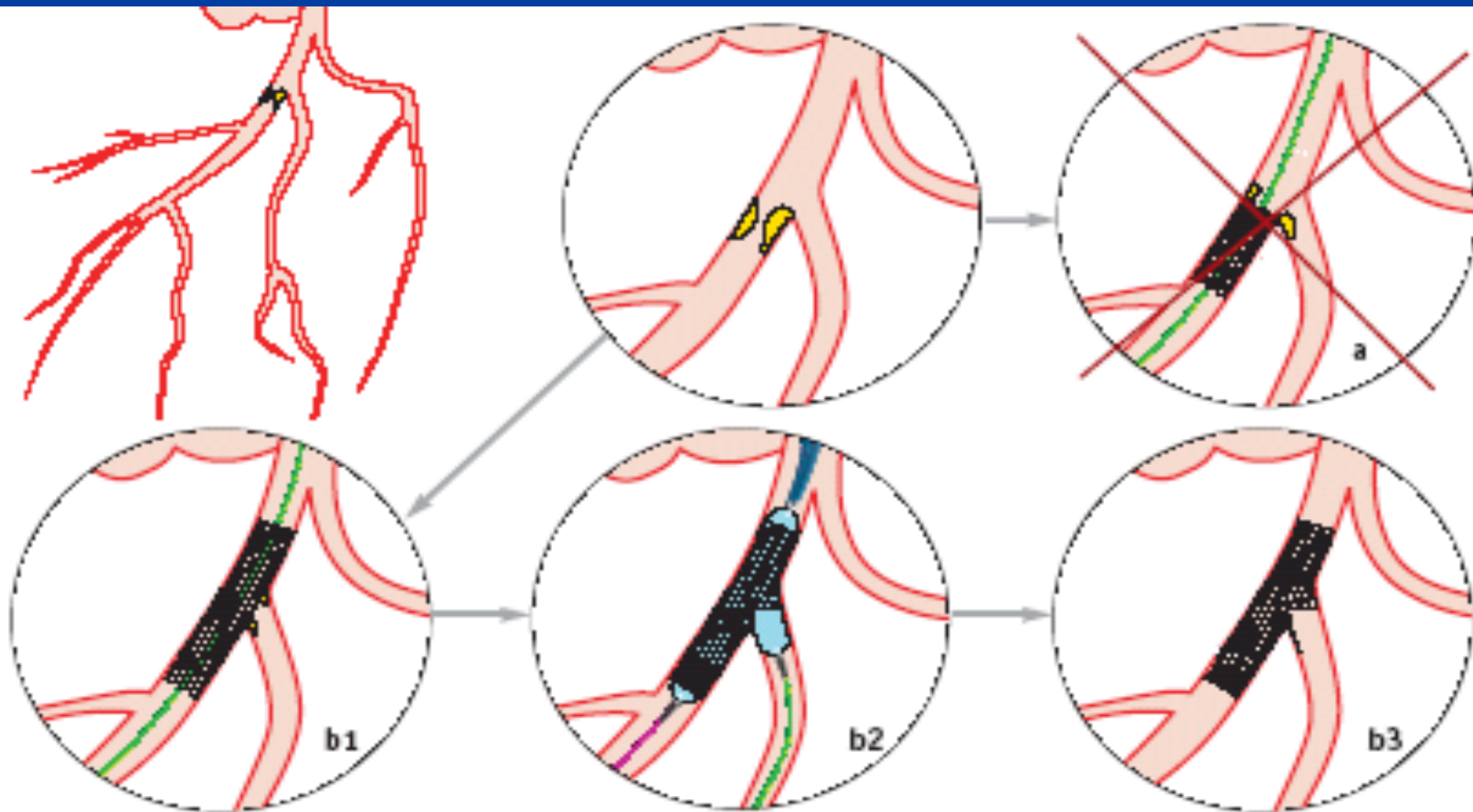
Snow-plough effect



EuroPCR T. Lefevre Paris Sud - Massie

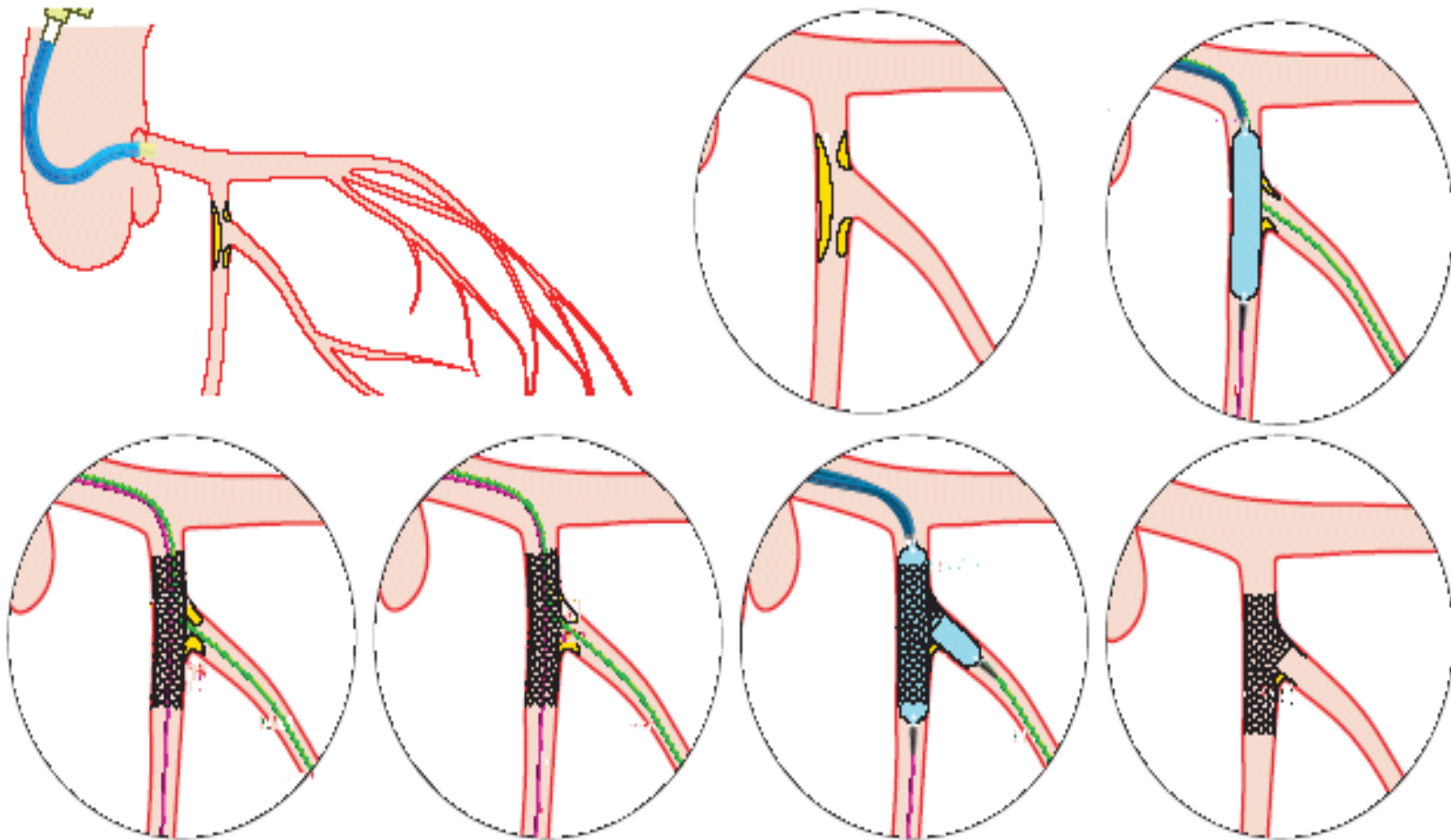


False bifurcation → true bifurcation



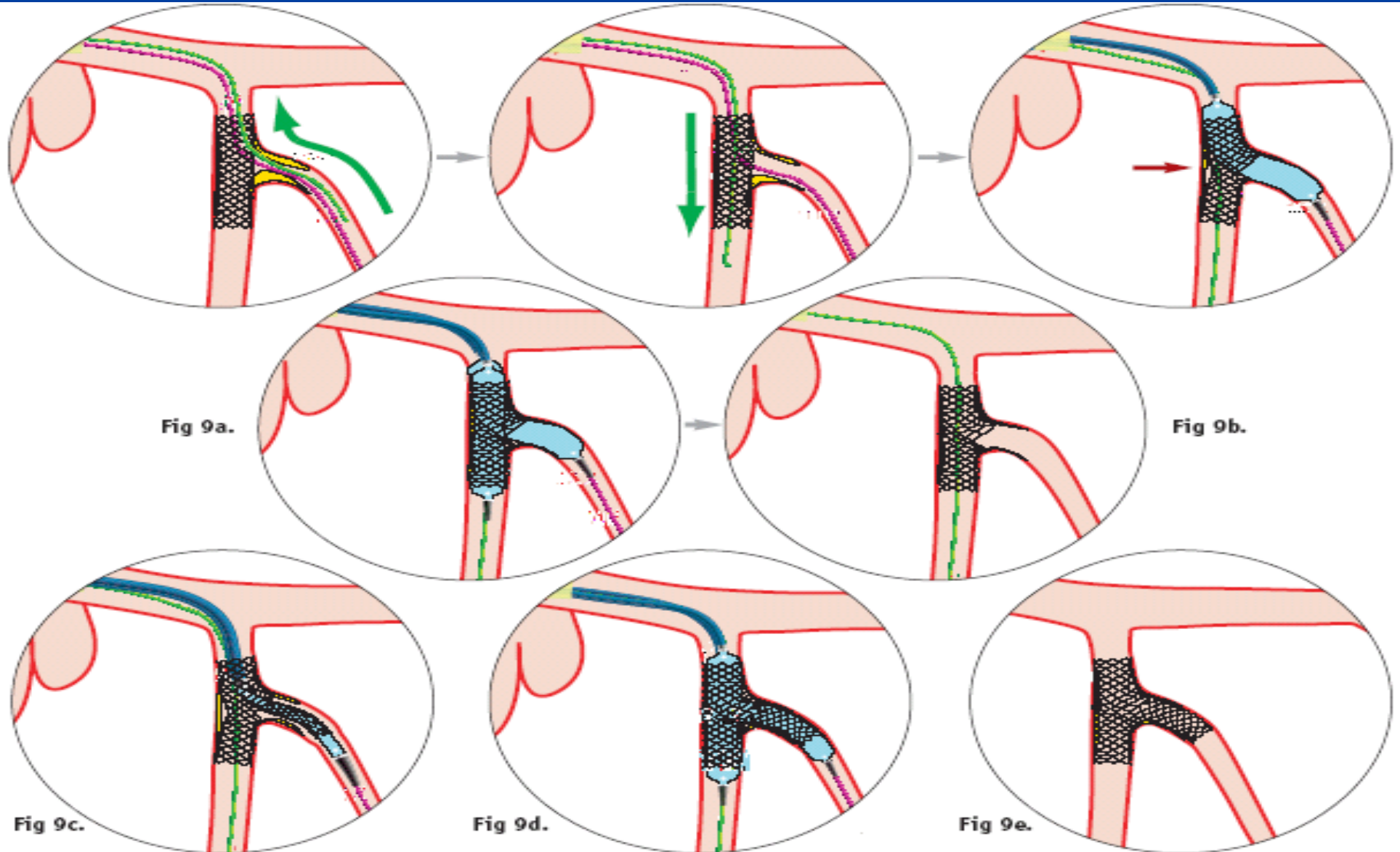
Snow-plough effect in type 4a lesion after coronary stenting. Using the "classical approach, high risk of plaque shifting proximal to the bifurcation (a). Covering the side branch (b) is a better approach because plaque shifting occurs only in the side branch and can be connected by kissing balloon inflation..

Side branch stent only provisional



Type 2 Y shape lesion. Predilatation of the main branch with axial plaque redistribution in the side branch. Main branch stenting, kissing balloon inflation. Side branch stenting is only provisional.

Stent also in side branch



STENT TECHNIQUES

- Provisional stenting
- T shaped stenting
- Inverted V technique
(*Kissing stenting*)
- Inverted Y technique
- Trouser-like stenting
- Fork stenting
- Culotte technique
- Debulking + stenting
- Crush

... none of them has been definitively accepted. Basically, could be divided in 2 strategies:



SIMPLE

VS



COMPLEX

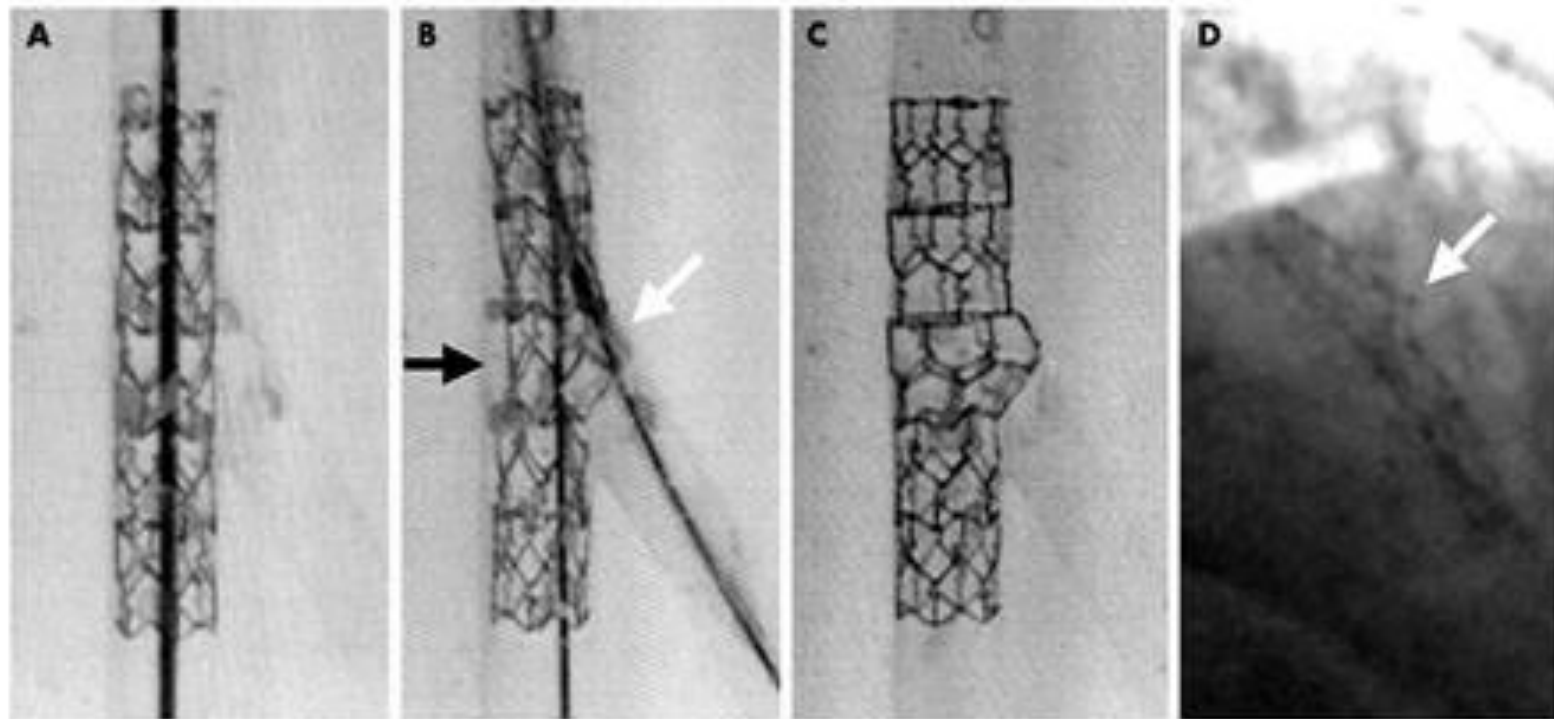
Stenting in bifurcation lesions

Simple Strategy :



stent only in main
branch

Option 1 Kiss to open struts



We can Stent Both Branches With 1 Stent !

Bestent



Biocompatible



BX Velocity



Carbostent



Penta



R stent



Final Kissing



Always 2wires

False and true bifurcations near identical

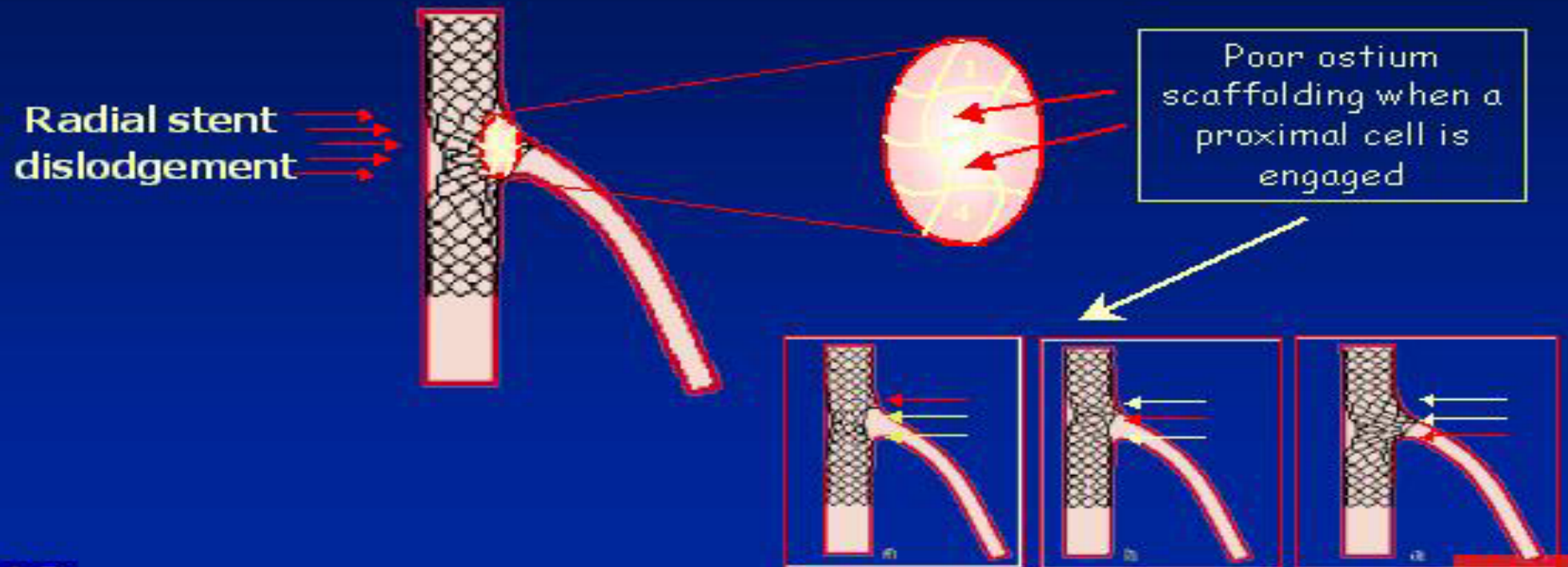
One stent is preferred in most cases

But use a second one when necessary

And kiss in all cases

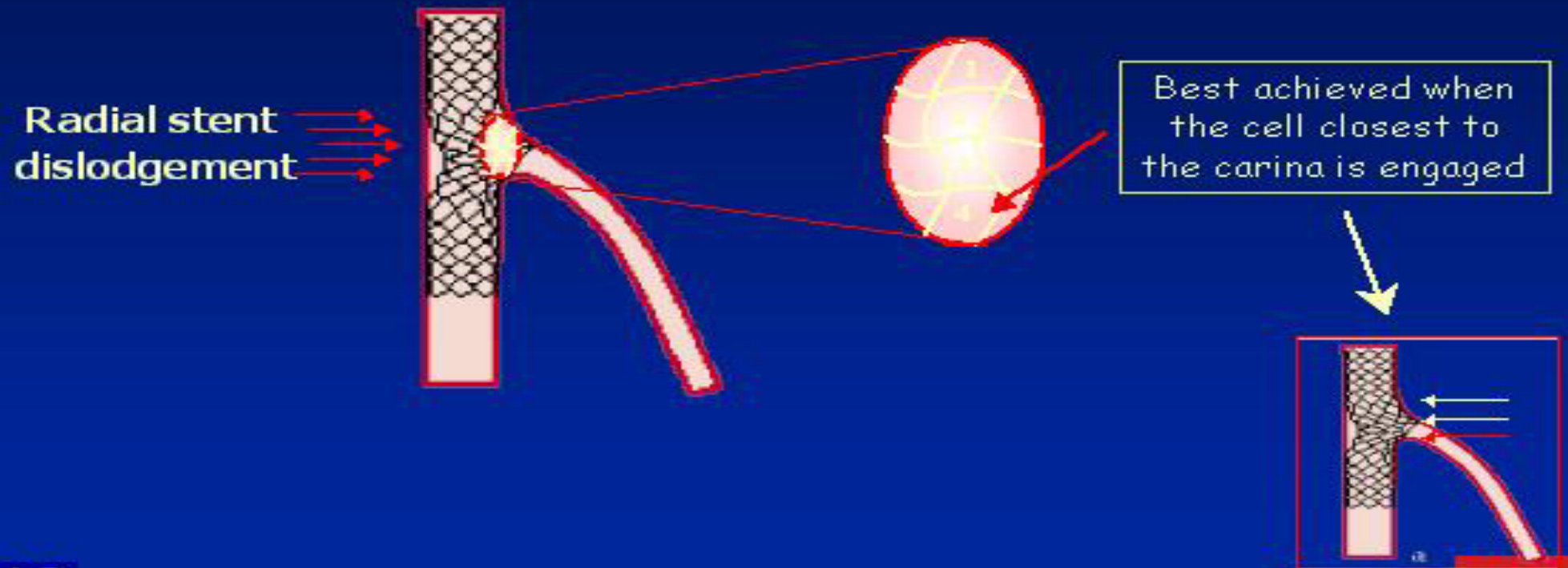
Effetti del Kissing finale

The "good" side of stent deformation



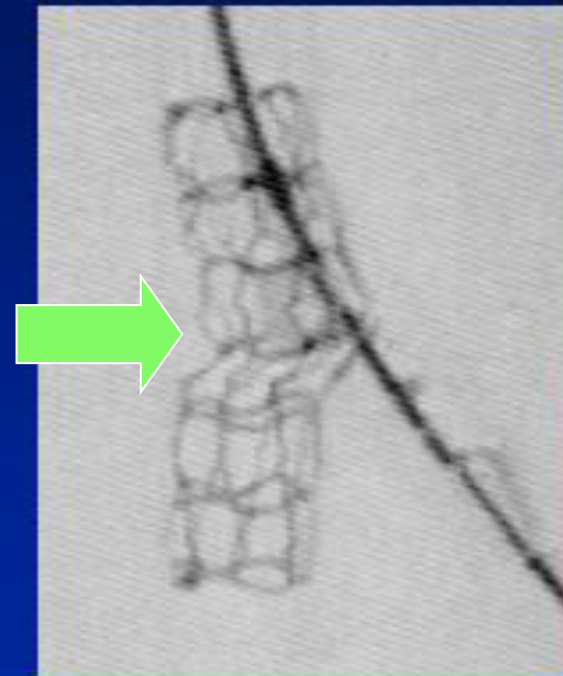
Effetti del Kissing finale

The "bad" and the "good" of Stent Deformation

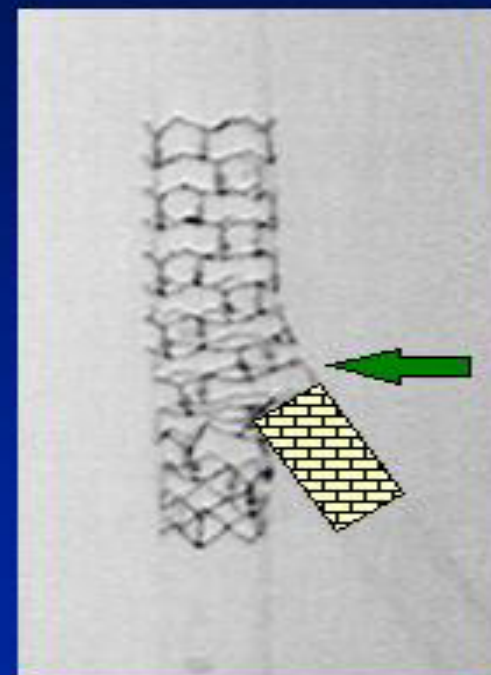
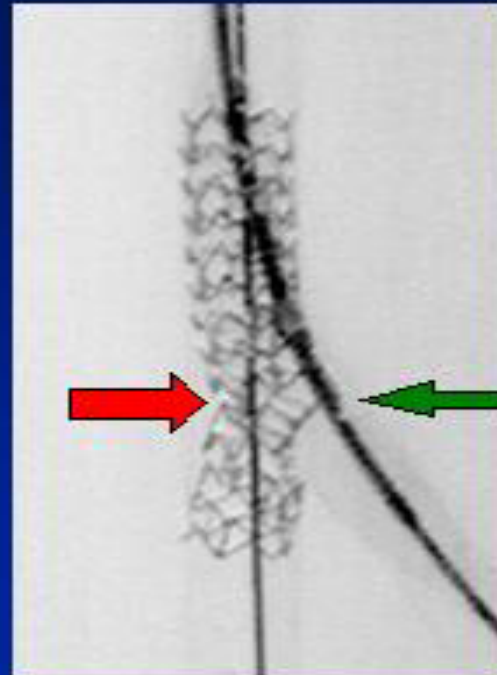
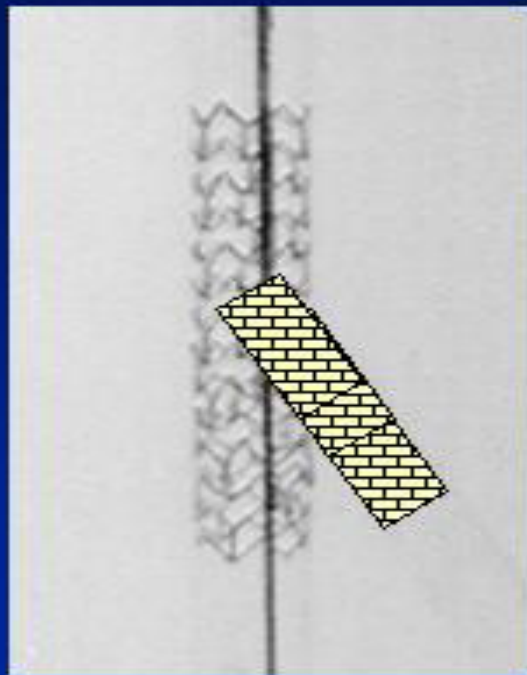


Lessons from Bench Testing

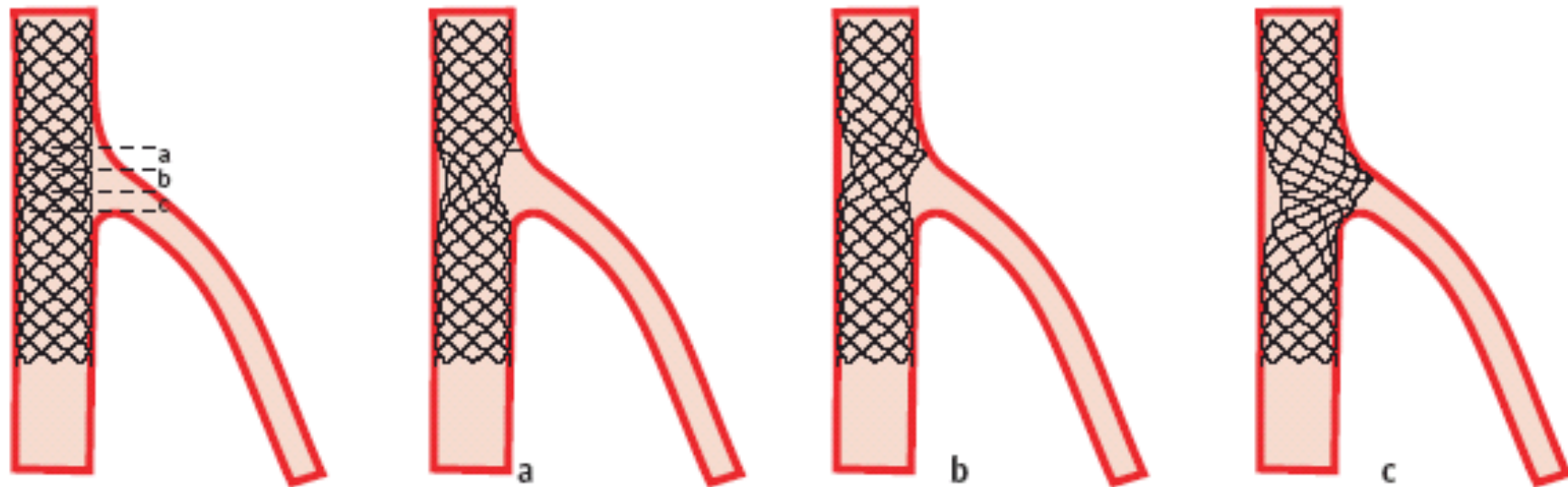
The "bad" side
of stent deformation



The "good" side of stent deformation



Multi-link Penta

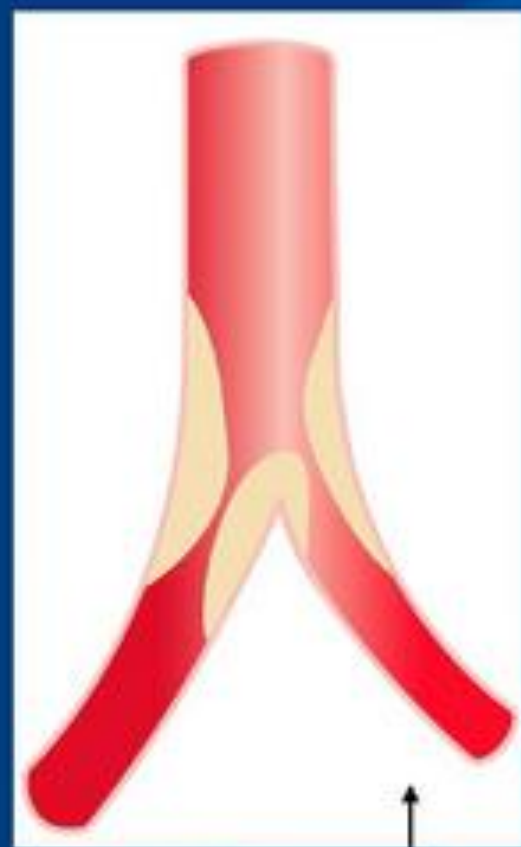


When opening the main branch stent towards the side branch, two or three struts are generally accessible: a) opening of the most proximal strut. b) opening the mid strut. c) opening the distal strut. The stent deformation in the main branch is corrected by kissing balloon inflation. Side branch scaffolding is obtained only if the most distal strut is open.

Provisional T stenting

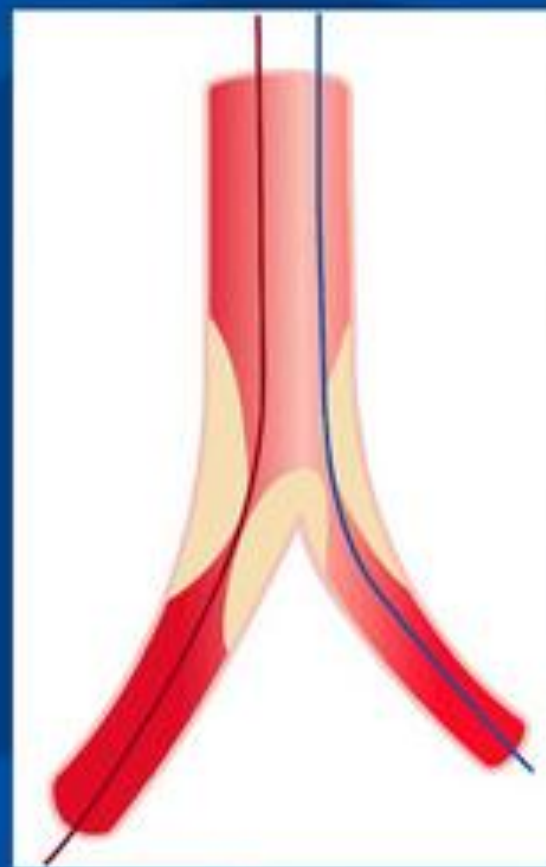
- Wiring of both branches
- Predilatation
- Stent on main branch with jailed wire in side branch
- Switch of wires
- Opening strut toward side branch
- Kissing balloon
- Provisional T stenting of side branch

PCI STRATEGY IN TRUE BIFURCATION LESIONS

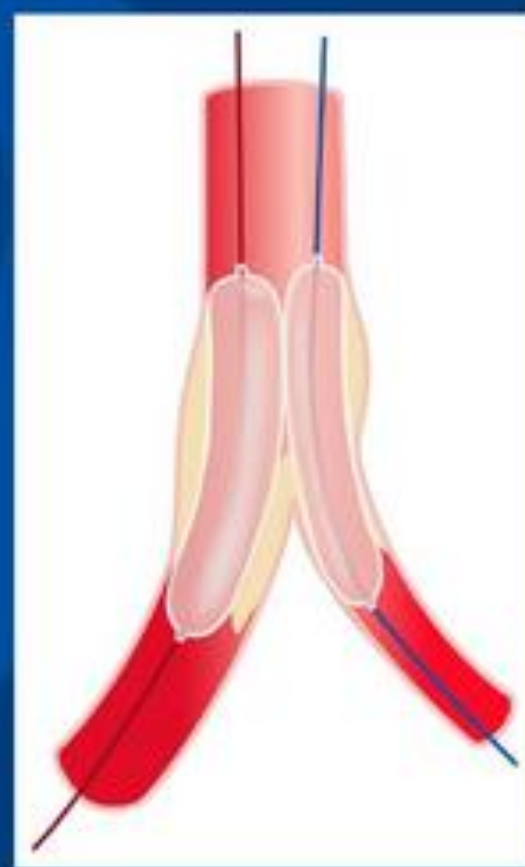


MAIN
VESSEL

SIDE
BRANCH



DOUBLE WIRE TECHNIQUE

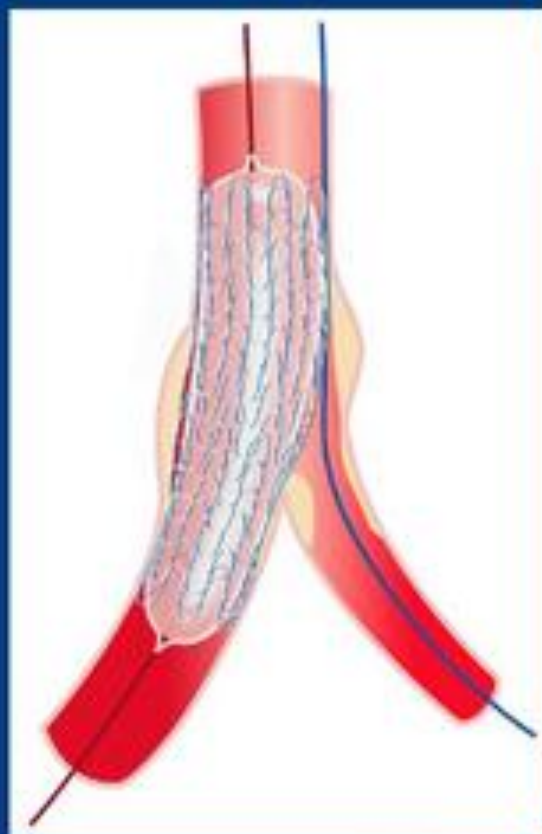


PREDILATATION

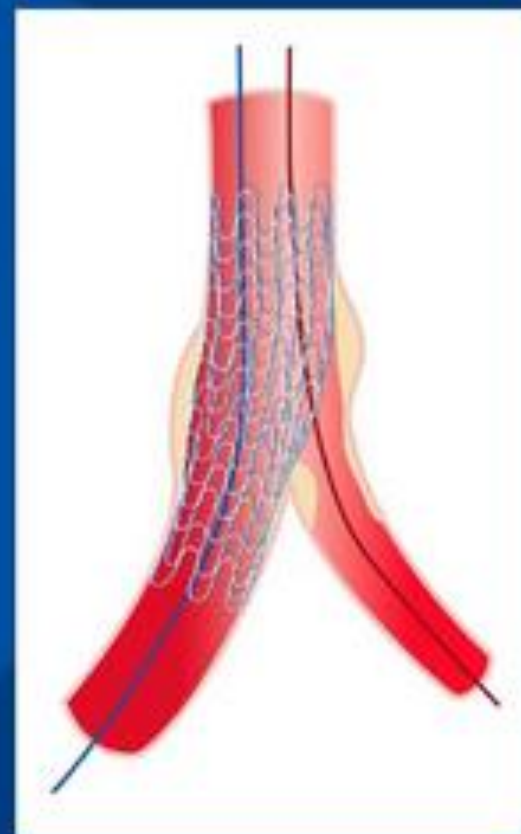
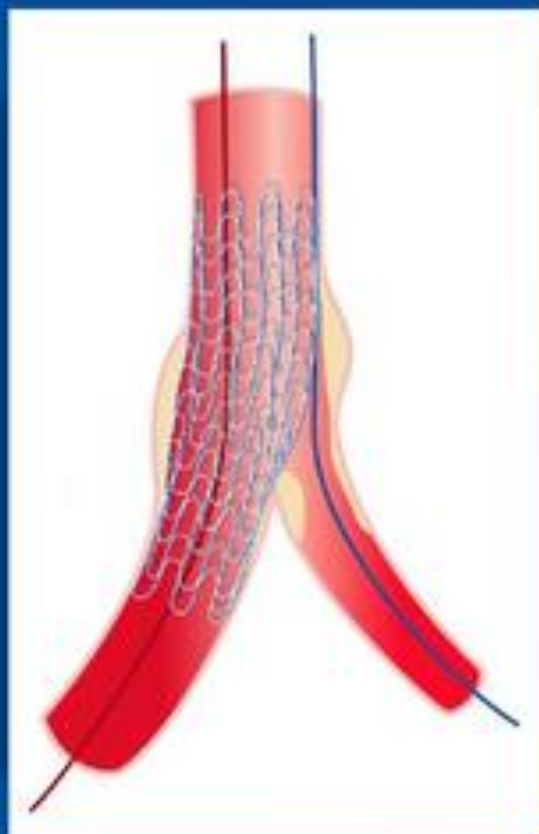


PCI STRATEGY IN TRUE BIFURCATION LESIONS

B.



STENTING of MAIN VESSEL
with JAILED WIRE in SIDE BRANCH

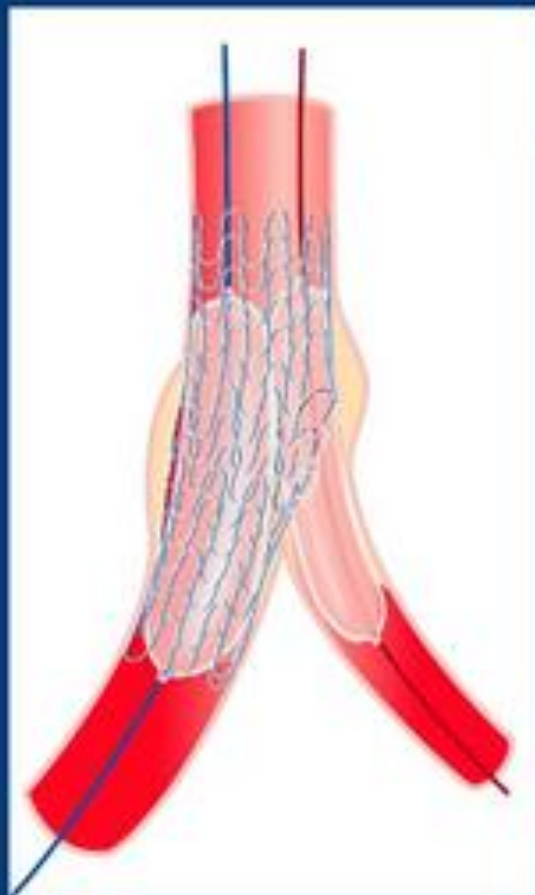


SWICH
of WIRES

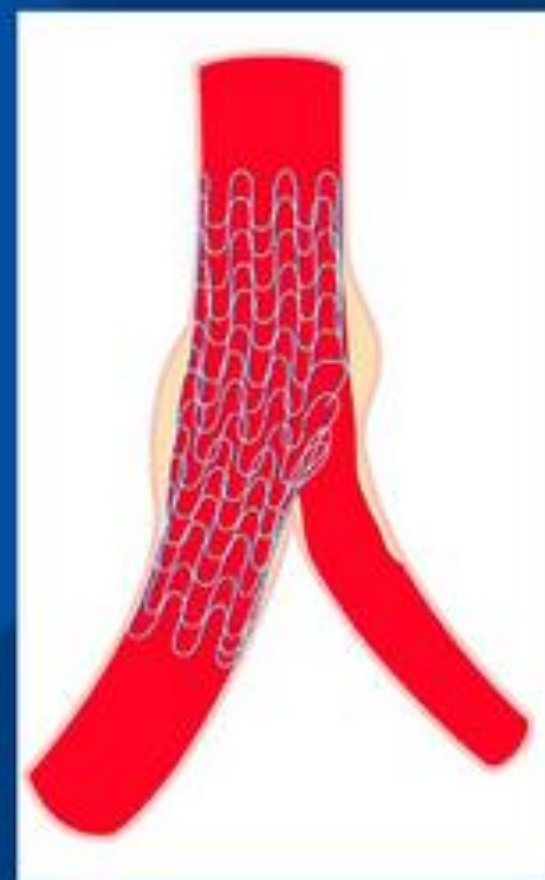
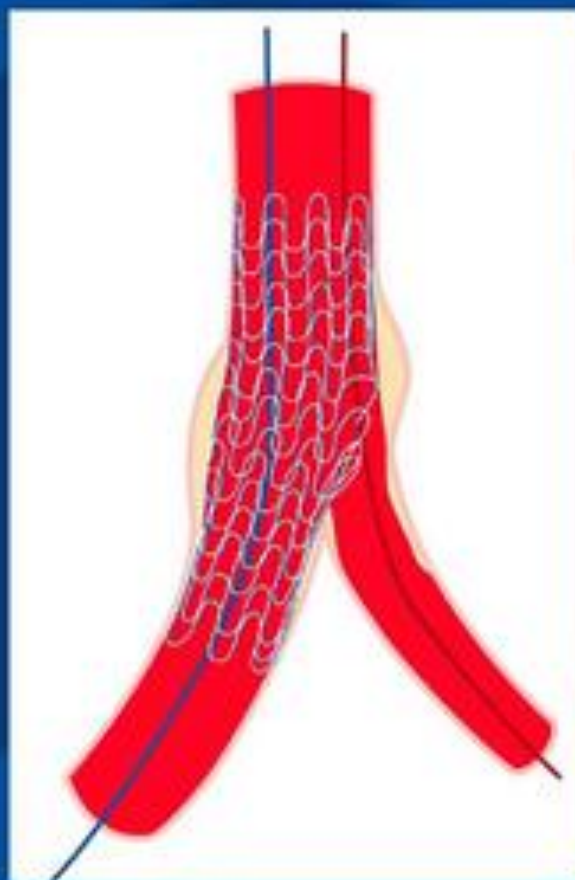


PCI STRATEGY IN TRUE BIFURCATION LESIONS

C.



FINAL
KISSING INFLATION

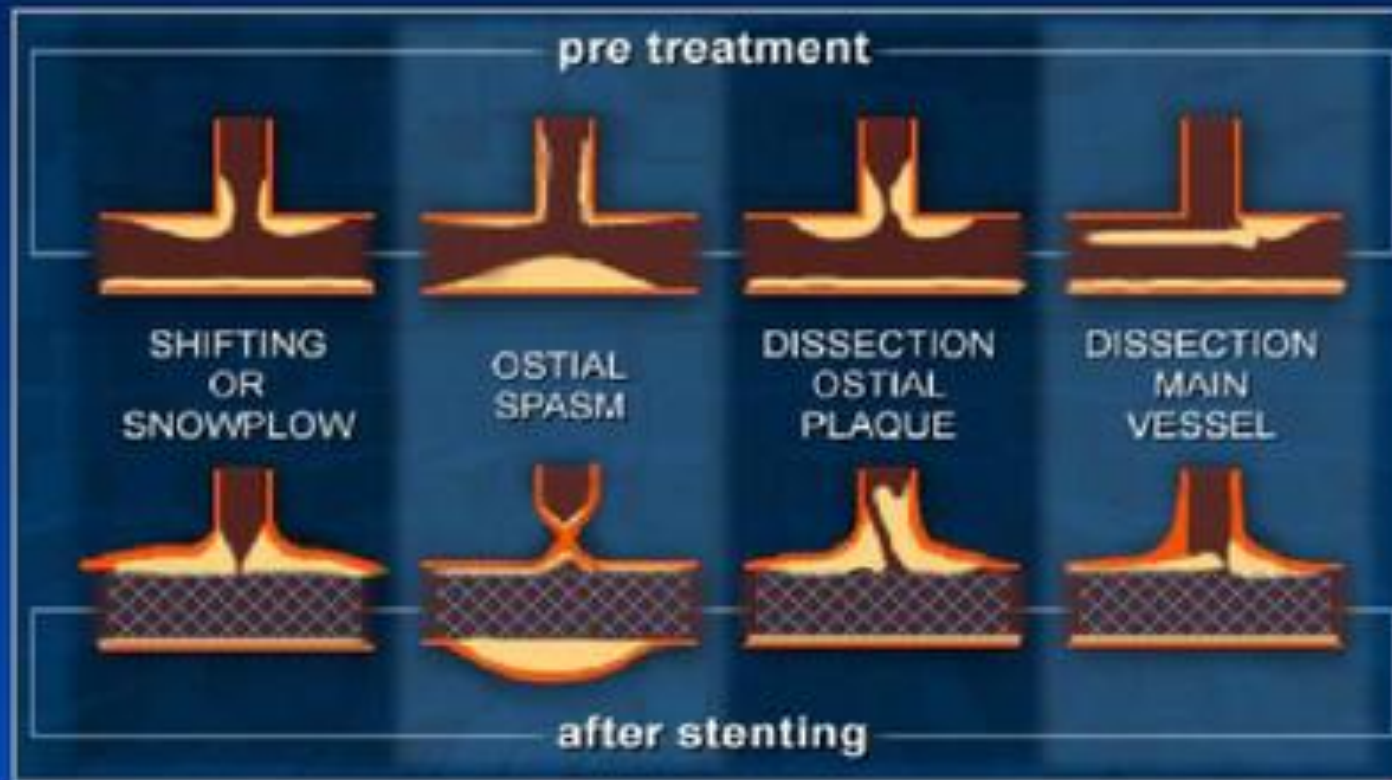


EXPECTED
FINAL RESULT



Side Branch Loss

Main Mechanism of Adverse Outcomes



First consideration: one (provisional) or two stents



- How large and important is the side branch?
- Does the side branch comes out from the main with an acute angle?
- Does the ostium or the proximal segment of the side branch have a significant narrowing?
- Is the side branch very difficult to be wired?
- Is the patient a very high risk patient and the side branch appears relatively important?
- Is main branch severely narrowed with a lot of plaque burden?

If the answer is YES the operator will lean more towards two stents

- **Sometimes a decision should be made only following predilatation of the main branch and of the side branch**

Stenting in bifurcation lesions

Complex Strategy :



stent also in side
branch

BIFURCATION STENTING STRATEGIES

T Stenting



Advantages

- Good coverage (angle $75^{\circ}+$)

Disadvantages

- Poor coverage (angle $<75^{\circ}$)
- Cross through side of stent for kissing inflation

Culotte



- Good coverage (all lesions)

- Must cross through side of stent, once or twice

V Stenting



- Maintained guidewire position
- Good coverage

- Limited lesion suitability

Crush

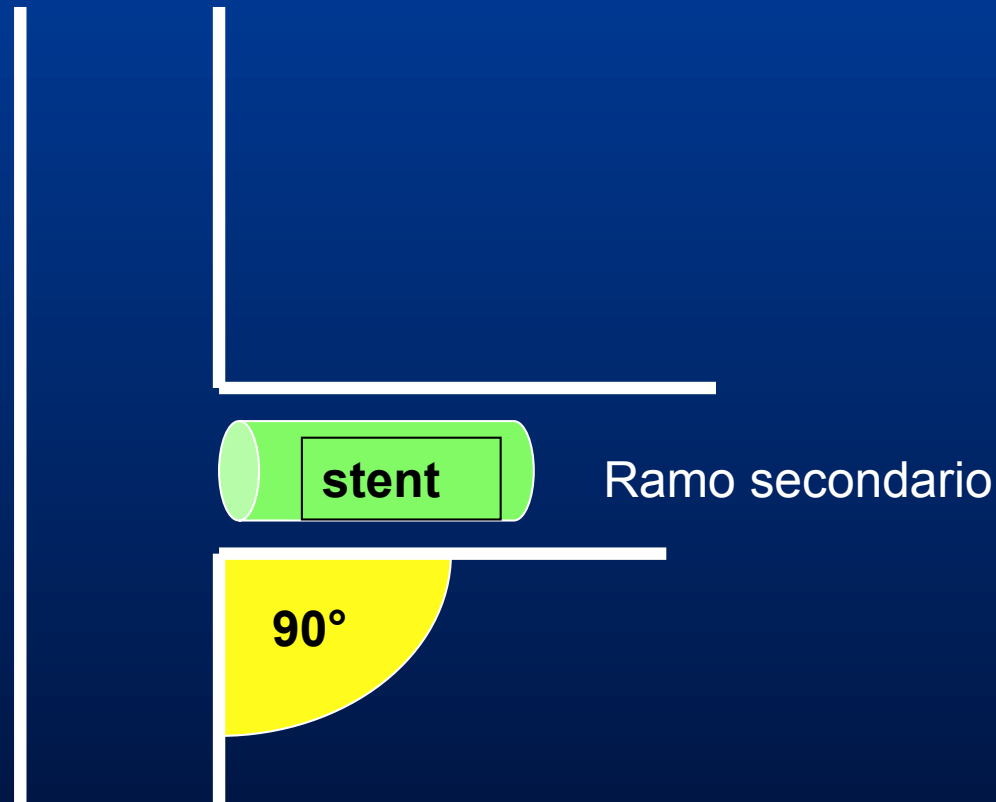


- Simple
- Good coverage

- Difficult branch access

T stent : angolo retto

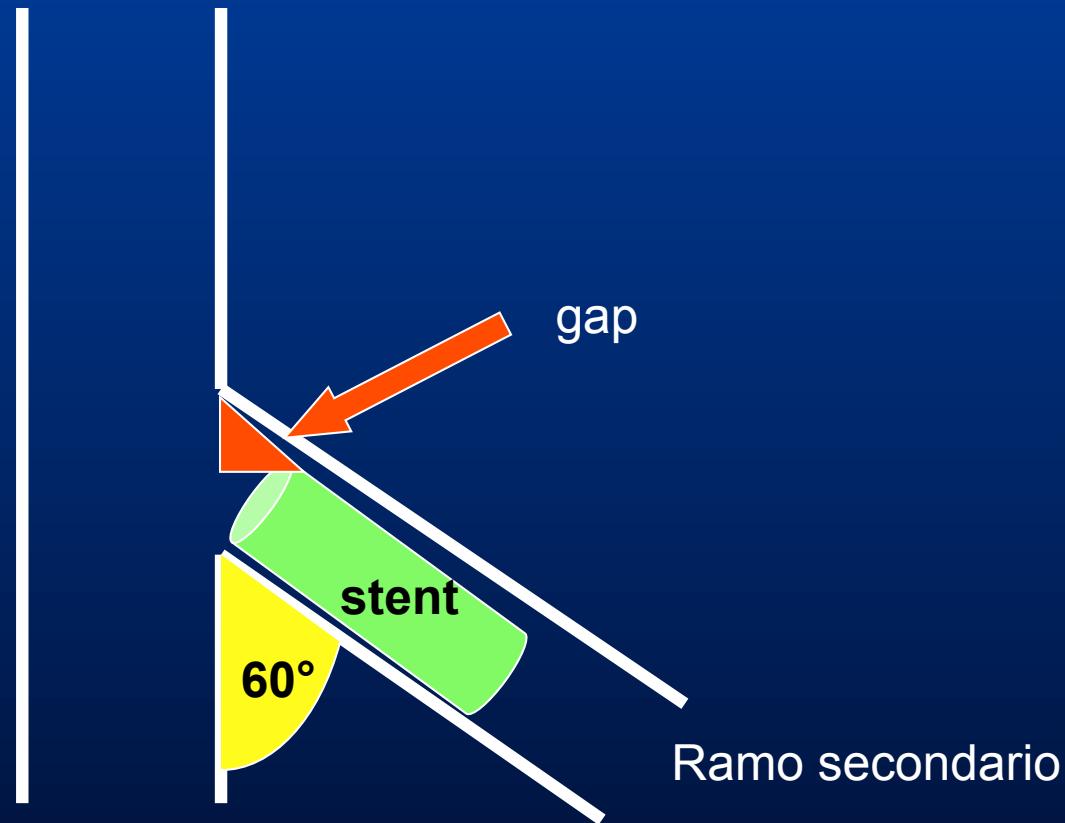
Ramo principale



Impianto ottimale con buona copertura a livello della biforcazione

T stent : angolo acuto

Ramo principale

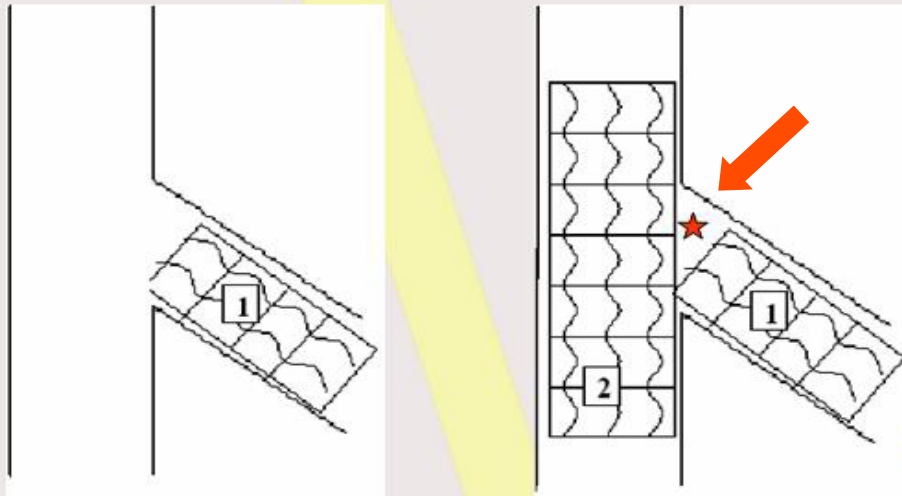


Parziale copertura della biforcazione



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BIFURCATION CLUB

« A » Family: SB stenting first



T Stenting

• « True » bifurcation lesions

• Y Angle

• Difficult SB access

• 6F

• GAP at SB ostium

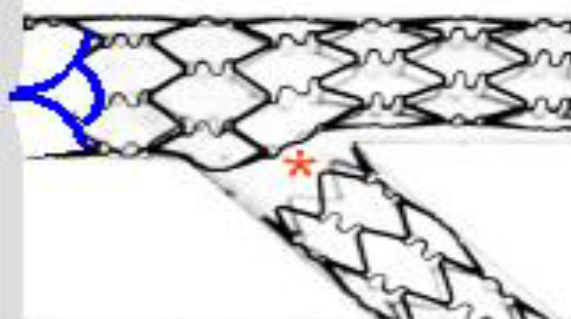
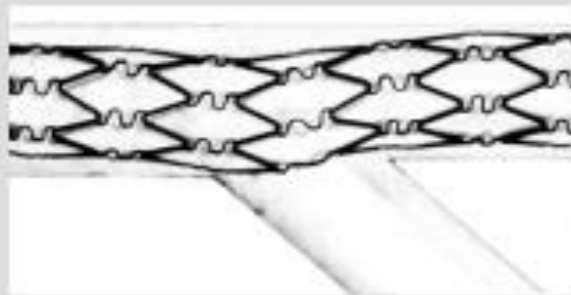
• Difficulties

- SB stent positioning
- MB stent crossing

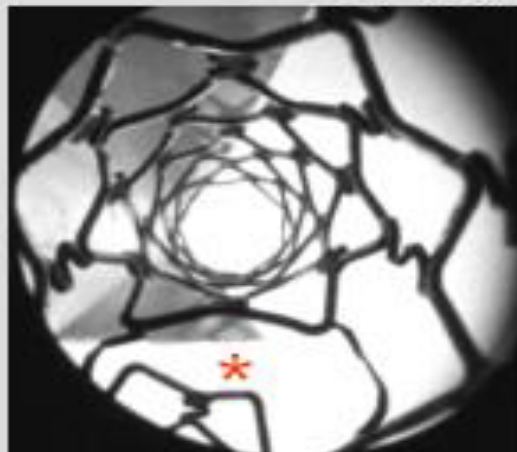
• Systematic double stenting

• Cost

Provisional "T" Stenting



The side-branch stent may be deployed too distally leaving gaps * in scaffolding and drug application with potential for restenosis(1)

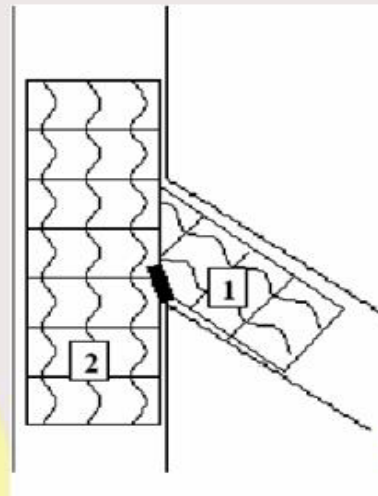
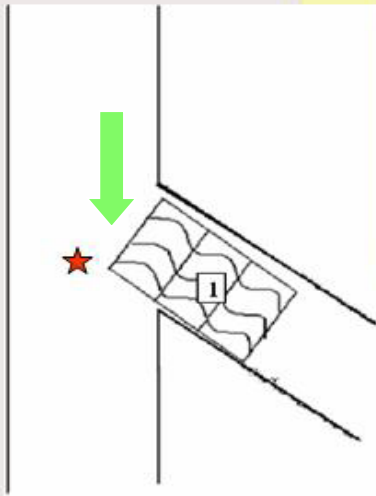


1. In the "Randomized Trial to Evaluate Sirolimus-eluting Stents in Coronary Bifurcations" most restenoses with 2 stents were at the side-branch ostium and thought to be due to gaps in scaffolding and drug application (Colombo, Circulation March 04)



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BIFURCATION CLUB

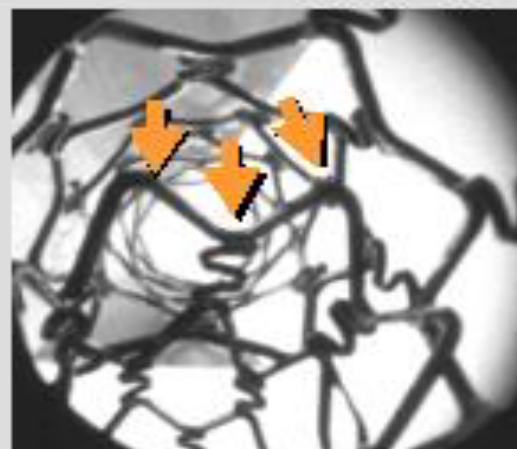
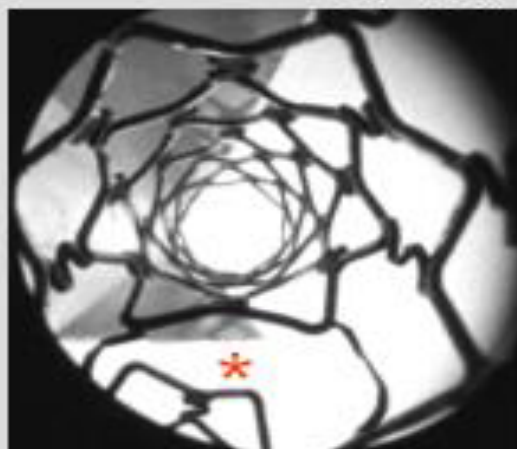
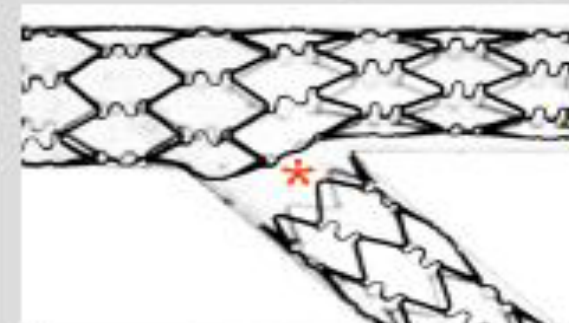
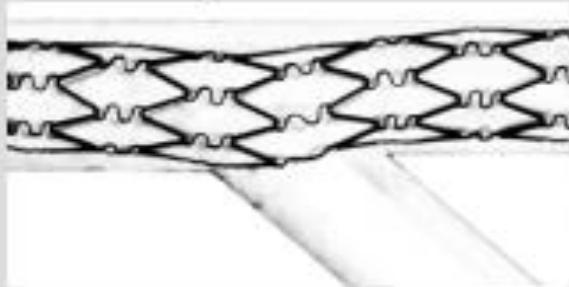
« A » Family: SB stenting first



T Stenting

- « True » bifurcation lesions
- Y Angle
- Difficult SB access
- 6F
- good covering? Metal excess?
- Difficulties
 - SB stent positioning
 - MB STENT CROSSING
- Systematic double stenting
- Cost

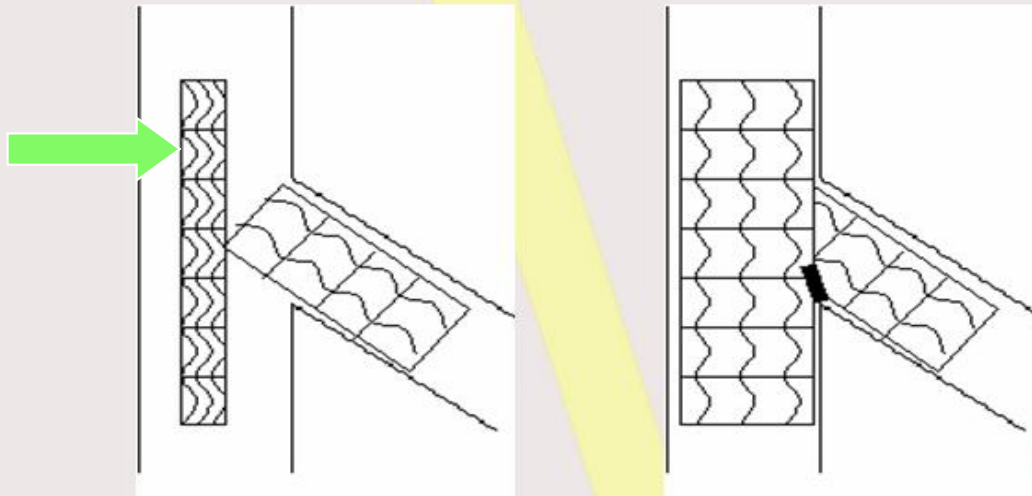
Provisional "T" Stenting



Or the stent may be too proximal with the potential for obstruction of subsequent access



« A » Family: SB stenting first



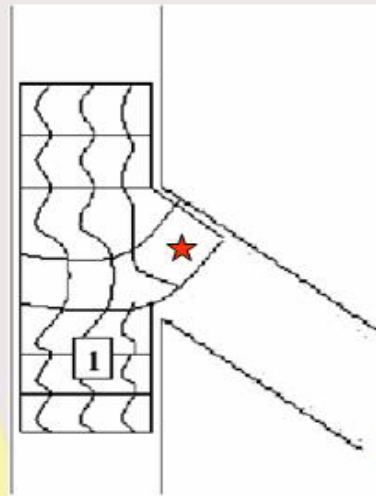
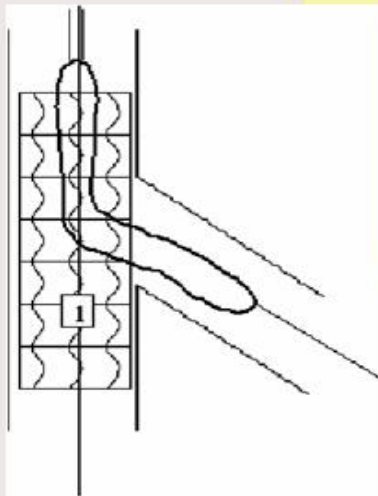
« Modified T Stenting »

- « True » bifurcation lesions
- All angles
- Difficult SB access
- **8F (7F)**
- Good covering? Metal excess?
- Difficulties
 - Predilatation
 - MB stent crossing
- Systematic double stenting
- Cost



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« B » Family: MB stenting accross SB first



« Provisional T Stenting * »

• « True / False » bifurcations

• All angles?

• Difficult SB access?

• 6F

• SB ostium stenting? Chance

• Difficulties

- wire/balloon a stent cell
- stent through a cell

• Provisional SB stenting

• Cost

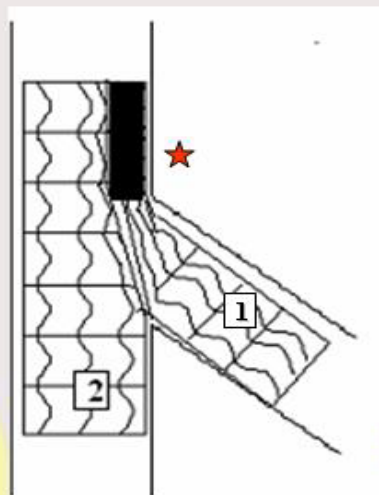
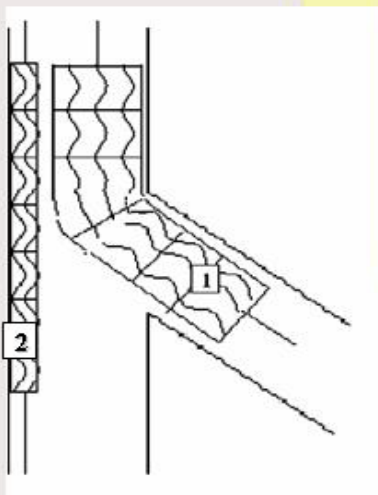


Dal 2002 DES: CRUSH technique



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« A » Family: SB stenting first



« Crush technique » « External crush »

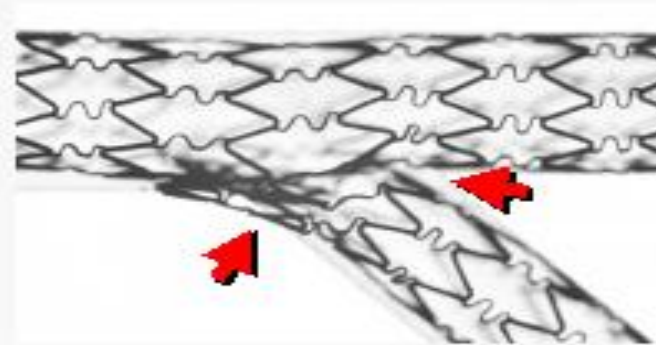
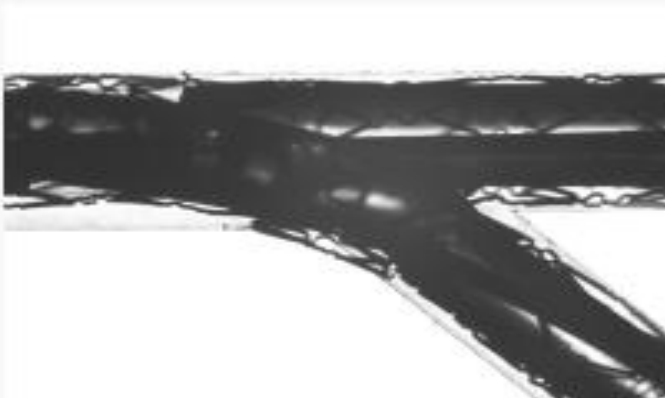
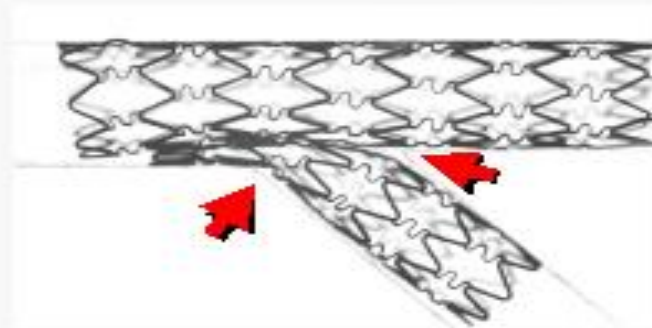
- « True » bifurcation lesions
- All angles
- Difficult SB access
- 8F (7F)
- Good covering? Metal excess?
- Difficulties
 - Predilatation
 - MB stent crossing
- Systematic double stenting
- Cost

A. Colombo, « Modified T-stenting technique with crushing » CCVI 2003, 60:145-51



Crush + kissing

Cypher Stent Bifurcation “Crush” and “Kissing Balloons”



Ormiston PCR 2003

Problems in Crush technique

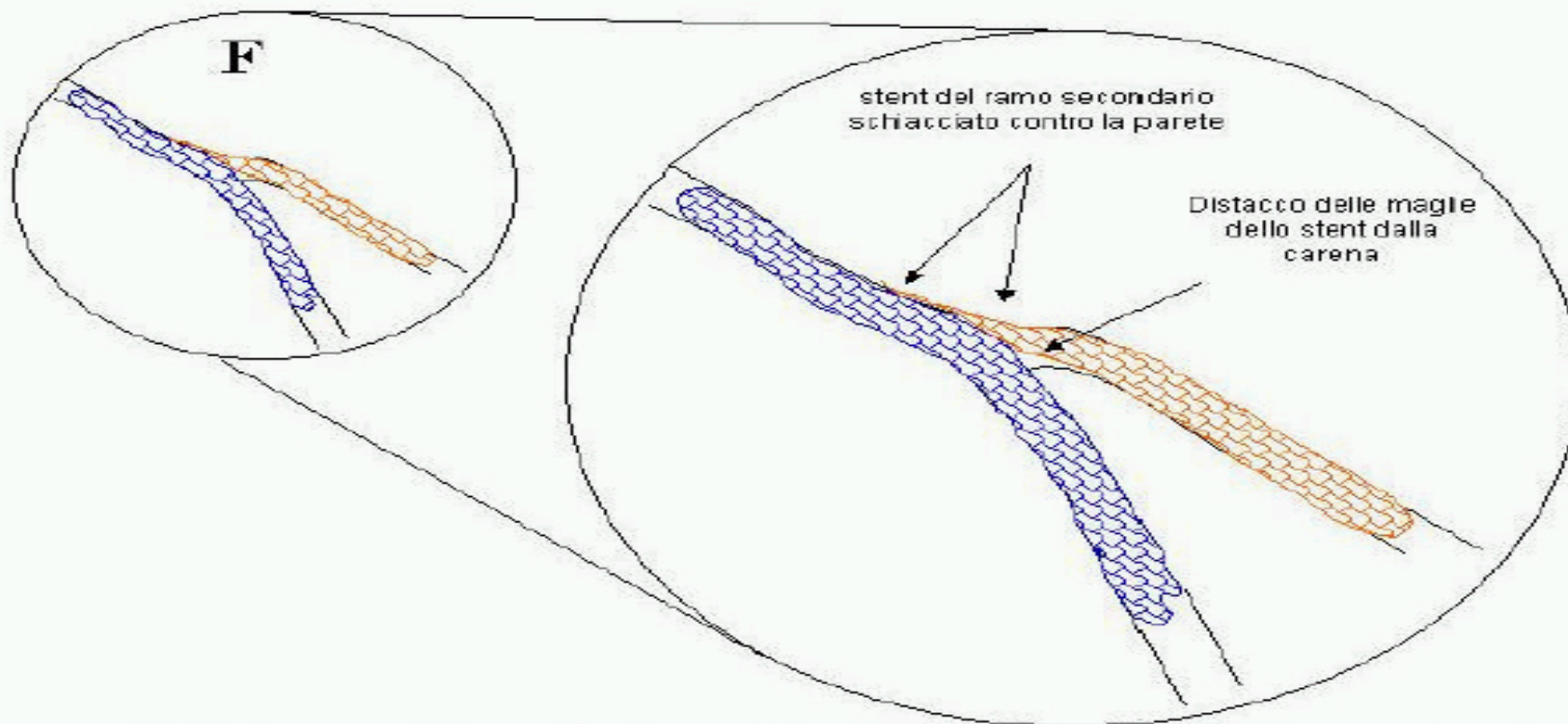
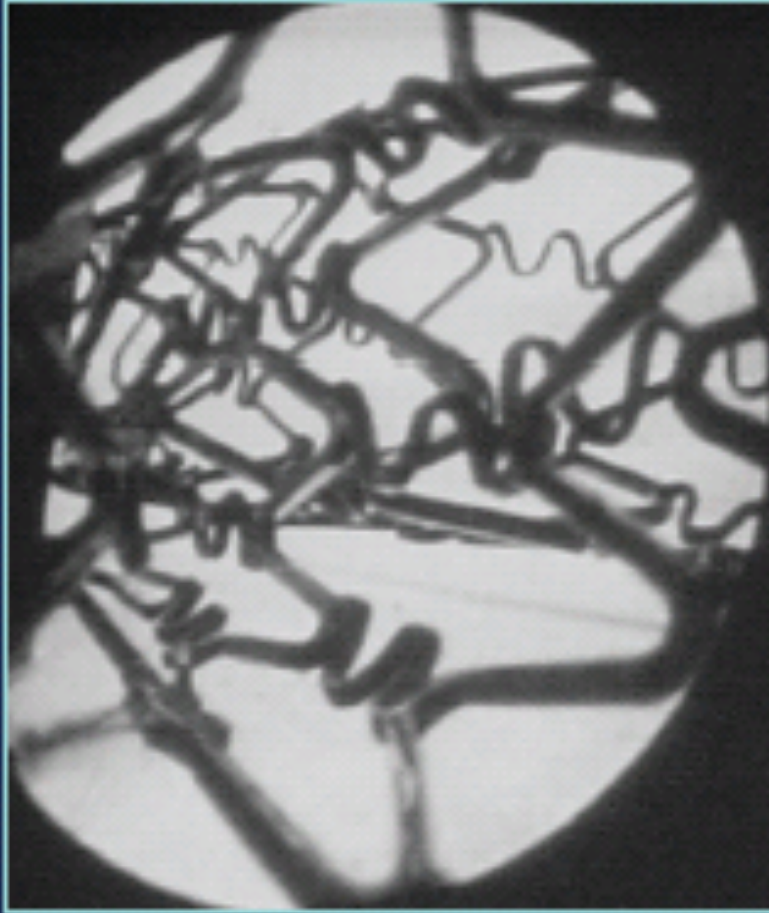
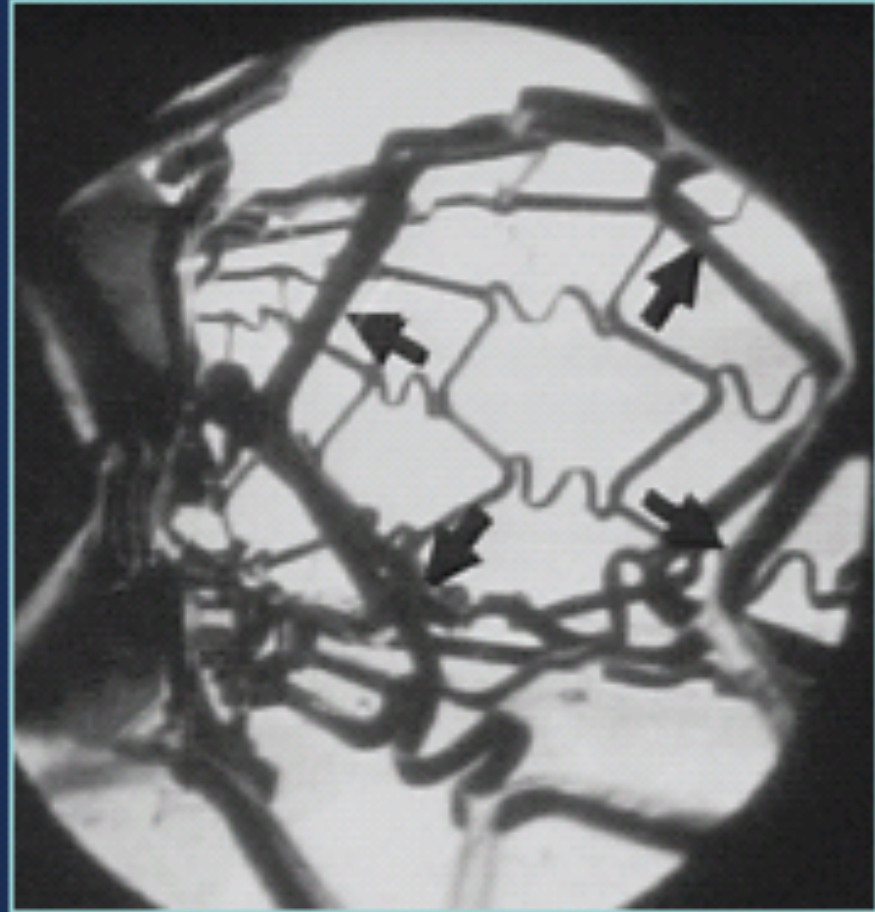


Figura 2. Schema della risultato dopo espansione dello stent nel vaso principale, e prima del “kissing balloon” finale. Deformazione e schiacciamento dello stent nel ramo secondario con parziale distacco delle maglie dello stent dalla carena.

Side brunch ostium after Crush



Pre-kissing

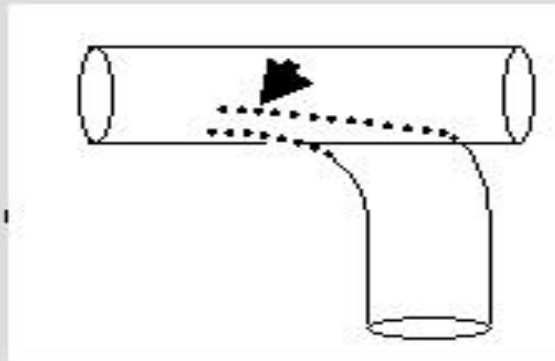


Post-kissing

Provisional Internal Crush

“Internal” (or “reverse”) Crush

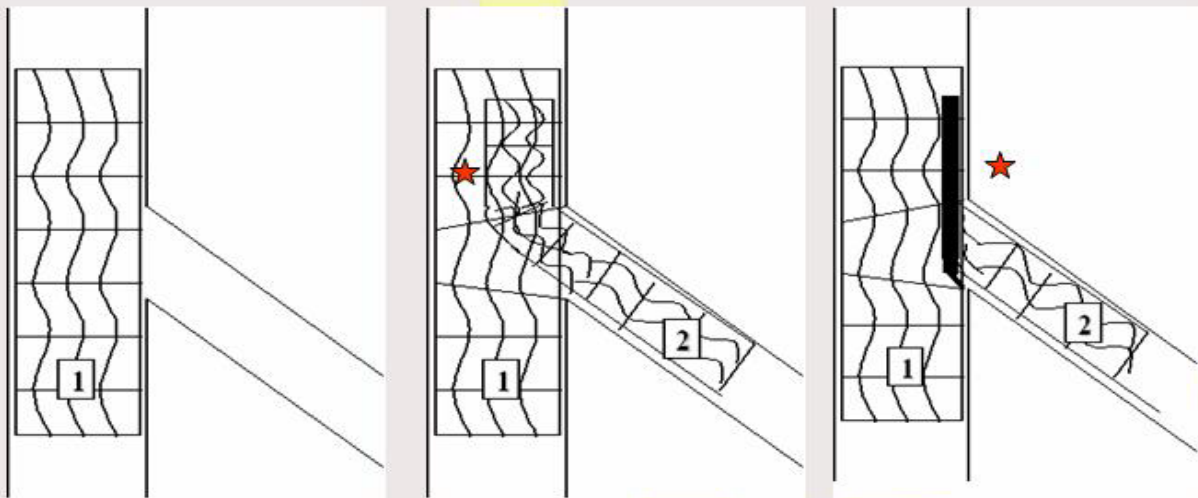
A provisional side-br stenting strategy where the second stent is deployed and crushed **inside** the main branch stent





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« B » Family: MB stenting accross SB first



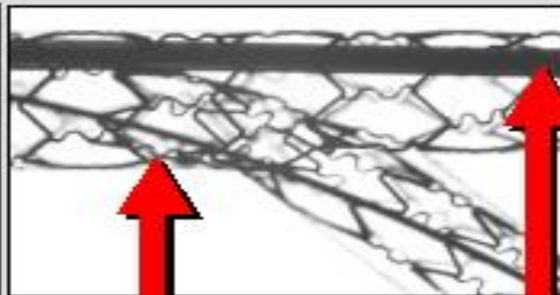
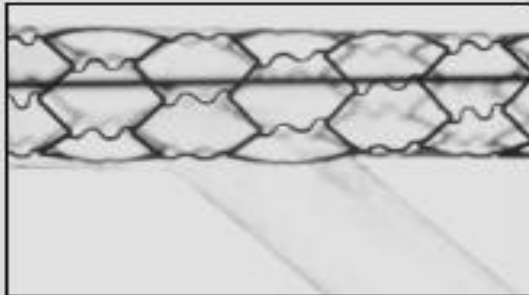
« Internal crush », « *Reverse crush »

- « True » bifurcation lesions
- All angles?
- Difficult SB access?
- 6F
- Good covering? Metal excess?
- Difficulties
 - wire/balloon a stent cell
 - stent through a cell
- Provisional SB stenting
- Cost

* A. Colombo

Internal Crush

If the side-branch is unsatisfactory after balloon dilatation, an attempt can be made to deploy a DES in the side-branch with a balloon parked in the main branch



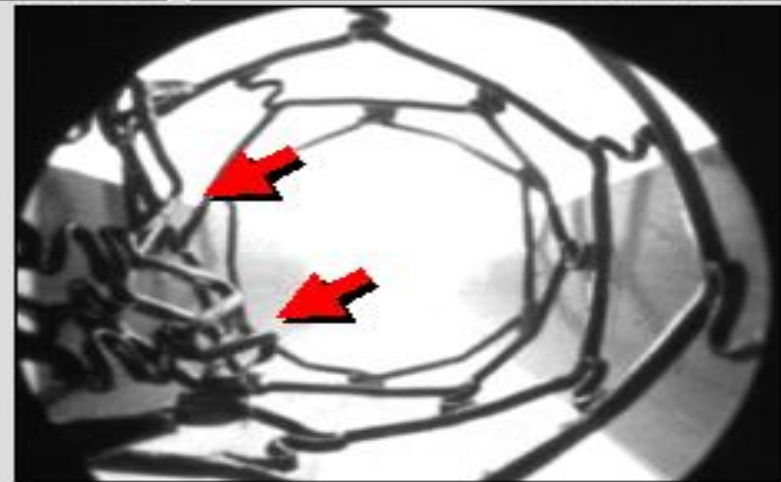
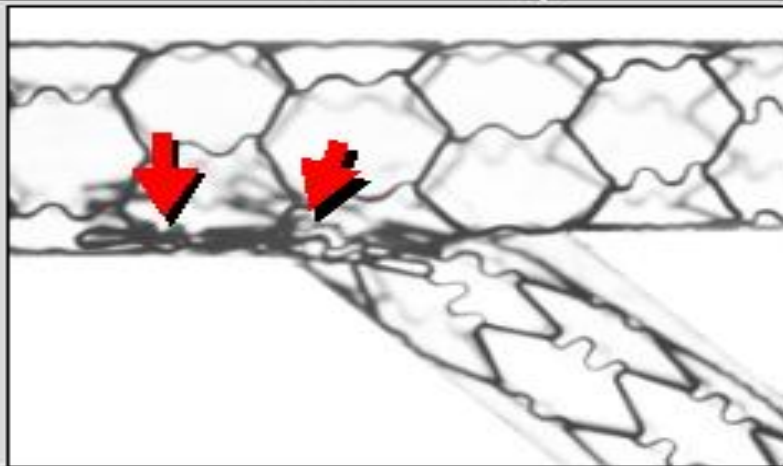
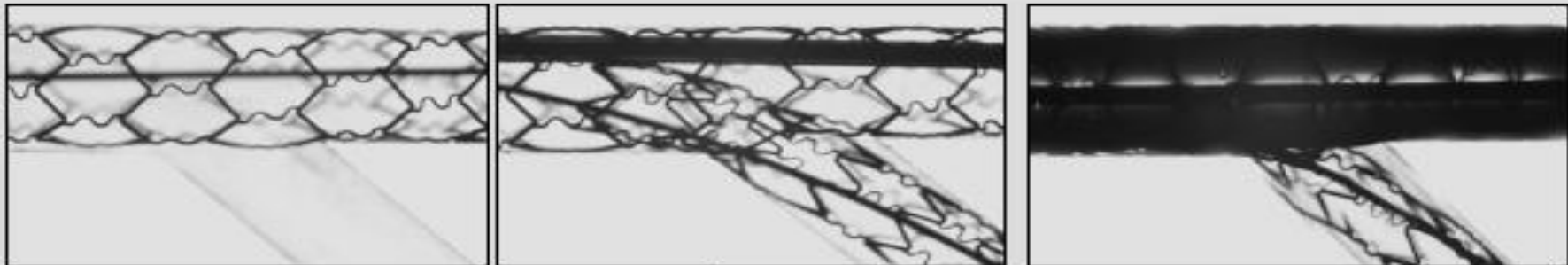
**Deploy
DES in
side-br**

**Balloon
parked in
main br**

Omiston, PCR 04

Internal Crush

“Internal Crush”. The stent is crushed and flattened against the inside of the main branch stent



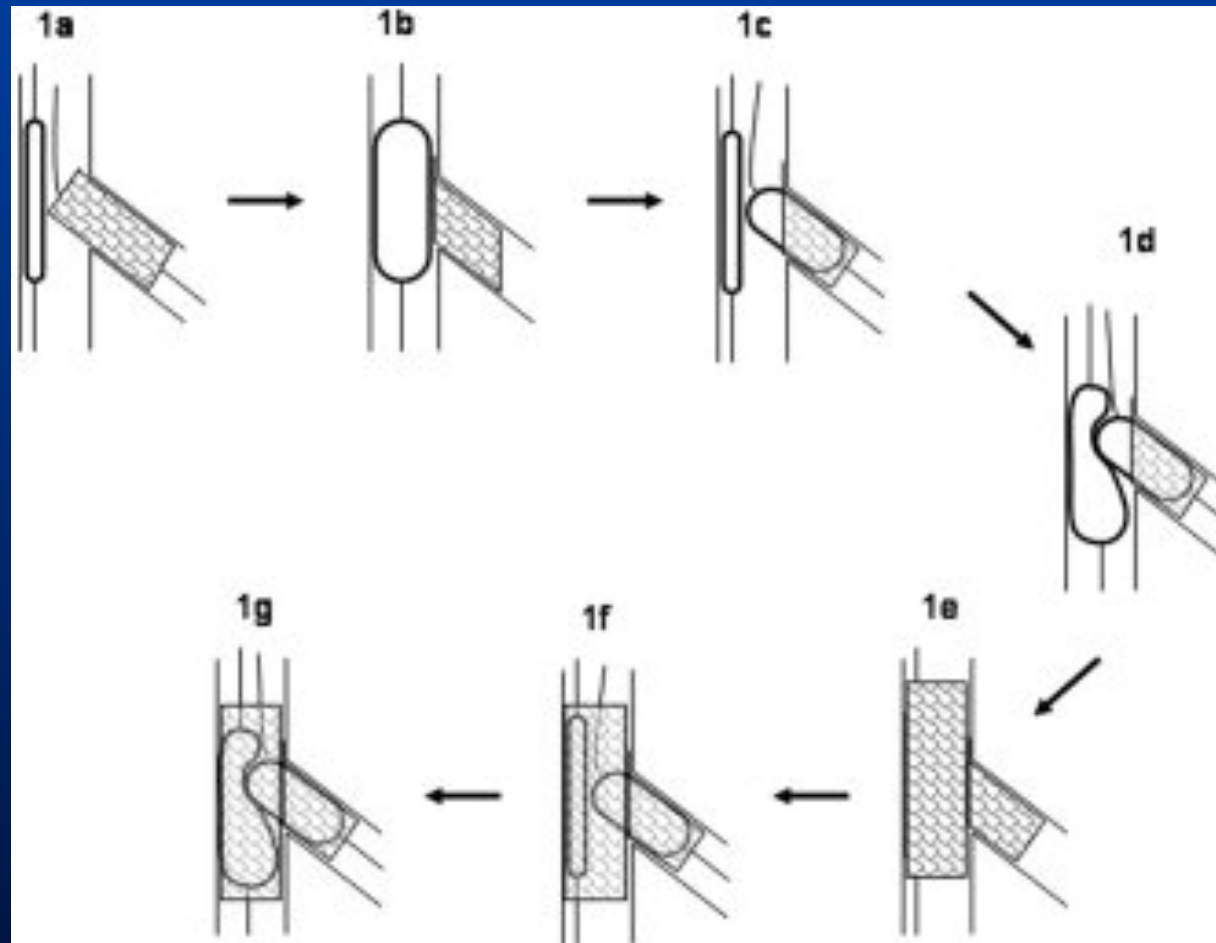
Ormiston, PCR 04

“Kissing” Balloon Post-dilatation

- After “External Crush” corrects distortion
- After “Internal Crush” causes distortion!!



Modified Crush (sleeve technique)



Stenting Bifurcations: The Last Frontier for Fantasy in Coronary Interventions
Antonio Colombo

Man-Hong J, Hee-Hwa H, Miu R, Wing-Hing C.

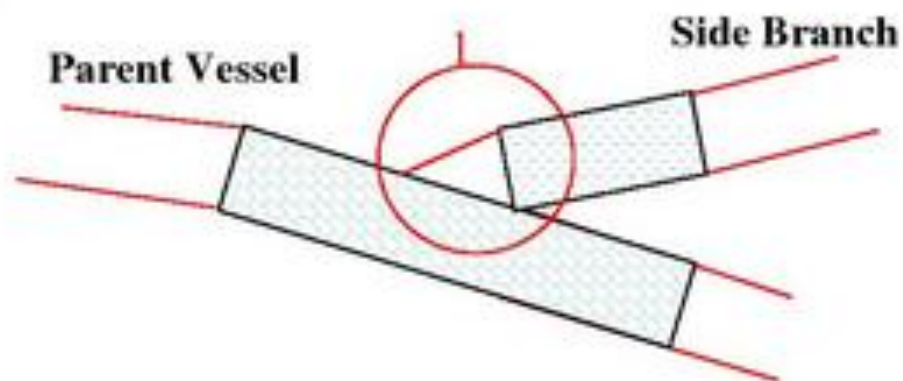
Catheter Cardiovasc Interv 2006; **67**: 404-410.

Current PCI for Bifurcation Lesions

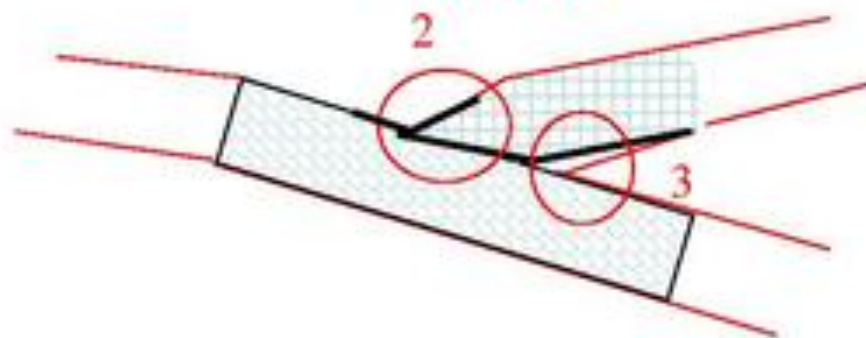
Failures are probably related to implant technique and stent design:

- T-stenting can leave a gap in coverage at the SB ostium (1)
- Crush technique leaves 2 or 3 stent layers to block side branch flow (2), and
- The crushing action pulls the stent away from the carina (3)

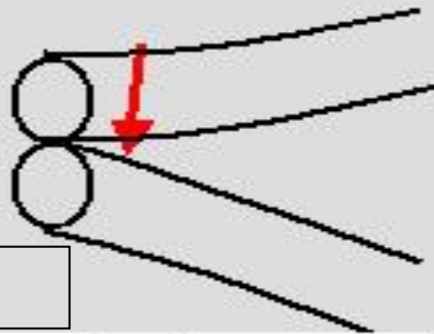
“T-stent”



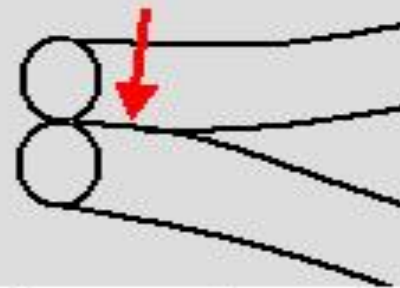
“Crush”



“V” Stenting



Touch



Kissing

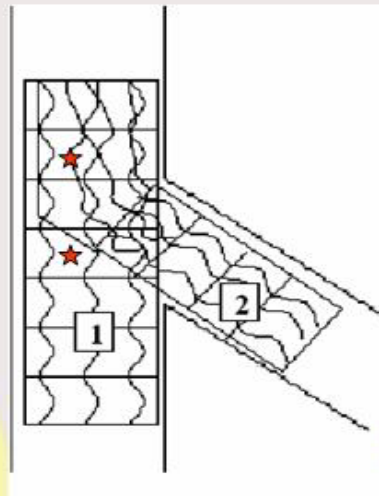
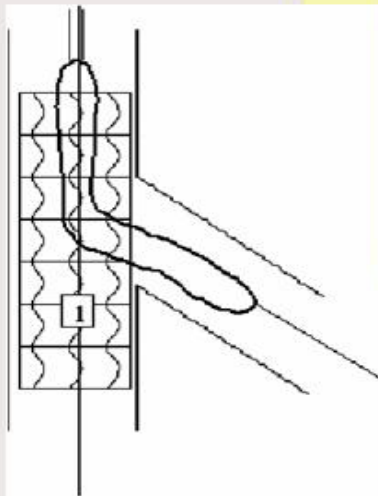
- Two stents are deployed simultaneously.
- The "carina" may be moved proximally
- Safe, quick, side-br wires retained throughout
- Applicable to limited anatomy (big prox vessel)
- Is a commitment to 2 stents

“Culotte” technique



EUROPEAN
BIFURCATION CLUB

« C » Family: double stenting of proximal MB

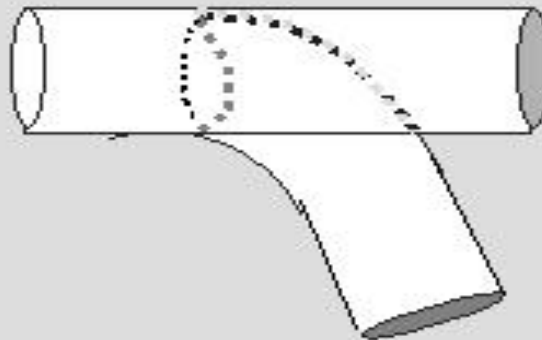


« *Culotte »

- « True » bifurcation lesions
- All angles?
- Difficult SB access?
- 6F
- Good covering? Metal excess?
- Difficulties
 - wire/balloon a stent cell
 - stent through a cell
- Provisional SB stenting
- Cost

*Trousers, Y...

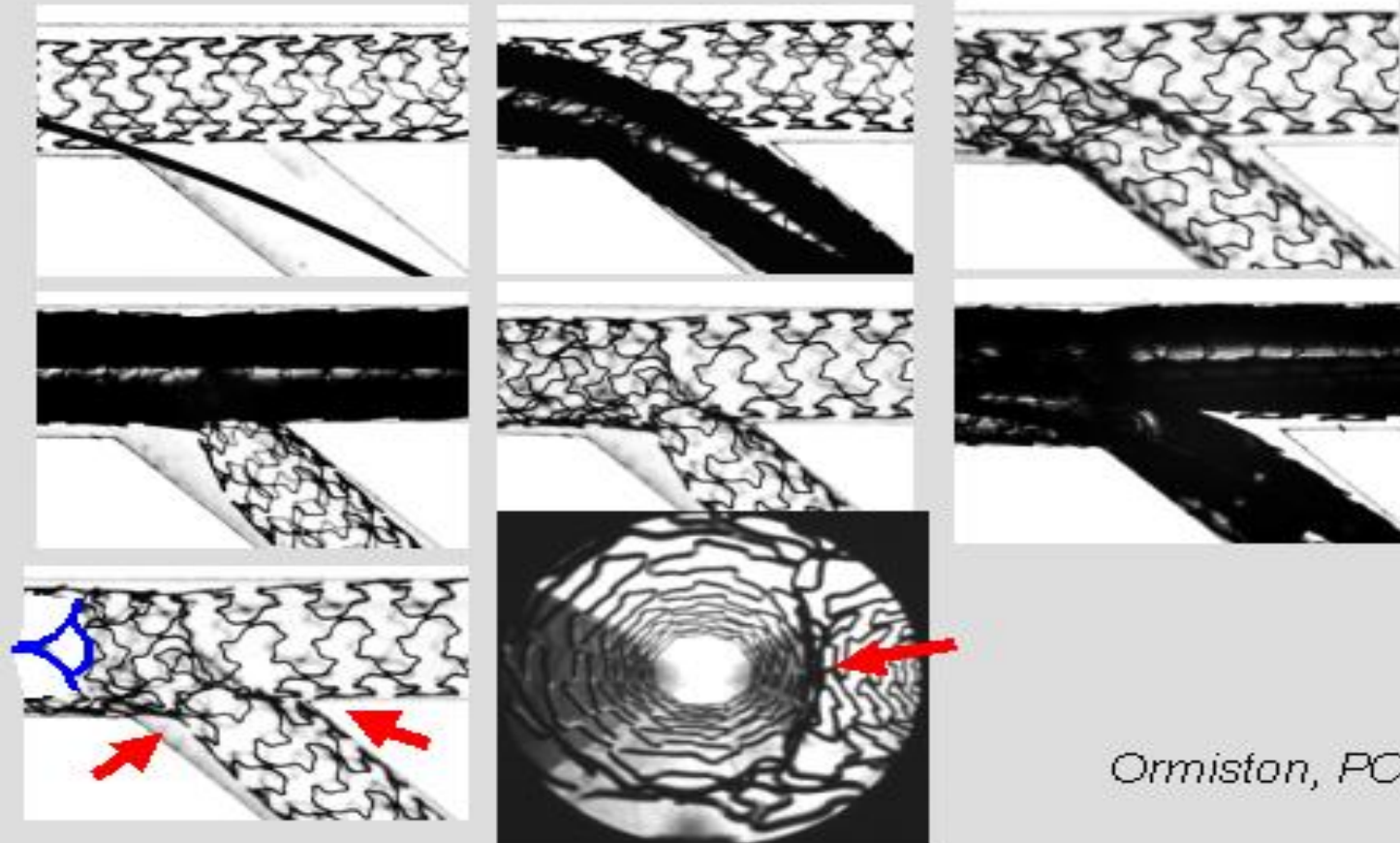
The “Culotte” Technique-
Provisional side-br stenting in the DES era



Ormiston, PCR 04

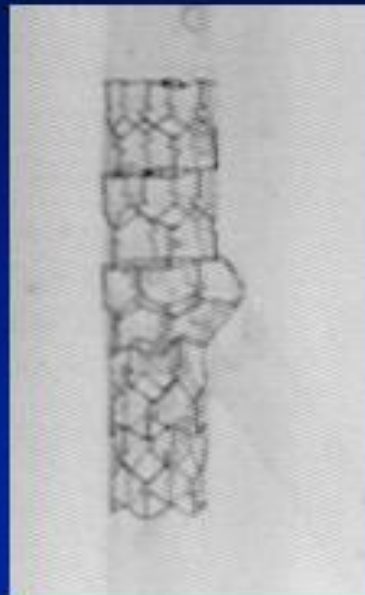
“Culotte” technique

"There is no main branch obstruction after kissing

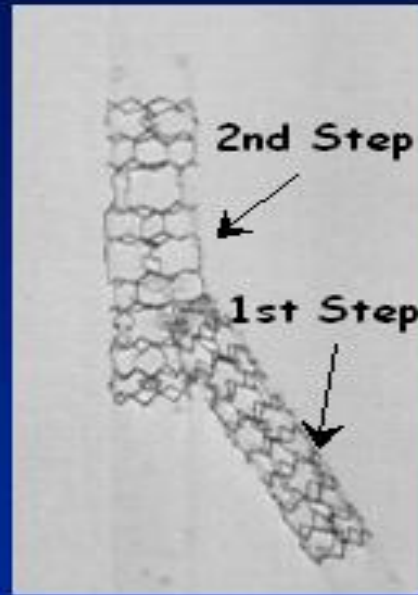


Ormiston, PCR 04

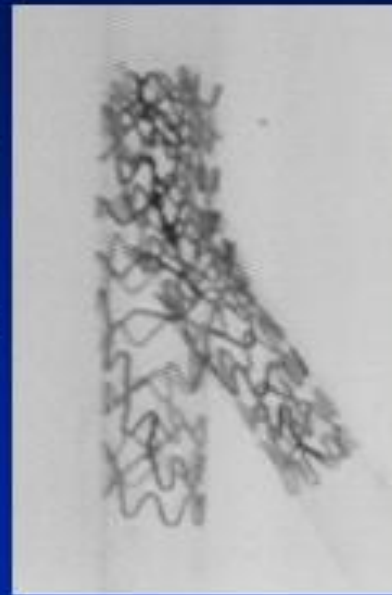
Bifurcation Stenting



T stenting



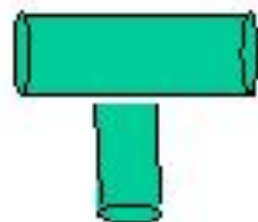
"Culotte"



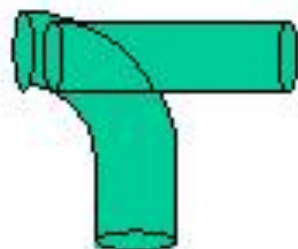
V stenting



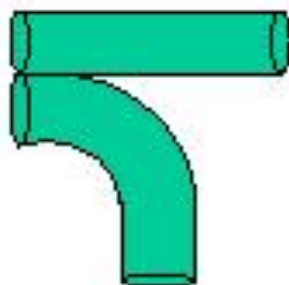
LEFT MAIN STENTING: DRUG ELUTING STENTS



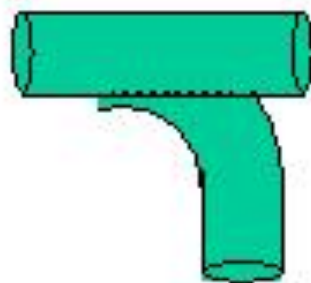
T



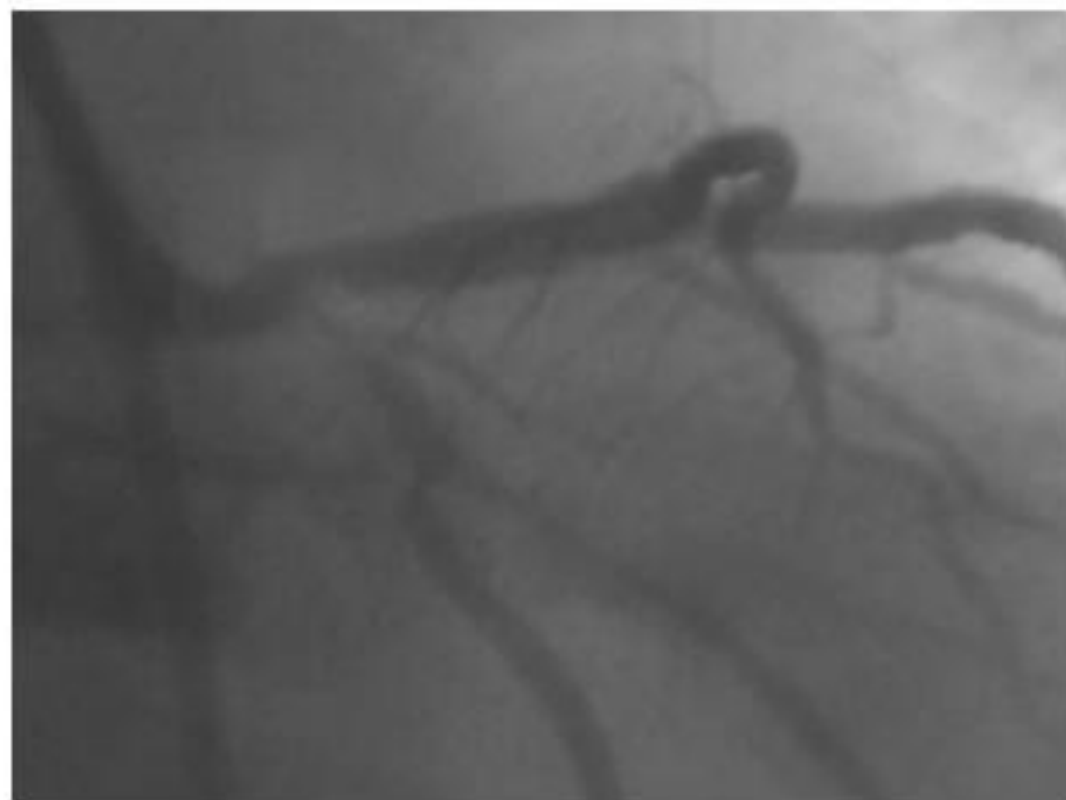
Culotte



V

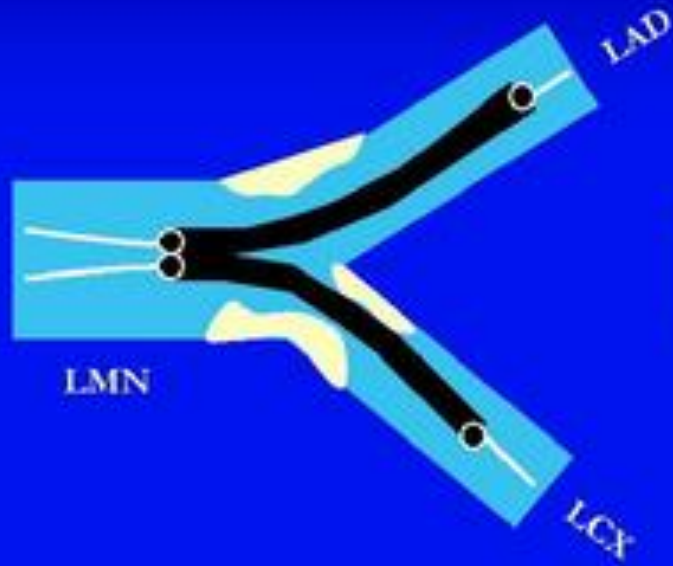


Crush

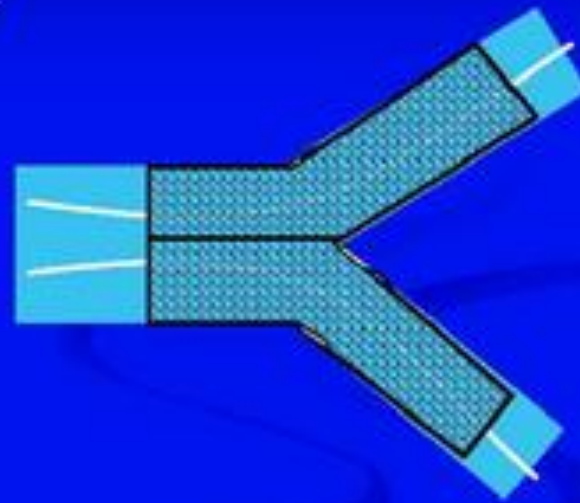


Bifurcation left main

Approaches to LMN Bifurcation Stenting: The “Double Barrel” Technique



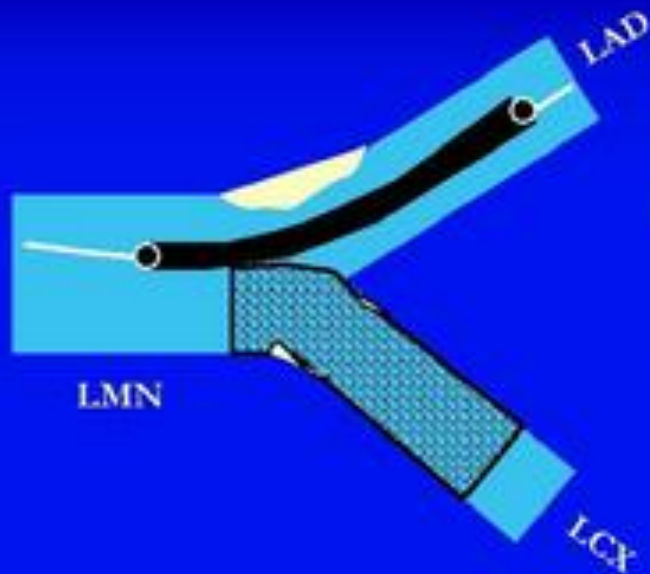
Positioning of stents



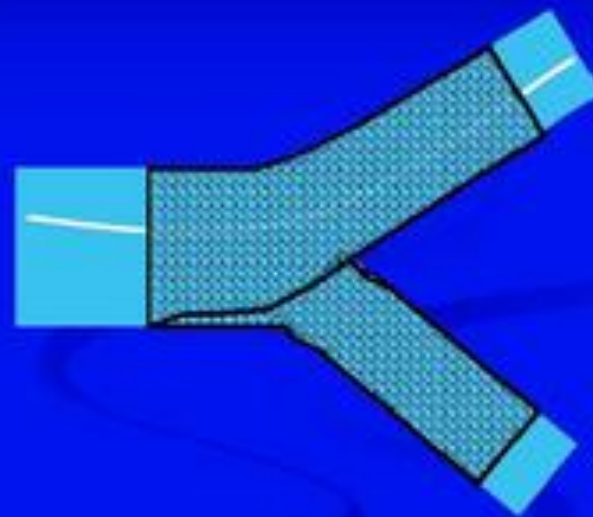
Simultaneous deployment of both stents

Bifurcation left main

Approaches to LMN Bifurcation Stenting: The “Crush” Technique



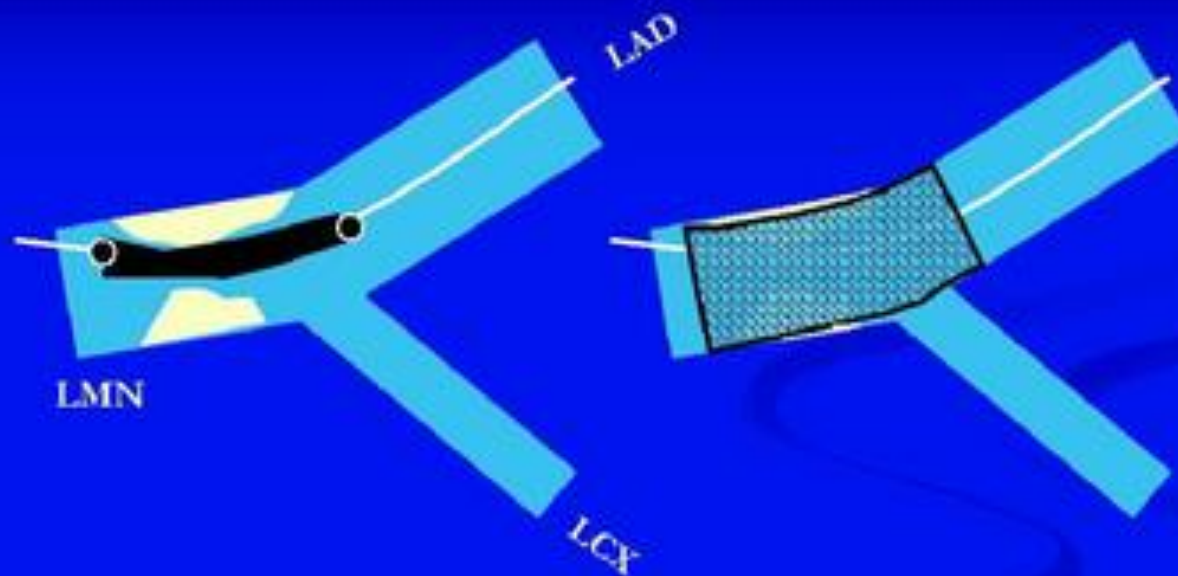
Withdrawal of LCX wire



Deployment of LAD stent

Bifurcation left main

Approaches to LMN Bifurcation Stenting:
Stent across small, non-dominant LCX

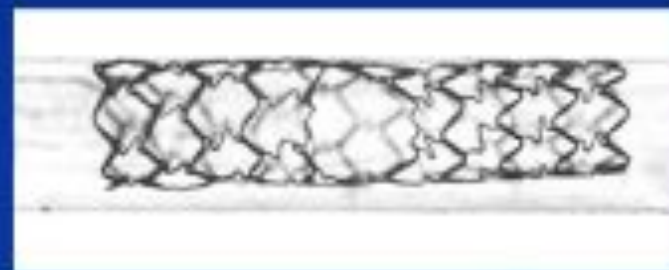


1. Wire LAD, position stent

2. Deploy stent (rewire LCX, PTCA if needed)

Dedicated Bifurcation Stents by Boston Scientific

AST
SLK



AST
Petal



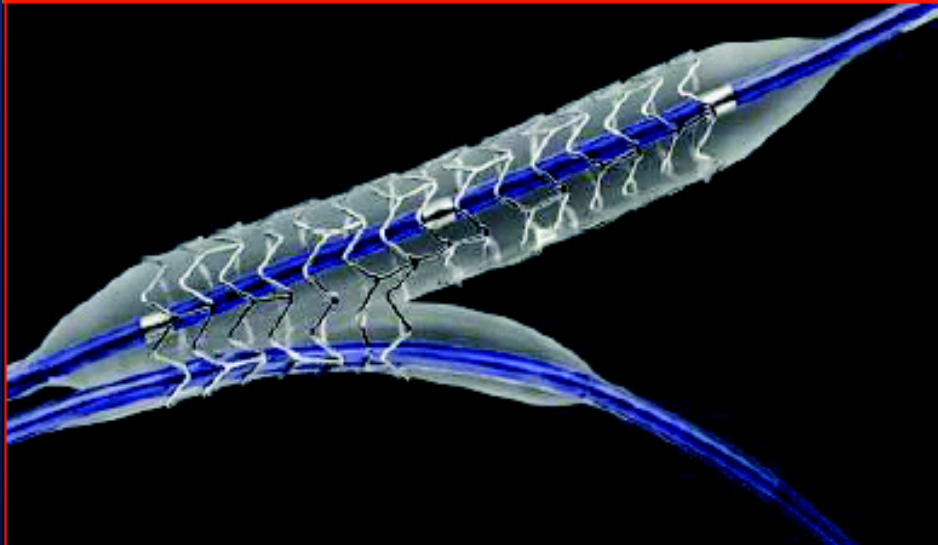
- Double wire system
- Unique balloon design



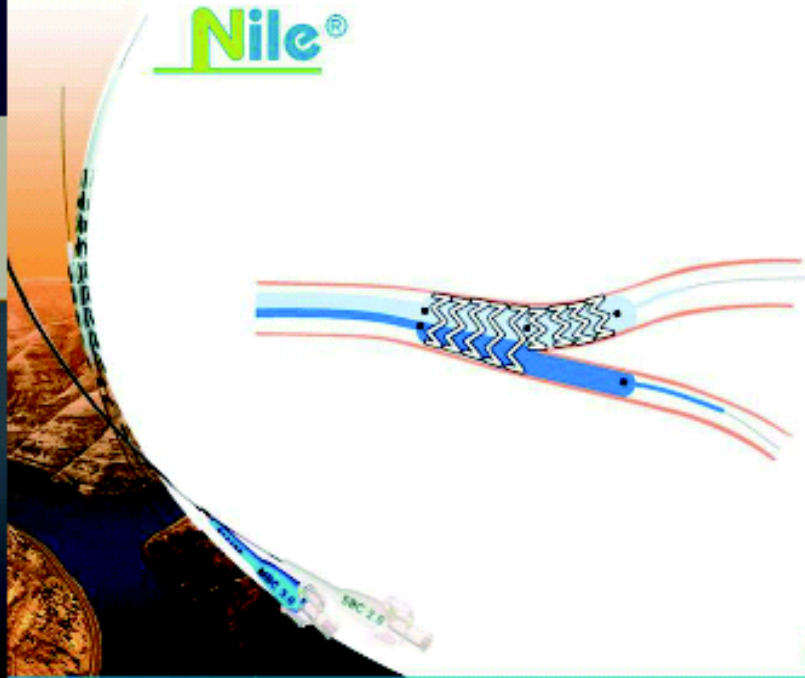
MULTI-LINK
FRONTIER™
Coronary Bifurcation Stent System



GUIDANT



Nile®



minivasys



INVATEC
Innovative Technologies

Dedicated Main Vessel bifurcation stents

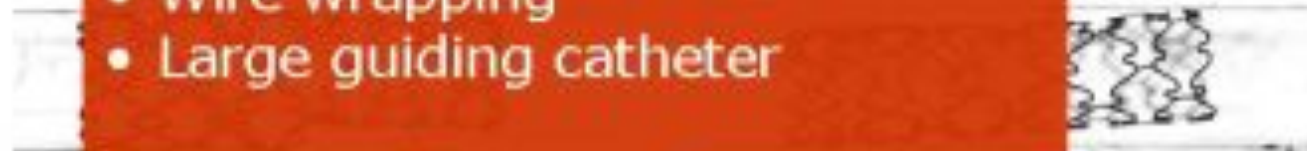
Frontier



Issues:

- Difficult to deliver
- Wire wrapping
- Large guiding catheter

Invatec



AST - Petal



- 4.8 Fr profile
- Suited to narrow angles only
- Gives up access to one branch during delivery
- Low adoption rate thusfar

Devax



Bifurcation lesion

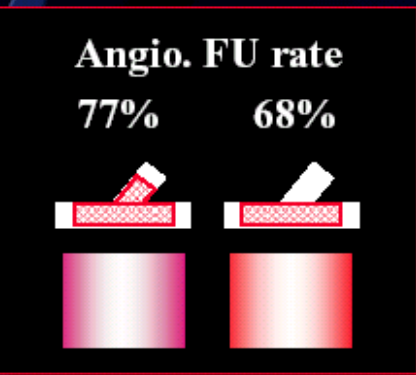
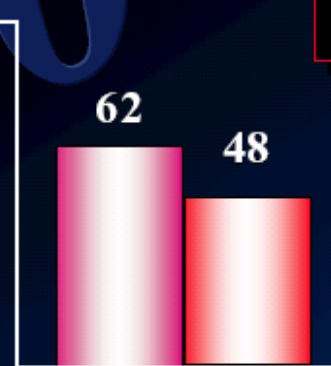
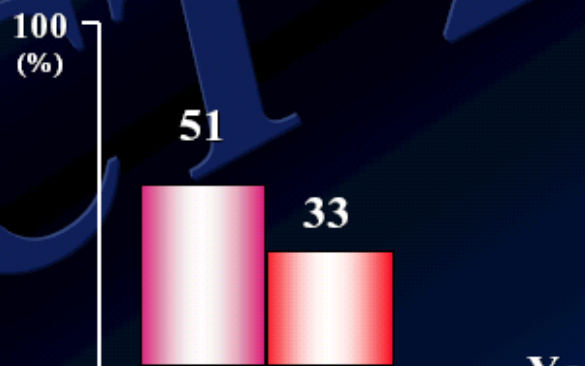
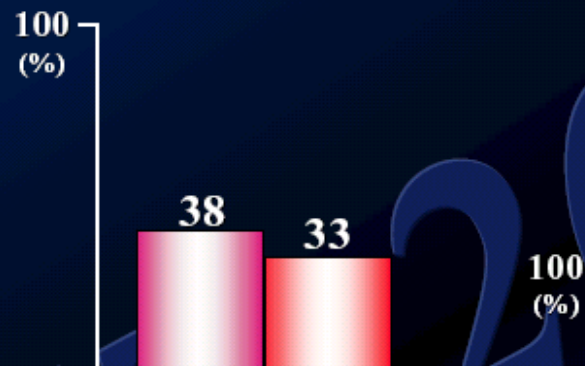


Restenosis with bare metal stent

Main Branch

Restenosis rates

Side Branch



Global restenosis rate

Yamashita et al. JACC 2000; 35: 929-36

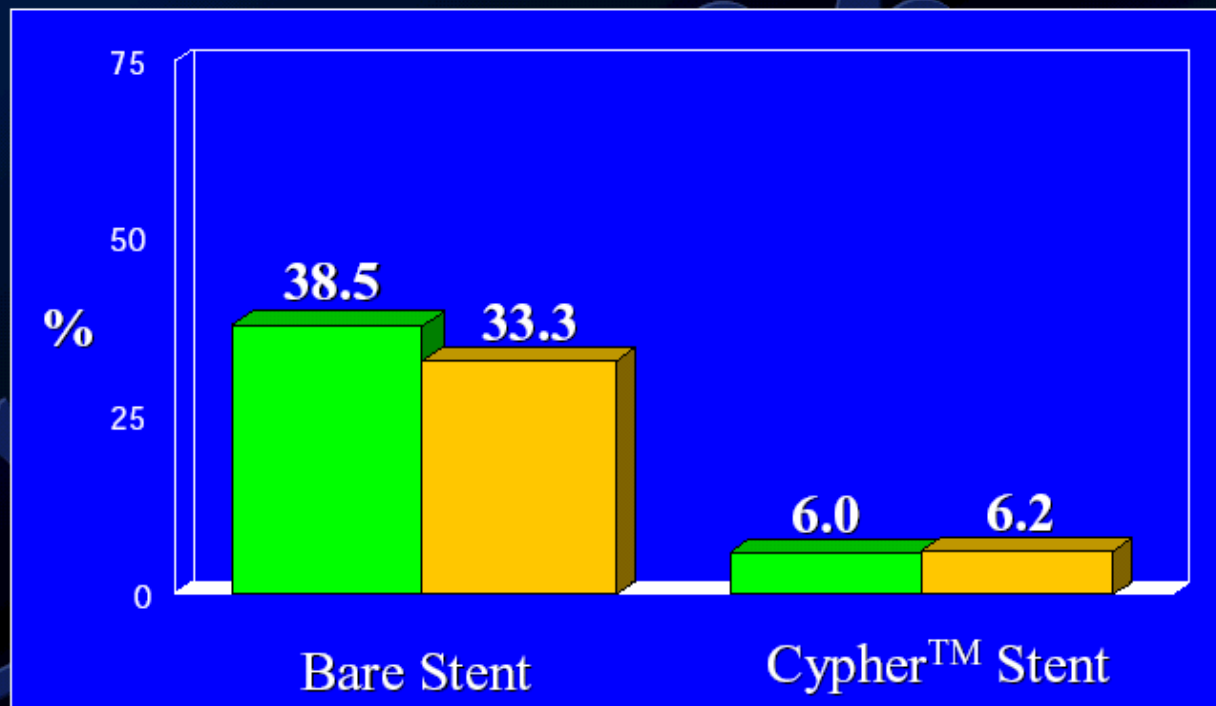
Kusatsu Heart Center, Shiga, Japan

Bifurcation lesion



Comparison with historical data

**Main Branch
In-Segment
Restenosis**



Stent + Stent



Stent + PTCA

Kusatsu Heart Center, Shiga, Japan

Bifurcation lesion

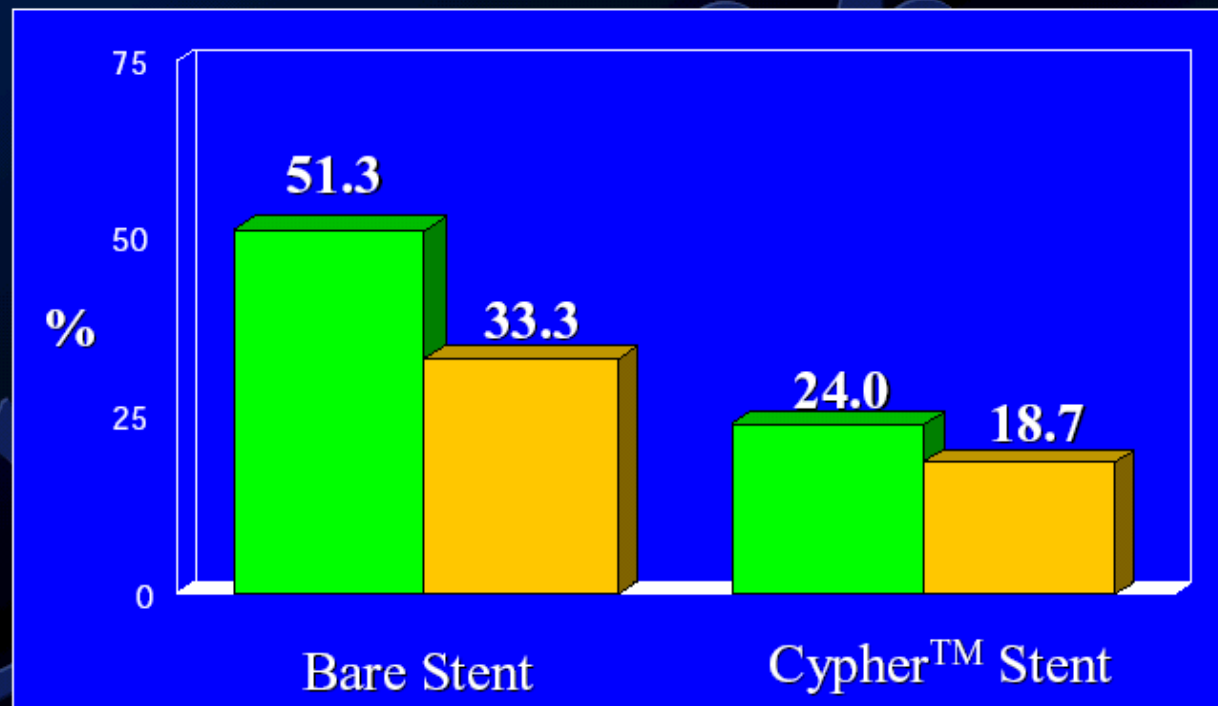


Comparison with historical data

Side Branch

In-Segment

Restenosis



Stent + Stent



Stent + PTCA

Kusatsu Heart Center, Shiga, Japan

Nordic PCI study:

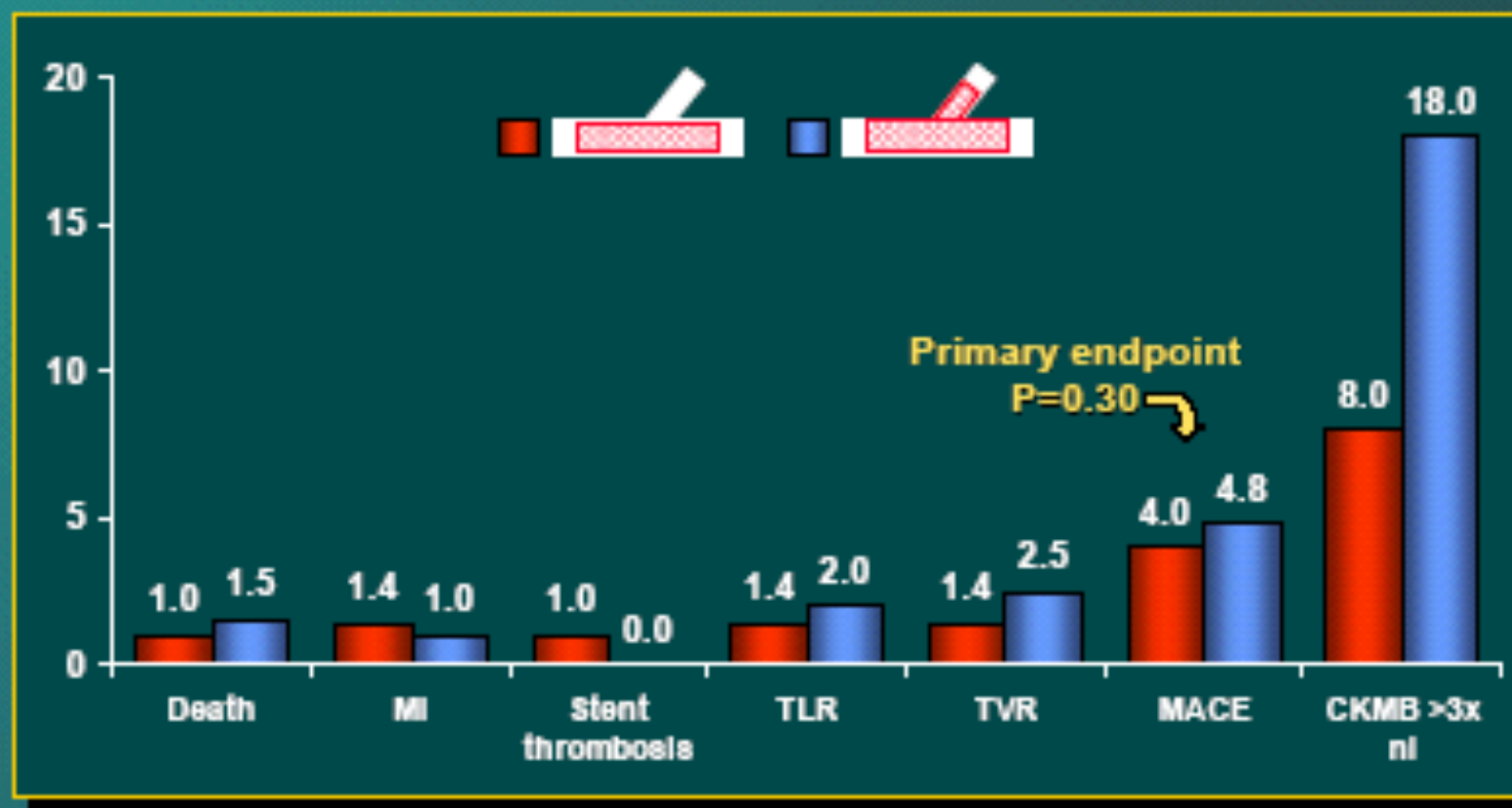
no clinical difference at 6 m with routine DES stenting of SB

Procedural outcomes	MV, no routine SB stent, n=207	MV + routine SB stent, n=206	p
<u>Biomarker elevation</u> >3x ULN (%)	8	18	0.011
Biomarker elevation >5x ULN (%)	4	13	0.008
<u>Procedure time</u> (mean min)	59	74	<0.001
<u>Fluoroscopy time</u> (mean min)	15	21	<0.001
<u>Contrast</u> agent used (mean mL)	233	283	<0.001

*Study eligibility required a need for stenting of a main vessel at a main side branch ≥ 2 mm in luminal diameter. Biomarkers measured at procedure and 12 to 18 hours later. ULN=upper limit of normal.

Nordic Bifurcation Study (n=413)

6 Month Endpoints



**Bifurcation lesions: 2 stents
are better and usually
necessary!** Colombo

**Bifurcation Lesions:
One DES is Best and is Usually
Feasible!** Lefevre

- **We need to overcome the issue
1 vs. 2 stents!**
- **In most bifurcational lesions one stent is the
treatment of choice**
- **Most bifurcations need the SB to stay open
at the end of the procedure, residual
stenosis appears less relevant**
 - ➔ **1 stent strategy**
 - Angio F-U only if clinically needed**



Antonio Colombo at ACC Atlanta march 2006

CRF DES Evidence-based Medicine Guidelines Summary 2006

IIa



- Bifurcation (DES main branch, side branch PTCA w/provisional DES)

IIb



- Bifurcation (planned 2 stent – either routine T-stent or crush (with final kiss) or SKS (V-stent)*

* IIaC for Crush or SKS when side branch is large and diffusely diseased

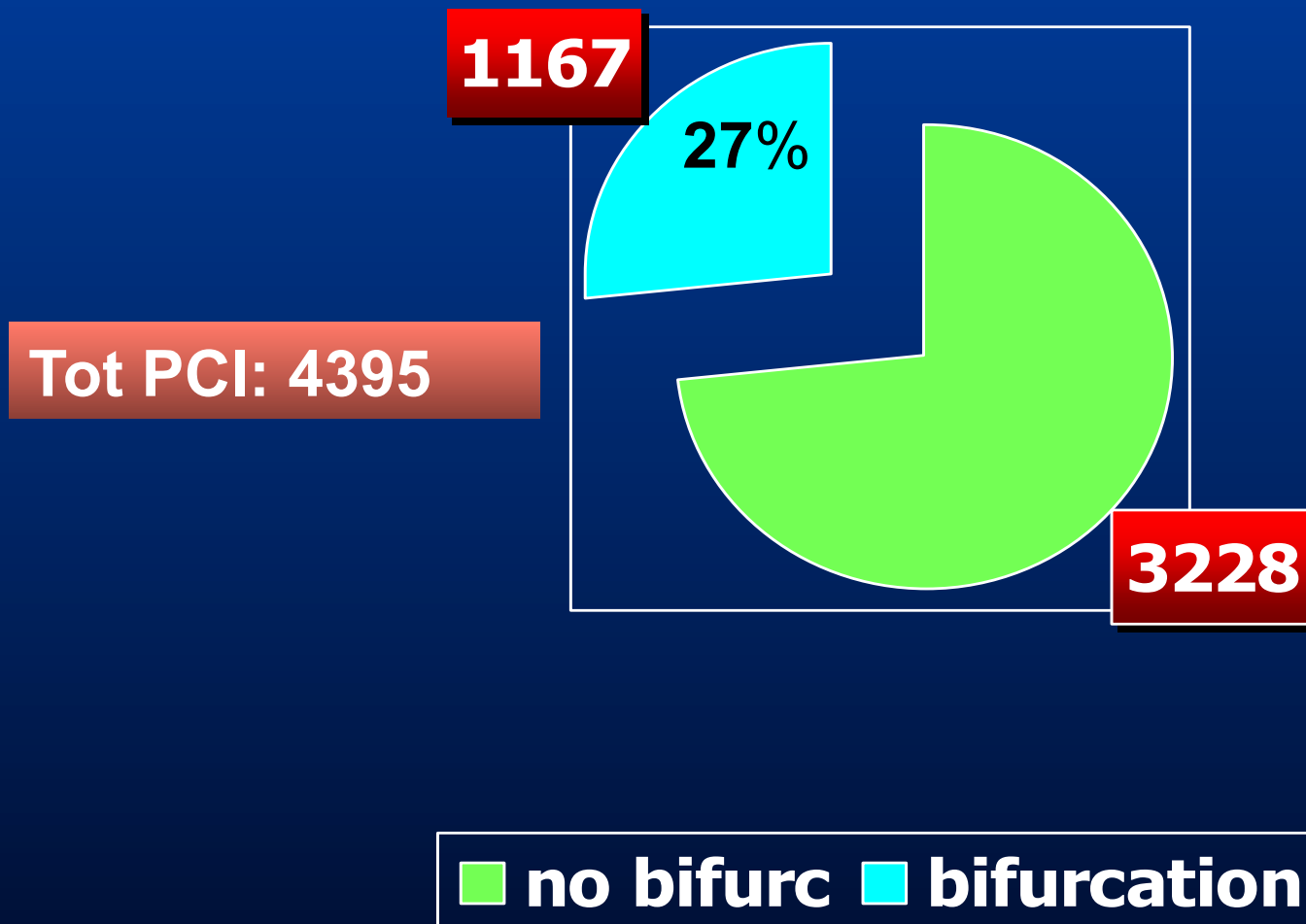
Nostra casistica biforcazioni (dal 2000 a marzo 2006)

- Tot PCI : 4395
- Biforcazioni : 1167 (27%)
- Stent solo ramo principale (MB): 424 (42%)
- stent solo MB con dilatazione strut : 464 (46%)
- Stent anche su ramo secondario : 67 (7%)
- Debulking: 99 (16%) con aterotomo o rotablator
- Stent medicati (dal 2003): 254 (64%)

Emodinamica San Martino

1978	Inizio attività diagnostica
1985	PTCA (POBA)
1990	Stent 1[^] generazione
2002	Stent medicati
2006	Oltre 40 000 procedure circa 9000 PCI

Nostra casistica biforcazioni dal 2000



Nostra casistica biforcazioni dal 2000



Stent solo ramo principale:

88% di cui

46% con dilatazione attraverso lo stent

(kissing o singola)



Stent anche ramo secondario:

7% di cui

79% T stenting

Nostra casistica biforcazioni dal 2000

- Debulking con aterotomo o rotablator
(fino al 2003):
99 pts (12%)
- Stent medicati dal 2002:
254 pts (64%)

Nostra casistica biforcazioni dal 2000

Complicanze in fase acuta:

(maggio 2002 - marzo 2006)

CPK > 600 (ad 8 e 24h) : 14%

Nostra casistica biforcazioni dal 2000 follow-up (82%)

- Follow-up angiografico: 360 pz (31%)

Ristenosi binaria: 130 / 1167 pz (11%)

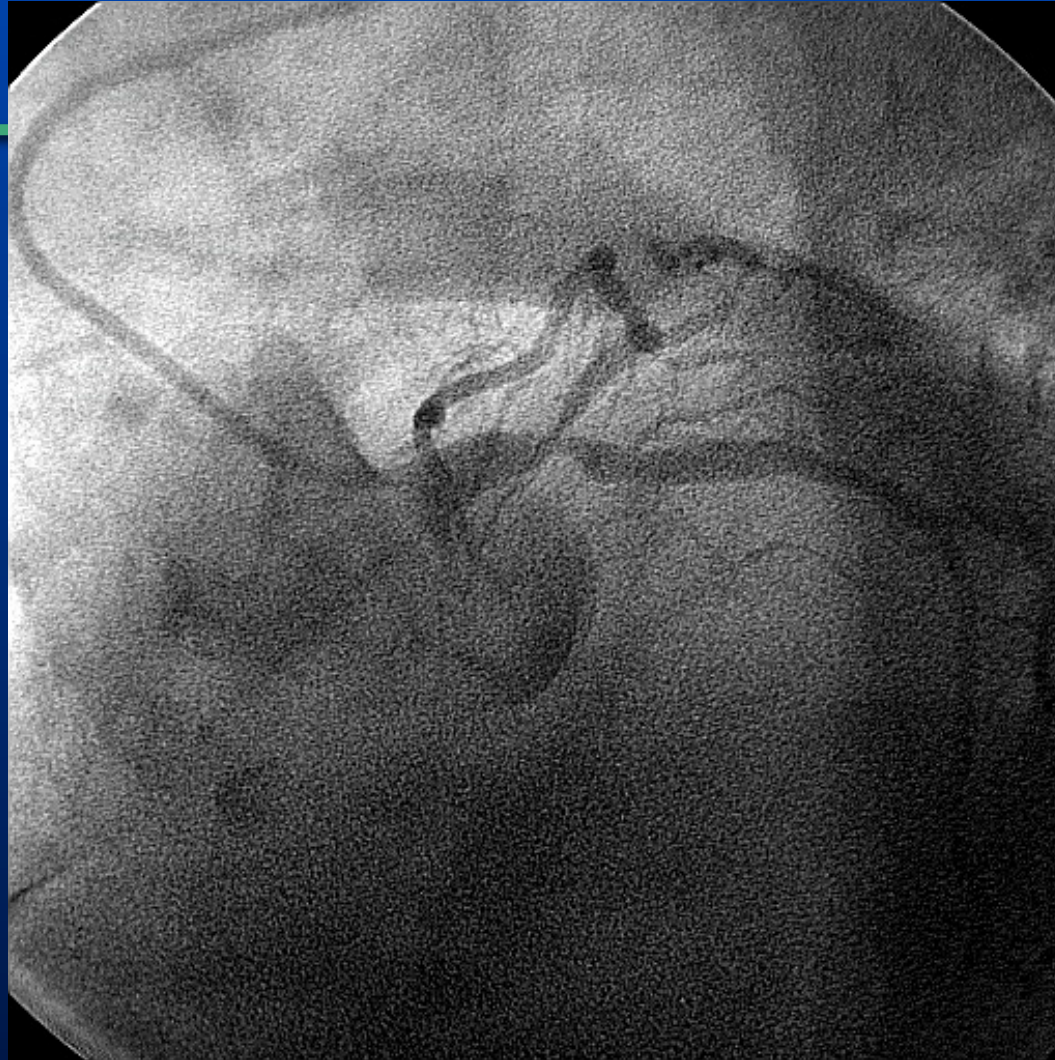
- Follow-up clinico : 596 pz (51%)

Asintomatici : 57%

MACE : 28%

TLR : 8 %

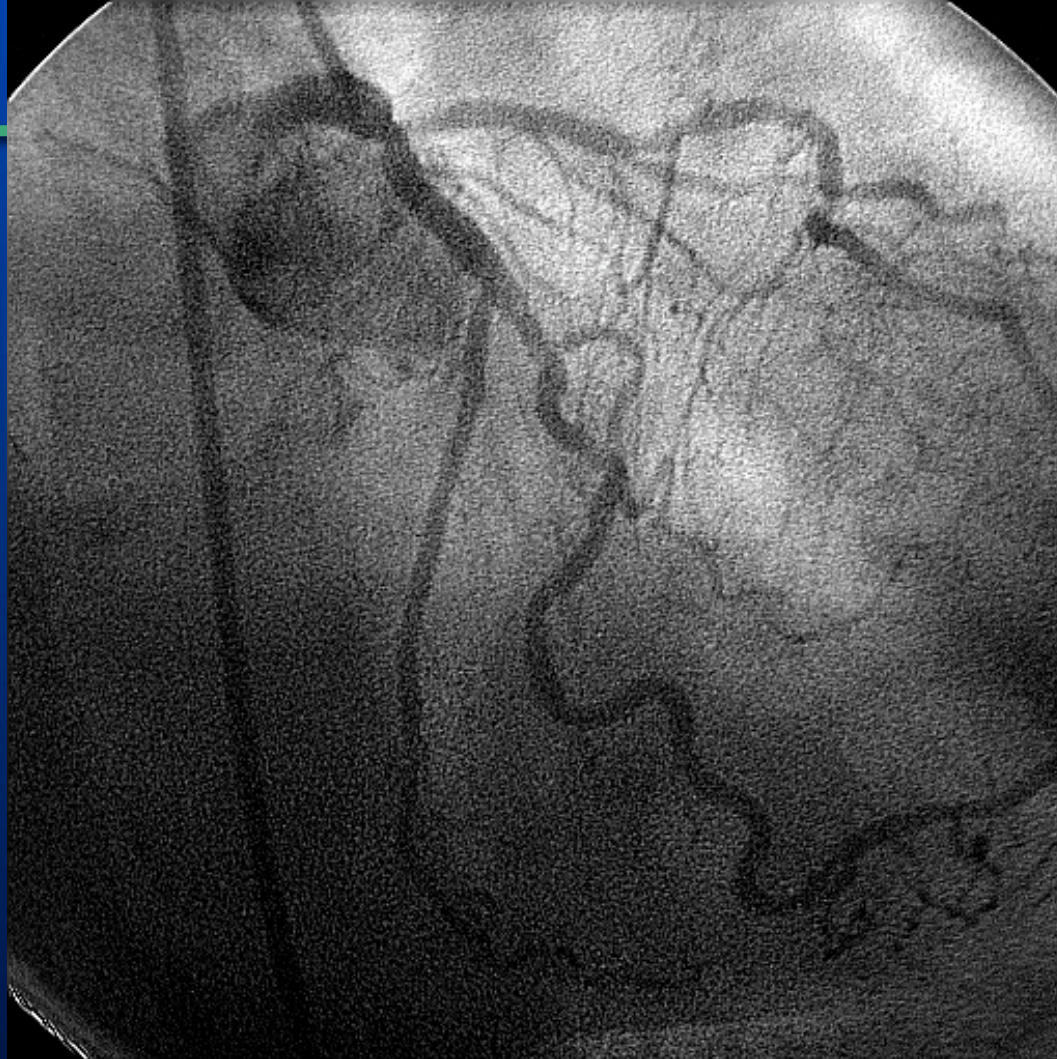
“V” stenting su TC



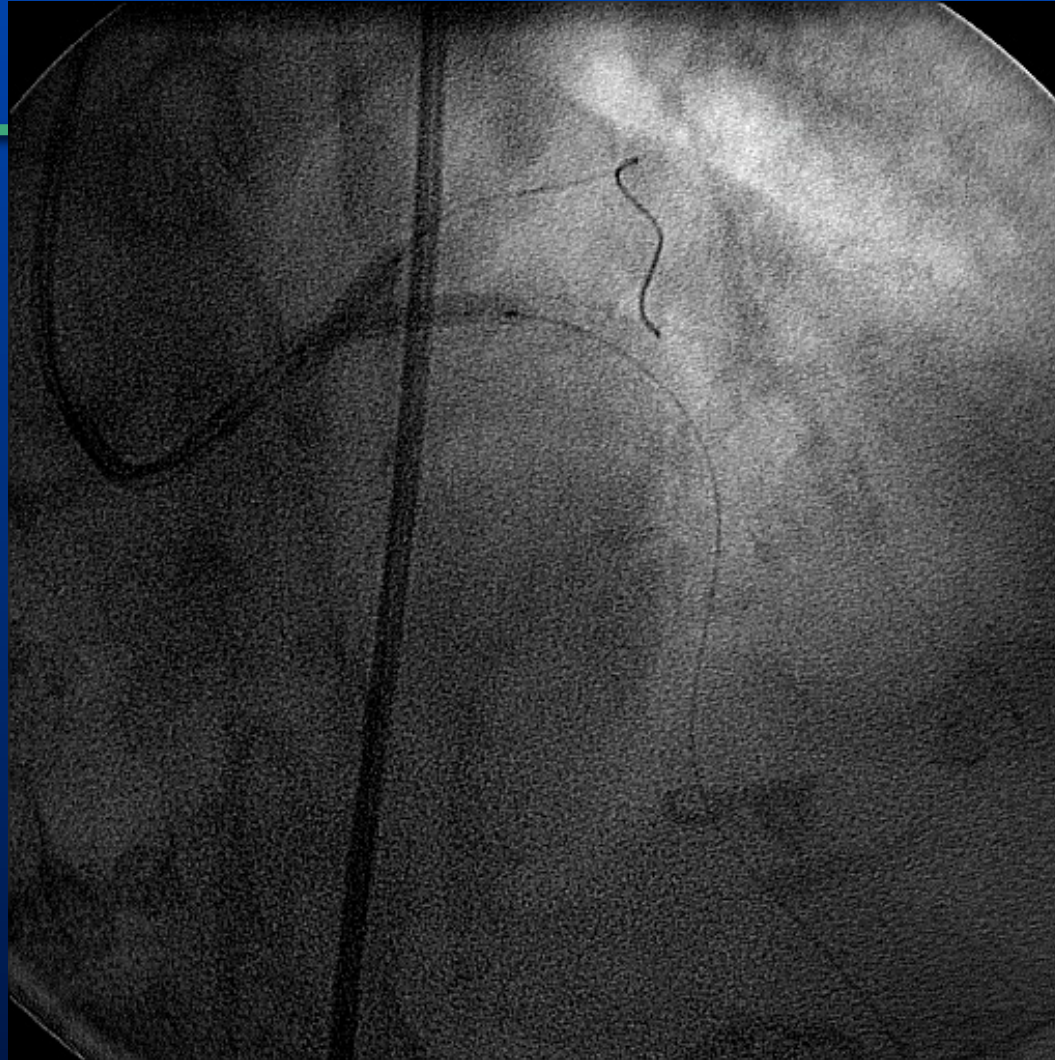
09-05-06

Sig.ra F.S. 95 a ACS STEMI anteriore

“V” stenting su TC



“V” stenting su TC

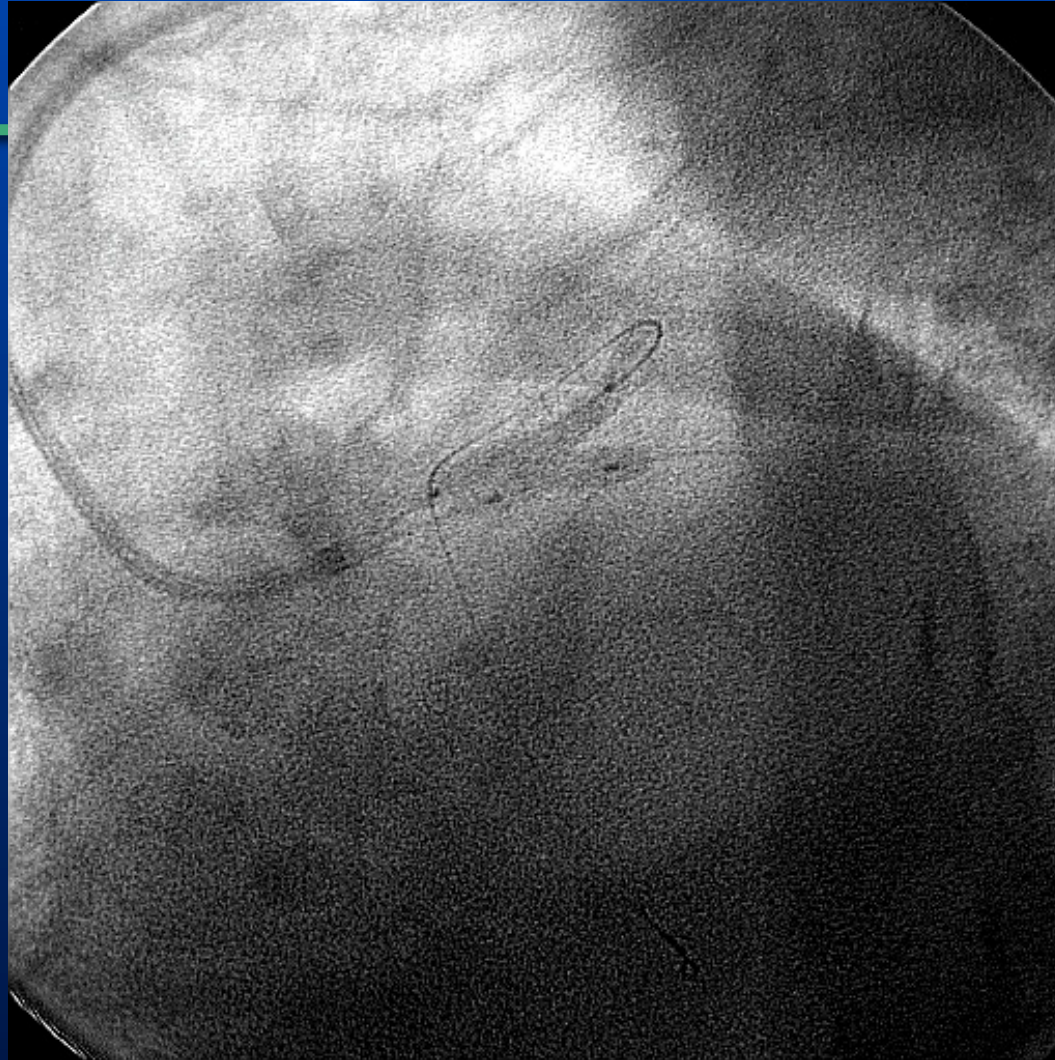


JL4 7F

Cypher 2.75 x 18 su IVA

Cypher 3.0 x 8 su Cx

“V” stenting su TC



Quantum 3.5 x 12 su Cx

2.75 x 18 su IVA entrambi a 14 atm

“V” stenting su TC

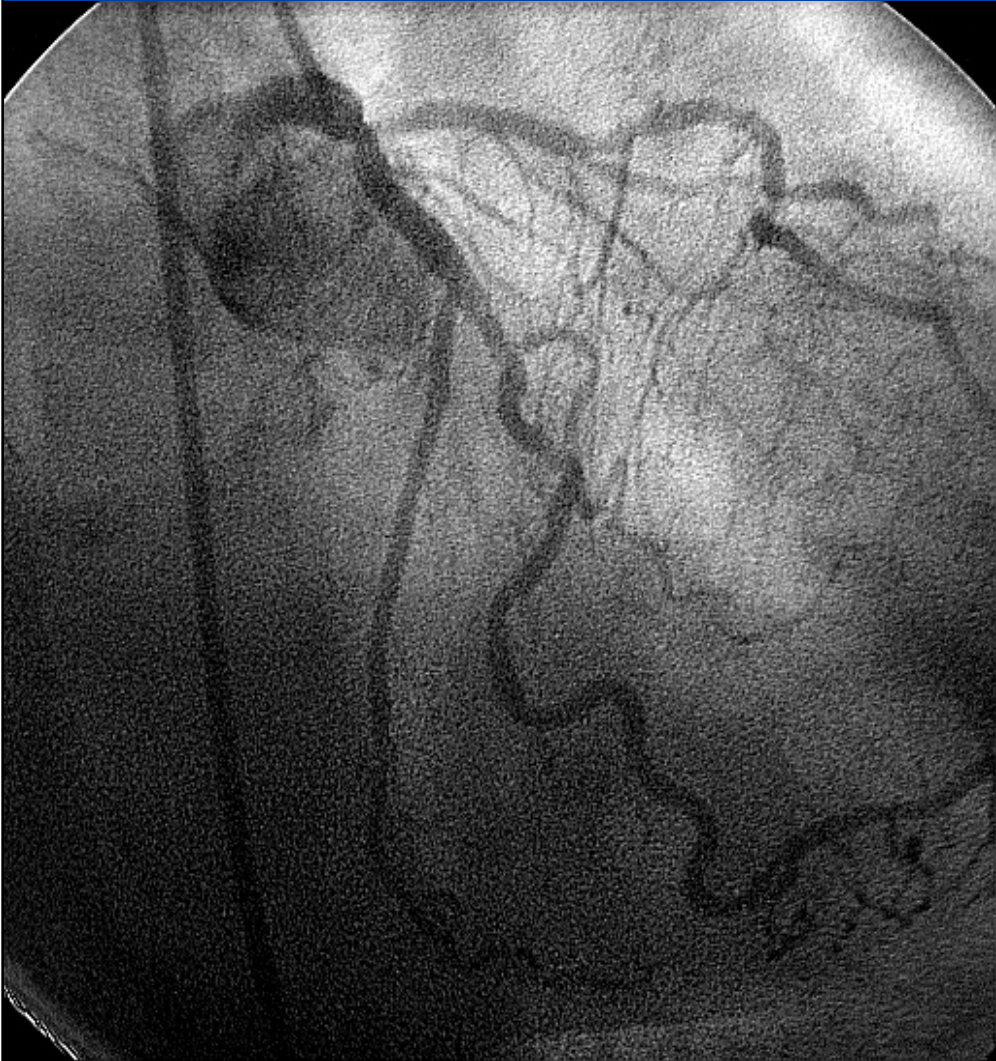


pre



post

“V” stenting su TC

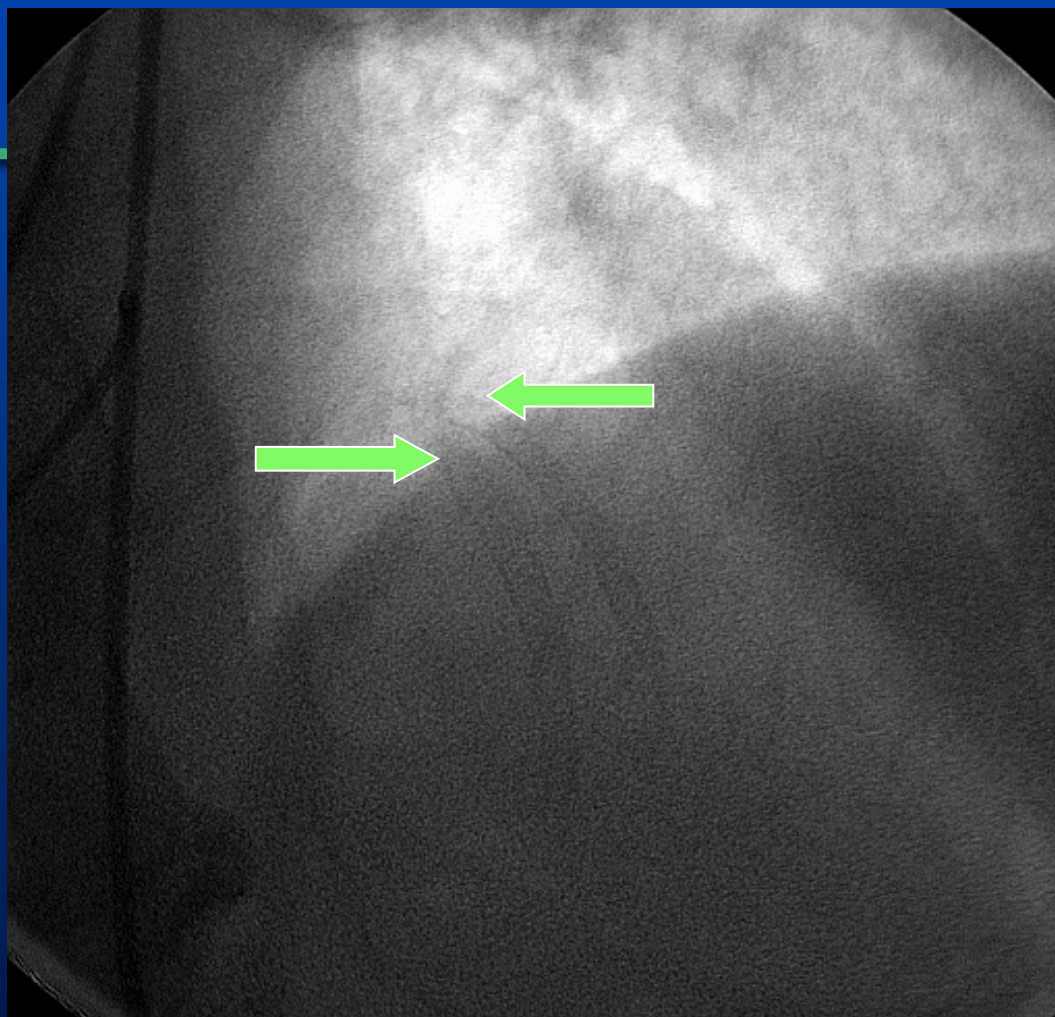


pre



post

Caso clinico 1



Sig. U.F. 68 a

Feb 04 2 BMS su IVA e diagonale: biforcazione non coperta (altro centro)

Coro per angina da sforzo il 9-3-06 . Recente diagnosi di leucemia

Caso clinico 1

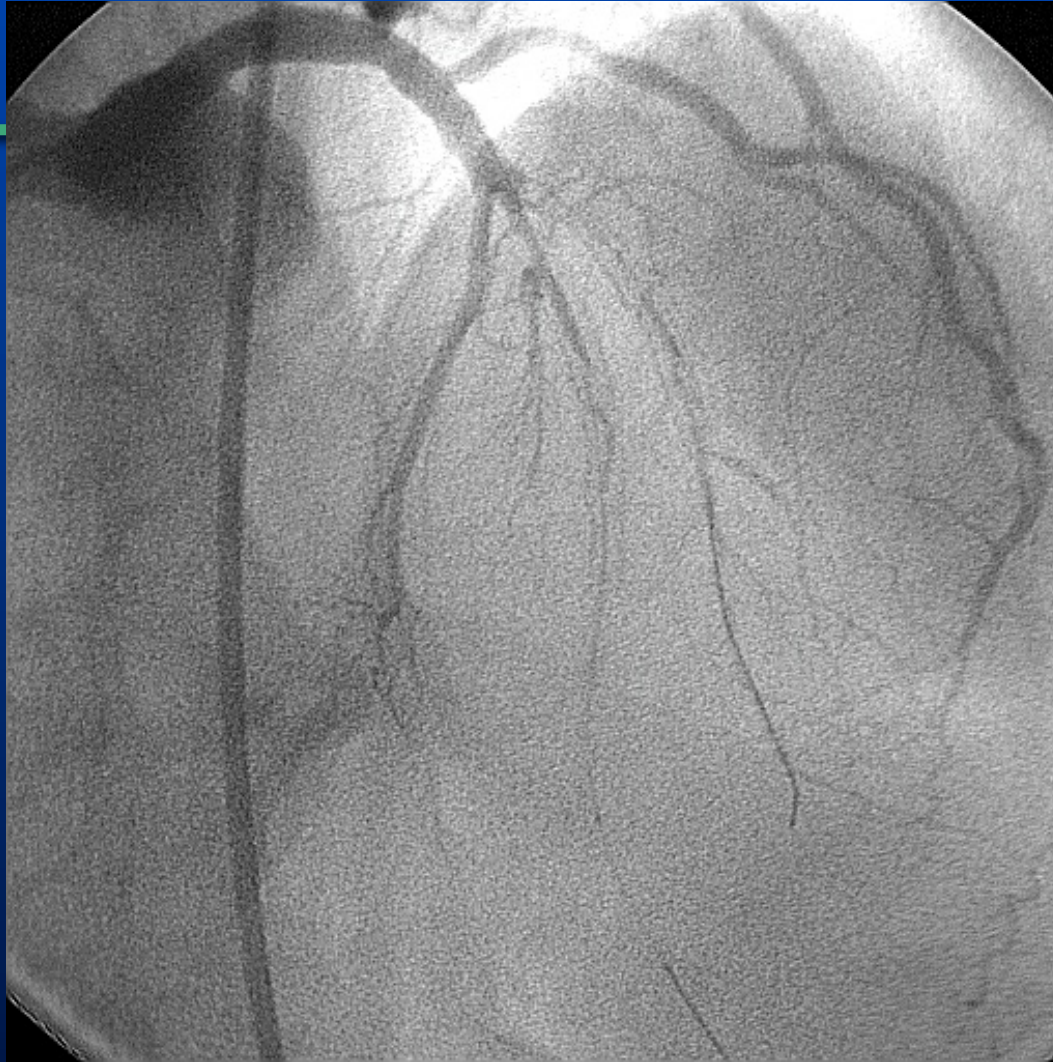


Ristenosi serrate, proliferative, intra-stent su entrambi rami

Caso clinico 1

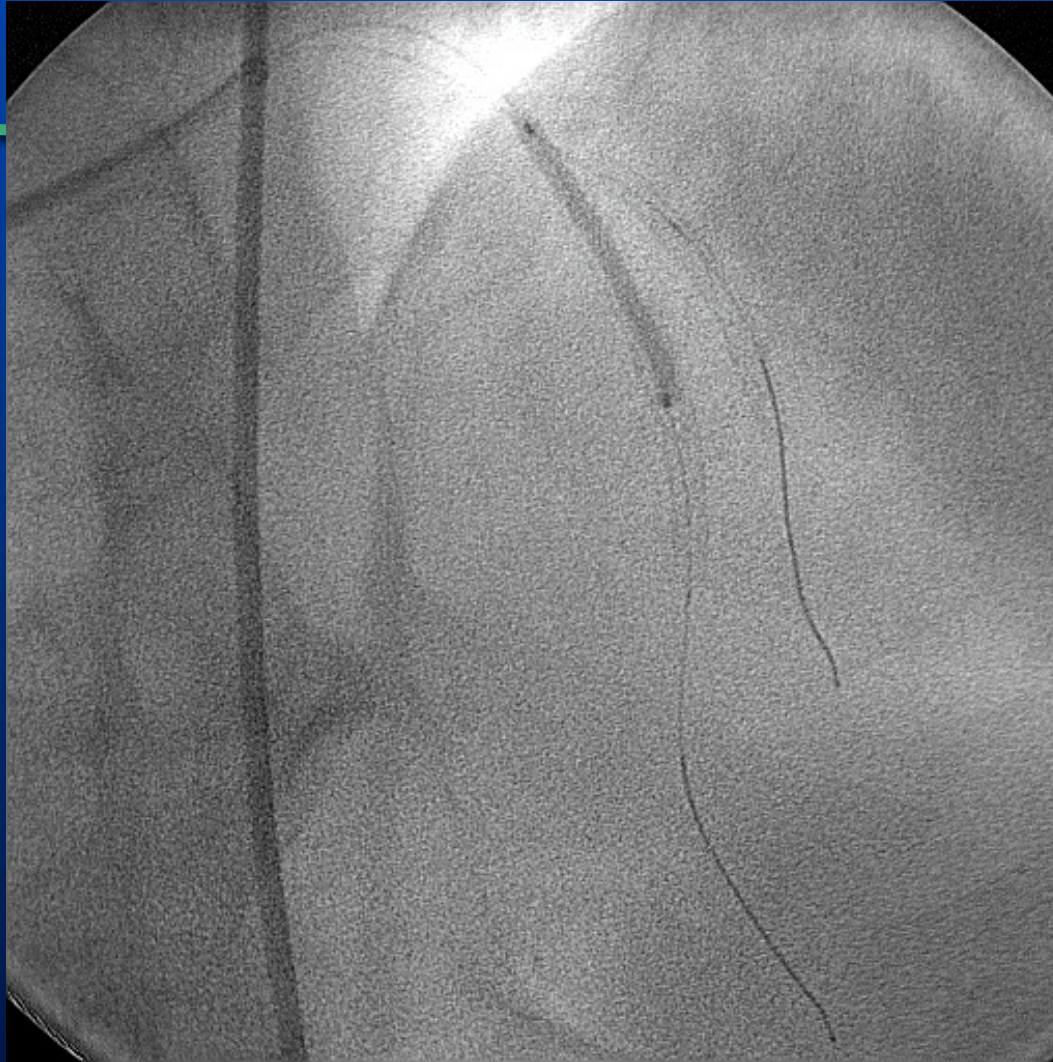
- **Indicazione ad impianto di stent medicati per ristenosi diffusa intrastent**
- **Il riscontro di leucemia con trombocitopenia sconsiglia l'uso di farmaci che richiedono un prolungato uso di antiplatefici**
- **La strategia scelta è quella di trattare la biforcazione, precedentemente non coperta, con impianto di due carbestent, con tecnica a T, su entrambi i rami**

Caso clinico 1



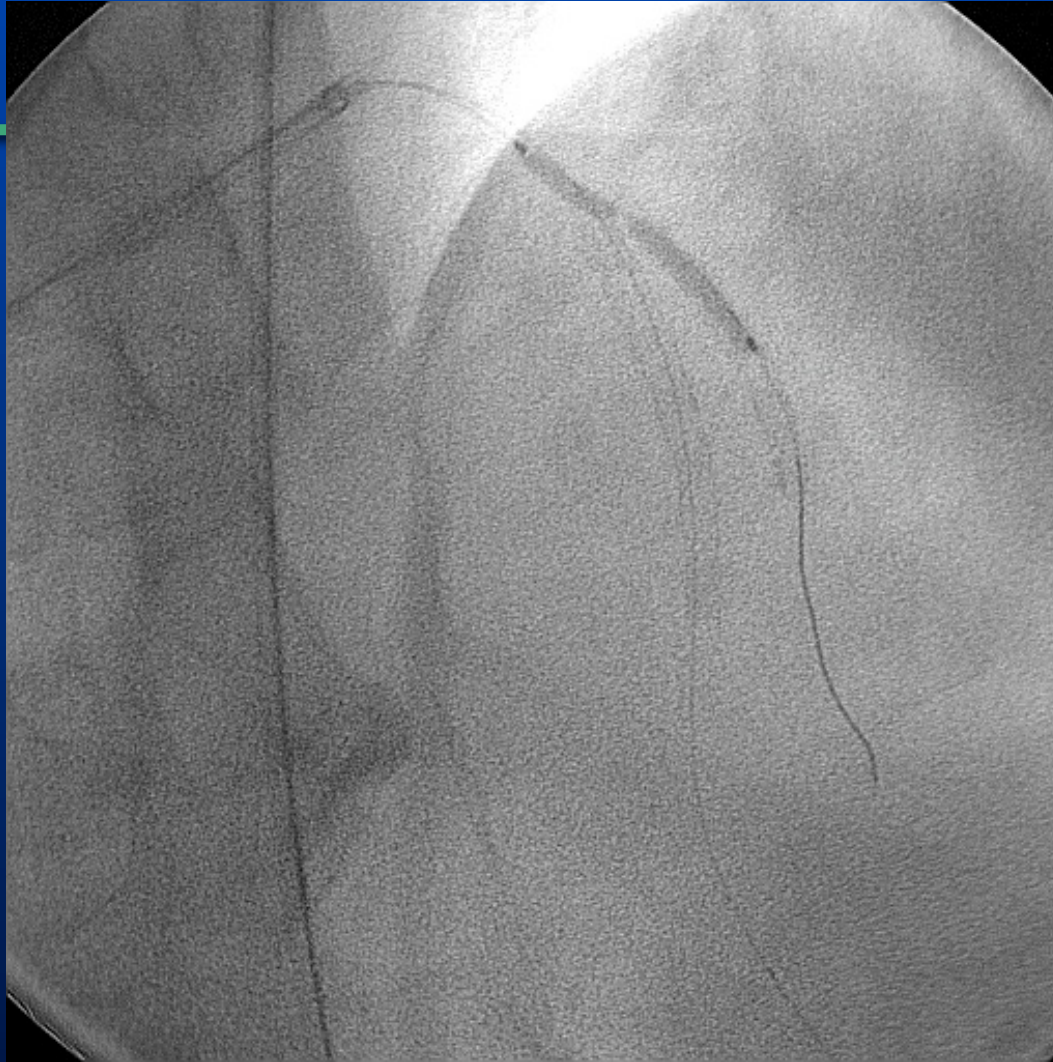
Posizionamento di guide su entrambi rami

Caso clinico 1



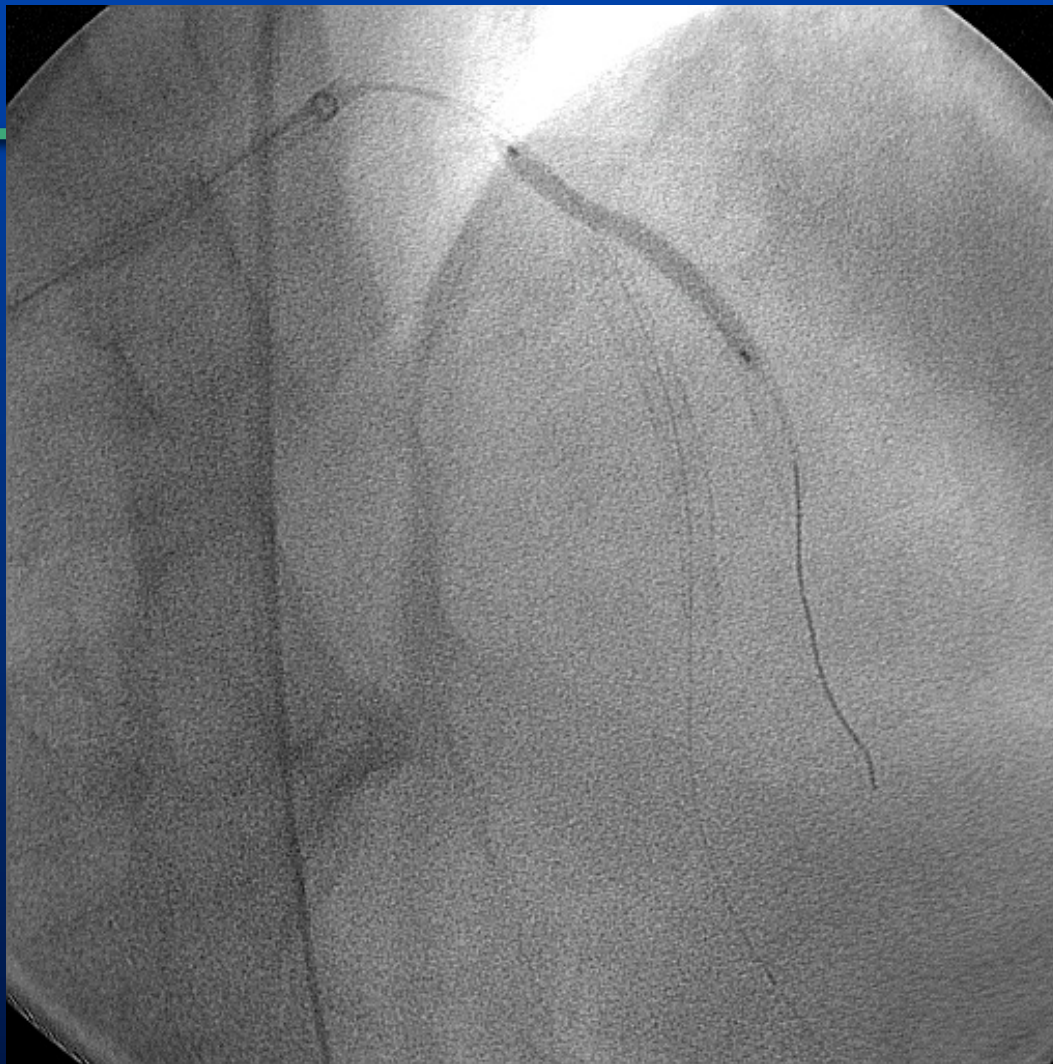
Pre-dilatazione su IVA a vari livelli

Caso clinico 1



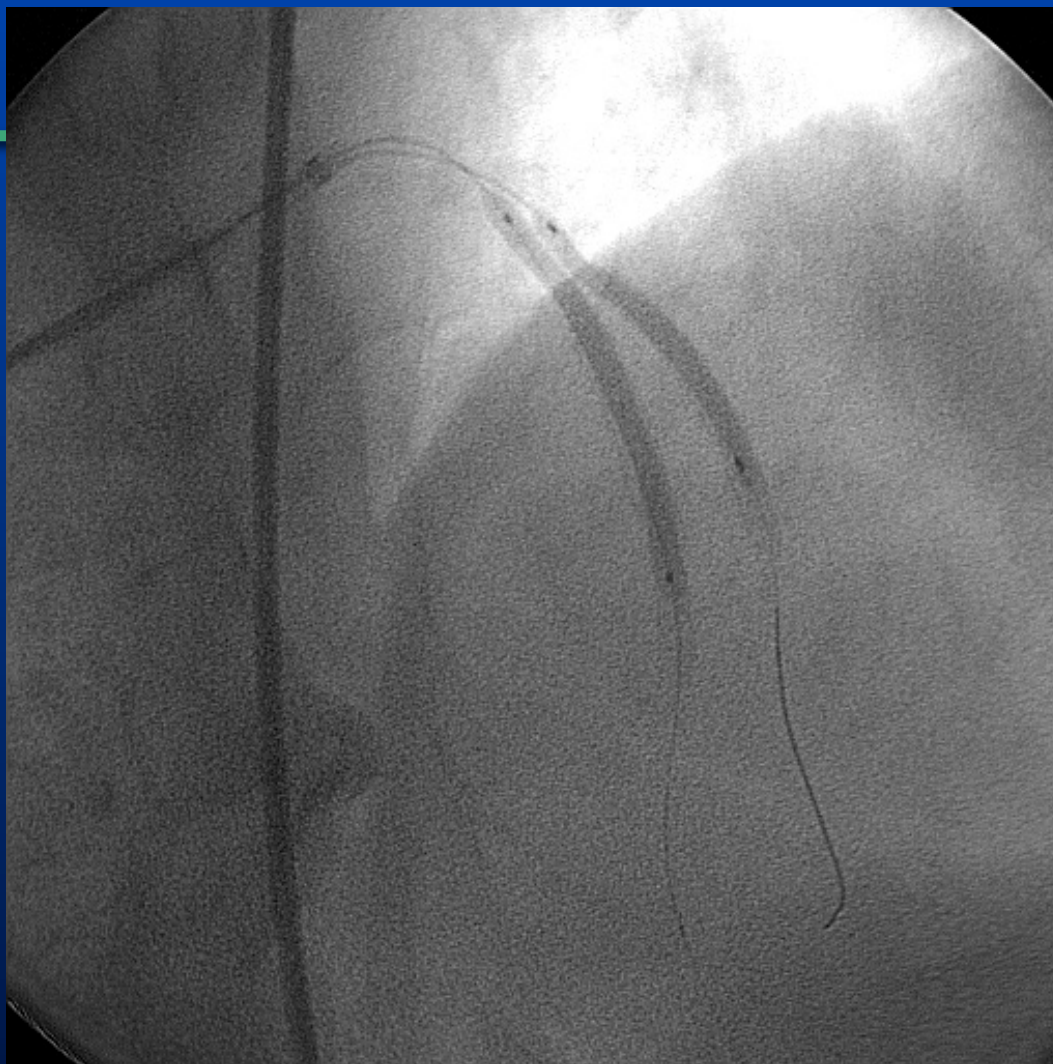
Pre-dilatazione su diagonale: incisura

Caso clinico 1



Pre-dilatazione su diagonale: espansione completa

Caso clinico 1



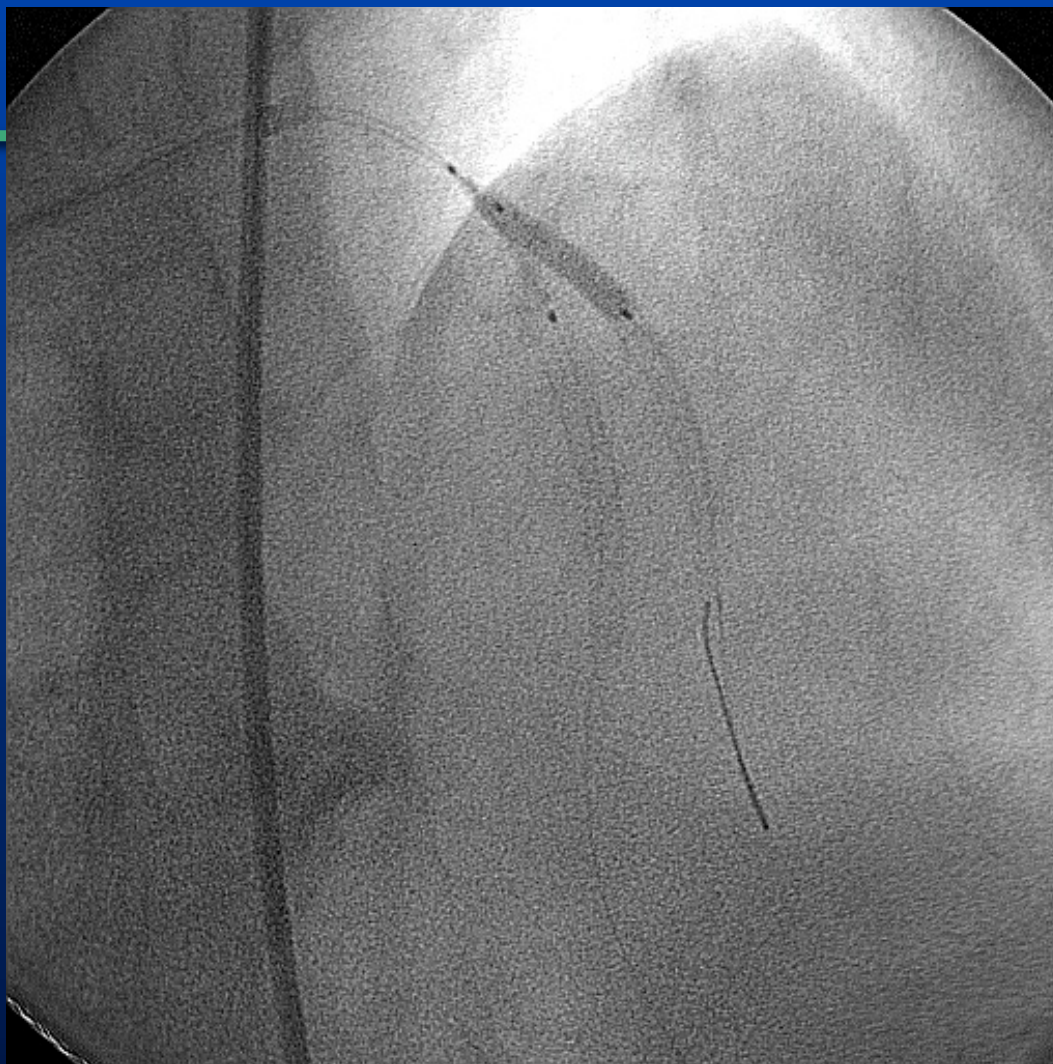
Kissing balloon

Caso clinico 1



Risultato dopo solo pallone

Caso clinico 1



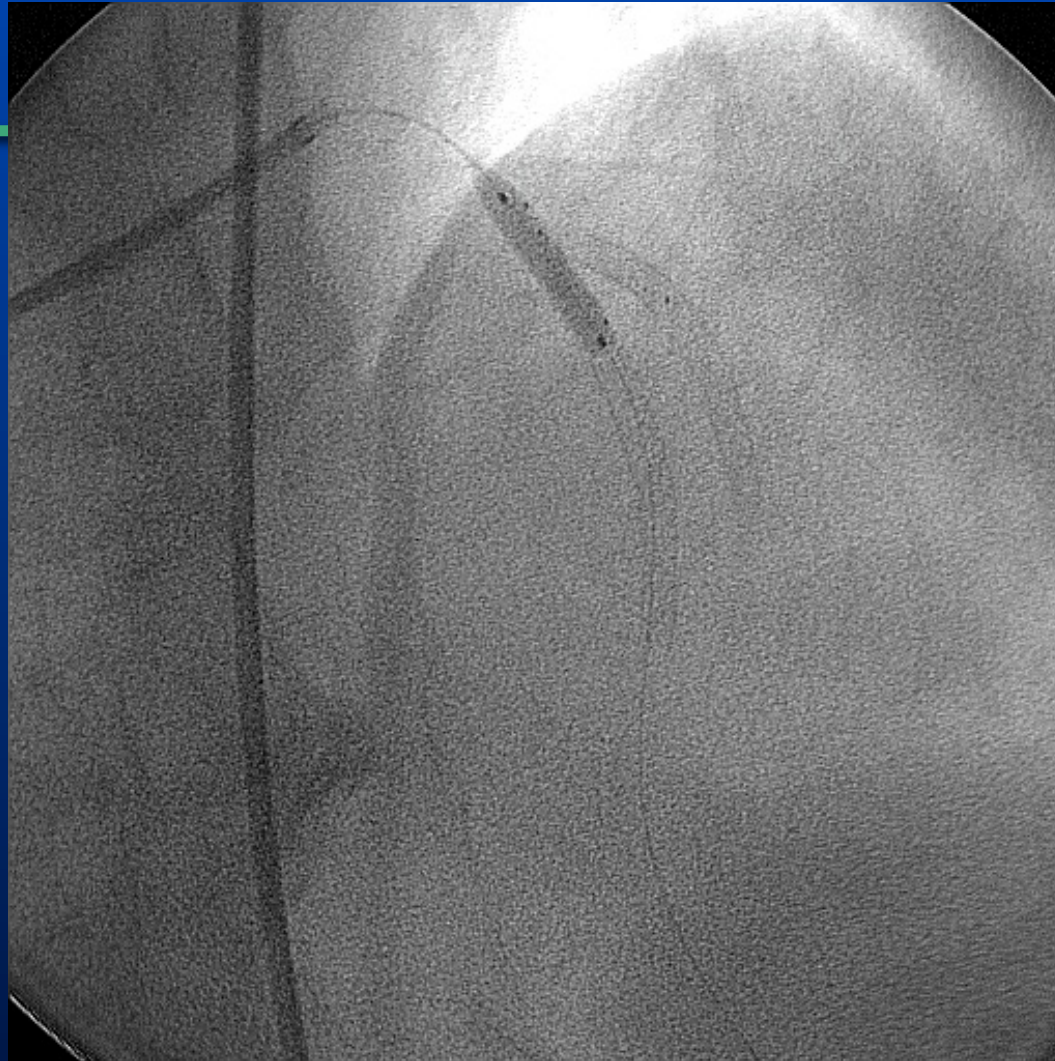
Carbostent
3.0 x 15mm

T stenting: impianto su diagonale ostiale

Stent su IVA posizionato ma non impiantato

Caso clinico 1

Carbostent
3.5 x 15 mm



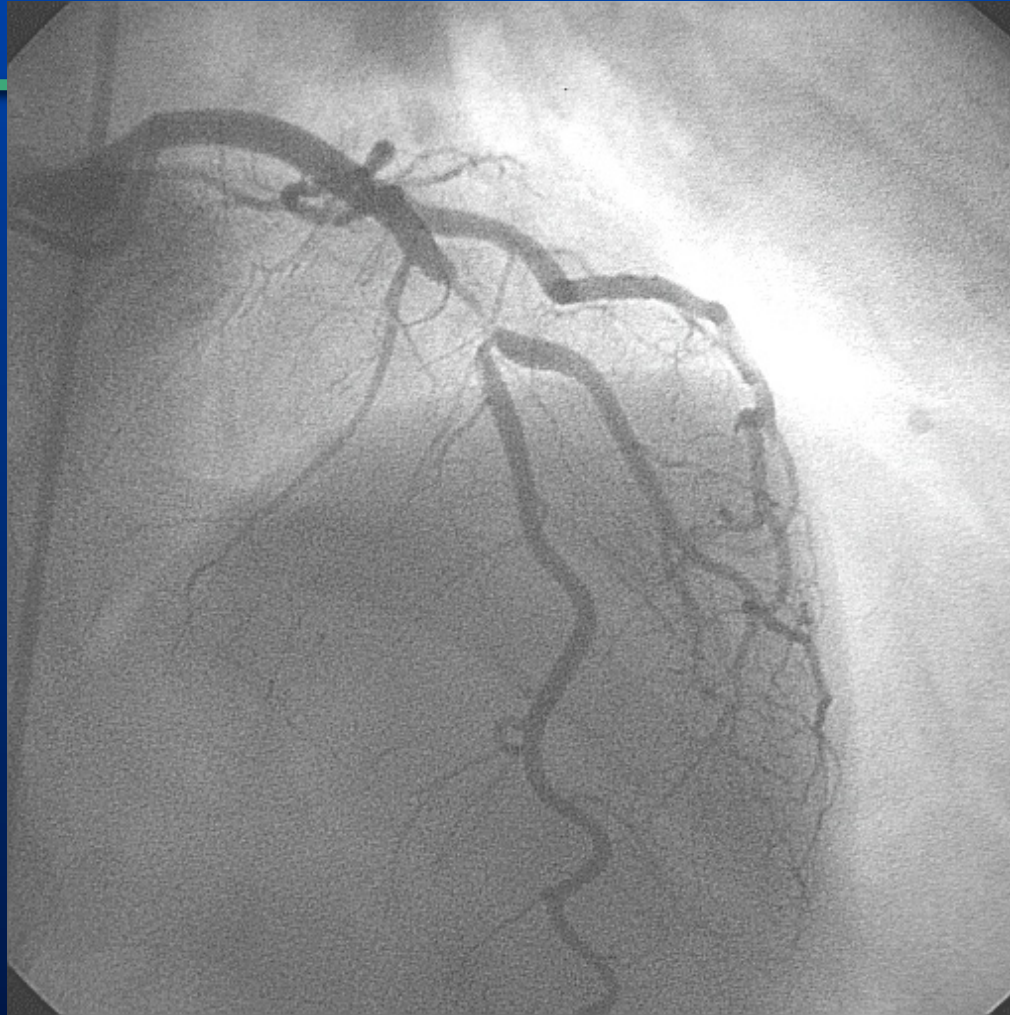
T stenting: impianto su IVA

Caso clinico 1



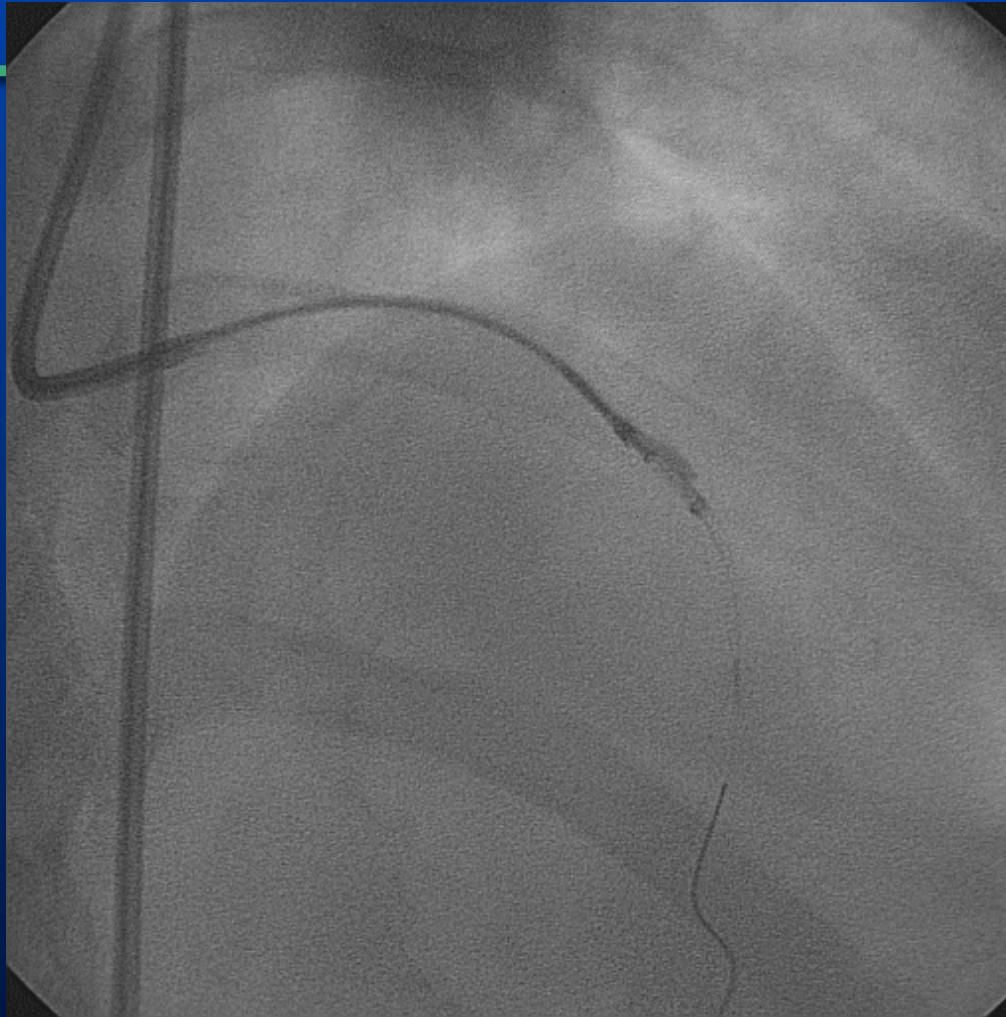
Risultato finale

Caso clinico 2: plurimi PCI su bif



Donna di 51 anni con angina da sforzo
Basale, aprile 2001: stenosi serrata alla biforcazione IVA-diagonale
Buona funzione ventricolare sn.

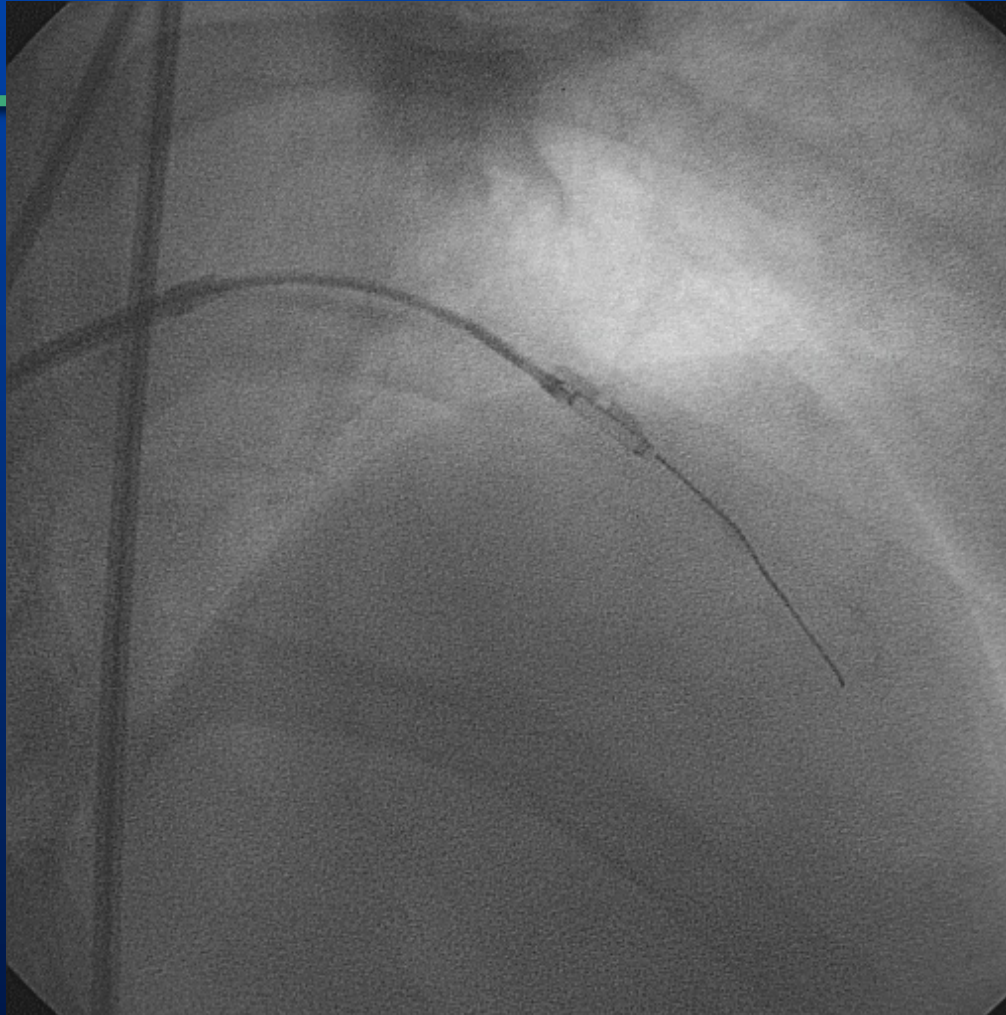
Caso clinico 2



Aprile 2001. Aterectomia direzionale su IVA: Flexicut 3.0-3.4

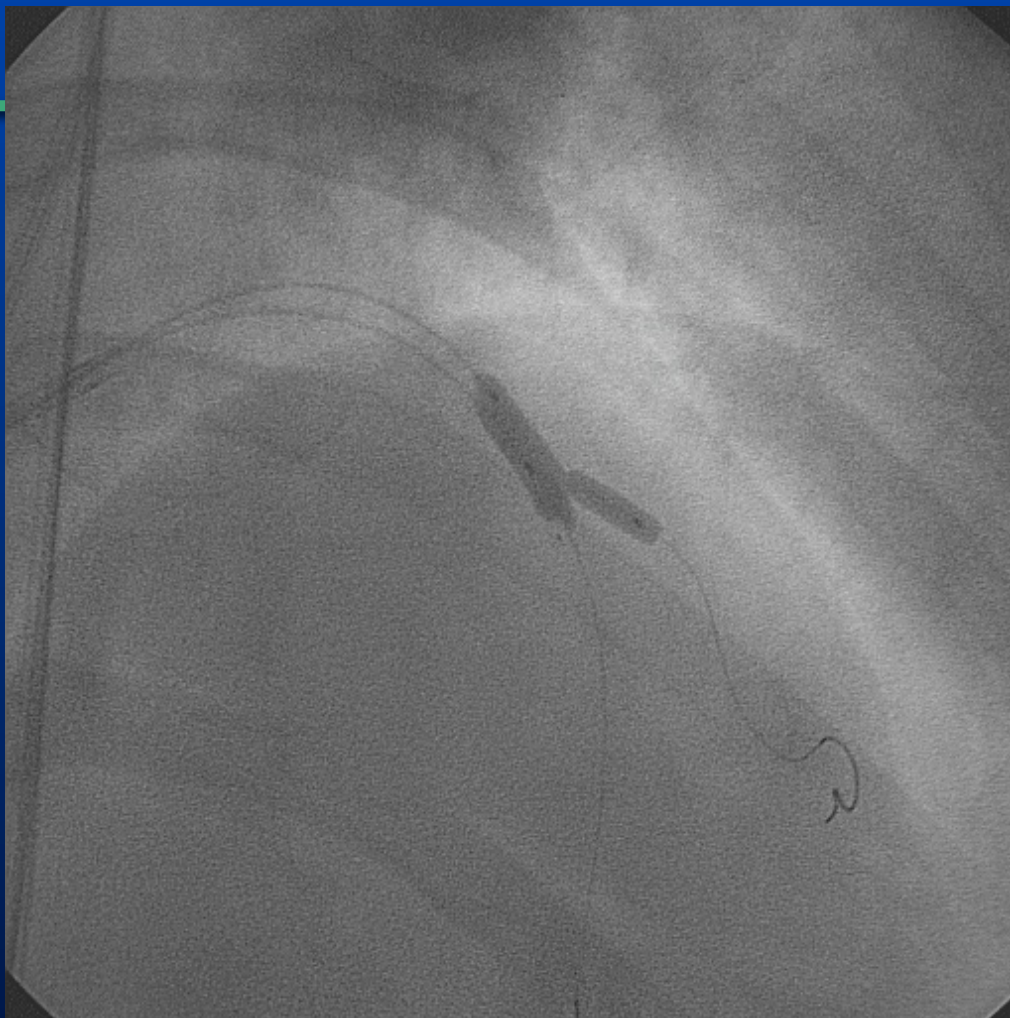
1° PCI

Caso clinico 2



Aprile 2001. Aterectomia direzionale su diagonale: Flexicut 3.0-3.4

Caso clinico 2



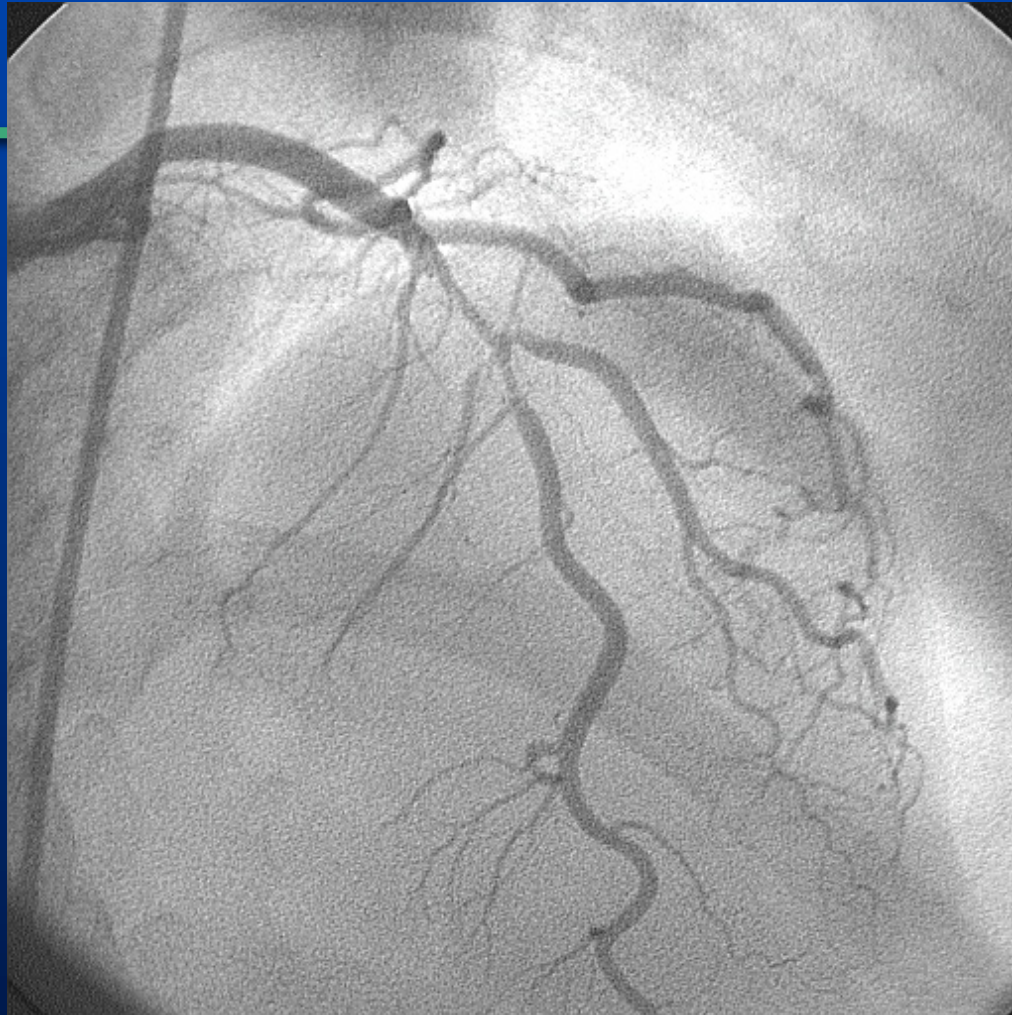
Aprile 2001. Stent su IVA, 3.0 x 15 e kissing balloon finale: 3.75 su IVA e 3.0 su diagonale

Caso clinico 2



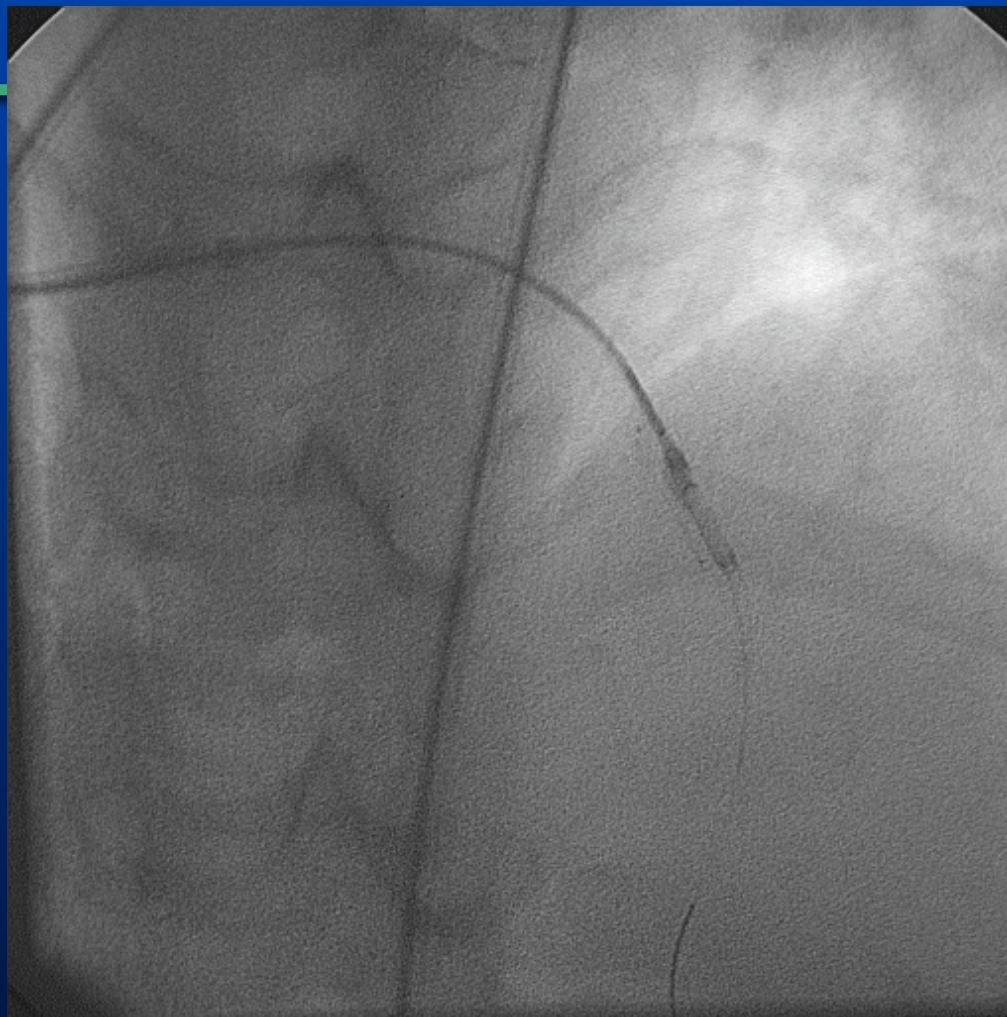
Aprile 2001 : risultato finale

Caso clinico 2



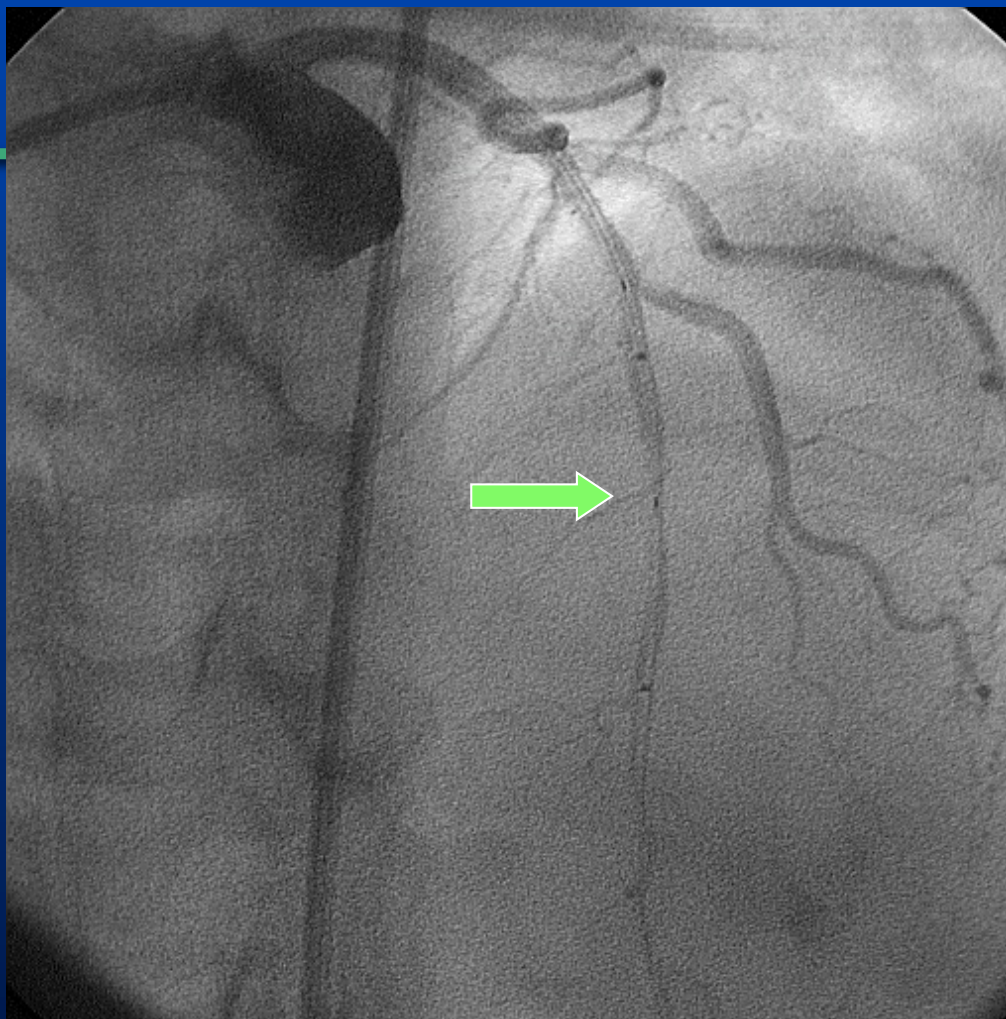
Novembre 2001: 1^ ristenosi diffusa intra-stent

Caso clinico 2



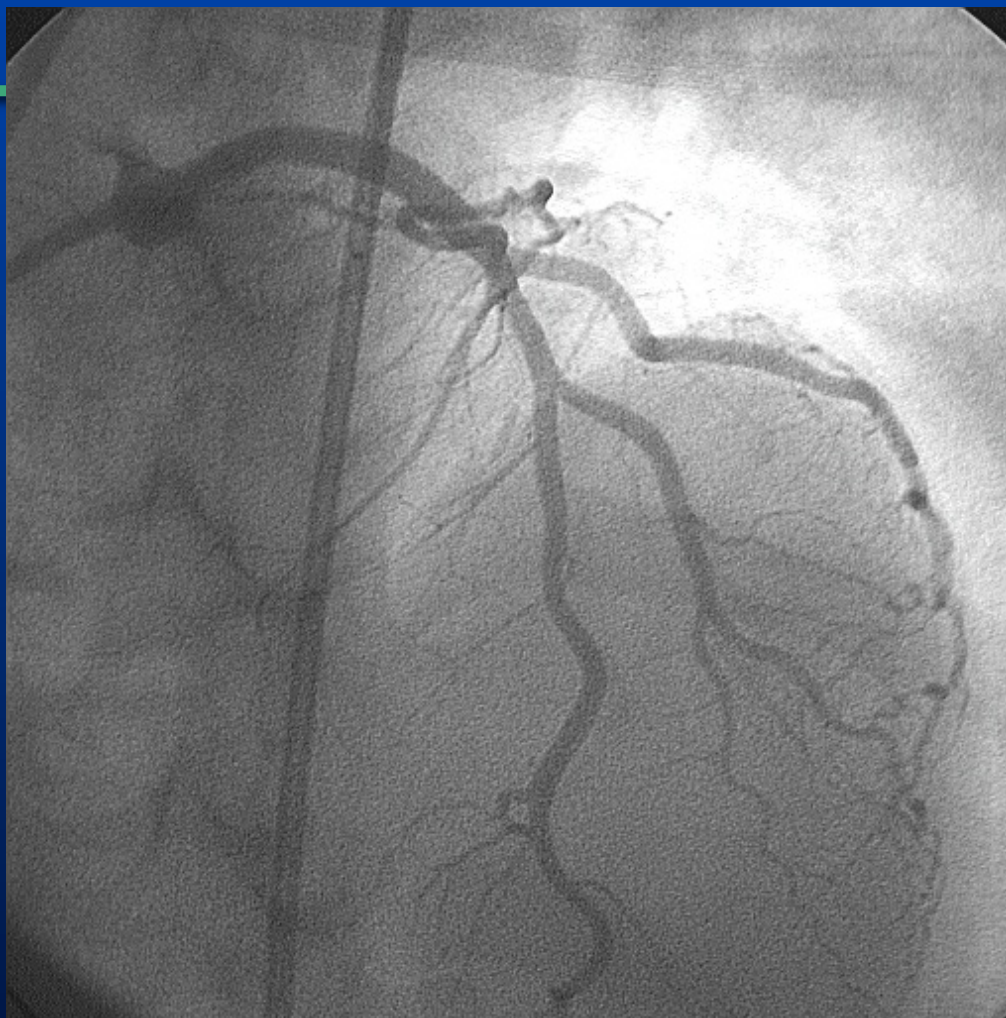
Novembre 2001. Debulking con re-aterectomia direzionale (DCA) su IVA seguito da kissing balloon, 3.0 a 20 atm su IVA e 2.5 su diagonale

Caso clinico 2



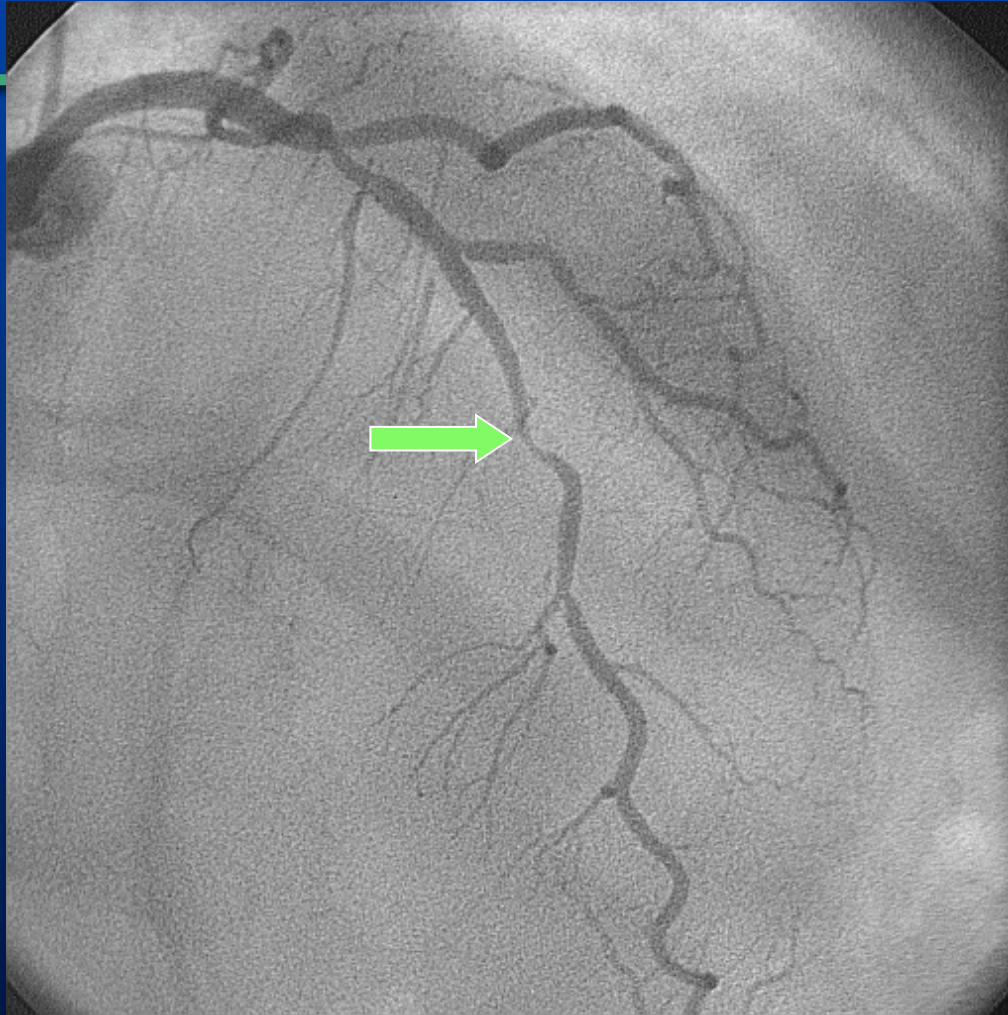
Novembre 2001. Radioterapia beta su IVA: notare il posizionamento del marker distale della sorgente

Caso clinico 2



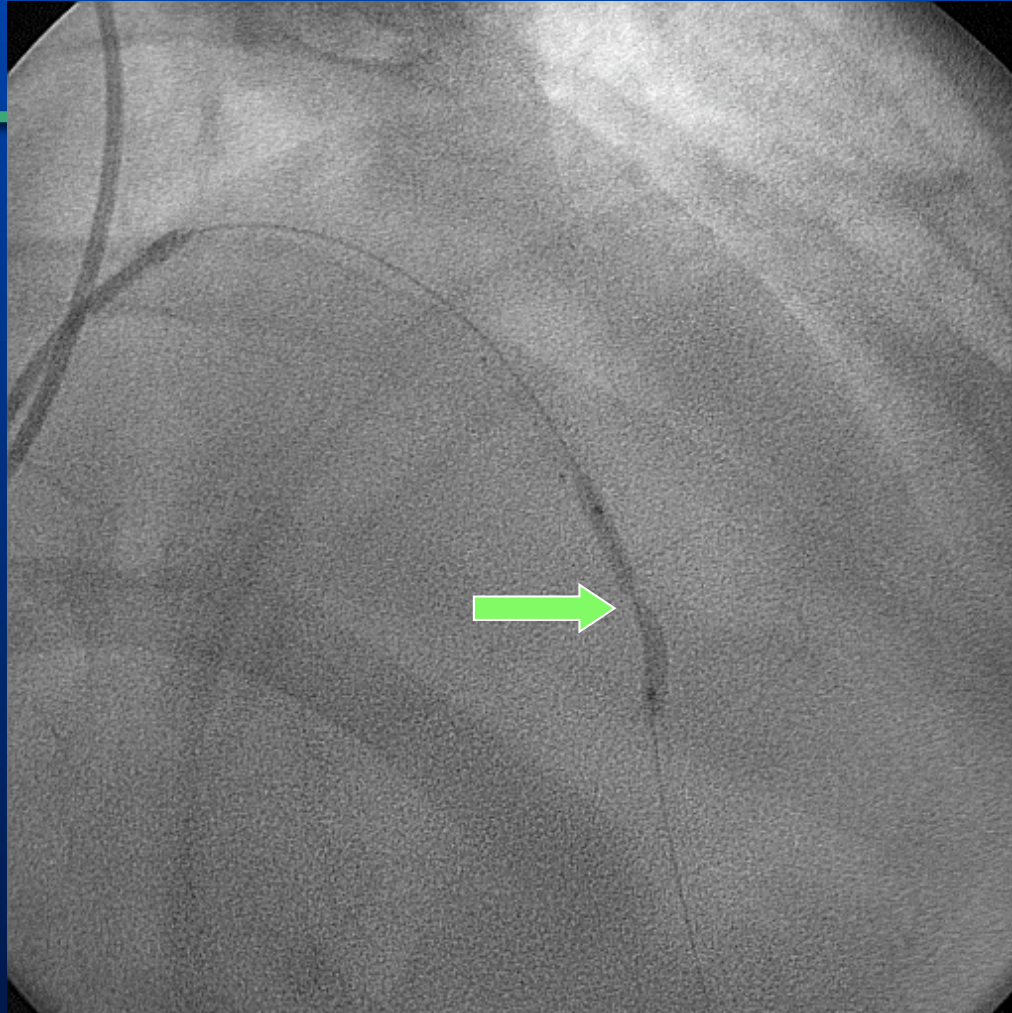
Novembre 2001: risultato finale

Caso clinico 2



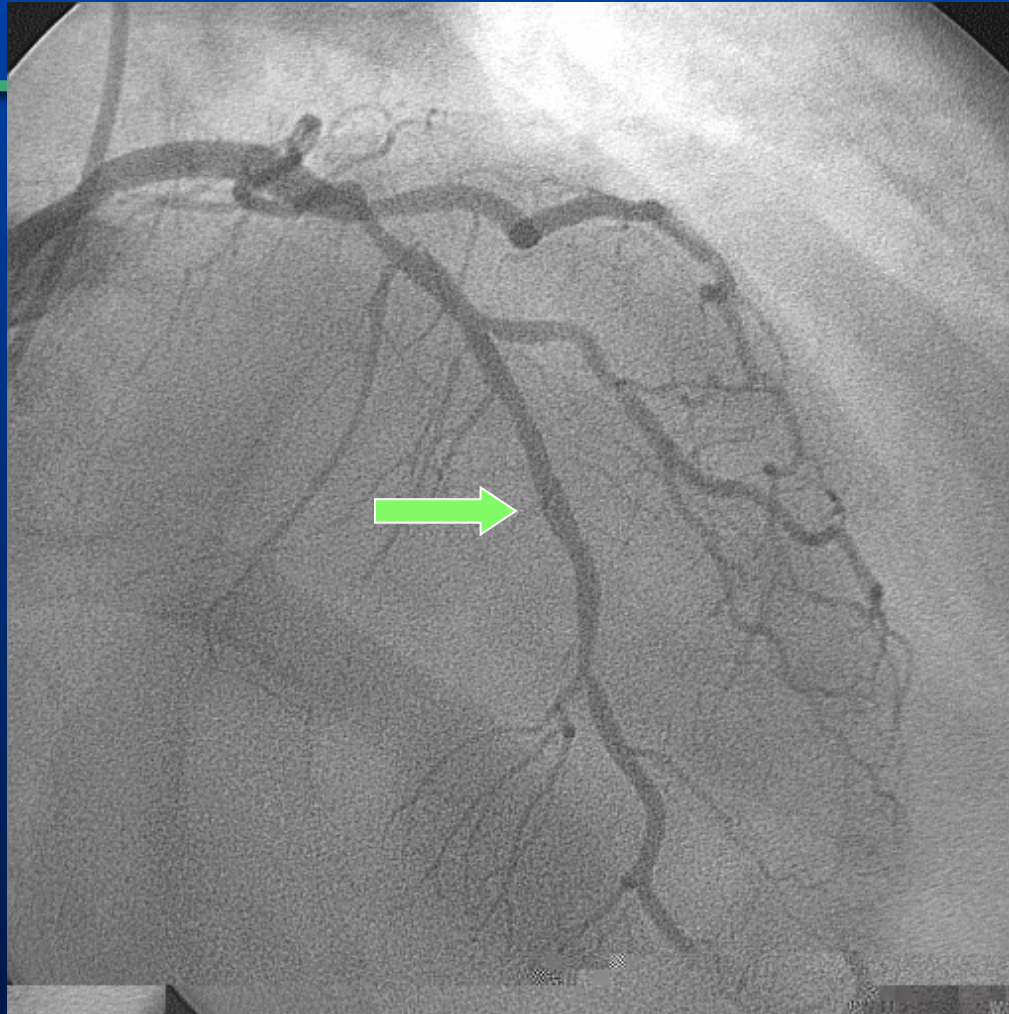
Luglio 2003: controllo per sintomi. Ristenosi al bordo distale del segmento irradiato

Caso clinico 2



Luglio 2003: incisura su palloncino 2.5 mm a 14 atmosfere : cutting balloon

Caso clinico 2



Luglio 2003: dopo Cypher 3.0 x 18 mm

Caso clinico 2



Luglio 2004: follow-up ad un anno dopo Cypher

Caso clinico 2 : conclusioni

Caso particolare di ristenosi “edge” dopo radioterapia beta in paziente già sottoposta a due precedenti interventi percutanei sullo stesso vaso.

La ristenosi, situata al bordo distale del segmento precedentemente trattato con radioterapia beta, è risultata resistente alla dilatazione ed è stato necessario utilizzare un cutting balloon per un efficace pre-dilatazione.

L' impianto di DES ha consentito di evitare ulteriori ristenosi, ad un anno dall' impianto.

Conclusione

- Il trattamento di lesioni complesse come le biforcazioni è ancora un problema solo parzialmente risolto
- Sono tuttora in evoluzione sia i dispositivi, sia le tecniche:
attualmente, nonostante i DES, prevale la strategia più semplice di stenting del solo ramo principale
- L'adattamento alla specifica anatomia della lesione richiede un lavoro artigianale non ancora standardizzato