Università degli Studi di Pavia

Dipartimento di Meccanica Strutturale

in collaborazione con

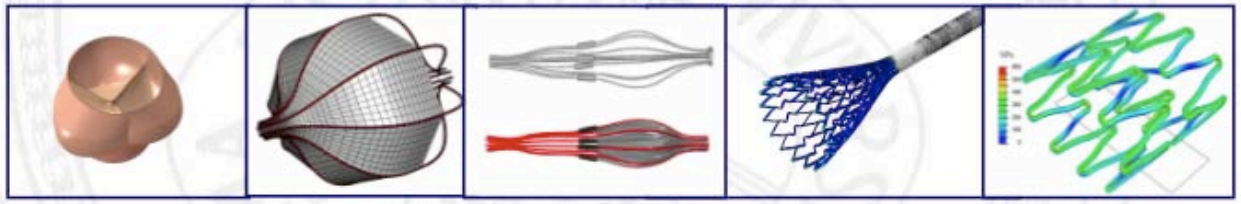
Centro di Simulazione Numerica Avanzata – CeSNA

Istituto Universitario di Studi Superiori

SEMINARIO

La Cardiologia Interventistica oggi: applicazioni e problemi aperti

Le malattie cardiovascolari sono diventate la prima causa di mortalità e morbilità nel mondo, generando un'enorme richiesta di prevenzione, diagnosi e cura. A questo problema, lo sviluppo della Cardiologia Interventistica ha rappresentato una risposta di estrema efficacia. Grazie a una straordinaria evoluzione tecnologica è attualmente possibile trattare con elevata efficienza e con un rischio basso un'ampia proporzione dei pazienti affetti da infarto miocardico, sindrome coronarica acuta e cardiopatia ischemica cronica. Attraverso un accesso vascolare ottenuto pungendo un'arteria del polso o dell'inguine è generalmente agevole raggiungere le arterie coronarie mediante appropriati cateteri e valutare la presenza e la gravità di placche aterosclerotiche che limitano il flusso di sangue e l'apporto di ossigeno al cuore. In caso di significativa ostruzione di uno o più vasi, diversi presidi, tra i quali i più importanti sono i palloncini da angioplastica e gli stent, consentono di ripristinare la pervietà della coronaria. Con gli anni questi strumenti sono diventati via via più sofisticati permettendo, anche grazie all'avvento di tecnologie innovative, di spostare sempre più i limiti della disciplina. Sono tuttavia comparse nuove problematiche legate alla varia interazione tra i dispositivi, la risposta dell'organismo e i farmaci mentre alcune lesioni quali gli osti coronarici, le biforcazioni, le occlusioni croniche, la malattia del tronco comune e dei graft venosi sembrano resistere allo sviluppo tecnico più che all'ingegno dell'operatore. L'impegno per la più proficua collaborazione tra le diverse figure coinvolte nello sviluppo delle tecniche e degli strumenti utilizzati in Cardiologia Interventistica è necessario per poter garantire ad ogni persona affetta da una patologia cardiovascolare il trattamento più efficace e sicuro possibile.



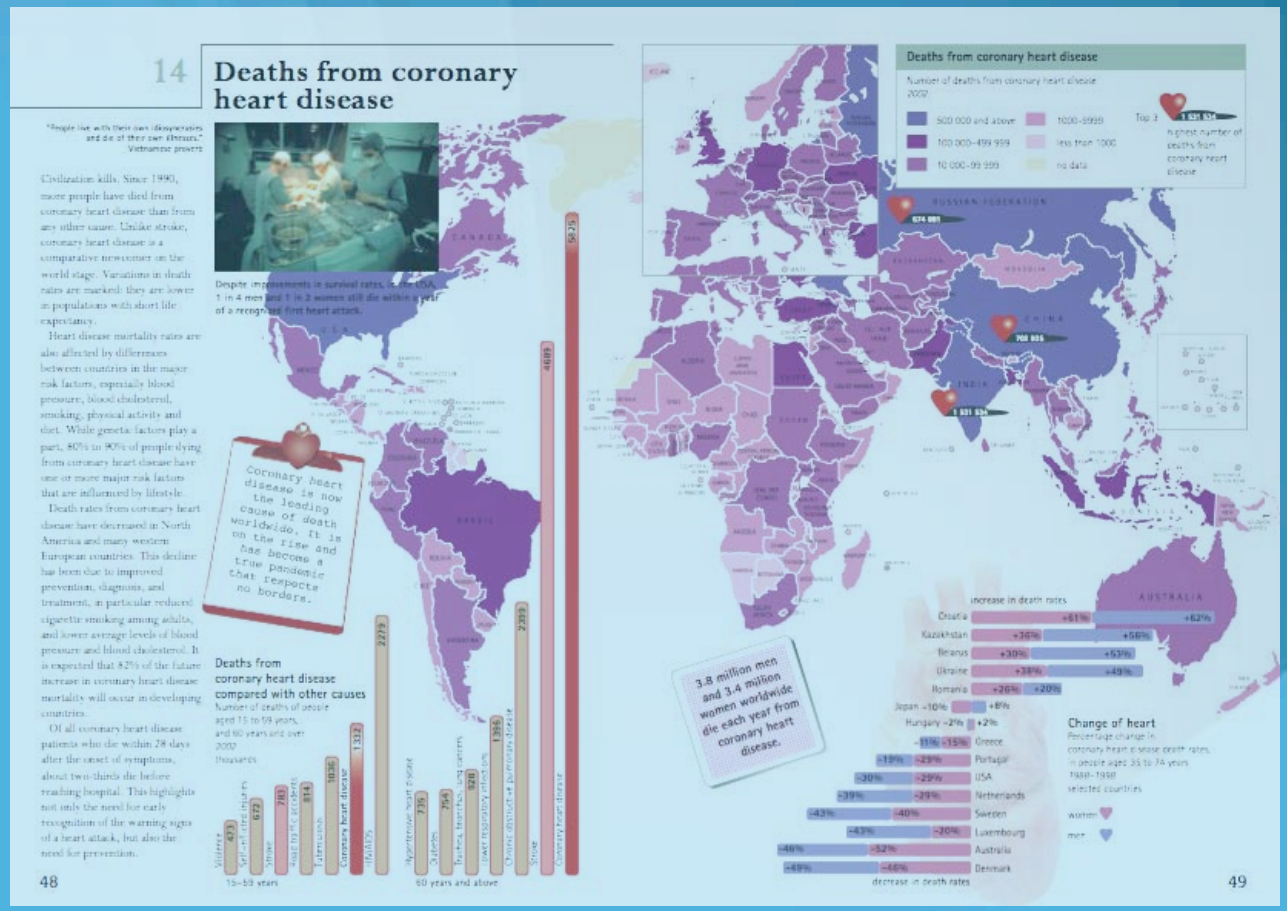
Dr. Gregory Angelo Sgueglia
Dirigente medico di I livello
UOC di Emodinamica e Cardiologia Interventistica
Ospedale Santa Maria Goretti di Latina

Lunedì 18 Ottobre
Aula MS1, 11.30 – 13.00
Dipartimento di Meccanica Strutturale
Via Ferrata,1 – Pavia

PARTE I

CONCETTI GENERALI

the WHO Atlas of Heart Disease



14

Deaths from coronary heart disease

"People live with their own idiosyncrasies and die of their own illnesses."
Vietnamese proverb

Civilization kills. Since 1990, more people have died from coronary heart disease than from any other cause. Unlike stroke, coronary heart disease is a comparative newcomer on the world stage. Variations in death rates are marked: they are lower in populations with short life expectancy.

Heart disease mortality rates are also affected by differences between countries in the major risk factors, especially blood pressure, blood cholesterol, smoking, physical activity and diet. While genetic factors play a part, 80% to 90% of people dying from coronary heart disease have one or more major risk factors that are influenced by lifestyle.

Death rates from coronary heart disease have decreased in North America and many western European countries. This decline has been due to improved prevention, diagnosis, and treatment, in particular reduced cigarette smoking among adults, and lower average levels of blood pressure and blood cholesterol. It is expected that 82% of the future increase in coronary heart disease mortality will occur in developing countries.

Of all coronary heart disease patients who die within 28 days after the onset of symptoms, about two-thirds die before reaching hospital. This highlights not only the need for early recognition of the warning signs of a heart attack, but also the need for prevention.

Despite improvements in survival rates, in the USA 1 in 4 men and 1 in 3 women still die within a year of a recognized first heart attack.

Coronary heart disease is now the leading cause of death worldwide. It is on the rise and has become a true pandemic that respects no borders.

Deaths from coronary heart disease compared with other causes
Number of deaths of people aged 15 to 59 years, and 60 years and over
2007
thousands

15–59 years: Violence 473; Spinal cord injury 672; Stroke 783; Road traffic accidents 814; Tuberculosis 1036; Coronary heart disease 1332; Homicide 2279

60 years and above: Hypertensive heart disease 735; Suicide 754; Trachea, bronchus, lung cancers 920; Lower respiratory infections 1395; Chronic obstructive pulmonary disease 2393; Stroke 4608; Coronary heart disease 6275

Deaths from coronary heart disease
Number of deaths from coronary heart disease 2007
500 000 and above
100 000–499 999
10 000–99 999
1000–9999
less than 1000
no data
Top 3
highest number of deaths from coronary heart disease
RUSSIAN FEDERATION 674 881
CHINA 768 805
INDIA 1 931 836

3.8 million men and 3.4 million women worldwide die each year from coronary heart disease.

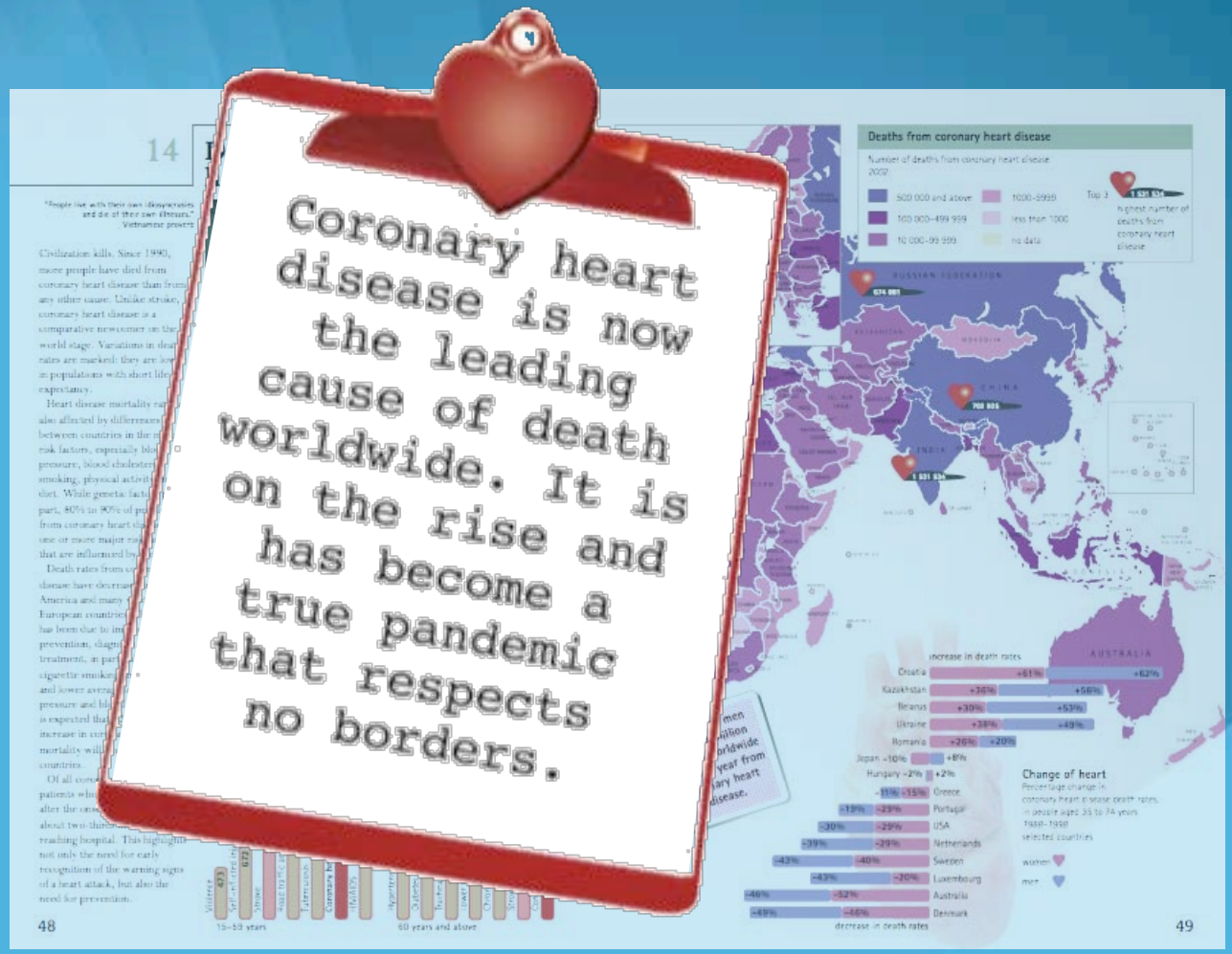
Increase in death rates
Croatia +61% +62%
Kazakhstan +36% +56%
Belarus +30% +53%
Ukraine +38% +49%
Romania +26% +20%
Japan -10% +8%
Hungary -2% +2%
Greece -11% -15%
Portugal -13% -23%
USA -30% -29%
Netherlands -19% -29%
Sweden -43% -40%
Luxembourg -43% -20%
Australia -46% -52%
Denmark -49% -46%
decrease in death rates

Change of heart
Percentage change in coronary heart disease death rates, in people aged 35 to 74 years 1980–1990 selected countries
women
men

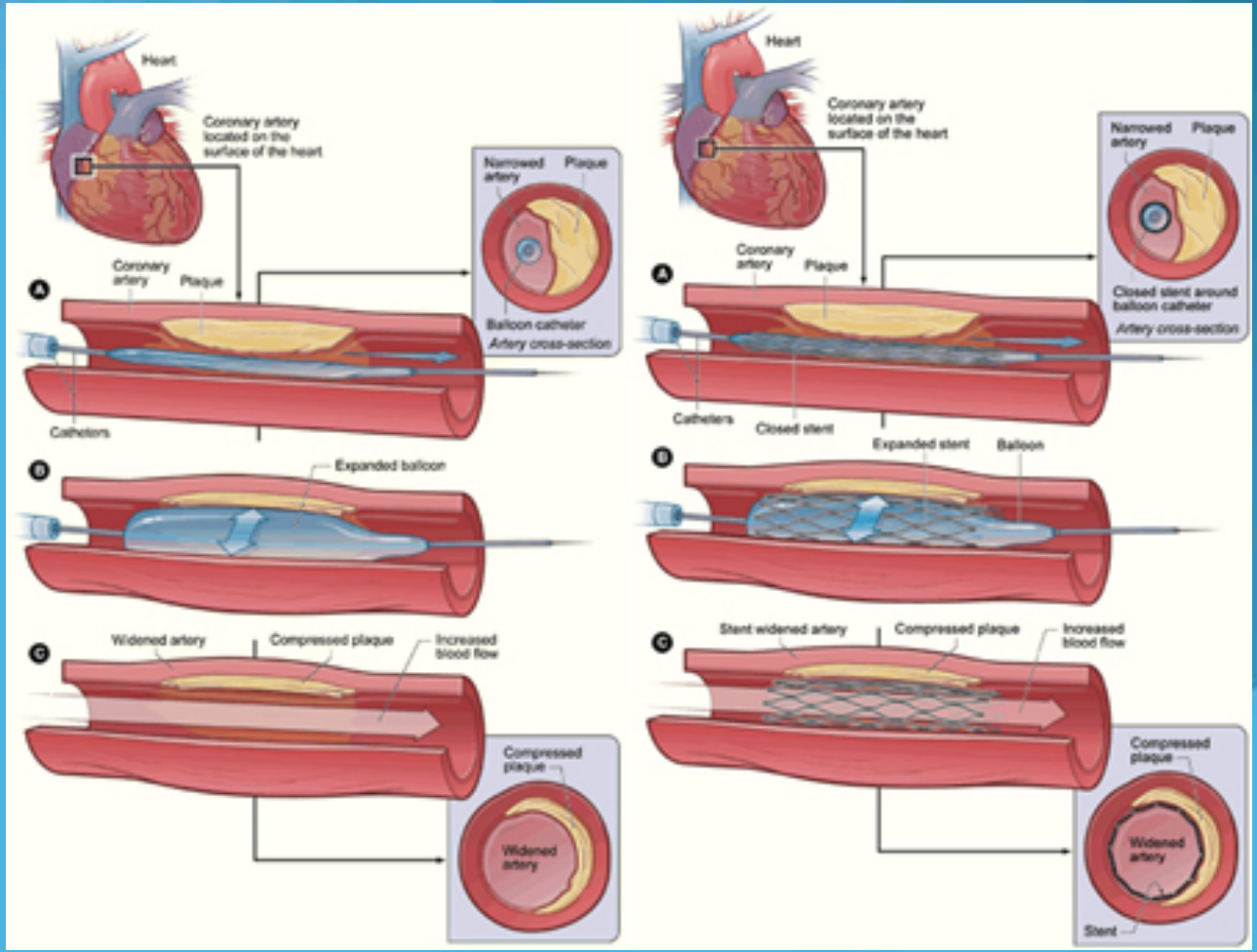
48

49

the WHO Atlas of Heart Disease



intervento coronarico percutaneo



infarto miocardico acuto

- ostruzione di una arteria coronaria a seguito della fissurazione di una placca aterosclerotica con formazione di un trombo occludente e conseguente necrosi del tessuto miocardico
- patologia grave: mortalità intra-ospedaliera 5-10%
- il trattamento di scelta è l'intervento coronarico percutaneo primario

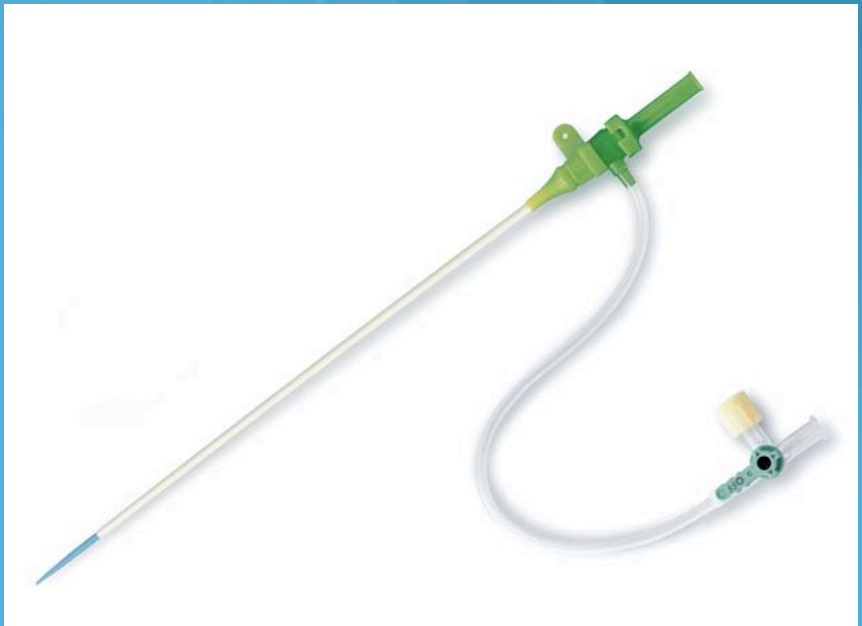
angina cronica stabile

- situazione clinica caratterizzata da sintomi quali dolore toracico e/o dispnea tipicamente indotti dallo sforzo fisico e dovuti al ridotto apporto di ossigeno al miocardio a causa di una o più stenosi coronariche
- gravità moderata della patologia: mortalità annua compresa tra 2 e 3%
- il trattamento percutaneo è uno dei trattamenti possibili ma il suo impatto sulla prognosi non è stabilito

sindrome coronarica acuta

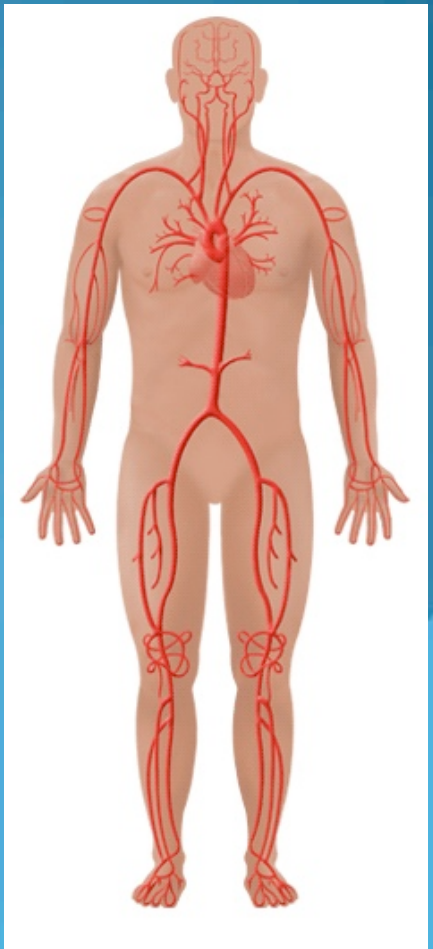
- sindrome clinica eterogenea variamente caratterizzata da dolore toracico, alterazioni di parametri di laboratorio e compromissione della meccanica cardiaca associata ad un insieme di quadri patologici ostruttivi acuti a carico delle arterie coronarie
- patologia grave: mortalità intra-ospedaliera attorno al 5%
- l'intervento coronarico percutaneo l'intervento di scelta nella forme di gravita media ed elevata

l'accesso arterioso

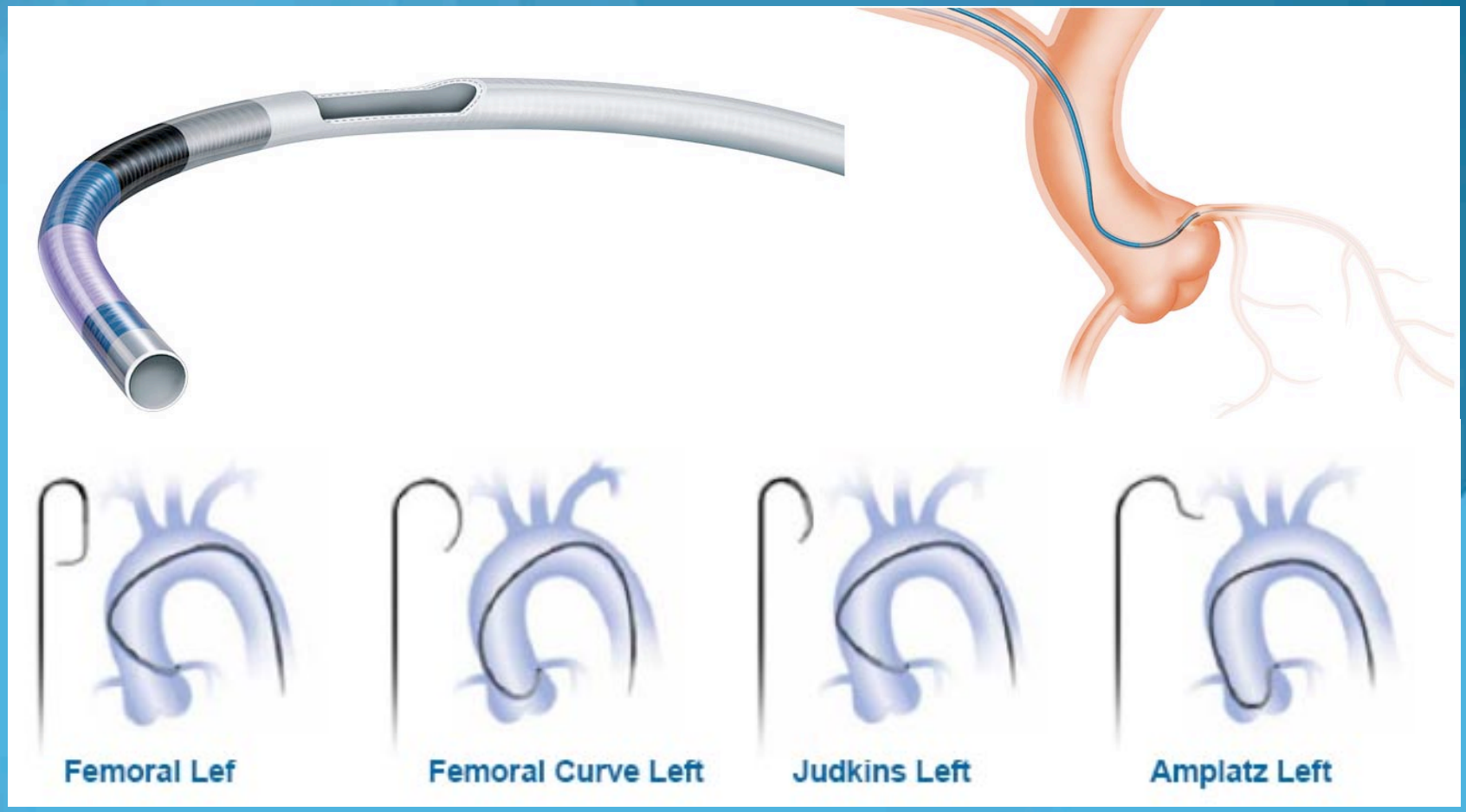


4F	1,3 mm
5F	1,7 mm
6F	2,0 mm

7F	2,4 mm
8F	2,7 mm

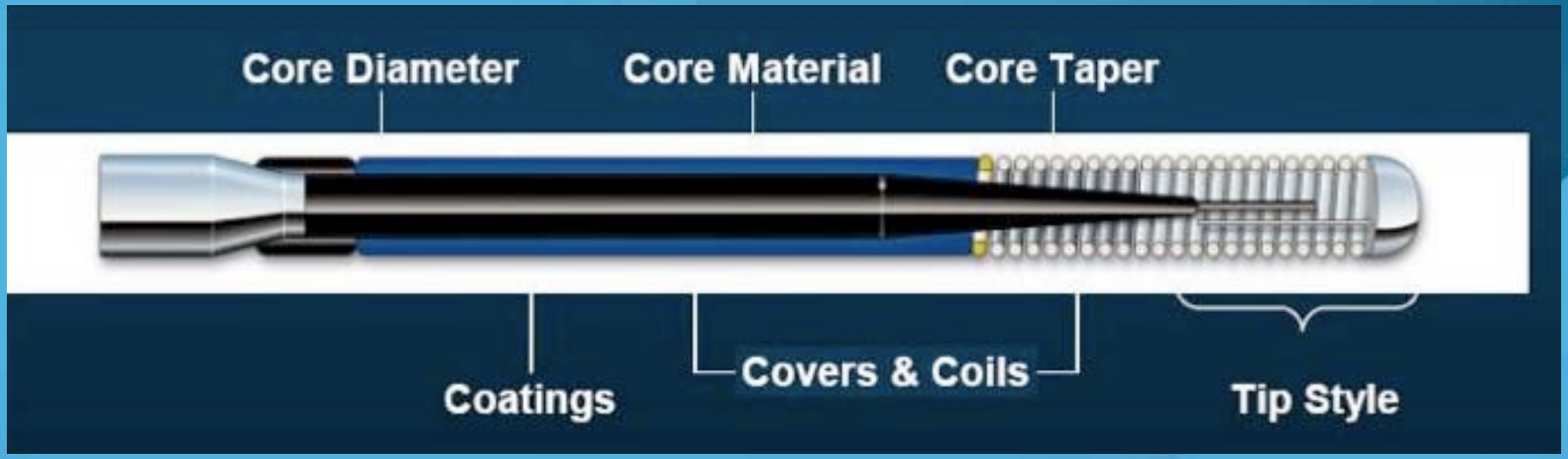


i cateteri

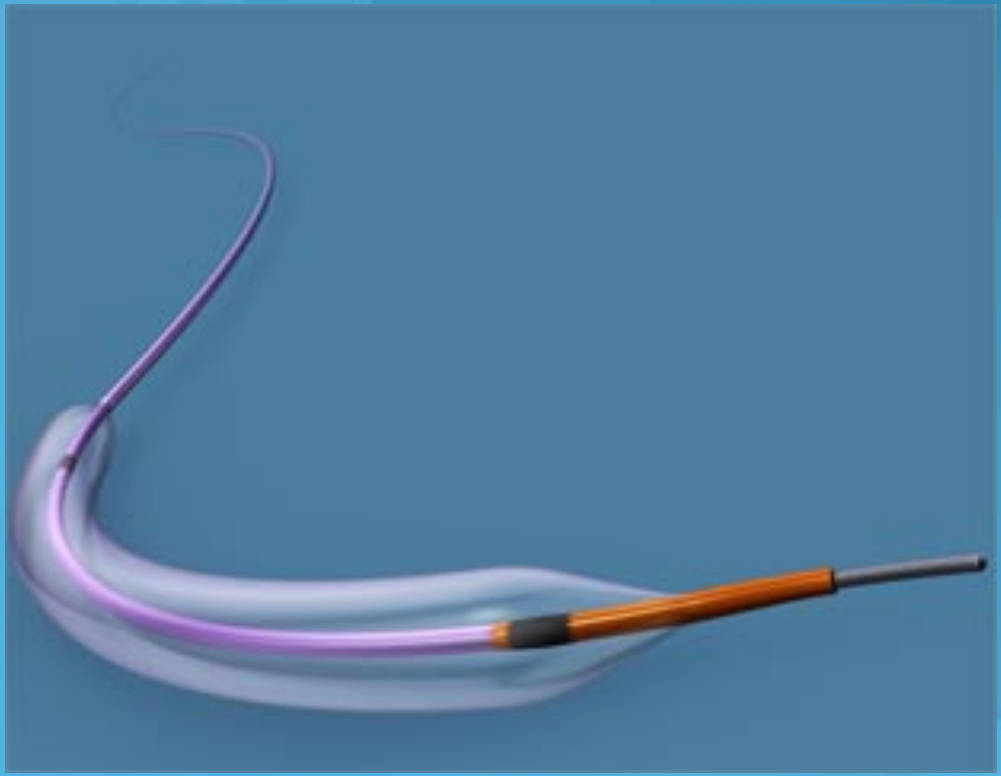


le guide

le guide

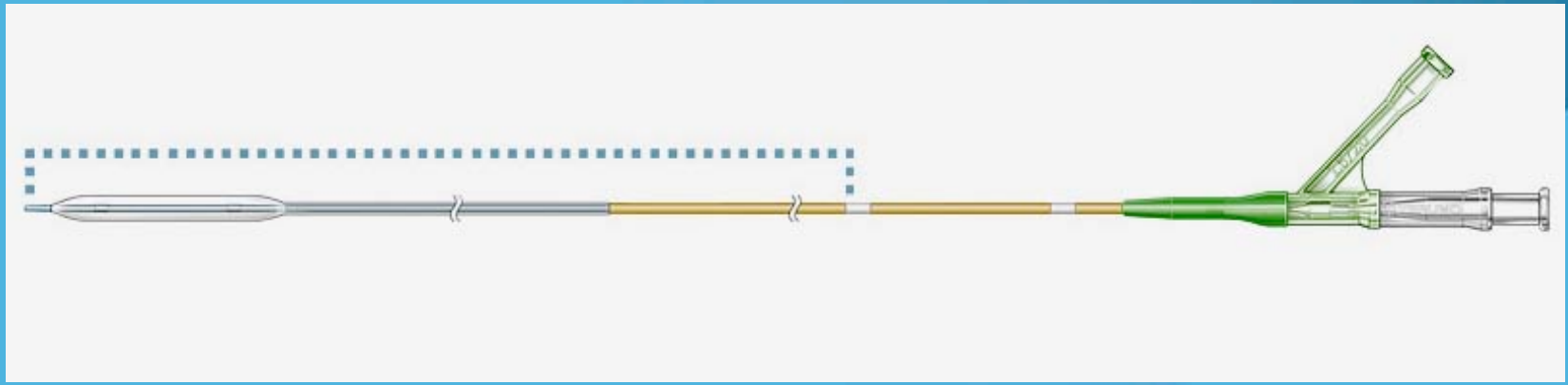

Core Diameter
Core Material
Core Taper
Coatings
Covers & Coils
Tip Style

i palloni



i palloni

- palloni semi-complianti
- palloni non complianti
- palloni speciali
- rapid exchange and over the wire



i palloni

5 Key Balloon Attributes

- **Entry** – pushability and crossability
- **Tracking** – guidewire compatibility
- **Crossability** – profiles and transition angles
- **Dilatation** – balloon material and shoulders
- **Withdrawal** – rewrap

i palloni

Balloon Material

More Compliant

POC

PE

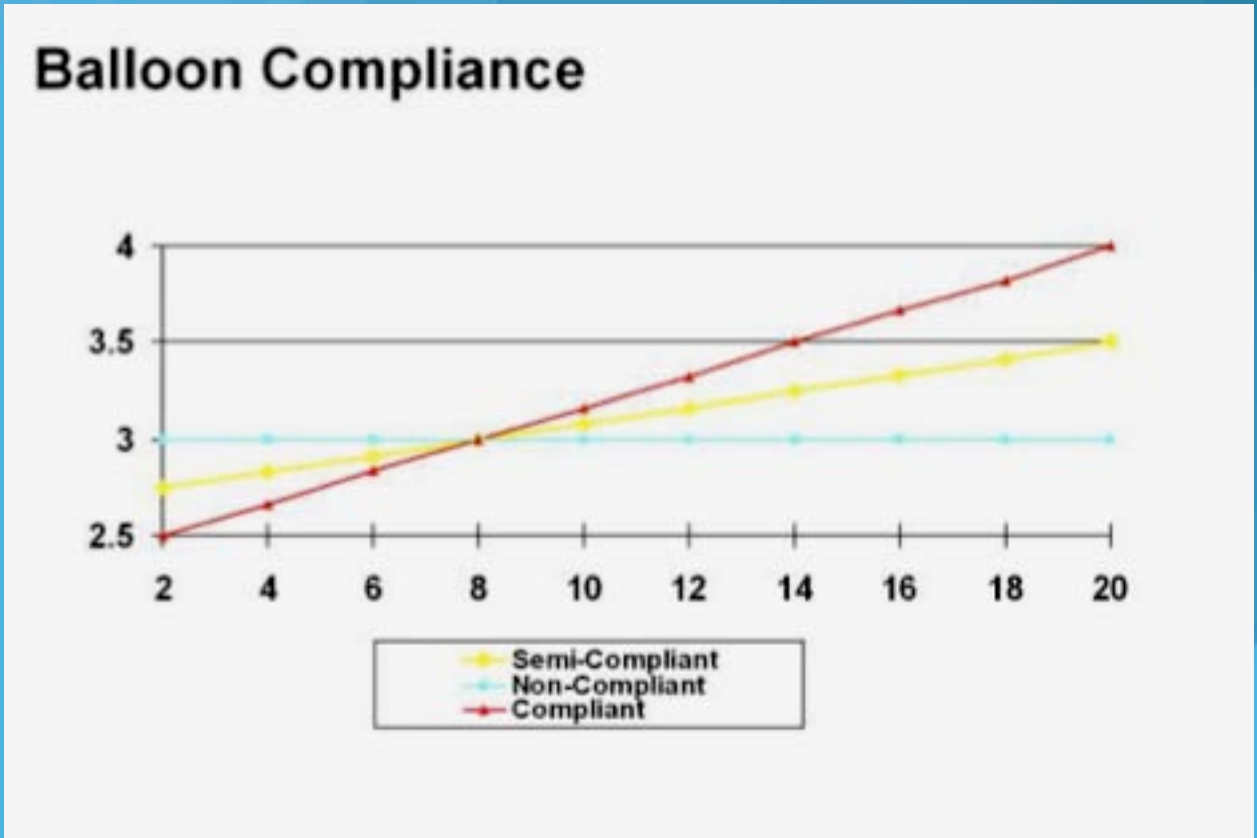
Nylon

PET

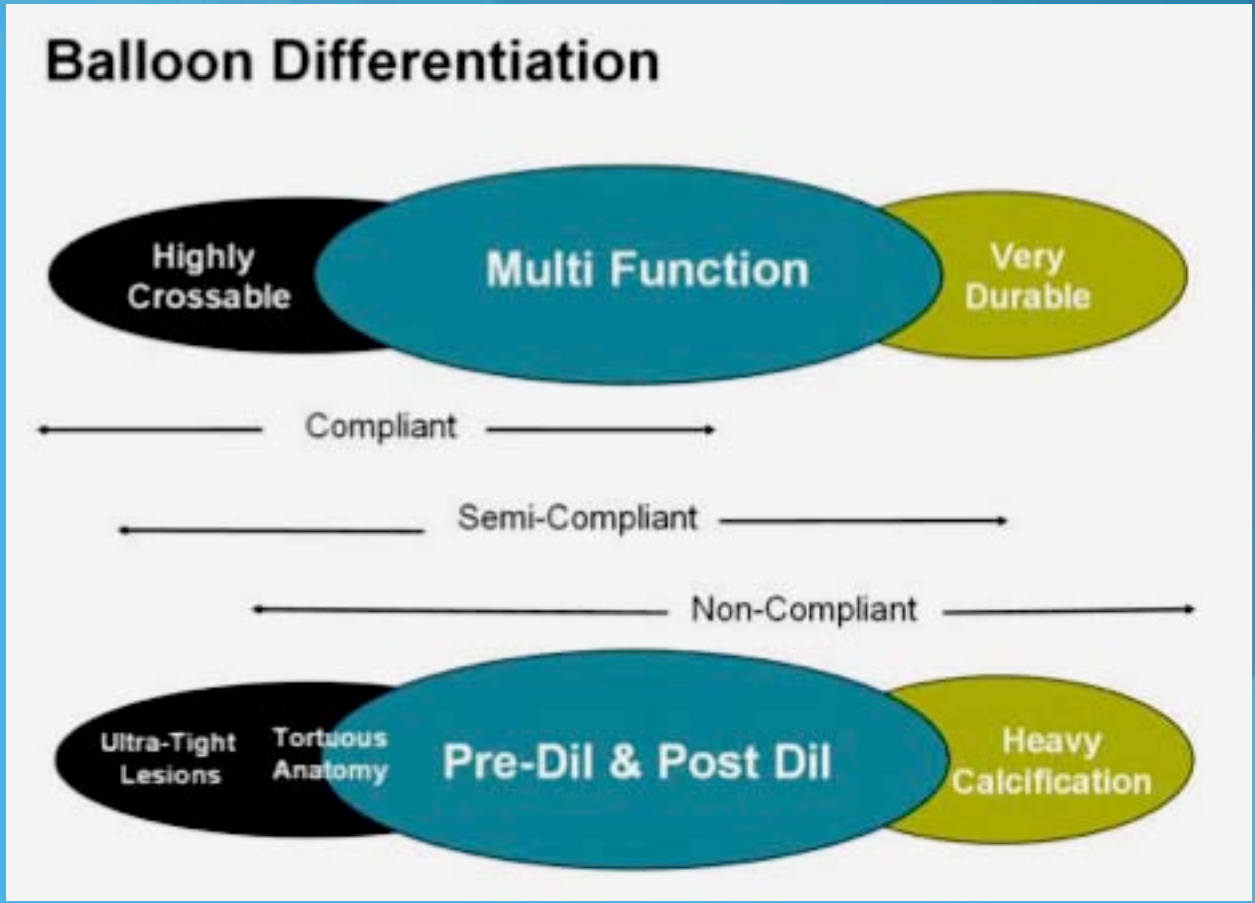
Less Compliant

Manufacturers use different balloon materials and blends to design their balloon portfolio.

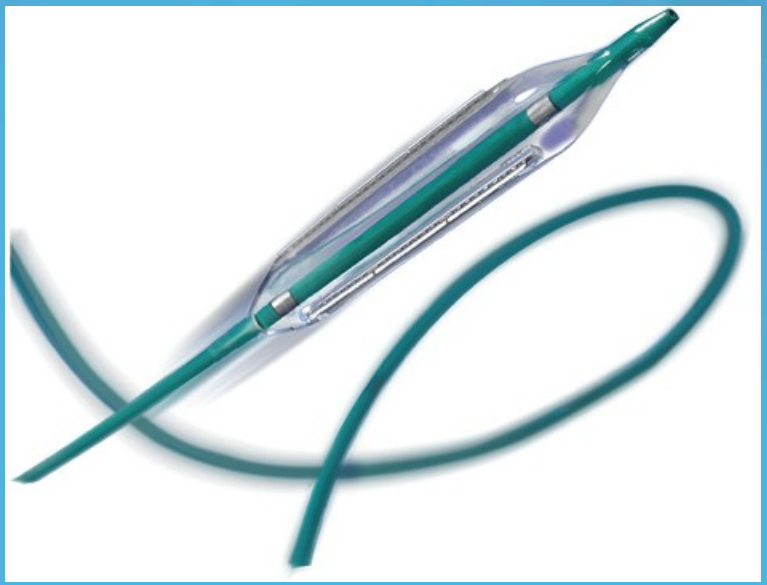
i palloni


Balloon Compliance
4
3.5
3
2.5
2
4
6
8
10
12
14
16
18
20
Semi-Compliant
Non-Compliant
Compliant

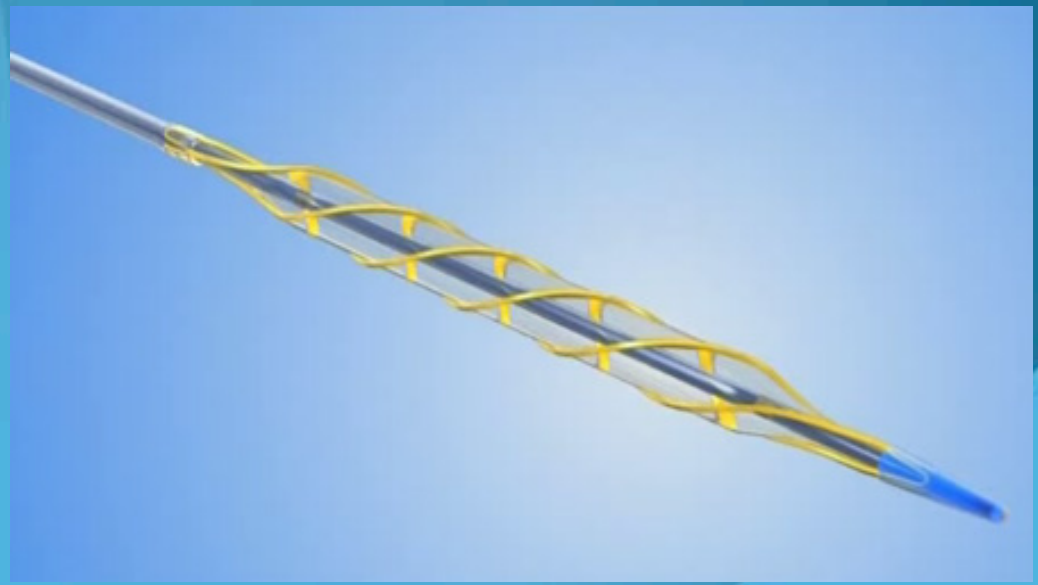
i palloni


Balloon Differentiation
Highly Crossable
Multi Function
Very Durable
Compliant
Semi-Compliant
Non-Compliant
Ultra-Tight Lesions
Tortuous Anatomy
Pre-Dil & Post Dil
Heavy Calcification

i palloni speciali: scoring

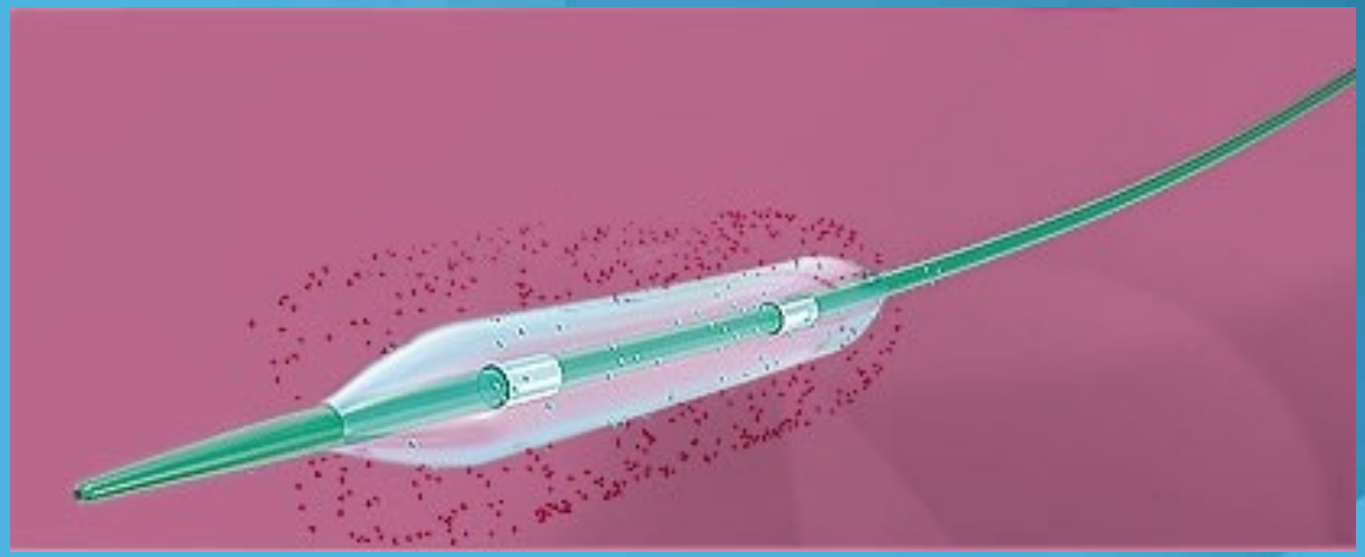


Cutting Balloon

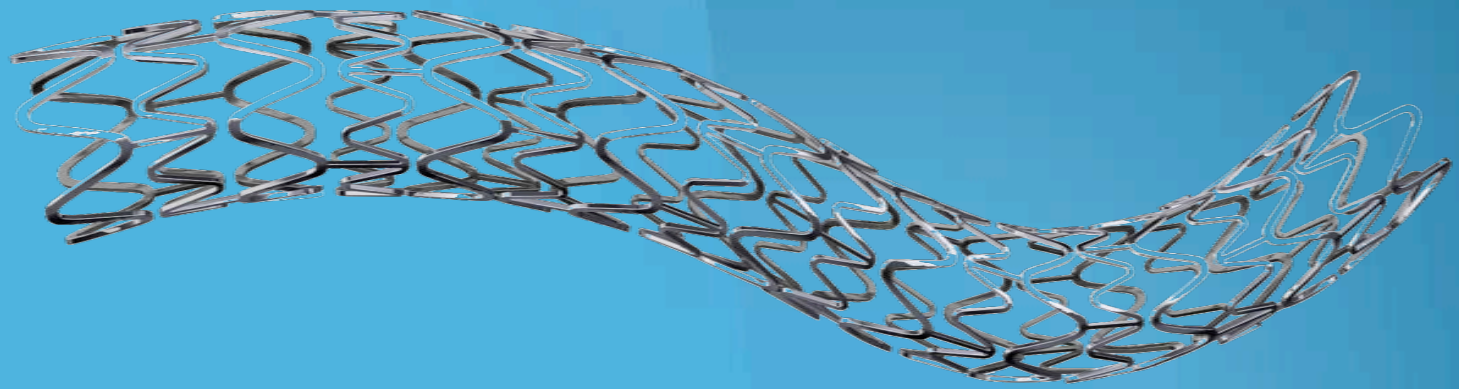


AngioSculpt

i palloni speciali: paclitaxel-eluting



gli stent



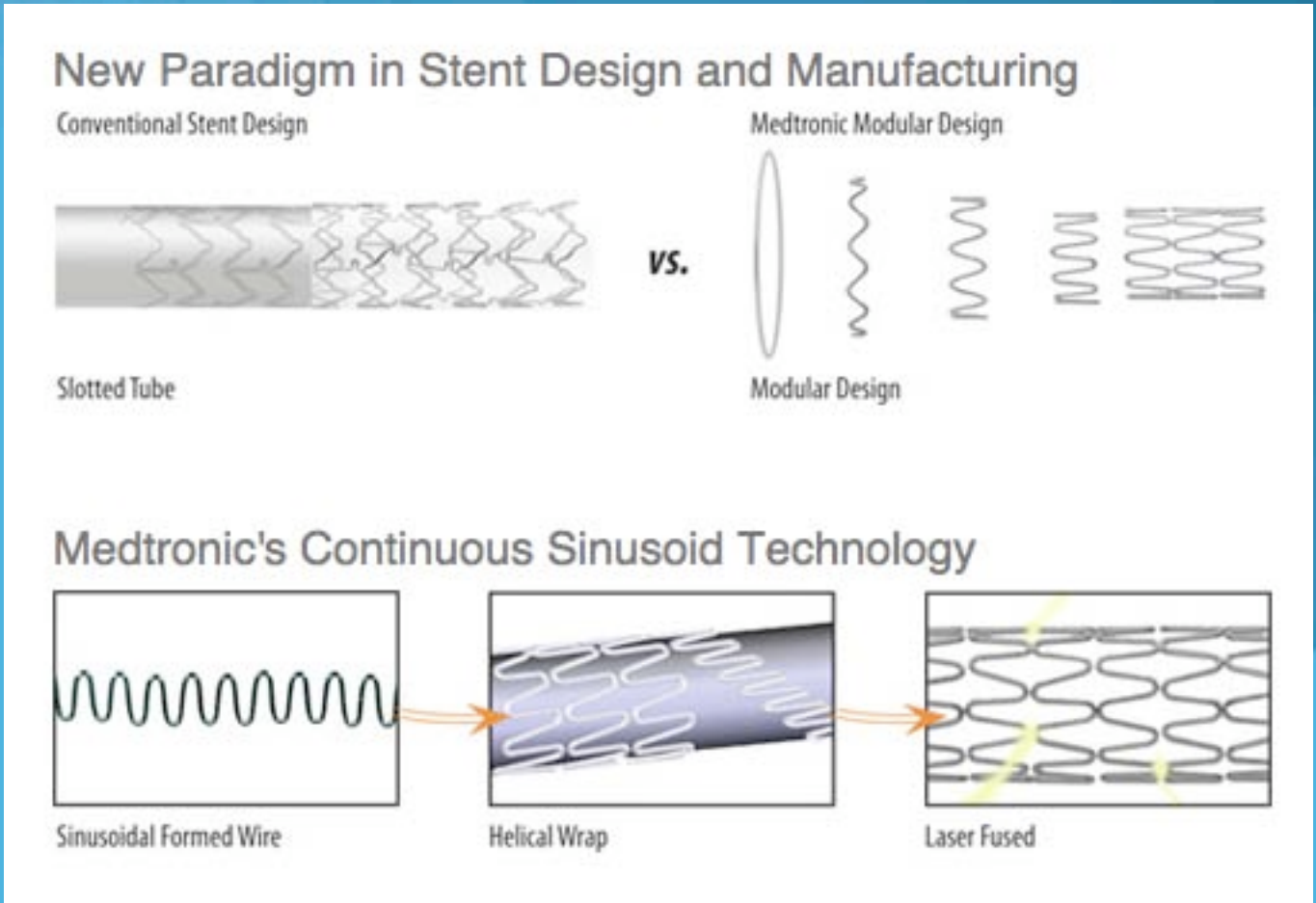
le pietre miliari

- 1986 impianto del primo stent coronarico in acciaio
- 1993 studi BENESTENT e STRESS con stent Palmaz-Schatz
- 2002 primo stent medicato
- 2002 primo stent in cromo-cobalto
- 2006 il problema della trombosi degli stent medicati

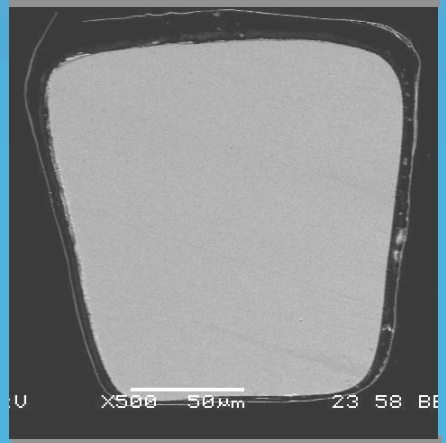
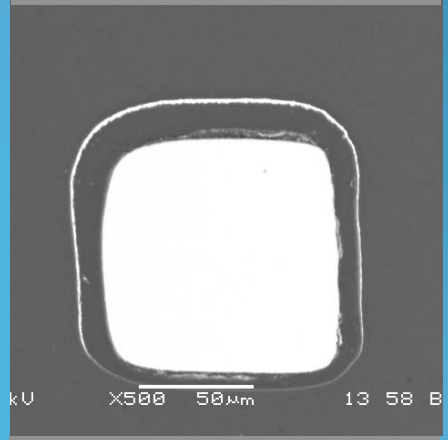
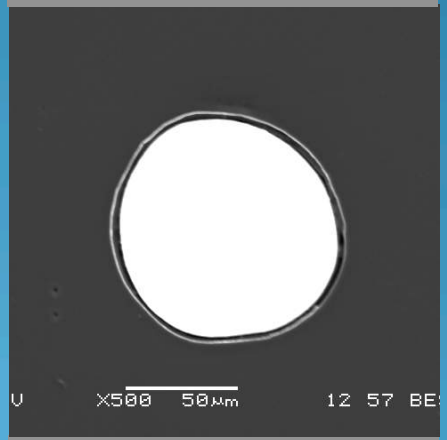
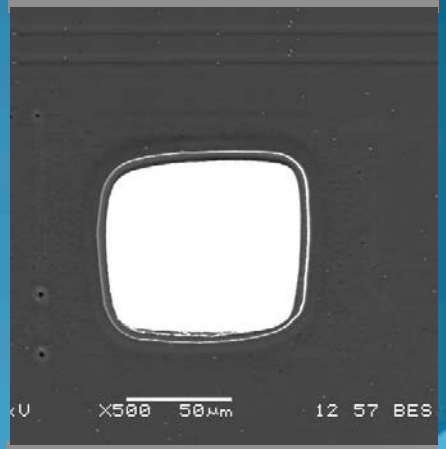
materiali

- Acciaio 316L (i primi stent metallici, Cypher e Taxus)
- lega cromo-cobalto tipicamente 605L (Driver/Resolute e Vision/Xience)
- lega platino cromo, la prima lega specificamente sviluppata per gli stent coronarici (stent Element)

produzione

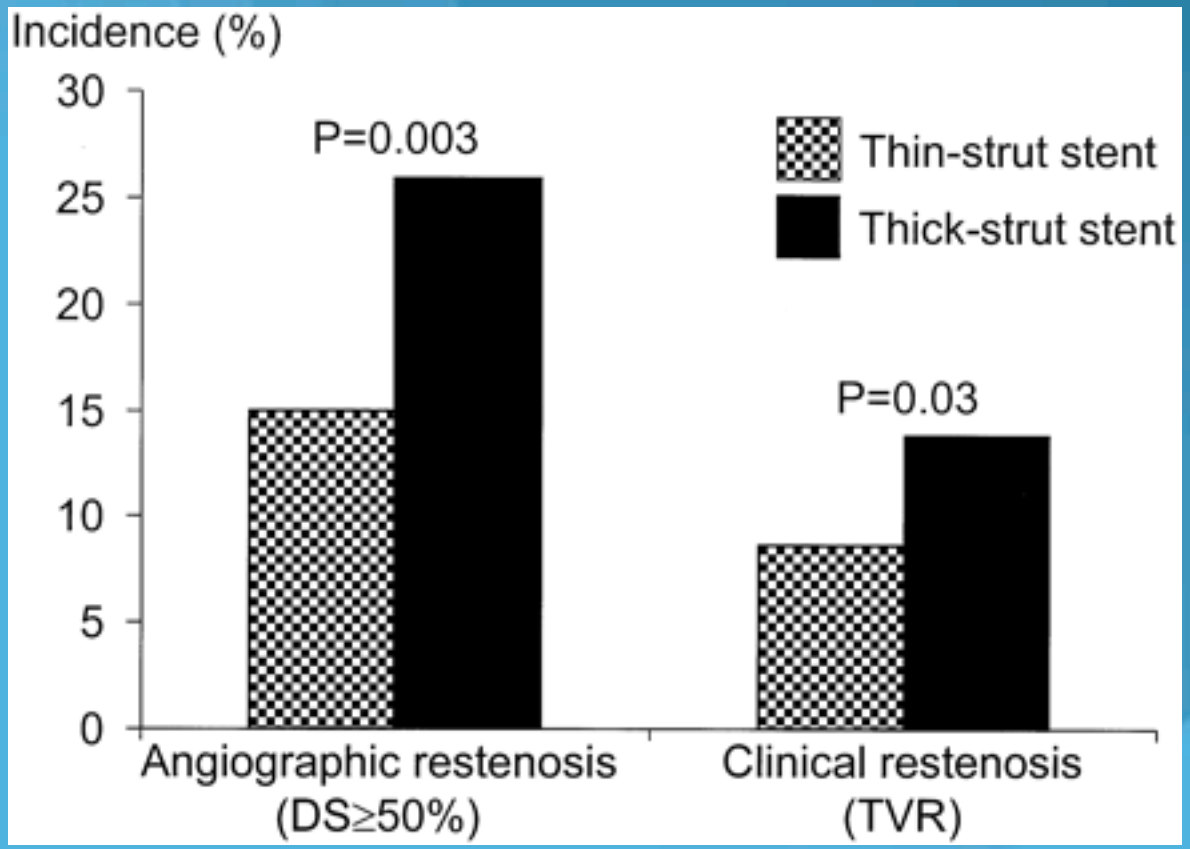

New Paradigm in Stent Design and Manufacturing
Conventional Stent Design
Medtronic Modular Design
VS.
Slotted Tube
Modular Design
Medtronic's Continuous Sinusoid Technology
Sinusoidal Formed Wire
Helical Wrap
Laser Fused

spessori degli struts

CYPHER®	TAXUS® Liberté	ENDEAVOR™	XIENCE V™
			
Strut Thickness:	**Strut Thickness:**	**Strut Thickness:**	**Strut Thickness:**
140 µm	**97 µm**	**91 µm**	**81 µm**
Coating Thickness:	**Coating Thickness:**	**Coating Thickness:**	**Coating Thickness:**
12.6 µm	**17.8 µm**	**4.8 µm**	**7.8 µm**

3.0 mm diameter stents, 500x magnification

spessori degli struts



Kastrati *Circulation* 2001

dimensioni

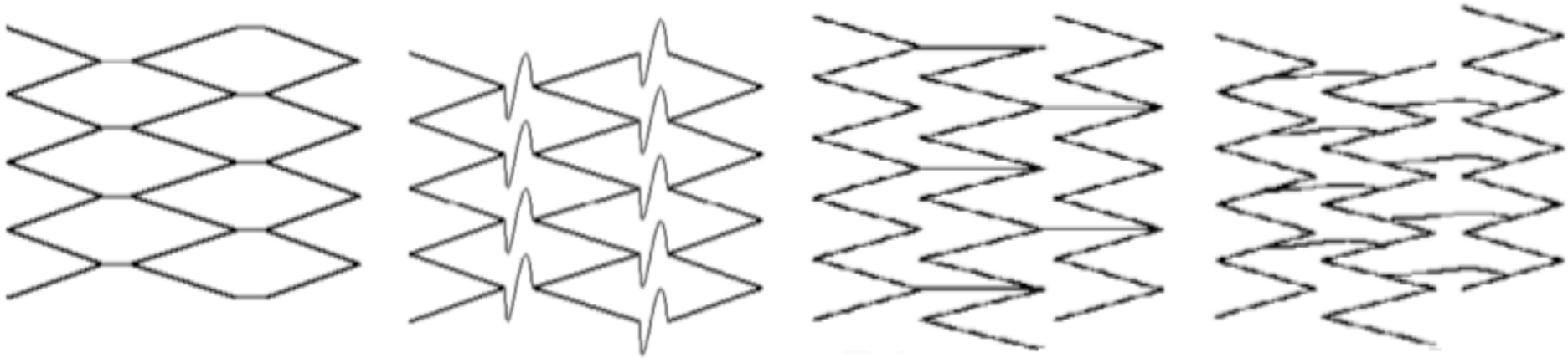
- tipicamente gli stent esistono in due configurazioni che coprono tutta la gamma dei diametri
  - piccola (fino al 2,75 mm) può raggiungere 3,5 mm
  - grande (dal 3 mm) può raggiungere 4,5 mm
- con l'introduzione della serie Element le configurazioni sono 4
  - molto piccola (2,25 mm) può raggiungere 2,75 mm
  - piccola (2,5 e 2,75 mm) può raggiungere 3,5 mm
  - Media (3,0 e 3,5 mm) può raggiungere 4,25 mm
  - Grande (4,0 mm) può raggiungere 4,75 mm

geometria

- geometria ad anelli sequenziali costituiti da strutture a forma di Z (struts o maglie) connesse tra di loro

Celle aperte

Celle chiuse



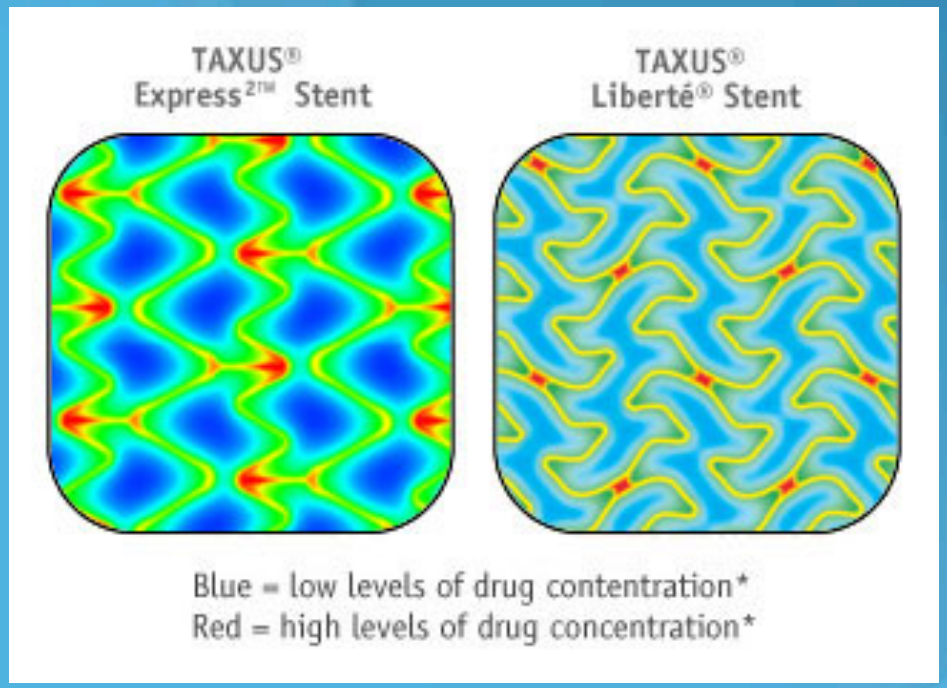
Palmaz-Schatz

BX-Velocty

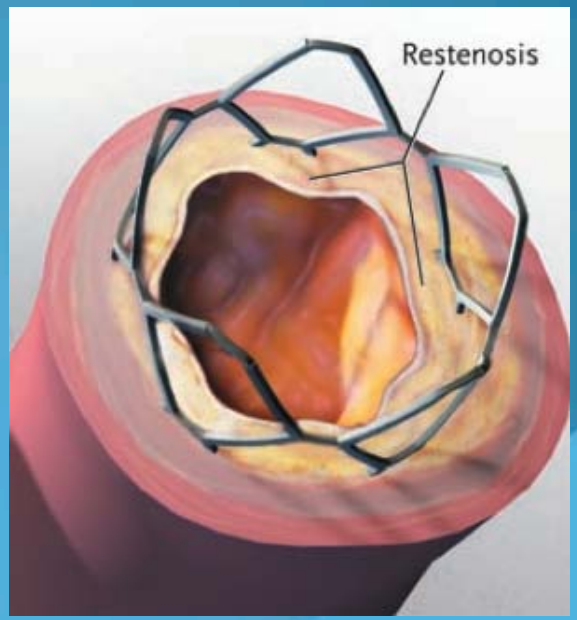
MultiLink

Carbostent

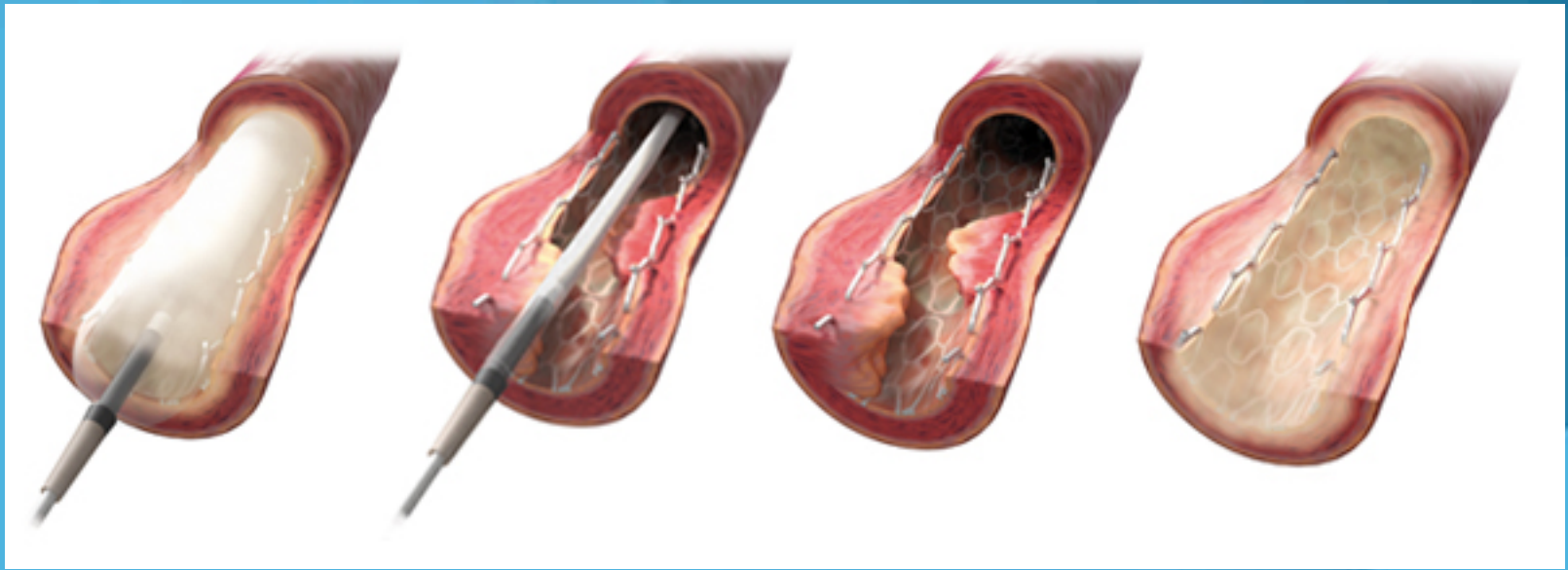
geometria


TAXUS®
Express²™ Stent
TAXUS®
Liberté® Stent
Blue = low levels of drug contentration*
Red = high levels of drug concentration*

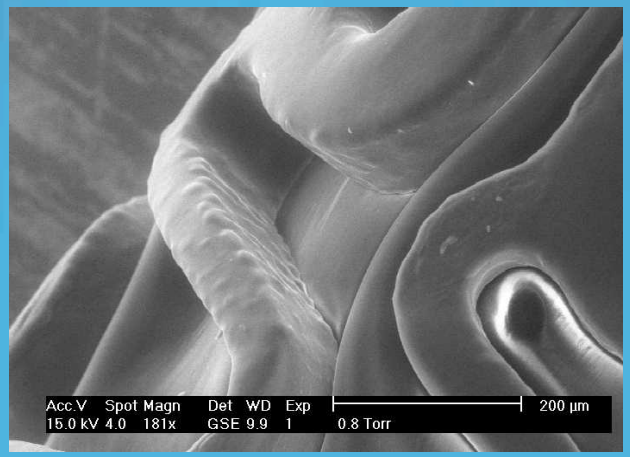
la malattia da stent



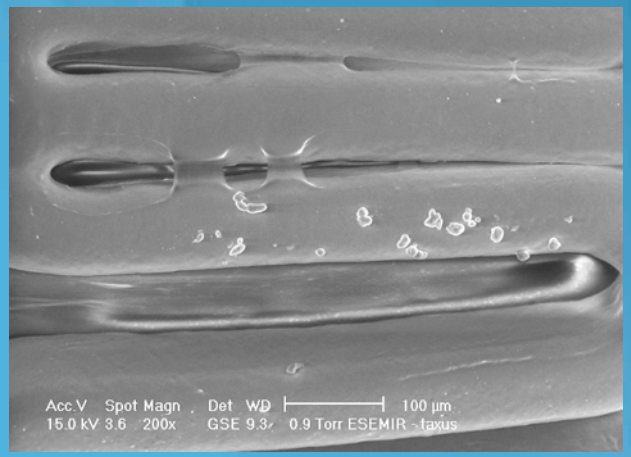
il trattamento della restenosi



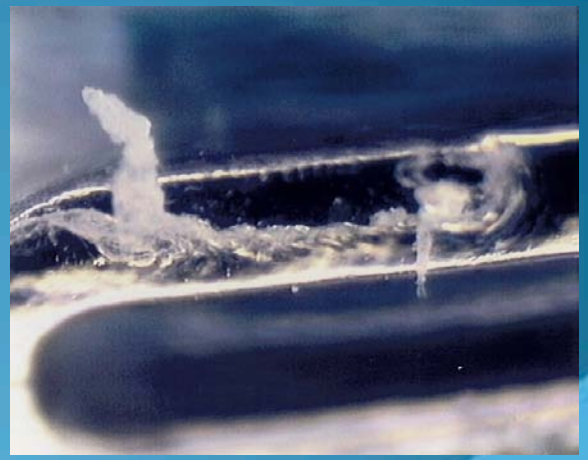
i limiti strutturali del polimero



rivestimento non uniforme



webbing

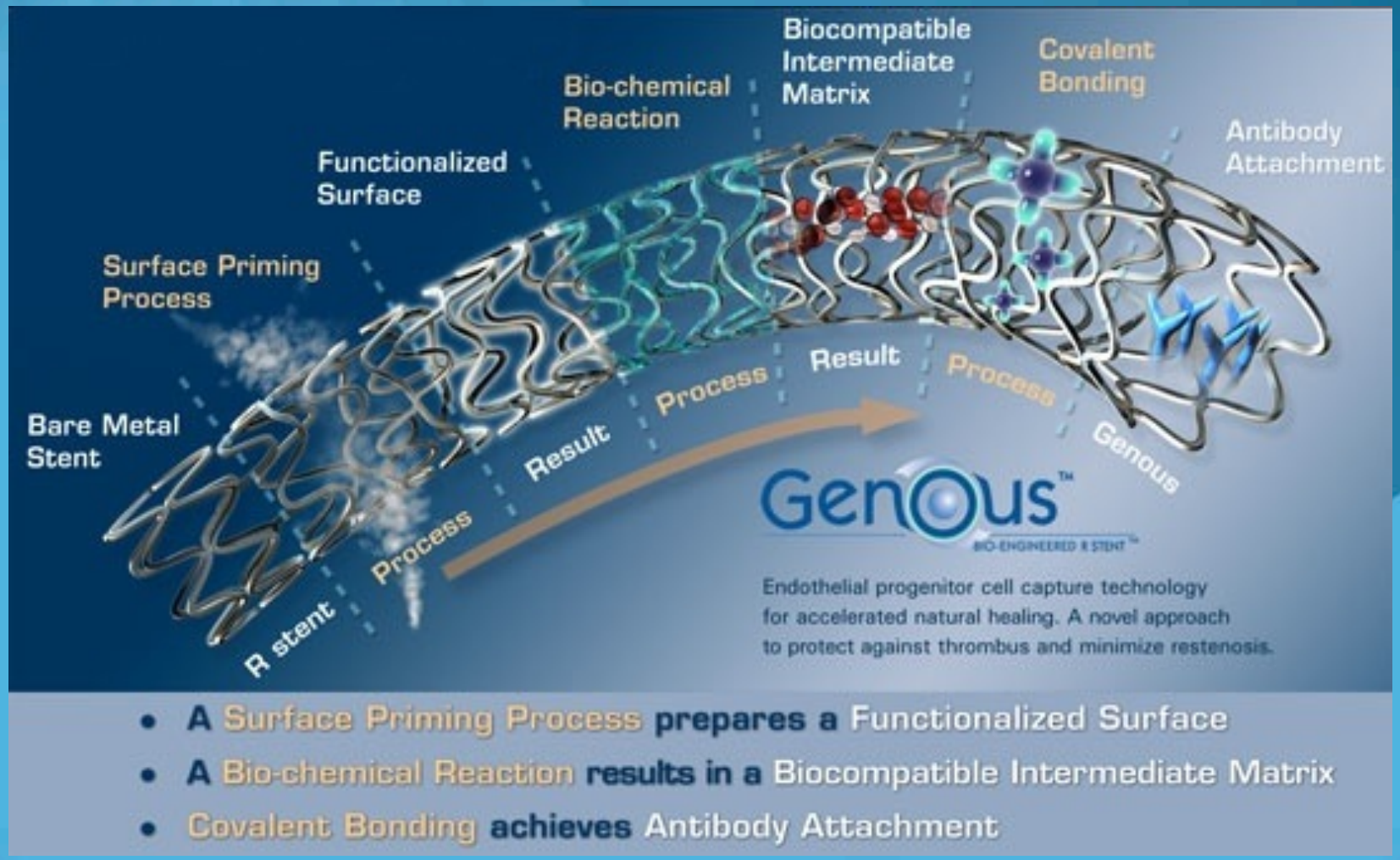


delaminazione

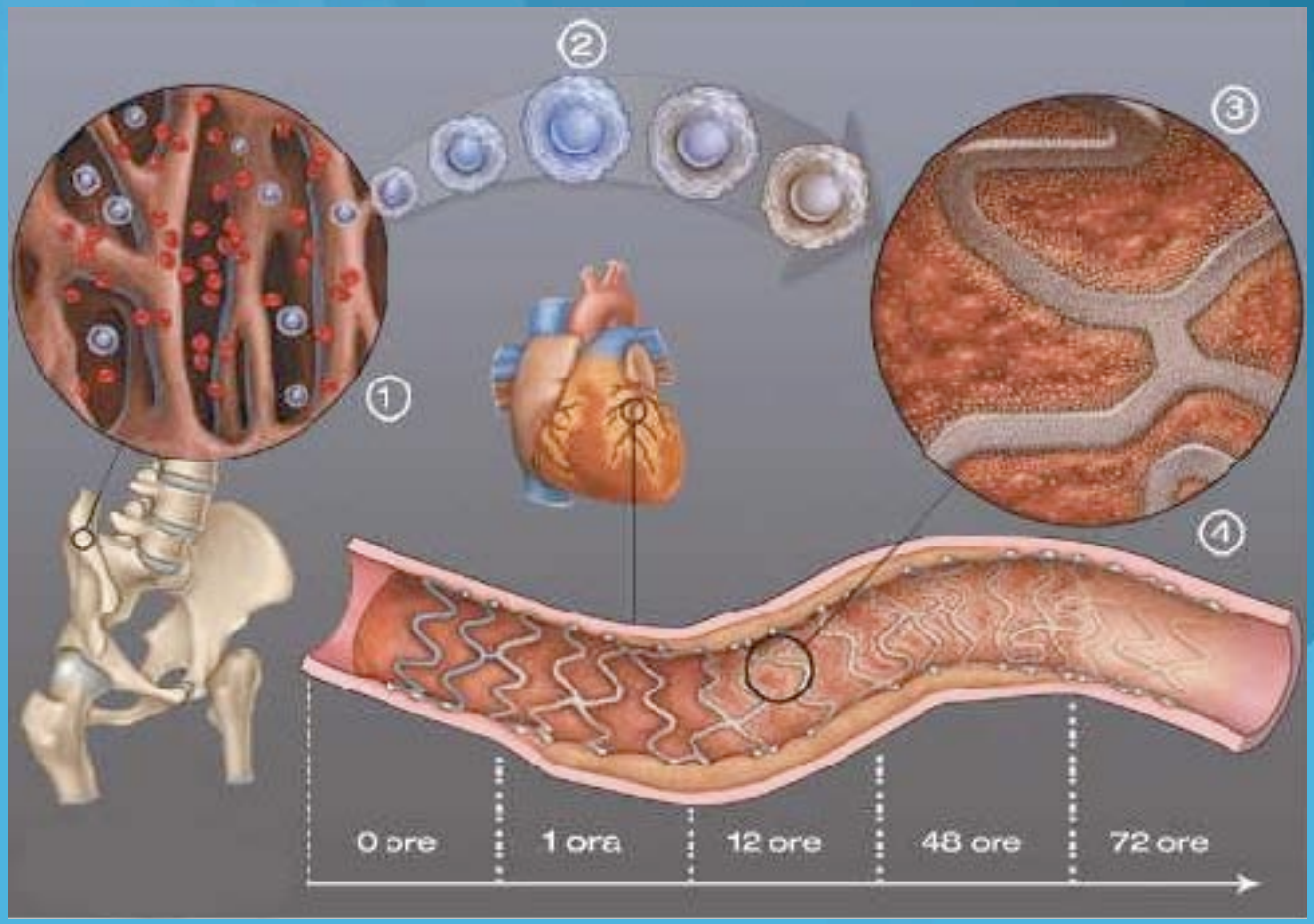
lo stent bioattivo

- rivestimento in carbonio (Chrono e AvantGarde – cromo-cobalto)
- rivestimento in ossido di titanio (TiTan2 – acciaio)
- rivestimento in Polyzene-F (Catania – cromo-bobalto)

lo stent bioingegnerizzato

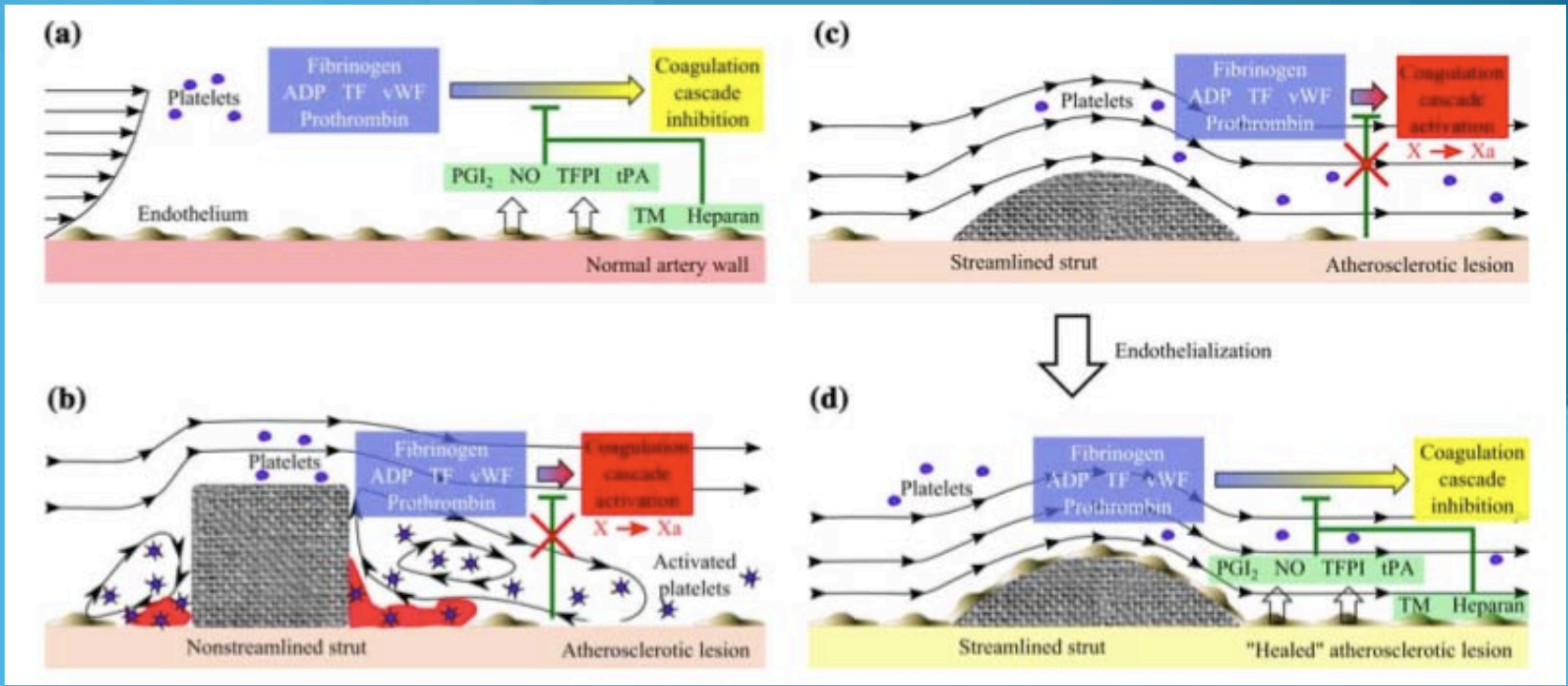


lo stent bioingegnerizzato



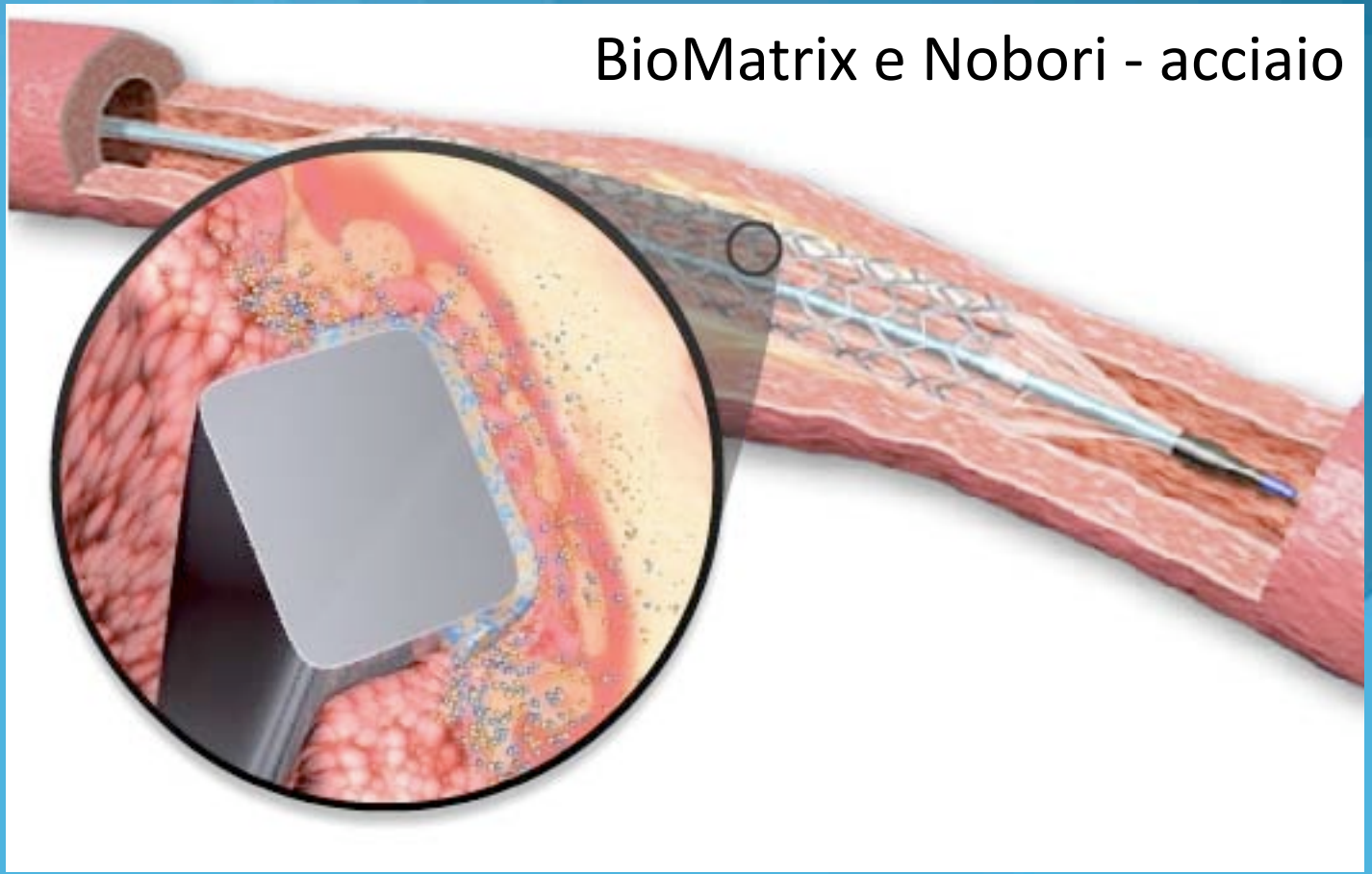
lo stent bioingegnerizzato

AvantGarde – cromo-cobalto



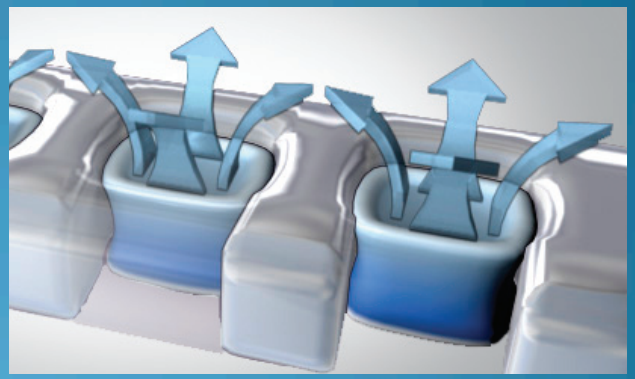
Jimenez JM *Ann Biomed Eng* 2009

il polimero biodegradabile



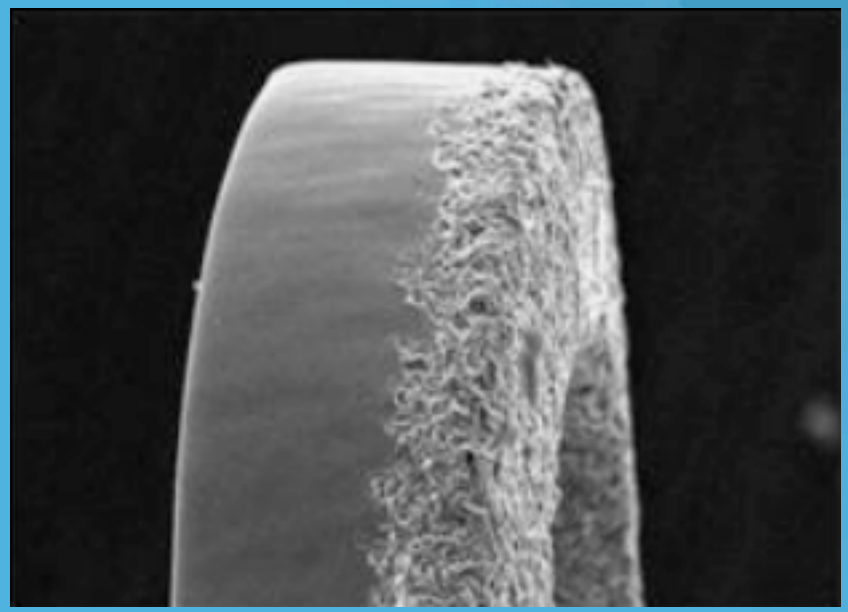
la tecnologia Reservoir

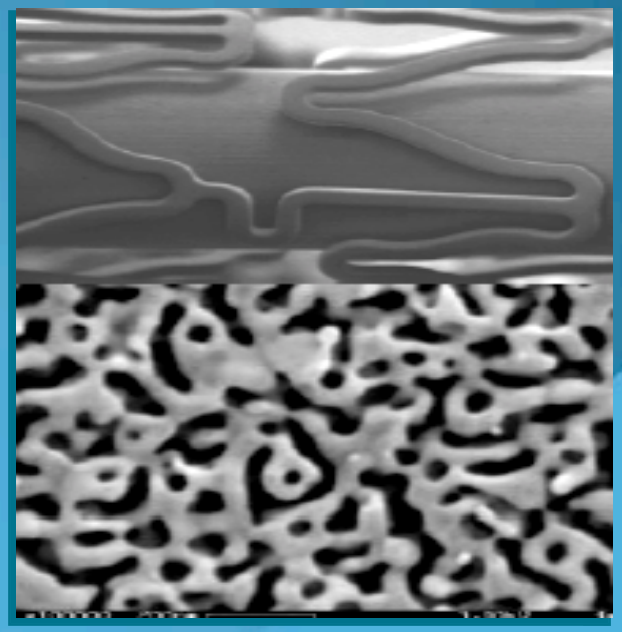
Nevo – cromo-cobalto



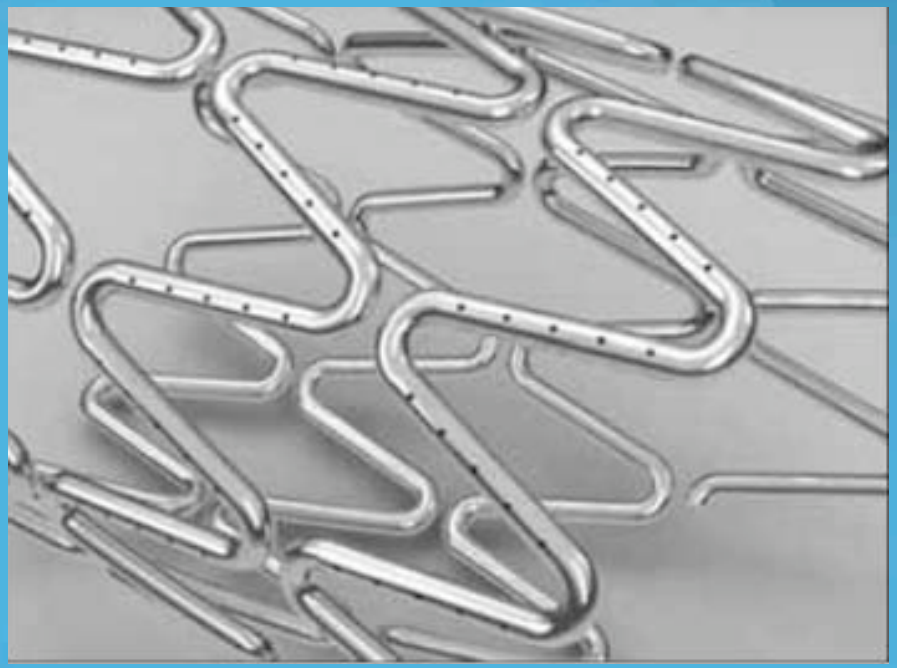
la Surface Modification

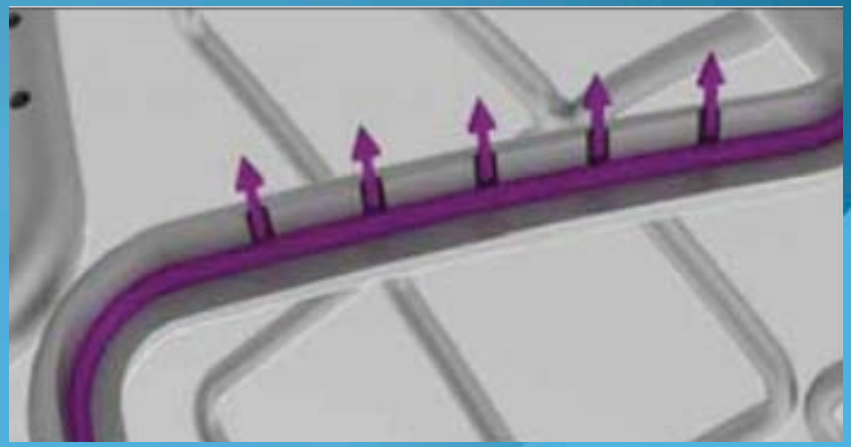
BioFreedom – acciaio



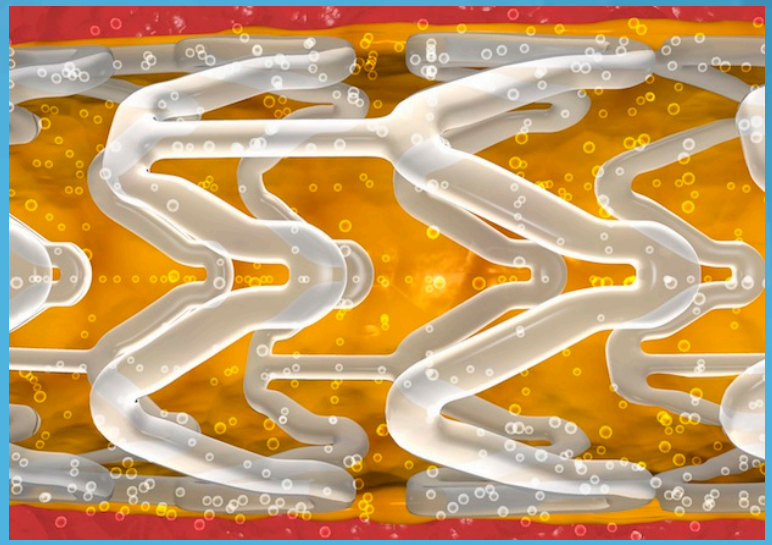


il Drug-Filled Stent

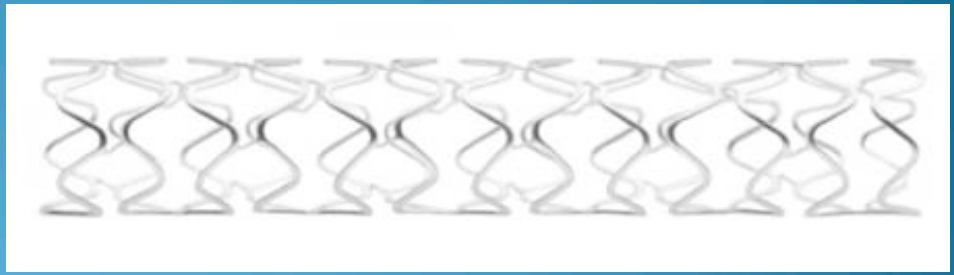




lo stent riassorbibile



BVS
Biodegradable Vascular Scaffold

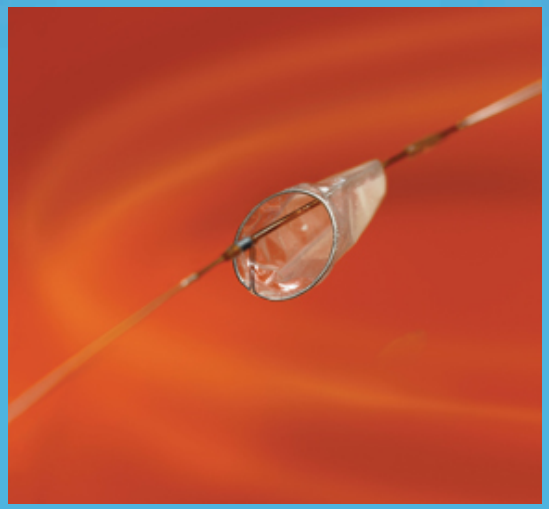


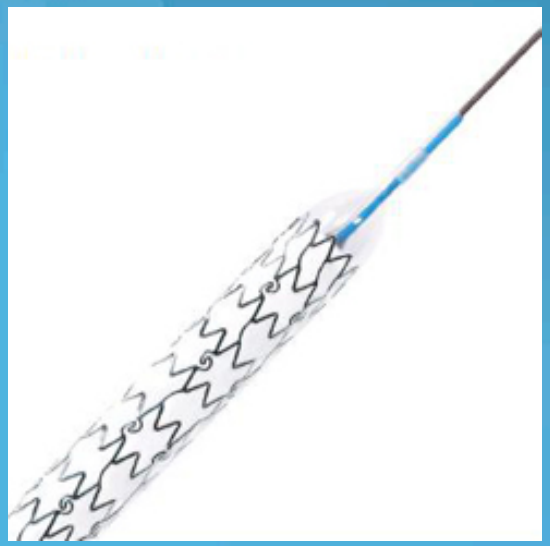
DREAMS
Drug Eluting Absorbable Metal Scaffold

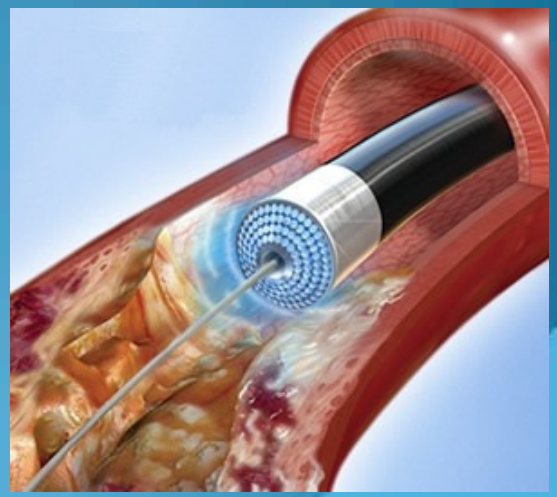
le frontiere

- i graft venosi
- le occlusioni croniche
- le lesioni ostiali
- le biforcazioni

i graft venosi – le soluzioni proposte

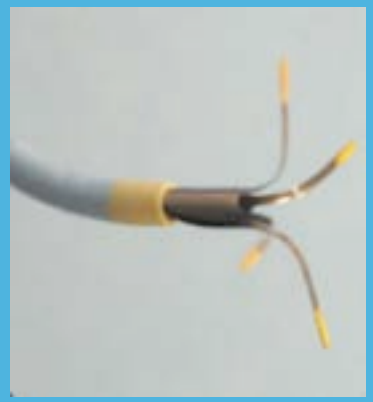


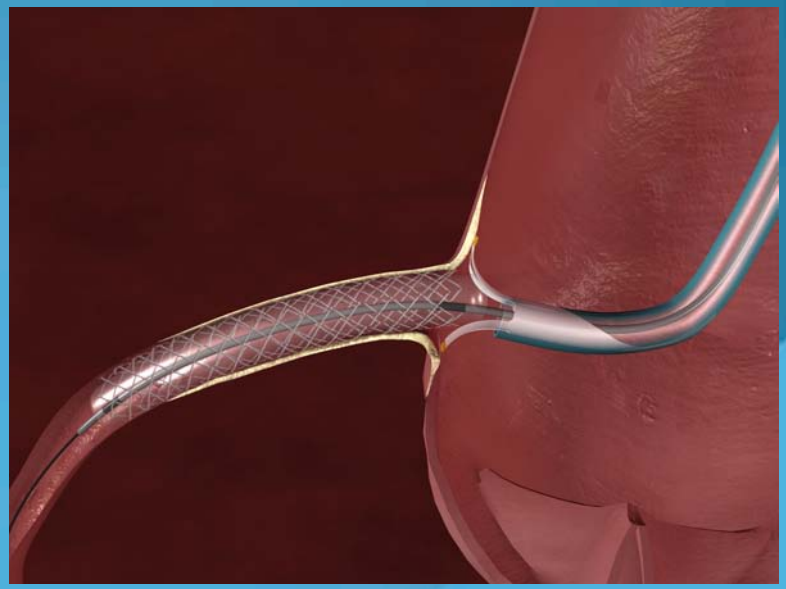




lesioni ostiali – le soluzioni proposte

Ostial Pro System





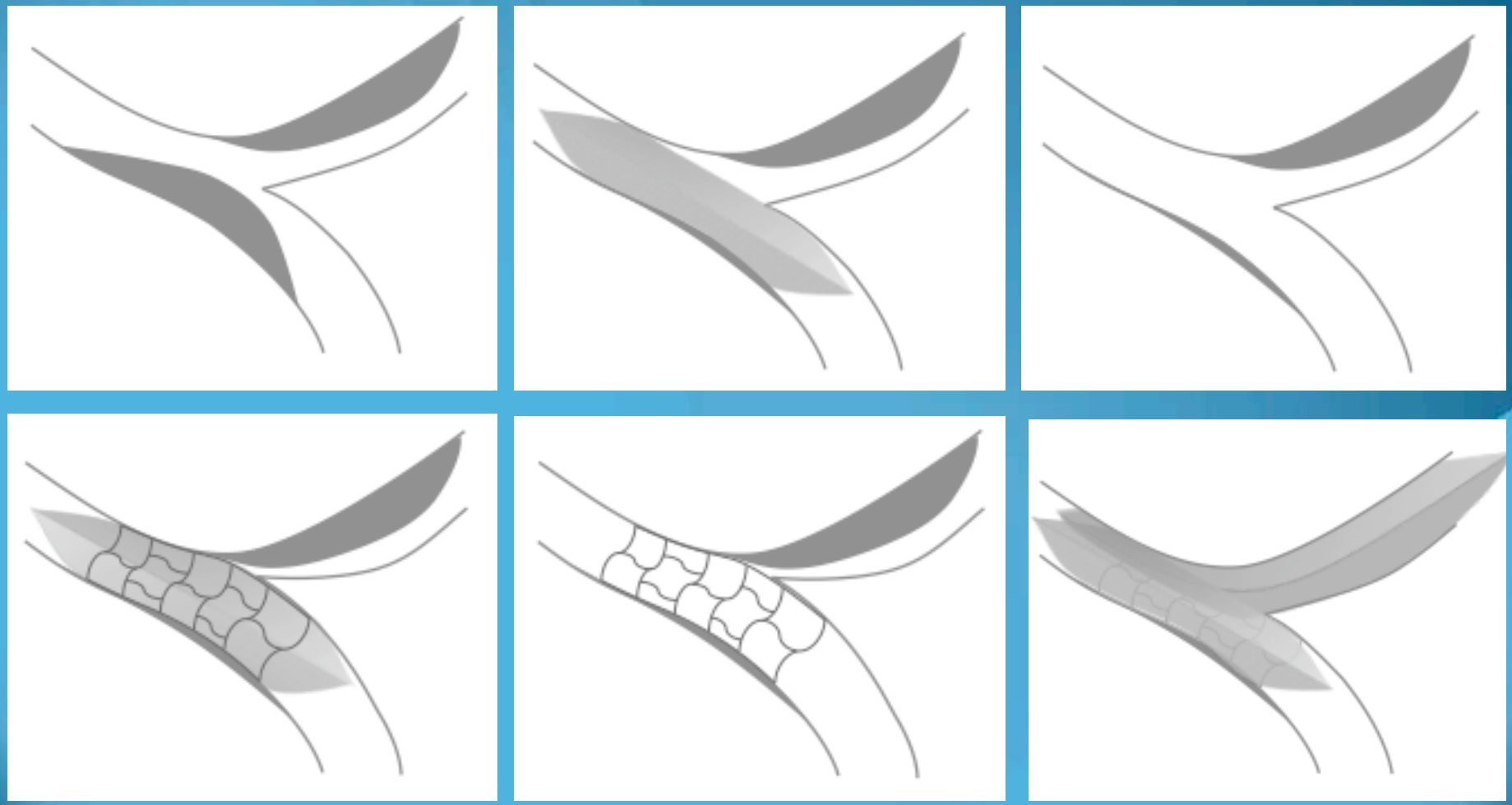
occlusioni totali croniche – tante proposte

- wire drilling
- parallel wire technique
- controlled anterograde and retrograde subintimal tracking (CART technique)
- subintimal tracking and reentry (STAR)

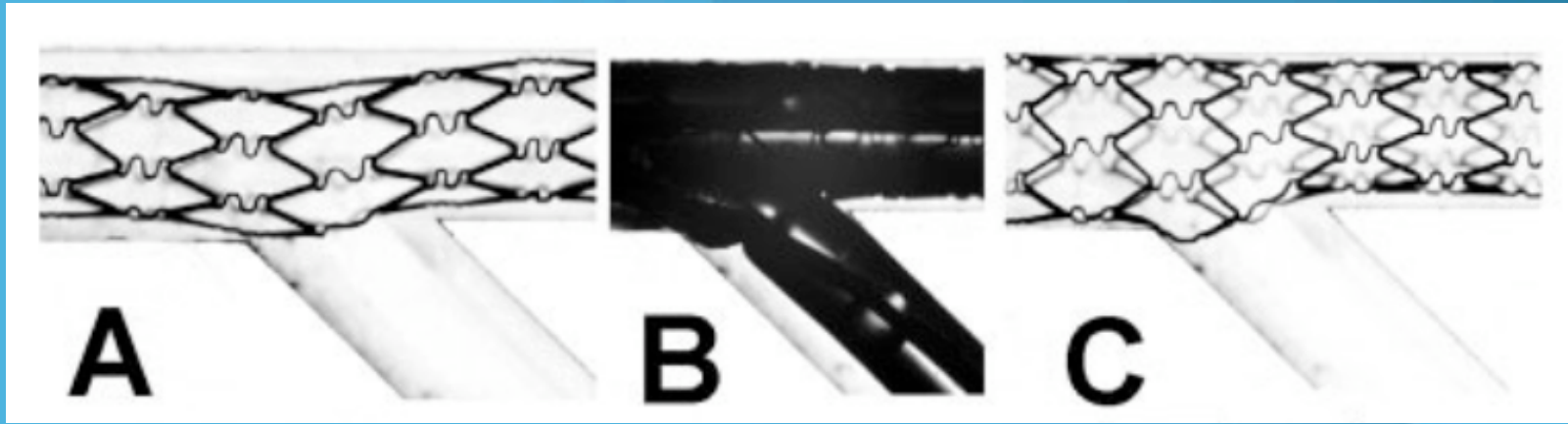
PARTE II

BIFORCAZIONI CORONARICHE

tecnica provisional

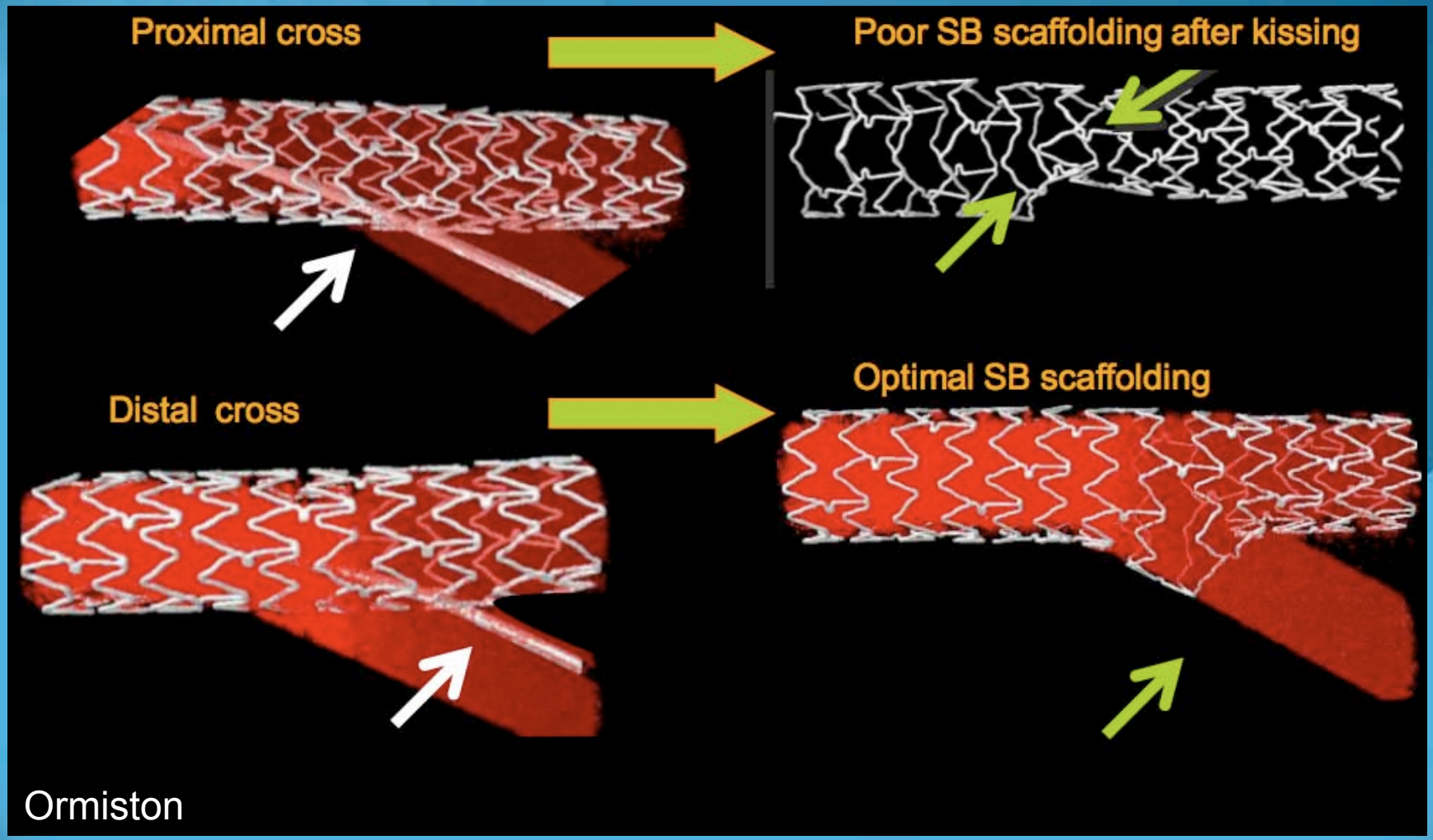


kissing-balloon

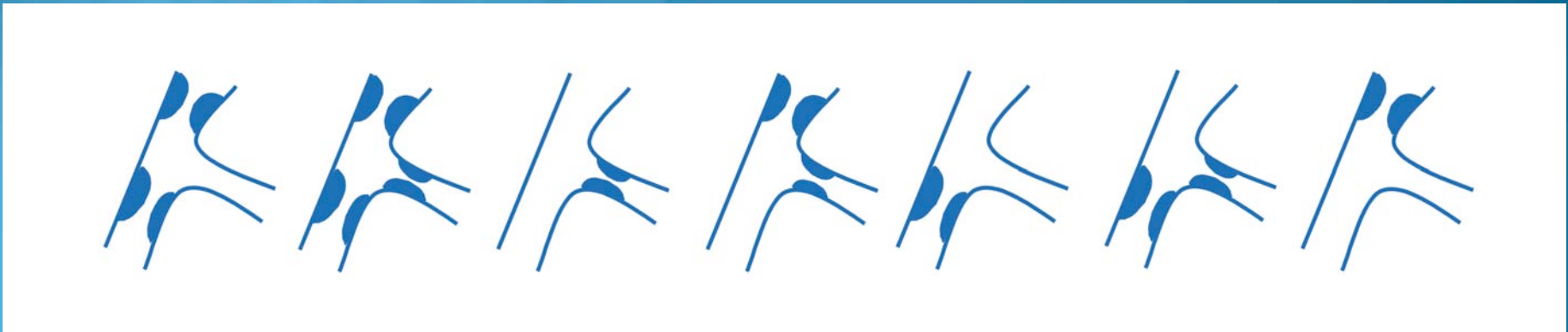


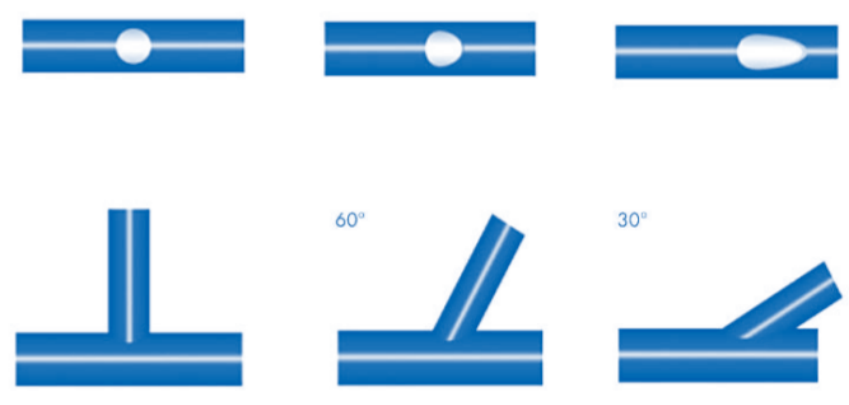
Ormiston

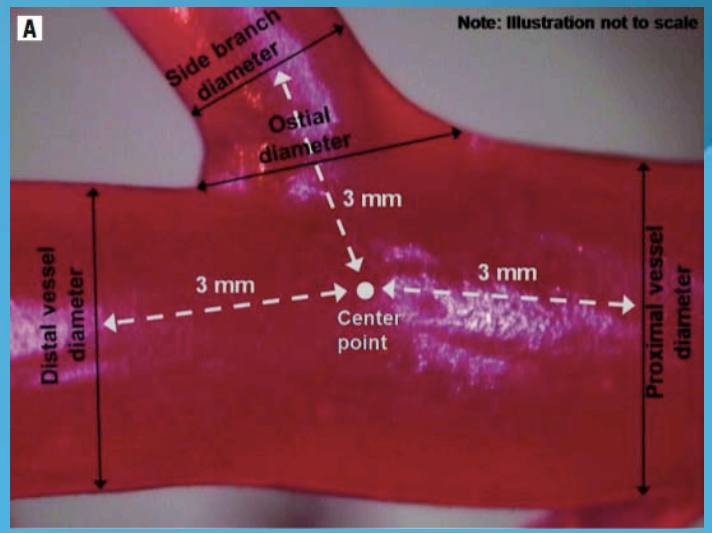
rewiring


Proximal cross
Poor SB scaffolding after kissing
Distal cross
Optimal SB scaffolding
Ormiston

elevata variabilità anatomica







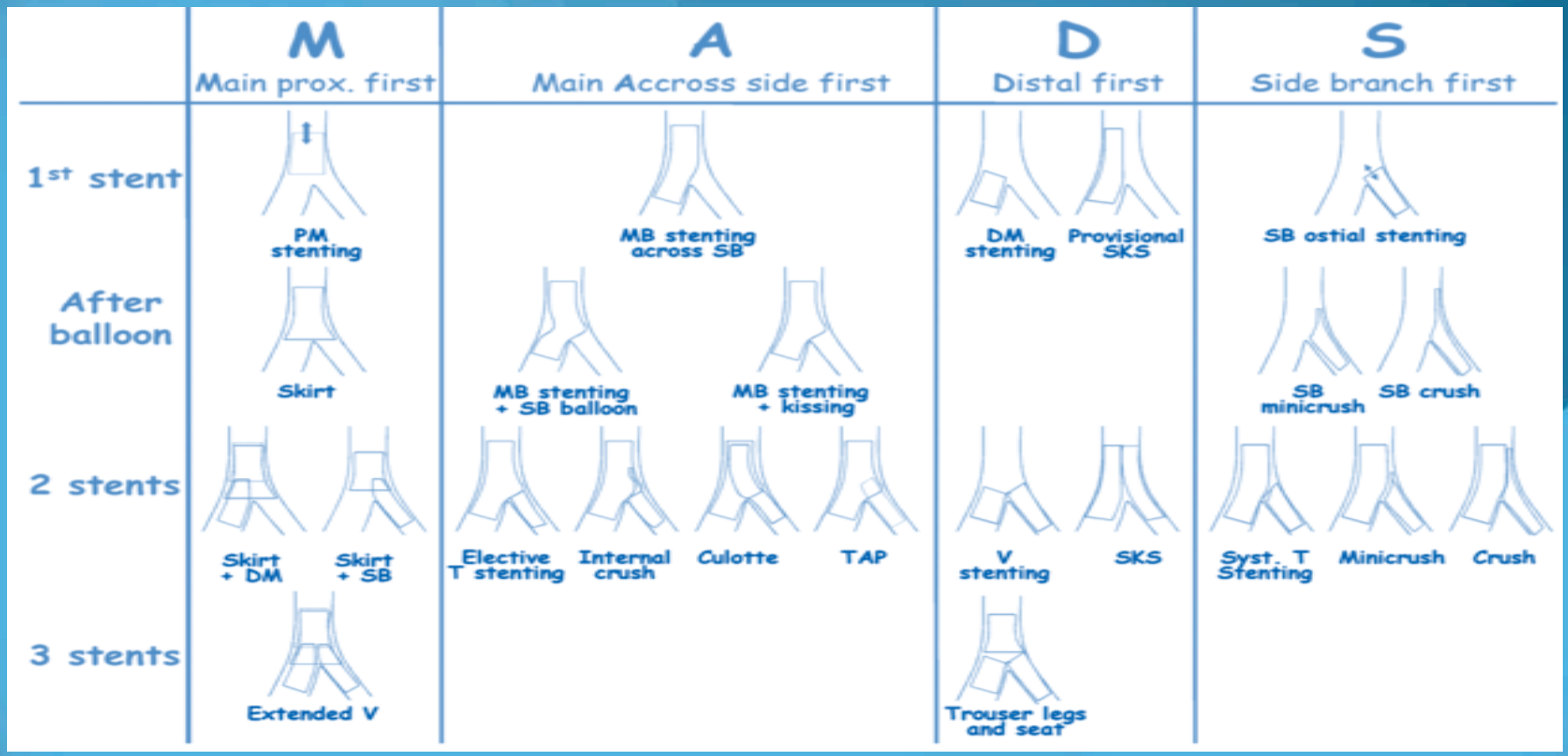
complessità anatomica

Fractal geometry of arterial coronary bifurcations: a quantitative coronary angiography and intravascular ultrasound analysis

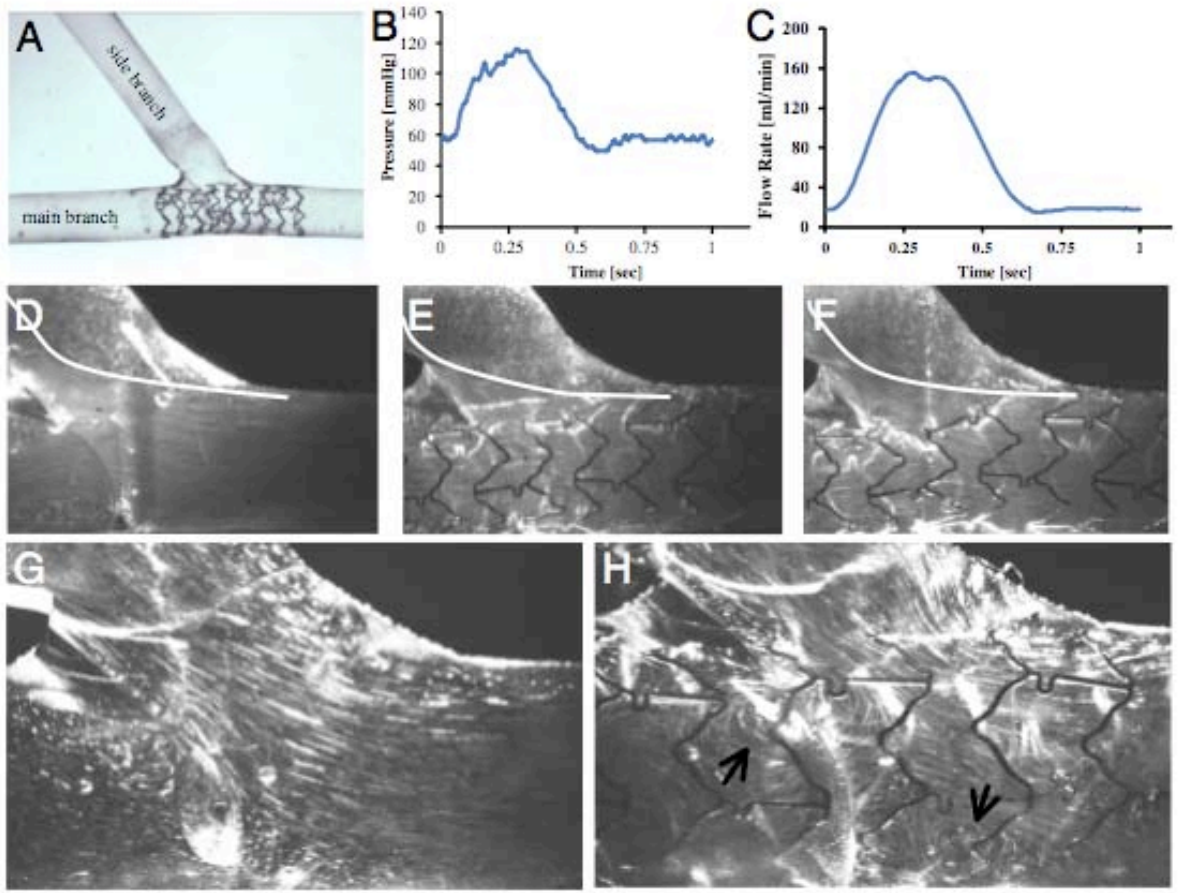
Gérard Finet*, MD PhD; Martine Gilard, MD; Béatrice Perrenot, PhD; Gérard Rioufol, MD PhD; Pascal Motreff, MD; Laurence Gavit, PhD; Rémy Prost, PhD

Department of Interventional Cardiology, Cardiovascular Hospital and Claude Bernard University, CREATIS, Research Unit associated to CNRS (UMR 5515) and INSERM Unit 630, Lyon, France

tecniche


M
Main prox. first
A
Main Accross side first
D
Distal first
S
Side branch first
1st stent
PM stenting
MB stenting across SB
DM stenting
Provisional SKS
SB ostial stenting
After balloon
Skirt
MB stenting + SB balloon
MB stenting + kissing
SB minicrush
SB crush
2 stents
Skirt + DM
Skirt + SB
Elective T stenting
Internal crush
Culotte
TAP
V stenting
SKS
Syst. T Stenting
Minicrush
Crush
3 stents
Extended V
Trouser legs and seat

il flusso dopo kissing-balloon

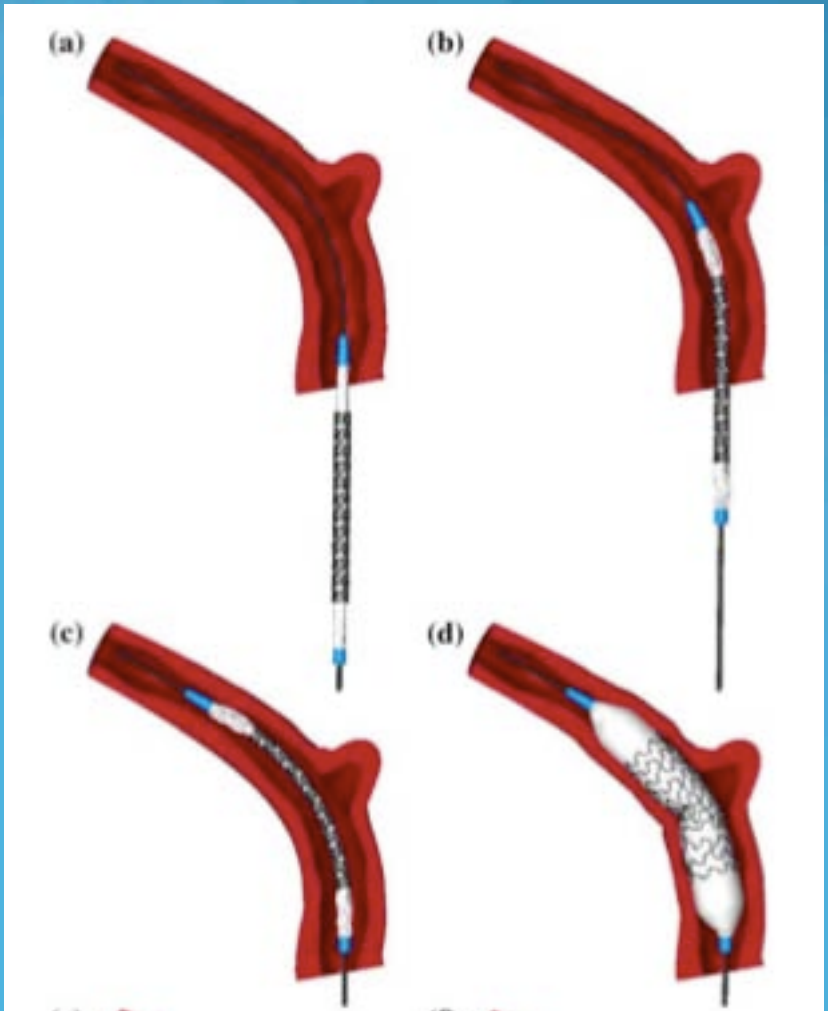


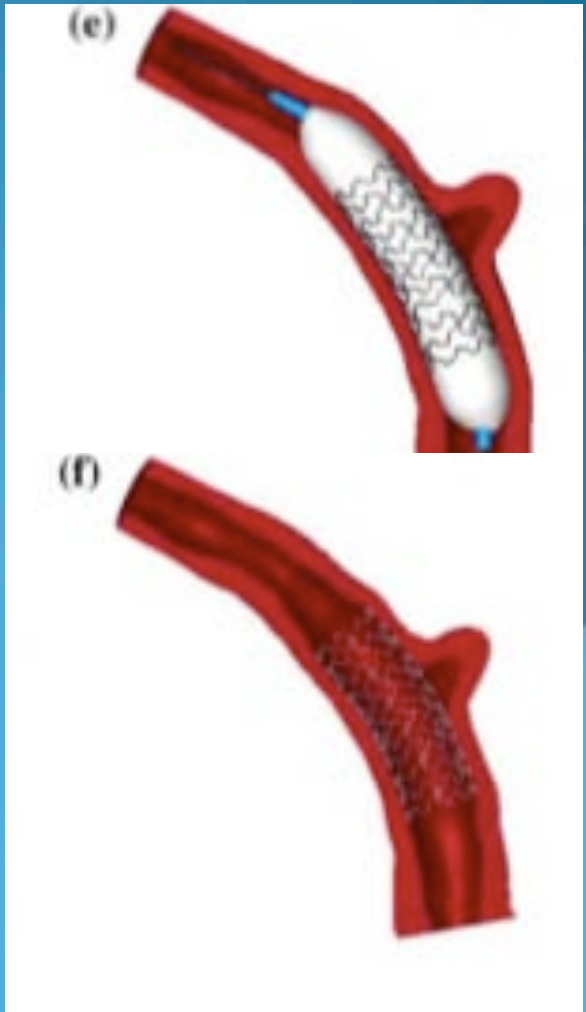
Virmani

alcune domande

- come si deformano i nuovissimi stent dopo kissing-balloon?
- come cambia il flusso dopo kissing-balloon?
- è meglio scegliere il diametro dello stent in base al main vessel prossimale o distale
- se lo si sceglie sulla base del main vessel distale, dopo il kissing lo stent diventa ovale e perde contatto con la parete del vaso nel tratto prossimale?
- come scegliere il diametro dei palloni per il kissing-balloon?
- come si dispongono i palloni durante il kissing-balloon?
- sono da preferire i palloni non-complianti?

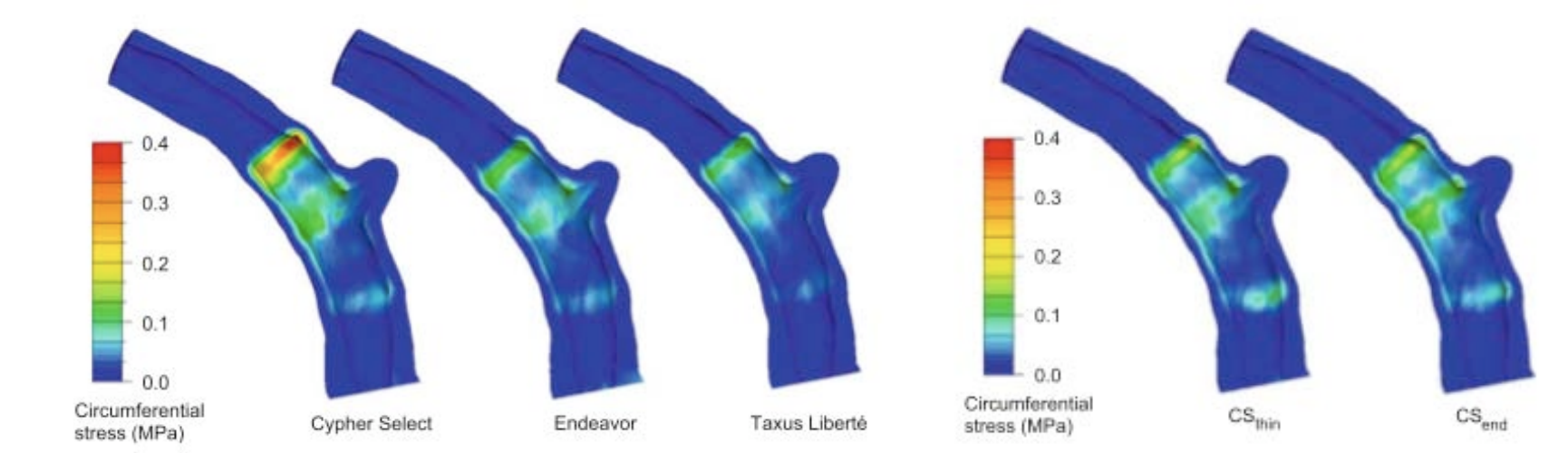
alcune cose già viste



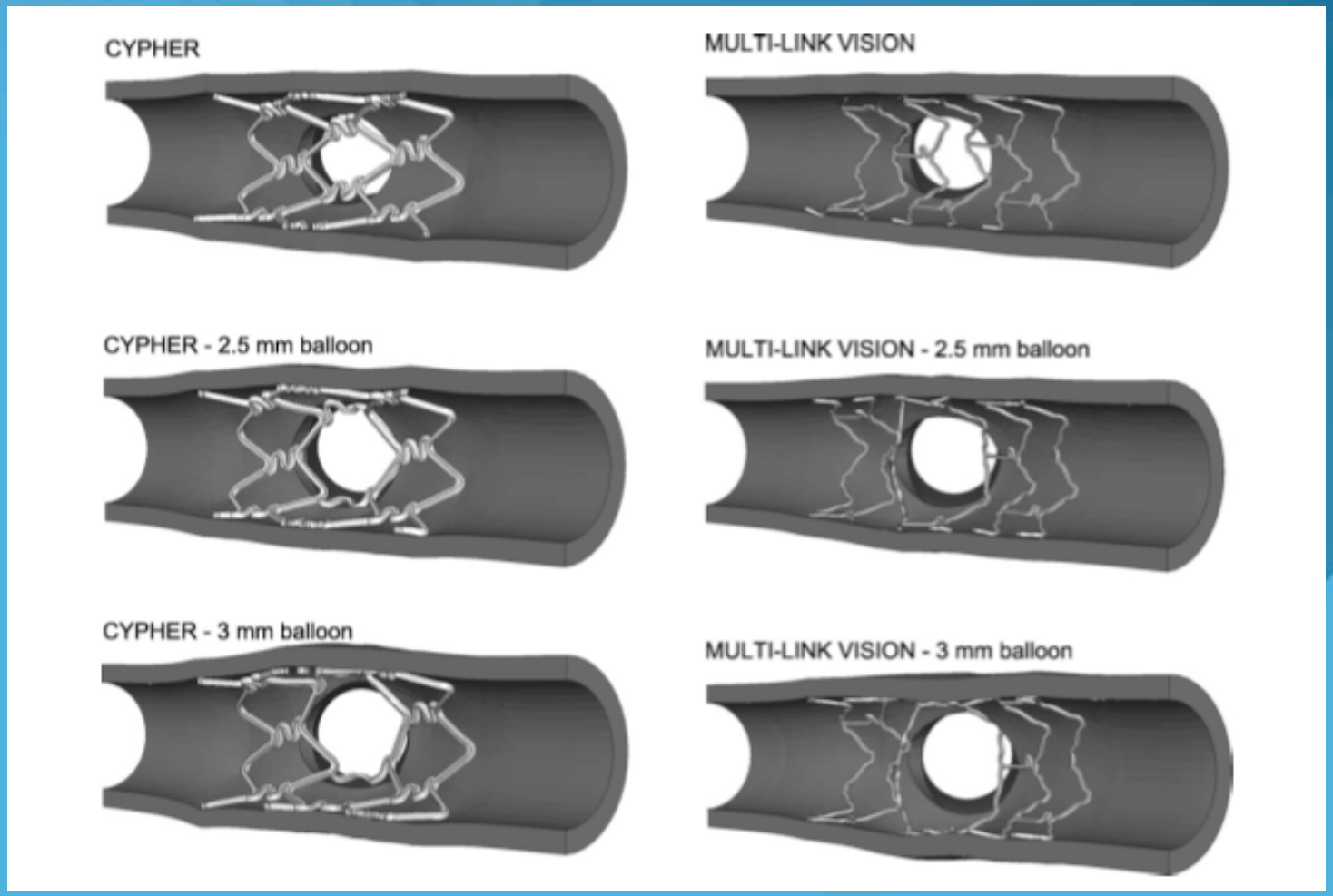


Mortier

alcune cose già viste

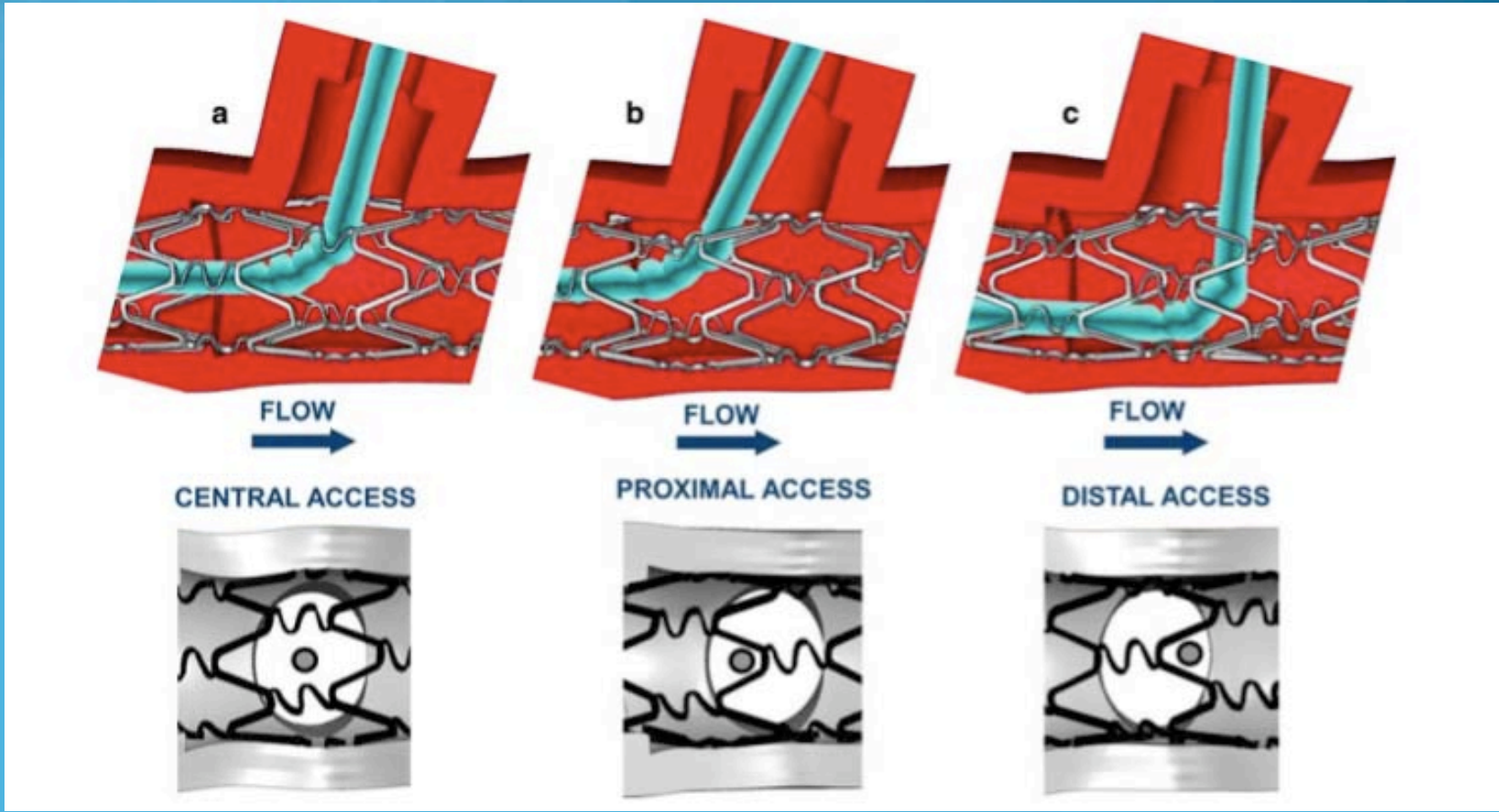


alcune cose già viste



Mortier

alcune cose già viste



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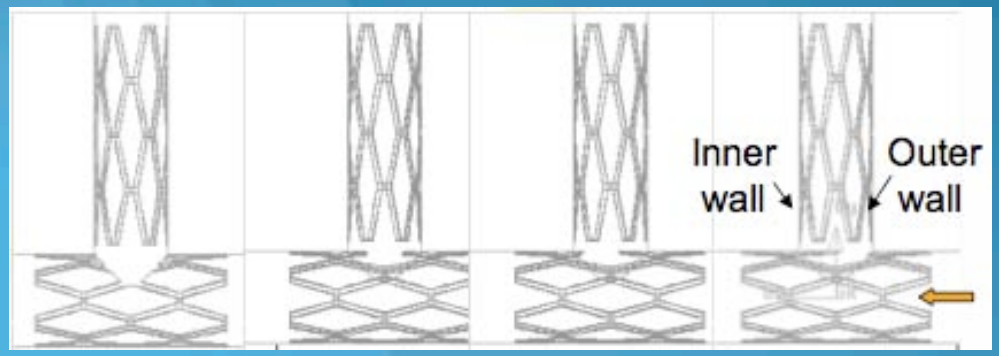
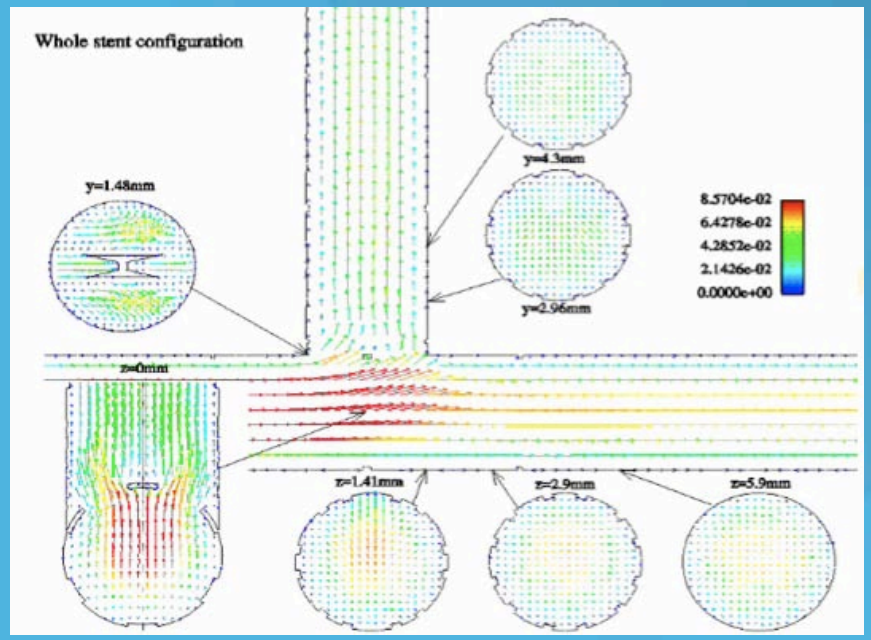
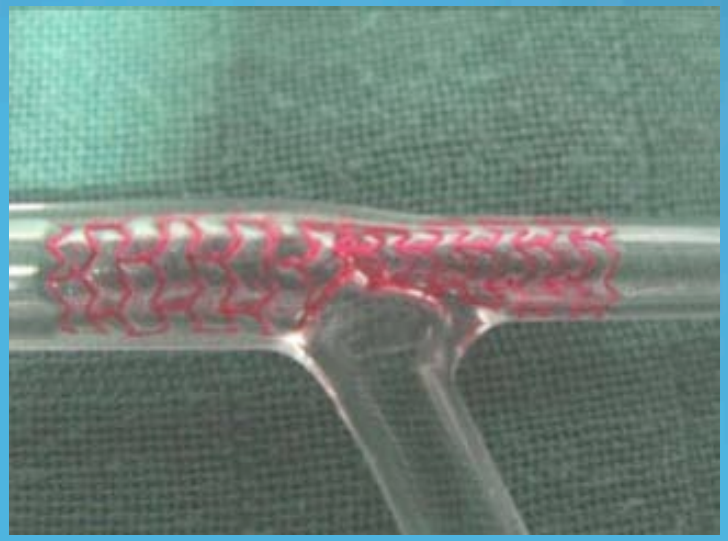




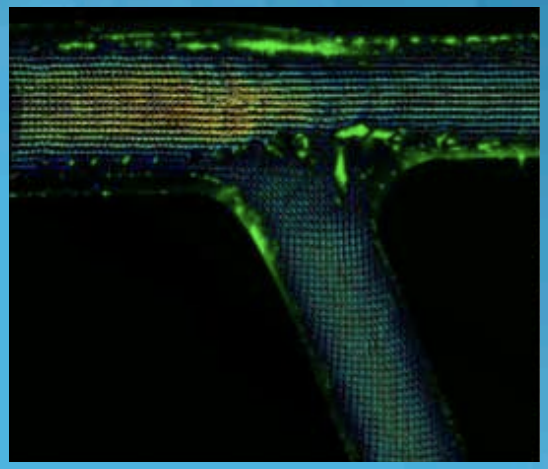
Deplano

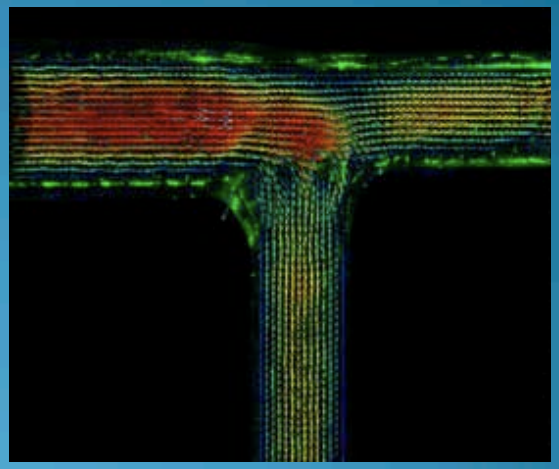
alcune cose già viste

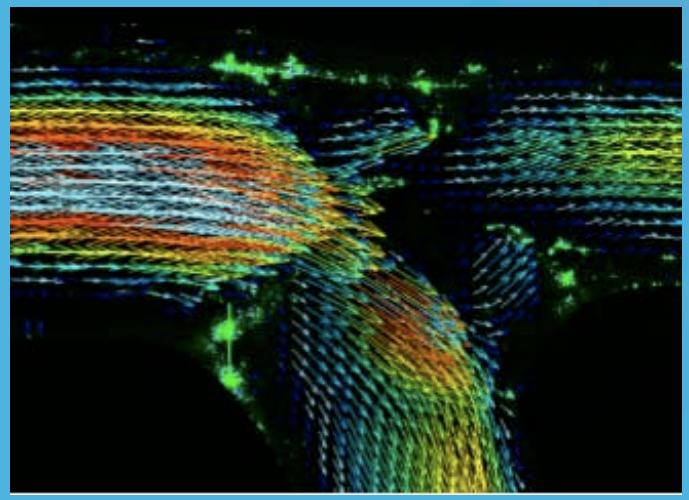


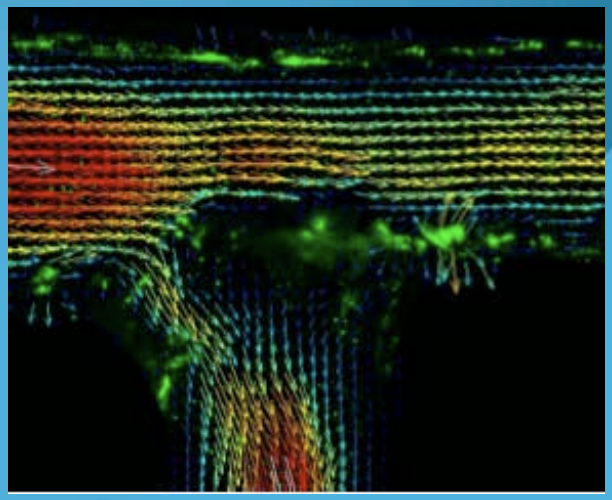
- Angoli di biforcazione: 60° e 90°
- Prima e dopo kissing balloon con attenzione a ricrossare la amglia distale

alcune cose già viste









Coisne