What Stent to Use?

JASVINDAR SINGH MD, FACC
ASSOCIATE PROFESSOR OF MEDICINE
WASHINGTON UNIVERSITY IN ST. LOUIS
DIRECTOR, CARDIAC CATHETERIZATION LAB
BARNES-JEWISH HOSPITAL
What Stent to Use?

Jasvindar Singh, MD

Disclosure

Research /Grant support: Volcano Corp., Abbott Vascular, Medtronic Vascular, Boston Scientific

Consulting: Volcano Corp, Trireme Medical

Boston-Scientific, Abbott Vascular, Medtronic Vascular, Spectranetics
Outline

- Introduction
- Clinical scenarios
- Anatomic Subsets
- Future
- Questions and discussion
Current Stents
Evolution of Early Stent Technology

The Evolution of Stent Designs

Wire Mesh Stent

Tubular Slotted Stents

Guidant Multi-Link

Boston Scientific NIR

J&J Palmaz-Schatz

Wire Coil Stents

Cook GR II

Medtronic Wiktor

Modular Stents

Medtronic Vascular
Support segments are connected at 3 places

Support segments are fully connected

OPEN

CLOSED
Open
- Radial Strength
- Plaque Prolapse
- Metal:Artery Ratio
- Conformability
- Side Branch Access

Closed
- Radial Strength
- Plaque Prolapse
- Metal:Artery Ratio
- Conformability
- Side Branch Access
Expectations of Stent Technology

**Efficacy**
- Deliverable
- Low TLR
- Low Restenosis
- Low Late Lumen Loss
- Cost-Effective

**Safety**
- No Device Malfunction
- No Early MACE
  - Q AMI
  - Non-Q AMI
- No Stent Thrombosis
Drug-eluting Stents “1st Generation US”

TAXUS
- Paclitaxel
- Drug

Cypher
- Sirolimus

Polyolefin derivative
- Polymer
- PEVA + PBMA blend

Express ⇒ Liberté
- Stent
- BX Velocity
1st Generation DES Cypher and Taxus Stents Both Effectively Reduce TLR

9 prospective, double-blind, randomized trials

RAVEL, SIRIUS, E-SIRIUS, C-SIRIUS
(n = 1748)

TAXUS I, II, IV, V, VI
(n = 3506)

92.2% (66)  P < 0.0001
76.4% (202)

89.9% (164)  P < 0.0001
80.0% (337)

Bare metal stent (n = 878)
CYPHER stent (n = 870)

Bare metal stent (n = 1757)
TAXUS stent (n = 1749)

Time after initial procedure (years)

Independent CRF patient-level meta-analysis from TCT 2006.
DES... the good, the bad, and the ugly!

Late loss = 0

48 months

BMS  DES

Delayed Healing!

Incomplete apposition

Late stent thrombosis

IVUS

Abn Vasomotion

Sirolimus Control

*P<0.001 vs. control
### Table 1: Specifications of the Food and Drug Administration-Approved Drug-Eluting Stents

<table>
<thead>
<tr>
<th>Stent</th>
<th>Drug (Concentration [µg/cm²])</th>
<th>Drug Mechanism</th>
<th>Polymer</th>
<th>Polymer Thickness, µm</th>
<th>Release Kinetics, 28 Days</th>
<th>Metal</th>
<th>Geometry</th>
<th>Strut Thickness, µm</th>
<th>Crimped Profile, mm²</th>
<th>Maximum Cell C/O, mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYPHER</td>
<td>Sirolimus (140)</td>
<td>Inhibits mTOR, cytoplastie</td>
<td>Polyethylene co-vinyl acetate and poly-a-butyl methacrylate</td>
<td>12.6</td>
<td>80%</td>
<td>SS</td>
<td>Closed cell</td>
<td>140</td>
<td>1.198</td>
<td>9.5/3.0</td>
</tr>
<tr>
<td>TAXUS Express</td>
<td>Paclitaxel (100)</td>
<td>Microtubule inhibitor, cell cycle arrest in G0/G1 and G2/M</td>
<td>Poly(styrene-b-isobutylene-b-styrene)</td>
<td>16.0</td>
<td>&lt;10%</td>
<td>SS</td>
<td>Open cell</td>
<td>132</td>
<td>1.245</td>
<td>11.9/3.8</td>
</tr>
<tr>
<td>TAXUS Liberté</td>
<td>Paclitaxel (100)</td>
<td>Microtubule inhibitor, cell cycle arrest in G0/G1 and G2/M</td>
<td>Poly(styrene-b-isobutylene-b-styrene)</td>
<td>16.0</td>
<td>&lt;10%</td>
<td>SS</td>
<td>Hybrid</td>
<td>97</td>
<td>1.219</td>
<td>13.7/4.4</td>
</tr>
<tr>
<td>Endeavor</td>
<td>Zotarolimus (100)</td>
<td>Inhibits mTOR, cytoplastie</td>
<td>Phosphorylcholine</td>
<td>4.1</td>
<td>95%†</td>
<td>CoCr</td>
<td>Open cell</td>
<td>91</td>
<td>1.130</td>
<td>19.8/6.3</td>
</tr>
<tr>
<td>Xience V</td>
<td>Everolimus (100)</td>
<td>Inhibits mTOR, cytoplastie</td>
<td>Polynylidene fluoride co-hexafluoropropylene and poly-a-butyl methacrylate</td>
<td>7.8</td>
<td>80%</td>
<td>CoCr</td>
<td>Open cell</td>
<td>81</td>
<td>1.055</td>
<td>12.6/4.0</td>
</tr>
</tbody>
</table>
Drug-eluting Stents “2nd Generation US”

Endeavor

Zotarolimus
Drug

Phosphorylcholine
Polymer

Driver
Stent

Xienced V*

Everolimus

VDF + HFP copolymer

Vision
BMS vs 1st Gen DES vs. 2nd Gen DES

SCAAR: 94,384 consecutive pts in Sweden 2006-2010
(BMS 64,631; 1st gen DES 19,202; 2nd gen DES 10,551
1st gen = Cypher, Taxus, Endeavor. 2nd gen = Resolute, Xience, Promus Element

Adjusted Event Rates

Angio Demonstrating Restenosis

Definite Stent Thrombosis

Adj HR of 2nd gen DES vs. 1st gen DES: 0.62 [0.53–0.72]
vs. BMS: 0.29 [0.25–0.33]

Adj HR of 2nd gen DES vs/ 1st gen DES: 0.57 [0.41–0.79]
vs. BMS: 0.38 [0.28–0.52]

Sarno G et al. EHJ 2012;33:606–13
BMS vs 1\textsuperscript{st} Gen DES vs. 2\textsuperscript{nd} Gen DES

**SCAAR:** 94,384 consecutive pts in Sweden 2006-2010
(BMS 64,631; 1\textsuperscript{st} gen DES 19,202; 2\textsuperscript{nd} gen DES 10,551)

1\textsuperscript{st} gen = Cypher, Taxus, Endeavor. 2\textsuperscript{nd} gen = Resolute, Xience, Promus Element

**Adjusted Event Rates: Death**

![Graph showing the comparison of death rates over months between BMS, 1\textsuperscript{st} gen DES, and 2\textsuperscript{nd} gen DES.]

- Adj HR of 2\textsuperscript{nd} gen DES vs. 1\textsuperscript{st} gen DES: 0.77 [0.63–0.95]
- Adj HR of 2\textsuperscript{nd} gen DES vs. BMS: 0.55 [0.46–0.67]

Sarno G et al. *EHJ* 2012; 33:606–13
**Figure 2**  Drug eluting stents with durable or biodegradable polymer coatings. SS, stainless steel; CoCr, cobalt chromium; PtCr, platinum chromium; SIBS, poly(styrene-b-isobutylene-b-styrene); PEVA, poly-ethylene-co-vinyl acetate; PBMA, poly n-butyl methacrylate; PVDF-HFP, co-polymer of vinylidene fluoride and hexafluoropropylene; MPC, methacryloyloxyethyl phosphorylcholine; LMA, lauryl methacrylate; HPMA, hydroxypropyl methacrylate; 3-MPMA, trimethoxysilylpropyl methacrylate; PVP, polyvinyl pyrrolidinone; PHMA, polyhexyl methacrylate; PVA, polyvinyl acetate; PLGA, poly-lactic co-glycolic acid; PLLA, poly-L-lactic acid; PDLLA, poly-D, L-lactic acid.
Clinical Scenarios

- ACS – STEMI
- Diabetes
- ESRD
- Patients on Chronic anticoagulation
- Patients Pre-op for non cardiac surgery
Outcomes with Various DES or BMS in Patients with STEMI: Mixed Treatment Comparison Analysis

28 randomized trials involving 14,740 patients and 34,068 patient-years of follow-up, published between 2003 and 2012.

- Compared with BMS, SES, PES, and EES were associated with a significant reduction in TVR (53%, 31% and 57%, respectively)
- EES were associated with a 58% reduction in the rate of any stent thrombosis vs. BMS
- There was a 53% and a 42% probability, respectively, that EES and BMS had the lowest very late stent thrombosis rates

Implications: DES, particularly EES, show an advantage over BMS in reducing TVR with no increased safety concerns in STEMI.

ACS - STEMI

EXAMINATION Trial
1504 pts with STEMI undergoing PCI within 48° (85% primary PCI within 12°) were randomized to Xience V EES vs. Vision BMS
Stent thrombosis (Def/prob) within 1 year

- Acute
- Subacute
- Late

Vision: 2.6%
Xience V: 0.9%
p = 0.01

Definite ST was reduced with Xience V from 1.9% to 0.5%, p=0.01

Sabate M et al. Lancet 2012
Comparison of 2-year Outcomes Between Zotarolimus-Eluting and Everolimus-Eluting New-Generation Cobalt–Chromium Alloy Stents in Real-World Diabetic Patients

Tadashi Miyazaki,1,2,3 MD, Azeem Latib,1,2 MD, Vasileios F. Panoulas,1,2,4 MD, PhD, MRCP, Sakiko Miyazaki,1,3 MD, PhD, MPH, Charis Costopoulos,1,2 MD, Katsumasa Sato,1,2 MD, Toru Naganuma,1,2 MD, Hiroyoshi Kawamoto,1,2 MD, Hiroyuki Daida,3 MD, PhD, and Antonio Colombo,1,2* MD

Background: To date, it remains unknown whether different types of new-generation drug-eluting stents have a differential impact on long-term outcomes in diabetic patients. Methods and Results: In this historical cohort study (two Italian centers), we analyzed 400 diabetic patients with 553 coronary lesions treated with new-generation CoCr zotarolimus-eluting stents (R-ZES: 136 patients, 196 lesions) or everolimus-eluting stents (EES: 264 patients, 357 lesions) between October 2006 and August 2012. Primary endpoint was the occurrence of major adverse cardiac events (MACE) over a 2-year follow-up period. MACE was defined as all-cause mortality, any myocardial infarction (MI) and/or target lesion revascularization (TLR). Multivessel revascularization, intervention for restenotic lesion and use of intravascular ultrasound were significantly higher in the R-ZES group, whereas small stent (≤2.5 mm) deployment was significantly higher in the EES group. At 2-year follow-up, there was no significant difference in occurrence of MACE (R-ZES vs EES: 22.8% vs 18.9%, P = 0.39). Similarly, no significant differences were observed in the composite endpoint of all-cause mortality/MI (10.0% vs 10.3%, P = 0.86) or TLR (12.4% vs 7.4%, P = 0.11). Adjustment for confounders and baseline propensity-score matching did not alter the aforementioned associations. Conclusion: After 2 years of follow-up similar outcomes (MACE, all-cause mortality/MI, TLR) were observed in real-world diabetic patients, including those with complex lesions and patient characteristics, treated with R-ZES and EES.
Other areas of concern

Pts on anticoagulation
<table>
<thead>
<tr>
<th>Balloon Max. size</th>
<th>Element</th>
<th>Xience</th>
<th>Taxus</th>
<th>Integrity</th>
<th>BioMatrix</th>
<th>Cypher</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>2.25</td>
<td>Medium vessel workhorse (6 crowns, 2 cells) max expansion: 4.4mm</td>
<td>Small vessel workhorse (6 crowns, 2 cells) max expansion: 4.4mm</td>
<td>Small vessel workhorse (7 crowns, 2 cells)* max expansion: 4.9mm</td>
<td>Medium vessel workhorse (6 crowns, 2 cells) max expansion: 4.8mm</td>
<td>Medium vessel workhorse (6 crowns, 6 cells) max expansion: 4.7mm</td>
</tr>
<tr>
<td>2.50</td>
<td>2.75</td>
<td>Medium vessel workhorse (8 crowns, 2 cells) max expansion: 3.8mm</td>
<td>Medium vessel workhorse (9 crowns, 3 cells) max expansion: 4.8mm</td>
<td>Medium vessel workhorse (10 crowns, 2 cells) max expansion: 5.4mm</td>
<td>Large vessel (9 crowns, 3 cells) max expansion: 5.8mm</td>
<td>Large vessel (7 crowns, 7 cells) max expansion: 5.8mm</td>
</tr>
<tr>
<td>3.00</td>
<td>3.50</td>
<td>Medium vessel workhorse (8 crowns, 2 cells) max expansion: 4.4mm</td>
<td>Large vessel (9 crowns, 3 cells) max expansion: 5.0mm</td>
<td>Large vessel (10 crowns, 3 cells) max expansion: 6.0mm</td>
<td>Large vessel (9 crowns, 3 cells) max expansion: 5.9mm</td>
<td>Large vessel (7 crowns, 7 cells) max expansion: 5.8mm</td>
</tr>
<tr>
<td>5.0</td>
<td>4.00</td>
<td>Large vessel (10 crowns, 2 cells) max expansion: 5.7mm</td>
<td>Large vessel (9 crowns, 3 cells) max expansion: 6.0mm</td>
<td>Large vessel (9 crowns, 3 cells) max expansion: 5.8mm</td>
<td>Large vessel (9 crowns, 3 cells) max expansion: 5.9mm</td>
<td>Large vessel (7 crowns, 7 cells) max expansion: 5.8mm</td>
</tr>
<tr>
<td>6.0</td>
<td>4.50</td>
<td>Large vessel (10 crowns, 2 cells) max expansion: 5.7mm</td>
<td>Large vessel (9 crowns, 3 cells) max expansion: 6.0mm</td>
<td>Large vessel (9 crowns, 3 cells) max expansion: 5.8mm</td>
<td>Large vessel (9 crowns, 3 cells) max expansion: 5.9mm</td>
<td>Large vessel (7 crowns, 7 cells) max expansion: 5.8mm</td>
</tr>
</tbody>
</table>

- Minimal stent ID excluding struts
- Limited to 6.0 mm balloon at 14 ATM
Bifurcation

- Smooth round struts to facilitate easy wire and sidebranch access
- Open cell design is expandable to over 3.8 mm for large sidebranches
- Stent overexpansion to 4.75 mm for proximal vessel optimization
- High conformability and flexibility contribute to improved strut apposition in provisional bifurcation treatments

Square struts

Round struts
Figure 6. Virtual Evaluation of Stent Strut Malapposition

An illustrative example of bifurcation model A is shown for each stent (top, front view as shown in Figure 1; bottom, back view). Struts with a strut-artery distance >100 μm are shown in red.
Ostial

- Closed cell
- Radioopacity
- Structural integrity
- Radial strength
- Expansion
Tortuosity
Stent fracture

- Recognized for at least 10 years (Chowdhry, NEJM 2002)

- Associated with MACE (may cause of ST, restenosis, late “catch up”)

- Meta-analysis of 8 studies with 5321 patients and 108 stent fractures. Incidence of fracture was 4% (All but one were in Cypher) (Charkravarty, AJC 2010)

- The probability of fracture is increased with long stents, overlapping stents, RCA, bend points, DES, stent design

- Recent single center report: Xience V implanted in 1339 lesions. Fracture at 6-9 months in 2.9% lesions, 3.8% patients. MACE higher in fracture group vs no-fracture (25.6% vs 2.3%; P<0.001) (Kuramitsu, Circ Int 2012)
Stent Fracture

Bend cycles to fracture for 6 platforms n=15

- All ML8 stents fractured
- Most fractures occurred in connectors between 2\textsuperscript{nd} and 3\textsuperscript{rd} hoops
- 6 fractures between 3\textsuperscript{rd} and 4\textsuperscript{th} connectors
- 2 stents had hoop fractures
- Only one stent had more than 1 fracture

These did not fracture by 10 million cycles
Comparison Among Drug-Eluting Balloon, Drug-Eluting Stent, and Plain Balloon Angioplasty for the Treatment of In-Stent Restenosis

A Network Meta-Analysis of 11 Randomized, Controlled Trials

Joo Myung Lee, MD, MPH,* Jonghanse Park, MD,* Jeehoo Kang, MD,* Ki-Hyun Jeon, MD,* Ji-Hyun Jung, MD,* Sang Eun Lee, MD, PhD,* Jung-Kyu Han, MD, PhD,* Hack-Lyoung Kim, MD, PhD,* Han-Mo Yang, MD, PhD,* Kyung Woo Park, MD, PhD,* Hyun-Jae Kang, MD, PhD,* Bon-Kwon Koo, MD, PhD,* Hye-Soo Kim, MD, PhD,*

ABSTRACT

OBJECTIVES A Bayesian network meta-analysis was performed comparing the efficacy and safety of drug-eluting balloons (DEB), drug-eluting stents (DES), or plain old balloon angioplasty (POBA) for treatment of in-stent restenosis (ISR).

BACKGROUND Optimal treatment options for ISR have not been well established.

METHODS Randomized, controlled trials comparing DEB, DES, and POBA for the treatment of ISR after percutaneous coronary intervention with bare metal stent or DES were included. The primary outcome was target lesion revascularization (TLR). The pairwise posterior median odds ratio (OR) with 95% credible interval (CrI) was the effect measure.

RESULTS This analysis included 2,059 patients from 11 RCTs. The risk of TLR was markedly lower in patients treated with DEB (OR: 0.22, 95% CrI: 0.10 to 0.42) or DES (OR: 0.24, 95% CrI: 0.11 to 0.47) than in those treated with POBA in a random-effects model. In a comparison of DEB and DES, the risk of TLR (OR: 0.92, 95% CrI: 0.43 to 1.90) was similar. The risk of MI or all-cause mortality was lowest in the DEB group compared with the DES and POBA groups, which did not meet statistical significance. The risk of major adverse cardiac events, which was mainly driven by TLR, was significantly lower in the DEB group and DES group (OR: 0.28, 95% CrI: 0.14 to 0.53) than in the POBA group, but it was similar between the DEB and DES groups (OR: 0.84, 95% CrI: 0.45 to 1.60). The probability of being ranked as the best treatment was 59.9% (DEB), 40.1% (DES), and 0.1% (POBA) in terms of TLR, whereas it was 63.0% (DEB), 35.3% (POBA), and 1.7% (DES) in terms of MI.

CONCLUSIONS Local drug delivery by DEB or DES for ISR lesions was markedly better than POBA in preventing TLR, but not for MI or mortality. Among the 2 different strategies of drug delivery for ISR lesions, treatment with DES showed a trend of less development of MI than did treatment with DES. (J Am Coll Cardiol Intv 2015;8:382-94) © 2015 by the American College of Cardiology Foundation.

Different Drug (Switch Strategy) in Patients With Drug-Eluting Stent Restenosis

Results From a Prospective Multicenter Study (RIBS III [Restenosis Intra-Stent: Balloon Angioplasty Versus Drug-Eluting Stent])

Fernando Alfonso, MD,* Maria J. Pérez-Yuscayo, MD,* Jaime Dutary, MD,* Javier Zuco, MD,† Angel Cequier, MD,‡ Arturo Garcia-Touchar, MD,§ Vicens Martí, MD,¶ Iligio Lozano, MD,¶ Juan Angel, MD,¶ José M. Hernández, MD,** José R. López-Minguez, MD,†† Rafael Melgares, MD,‡‡ Raul Moreno, MD,†¶ Bernhard Seidelberger, MD,¶¶ Cristina Fernández, MD,* Rosana Hernandez, MD,* for the RIBS-III Study Investigators (under the auspices of the Working Group on Interventional Cardiology of the Spanish Society of Cardiology)

Madrid, Santander, Barcelona, Oviedo, Malaga, Badajoz, and Granada, Spain

Objectives This study sought to assess the effectiveness of a strategy of using drug-eluting stents (DES) with a different drug (switch) in patients with DES in-stent restenosis (ISR).

Background Treatment of patients with DES ISR remains a challenge.

Methods The RIBS-III (Restenosis Intra-Stent: Balloon Angioplasty Versus Drug-Eluting Stent) study was a prospective, multicenter study that aimed to assess results of coronary interventions in patients with DES ISR. The use of a different DES was the recommended strategy. The main angiographic endpoint was minimal lumen diameter at 9-month follow-up. The main clinical outcome measure was a composite of cardiac death, myocardial infarction, and target lesion revascularization.

Results This study included 363 consecutive patients with DES ISR from 12 Spanish sites. The different-DES strategy was used in 274 patients (75%) and alternative therapeutic modalities (no switch) in 89 patients (25%). Baseline characteristics were similar in the 2 groups, although lesion length was longer in the switch group. At late angiographic follow-up (77% of eligible patients, median: 278 days) minimal lumen diameter was larger (1.86 ± 0.7 mm vs. 1.40 ± 0.8 mm, p = 0.003) and recurrent restenosis rate lower (22% vs. 40%, p = 0.008) in the different-DES group. At the last clinical follow-up (99% of patients, median: 771 days), the combined clinical endpoint occurred less frequently (23% vs. 35%, p = 0.039) in the different-DES group. After adjustment using propensity score analyses, restenosis rate (relative risk: 0.41, 95% confidence interval [CI]: 0.21 to 0.80, p = 0.01), minimal lumen diameter (difference: 0.41 mm, 95% CI: 0.19 to 0.62, p = 0.001), and the event-free survival (hazard ratio: 0.58, 95% CI: 0.33 to 0.96, p = 0.038) remained significantly improved in the switch group.

Conclusions In patients with DES ISR, the implantation of a different DES provides superior late clinical and angiographic results than do alternative interventional modalities. (J Am Coll Cardiol Intv 2012;5:738–37) © 2012 by the American College of Cardiology Foundation.)
Which Design in Which Patients

Superior Scaffolding, large vessel, bulky lesions, SVGs, tortuosity

Better Side Branch Access, smaller vessels (better M/A ratio)

Uniform Side Branch expansion / less distortion
## Current DES Market

<table>
<thead>
<tr>
<th></th>
<th>Efficacy</th>
<th>Safety</th>
<th>Data</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Xience (EES)</strong></td>
<td>++++</td>
<td>++++</td>
<td>+++</td>
<td>4 4 3</td>
</tr>
<tr>
<td><strong>Taxus ION (PES)</strong></td>
<td>++</td>
<td>++</td>
<td>+++</td>
<td>4 1 3</td>
</tr>
<tr>
<td><strong>Promus Premier (EES)</strong></td>
<td>++++</td>
<td>+++</td>
<td>++</td>
<td>5 3 3</td>
</tr>
<tr>
<td><strong>Endeavor (ZES 1)</strong></td>
<td>++</td>
<td>++++</td>
<td>+++</td>
<td>4 3 4</td>
</tr>
<tr>
<td><strong>Resolute (ZES 2)</strong></td>
<td>++++</td>
<td>++++</td>
<td>++</td>
<td>4 3 4</td>
</tr>
</tbody>
</table>

*D- deliveribility
*S- structural Integrity
*B- bifurcation SB access
Choosing DES in 2015 – Lesion subsets

- Left Main (Body or Distal): Promus / Xience / Resolute
- Ostial LM / RCA: Cypher, now Xience / Resolute
- Calcified: Promus Premier / Resolute / Xience
- Severe Tortuosity: Promus / Resolute / Xience
- Bifurcation: Resolute / Xience / Promus
- Diabetes: EES (Promus/Xience) / Resolute / Taxus ION
- STEMI: EES (Xience/Promus) / Resolute / Taxus/Endeavor/BMS
- Bulky Lesion / SVGs: Resolute / Promus / Xience
Etiology of metallic stent events beyond 1 yr

Very late thrombosis and restenosis

Possible causes

1. Uncovered stent struts (thrombosis)
2. Persistent stimulation of SMCs, from adherent fibrin and/or loss of normal vessel curvature
3. Abnormal shear stress from protruding struts and/or loss of cyclic strain relief (compliance mismatch)
4. Chronic inflammation due to late foreign body reactions and polymer hypersensitivity
5. Positive remodeling with strut malapposition
6. Strut fracture
7. Neoatherosclerosis
Three Approaches to Improve Late DES Outcomes

1. Metallic DES with bioabsorbable polymers
2. Metallic DES, polymer-free
3. Bioresorbable scaffolds (BRS)
How do a drug + DURABLE polymer coating affect the healing cascade?

Drug minimizes restenosis
Durable polymer may delay healing
→ Increase DAPT duration
→ Increased risk of late events

Minimizes Restenosis + Reduces DAPT + Reduces Late Events

Meta-analysis of Bioresorbable Polymer DES: ISAR-TEST 3, ISAR-TEST 4, and LEADERS at 4 yrs

4,062 randomized pts assigned to bioresorbable polymer eluting sirolimus or biolimus A (2,388) or Cypher (1,704)

Definite Stent Thrombosis

Stefanini GG et al. EHJ 2012;33:1214–22
**SYNERGY Stent Technology Design Goals**

**Platform**
- Platinum chromium
  - 74 µm (0.0029in)
  - Increased Visibility

**Drug & Polymer Coating**
- Everolimus Drug
- PLGA Polymer
  - Abluminal (4 µm)
  - 85:15 ratio
  - < 4 month absorption time
  - 3 month release time

**Drug**
- Everolimus
  - 100 µg/cm²

The SYNERGY™ stent is an investigational device and not for sale in the US.
Impact of Strut Thickness on Thrombogenicity

Thicker Struts Associated with Increased Acute Thrombogenicity

Thrombus formation assessed by immunofluorescence staining for platelet marker CD61 after 1 hour in ex-vivo pig AV shunt model.


The SYNERGY™ stent is an investigational device and not for sale in the US.
SYNERGY Stent Case Study
Distal LAD – SYNERGY Stent 2.25 mm x 38 mm

Complete coverage of SYNERGY Stent at 2 months (OCT Assessment)

Presented by Jose de la Torre Hernandez, MD, EuroPCR 2014

Case study not necessarily representative of all cases. Results in other cases may vary.
The SYNERGY™ stent is an investigational device and not for sale in the US.
DFS: Drug Filled Stent (Medtronic)
Drug elution controlled by diffusion physics
<table>
<thead>
<tr>
<th>Bioresorbable Vascular Scaffolds (BRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Igaki-Tamai</td>
</tr>
<tr>
<td>PLLA</td>
</tr>
<tr>
<td>PLLA (eluting everolimus)</td>
</tr>
<tr>
<td>Abbott Absorb</td>
</tr>
<tr>
<td>PLLA</td>
</tr>
<tr>
<td>PLLA (eluting novolimus)</td>
</tr>
<tr>
<td>Elixir DESolve</td>
</tr>
<tr>
<td>PLLA</td>
</tr>
<tr>
<td>Iodinated tyrosine-derivative</td>
</tr>
<tr>
<td>Reva ReSolve</td>
</tr>
<tr>
<td>Magnesium</td>
</tr>
<tr>
<td>Biotronik Dreams</td>
</tr>
<tr>
<td>Magnesium</td>
</tr>
<tr>
<td>(eluting sirolimus)</td>
</tr>
</tbody>
</table>
Absorb metabolism: Poly-lactide (PLA) Polymer

$$R\text{--O--R} + H_2O \rightarrow R\text{--O--OH} + HO\text{--R} \quad \text{where } R,R'=CH_3$$

Vessel wall

Coating

Thin coating of amorphous PDLA containing everolimus at a ratio of 1:1. Controlled drug release

PLLA scaffold backbone. Semicrystalline. Provides scaffold integrity. Increased radial strength.

Molecular Weight

Lactic Acid

Mass Loss

Mass Transport

Krebs Cycle

$\text{CO}_2 + \text{H}_2\text{O}$

Hydrolysis

PLA
FIGURE 3 Degradation and Late Lumen Enlargement of the Absorb BVS Between 1 and 42 Months After Implantation and Comparison With an Everolimus-Eluting Stent

Porcine coronary artery model photomicrographs demonstrating continuous degradation of the poly-L-lactic acid-based Absorb BVS (bioresorbable vascular scaffold) (Abbott Vascular, Santa Clara, California), ending in almost complete scaffold strut replacement by a provisional cellular matrix after 42 months. Late lumen enlargement can be observed compared with an everolimus-eluting stent. (Image provided by Abbott Vascular, Santa Clara, California.)