Flash presentation: Treatment algorithm for a “leaving as little as possible behind” strategy in femoro-popliteal lesions

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For the 12 months preceding this presentation, I disclose the following types of financial relationships:

- **Honoraria received from**: Abbott Vascular, Bard Peripheral Vascular, Veryan, Biotronik, Boston Scientific Corp., Cook Medical, Gore & Associates, Medtronic, Philips-Spectranetics, TriReme, Veryan, Shockwave, Biotronik
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- **Common stock**: QT Medical
12-month Restenosis vs. Lesion Length: Data from Randomized Trials
12-month Restenosis vs. Lesion Length: Data from Randomized Trials

Primary Patency vs. Lesion Length (cm)

- **FemPac**: 81%
- **ZILVER PTX**: 86%
- **RESILIENT**: 86%
- **THUNDER**: 76%
- **DURABILITY I**: 72%
- **SUPERA**: 63%
- **ABSOLUTE**: 58%
- **VIBRANT Viabahn**: 55%
- **VIBRANT BMS**: 53%
- **DURABILITY 200**: 65%

Stent Studies

1. Werk et al. Circ 2008;118
2. Tepe et al. NEJM 2008;358:889-99
3. Ramee MEET 2008
5. Schillinger, NEJM 2006;354:1879-88
6. Braunich LINC 2010
7. Ansel, LINC 2010
8. Bosiers, CIRSE 2010

Drug-eluting Balloon Studies
Endovascular Treatment of SFA-ISR

How to best treat?

How to approach ISR?
1. POBA
2. Cutting balloon
3. Atherectomy
   1. Laser
   2. Silverhawk
   3. Pathway
4. DCB
5. DES
6. Endoprosthesis
7. Bypass-Surgery

Figure: Stent-struts and Neo-intimal hyperplasia.
Do we Need Implants?

Bailout Stent Rates across DCB Trials

<table>
<thead>
<tr>
<th></th>
<th>IN.PACT SFA (DCB Arm)</th>
<th>IP Global ISR</th>
<th>IP Global Long Lesion</th>
<th>IP Global CTO</th>
<th>IN.PACT Global Clinical Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>220</td>
<td>131</td>
<td>157</td>
<td>126</td>
<td>1406</td>
</tr>
<tr>
<td>Lesion Length [cm]</td>
<td>8,9</td>
<td>17,2</td>
<td>26,4</td>
<td>22,8</td>
<td>12,1</td>
</tr>
<tr>
<td>Total Occlusion</td>
<td>25,8%</td>
<td>34,0%</td>
<td>60,4%</td>
<td>100,0%</td>
<td>35,5%</td>
</tr>
<tr>
<td>Primary Patency (KM @ 360 days)</td>
<td>87,5%</td>
<td>88,7%</td>
<td>91,1%</td>
<td>85,3%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

DCB Limitations: High rate of Provisional Stent

1. Tepe G et al., Circulation 2015
2. Brodmann M et al., JACC Cardiovasc Inverv. 2017
Every Aspect of Stent Design and Placement Has Some Association with Restenosis

- Mesh configuration
- **Chronic outward force** (stent oversizing)
- Stent material (nitinol > elgiloy > stainless steel)
- Strut thickness (coronaries)
- Stent length
- Stent overlap

Outcomes of Spot Stenting Versus Long Stenting After Intentional Subintimal Approach for Long Chronic Total Occlusions of the Femoropopliteal Artery

Sung-Jin Hong, MD, Young-Guk Ko, MD, Dong-Ho Shin, MD, MPH, Jung-Sun Kim, MD, Byeong-Keuk Kim, MD, Donghoon Choi, MD, Myeong-Ki Hong, MD, Yangsoo Jang, MD

Retrospective Analysis

Total limbs
n=196

Spot stenting
n=129

Loss of patency
n=37 (29%)

Out-stent
n=9 (24%)

Type 1
n=4 (11%)

Type 2
n=10 (27%)

Type 3
n=23 (62%)

In-stent
n=28 (76%)

Type 1
n=2 (7%)

Type 2
n=9 (30%)

Type 3
n=19 (63%)

Long stenting
n=67

Loss of patency
n=30 (45%)

In-stent
n=30 (100%)

Type 1
n=2 (7%)

Type 2
n=9 (30%)

Type 3
n=19 (63%)

Patent
n=92 (71%)

In-stent
n=23 (62%)

Patent
n=37 (55%)

FIGURE 1 Restenotic Patterns

These patency patterns were similar between groups (p = 0.830).
**TABLE 2** Lesion and Procedural Characteristics According to the Stenting Strategies

<table>
<thead>
<tr>
<th></th>
<th>Spot Stenting 129 Limbs</th>
<th>Long Stenting 67 Limbs</th>
<th>p Value*</th>
<th>p Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean lesion length, cm</td>
<td>25.7 ± 8.6</td>
<td>24.2 ± 7.8</td>
<td>0.225</td>
<td>0.224</td>
</tr>
<tr>
<td>Proximal SFA</td>
<td>107 (83)</td>
<td>52 (78)</td>
<td>0.365</td>
<td>0.364</td>
</tr>
<tr>
<td>Lesions with P2 or P3 segment involvement</td>
<td>21 (16)</td>
<td>15 (22)</td>
<td>0.295</td>
<td>0.262</td>
</tr>
<tr>
<td>Lesion type, TASC II</td>
<td></td>
<td></td>
<td>0.007</td>
<td>0.020</td>
</tr>
<tr>
<td>B</td>
<td>3 (2)</td>
<td>8 (12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>25 (19)</td>
<td>14 (21)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>101 (78)</td>
<td>45 (67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcified lesion</td>
<td>36 (28)</td>
<td>24 (36)</td>
<td>0.254</td>
<td>0.258</td>
</tr>
<tr>
<td>Right side</td>
<td>57 (44)</td>
<td>33 (49)</td>
<td>0.499</td>
<td>0.483</td>
</tr>
<tr>
<td>Distal run-off vessels ≤1</td>
<td>45 (35)</td>
<td>28 (42)</td>
<td>0.343</td>
<td>0.338</td>
</tr>
<tr>
<td>Pre-procedural ABI</td>
<td>0.48 ± 0.17</td>
<td>0.45 ± 0.19</td>
<td>0.494</td>
<td>0.482</td>
</tr>
<tr>
<td>Use of re-entry device</td>
<td>5 (4)</td>
<td>5 (7)</td>
<td>0.314</td>
<td>0.284</td>
</tr>
<tr>
<td><strong>Number of stents</strong></td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>112 (87)</td>
<td>16 (24)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>17 (13)</td>
<td>42 (63)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>9 (13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stented length, cm</td>
<td>10.3 ± 3.6</td>
<td>24.6 ± 8.7</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean stent diameter, mm</td>
<td>7.3 ± 0.7</td>
<td>6.5 ± 0.5</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean femoral artery diameter, mm†</td>
<td>6.2 ± 1.0</td>
<td>5.8 ± 0.9</td>
<td>0.010</td>
<td>0.011</td>
</tr>
<tr>
<td>Stent-to-artery ratio†</td>
<td>1.2 ± 0.2</td>
<td>1.1 ± 0.2</td>
<td>0.232</td>
<td>0.331</td>
</tr>
<tr>
<td>Proximal stent diameter, mm</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>6</td>
<td>23 (18)</td>
<td>29 (43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>54 (42)</td>
<td>32 (48)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>52 (40)</td>
<td>6 (9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stent type</td>
<td></td>
<td></td>
<td>0.165</td>
<td>0.339</td>
</tr>
<tr>
<td>S.M.A.R.T.</td>
<td>110 (85)</td>
<td>51 (76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zilver</td>
<td>8 (6)</td>
<td>3 (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Pro</td>
<td>3 (2)</td>
<td>5 (8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete SE</td>
<td>2 (2)</td>
<td>4 (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protégé Everflex</td>
<td>6 (5)</td>
<td>4 (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extent of popliteal artery stent coverage</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Popliteal artery, P1 segment</td>
<td>7 (5)</td>
<td>23 (34)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Popliteal artery, P2 or P3 segment</td>
<td>2 (2)</td>
<td>15 (22)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 3** Immediate Procedural Results and Stent Fractures During Follow-Ups

<table>
<thead>
<tr>
<th></th>
<th>Spot Stenting 129 Limbs</th>
<th>Long Stenting 67 Limbs</th>
<th>p Value*</th>
<th>p Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-procedural ABI</td>
<td>0.82 ± 0.18</td>
<td>0.86 ± 0.18</td>
<td>0.262</td>
<td>0.281</td>
</tr>
<tr>
<td>Immediate procedural</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>complications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure-related deaths</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Distal embolization</td>
<td>7 (5)</td>
<td>2 (3)</td>
<td>0.721</td>
<td>0.446</td>
</tr>
<tr>
<td>Arterial perforation</td>
<td>2 (2)</td>
<td>1 (2)</td>
<td>1.000</td>
<td>0.975</td>
</tr>
<tr>
<td><strong>Stent fracture‡</strong></td>
<td></td>
<td></td>
<td>0.405</td>
<td>0.196</td>
</tr>
<tr>
<td>No fracture</td>
<td>38 (78)</td>
<td>18 (67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 1</td>
<td>5 (10)</td>
<td>3 (11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 2</td>
<td>2 (4)</td>
<td>3 (11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 3</td>
<td>4 (8)</td>
<td>2 (7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 4</td>
<td>0</td>
<td>1 (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 5</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The spot stenting group had higher (A) primary patency rates and (B) target lesion revascularization (TLR)-free survival rates than the long stenting group. There was a graded relationship between the primary patency and the extent of popliteal artery coverage (C). These findings were consistent after adjustment using inverse probability of treatment weighting (IPTW) (D-F).
# FIGURE 3 Univariate Analysis of Risk Factors for Restenosis

<table>
<thead>
<tr>
<th>Variables</th>
<th>HR (95% CI)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.02 (0.99-1.05)</td>
<td>0.209</td>
</tr>
<tr>
<td>Female</td>
<td>1.23 (0.68-2.21)</td>
<td>0.495</td>
</tr>
<tr>
<td>Body mass index</td>
<td>0.92 (0.86-0.99)</td>
<td>0.019</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.48 (0.90-2.42)</td>
<td>0.123</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.87 (0.51-1.46)</td>
<td>0.593</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>0.98 (0.53-1.79)</td>
<td>0.934</td>
</tr>
<tr>
<td>Critical limb ischemia</td>
<td>2.07 (1.28-3.34)</td>
<td>0.003</td>
</tr>
<tr>
<td>Non-use of clopidogrel</td>
<td>2.10 (1.21-3.65)</td>
<td>0.008</td>
</tr>
<tr>
<td>Non-use of cilostazol</td>
<td>1.57 (0.94-2.63)</td>
<td>0.086</td>
</tr>
<tr>
<td>Non-use of statin</td>
<td>1.25 (0.77-2.02)</td>
<td>0.365</td>
</tr>
<tr>
<td>Non-use of ACE inhibitor or ARB</td>
<td>1.61 (0.95-2.71)</td>
<td>0.076</td>
</tr>
<tr>
<td>Lesion length (mm)</td>
<td>1.00 (0.99-1.00)</td>
<td>0.456</td>
</tr>
<tr>
<td>Initial P2 or P3 segment involvement</td>
<td>1.44 (0.81-2.56)</td>
<td>0.214</td>
</tr>
<tr>
<td>Distal run-off vessels ≤1</td>
<td>2.31 (1.42-3.74)</td>
<td>0.001</td>
</tr>
<tr>
<td>Vessel diameter (mm)</td>
<td>0.79 (0.59-1.07)</td>
<td>0.128</td>
</tr>
<tr>
<td>Stent diameter (mm)</td>
<td>0.63 (0.45-0.90)</td>
<td>0.010</td>
</tr>
<tr>
<td>Stent-to-artery ratio</td>
<td>0.72 (0.17-3.02)</td>
<td>0.658</td>
</tr>
<tr>
<td>Stent fracture</td>
<td>0.95 (0.49-1.85)</td>
<td>0.887</td>
</tr>
<tr>
<td>Postprocedural ABI</td>
<td>0.08 (0.02-0.28)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Extent of popliteal artery coverage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coverage of P1 segment</td>
<td>1.67 (0.90-3.10)</td>
<td>0.105</td>
</tr>
<tr>
<td>Coverage of P2 or P3 segment</td>
<td>3.03 (1.47-6.22)</td>
<td>0.003</td>
</tr>
<tr>
<td>Long stenting</td>
<td>2.20 (1.35-3.59)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

The circles represent the hazard ratios (HR). The error bars show the 95% confidence intervals (CI). ABI = ankle-brachial index; ACE = angiotensin-converting enzyme; ARB = angiotensin receptor blocker.
Angiographic Characterization of Dissections: NHLBI Modification

A. Minor radiolucent areas
B. Linear dissection
C. Contrast outside the lumen
D. Spiral dissection
E. Persistent filling defects
F. Total occlusion w/o distal antegrade flow

Courtesy of Marianne Brodmann
BioMimics

Proof of concept: Cadaver

Helical curvature of biomimetic stent accommodates femoropopliteal shortening in leg flexion

Biomimics stent not approved for use in the US
Limitations of Stents

Stent Fracture
VascuFlex® Multi-LOC

- Multiple Stent Delivery System (MSDS)
- 6 individual stents on top of one delivery system:

  - Stent-diameter: 5-8 mm
  - Stent-length: 13 mm (6 / system),
  - Delivery system: 6F-system (0.035“ guide wire)
  - Shaft lengths: 80 cm / 130 cm

- Indication:
  - pAVK → SFA and popliteal artery (p1-p3 segment)
Right SFA occlusion

predilatation

5/300mm PTA

6 mm DCB
Right SFA after DCB
5/300mm PTA after 11x 6/12mm-Ministents
Final result
Focal Stenting of Complex Femoropopliteal Lesions with the Multi-LOC Multiple Stent Delivery System: 12-Month Results of the Multicenter LOCOMOTIVE Study

INTRODUCTION:
The purpose of this observational study is to report the 12-month clinical outcomes with the novel Multiple Stent Delivery System (MSDS) to treat complex femoropopliteal lesions. Previously, we reported the 6-month clinical outcomes of the all-comers LOCOMOTIVE study, which demonstrated the safety and efficacy of the MSDS with a favorable target lesion revascularization (TLR) rate of 5.3% and a 90.7% patency rate at 6 months in claudicants and critical limb ischemia patients. The 12-month outcomes of LOCOMOTIVE registry are presented in this report. ClinicalTrials.gov Identifier: NCT02531230.

METHODS:
The LOCOMOTIVE study (Multi-LOC for fLOw liMiting Outcomes after POBA and/or DCB Treatment in the infrainguinal position with the objecIVE to implant multiple stent segments) investigates the efficacy and safety of the MSDS approach in an all-comers population. Clinical follow-ups at 6 and 12 months are scheduled to assess TLR, ABI, and vessel patency based on sonographic imaging.

RESULTS:
At 12 months, the primary unassisted patency was 85.7% and all-cause TLR rate was 9.3% in the overall cohort. Between baseline and 12 months, the target leg ABI increased from 0.62 ± 0.24 to 0.91 ± 0.38 (p < 0.001) and the mean Rutherford class improved from 3.5 to 1.9 (p < 0.001).

CONCLUSIONS:
Over a 12-month post-procedural period, MSDS for focal provisional stenting of complex femoropopliteal lesions demonstrated a promising primary patency and freedom from TLR after 12 months. In addition, significant improvements were observed in symptom classification and hemodynamics.
Focal Stenting of Complex Femoropopliteal Lesions with the Multi-LOC Multiple Stent Delivery System: 12-Month Results of the Multicenter LOCOMOTIVE Study

- 75 patients (72.9 ± 9.2 years of age) with symptomatic peripheral artery disease RF 2 to 5

“Tacking” – A new modality

• GOAL:
  – Provide anatomic result of stent
  – Minimize injury – Minimize hyperplasia
  – Maintain physiologic vessel compliance
  – Operator control
    • Placement
    • Number of tacks
    • Timing
  – Maintain options for future reintervention
TOBA II Study 1-Year Results

Post-Tack: Dissections Resolved

92.1% of all dissections were completely resolved with Tack.

Primary Patency at 12 Months

Freedom from CD-TLR 86.5%
(100% dissected vessels)

Primary Patency 79.3%
(100% dissected vessels)

*Dissections are site-reported (visual estimate during index procedure), 90-95% core-lab adjudicated dissection rate.
Conclusion

- Long distant stent implantation is associated with:
  - Reduced patency
  - Increased fracture rate
  - Impairment of vessel physiology and anatomy during leg motion

- Multiple short stents might overcome the limitations of a full metal jacket

- Prospective studies are on the way (LOCOMOTIVE, TOBA series)
Treatment Algorithm in TASC C & D Femoropopliteal Lesions (not severely calcified)

Predilatation of the SFA-lesion with a standard balloon

(Usual treatment-path before DCB)

- In case of severe dissection / recoil
- Good result

DES / Supera / Viabahn

DCB according to the RVD + 1mm

Focal stent or Tack on indication (Multi-LOC)
Treatment Algorithm in TASC C & D Femoropopliteal Lesions (severely calcified)

Predilatation of the SFA-lesion with a dedicated vessel prep device (lithotripsy, flex catheter)

In case of severe dissection / recoil

Aggressive dilatation (non-compliant balloon & Supera (& Viabahn?))

Good result

DES or Supera or Multi-LOC
T. Zeller, MD

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Bad Krozingen, Germany

Flash presentation: Treatment algorithm for a “leaving as little as possible behind” strategy in femoro-popliteal lesions