In-stent Restenosis Superimposed By Very Late Thrombosis

OCT is the answer for Many Questions

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I do not have any potential conflict of interest

Case History

- 53 y/o Indian male patient.
- Known h/o PCI/stent to LCX (in India since 4 years).
- Presented after severe chest pain for 20 hours durations with nausea, vomiting at the beginning of chest pain.

- h/o DM, HTN, dyslipidemia, Cigarette smoker.
- Troponin 19, CK 735, CK-MB 21, HbA1c 8.8.
- ECG: T-wave inversion in inferior-lateral leads.
- ECHO:
  - Hypokinesia of inferior-lateral wall.
  - EF 45% mild LVH, DD grade I.
Right Coronary Angiogram

Non dominant RCA

Left Coronary Angiogram

LCX Totally occluded

h/o PCI/stent to LCX since 4 years
**NON-STEMI With Totally Occluded Culprit**

**Background:** The prevalence and impact of total coronary occlusion of an infarct-related artery (IRA) on outcomes in patients with non-ST-elevation myocardial infarction (NSTEMI) remain unclear.

**Aim:** We evaluated the clinical significance of total coronary occlusion in NSTEMI patients.

**Methods:** A total of 2767 patients with NSTEMI enrolled in the Polish Registry of Acute Coronary Syndromes, who underwent percutaneous coronary interventions, were analysed. The patients were divided into two groups according to preprocedural culprit vessel thrombolysis in myocardial infarction (TIMI) flows (TIMI flow 0 — total coronary occlusion (TO); 72%, 26.3% of the patients, and TIMI flow 1–3 — non-total occlusion (non-TO); 2039, 73.7% of the patients).

**Results:** Patients with total occlusion were younger, were more often current smokers, and had lower incidence of hypertension and diabetes mellitus. The left circumflex artery (LCA) was the major IRA in the TO group (48%), whereas the left anterior descending artery (LAD) was more commonly the IRA in the non-TO group (38.8%). Multivariate analysis revealed that LCA as the culprit lesion (OR = 9.93; CI 1.34–78.86, p < 0.0001) was an independent predictor of TIMI flow 0 in IRA. In-hospital and one-month mortality occurred more frequently in the TO group (4.6% vs. 1.7%, p = 0.0005 and 5.3% vs. 3.5%, p = 0.077, respectively), no differences in the 13-, 24-, or 36-month mortalities were observed between these groups.

**Conclusions:** Only LCA as a culprit lesion was an independent predictor of total occlusion in 18%. The NSTEMI patients with TO had higher in-hospital and one-month mortalities, but their long-term outcomes were similar to those of non-TO patients.

**Keywords:** acute total coronary occlusion, long-term mortality, non-ST-segment elevation myocardial infarction, percutaneous coronary interventions

**Very late stent thrombosis (PCI > 4 years)**

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**In-Stent Total occlusion**

**DIFFUSE ISR**

(Pattern II, III, IV)

- Diffuse ISR is rare with SES.
- But more often with PES, ZES.
PCI to LCX (In-Stent Total occlusion pattern)

Fielder FC successfully crossed:
- After deep engagement of guide cath.
- River CTO balloon support (0.75 × 10 mm).

Balloon Predilatation

River CTO balloon inflated (0.75 × 10 mm) 8 atm

Fielder wire replaced by BMW wire which repositioned to distal branch
Resistance at mid of old stent

Guider disengagement

Resistance at the mid of the old stent

Short Balloon

Sprinter balloon
(2.5 x 15 mm) 12 atm

NC Euphora balloon
(2.5 x 30 mm) 12 atm

After Balloon Dilatation
Long Stent Cannot Cross Distally

**XIENCE Xpedition LL**  
(3 x 38 mm)

**The Long Stent Cannot Cross Distally**

**XB guider (not supportive) was replaced by AL1**

Again  
The Long Stent Cannot Cross Distally and damaged during pullback

Stent Crossing Failure

**Predictors of PCI Failure of In-Stent CTO**


1. Longer In-Stent CTOs.  
2. Ostial Location  
3. Fractured Stent  
4. Undersized Stent  
5. Deformed Stent  
7. Wire tracking under struts

**OCT Imaging**
**OCT Image Acquisition**

- Intravascular OCT requires a **blood-free field lasting several seconds** to allow imaging as blood strongly **scatters** light.

<table>
<thead>
<tr>
<th>Catheter Features</th>
<th>IVUS</th>
<th>OCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 F Compatible</td>
<td><strong>YES</strong></td>
<td>6 F</td>
</tr>
<tr>
<td>Tip to Transducer Distance</td>
<td>20 mm</td>
<td>31 mm²</td>
</tr>
<tr>
<td>Tissue Penetration</td>
<td>10 mm</td>
<td>1–2 mm²</td>
</tr>
<tr>
<td>Vessel Diameter Imaging Range</td>
<td>up to 6 mm</td>
<td>2.0–3.5 mm³</td>
</tr>
<tr>
<td>Use in Left Main</td>
<td><strong>YES</strong></td>
<td>NO†</td>
</tr>
<tr>
<td>Pullback Distance</td>
<td>10 cm</td>
<td>5 cm³</td>
</tr>
<tr>
<td>Imaging Without Contrast</td>
<td><strong>YES</strong></td>
<td>NO†</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Imaging Results Features</th>
<th>IVUS</th>
<th>OCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel Borders</td>
<td><strong>YES</strong></td>
<td>Limited*</td>
</tr>
<tr>
<td>Lesion Length</td>
<td><strong>YES</strong></td>
<td>Limited*</td>
</tr>
<tr>
<td>Dissections, Thrombus, Protrusion</td>
<td><strong>YES</strong></td>
<td>YES‡</td>
</tr>
<tr>
<td>Incomplete Stent Apposition</td>
<td><strong>YES</strong></td>
<td>YES‡</td>
</tr>
<tr>
<td>Stent Strut Coverage</td>
<td>Limited</td>
<td>YES‡</td>
</tr>
<tr>
<td>Thin Cap Fibroatheromas</td>
<td>Limited</td>
<td>YES‡</td>
</tr>
</tbody>
</table>

**Tight Lesion Distally**

- Tight Lesion Distally
- Problem for OCT Catheter
- Wire crossing

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*Boston Scientific OPTICROSS™ Imaging Catheter*  
*St. Jude Medical Dragonfly™ Duo OCT Imaging Catheter*
Balloon dilatation of the distal lesion

BMW Wire cross distal lesion

Balloon dilatation of the distal lesion

OCT Imaging

Safety of OCT?

• The most frequent complication (Transient events) such as;
  1. Chest discomfort
  2. Brady or tachycardia
  3. ST-T changes on ECG
  4. All resolved immediately after the procedure.

• No major complications were observed like (MI, emergency revascularization, death, acute vessel occlusion, dissection, thrombus formation, embolism, or vasospasm along the procedure related artery).

Is there another explanation for VF?

But with selective hand injection while Guidezilla was in LCX the patient developed VF.

DC shock 200 J
**OCT imaging proximal to ISR**

*Calcification* (signal-poor region with sharply delineated borders)

**OCT imaging for ISR with thrombosis**

*Thrombus* (with underlying heterogeneous intimal hyperplasia)
ISR due to Underlying Fracture Stent

Misaligned Strut Architecture

OCT 3-D rendering technique allows direct configuration on the stent geometry with the adjacent arterial structure.

3 D reconstruction of OCT demonstrating:
- Misaligned strut architecture, Deformity of adjacent vascular wall.

Sunwon Kim et al.; Circulation. 2014;129:e24-e27
Pathogenesis

ISR Pattern IV: Total occlusion

Pathogenesis of In-stent Total Occlusion

1 - In-Stent Restenosis
2 - Chronic stent thrombosis
3 - Mixed
**Due To In-stent Restenosis**

Neointimal hyperplasia from VSMCs proliferation completely obliterates the stent lumen

**Angiographic Feature**

- Etiology/ Risk Factors:
  - Underexpansion/ malapposition
  - Fracture
  - Small/long stent
  - Geographical miss
  - Diabetes
  - Previous in-stent (especially DES) restenosis
  - Bare-metal stent

**OCT Feature**

- Neointimal Hyperplasia
- Homogeneous type

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**Due To Chronic Stent Thrombosis**

**Angiographic Feature**

- Etiology/ Risk Factors:
  - Underexpansion/ malapposition
  - Distal dissection
  - Poor outflow
  - Small/long stent
  - Implantation in ACS
  - DAPT cessation/ non-responsiveness

**OCT Feature**

- Organized in-stent thrombosis
- Spider web like or cheese like

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In-Stent TO

Mixed

TCFA

Restenosis

Rupture thrombus

Late stent thrombosis

Intimal Rupture

Neointima

Lipidic tissue

Neoatherosclerosis

TCFA-containing Neointima

Red Thrombus (Intraluminal)

Healed rupture

Back to our case

(J Am Coll Cardiol 2012;59:2051–7)
Aggressive Balloon Dilatation
(High Pressure Up To 16 Atm)

NC trek balloon
(3 × 15 mm) 12,14,16 atm

2 DES Successfully Crossed and deployed

XIENCE Xpedition LL
(2.5 × 15 mm) 16 atm

XIENCE Xpedition LL
(3 × 28 mm) 16 atm
Final Results

Take Home Message

- **Non-STEMI** occasionally has atypical association with **complete** (total) occlusion of the culprit artery.
- **Stent Fractures** is underestimated and unrecognized mechanism of In-Stent restenosis and thrombosis.
- **Acquisition Methodology** is needed to detect stent fractures as movement toward **a thinner struts and more radiolucent stents** will make the detection of stent fracture much more difficult without the use of enhancement.
- **OCT imaging** is a one of the efficient tool to diagnose stent fracture and the underling mechanism of ISR and thrombosis.
Predictors For In-Stent Restenosis after DES

- **Biological factors**
  - Drug resistance
  - Hypersensitivity

- **Mechanical factors**
  - Stent underexpansion
  - Nonuniform stent strut distribution
  - Stent fracture
  - Nonuniform drug elution/deposition
  - Polymer peeling

- **Technical factors**
  - Barotrauma outside stented segment
  - Stent gap
  - Residual uncovered atherosclerotic plaques

Types Stent fracture

Stent Fracture Type V

Total Separation with gap

Predictors For Stent Fracture

- Extensive calcification
- Lesions with hinge motion

Other predictors:
- aorto-ostial lesions
- Ostial stent location.
- overlapping stents
- Lesion length ≥ 20 mm.
- Proximal vessel tortuosity.
- Total occlusions.
- Aggressive post dilatation.

Kadota et al. JACC 2008; 51: B7
Rao et al. JACC 2008; 51: B4 (abstract)
Stent Fatigue

Early

(≤ 1 month)

- Mechanical
  - Stent Material and Design
  - Mechanical fatigue
  - Overlapping Stents
  - Stent Length
  - RCA location
  - Calcified and tortuous lesion
  - Hinge points
  - Angulation
  - Aggressive post-dilatation

Stent Fatigue

The stress mainly occurred in the bridge struts

Bridge Struts (Connectors)

Inverse relationship between connector number and flexibility

Cardiovascular Revascularization Medicine 17 (2016) 404–411

<table>
<thead>
<tr>
<th>Stent</th>
<th>Alloy</th>
<th>Strut thickness (µg/mm²)</th>
<th>Drug</th>
<th>Polymer</th>
<th>No. of crowns</th>
<th>No. of connectors</th>
<th>Connectors design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cipher</td>
<td>Stainless steel</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>6</td>
<td>Connectors with out-of-phase sinusoidal rings and mid-strut connector at 30° from the stent long axis</td>
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<tr>
<td>Select</td>
<td>(316 L)</td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td></td>
<td>Largely out-of-phase sinusoidal hoops linked directly by welds</td>
</tr>
<tr>
<td>Xience</td>
<td>Cobalt–chromium</td>
<td>81</td>
<td></td>
<td>Zotarolimus</td>
<td>6</td>
<td>3</td>
<td>Connectors link in-phase sinusoidal hoops</td>
</tr>
<tr>
<td>V</td>
<td>(L-605)</td>
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<td></td>
<td>Biolinx polymer</td>
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<td></td>
<td>U-shaped loop in the connector improves flexibility</td>
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<tr>
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<td></td>
<td>Straight connecters link off-set peaks of the in-phase sinusoidal hoops</td>
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<tr>
<td>Resolute</td>
<td>Cobalt–chromium</td>
<td>91</td>
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<td>Everolimus</td>
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<tr>
<td>Element</td>
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<td>Fluorinated polymer</td>
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<tr>
<td></td>
<td>Platinum</td>
<td>81</td>
<td></td>
<td></td>
<td>8</td>
<td>2</td>
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</tbody>
</table>

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More Flexible
Complications of Stent Fracture

It is one of the recognized Causes Of Stent Failure.

Stent Fracture is associated with:

1. In-stent restenosis (Focal pattern).
2. stent thrombosis and Total occlusions.
3. Higher rate of TLR (Target lesion revascularization).

Popma et al. 2009 Am J Cardiol;103:923–9

ISR due to Stent Fracture

+ Angina

ISR at FS > 70% .... (heterogeneous stent).
ISR at FS > 50-70% .... Stress test ± IVUS IF positive ..... heterogeneous stent.
ISR at FS < 50% .... conservative including DAPT.

No angina

ISR at FS > 70% .... (heterogeneous stent).
ISR at FS < 70% .... conservative including DAPT.

THANK YOU
For Your Attention