Coronary Chronic Total Occlusions: When, How and Why to Intervene

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What is a CTO?

**Clinical Definition** – Coronary CTOs are commonly encountered complex lesions defined as >99% blockage for 3 months or more, and are responsible for a clinically significant decrease in blood flow (TIMI 0-1).

**Practical Definition** – Any fully occluded artery that the interventionalist can’t immediately cross with a workhorse wire.
Example
Myths of Chronic Total Occlusions

CTO’s are a rare finding
CTO’s rarely cause ischemia due to robust collaterals
Medical therapy is fine
CTO’s do not affect mortality
CTO’s have a poor success rate
Myth #1

CTO’s are rare
Chronic Total Occlusions

- NHLBI Dynamic Registry and BARI study 1997-1999
- n=1,761

- Presence of a total occlusion 31%
- Attempted total occlusion 7.5%

Srinivas et al. Circulation 2002
CTO Canadian Registry

CTO’s identified in 1,697 (18.4%) patients with significant CAD

Fefer et al, J Am Coll Cardiol 2012;59:991–7
Myth #2

CTO’s rarely cause ischemia
Collaterals are usually not sufficient to significantly reduce ischemia in CTO

Werner GS et al. European Heart Journal 2006
Effectiveness of Recanalization of CTO: A systematic review and meta-analysis Effect on Angina

55% reduction in anginal symptoms

64 year old female
DM, HTN, Dyslipidemia
S/P PCI DES LAD 2007
Coronary angiography for CCS class 3 angina
LAD stent is patent....
How would you treat this?
Now, how would you treat this?
Presence of a CTO influences treatment choices

With Occlusion (n=220)

- Angioplasty: 47%
- Bypass: 31%
- Medical: 22%

Without Occlusion (n=357)

- Angioplasty: 73%
- Bypass: 18%
- Medical: 9%

Delacretaz et al, 1997
Presence of a CTO influences treatment choices

BARI Registry Substudy

<table>
<thead>
<tr>
<th></th>
<th>PCI</th>
<th>CABG</th>
<th>Med Rx</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTO</td>
<td>11</td>
<td>40</td>
<td>49</td>
</tr>
<tr>
<td>NonCTO</td>
<td>36</td>
<td>28</td>
<td>25</td>
</tr>
</tbody>
</table>

Christofferson et al, AJC, 2005, 1088-91 and Grantham et al. JACC: 2009
Myth #3

CTOs don’t affect mortality
CTO PCI Success on MI rates

CTO PCI Success on mortality

Concept of “double jeopardy”
CTO impact on (Non-CTO vessel) AMI mortality

Concept of “double jeopardy”

Mortality in 1,417 patients treated for STEMI with PCI

Van der Schaaf RJ et al. Am J Cardiology 2006; 98: 1165
CTO Treatment and Improved Long-term Survival (all p <.05)

Hoye et al. EHJ 2005
Myth #4

CTOs’s have a poor success rate
Angiographic Success and Procedural Complications in Patients Undergoing Percutaneous Coronary Chronic Total Occlusion Interventions

A Weighted Meta-Analysis of 18,061 Patients From 65 Studies

Vishal G. Patel, MD,* Kimberly M. Brayton, MD, JD,* Aracely Tamayo, MSW, MPH,† Owen Mogabgab, MD,* Tesfaldet T. Michael, MD, MPH,* Nathan Lo, MD,* Mohammed Alomar, MD,* Deborah Shorrock,* Daisha Cipher, PhD,* Shuaib Abdullah, MD,* Subhash Banerjee, MD,* Emmanouil S. Brilakis, MD, PhD*
Meta-analysis of 18,061 patients from 65 studies

<table>
<thead>
<tr>
<th>Event</th>
<th>Rate, %</th>
<th>Min-Max %</th>
<th>Count</th>
<th>Mean, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angiographic success</td>
<td>77.0</td>
<td>74.3-79.641.2-100.0</td>
<td>14,414/18,828</td>
<td>94.4 1,120.6 &lt;0.0001</td>
</tr>
<tr>
<td>MACE</td>
<td>3.1</td>
<td>2.4-3.7</td>
<td>0.19.4</td>
<td>500/15,718</td>
</tr>
<tr>
<td>Death</td>
<td>0.2</td>
<td>0.1-0.3</td>
<td>0.0-3.6</td>
<td>77/18,061</td>
</tr>
<tr>
<td>Emergent CABG</td>
<td>0.1</td>
<td>0.0-0.2</td>
<td>0.2-3.6</td>
<td>52/18,061</td>
</tr>
<tr>
<td>Stroke</td>
<td>&lt;0.01</td>
<td>0.0-0.1</td>
<td>0.0-1.1</td>
<td>11/18,061</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>2.5</td>
<td>1.9-3.0</td>
<td>0.19.4</td>
<td>490/15,718</td>
</tr>
<tr>
<td>Q-wave myocardial infarction</td>
<td>0.2</td>
<td>0.1-0.3</td>
<td>0.0-2.6</td>
<td>61/13,353</td>
</tr>
<tr>
<td>Coronary perforation, 2.9 per lesion</td>
<td>2.9</td>
<td>2.2-3.6</td>
<td>0-11.9</td>
<td>418/12,254</td>
</tr>
<tr>
<td>Tamponade</td>
<td>0.3</td>
<td>0.2-0.5</td>
<td>0.4-7.2</td>
<td>74/13,103</td>
</tr>
<tr>
<td>Acute stent thrombosis</td>
<td>0.3</td>
<td>0.1-0.5</td>
<td>0.2-2.0</td>
<td>51/9,338</td>
</tr>
<tr>
<td>Vascular complication</td>
<td>0.6</td>
<td>0.3-0.9</td>
<td>0.2-2.8</td>
<td>66/7,308</td>
</tr>
<tr>
<td>Major bleed</td>
<td>0.4</td>
<td>0.0-0.7</td>
<td>0.3-7.2</td>
<td>325,108</td>
</tr>
<tr>
<td>Contrast nephropathy</td>
<td>3.8</td>
<td>2.4-5.3</td>
<td>2.4-18.1</td>
<td>1654,796</td>
</tr>
<tr>
<td>Radiation skin injury</td>
<td>&lt;0.01</td>
<td>0.0-0.1</td>
<td>0.0-11.1</td>
<td>3/2,857</td>
</tr>
</tbody>
</table>
Success with the Hybrid Approach

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>n</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nombela-Franco</td>
<td>2013</td>
<td>209</td>
<td>Technical success of <strong>90.4%</strong>, despite J-CTO score of 2.18±1.26 (difficult cases). Good discrimination and calibration of J-CTO score. However, final success rate was not predicted by J-CTO score with the hybrid approach.</td>
</tr>
<tr>
<td>Michael</td>
<td>2014</td>
<td>73</td>
<td>Technical success was <strong>90.4%</strong>. Final successful crossing strategy was antegrade wire escalation in 50.0%, antegrade dissection/reentry in 24.2%, and retrograde in 25.8%</td>
</tr>
<tr>
<td>Pershad</td>
<td>2014</td>
<td>198</td>
<td>Technical success was <strong>95.4%</strong> in the post “hybrid” algorithm group vs. 79.4% among patients treated before introduction of the “hybrid” algorithm.</td>
</tr>
<tr>
<td>Christopoulos</td>
<td>2014</td>
<td>497</td>
<td>Technical and procedural success in <strong>91.5% and 90.7% of cases</strong>, respectively and were significantly higher than the pooled technical and procedural success rates from previously published studies (76.5%, p&lt;0.001 and 75.2%, p&lt;0.001 respectively). Major procedural complications in 1.8% of patients, an incidence similar to that of prior studies (pooled rate 2.0%, p=0.72)</td>
</tr>
<tr>
<td>Christopoulos</td>
<td>2014</td>
<td>496</td>
<td>Technical and procedural success was lower among patients with previous CABG (88.1% vs 93.4%, p = 0.044 and 87.5 vs 92.5%, p = 0.07, respectively).</td>
</tr>
<tr>
<td>Christopoulos</td>
<td>2014</td>
<td>521</td>
<td>Technical success in the in-stent restenosis and de novo group was <strong>89.4% vs. 92.5%</strong> (p=0.43), respectively; procedural success was 86.0% vs. 90.3% (p=0.31), respectively; and the incidence of major adverse cardiac events was 3.5% vs. 2.2%, respectively (p=0.63).</td>
</tr>
</tbody>
</table>
The Hybrid Algorithm for CTO PCI provisional approaches

Dual Catheter Angiography

1. Clear proximal cap
2. Good Distal Target

Antegrade

Wire escalation
fail

Dissection Reentry (Crossboss-Stingray)

fail

Dissection Reentry (reverse CART)

Retrograde

Wire escalation

fail

Dissection Reentry (reverse CART)

fail

Dissection Reentry (Crossboss-Stingray)

fail
Hybrid Algorithm Angiographic Considerations

1. Proximal Cap Geometry
   - Clear starting point
   - Ambiguous/confusing
   - Flush Occlusion / Poor Guide Support

2. Occlusion Length
   - Always do Bilateral Injections
   - < 20mm – higher likelihood of successful guide wire crossing
   - > 20 mm – lower likelihood guidewire success, higher likelihood of entering the subintimal space

3. Distal Landing Zone
   - Important branch/bifurcation at distal cap
   - Highly diseased distal vessel

4. Presence of Interventional Collaterals
   - Is retrograde possible?
Tool Box for CTO PCI

- Sheaths
- Guiding catheters
- Guide wires
- Microcatheters
- Snares and externalization wires
- Complication management
Conclusions

1. CTO’s are not infrequent (15-30%)

2. Opening CTO’s reduce angina, collaterals insufficient.

3. Interventional Cardiologists often don’t attempt CTO (15%), but they do refer for surgery.

4. Although CTO’s likely do not cause STEMI, the presence of a CTO increases mortality during future events (NSTEMI)

5. High success rates can be achieved, with low complications, using Hybrid algorithm