Clinical Considerations for CTO Revascularization

Whom to treat, Who derives benefit and What can we achieve?

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Disclosure: No conflict of interest
CTOs in Perspective

Despite novel technologies/DES, frequency of attempted CTOs has not changed over the past decade\textsuperscript{1,2}

- Technical/procedural challenges
- Misperceptions regarding viability, collateral flow
- Uncertainty regarding which patients may benefit balanced by
- Concern for complications in patients who may not derive clinical benefit

SYNTAX CTO Prevalence\textsuperscript{3}

Randomized Trial: 10% vs CABG Registry: 40%

Srinivas et al. Circulation 2002
Christofferson et al. Am J Cardiol 2005
Serruys et al. JACC Interven 2008
Frequency and Impact of Incomplete Coronary Revascularization

SYNTAX Trial

- SYNTAX CTO Prevalence
  
  *Randomized Trial: 10% vs CABG Registry: 40%*

- Complete Revascularization: 57% PCI vs 63% CABG (P=0.005)

New York State Database

- 68.9% of MVD patients undergoing PCI had incomplete revascularization

- 30.1% had CTOs and/or ≥2 diseased major vessels with incomplete revascularization

* Mortality highest in this subgroup (HR 1.36, 1.12-1.66)
Why the Occluded Artery Trial (OAT) Does Not Apply to CTO Revascularization

OAT: Subacute (3-28 days) total occlusions following MI

OAT: Relatively asymptomatic population excluding severe ischemia by functional study, rest angina and multivessel disease

Absence of improvement in LV function in OAT substudy

- Baseline LVEF 48% (difficult to improve upon relatively normal)
- Spontaneous recanalization (TIMI 2/3) observed at 1 year in 25% of medical therapy cohort
- Reocclusion in ~9% of PCI cohort; no DES
- Greatest predictor of improved LVEF was having a patent target vessel at 1 year follow up

Hochman et al. NEJM 2006
Dzavik et al. Circulation 2006
Theoretical Rationale for CTO Revascularization
‘Open Artery Hypothesis’

- Increase long-term survival
- Improve left ventricular function
- Electrical stability of myocardium and reduced predisposition to arrhythmic events
- Increased tolerance of future coronary occlusion events
### Long-term Survival with Successful CTO Revascularization
Support for the Late Open Artery Hypothesis

<table>
<thead>
<tr>
<th>Trial</th>
<th>Success (N)</th>
<th>Failure (N)</th>
<th>Follow-up Duration (years)</th>
<th>Mortality (%)</th>
<th>Success</th>
<th>Failure</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Columbia Cardiac Registry¹</td>
<td>1118</td>
<td>340</td>
<td>6</td>
<td>10.0</td>
<td>19.0</td>
<td></td>
<td>&lt;0.001</td>
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<tr>
<td>Suero et al.²</td>
<td>1491</td>
<td>514</td>
<td>10</td>
<td>26.0</td>
<td>35.0</td>
<td></td>
<td>0.001</td>
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<tr>
<td>TOAST-GISE³</td>
<td>286</td>
<td>83</td>
<td>1</td>
<td>1.1</td>
<td>3.6</td>
<td></td>
<td>0.13</td>
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<tr>
<td>Aziz et al.⁴</td>
<td>377</td>
<td>166</td>
<td>2.4</td>
<td>2.5</td>
<td>7.3</td>
<td></td>
<td>0.049</td>
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<tr>
<td>Hoye et al.⁵</td>
<td>568</td>
<td>306</td>
<td>5</td>
<td>6.5</td>
<td>12.0</td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>Valenti et al.⁵</td>
<td>344</td>
<td>142</td>
<td>2</td>
<td>91.6</td>
<td>87.4</td>
<td></td>
<td>0.025</td>
</tr>
</tbody>
</table>

Patient Selection
Clinical Considerations

- Is this patient symptomatic, and how? Angina? Heart failure? Arrhythmia?
- What is the chance of procedural success?
- Will successful recanalization improve this patient’s symptoms?
- Will successful recanalization improve this patient’s prognosis?
- What are the risks of attempted recanalization in this patient?
Recovery of LV Function After CTO Recanalization

Predictors of Improvement in LV Function

- Increase LVEF
  - Baseline LV dysfunction
  - Preserved microvasculature

- No Effect
  - Collateral development
  - Prior MI
  - Duration of occlusion
  - Nonocclusive restenosis

- Decrease LVEF
  - Reocclusion

Werner GS et al. Am Heart J 2005
Shifting Focus Downstream from CTOs
Insights to Myocardial Recovery Following CTO Recanalization

Signal Intensity-Time Curves and Stress Perfusion Images Demonstrating No Change in Hyperemic MBF in a Medically Managed Patient With a CTO

Cheng et al. JACC Intv 2008
Shifting Focus Downstream from CTOs
*Insights to Myocardial Recovery Following CTO Recanalization*

Signal Intensity-Time Curves and Stress Perfusion Images Demonstrating Changes in Hyperemic MBF After CTO PCI

Cheng et al. *JACC Intv* 2008
Principles of CTO Revascularization
Advanced Strategies and Technique

- Contralateral angiography
- Guiding catheter selection
- Mother-in-Child Technique

Identification of the entry with IVUS
Distinguish false and true lumen

Penetration vs Drilling
Parallel wire technique
Subintimal Tracking and Re-entry

Retrograde crossing
Kissing Wire
CART, Reverse CART, Wire Externalization

↑ Success vs.
↑ Complications
**ACROSS – CYPHER**

**6 Month Angiographic Restenosis**

- **TOSCA I - BMS** (n=202)
- **SES** (n=200)

**In-treated-segment** refers to length of contiguous target segment exposed to balloon inflation.
**In-segment** includes stented area plus 5 mm proximal and distal to stent.

- **55.2%** (33% absolute reduction) for TOSCA-I BMS
- **22.6%** (85% adjusted relative reduction) for SES

Kandzari et al. JACC Interv In press
CTO Revascularization and Late Clinical Benefit with DES: 2 year Survival

<table>
<thead>
<tr>
<th></th>
<th>CTO PCI Failure</th>
<th>CTO PCI Success</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>87.4 ± 2.9%</td>
<td>91.6 ± 2.0%</td>
<td>0.025</td>
</tr>
<tr>
<td>Single vessel disease (N=70)</td>
<td>93.3 ± 6.4%</td>
<td>93.6 ± 3.6%</td>
<td>0.986</td>
</tr>
<tr>
<td>Multi vessel disease (N=416)</td>
<td>86.6 ± 3.1%</td>
<td>91.4 ± 2.2%</td>
<td>0.021</td>
</tr>
</tbody>
</table>

Valenti et al. *Eur Heart J* 2008
Alternative to DES in CTO Revascularization: Drug-Eluting Balloon

PEPCAD CTO

- **Sample size:** 48 pts with *de novo* CTO, 2.5 to 4.0 mm RVD
- **Study design:** Non-randomized, single arm
- **Treatment:** Paclitaxel drug-eluting balloon (SeQuent Please) and bare metal stents
- **DAPT regimen:** 6 months
- **Primary Endpoint:** 6-month late loss compared with PACTO study historical control
- **Status:** TCT 2009 presentation

Source: [www.clinicatrials.gov](http://www.clinicatrials.gov), Prof. Gerald Werner
Treatment of CTOs has introduced new benefits, new dilemmas

- Historical predictors of procedural success are ‘historic’
- Patient identification with non-invasive imaging
- Strut fracture and LSM may be more common; clinical implications uncertain

DES are a revolutionary step toward improving CTO outcomes (but there is need for technology to improve procedural success!)

- Aside from ↓ ABR, long term patency with DES may be associated with preservation of improved LV function
- Implications for technique: ↑ restenosis when less DES coverage

Despite more advanced strategies and technologies, there is little systematic evidence that procedural outcomes have changed for the better or worse

- New techniques, new complications
- Need CTO-specific clinical trials that better inform procedural outcomes