CTO Revascularization in 2015

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Disclosure Statement of Financial Interest

I, Jeffrey W. Moses, MD am a consultant to BSC, Abbott, Medtronic (minor)
False Assumptions about Coronary Chronic Total Occlusions

- The CTO is well collateralized and therefore there is minimal impact on quality of life and prognosis
- CTO is a closed vessel and therefore not at risk for/or during ACS/AMI
- CTO outcomes are more benign than non CTO coronary disease
Current Perspectives on Coronary Chronic Total Occlusions

The Canadian Multicenter Chronic Total Occlusions Registry

Paul Fefer, MD,† Merril L. Knudtson, MD,‡ Asim N. Cheema, MD, PhD,§ P. Diane Galbraith, BN, MSC,‡ Azriel B. Osherov, MD,* Sergey Yalonetsky, MD,* Sharon Gannot, BS,† Michelle Samuel,* Max Weisbrod,* Daniel Bierstone,* John D. Sparkes, MSC,* Graham A. Wright, PhD,* Bradley H. Strauss, MD, PhD*

**Figure 1. Management of CTO Registry Patients**

Flow chart of patients with chronic total occlusion (CTO) registry patients showing management up to 12 months after index angiography. PCI = percutaneous coronary intervention.

Conclusions

Chronic total occlusions are common in contemporary catheterization laboratory practice. Prospective studies are needed to ascertain the benefits of treatment strategies of these complex patients.  (J Am Coll Cardiol 2012;59:991–7) © 2012 by the American College of Cardiology Foundation
### National Attempt Rates

**ACC-NCDR**

<table>
<thead>
<tr>
<th>Year</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004^</td>
<td>13.6</td>
</tr>
<tr>
<td>2005</td>
<td>11.7</td>
</tr>
<tr>
<td>2006</td>
<td>12.4</td>
</tr>
<tr>
<td>2007*</td>
<td>11.8</td>
</tr>
</tbody>
</table>

^ Jan 1 2004-Mar 31 2005

* Through Q3

**National Attempt Rate Over Time**

Courtesy J Aaron Grantham and ACC/NCDR
Clinical Indications
Why Open a Chronically Occluded Coronary Artery?

- Symptom control
  - Angina
  - CHF
  - Fatigue
- Improve LV function
  - Regional
  - Global
- Survival
  - Improved tolerance of AMI
  - Complete revascularization
  - Ischemic Risk
Collaterals are Usually not Sufficient to Substantially Reduce Ischemia in CTO

Modified from Werner GS et al, European Heart Journal 2006, courtesy Werner GS
Evidence for Quality of Life Benefit

125 pts completed the Seattle Angina Questionnaire (SAQ) before and one month after PCI. 69 procedural success (55%), 56 failures (45%).

Asymptomatic
- SAQ Angina Frequency: 4.3 (-5.4, 13.9)
- SAQ Physical Limitation: 6.3 (-5.0, 17.6)
- SAQ Quality of Life: 8.5 (-3.7, 20.7)

Symptomatic
- SAQ Angina Frequency: 10.3 (-0.8, 21.3)
- SAQ Physical Limitation: 15.9 (5.1, 26.7)
- SAQ Quality of Life: 27.3 (16.5, 38.0)

Impact of Successful CTO-PCI: Angina

Long-term angina benefit favors CTO-PCI success

**Study or Subgroup**

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>PCI success</th>
<th>PCI failure</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Total</td>
<td>Events</td>
</tr>
<tr>
<td>Angioi et al.</td>
<td>10</td>
<td>93</td>
<td>28</td>
</tr>
<tr>
<td>Aziz et al.</td>
<td>12</td>
<td>377</td>
<td>36</td>
</tr>
<tr>
<td>Drozd et al.</td>
<td>10</td>
<td>280</td>
<td>12</td>
</tr>
<tr>
<td>Finci et al.</td>
<td>7</td>
<td>100</td>
<td>37</td>
</tr>
<tr>
<td>Hoye et al.</td>
<td>71</td>
<td>567</td>
<td>117</td>
</tr>
<tr>
<td>Ivanhoe et al.</td>
<td>41</td>
<td>317</td>
<td>59</td>
</tr>
<tr>
<td>Noguchi et al.</td>
<td>9</td>
<td>134</td>
<td>26</td>
</tr>
<tr>
<td>Olivari et al.</td>
<td>7</td>
<td>286</td>
<td>13</td>
</tr>
<tr>
<td>Valenti et al.</td>
<td>7</td>
<td>344</td>
<td>13</td>
</tr>
<tr>
<td>Warren et al.</td>
<td>3</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td>2524</td>
<td>1325</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Total events: 177 (PCI success) and 348 (PCI failure).

Heterogeneity: Tau² = 0.01, Chi² = 9.90, df = 9 (P = .36), I² = 9%

Test for overall effect: Z = 13.41 (P < .00001)
Impact of Successful CTO-PCI: Mortality

Long-term survival benefit favors CTO-PCI success

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>PCI success Events</th>
<th>PCI success Total</th>
<th>PCI failure Events</th>
<th>PCI failure Total</th>
<th>Weight</th>
<th>M-H, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angioli et al.</td>
<td>3</td>
<td>93</td>
<td>9</td>
<td>108</td>
<td>3.4%</td>
<td>0.37 [0.10, 1.40]</td>
</tr>
<tr>
<td>Aziz et al.</td>
<td>9</td>
<td>377</td>
<td>12</td>
<td>166</td>
<td>6.7%</td>
<td>0.31 [0.13, 0.76]</td>
</tr>
<tr>
<td>Drozd et al.</td>
<td>7</td>
<td>280</td>
<td>5</td>
<td>149</td>
<td>4.3%</td>
<td>0.74 [0.23, 2.37]</td>
</tr>
<tr>
<td>Fini et al.</td>
<td>5</td>
<td>100</td>
<td>3</td>
<td>100</td>
<td>2.9%</td>
<td>1.70 [0.40, 7.32]</td>
</tr>
<tr>
<td>Hoyer et al.</td>
<td>37</td>
<td>567</td>
<td>36</td>
<td>304</td>
<td>14.4%</td>
<td>0.52 [0.32, 0.84]</td>
</tr>
<tr>
<td>Ivanhoe et al.</td>
<td>3</td>
<td>317</td>
<td>7</td>
<td>163</td>
<td>3.2%</td>
<td>0.21 [0.05, 0.83]</td>
</tr>
<tr>
<td>Labriolle et al.</td>
<td>7</td>
<td>127</td>
<td>2</td>
<td>45</td>
<td>2.4%</td>
<td>1.25 [0.25, 6.27]</td>
</tr>
<tr>
<td>Noguchi et al.</td>
<td>7</td>
<td>134</td>
<td>15</td>
<td>92</td>
<td>6.1%</td>
<td>0.28 [0.11, 0.72]</td>
</tr>
<tr>
<td>Olivari et al.</td>
<td>2</td>
<td>286</td>
<td>3</td>
<td>83</td>
<td>1.9%</td>
<td>0.19 [0.03, 1.14]</td>
</tr>
<tr>
<td>Prasad et al.</td>
<td>228</td>
<td>914</td>
<td>101</td>
<td>348</td>
<td>21.6%</td>
<td>0.82 [0.62, 1.08]</td>
</tr>
<tr>
<td>Suero et al.</td>
<td>395</td>
<td>1491</td>
<td>180</td>
<td>514</td>
<td>23.8%</td>
<td>0.67 [0.54, 0.83]</td>
</tr>
<tr>
<td>Valenti et al.</td>
<td>17</td>
<td>344</td>
<td>17</td>
<td>142</td>
<td>9.3%</td>
<td>0.38 [0.19, 0.77]</td>
</tr>
<tr>
<td>Warren et al.</td>
<td>0</td>
<td>26</td>
<td>0</td>
<td>18</td>
<td>Not estimable</td>
<td></td>
</tr>
</tbody>
</table>

Total (95% CI): 5056/2232 = 100.0% 0.56 [0.43, 0.72]

Total events: 721/390 = 184.8

Heterogeneity: Tau² = 0.06; Chi² = 18.74, df = 11 (P = .07); I² = 41%

Test for overall effect: Z = 4.39 (P < .0001)
COURAGE
Rates of Death or MI by Residual Ischemia

Shaw et al, Circ 2008;117
Residual SYNTAX Score in SYNTAX Trial

Low Baseline SYNTAX Score (0-22)

Intermediate Baseline SYNTAX Score (23-32)

High Baseline SYNTAX Score (≥33)

Estimated Event Rate

All-Cause Death (y)

Log–rank P value .022

Log–rank P value <.001

Log–rank P value <.001

Material and Methods

- Retrospective analysis of coronary angiography performed with regard to procedure details and angiographic completeness of revascularization
- Complete angiographic revascularization defined as:
  - No angiographically significant stenosis in all vessels with diameter of at least 2mm
  - Significant stenosis defined as: LM and proximal LAD ≥ 50% MLD and ≥70% in all other arteries

1078 pts with heart failure

709 pts with ischemic heart failure

495 pts with ischemic heart failure + coronary angiography

56 CABG-qualified pts excluded

222 pts with complete revascularization

217 pts with incomplete revascularization
# Results
## 12 Months

<table>
<thead>
<tr>
<th>Variable</th>
<th>Complete revasc (n=222)</th>
<th>Incomplete revasc (n=217)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myocardial infarction</td>
<td>2.3%</td>
<td>5.5%</td>
<td>0.125</td>
</tr>
<tr>
<td>All-cause mortality</td>
<td>10.4%</td>
<td>18.4%</td>
<td>0.01</td>
</tr>
<tr>
<td>Death or MI</td>
<td>11.7%</td>
<td>23.5%</td>
<td>0.002</td>
</tr>
</tbody>
</table>
Retrograde Approach

Aorta-PD graft

Fielder

Transit™
CTO Crossing
Successful strategy

- Kissing Wire Technique: 10.1%
- CART: 2.2%
- Retrograde Wire Cross: 56.9%
- Reverse CART: 30.7%

Figure 13: 4 Patterns of Success in Retrograde Wire Technique
- Kissing Wire Cross
- Retrograde Wire Cross
- CART
- Reverse CART

~ 90%
Reverse CART

Courtesy of Dr. Masahiko Ochiai
Reverse CART

Distal cap access

Advance corsair into antegrade guide
Exchange for viper wire

Reverse CART

Trap prn

3.0mm rx antegrade
Corsair
IVUS Guided Identification of the Entry
IVUS Guided Technique for Looking For the Entry

Complex CTO of MLCX

Where is the origin?

IVUS in LA branch
The Stingray™ CTO Re-Entry System

The StingRay™ System (Catheter and Guidewire) is designed to accurately target and re-enter the true lumen from a subintimal position.

Unique self-orienting balloon has a flat shape for true lumen targeting

180° opposed and offset exit ports for selective guidewire re-entry

Compatibility:
Coronary: 0.014” Wire

Re-entry probe at Stingray Guidewire tip
The CrossBoss™ CTO Crossing Catheter

The CrossBoss™ catheter is an OTW stainless steel catheter designed to quickly and safely pass through the CTO to gain access to the distal true lumen or enter subintimal pathways. The catheter is advanced by using rapid bi-directional rotation.

- Multi-wire coiled shaft
- Tracks via FAST Spin Technique
  - Highly torqueable coiled-wire shaft
  - FAST Spin reduces push required to cross CTO
- Atraumatic distal tip advanced across a CTO ahead of the guidewire
- OTW 0.014” guidewire compatible
Hybrid Strategy Treatment Algorithm

1. Dual injection
   - 1. Ambiguous proximal cap
   - 2. Poor distal target
   - 3. Appropriate “interventional” collaterals

   no
   - Antegrade
     - 3. Lesion length <20 mm
       - yes
         - Antegrade wiring
       - no
         - Antegrade dissection and reentry
           - Controlled (Stingray)
           - Wire based (LaST)

   yes
   - Retrograde
     - 6. Retrograde true lumen puncture
     - Retrograde dissection and reentry

7. Switch Strategy
Antegrade Paradigm

- 48 year old man with hypertension, hyperlipidemia, known coronary artery disease
  - 3 months prior to admission presented to outside hospital with acute chest pain, STEMI, and underwent thrombus aspiration and PCI to RCA
  - LAD CTO intervention attempted but abandoned due to vessel perforation
  - Continued to have exertional chest pain, so he was referred to Columbia for second opinion
Dual Injection
Antegrad – Crossing the lesion

- Corsair
- Attempted wires: Asahi Gaia 1, 2, 3
- Confianza Pro 12 used to pierce
- Gaia 2 used to cross lesion
Confienza
Corsair Tip In
Aligning
Crossing
In Distal Vessel
LAD lesion prep

- Gaia exchanged for BMW wire
- Corsair removed with trapping balloon
- Mid-LAD dilated with NC 2.5 and 3.0 x 8mm balloons
Typical Retrograde Wire Sequence

- 78 year old man with hypertension, prior tobacco use, prostate cancer, carotid stenosis and coronary artery disease
  - 1987: Cardiac catheterization via brachial approach in with PTCA to unknown vessel complicated by endocarditis
  - 2014: Presented with one month of worsening exertional chest pain to outside hospital
  - Echocardiogram: normal systolic function, no wall motion or valvular abnormalities
  - Coronary angiogram: complex multi-vessel disease including chronic total occlusion of the PDA for which he was transferred to Columbia-Presbyterian
Initial dual injection

8F bright-tip sheaths
8F JR4
5F diagnostic JL4
Left coronary intervention

- 7F FL 4.0 Guide for antegrade left coronary intervention
- BMW, Prowater wires
- Angiosculpt 3 x 10mm in left main 18atm
- NC 3 x 12mm balloon in mid LAD
Left coronary intervention

- Premier 3 x 12mm stent in LAD
- Premier 4 x 8mm stent in LM
- NC 4.5 x 8mm in LM stent post-dilation
- IVUS
- NC 4 x 8mm post-dilate
Retrograde RCA CTO Intervention

- 150cm Corsair
- Prowater used to access septal collaterals
- Sion wire for collateral surfing, successfully accessed RPDA
Setup for reverse CART

- Miracle 6 in corsair antegrade
- Pilot 200 retrograde
Retrograde RCA CTO Intervention

- 2.5 x 30 balloon in distal RCA
- 8F Guideliner entered with Confienza Pro 12 and exchanged for Viper wire
RCA stents

- Resolute 2.5 x 30mm stent in distal RCA
- Resolute 3 x 38mm stent in mid RCA
- Resolute 3.5 x 22mm stent in proximal RCA
Final pictures
Antegrade Dissection Reentry
### J-CTO Score Sheet

<table>
<thead>
<tr>
<th>Category of difficulty (total point)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>□ easy (0)</td>
<td>□ Intermediate (1)</td>
</tr>
<tr>
<td>□ difficult (2)</td>
<td>□ very difficult (≥3)</td>
</tr>
</tbody>
</table>

#### Tapered vs. Blunt Entry
- **Tapered**: Entry with any tapered tip or dimple indicating direction of true lumen is categorized as “tapered.”
- **Blunt**: Does not have a tapered tip.

#### Calcification
- Regardless of severity, 1 point is assigned if any evident calcification is detected within the CTO segment.

#### Bending >45°
- One point is assigned if bending > 45 degrees is detected within the CTO segment. Any tortuosity separated from the CTO segment is excluded from this assessment.

#### Occlusion length
- Using good collateral images, try to measure “true” distance of occlusion, which tends to be shorter than the first impression.

#### Re-try lesion
- Is this Re-try (2nd attempt) lesion? (previously attempted but failed)
- □ No (0)  □ Yes (1)

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**Reference:**
Morino Y et al. JACC Interv, 2011;4: 213-221
### Predicting Success: The J-CTO Score

<table>
<thead>
<tr>
<th>J-CTO Score</th>
<th>Final GW success, %</th>
<th>Risk groups</th>
<th>Patient number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>97.8</td>
<td>Easy</td>
<td>494</td>
</tr>
<tr>
<td>1</td>
<td>92.3</td>
<td>Intermediate</td>
<td>91</td>
</tr>
<tr>
<td>2</td>
<td>88.4</td>
<td>Difficult</td>
<td>130</td>
</tr>
<tr>
<td>&gt;=3</td>
<td>73.3</td>
<td>Very difficult</td>
<td>138</td>
</tr>
</tbody>
</table>

Morino Y et al. JACC Interv, 2011;4:213-221
Successful Hybrid Strategies

- 51% Antegrade DR
- 26% Antegrade Wiring
- 18% Retrograde DR
- 5% Retrograde Wiring

Total = 137
Revascularization for CTO
Conclusions

- CTOs negatively impact our patients quality of life as well as prognosis
- Patients with symptoms, multivessel CAD, and moderate to large CTO-mediated ischemic burden derive clinical benefit
- We under treat these patients
- Great opportunity exists to benefit public health by expanding CTO revascularization