CTO Data Review 2017:
When to attempt a CTO & when to walk away??

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Director Cardiac Catheterization Laboratories
Banner University Medical Center Phoenix AZ
What this talk is not about?

• Discussing another meta-analysis of successful versus unsuccessful CTO PCI
  – Life expectancy benefit
  – Symptom improvement
  – LV function recovery
  – “Double jeopardy” benefit in STEMI patients
  – Arrhythmia protection

• Discuss another self reported, non audited registry about how success rates have improved and complications rates are lower than ever
• Discuss another scoring system for CTO-s
• Show some really cool angiograms with pre and post pics-to show off
What this talk is about?

- Discuss contemporary indications of CTO PCI in the context of the recently presented negative RCT’s
- Discuss management of CTO in the context of complete revascularization of CAD in both the stable and ACS settings
- Practical real life case examples
- Primum non nocere- Clear guidelines on when to NOT attempt a CTO and walk away
Example 1 - CTO Revascularization in the context of LV dysfunction

- 63 year old female with troponin positive ACS
- 2V CAD - CX 70% and LAD 100%. PCI to CX performed
- Presents to community hospital in Phoenix
Example 1- CTO Revascularization in context of LV dysfunction
Example 1- CTO Revascularization in context of LV dysfunction

What additional information would be helpful in the decision making for this patient

- MRI
- Dobutamine Echo
- MPI
- PET
- Nothing

MRI with Gadolinium
Recovery of Left Ventricular Function in Coronary Chronic Total Occlusion


University Heart Center Freiburg · Bad Krozingen
Bad Krozingen / Germany
Primary Endpoint:
Segmental wall thickening (SWT) measured by cMRI after 6 months

Baseline

6 months

Study endpoints

• Primary endpoint:
  – Change in segmental wall thickening (SWT) in the CTO territory according to the 17-segment model between baseline and follow-up at 6 months

• Secondary endpoints:
  – Changes in LV end-diastolic and end-systolic volume indices and left ventricular ejection fraction (LVEF)

• Clinical outcomes:
  – MACE at 12 months was defined as all-cause death, myocardial infarction and any clinically driven repeat revascularization.
Patient selection-

Major inclusion criteria

• CTO with an estimated reference vessel diameter of 2.5-4.0mm.
• Clinical symptoms or positive functional study for ischemia

Exclusion criteria

• Left ventricular ejection fraction < 25%
• Acute coronary syndrome < 72 hours preceding the index procedure
• Contraindications to cMRI
Baseline demographic and angiographic characteristics

<table>
<thead>
<tr>
<th></th>
<th>no-CTO-PCI (n = 104)</th>
<th>CTO-PCI (n = 101)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>68 [61 - 74]</td>
<td>65 [57 - 72]</td>
<td>0.02</td>
</tr>
<tr>
<td>Male gender</td>
<td>90 (86.5)</td>
<td>91 (90.1)</td>
<td>0.43</td>
</tr>
<tr>
<td>Diabetes</td>
<td>31 (29.8)</td>
<td>32 (31.6)</td>
<td>0.77</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>59.6 [45.8 - 64.3]</td>
<td>47 [42.9 - 65.1]</td>
<td>0.48</td>
</tr>
<tr>
<td>Previous PCI</td>
<td>33 (31.7)</td>
<td>28 (27.7)</td>
<td>0.53</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>38 (36.5)</td>
<td>39 (38.6)</td>
<td>0.76</td>
</tr>
<tr>
<td>Previous bypass operation</td>
<td>14 (13.5)</td>
<td>12 (11.9)</td>
<td>0.73</td>
</tr>
</tbody>
</table>
## Angiographic characteristics

<table>
<thead>
<tr>
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<th>no-CTO-PCI (n = 104)</th>
<th>CTO-PCI (n = 101)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary artery disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-vessel disease</td>
<td>10 (9.6)</td>
<td>14 (13.9)</td>
<td>0.55</td>
</tr>
<tr>
<td>2,3-vessel disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYNTAX-Score</td>
<td>16 [11 - 21]</td>
<td>14 [9 - 22]</td>
<td>0.33</td>
</tr>
<tr>
<td>Residual SYNTAX-Score</td>
<td>11 [8 - 16]</td>
<td>2 [0 - 7]</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>J-CTO Score</td>
<td>2 [1 - 2]</td>
<td>2 [1 – 3]</td>
<td>0.43</td>
</tr>
<tr>
<td>PROGRESS Score</td>
<td>0 [0 – 1]</td>
<td>1 [0 – 1]</td>
<td>&lt;0.01</td>
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</tbody>
</table>
Primary Endpoint -

Change in Segmental Wall Thickening (%)

All CTO segments

OMT ± no-CTO PCI
OMT + CTO PCI

p = 0.57

Segmental Wall Thickening (%)

baseline 6M FU baseline 6M FU

OMT ± no-CTO PCI
OMT + CTO PCI

p = 0.57

All CTO segments
Major adverse cardiac events at 12 months (death, infarction, any revascularization)
Conclusion

• In the entire cohort, CTO-PCI did not improve regional or global left ventricular function over no-CTO PCI.

• In the entire cohort, CTO-PCI resulted in clinical benefit over no CTO-PCI as evidenced by reduced MACE rates at 12 months.
Long Term LV Function Improvement with CTO-PCI
Most Significant Improvement with <25% Infarction

- Improvements in LV volume maintained at 3 years
- Degree of transmurality of scar by MRI

Kirschbaum SW et al. American Journal of Cardiology 2008
Medical Therapy May Not be Enough

Higher Ischemic Burden Correlated to Mortality

Shaw et al, Circulation 2008;117

<table>
<thead>
<tr>
<th>Ischemic Burden</th>
<th>Death or MI Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% (n=23)</td>
<td>0.0%</td>
</tr>
<tr>
<td>1%-4.9% (n=141)</td>
<td>15.6%</td>
</tr>
<tr>
<td>5%-9.9% (n=88)</td>
<td>22.3%</td>
</tr>
<tr>
<td>≥10% (n=62)</td>
<td>39.3%</td>
</tr>
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</table>

p=0.063
p=0.023
p=0.002
Impact of Residual Syntax Score-Clinical Outcomes after Incomplete Revascularization- Fuwai Experience, Beijing

Ying Song, Zhan Gao, Xiafao Tang et al. doi.10.4244 EIJ/D-17-00132
Conclusions from Example 1

• LV function improvement is not absolute but is more likely in <25% “hyperenhanced LV” on c-MRI
• r-Syntax score <8% is clearly correlated to superior 1 year MACE rates
• Attempts to achieve r-SS of 0-8 should be the goal of every PCI-CTO PCI included
Example 2 - CTO in the context of prior CABG

- 63 year old female with CCS class 3 angina
- Inspite of being on GDMT- Nitrates; Ranolazine; Beta blocker
- Prior CABG
- MPI with 18% of LV mass ischemic
- Has been treated medically and told that nothing can be done for her or needs to be done based on “new” data
- Turned down by CTS for poor distal targets and co-morbidities
Example 2 - CTO in the context of prior CABG/surgical turndown
Example 2- CTO in the context of prior CABG/surgical turndown
The myocardium supplied by a chronic total occlusion is a persistently ischemic zone with comparable benefit of revascularization as non CTO.
Ischemia in “Adequately Collateralized” CTOs
No CTOs are Adequately Collateralized

**FFR in 59 pts after successful wire crossing of a CTO**

DECISION CTO Trial-Application in Example 2

- **DESIGN:** a prospective, open-label, randomized trial
- **OBJECTIVE:** To compare the outcomes of OMT alone with PCI coupled with OMT in patients with CTO.
- **PRINCIPAL INVESTIGATOR**
  Seung-Jung Park, MD, PhD,
  Asan Medical Center, Seoul, Korea
Major Exclusion Criteria

- CTO located in
  - Distal coronary artery
  - 3 different vessel CTOs in any location
  - 2 proximal CTOs in separate coronary artery
  - Left main segment
  - In-stent restenosis
  - Graft vessel
- LVEF < 30%
- Severe comorbidity
Original Power Calculation

Non-inferiority Design for Primary Endpoint

- Assumed primary event rate: 17% at 3 years
- A noninferiority margin: event rate ratio 0.7
- A one-sided type I error rate: 0.025
- Power: 80%
- Dropout rate: 5%
- Assumed sample size: 1,284 patients
# Reasons for Crossover

## OMT to PCI (N=77)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Number of Patients</th>
</tr>
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<tbody>
<tr>
<td>Doctors’ preference (PI feels PCI is beneficial for patient)</td>
<td>25</td>
</tr>
<tr>
<td>For symptom control</td>
<td>5</td>
</tr>
<tr>
<td>Decreased LV systolic function</td>
<td>10</td>
</tr>
<tr>
<td>Positive noninvasive stress test</td>
<td>12</td>
</tr>
<tr>
<td>Multiple risk factors</td>
<td>1</td>
</tr>
<tr>
<td>For improvement of vital status</td>
<td>1</td>
</tr>
<tr>
<td>Patients’ preference (patient strongly wants PCI)</td>
<td>24</td>
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</table>

## PCI to OMT (N=65)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Number of Patients</th>
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<tbody>
<tr>
<td>Failed PCI</td>
<td>36</td>
</tr>
<tr>
<td>Doctors’ preference (PI feels OMT is beneficial for patient)</td>
<td></td>
</tr>
<tr>
<td>Controlled or improved symptom</td>
<td>12</td>
</tr>
<tr>
<td>Negative noninvasive stress test</td>
<td>3</td>
</tr>
<tr>
<td>High probability of failure</td>
<td>2</td>
</tr>
<tr>
<td>High risk of procedure</td>
<td>2</td>
</tr>
<tr>
<td>Patients’ preference</td>
<td>10</td>
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</table>
Primary End Point
(Death, MI, Stroke, Any Repeat Revascularization)

Crude HR 0.95 (95% CI, 0.74-1.22), P=0.67
Adjusted HR 0.91 (95% CI, 0.68-1.23), P=0.54

No. at Risk
OMT  398  305  246  178  129  72
PCI  417  293  241  175  117  65
Conclusions from Example 2

• Data from RCT should not be blindly followed without careful audit of your patient and the applicability of the data to your patient.

• Example 2 even maps as appropriate in the AUC for PCI for CTO.
Example 3- CTO in native and failing vein grafts

- 70 yr female with angina CCS class 2-3
- MPI with inferior wall ischemia 8% of LV mass
- LIMA and OM graft patent
- CABG 3 years ago
Example 3 - CTO in native and failing vein grafts
Long-term Patency of Vein Graft vs PCI

Fig 1. Rates of vein graft failure with 1-year angiography and restenosis and stent thrombosis rates in drug-eluting stents (7–12, 66).
Illustration: One Year Patency with Surgical Approach using a SVG

100 Patients with a CTO

Syntax CTO substudy\(^1\)

68% Bypassed

Bypass to CTO

PRAGUE 4\(^2\)

23% Vein Grafts Patent

1 Yr Success

16% patent grafted vessel in 1 yr

2. Widimsky Circ 2004;110:3418-23
Illustration: One Year Patency with PCI Approach

100 Patients with a CTO

PROGRESS CTO Registry\(^1\)  
90% primary Success

Successful CTO-PCI

ACROSS/TOSCA \(^2\)  
11% 1 yr Target Vessel Failure Rate

Durability

79% patent vessel at 1 yr

1. Brilakis 2015 NY CTO Summit
Reasons for Incomplete Revascularization
SYNTAX CTO Subset

CABG

Reasons not bypassed:

• Not intended to treat (n=12)
• Diseased vessel (n=11)
• Inadequate conduit (n=2)
• Insignificant vessel (n=19)
• Unable to find vessel (n=1)
• Not specified (n=36)

60% of unattempted/unsuccessful PCI due to CTO

Why?

PCI

Reasons not attempted:

• Total occlusion (n=9)
• Insignificant vessel (n=2)
• Not specified (n=6)

Reasons unsuccessful:

• Total occlusion (n=72)
• Unable to dilate lesion (n=18)
• Insignificant vessel (n=11)
• Vessel <1.5mm (n=4)
• Vessel leading to infarct area (n=5)
• Not specified (n=9)
Lessons from Example 3

- Use the failing graft as a retrograde conduit and open the native vessel
- Never stent a graft across the distal anastomosis - opening the native becomes challenging
- TLR rates for vein graft intervention at 1 year are 15% and complications are 1.5% in the NCDR dataset (higher than CTO PCI)
Example 4- CTO in non culprit in setting of STEMI
Background STEMI + MVD CTO

- Chronic total occlusion in 10% of STEMI patients
- Excess mortality in MVD mainly driven by CTO
- Reduced LVF in MVD mainly driven by presence of CTO

Van der Schaaf et al, *Heart*, 2006
Claessen et al. *JACC: Cardiovascular Interventions*, 2009
EXPLORE Trial design

• Design
  Global, multi-center, randomized, trial
  Blinded evaluation of endpoints

• Objective
  To determine whether PCI of the CTO results in a higher LVEF and a lower LVEDV assessed by CMR at 4 months
Primary endpoints

Henriques et al. JACC 2016
Clinical Impact-Timing of CTO PCI

- CTO PCI was performed after 5±2 days (post-STEMI)
- Inflammatory and pro-thrombotic setting > larger infarct sizes and adverse LV remodeling
- Success rate 73%
Explore- Demystified

• EXPLORE: the first RCT in the field of CTO

• Routine **early** CTO PCI in STEMI patients seems to hold little benefit over conservative treatment

• CTO PCI: A good therapy for residual angina and ischemia and not necessary in all patients
Example 5-What about in Pauls favorite clinical situation?
The RCA CTO with minimal symptoms

- 36 yr old female with 2 V CAD and a 40 year old male
- LAD PCI done for female and CX/OM PCI done for male
- Now with residual ischemia on MPI in the inferior wall
- No symptoms and on appropriate secondary prevention
Example 5-What about in Pauls favorite clinical situation?-The RCA CTO with minimal symptoms
Example 6 - What about in Paul's favorite clinical situation? - The RCA CTO with minimal symptoms.
Rigor Used in OPEN CTO

- Auditing through NCDR
- Truly consecutive, unselected, fully reported
- Angiographic core lab analysis
- Unbiased QCA
- Centralized call center follow up (96%)
- CEC adjudication
- Broad spectrum of operators using a single methodological approach
Health Status Trajectory After CTO PCI

Angina Frequency

- Success (N=862)
- Failure (N=138)

* p<0.05 vs Success

Quality of Life

Baseline 1 Month 6 Months 1 Year
Baseline 1 Month 6 Months 1 Year

0 20 40 60 80 100

0 20 40 60 80 100

Banner University Medicine
Health Status Trajectory After CTO PCI

Physical Limitation

Success (N=862)  Failure (N=138)  * p<0.05 vs Success

Summary Score

Success (N=862)  Failure (N=138)  * p<0.05 vs Success

Health Status Trajectory After CTO PCI

Success (N=862)  Failure (N=138)  * p<0.05 vs Success

Dyspnea

Depression

*
Impact of CTO PCI on Dyspnea Symptoms

80% reported dyspnea at baseline, 70% reported improved dyspnea

<table>
<thead>
<tr>
<th>RDS=3/4</th>
<th>RDS=1/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful PCI Baseline</td>
<td>42%</td>
</tr>
<tr>
<td>Failed PCI Baseline</td>
<td>40%</td>
</tr>
<tr>
<td>Successful PCI 1 month</td>
<td>16%</td>
</tr>
<tr>
<td>Failed PCI 1 month</td>
<td>30%</td>
</tr>
</tbody>
</table>

P=0.5
P<0.001

Qintar et al. Abstract TCT 2016
Ventricular arrhythmia occurrence in SCD with ICD therapy is related to CTO

JACC Cardiovasc Interv. 2017;10:879-888
When to walk away? Please don’t do this
Summary Slide-When to walk away

- Myocardium supplied by CTO is non viable
- Patient without symptoms on no medical therapy and low ischemic burden
- Outside your comfort zone-Refer to an expert
- Occurrence of a complication-Refer to an expert operator
Thank You!