**MHIF FEATURED STUDY:**

**Rhapsody**

**CONDITION:**

Pericarditis

**PI:**

David Lin, MD

**RESEARCH CONTACT:**

Christine Majeski

Christine.Majeski@allina.com | 612-863-3546

**SPONSOR:**

Kiniksa Pharmaceuticals

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**DESCRIPTION:**

First multinational, phase 3, double-blinded, placebo-controlled, randomized withdrawal, study assessing the efficacy of rilonacept, an interleukin 1 alpha and beta receptor decoy, in the treatment of recurrent pericarditis.

**CRITERIA LIST/QUALIFICATIONS:**

- **Inclusion**
  - Diagnosis of recurrent pericarditis

- **Exclusion**
  - Pericarditis secondary to specific prohibited etiologies, including tuberculosis (TB); neoplastic, purulent, or radiation etiologies
  - Post-thoracic blunt trauma (e.g., motor vehicle accident)
  - Myocarditis
  - Systemic autoimmune diseases with exception of Still’s disease, pregnancy, hx HIV, prednisone > 60 mg/day, positive Hep B or C, serious infection

---

MHIF was first in the world to enroll in this trial and has 4 subjects enrolled out of the 9 in the world. Pericarditis patients are experiencing significant benefits and most often have no chest pain after starting this medication.
Minneapolis Heart Institute Foundation® Cardiovascular Grand Rounds

Title: Update on Chronic Total Occlusion (CTO) Percutaneous Coronary Intervention
Speaker: Emmanouil S. Brilakis, MD, PhD
  Director, Center for Complex Coronary Artery Disease
  Minneapolis Heart Institute® at Abbott Northwestern Hospital
  Adjunct Professor of Medicine
  University of Texas Southwestern Medical School
Date: April 15, 2019
Time: 7:00 – 8:00 AM
Location: ANW Education Building, Watson Room or Auditorium A

OBJECTIVES
At the completion of this activity, the participants should be able to:
1. Understand the indications for treating coronary CTOs.
2. Examine various treatment strategies for coronary CTOs.
3. Future directions in CTO interventions.

ACCREDITATION
Physician - Allina Health is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians. Allina Health designates this live activity for a maximum of 1.0 AMA PRA Category 1 Credit(s)™. Physicians should only claim credit commensurate with the extent of their participation in the activity.

Nurse - This activity has been designed to meet the Minnesota Board of Nursing continuing education requirements for 1.0 hours of credit. However, the nurse is responsible for determining whether this activity meets the requirements for acceptable continuing education.

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Moderator(s)/Speaker(s)
Dr. Emmanouil Brilakis has disclosed the following relationships: Grant/Research Support (self): Boston Scientific, Siemens, Regeneron, and Osprey; Consultant (self): Amgen, Abbott Vascular, CSI; Speaker’s Bureau (self): Abbott Vascular, ACIST, CSI, GE Healthcare, Medtronic; Royalties (self): Elsevier; Honoraria (self): American Heart Association, Cardiovascular Innovations Foundation.

Planning Committee
Dr. Alex Campbell, Jake Cohen, Jane Fox, Dr. Mario Gössl, Dr. Kevin Harris, Dr. Kasia Hryniewicz, Rebecca Lindberg, Amy McMeans, Dr. Michael Miedema, Dr. JoEllyn Moore, Pamela Morley, Dr. Scott Sharkey, and Jolene Bell Makowesky have disclosed that they DO NOT have any real or apparent conflicts with any commercial interest as it relates to the planning of this activity/course. Dr. David Hurrell has disclosed the following relationship - Boston Scientific: Chair, Clinical Events Committee.

NON-ENDORSEMENT OF COMMERCIAL PRODUCTS AND/OR SERVICES
We would like to thank the following company for exhibiting at our activity.

Novartis
Regeneron

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Each attendee at an activity is responsible for determining whether an activity meets their requirements for acceptable continuing education and should only claim those credits that he/she actually spent in the activity.

Maintaining these details are the responsibility of the individual.

PLEASE SAVE A COPY OF THIS FLIER AS YOUR CERTIFICATE OF ATTENDANCE.

Signature: __________________________________________________________________________

My signature verifies that I have attended the above stated number of hours of the CME activity.

Allina Health - Learning & Development - 2925 Chicago Ave - MR 10701 - Minneapolis MN 55407
Update in CTO PCI

Emmanouil S. Brilakis, MD, PhD

Disclosures

- Consulting/speaker honoraria: Abbott Vascular, American Heart Association (associate editor Circulation), Boston Scientific, Cardiovascular Innovations Foundation (Board of Directors), CSI, Elsevier, GE Healthcare, InraRedx, Medtronic
- Research support: Regeneron, Siemens
- Shareholder: MHI Ventures
- Board of Trustees: Society of Cardiovascular Angiography and Interventions
**CTO: occlusion in the coronary artery with TIMI 0 flow of ≥3 months duration**

![Image showing coronary artery occlusion with TIMI 0 flow.](image1)

**Dallas VAMC: CTO prevalence and revascularization**

<table>
<thead>
<tr>
<th>Category</th>
<th>Diagnostic caths 1/2011 to 12/2012:</th>
<th>Unique patients:</th>
</tr>
</thead>
<tbody>
<tr>
<td>No prior CABG; CAD</td>
<td>2,193</td>
<td>1,699</td>
</tr>
<tr>
<td>CTO, n=319, 31%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCI n=161, 50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical Rx n=61, 19%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CABG n=97, 30%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior CABG; n=344</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTO, n=305, 89%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCI n=182, 60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical Rx n=121, 40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CABG n=2, 0.6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Case 1
55-year-old diabetic. EF=26% Referred for Circ CTO PCI

Referred for circ CTO PCI
Case 2

When should CTO PCI be done?

Update in the Percutaneous Management of Coronary Chronic Total Occlusions

Abstract

Percutaneous coronary intervention (PCI) for chronic total occlusions (CTO) has been rapidly evolving during recent years, with improvements in equipment and techniques. High success rates can be achieved in experienced centers, although several unique risks remain. Percutaneous, contrast-enhanced intravascular ultrasound (IVUS) and optical coherence tomography (OCT) are critical for visualization of CTOs and selecting the optimal approach. New high-quality studies of the clinical outcomes of techniques in CTO PCI have been published, and the equipoise between experts continues to evolve. This presentation will discuss the technical advances in CTO PCI and provide an overview of the current status of the field.

Patient testimonial after CTO PCI
**Impactor CTO**

- Single center
- 94 pts
- 83% CTO PCI success

---

Anton A. Obedinskiy et al. J hypnot 2018;11:1309-1311
7 Global Principles for CTO PCI

1. Principal indication: to improve symptoms
2. Dual angiography + careful angiographic review
3. Use of microcatheter for guidewire support
4. 4 CTO crossing strategies: AWE, ADR, RWE, RDR
5. Change increases likelihood of success
6. CTO PCI should be done at experienced-well equipped centers
7. Stent deployment should be optimized

101 operators - 50 countries – Circulation 2019; in press
Effects of CTO PCI on QoL in Depressed and Non-Depressed Patients

- Following CTO PCI, depressed patients experienced ~3x the angina benefit as not depressed patients
- CTO PCI patients have 3-fold less depression at 1 month

Bruckel et al, J Invasive Cardiol 2016

Impact of CTO on outcomes post STEMI

The myocardium supplied by a chronic total occlusion is a persistently ischemic zone

Sachdeva et al. CCI 2013

50 CTOs

Proc (Bayl Univ Med Cent) 2015;28(2):196–199
Complete vs. incomplete revascularization

89,883 Patients

12,259 out of 89,883 (13%) died during follow up.

Mortality benefit in patients treated with CABG (RR 0.70; 95% CI:0.61-0.80, p<0.001) and PCI (RR 0.72, 95% CI:0.64-0.81, p<0.001.

Mortality benefit did not vary with definition of CR.

Case 3
History

- 61-year-old man with NSTEMI
- History of DM, HTN, dyslipidemia, PVD
- 3-vessel disease - turned down for CABG
- s/p LAD and Cx OM PCI (6 years prior)
- ICD implantation for secondary prevention (May, 2016)
- Echocardiography: severely depressed LV systolic function (EF: 24%), hypokinetic anterior septum, akinetic basal posterior, posterolateral and mid inferior segments
EXPLORE trial design

- **Patients**
  Patients with STEMI treated with pPCI and with a non-infarct related CTO.

- **Design**
  Global, multi-center, randomized, prospective two-arm trial with either CTO PCI or no CTO intervention after STEMI.
  Blinded evaluation of endpoints.

- **Objective**
  To determine whether PCI of the CTO within 7 days after STEMI results in a higher LVEF and a lower LVEDV assessed by MRI at 4 months


EXPLORE trial results

Revasc trial  
**Primary endpoint:**

![Graph showing change in segmental wall thickening](image1)

![Graph showing segmental wall thickening](image2)

---

**Final result**

EF improved to 45% 3 months later
Ischemic cardiomyopathy + CTO

No CTO PCI (n=71)

CTO PCI (n=71)

Clinical FU
Questionnaires
Cardiopulmonary exercise test

• Cardiac MRI
• Questionnaires
• Cardiopulmonary exercise test

Primary endpoint
Change in LV EF by cardiac MRI

142 pts

Baseline
1 m
3 m
6 m

Case 4
81-year-old woman with non-NSTEMI

Occluded SVG-RCA

Stent under-expansion despite high pressure balloon inflations
SVGs have poor long-term outcomes

Target vessel failure

Median FU: 2.7 years

Log-Rank = 0.79
p-value = 0.42
Total Events = 208
Hazard Ratio of DES Relative to BMS = 1.12
HR 95% CI = 0.85 - 1.47

* - After 12 months post-randomization, this analysis uses reported TVF events because adjudication was only done for TVF events occurring during the first 12 months post-randomization.

Brilakis et al. Lancet 2018

Native coronary PCI better than SVG PCI
2010: The “future”: treat native coronary instead of SVG?

Case Reports
Retrograde Recanalization of Native Coronary Artery Chronic Occlusions via Acutely Occluded Vein Grafts
Emmanuel S. Brilakis, MD, FACC, Satish Bhanji, MD, FACC, and William J. Lombardi, MD, FACC

Treatment of acutely occluded saphenous vein grafts may be challenging due to large intimal burden and diffuse disease. We report two cases of retrograde saphenous vein graft occlusion, in which percutaneous attempts to recanalize the saphenous vein graft failed. In both cases, the native reoccluded coronary artery lesions that occluded the retrograde pathway were native coronary artery lesions that were amenable to percutaneous revascularization once the saphenous vein graft was opened. Key words: percutaneous coronary intervention; coronary artery bypass graft; saphenous vein graft.

SVG lesion

Candidate for redo CABG?

Need for additional revascularization?

LIMA to LAD feasible?

Corresponding native coronary lesion complex?

SVG lesion complex?

Able to treat native lesion?

Consider redo CABG

Native lesion PCI

Brilakis et al. JACC 2018
Additional options = Grafts


3 weeks later
CT-angio

Antegrade wire escalation
Unable to cross through prior stent

- Hornet 14
- Pilot 200
- Gaia 2nd
- Gaia 3rd

Pilot 200 subintimal (sub-stent) followed by Corsair
Stingray wire

re-enter distal true lumen

exchanged for Pilot 200

“Stick and swap”

Pilot 200 into true lumen
**Conclusions**

- Native coronary artery PCI is preferred to SVG PCI (esp after SVG occlusion), if feasible

- Treating ISR CTOs: sub-stent crossing, re-entry, and crushing stents

- Balloon undilatable lesion: subintimal crossing can provide effective treatment

---

**“Staged SVG revascularization”**

<table>
<thead>
<tr>
<th></th>
<th>Stage 1</th>
<th>Stage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute SVG failure</td>
<td>SVG PCI</td>
<td>Native coronary PCI</td>
</tr>
</tbody>
</table>

Xenogiannis I et al. Catheter Cardiovasc Interv 2018
Case 5

History

- 70-year-old man presented to ED with acute substernal pain
- ECG: inferior STEMI
- CAD (PCI 20 years prior), DM type II, HTN, dyslipidemia
- Driven to cath lab for primary PCI
ST elevation
Change to right femoral access

Difficulty to pass external iliac due to aneurysm

Access was lost

Manual pressure over RFA, access through LFA

Hypotension
8x20 mm balloon
IV fluids, noradrenaline, adrenaline and RBC transfusion

Vascular surgeons were notified

Suddenly the patient collapsed => Cardiac arrest (VF)

CPR, Lukas device, Defib, intubation, VA-ECMO
The patient was transferred intubated, in critical condition to the ICU

Developed AKI and acute hypoxemic encephalopathy

VA-ECMO was decannulated 2 days later

Discharged after 17 days and referred to a rehabilitation center

Procedural time: 485 min
AK Radiation: 3.204 Gray
DAP Radiation dose: 24001 mGy
Contrast volume: 450 ml
Conclusions

1. Acute vessel closure can be a lethal complication
2. Indented bladder sign: retroperitoneal hematoma
3. VA-ECMO for cardiac arrest
4. ADR for acute vessel closure
5. Collaboration key to success!

Use of chronic total occlusion percutaneous coronary intervention techniques for treating acute vessel closure

Arslan Shaukat MD | Michael Mooney MD | M. Nicholas Burke MD | Emmanouil S. Brilakis MD, PhD

Abstract
Acute vessel closure due to dissection is a known complication of percutaneous coronary intervention and can be challenging to treat, especially if guidewire position is lost. Re-entering into the distal true lumen is commonly done during chronic total occlusion interventions, as part of antegrade dissection strategies. We report two cases of acute vessel closure and guidewire position loss in which the Stingray LP system was successfully used to advance a guidewire into the distal true lumen and recanalize the occluded vessel.

Keywords
complications, coronary aneurysm/dissection/perforation, coronary artery disease, PCI
Hybrid CTO crossing algorithm

Part I

1. Dual injection

Brilakis, Grantham, Rinfret, Wyman, Burke, Karmpaliotis, Lembo, Pershad, Kandzari, Buller, De Martini, Lombardi, Thompson, JACC Intv 2012
Hybrid CTO crossing algorithm

1. Ambiguous proximal cap
2. Poor distal target
3. Appropriate "interventional" collaterals

Part II

Antegrade

Lesion length <20 mm

Retrograde

Studying the CTO

1. By whom? Entire cath team
2. How long? 15-30 min
3. How? 4 characteristics

Brilakis, Grantham, Rinfret, Wyman, Burke, Karmpaliotis, Lembo, Pershad, Kandzari, Buller, De Martini, Lombardi, Thompson. JACC Intv 2012

Angiographic review: 4 key components

1. Proximal cap
2. Lesion length/Calcification/Tortuosity
3. Distal vessel
4. Collaterals
Studying the lesion

1. Proximal cap
   1. Proximal vessel tortuosity - caliber
   2. Ambiguous or clear?
   3. Tapered or blunt?
   4. Side branches?
   5. Calcification

Which proximal vessel would you rather have?

Jang Y. PCI for CTO. Springer 2019
Where is the proximal cap?
Flush RCA CTO?

courtesy Leszek Bryniarski, MD
Flush RCA CTO?

courtesy Leszek Bryniarski, MD

Where is the proximal cap?

Choi et al. JACC Interv 2015
Studying the lesion

2. Lesion length – tortuosity - composition

Lesion length

Calcification

Predictors of antegrade failure

- Length >32 mm
- Ostial or bifurcation lesions
- Negative remodeling

Remodeling

Jang Y. PCI for CTO. Springer 2019

Luo et al. JACC CV Imaging 2015
3. Distal vessel

1. Caliber and quality of distal vessel
2. Bifurcation
3. Prior bypass graft insertion sites

4. Collaterals

1. Type (septal, bypass grafts, epicardial)
2. Size (Werner classification)
3. Tortuosity
4. Dominance
5. Angle and location of entry
J-CTO Score

494 native CTO lesions Crossing within 30 minutes

Morino, Y. et al. JACC Intv 2011;4:213-221

PROGRESS CTO score

Choose the CTO lesions you attempt wisely...

Early: J-CTO 0-1

Next: J-CTO 2

Later: J-CTO ≥3
218 CTO PCIs in 205 pts
- 45% equal
- 30% higher
- 25% lower

Success: 82.6%
30-min wire crossing: 29.4%

Fujino et al. JIMG 2018;11:209-217
CCTA vs angiography J-CTO score

218 CTO PCIs in 205 pts
Success: 82.6%
30-min wire crossing: 29.4%

Fujino et al. JIMG 2018;11:209-217
CT-RECTOR Score Calculator

Predictors Definitions

Multiple Occlusion
- Presence of ≥2 complete interruptions of the contrast opacification separated by contrast-enhanced segment of ≥5 mm.
- Absence

Blunt Stump
- Presence of any transthoracic segment of any type at the entry or exit site.
- Absence

Severe Calcification
- Presence of any calcification involving ≥50% of the vessel cross-sectional area at the entry or exit site or within the stenosis.
- Absence

Bending ≥90°
- Presence of any bending ≥90° at the entry or exit site or within the stenosis.
- Absence

Second Attempt
- Presence of a failed PCI at CTO
- Absence

Duration of CTO
- Duration of CTO >12 months or unknown

Difficulty Group
- Easy (1)
- Difficult (2)
- Intermediate (3)
- Very Difficult (4)

Total Score

---

Success – Crossing within 2 minutes

- Image (A)
- Image (B)

Failure

- Image (C)
- Image (D)

Total Score
Real time CCTA fusion

• Centerlines are displayed. Coloring indicates degree of foreshortening (green=low, red=high)
• Calcification can be toggled on and off
• Individual vessel centerlines can be toggled on or off

Where is the retrograde wire?

Ghoshhajra, ...., Jaffer. European Radiology 2016
Failed re-entry
Why?

Hybrid CTO crossing algorithm

**Part III**

Brilakis, Grantham, Rin fret, Wyman, Burke, Karmpaliotis, Lembo, Pershad, Kandzari, Buller, De Martini, Lombardi, Thompson. JACC Intv 2012

Ghoshhajra, ... Jaffer. European Radiology 2016
All crossing strategies have a role

PROspective Global REgiStry for the Study of CTO interventions
www.progresscto.org

Successful crossing strategy stratified by J-CTO score

<table>
<thead>
<tr>
<th>J-CTO Score</th>
<th>Retrograde</th>
<th>ADR</th>
<th>AWE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>88.3%</td>
<td>71.6%</td>
<td>17.3%</td>
</tr>
<tr>
<td>1</td>
<td>9.0%</td>
<td>14.7%</td>
<td>4.7%</td>
</tr>
<tr>
<td>2</td>
<td>19.7%</td>
<td>50.6%</td>
<td>24.1%</td>
</tr>
<tr>
<td>3</td>
<td>35.3%</td>
<td>31.9%</td>
<td>41.5%</td>
</tr>
<tr>
<td>4</td>
<td>43.6%</td>
<td>20.2%</td>
<td>43.6%</td>
</tr>
<tr>
<td>5</td>
<td>16.9%</td>
<td>16.9%</td>
<td>16.9%</td>
</tr>
</tbody>
</table>

p<0.0001
**PROspective Global REgiStry for the Study of CTO interventions**

www.progresscto.org

**Procedural complications**

- **AWE**
- **ADR**
- **Retrograde**

<table>
<thead>
<tr>
<th>Category</th>
<th>AWE</th>
<th>ADR</th>
<th>Retrograde</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACE overall</td>
<td>1.09%</td>
<td>2.96%</td>
<td>5.61%</td>
</tr>
<tr>
<td>Death</td>
<td>0.36%</td>
<td>0.87%</td>
<td>1.50%</td>
</tr>
<tr>
<td>Acute MI</td>
<td>0.00%</td>
<td>1.22%</td>
<td>2.46%</td>
</tr>
<tr>
<td>Stroke</td>
<td>0.14%</td>
<td>0.35%</td>
<td>0.55%</td>
</tr>
<tr>
<td>Re-PCI</td>
<td>0.14%</td>
<td>0.52%</td>
<td>0.68%</td>
</tr>
<tr>
<td>Emergency CABG</td>
<td>0.14%</td>
<td>0.00%</td>
<td>0.14%</td>
</tr>
<tr>
<td>Pericardial tamponade</td>
<td>0.43%</td>
<td>0.87%</td>
<td>0.96%</td>
</tr>
<tr>
<td>Perforation</td>
<td>1.16%</td>
<td>5.22%</td>
<td>7.52%</td>
</tr>
</tbody>
</table>

- **p<0.0001**
- **p=0.0171**
- **p<0.0001**
- **p=0.2629**
- **p=0.1228**
- **p=0.6637**
- **p=0.2999**

**Hybrid CTO crossing algorithm**

**Part IV**

Switch Strategy

*Brilakis, Grantham, Rinfret, Wyman, Burke, Karmpaliotis, Lembo, Pershad, Kandzari, Buller, De Martini, Lombardi, Thompson, JACC Intv 2012*
7 Global Principles for CTO PCI

1. Principal indication: to improve symptoms
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5. Change increases likelihood of success
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7. Stent deployment should be optimized

101 operators - 50 countries – Circulation 2019; in press

STATE-OF-THE-ART REVIEW

A New Algorithm for Crossing Chronic Total Occlusions From the Asia Pacific Chronic Total Occlusion Club

Scott A. Harding, MD; Eugene R. Wu, MD; Sidney Lo, MBBCh; Sue Tze Lim, MD; Lei Ge, MD; Yi-Xian Chen, MD; Je Quan, MD; Seung Whan Lee, MD, PhD; Hiroshi Ise, MD; Daiso Tsuchikane, MD, PhD

ABSTRACT

Although the hybrid chronic total occlusion (CTO) algorithm has had many excellent recommendations, there has been infrequent adoption in the Asia Pacific region. The Asia Pacific CTO club proposes an algorithm for case selection based on the Japan CTO score and a new CTO algorithm, which is applicable globally. This algorithm allows for differing skill sets and equipment availability and contains practical teaching for CTO percutaneous coronary intervention. Similar to the hybrid algorithm there are 3 main questions that determine whether the primary approach is antegrade or retrograde. It is then proceed with angiography. It is the distal vessel of poor quality, and it is the retrograde technique present. In contrast to the hybrid algorithm occlusive lesion length alone does not determine the choice of either a wire inflation strategy or a re-entry strategy. Rather a combination of factors including angiography of the vessel, course, tortuosity, length, and previous failure are used to determine this. The role of intravascular ultrasound-guided entry to overcome proximal cap ambiguity and the Coronary catheter in occlusive in-stent restenosis are highlighted in the algorithm. Both the parallel wire technique and dissection re-entry with the Stenograph system have been included as options when the initial antegrade wire passage fails. Intravascular ultrasound-guided wire along with limited substent wire. The algorithm is the proof of concept algorithm. It is hoped that this algorithm will serve as the basis for future CTO percutaneous coronary intervention and training.

Scott A. Harding et al. JCNN 2017;10:2135-2143
Euro CTO algorithm

Consider CTO PCI failure in the following conditions, unless the procedure is well advanced:
- Procedural time > 3 hours
- Contrast load > 6 x eGFR (ml)
- AK Herma > 5 Gy

CTO PCI: the world is converging
7 Global Principles for CTO PCI

1. Principal indication: to improve symptoms
2. Dual angiography + careful angiographic review
3. Use of microcatheter for guidewire support
4. 4 CTO crossing strategies: AWE, ADR, RWE, RDR
5. Change increases likelihood of success
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7. Stent deployment should be optimized

101 operators - 50 countries – Circulation 2019; in press

Expand the stent!

Malapposition

Underexpansion

### Stent patency rates in CTO PCI

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Stent</th>
<th>n</th>
<th>FU angio time</th>
<th>Prior CABG</th>
<th>Total stent length (mm)</th>
<th>In-stent restenosis (%)</th>
<th>In-segment restenosis (%)</th>
<th>TLR (%)</th>
<th>TVR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRISON II</td>
<td>2006</td>
<td>SES</td>
<td>100</td>
<td>6 months</td>
<td>3</td>
<td>32±15</td>
<td>7</td>
<td>11</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>ACROSS-TOSCA 4</td>
<td>2009</td>
<td>SES</td>
<td>200</td>
<td>6 months</td>
<td>8.5</td>
<td>45.9 (30.2, 62.1)</td>
<td>9.5</td>
<td>12.4</td>
<td>9.8</td>
<td>11.4</td>
</tr>
<tr>
<td>GISSOC II</td>
<td>2010</td>
<td>SES</td>
<td>78</td>
<td>8 months</td>
<td>6.7</td>
<td>41+18</td>
<td>8.2</td>
<td>9.8</td>
<td>8.1</td>
<td>14.9</td>
</tr>
<tr>
<td>CIBELES</td>
<td>2012</td>
<td>SES</td>
<td>101</td>
<td>9 months</td>
<td>4</td>
<td>47±24</td>
<td>10.5</td>
<td>11.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACE-CTO</td>
<td>2012</td>
<td>EES</td>
<td>106</td>
<td>9 months</td>
<td>4.7</td>
<td>50±23</td>
<td>9.1</td>
<td>7.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### IVUS-CTO: Primary endpoint (Cardiac death, MI, TVR)

- **Angiography-guided group**
  - 12-month cumulative incidence (%): 2.6% (5)
- **IVUS-guided group**
  - 12-month cumulative incidence (%): 7.1% (14)

**HR=0.35, 95% CI = 0.13 – 0.97, p = 0.035**

---

*Kim et al. Circ Cardiovasc Interv. 2015;8:e002592*
## CTO PCI: success and complications

<table>
<thead>
<tr>
<th>First Author</th>
<th>Study Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Konstantinidis</td>
<td>2008-2015</td>
</tr>
<tr>
<td>Habara</td>
<td>2012-2013</td>
</tr>
<tr>
<td>Tajti</td>
<td>2012-2017</td>
</tr>
<tr>
<td>Wilson</td>
<td>2012-2014</td>
</tr>
<tr>
<td>Maeremans</td>
<td>2014-2015</td>
</tr>
<tr>
<td>Sapontis</td>
<td>2013-2017</td>
</tr>
<tr>
<td></td>
<td>Centers Cases</td>
</tr>
<tr>
<td>Konstantinidis</td>
<td>53 17,626</td>
</tr>
<tr>
<td>Habara</td>
<td>56 3,229</td>
</tr>
<tr>
<td>Tajti</td>
<td>20 3,055</td>
</tr>
<tr>
<td>Wilson</td>
<td>7 1,156</td>
</tr>
<tr>
<td>Maeremans</td>
<td>17 1,253</td>
</tr>
<tr>
<td>Sapontis</td>
<td>12 1,000</td>
</tr>
</tbody>
</table>

Success: 12 of 12
Complications: none
CTO PCI in NCDR

594,510 procedures
22,365 CTO PCI
2009-2013

% of total PCI  Procedural success  MACE

Brilakis, Banerjee, Karmpalisiotis, Lombardi, Tsai, Shunk, Kennedy, Sportus, Holmes, Grantham.
J Am Coll Cardiol Intv 2015;8:245–53

CTO PCI in England/Wales

Kinnaird et al. Circulation Intervention 2018
The present

Success

Less Experienced Center

Experienced Center

Technology

Education

The future

Ideal

Center

Crossing Techniques

Antegrade

Antegrade + Retrograde

Contrast, radiation, procedure time

Efficiency

Comparison

Contrast, radiation, procedure time

Contrast, radiation, procedure time

Contrast, radiation, procedure time

Contrast, radiation, procedure time

1. Training

The Four Stages of Learning CTO PCI

STAGE 1

STAGE 2

STAGE 3

STAGE 4

Lesion complexity/success rates

Techniques

Antegrade wire escalation

Antegrade dissection/re-entry

Antegrade dissection/re-entry

Antegrade wire escalation

Antegrade wire escalation

Antegrade dissection/re-entry

Antegrade wire escalation

Antegrade dissection/re-entry

Antegrade dissection/re-entry

Antegrade only

Antegrade and Retrograde

Retrograde via epicardial collaterals

Retrograde via septal collaterals and bypass grafts

Retrograde via septal collaterals and bypass grafts

Retrograde via septal collaterals and bypass grafts

Catheterization and Cardiovascular Interventions 89:656-657 (2017)
Naive practice

Purposeful practice
1. Goals
2. Challenge
3. Focused
4. Monitor progress
5. Motivated

Deliberate practice
Purposeful +
1. Well established field
2. Teacher

Mental representations

Approach to “balloon uncrossable” CTO

“Balloon Uncrossable” CTO
- Inflate 1.20-1.5 mm balloon, Threader, Glider
- Rupture balloon in vessel (granalplasty)

Tornus, Corsair, Finecross
- Wire “cutting”

Guide catheter extensions
- Anchor balloon strategies

Laser
- Rotational atherectomy

Subintimal: external “crush” - retrograde
- Subintimal: distal anchor
How to learn CTO PCI

1. Books
2. Journals
3. Online
4. Courses
5. Proctoring
6. Doing
7. Community
8. Participating in studies
9. Keep track of outcomes
10. Publish
only 8 operators performed 50 or more CTO PCI per year.

Brilakis, Banerjee, Karmpaliotis, Lombardi, Tsai, Shunk, Kennedy, Sportus, Holmes, Grantham.

J Am Coll Cardiol Intv 2015;8:245–53
2. Technology

1. Sheaths
2. Guides
3. Microcatheters
4. Guidewires
5. Dissection/re-entry
6. Snares
7. “Balloon Uncrossable” equipment
8. Intravascular Imaging - physiology
9. Complication management
10. Radiation protection
11. Balloons and Stents

A. “Big”
- Mamba
- Teleport Control
- M-Cath

B. “Small”
- Mamba Flex
- Teleport

C. Angulated
- Sasuke
- NHancer Rx
- NHancer Pro X
- ReCross
- SuperCross
- FineDuo
- Crusade
- Twin-Pass Torque
- Tornus

D. Dual lumen
- Turnpike
- Turnpike LP
- FineCross
- Venture
- Twin-Pass Torque
- Turnpike Gold

E. Plaque modification
- Nhancer Pro X
- MicroCross 14

Guidewires

1. Workhorse
   1. Composite core
      • Sion
      • Sion blue
      • Suoh 03
   2. Dual coil
      • Samurai RC
   3. Other
      • Runthrough
      • BMW
      • ?????

2. Polymer jacketed
   1. Fielder FC, XT, XT-A, XT-R
   2. Fighter
   3. Sion black
   4. Whisper
   5. Pilot 50
   6. Pilot 200
   7. PT2
   8. Gladius, Mongo
   9. Bandit, Raider

3. Stiff
   1. Gaia
   2. Confianza Pro 12
   3. Hornet 14

4. Support
   1. Grand Slam
   2. Ironman
   3. Mailman

5. Other
   1. Wiggle
   2. Suoh 03
   3. Externalization wires
   4. Rotafloppy - Viper

Upcoming techniques/devices

Guidance

Penetration

Soundbite system
E-CART (ElectroCautery-Assisted Re-enTry) of an Aorto-Ostial Right Coronary Artery Chronic Total Occlusion

First-in-Man

William Nicholson, MD,⁎ James Harvey, MD, MSc,⁎† Rajiv Dhawan, MD

Distal crossing tip of the guidewire was energized in cutting mode at 50 W for a 1-s burst, with immediate unimpeded crossing into the lumen of the aorta.


Coronary calcification
**Orbital Atherectomy**

**Mechanism of Action**

**Differential Sanding:**
- 30 micron diamond coating
- Bi-directional sanding, eccentric mounted crown
- Healthy elastic tissue flexes away minimizing damage to the vessel

**Centrifugal Force:**
- 360° crown contact designed to create a smooth, concentric lumen
- Allows constant blood flow and particulate flushing during orbit
- Increasing speed increases orbital diameter
- Ability to treat multiple vessel diameters with one crown
- Treat large vessels through 6 French

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**ECLIPSE trial**

**Evaluation of Treatment Strategies for Severe Calcium Coronary Arteries: Orbital Atherectomy vs. Conventional Angioplasty Prior to Implantation of Drug Eluting Stents**

- ~2000 pts with severely calcified lesions; ~60 US sites
- Randomize 1:1
- **Orbital Atherectomy Strategy**
  - 2nd generation DES implantation and optimization
  - 1st endpoints: 1) Post-PCI in-stent MSA by OCT (N~400 in imaging study) 2) 1-year TVF (all patients)
- **Conventional Angioplasty Strategy**
  - 2nd generation DES implantation and optimization

**Primary Endpoints**

**Imaging** - In-stent minimal cross-sectional area as assessed at the conclusion of the procedure in the imaging cohort.

**Clinical** - 1-year TVF (defined as the composite of cardiac death, target vessel related myocardial infarction, or clinically driven target vessel revascularization).
Coronary Lithoplasty: A Novel Treatment for CAC

• Based on 30 years of Lithotripsy technology
• Constant, ultra-low pressure
• Sonic pressure waves emitted
  ▪ Circumferential, unfocused
  ▪ 1 pulse/second
  ▪ Pulse exceeds 50 atm
• Sonic pressure waves crack calcium

How can you reduce radiation dose?

1. INTENSITY
2. TIME
3. DISTANCE
4. SHIELDING
Impact of X-ray machine

Anthropomorphic phantom

Martinez-Parachini R et al. ACC 2017

ControlRad System

• 75% dose reduction to medical staff
• No impact to workflow or image quality

Med. Phys. 43 (3), March 2016
ControlRad Eye-Tracker moves Region-of-Interest (ROI) in Real-Time

ControlRad is an integrated system that optimizes the X-ray beam to deliver the highest image quality inside the ROI while maintaining appropriate resolution in the periphery.

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Hiking and CTO PCI: Lessons Learned

1. Always Be Prepared

Our final day in the United States, we hiked two waterfalls. We rented a couple boats and hiked, but the dust of these was not our favorite, so we lifted the boats. We bought a boat to do a very easy hike to a very small lake, with a boat and a small boat, off a mountain. We drove to the waterfall, where we took several shots. The next day, we were on the edge of a hill, with a little bit of a hill on the left and a little bit of a hill on the right. This led me to make comparisons between Hiking and CTO PCI in the lab.
Many unanswered questions....

Patient questions
1. How will I feel afterwards?
2. Will I live longer?
3. What is the likelihood of success?
4. What is the likelihood of complications?
5. Will I die during the procedure?

MD questions
1. What strategy is most likely to be successful?
2. Which strategy should be avoided?
3. How long should I try a strategy before switching?
4. When should I stop?
5. Which is the best way to learn CTO PCI?

Payor/hospital questions
1. What is the cost-effectiveness of CTO PCI?
2. Which centers should be performing CTO PCI?
3. Have CTO PCI outcomes been improving over time?

Conclusions

CTO PCI

- CTO PCI: revascularization tool
- RCTs: important limitations
- Good results at experienced centers
- Poor results overall
- Key indication: Symptom Improvement
- Risk/benefit ratio key for pursuing CTO PCI
- Global consensus reached
- Need for more specialized experts and dedicated operators

www.progresscto.org
www.ctomanual.org