Expert Review on CTO PCI

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Cardiology Division
"Easy" CTO vs. "Tough" CTO

"Easy" CTO
1) Straight vessel
2) Stump without side branch
3) Short lesion
4) Convex type

"Tough" CTO
1) Tortuous vessel
2) No stump with side branch
3) Long lesion
4) Tapered type
5) Small side branch where IVUS cannot be inserted
# Usual guiding catheters in PCI of CTO

<table>
<thead>
<tr>
<th>_SEGMENT</th>
<th>CATHETER SIZE</th>
<th>MANUFACTURER</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAD</td>
<td>EBU (Medtronic)</td>
<td>XB, XBLAD (Cordis)</td>
</tr>
<tr>
<td>LCX</td>
<td>AL 1.0, 1.5</td>
<td>EBU 3.5, EBU 4.0 (Medtronic)</td>
</tr>
<tr>
<td>RCA</td>
<td>AL 0.75, 1.0</td>
<td>RBU (Medtronic)</td>
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</table>
### Selection of guiding catheter for RCA according to the site of ostium

<table>
<thead>
<tr>
<th>Normal</th>
<th>Downsloping (inferior)</th>
<th>Upsloping (superior)</th>
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<tbody>
<tr>
<td>JR 4, AL 1, AL 2</td>
<td>(inferior)</td>
<td>AL 1,2</td>
</tr>
<tr>
<td>Multipurpose</td>
<td></td>
<td>Hockey-stick</td>
</tr>
<tr>
<td>RBU (Medtronic)</td>
<td></td>
<td></td>
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<tr>
<td>XBRCA, XBR (Cordis)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiesz, All Right (Boston)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Multipurpose</td>
<td>XBRCA (Cordis)</td>
</tr>
<tr>
<td></td>
<td>JR 4,</td>
<td>All Right (Boston)</td>
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## Catheter-Support Techniques

<table>
<thead>
<tr>
<th>Passive Support</th>
<th>Active Support</th>
<th>Mother-Child Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using large-diameter guiding catheter (usu. 7-8Fr with sie holes). A large left Amplatz sits at the ostium of the RCA</td>
<td>A 5 or 6F short tip Judkins right or multipurpose is deeply engaged the RCA</td>
<td>Dual coaxial guide catheter technique with a smaller inner (“Child”; 5, or 6F) inserted intracoronary via a larger (7, or 8F) guiding catheter</td>
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</table>
Hybrid techniques of guiding catheter stabilization – Anchor wire / balloon techniques

A: “Anchor” wire in atrial branch of the RCA proximal to the lesion

B: “Buddy” wire in the posterior descending artery (PDA) distal to the lesion

C: “Anchoring balloon” in atrial branch of the RCA proximal to the lesion

D: “Anchoring balloon” inflated in the distal third segment of the RCA.
Wiring Strategy
Proposed by the Japanese Operators

Pre-procedural Examination of Angiogram w/wo MSCT

Antegrade approach
1. Single wire manipulation
2. Parallel wiring
3. IVUS guided wiring

Retrograde approach
1. Wiring through collateral
2. Retrograde wiring
   • Retrograde wire crossing
   • Kissing wire technique
   • Knuckle wire technique
   • CART
   • Reverse CART
During the wire handling,

- **Pay** attention to the feel of wire tip against the lesion by push and **occasional pullback**, 

  1. To keep the true channel
  2. Not to slip it into the false channel
  3. To change the wire appropriately

- **Never advance it fast**, and **never rotate it rough**!
Special shaping of the wire tip

Penetration from subintimal space

Penetration of proximal or distal fibrous cap
The tip of the guidewire often curves back at the proximal fibrous cap due to poor backup support.

Micro-catheter reinforces torque transmission of guidewire and creates better backup support for penetration of the complex lesion.
Single Wire Manipulation - 1

- Your favorite **soft wire** should be used to advance the support catheter ahead of CTO.

- Recent occlusion without bend in CTO
  
  Any soft wire

- Recent occlusion with bend in CTO
  
  Hydrophilic soft wire
Fielder XT (X-treme)

Fielder FC
Fielder XT enables precise tip shaping due to its short soldering tip.
Micro Channels in CTOs

- Histological average size is 200 μm (0.008 inch)
Single Wire Manipulation - 2

- Micro-channel in CTO
  - Hydrophilic soft wire (Fielder XT)

- Usual old CTO
  - Fielder XT
  - MIRACLE 3
  - MIRACLE 6
  - MIRACLE 12 or Conquest Family

After penetration of proximal fibrous cap
MIRACLE family

Tip load: 3g, 6g, 12g

- Applying the structure with further improves torque performance for CTO use.
- This tip part has the structure which is difficult to be trapped by the lesions.
Conquest family

- Hydrophilic coating over the spring coil (exclude coil tip).
- Conquest Pro is hydrophilic coated version of Conquest. Higher slip ability is provided.
Single Wire Manipulation - 3

- **MIRACLE Family**
  - Better torque performance
  - Less penetration force
  - Better crushing force
  - Better tactile feeling

- **Conquest Family**
  - Less torque performance
  - Better penetration force
  - Less crushing force
  - Less tactile feeling
MIRACLE Family
  is good for controlled drilling!

Conquest Family
  is good for penetration technique!
Concept of Parallel Wire Technique

LAD cranial view

1st wire
2nd wire
2nd wire position (a)
2nd wire position (b)
subintimal space
1st septal
DX1

RAO view

2nd wire position (a)
2nd wire position (b)
1st wire
2nd wire
1st septal
DX1
See-Saw Wiring or Stepwise Buddy Wire Technique

- Advanced form of parallel wire technique
- Using two microcatheters or OTW balloons
- Easy to change guidewires
IVUS guided wiring technique

- False lumen
- True lumen
- Guide wire
Technical pitfall and drawback of IVUS guided penetration

- Dilatation of subintimal space is required to deliver an IVUS catheter when necessary.
- This technique cannot be used if major perforation from subintimal space is already observed.
- 8Fr GC is required for simultaneous wiring with IVUS.
- Stiff wire such as Confianza are required.
- Multiple stenting is indispensable to fully cover the large subintimal space after successful wiring.
Current Antegrade Strategy for CTO

Fielder XT → Miracle 3 → Miracle 12 Conquest

Parallel wiring

Retrograde approach → No work

IVUS guidance → Failure

TCT-AP 2009
Wiring Strategy
Proposed by the Japanese Operators

Pre-procedural Examination of Angiogram w/wo MSCT

Antegrade approach
1. Single wire manipulation
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   • Kissing wire technique
   • Knuckle wire technique
   • CART
   • Reverse CART
Concept of CART™ technique
(Controlled Antegrade and Retrograde subintimal Tracking)

- make connection between antegrade and retrograde subintimal space utilizing behavior of subintimal dissection.
- antegrade wire automatically gets into distal true lumen.

Toyohashi Heart Center
CART vs. Reverse CART

Standard CART

Reverse CART

Antegrade

Retrograde

Antegrade

Retrograde
Remaining Issues with Retrograde Approach

- **Technical Complexity**
  - Necessary to dilate channel, loss of wire manipulation, etc.
  - Learning curve

- **Safety**
  - Possibility of vessel perforation or rupture (especially with epicardial channels, leading to tamponade)
Guidewire-Support Devices

- Microcatheters
- Over-the-wire (OTW) balloon catheter
- Tornus
- Corsair (Channel-dilator)
- 5Fr Heartrail guiding catheter (using as Mother-child technique)
# Comparison between OTW balloon and Microcatheter

<table>
<thead>
<tr>
<th></th>
<th>OTW balloon</th>
<th>Microcatheter</th>
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<tbody>
<tr>
<td>Support power</td>
<td>excellent</td>
<td>weak</td>
</tr>
<tr>
<td>Penetration power</td>
<td>excellent</td>
<td>weak</td>
</tr>
<tr>
<td>Detection of tip</td>
<td>difficult</td>
<td>easy</td>
</tr>
<tr>
<td>location</td>
<td>difficult</td>
<td>easy</td>
</tr>
<tr>
<td>Contrast injection</td>
<td>difficult</td>
<td>easy</td>
</tr>
<tr>
<td>Flexibility</td>
<td>stiff</td>
<td>very flexible</td>
</tr>
</tbody>
</table>
Structure of Microcatheter (Finecross MG by Terumo, Japan)
Structure of Tornus 1

- The metal catheter consists of 8 stainless steel ropes formed in a spiral structure.

- Combined 8 wires enable high torque performance.
- Spiral structure gives high penetration power by counter-clockwise rotation.
- Helical cut surface provides stronger anchor effects.
Structure of Tornus 2

- The tapered structure with 150mm from the distal tip.
Structure of Tornus 3

• Magnified Tornus Tips
Application of Tornus in CTO-PCI

1. Lesion penetration after wire crossing
   - Enhanced power by Tornus 88flex, Tornus-Pro
   - Wire exchange to RotaWire when necessary

2. Support for wire handling
   - For long tight CTO lesions
   - To stretch the proximal wire kink
   - Pay attention to the wire kink at the Tornus tip

3. Making channel
   - Instead of balloon to avoid vessel dissection
   - Before antegrade balloon in reverse CART
Channel Dilator  Corsair
The Advantage of Corsair

For Channel Tracking
- Excellent cross-ability through collateral channel
- No need of channel dilatation
- Less channel injury
- Expanded indication for epicardial channel

For Retrograde Wiring of CTO
- Excellent support for wire manipulation
- Good cross-ability into/through the occlusion
- Enabled usage of 300cm wire or snare wire
Mother-Child Catheter Method – 5 Fr Heartrail (Terumo, Japan)

Hemostatic valve
Heartrail 5 Fr Y connector
straight

Heartrail 6 Fr

5 Fr Heartrail in 6 Fr guiding catheter
Clinical Impact of MDCT on PCI of CTO

- Regional distal calcium scoring can be useful to predict procedural outcome with antegrade approach in PCI of CTO.

- By quantitatively evaluating amount of calcium, identifying the route and the length of the CTO segment, MDCT may be useful for Pre-Procedural Strategy judgments for PCI method of CTO in the future.
Standardization of Pre-Procedural Strategy For CTO-PCI

Patient with CTO

64 MD CT angiogram

Use Beta-blocker to slow down HR

Simultaneous both coronary angiogram

Critical evaluation of coronary angiogram
Standardization of Pre-Procedural Strategy For CTO-PCI

- Easily seen distal stump, or microchannel by angio
  - Occluded segment <30 mm by MDCT
  - Low distal stump calcium by MDCT (Calcium Area<4mm²)

- Poorly seen distal stump, without microchannel by angio
  - Occluded segment >30 mm by MDCT
  - High distal stump calcium by MDCT (Calcium Area>4mm²)

Antegrade Approach → Retrograde Approach

Failed Ante → Severe calcium and/or angulation in mid lesion or fail to antegrade and retrograde approach → CART or Retrograde CART technique
73 Year-old woman

C.C  Chest pain for 1 month

P.Hx  HTN (+) on medication for 10yrs

R.O.S  Dyspnea (-)

P.Ex  V/S 120 / 80-72 - 20 - 36.6

RHB without murmur
CBS without rale, wheezing

# 5460316
Initial diagnostic approach
Cardiac CT
Initial angiography (RCA)
2010-03-21
Initial angiography (LCA)

RAO caudal view

Collaterals from OM->Diagonal
LCA angiography

LAO cranial view

LAD 진행방향

Collaterals
Dual (bilateral) angiography

RAO cranial view

LAO cranial view
Collaterals from PD->septal, OM->diagonal
Could estimate obstructed lesion length
Could determine revascularization strategy

Retrograde approach:
Too complicate
During angioplasty

Guide wire was inserted into Diagonal branch
During angioplasty

Guide wire was inserted into LAD
After balloon angioplasty
After stent implantation
54 Year-old man

C.C
Dyspnea for 1 week

P.Hx
Hypertension for 7 years
ESRD on CAPD for 1 year
CAOD 2-VD (dRCA & LAD-CTO):
diagnosed with angiography at 1 year ago

R.O.S
Dyspnea (+)
Chest pain (-)
Fever/Cough/Sputum (+/+/+)

P.Ex
V/S 100/50- 80 - 24 – 37.9
RHB without murmur
CBS with rale

# 5508065
# Lab finding

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
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<tbody>
<tr>
<td>CBC</td>
<td>9670- 9.6/28.9- 243000</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Calcium: 8.5/ In-P: 5.2 (mg/dL)</td>
</tr>
<tr>
<td></td>
<td>Bun/Cr: 56.9/12.28 (mg/dL)</td>
</tr>
<tr>
<td></td>
<td>Cholesterol: 127 mg/dL</td>
</tr>
<tr>
<td></td>
<td>AST/ALT: 73/19 (IU/L)</td>
</tr>
<tr>
<td></td>
<td>CK/CK-MB: 710/94.23 (IU/L, ng/mL)</td>
</tr>
<tr>
<td></td>
<td>Tro-T: 2.91 (0~0.1 ng/mL)</td>
</tr>
<tr>
<td>aBGA</td>
<td>7.46-30.9/95.6-22.4-98.3%</td>
</tr>
</tbody>
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Echocardiography

2009-02-19

- RWMA: LAD territory
- LVEDD: 58mm, LAVI 26 ml/m²
- EF: 39%

2010-03-30

- RWMA: LAD and RCA territory
- LVEDD: 65mm, LAVI: 38 ml/m²
- EF: 29%
Initial angiography (RCA)

2010-04-02
Initial angiography (LCA)
RCA angioplasty

Endeavor resolute 2.75x30

After stent deployed
Retrograde approach (RAO-cranial view)

Microcatheter angiography

Wire passed into the LAD through collaterals
Retrograde approach

A wire with microcatheter couldn’t reach to the pLAD d/t long length of collaterals
Retrograde Approach
Medtronic Guiding

1. GW was not able to reach Lt Main due to big heart and long collateral pathway.
2. Guiding Catheter preparation-Protection of GW with stainless steel tube
Retrograde Approach

1. Guiding catheter was held down with mosquito to stop bleeding.
2. Guiding catheter was cut with scissors under the protection of stainless tube.
Retrograde Approach

1. Detach the hub from the proximal part of the guiding catheter.
2. Balloon catheter (2.5mm) was inserted to the hub of the guiding catheter through Y-connector.
Retrograde Approach

1. Proximal part of GW, which was in the LAD through collateral channel retrogradely, was inserted to the Y-connector.

2. Balloon catheter was inserted and inflated to prevent bleeding during assembling.
Retrograde Approach

1. The hub of the guiding was easily assembled with minimized bleeding.
Retrograde approach

The enough length was secured for retrograde approach
Bilateral approach

The several types of G/W were attempted to entering at tough CTO lesion bilaterally.
IVUS finding (intermedius br.)

After retro-G/W passed to the main coronary a.

Eccentric plaque noted from opposite direction to LAD, LCX
Bilateral approach

G/W with microcatheter successfully entered into a LCA catheter

1.5x15 balloon -> 2.5x15 balloon at p-m LAD
Antegrade approach

Then, the G/W with microcatheter was successfully entered into the LAD with antegrade approach
Antegrade angioplasty

2.5x15 balloon 8atm/10sec at p-m LAD several times
Antegrade angioplasty

Endeavor R 2.5x30 at mLAD, 2.75x18 at pLAD
Antegrade angioplasty

LCX br. was jailed after LAD stenting
Antegrade angioplasty

Kissing balloon with 2.5x15 at pLAD, 1.5x15 at LCX was done
Antegrade angioplasty

Intermedius br. Flow was suddenly disappeared after LCX ballooning
LCX plaque also located at opposite direction of LAD bifurcation site
Antegrade angioplasty

Endeavor R 2.75x18 was deployed at pLCX
Antegrade angioplasty

Intermedius br. flow was spontaneously recovered after stenting
Final angiogram
Welcome to e-CTO

e-Chronic Total Occlusion Club

e-CTO Club is?

By definition, CTO is totally occluded lumen without antegrade blood flow (TIMI grade 0) and duration of disease is over 3 months which calculated on the basis of clinical or angiographic data. Percutaneous revascularization of chronic total occlusion (CTO) still remains as a main hurdle, despite advances in angioplasty technology and operator experiences. Several decades ago, some reports said that chronic total occlusion (CTO) has been considered unsuitable lesion for coronary angioplasty.

However, due to recent technological advances and enormous Japanese operator’s efforts, percutaneous transluminal coronary angioplasty (PTCA) has been attempted in a large number of patients with CTO recent years.

E-CTO club would like to guide and support you to perform successful CTO intervention with the expertise’s help about details of methodology including selection of instruments such as guiding catheter for adequate support, specialized guidewires for penetration and experienced hand skills. And furthermore, new evolving technology and crossing techniques was introduced as supportive informations for our colleagues.

I hope all the colleagues enjoy the prosperous outcome with CTO lesions via e-CTO club.

Thanks for your participation
Yangsoo Jang, MD, PhD, FACC

http://www.e-cto.org/
Thank you for your attentions!