PCI for Chronic Total Occlusions
Chronic Total Occlusions

Why not Medical Treatment?
Medical Treatment

CTO in 891 pts over 24 years

Mortality

High 10%

Low 2%

1 year 10 years

Puma JA, et al. JACC 1994;23:390A
Chronic Total Occlusions
20-40% of patients with CAD

Why should we open?
Effect on LV function

PCI in CTO improves LV function

Pre 6 Mo Post

LV EDVI

46 35

ESVI

49 57

EF

19 14

PCWP

Van Belle E, et al. AJC 1997;80:1150-1154

*P < 0.05
Reopening of CTO

Improves Survival

96 pts, EF<40%
F/U 40 ± 17 mo

Mortality
Successful: 19%
Failed PTCA: 40%
P < 0.05

CABG
Successful: 8%
Failed PTCA: 49%

Survival Outcomes
Successful vs Failed PTCA

5 year freedom from death, MI & CABG

*P < 0.001

Clin Investig 1994;72:442-7
Chronic Total Occlusion

**Rationale for Invasive Treatment**

- To relieve *symptom itself*
- To improve LV function
- To impact late outcomes
  
  *Improved mortality*
  
  *Freedom from subsequent CABG*
What are the problems in reopening of CTO?

- Low Procedural Success
- High Clinical and Angiographic Restenosis
# Procedural Success

## Predictors

- Duration of occlusion
- Length of occluded lesion
- Absence of antegrade flow
- Absence of stump
- Presence of bridging collateral
Procedural Success

**Favorable**

- Tapered stump
- Functional occlusion
- Pre or post occlusion
- Bridging collateral (-)

**Unfavorable**

- Stump absent
- Total occlusion
- Side branch (+)
- Bridging collateral (+)
### Procedural Failure

#### Multivariate analysis

<table>
<thead>
<tr>
<th>Variables</th>
<th>$P$ value</th>
<th>Odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcification</td>
<td>&lt; 0.01</td>
<td>2.56</td>
</tr>
<tr>
<td>Multivessel disease</td>
<td>&lt; 0.01</td>
<td>2.11</td>
</tr>
<tr>
<td>Lesion length $&gt;$20mm</td>
<td>&lt; 0.05</td>
<td>1.72</td>
</tr>
<tr>
<td>Duration of occlusion</td>
<td>0.96</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Failure of PCI in CTO

Why?

Crossing Failure of Guidewire
Reopening of CTO

- Conventional Guidewires
- New Generation Guidewires
- New Devices for crossing lesion

*FrontRunner™ Catheter*

*OCR SafeSteer™ System*

(Optical Coherence Reflectometry)
Wiring in CTO

Conventional Guidewire vs. New Generation
Conventional Wiring of CTO

- Success rate < 50%

- Age of occlusion is biggest determinant of failure
## Ability to Cross CTO

### Hydrophilic-coated Guidewire

<table>
<thead>
<tr>
<th></th>
<th>Conventional (n=46)</th>
<th>Crosswire (n=42)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; GW success (%)</td>
<td>35</td>
<td>74</td>
<td>0.001</td>
</tr>
<tr>
<td>Crossover (%)</td>
<td>59</td>
<td>26</td>
<td>0.009</td>
</tr>
<tr>
<td>GW success after crossover (%)</td>
<td>37</td>
<td>0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total GW No.</td>
<td>$1.7 \pm 0.6$</td>
<td>$1.3 \pm 0.5$</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Procedure (min)</td>
<td>$84 \pm 33$</td>
<td>$42 \pm 20$</td>
<td>0.013</td>
</tr>
</tbody>
</table>

Lefevre et al, Am J Cardiol 2000;85:1144-7
# Ability to Cross CTO

**Laser Guidewire**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedural Success</td>
<td>50-59 %</td>
</tr>
<tr>
<td>Coronary Perforation</td>
<td>1-21 %</td>
</tr>
<tr>
<td>Restenosis at 18 weeks</td>
<td>20-31 %</td>
</tr>
<tr>
<td>Improved Angina Status</td>
<td>66%</td>
</tr>
<tr>
<td>Death / MI / CABG</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Hamburger JN, et al. AJC 1997;80:1419-1423*

*Hamburger, et al. JACC 1997;30:649-656*

*Schofer et al. JACC 1997;30:1722-1728*
Guidewire in CTO PCI

New generation guidewires are an effective in the treatment of CTO refractory to conventional guidewires.
New Devices for CTO

Crossing Lesion

- FrontRunner™ Catheter
- OCR SafeSteer™ System
  (Optical Coherence Reflectometry)
FrontRunner Catheter

Intraluminal MicroDissection

- Blunt controlled passage through occlusion
- Uses elastic properties of adventitia vs inelastic fibrocalcific plaque
FrontRunner Catheter

**Advantages**
- Torqueable
- Guide support
- Directable/Steerable
- Hydrophilic coating
- Blunt tip to avoid perforation
- Avoids side branches

**Disadvantages**
- Difficult anatomy: tortuosity, small vessel, heavy calcium
- Expensive
- 8 Fr guiding for curved jaw
- Failure Modes
FrontRunner Technique

- 6 or 8 Fr guiding catheter
- Collateral visualization
- Tip shapeable and steerable
- Engagement in CTO & Jaw opening
- Torque and advance / retract
- Intraluminal vs subintimal
- Replace with guidewire
- Dilate and stent
Clinical Experiences

- 107 patients (mean 62 years)
- Refractory to guidewire
- Mean lesion length 21 ± 8 mm

Overall Success 60%
Complication Rate 5%

Mehttew Selmon et al, ACC 2002
OCR SafeSteer System

New Devices for CTO

• Forward looking guidance system, using OCR to determine tissue types (*plaque vs arterial wall*).

• Designed to navigate through total occlusion.
OCR SafeSteer System

OCR Wavefore Displays
OCR SafeSteer System

Conventional OCR Guide Wire

RF Ablation / OCR Guide Wire
## Clinical Experiences

<table>
<thead>
<tr>
<th></th>
<th>Safe-Cross (n=13)</th>
<th>Conventional wire (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>Male</td>
<td>92 %</td>
<td>85 %</td>
</tr>
<tr>
<td>Occlusion length</td>
<td>40.2 mm</td>
<td>12 mm</td>
</tr>
<tr>
<td>Occlusion age</td>
<td>3.4 years</td>
<td>5 years</td>
</tr>
<tr>
<td>Success crossing</td>
<td>11 (85 %)</td>
<td>8 (62 %)</td>
</tr>
</tbody>
</table>

Heuser RR et al, TCT 2002
New Devices

- *FrontRunner™* Catheter
- *OCR SafeSteer™* System

*may be advantages for specific CTO refractory to conventional system.*
To Achieve and Sustain Patency in CTO

How?

Stent vs PTCA
Debulking
Stent vs PTCA

Restenosis:
- Stent (n=48): 71%
- PTCA (n=48): 42%

Reocclusion:
- Stent (n=48): 7.9%
- PTCA (n=48): 16%

*P < 0.05

Stent vs PTCA

*TOSCA*

- TVR:
  - Stent (n=202): 8.4%
  - PTCA (n=208): 11%

- Restenosis:
  - Stent (n=202): 15%
  - PTCA (n=208): 20%

- MACE:
  - Stent (n=202): 16%
  - PTCA (n=208): 23%

*P < 0.05

Buller et al. Circulation 1999;100:236-42
Stent vs PTCA

SICCO

Stent (n=58)
PTCA (n=59)

*M P < 0.05

<table>
<thead>
<tr>
<th></th>
<th>Stent</th>
<th>PTCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACE</td>
<td>24%</td>
<td>59%</td>
</tr>
<tr>
<td>TLR</td>
<td>24%</td>
<td>53%</td>
</tr>
<tr>
<td>Restenosis</td>
<td>32%</td>
<td>73%</td>
</tr>
</tbody>
</table>

Sirnes et al. JACC 1998;32:305-310
STENT in CTO improve reocclusion and restenosis rates over PTCA results.
Late Clinical and Angiographic Outcomes after Stenting in CTO

AMC experience
Successful Recanalization of CTO

Procedural success

241/324 (74%)
## Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Stent length &lt; 20mm (n=113)</th>
<th>Stent length ≥ 20mm (n=107)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current smoker</td>
<td>50 (44.2%)</td>
<td>55 (51.4%)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>19 (16.8%)</td>
<td>22 (20.6%)</td>
</tr>
<tr>
<td>Hypercholesterolemia (&gt; 200 mg/dL)</td>
<td>41 (32.3%)</td>
<td>45 (42.1%)</td>
</tr>
<tr>
<td>Systemic hypertension</td>
<td>52 (46.0%)</td>
<td>47 (43.9%)</td>
</tr>
<tr>
<td>Previous MI</td>
<td>15 (13.3%)</td>
<td>10 (9.3%)</td>
</tr>
</tbody>
</table>
# Angiographic Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Stent length &lt; 20mm (n=113)</th>
<th>Stent length ≥ 20mm (n=107)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesion length (mm)</td>
<td>14.4±4.1</td>
<td>24.8±10.1*</td>
</tr>
<tr>
<td>Stent length (mm)</td>
<td>16.1±2.0</td>
<td>29.4±5.9 *</td>
</tr>
<tr>
<td>Balloon to artery ratio</td>
<td>1.11±0.12</td>
<td>1.13±0.16</td>
</tr>
<tr>
<td>Reference vessel size (mm)</td>
<td>3.14±0.47</td>
<td>3.12±0.48</td>
</tr>
</tbody>
</table>

* p<0.05
## Angiographic Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Stent length &lt; 20mm (n=113)</th>
<th>Stent length ≥ 20mm (n=107)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postintervention MLD</td>
<td>3.09±0.45</td>
<td>3.03±0.49</td>
</tr>
<tr>
<td>Follow-up MLD</td>
<td>1.91±0.94</td>
<td>1.72±0.87</td>
</tr>
<tr>
<td>Acute gain</td>
<td>3.09±0.45</td>
<td>3.03±0.49</td>
</tr>
<tr>
<td>Late loss</td>
<td>1.17±0.78</td>
<td>1.36±0.85</td>
</tr>
<tr>
<td>Loss index</td>
<td>0.39±0.27</td>
<td>0.44±0.27</td>
</tr>
</tbody>
</table>

MLD: minimal lumen diameter
Angiographic Restenosis

Overall restenosis: 26.4%

- Stent length < 20mm: 19.3%
- Stent length ≥ 20mm: 33.7%

*P < 0.05
Major Cardiac Events
Death, MI, TLR

F/U 29.1±10.8 Months

- Stent length < 20mm: 10.6%
- Stent length ≥ 20mm: 14.4%

P = NS
Predictors of Restenosis

Multivariate analysis

Postprocedural minimal lumen diameter

OR = 0.20, 95% CI 0.08-0.49, p < 0.01
Angiographic Restenosis According to MLD

- Post-procedure MLD < 3.0 mm
  - Total: 42%
  - Stent length < 20mm: 16%
  - Stent length ≥ 20mm: 29%

- Post-procedure MLD ≥ 3.0 mm
  - Total: 56%
  - Stent length < 20mm: 12%
  - Stent length ≥ 20mm: 19%

*P < 0.05
Debulking Strategy

Additive effect over stent alone? 

Controversial
## Debulking with Stent

**Debulking with Excimer Laser, Directional or Rotational Atherectomy**

<table>
<thead>
<tr>
<th></th>
<th>Debulking + S (n = 50)</th>
<th>Stent alone (n = 126)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success (%)</td>
<td>100</td>
<td>97</td>
<td>NS</td>
</tr>
<tr>
<td>Final MLD (%)</td>
<td>2.7 ± 0.6</td>
<td>2.6 ± 0.7</td>
<td>NS</td>
</tr>
<tr>
<td>In-Hosp. MACE (%)</td>
<td>2.3</td>
<td>3.7</td>
<td>NS</td>
</tr>
<tr>
<td>MACE at FU (%)</td>
<td>26</td>
<td>20</td>
<td>NS</td>
</tr>
<tr>
<td>TLR (%)</td>
<td>16</td>
<td>14</td>
<td>NS</td>
</tr>
</tbody>
</table>

Gruberg L et al. JACC 2000;35:151-6
Debulking with Stent

Rotational Atherectomy

RA+Stent (n=202)
Stent only (n=208)  * P< 0.05

Post-MLD  FU-MLD  Restenosis
2.7 mm  1.8 mm  29%
2.3  1.3  53%

PCI for Chronic Total Occlusions

Future perspective

drug eluting stent?
**SIRIUS - QCA Peri-Stent Analysis**

- **Silorimus (n=349)**
- **Control (n=353)**

<table>
<thead>
<tr>
<th>Margin</th>
<th>Silorimus (%)</th>
<th>Control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal</td>
<td>4.8</td>
<td>8.1</td>
</tr>
<tr>
<td>In-stent</td>
<td>3.2</td>
<td>35.4</td>
</tr>
<tr>
<td>Distal</td>
<td>2.0</td>
<td>7.2</td>
</tr>
</tbody>
</table>

- **P=0.285**
- **P<0.001**

- **P=0.002**
Drug-Eluting Stents

- Ostial lesions – no data
- Bifurcations – need more data
- In-stent restenosis – need more data
- SVGs – no data
- Small vessels – need more data
- Diffuse disease – need more data
- Left main disease – no data
- Total occlusions – no data