

# Live Case #8: KM, 53 yrs old M

**Presentation:** Progressive exertional Class II angina with + stress MPI for mild infero-lateral and large area of anterior ischemia

**Past History:** Hypertension, Hyperlipidemia, NIDDM, +F/H, Prior cath and failed PCI 5 yrs ago, Recent change in stress MPI

**Medications:** ASA, Lisinopril, Simvastatin, Atenolol, Clopidogrel, ADA med

**Cardiac Cath: 12/4/09:** 2 V CAD & LVEF 60%

SYNTAX  
score = 22

LAD: 100% Calcific prox LAD with distal LAD large and mild disease and fills via RCA collaterals

LCx: 70% OM1, rest of the vessel is ok

RCA: Mild diffuse disease

**Hospital course:** Ambulatory PCI using 2.5/15mm XienceV to OM1

**Plan Today:** PCI of CTO prox LAD using contra lateral injection

# **Chronic Total Occlusion (CTO)**

## *From Randomized Trials to Daily Practice*

- 1. From BARI trial to SYNTAX trial, the single most common reason for a patient to be referred to surgery and not randomized was a CTO with low success rate of recanalization**
- 2. Even in the recent era of increasing success rate of CTO recanalization, the PCI success rate for CTO lesions attempted in the SYNTAX trial was only 53%**

# Chronic Total Occlusion (CTO)

## *Adverse Factors for PCI*

1. Lower success rates: *disappointment*
2. Longer cases: *disrupts the schedule*
3. More radiation exposure: *dermatitis*
4. More resource utilization: *without ↑reimbursement*
5. Minimal incidence but potentially catastrophic complications: *thrombus, dissection, perforation, cardiac tamponade, collaterals shut off, side-branch occlusion, MI, Contrast Induced AKI*

# TOAST-GISE

*376pts (390 Occlusions) 29 Centers*

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<b>Technical success</b>	<b>301 (77.2%)</b>
<b>Procedural success</b>	<b>286 (73.3%)</b>
<b>Death</b>	<b>1 (0.26%)</b>
<b>Q-wave MI</b>	<b>1 (0.26%)</b>
<b>Non-Q-wave MI</b>	<b>16 (4.3%)</b>
<b>Urgent CABG</b>	<b>2 (0.53%)</b>
<b>Urgent repeat PCI</b>	<b>2 (0.53%)</b>
<b>Cerebrovascular accident</b>	<b>0</b>
<b>Vessel perforation</b>	<b>8 (2.1%)</b>
<b>In-hospital MACE</b>	<b>19 (5.1%)</b>

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# Chronic Total Occlusion (CTO)

*Why Bother to do PCI?*

Presence of CTO in CAD Imparts Adverse Prognosis

Because successful CTO recanalization may result in



**Angina/Ischemia relief**

**Freedom from subsequent CABG**

**Improved LV function**

**Improvement in event-free survival**

# **Chronic Total Occlusion (CTO)**

**Presence of CTO in CAD Imparts  
Adverse Prognosis**

# Impact of Completeness of PCI Revascularization on Long-Term Outcomes in the Stent Era

## *HRs for Mortality for Various Subgroups of Incomplete Revascularization*

	<b>N</b>	<b>Unadjusted HR Compared with CR [95%CI]</b>	<b>Adjusted HR Compared with CR [95%CI]</b>
<b>Complete Revascularization</b>	<b>6817</b>	<b>1.00</b>	<b>1.00</b>
<b>1 IR vessel with no CTO</b>	<b>8518</b>	<b>1.20 [1.04-1.38]</b>	<b>1.00 [0.87-1.15]</b>
<b>≥ 2 IR vessel with no CTO</b>	<b>2057</b>	<b>1.88 [1.57-2.27]</b>	<b>1.25 [1.03-1.50]</b>
<b>1 IR vessel CTO</b>	<b>3232</b>	<b>1.81 [1.53-2.13]</b>	<b>1.35 [1.14-1.59]</b>
<b>≥ 2 IR vessels at least 1 CTO</b>	<b>1321</b>	<b>2.77 [2.29-3.35]</b>	<b>1.36 [1.12-1.66]</b>

# Incomplete Revascularization in the Era of DES: NY State Database Report

- 11,294 stented pts with MVD; 88% had DES
- Oct 2003-Dec 2004, F/U through Dec 2005

Pt. Group	Adjusted HR for 18-month Mortality			
	No. of Cases	Mortality	HR	p-value
CR	3499 (31%)	5.1%	Ref	-
IR	7795 (69%)	6.2%	1.23	0.01
1 IR vessel no CTO	3815	6.2%	1.23	0.03
1 IR vessel CTO	1725	5.6%	1.11	0.39
≥ 2 IR vessel, no CTO	1233	5.9%	1.18	0.26
<b>≥ 2 IR with CTO</b>	<b>1022</b>	<b>7.1%</b>	<b>1.44</b>	<b>0.002</b>

# Incomplete Revascularization in the Era of DES: NY State Database Report

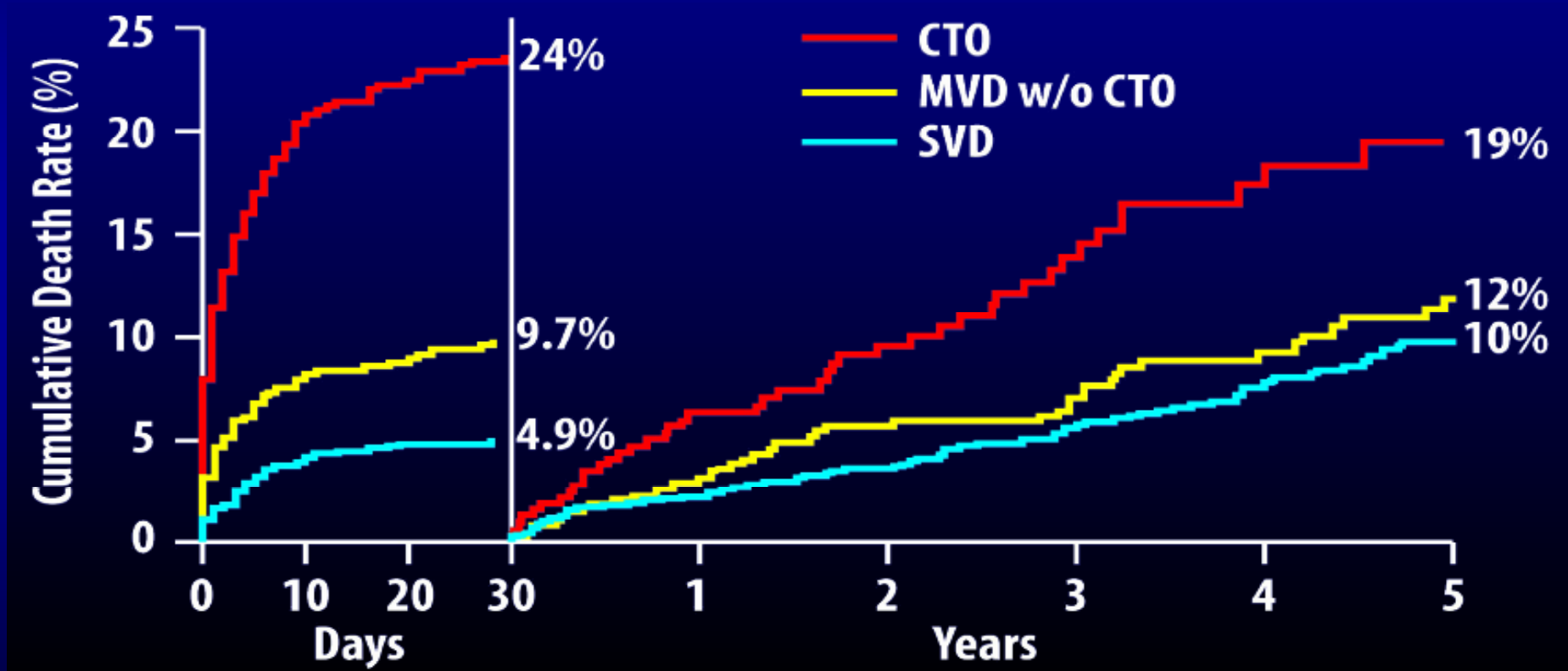
Pt. Group	Adjusted HR for 18-month Mortality/AMI			
	No. of Cases	Mortality/MI	HR	p-value
CR	3499 (31%)	6.7%	Ref	-
IR	7795 (69%)	8.3%	1.27	0.002
1 IR vessel no CTO	3815	8.1%	1.22	0.02
1 IR vessel CTO	1725	7.6%	1.14	0.24
≥ 2 IR vessels, no CTO	1233	8.7%	1.34	0.03
<b>≥ 2 IR vessels with CTO</b>	<b>1022</b>	<b>9.7%</b>	<b>1.50</b>	<b>&lt;0.001</b>

*Conclusion: Pts with ≥2 IR vessels with a CTO, have the worst long-term prognosis and greater need for CABG or re-PCI*

# Evaluation of the Effect of a Concurrent CTO on Long-Term Mortality and LVEF in Pts After Primary PCI in AMI

3277 STEMI pts 1997-05. SVD 65%, MVD 22%, MVD + CTO 13%

## Landmark Survival Analysis

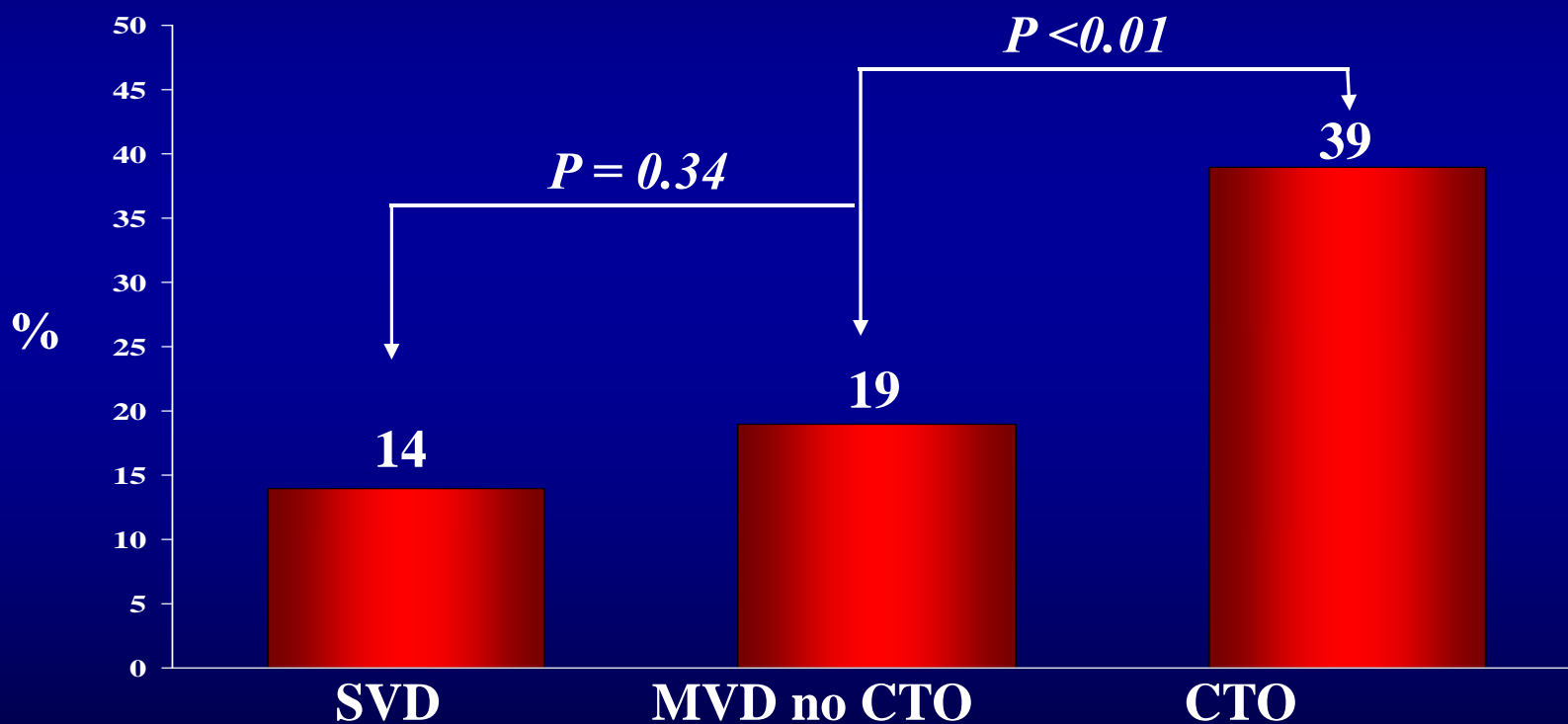


Endpoint: Survival at 5 yrs, LVEF at 12 mo (median F/U 3.1 yrs)

# Evaluation of the Effect of a Concurrent CTO on Long-Term Mortality and LVEF in Pts After Primary PCI in AMI

3277 STEMI pts 1997-05. SVD 65%, MVD 22%, MVD + CTO 13%

## Proportion of Patients With a Decrease in LVEF of at Least 1 Category Between Baseline and 1-Year Follow-Up



Endpoint: Survival at 5 yrs, LVEF at 12 mo (median F/U 3.1 yrs)

# **Chronic Total Occlusion (CTO)**

**Because successful CTO recanalization may result in**



**Angina/Ischemia relief**

**Freedom from subsequent CABG**

**Improved LV function**

**Improvement in event-free survival**

# Chronic Total Occlusion (CTO)

## *CTO Recanalization and Angina Relief*

Series Name/Year	Successful PCI (N)	FU (months)	Asymptomatic (%)
Olivari, 2003	248	12	89
Berger, 1996	139	6	87
Ivanhoe, 1992	264	36	69
Ruocco, 1992	160	24	69
Bell, 1992	234	32	76
<b>TOTAL</b>	<b>&gt;1000</b>	<b>&gt;24 mo</b>	<b>&gt;80%</b>

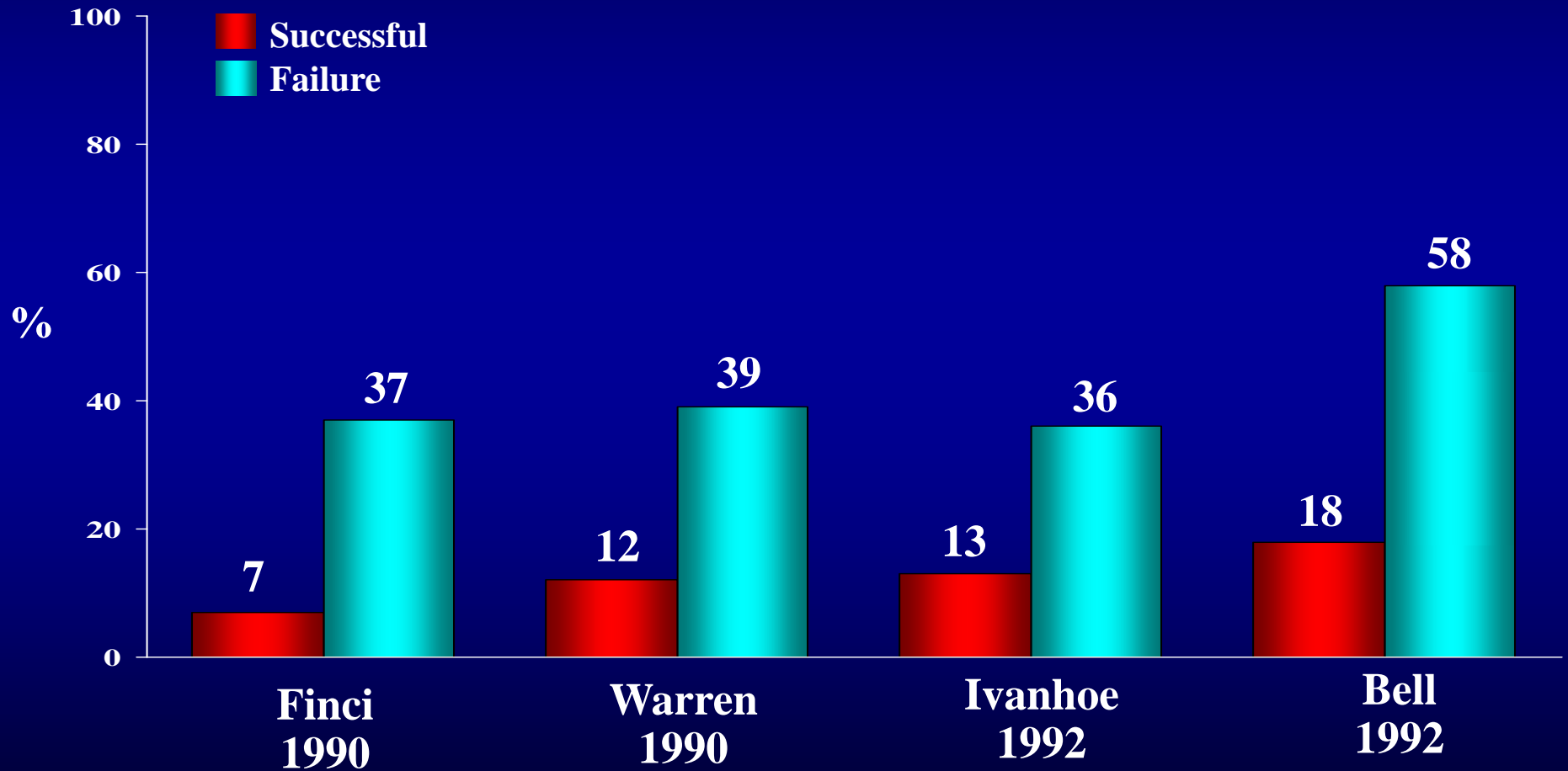
# TOAST-GISE

## *1 Year Clinical Status of Complication Free Patients*

	<b>CTO Success (n = 248)</b>	<b>CTO Failure (n = 60)</b>	<b>P Value</b>
<b>No angina</b>	<b>220 (88.7%)</b>	<b>45 (75.0%)</b>	<b>0.008</b>
<b>ETT performed</b>	<b>210 (84.7%)</b>	<b>42 (70.0%)</b>	<b>0.010</b>
<b>Maximal ETT</b>	<b>155 (62.5%)</b>	<b>20 (33.3%)</b>	<b>&lt;0.0001</b>
<b>Negative ETT</b>	<b>181 (73.0%)</b>	<b>28 (46.7%)</b>	<b>0.0001</b>

# Chronic Total Occlusion (CTO)

*Successful CTO Recanalization Reduces  
Long-Term Incidence of CABG*



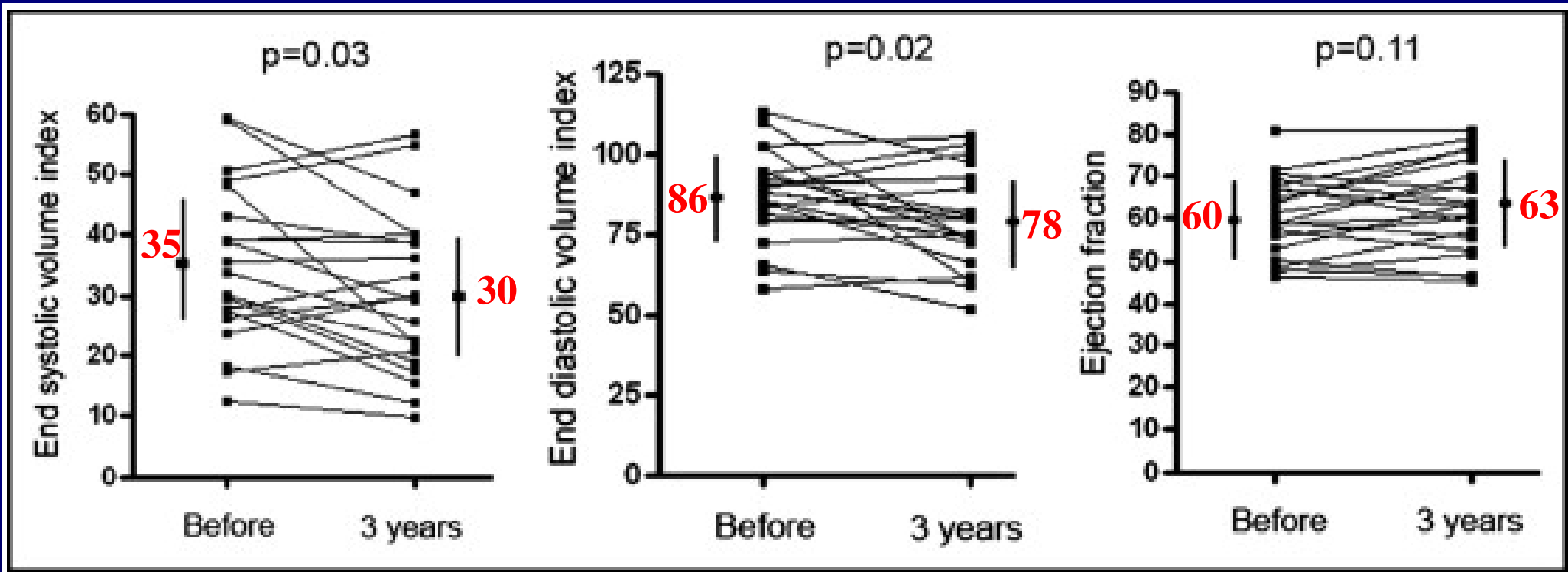
# TOAST-GISE

## *12-Month Clinical Outcome*

	CTO Success (n = 286)	CTO Failure (n = 83)	p Value
	n (%)	n (%)	
All deaths	3 (1.05)	3 (3.61)	0.130
Cardiac death	1 (0.35)	3 (3.61)	0.037
Nonfatal MI	2 (0.70)	3 (3.61)	0.077
<b>CABG</b>	<b>7 (2.45)</b>	<b>13 (15.7)</b>	<b>&lt;0.0001</b>
PCI, TLR	27 (9.44)	7 (8.43)	0.834
Any TLR	33 (11.5)	19 (22.9)	0.012
Any PCI	38 (13.3)	9 (10.8)	0.584
Any MACE	35 (12.2)	21 (25.3)	0.005

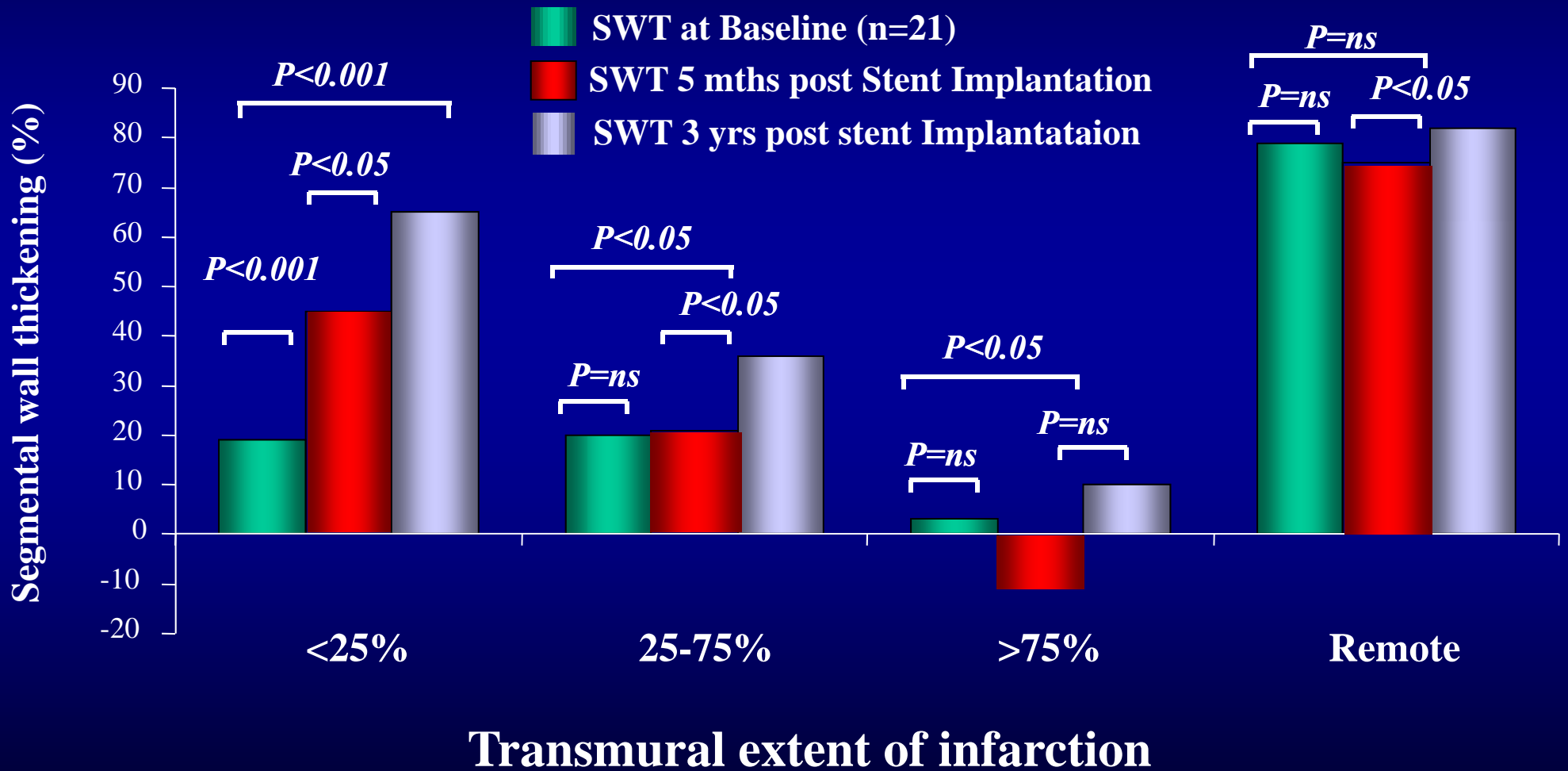
# Evaluation of LV Function 3-Yrs after Percutaneous Recanalization of CTO

*Changes in LV Volume Indexes and EF between Baseline and 3-Yr FU Measured Using Magnetic Resonance Imaging (N=21)*

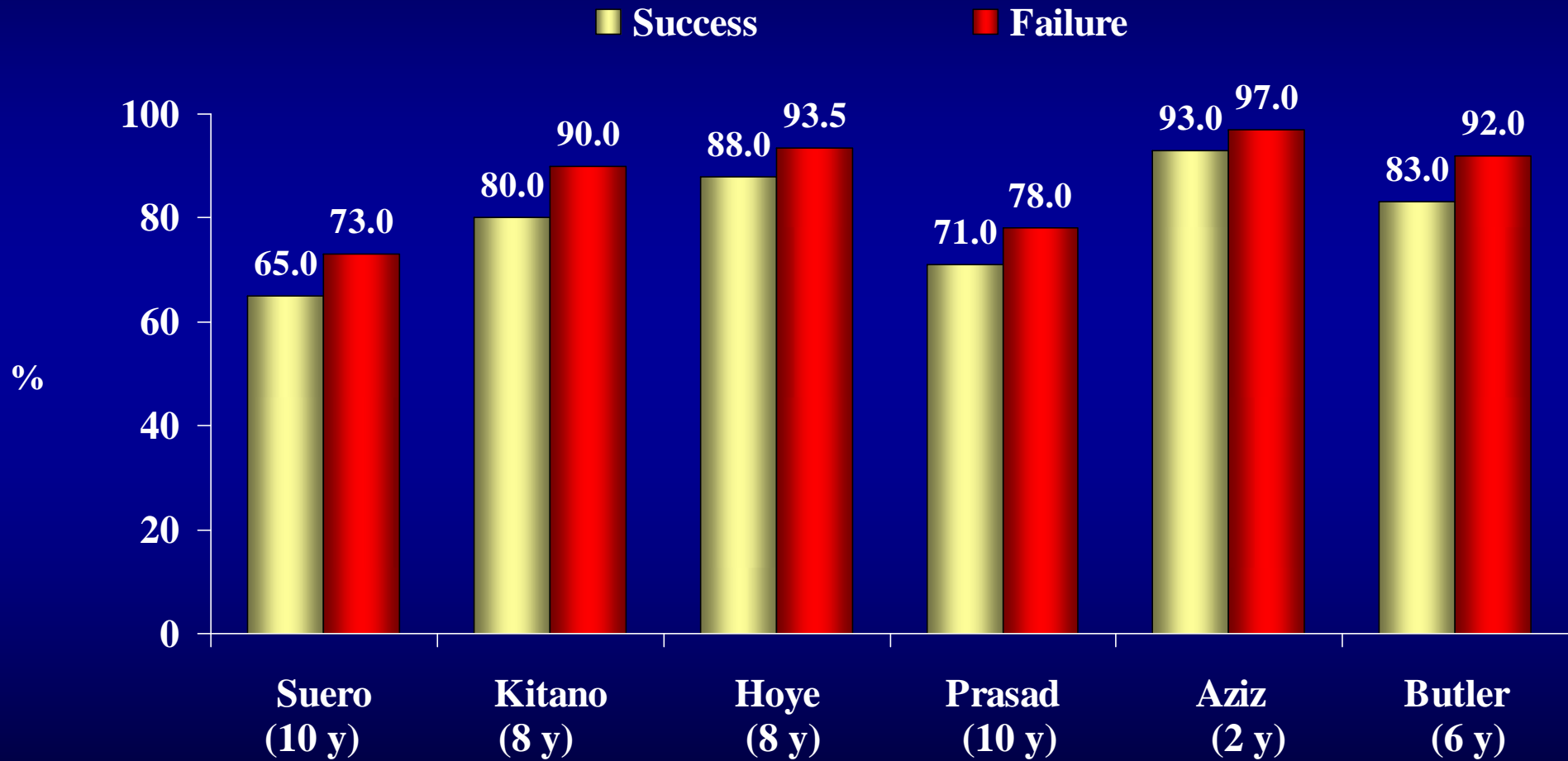


Mean ejection fraction was unchanged, but end-systolic and end-diastolic volume indexes decreased significantly. (Normal values for ejection fraction and end-systolic and end-diastolic volumes are  $63 \pm 4\%$ ;  $162 \pm 28$  ml, and  $60 \pm 11$  ml, respectively.)

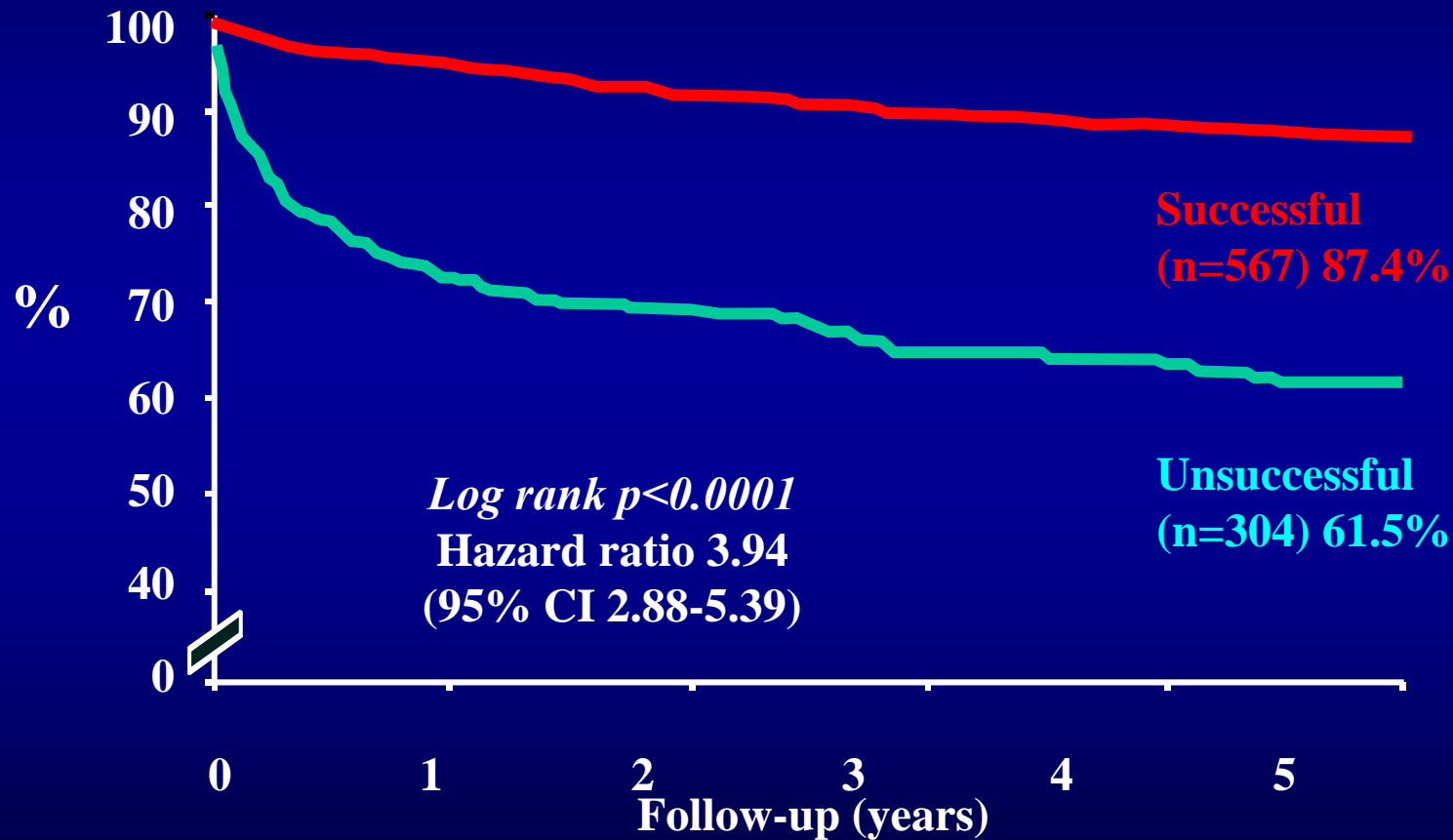
# MRI Predicts LV EF and Wall Motion Improvement with CTO Revascularization (N=21)



# CTO Treatment and Improved Long-term Survival



# Cumulative Survival-free of CABG at 5 Years with Respect to the Outcome of Attempted CTO Recanalization



# TOAST-GISE

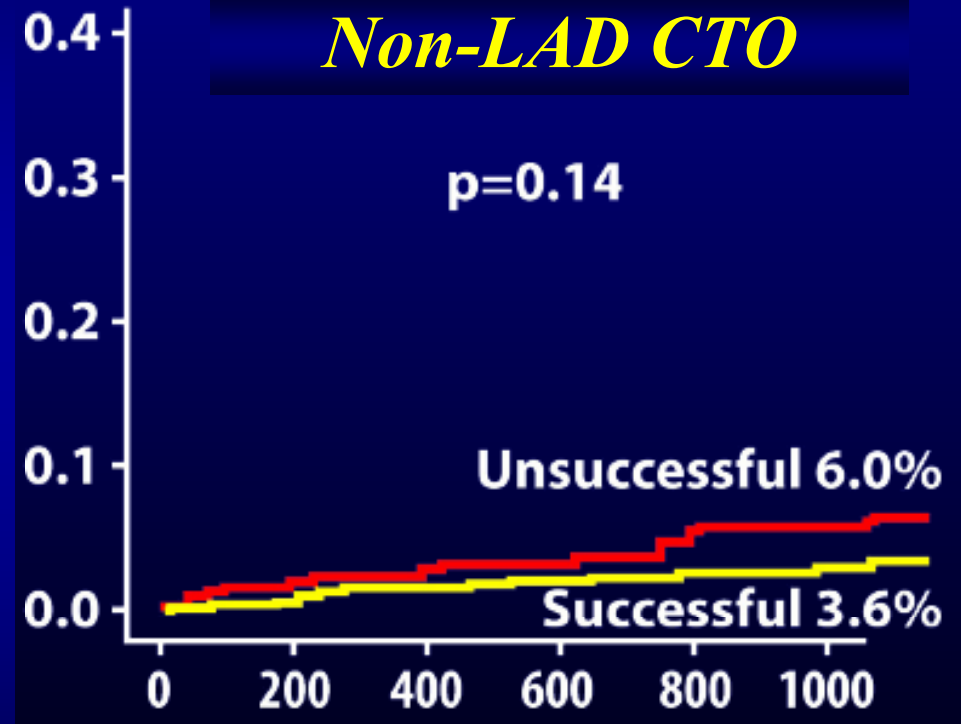
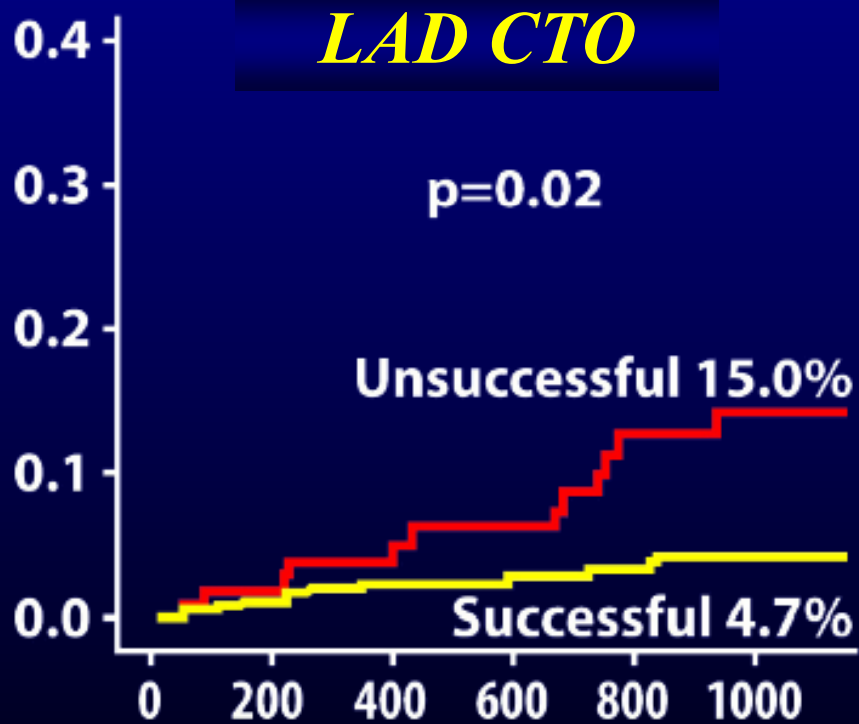
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PCI, TLR	27 (9.44)	7 (8.43)	0.834
Any TLR	33 (11.5)	19 (22.9)	0.012
Any PCI	38 (13.3)	9 (10.8)	0.584
Any MACE	35 (12.2)	21 (25.3)	0.005

# Clinical Impact of PCI in Totally Occluded LAD

1341 Consecutive Pts (1362 CTOs): Jan 2000-May 2007

Primary Endpoint: 3 yr mortality

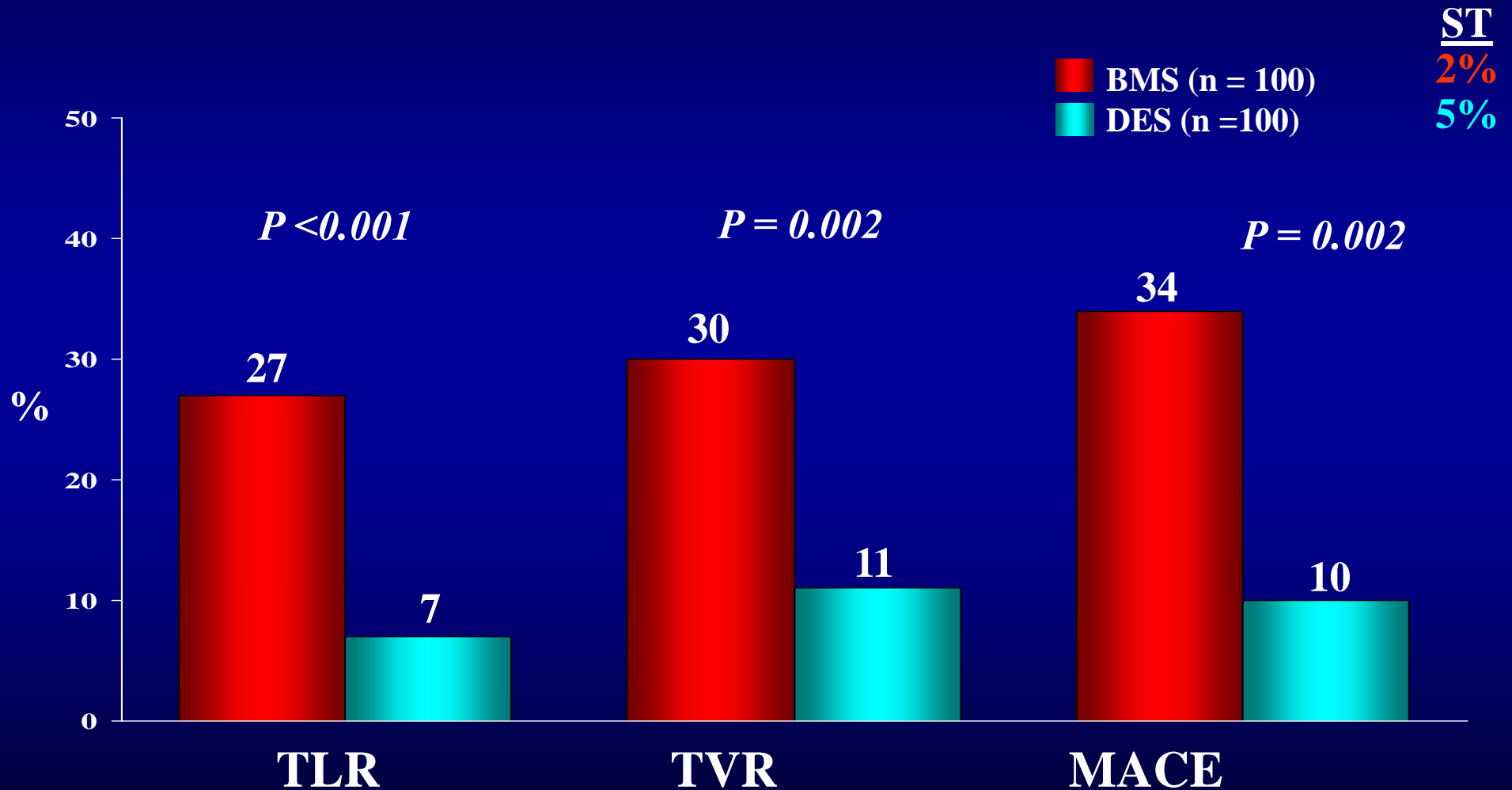


**Conclusion:** Patency of the LAD appears to be more important than patency of the LCX or RCA

Gordino et al. JACC 2009;53:A79

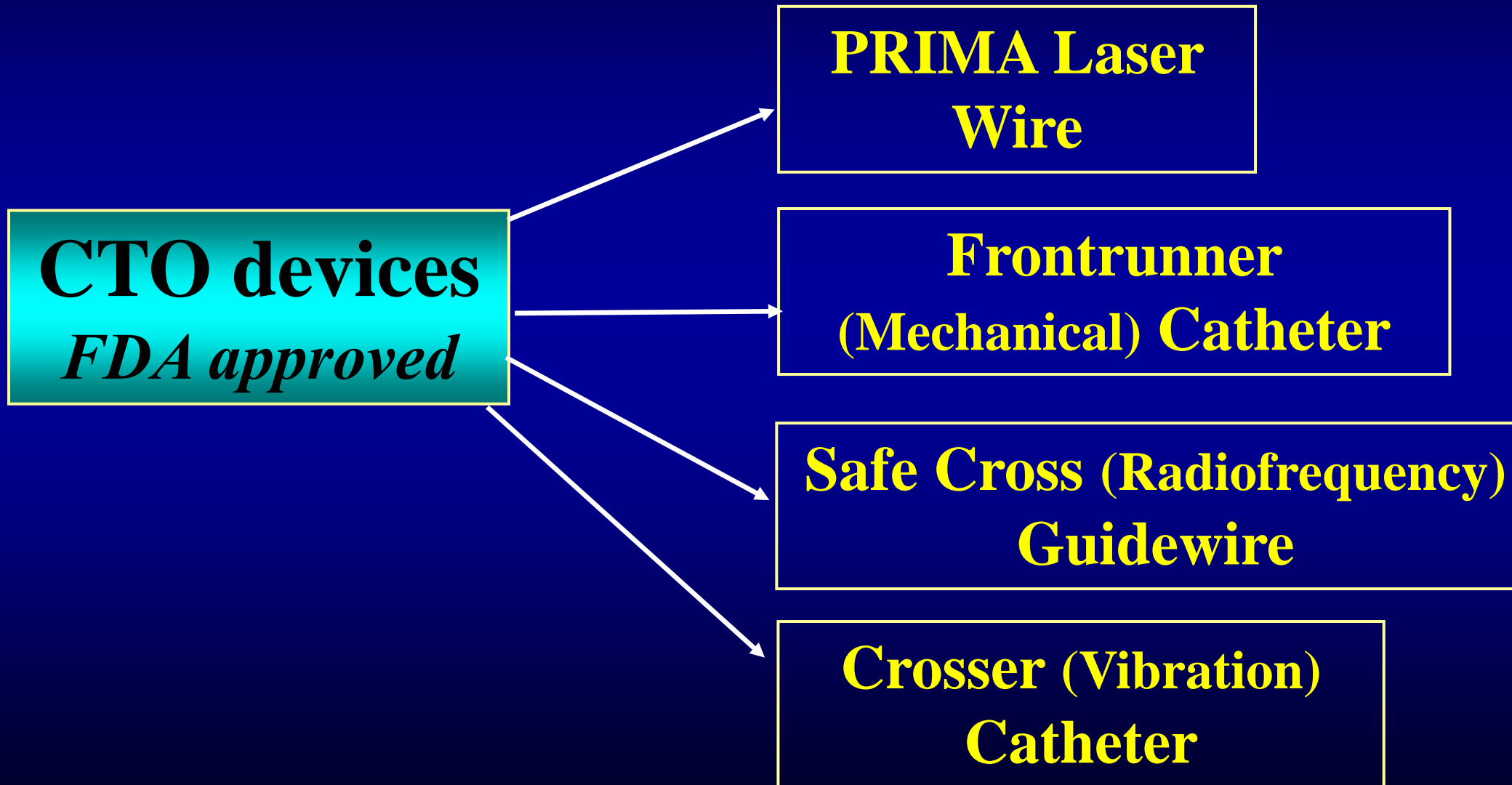
# Chronic Total Occlusion (CTO)

*PRISON II Trial: DES vs. BMS for CTO – 3 Year Outcome*



# New Devices for Chronic Total Occlusion

## *CTO Devices -Approved*



# New Devices for Chronic Total Occlusion

## *Novel Approach to CTO Under Investigation*

**Thrombolytic therapy**

**Collagenase infusion**

- **Therapeutic Ultrasound**  
Sonicross System  
Ultrasound wire

- **Lumen Re-entry**  
Pioneer catheter

- **Penetration device**  
Tornus, Corsair

- **Vibrational/Acoustic Devices**  
OmniWave, Resolution

- **Magnetic navigation**  
Cronus wire

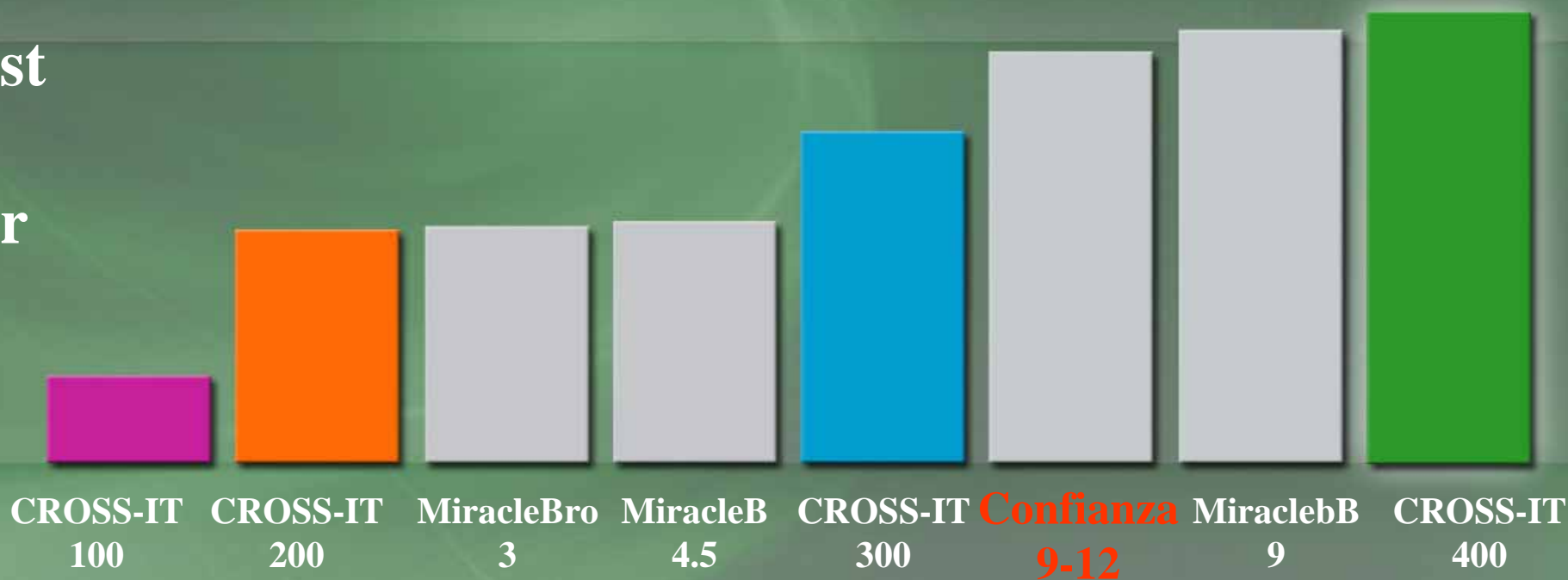
# Stiff Guide Wires for CSL/CTO

## Tip Stiffness


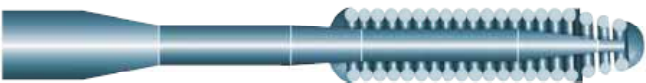

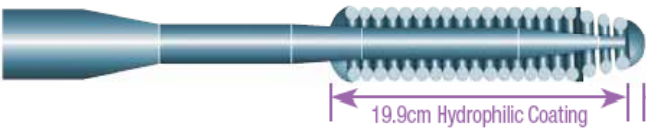

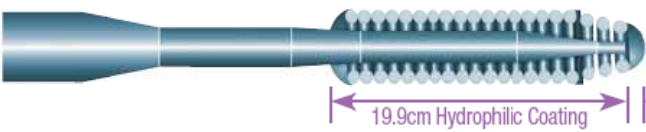
Stiffest

Stiffer

Stiff



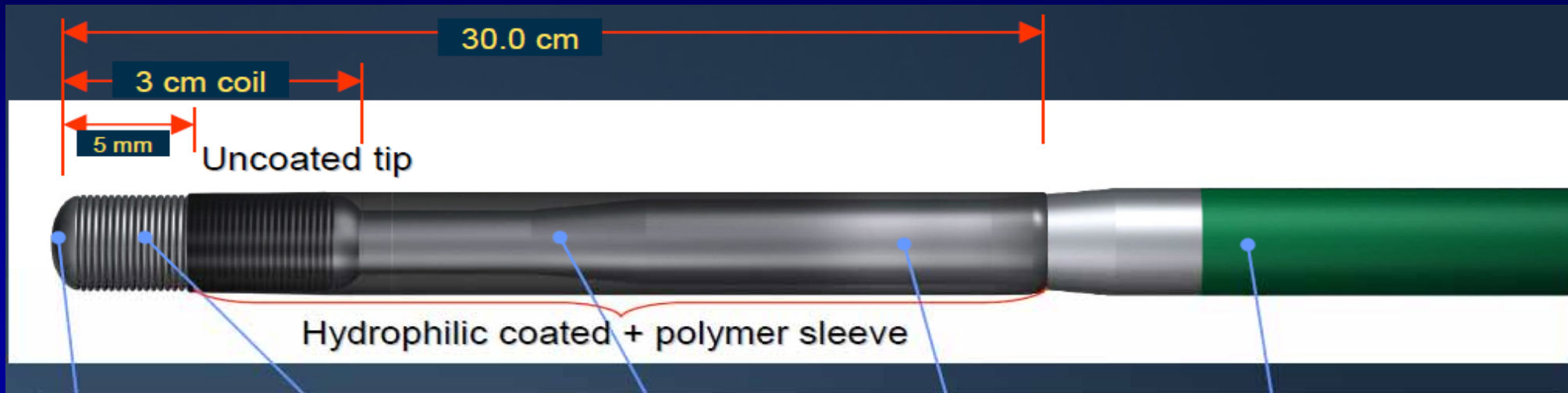
# Treating Chronically Stenosed Lesions (CSL) with Abbott Vascular Guide Wires

Straight Tip	Tapered Tip
<p><b>ASAHI MIRACLEBROS™ 3</b></p> <ul style="list-style-type: none"> <li>• TIP LOAD: 3.0G</li> <li>• Radiopacity length: 11cm</li> <li>• Joint-less</li> </ul> 	<p><b>ASAHI CONFIANZA™ 9</b></p> <ul style="list-style-type: none"> <li>• TIP LOAD: 9.0G</li> <li>• Radiopacity length: 20cm</li> <li>• Outside diameter: 0.014inch</li> <li>• Tip outside diameter: 0.009inch</li> <li>• Joint-less</li> </ul> 
<p><b>ASAHI MIRACLEBROS™ 4.5</b></p> <ul style="list-style-type: none"> <li>• TIP LOAD: 4.5G</li> <li>• Radiopacity length: 11cm</li> <li>• Joint-less</li> </ul> 	<p><b>ASAHI CONFIANZA PRO™ 9</b></p> <ul style="list-style-type: none"> <li>• TIP LOAD: 9.0G</li> <li>• Radiopacity length: 20cm</li> <li>• Outside diameter: 0.014inch</li> <li>• Tip outside diameter: 0.009inch</li> <li>• Joint-less</li> </ul> <p>The working length has a hydrophilic coating to ease navigation while the distal 1mm tip is hydrophobic for increased control and tactile feedback in chronic occlusions.</p>  <p>19.9cm Hydrophilic Coating</p>
<p><b>ASAHI MIRACLEBROS™ 6</b></p> <ul style="list-style-type: none"> <li>• TIP LOAD: 6.0G</li> <li>• Radiopacity length: 11cm</li> <li>• Joint-less</li> </ul> 	<p><b>ASAHI CONFIANZA PRO™ 12</b></p> <ul style="list-style-type: none"> <li>• TIP LOAD: 12.0G</li> <li>• Radiopacity length: 20cm</li> <li>• Outside diameter: 0.014inch</li> <li>• Tip outside diameter: 0.009inch</li> <li>• Joint-less</li> </ul> <p>The working length has a hydrophilic coating to ease navigation while the distal 1mm tip is hydrophobic for increased control and tactile feedback in chronic occlusions.</p>  <p>19.9cm Hydrophilic Coating</p>

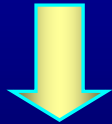
Increasing Support

# Chronic Total Occlusion (CTO)

## *HI-TORQUE PROGRESS Guidewires (40-200T)*



**Variation in tip diameter & stiffness**



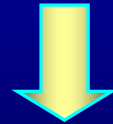
**Step up approach to penetrate lesions**

**Uncoiled, exposed tip coils**



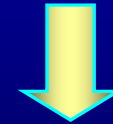
**Tactile feedback, minimize perforation**

**Tapered hydrophilic polymer**



**Lesion crossing and distal access**

**Core-to-tip transitionless core**



**Torque and control**

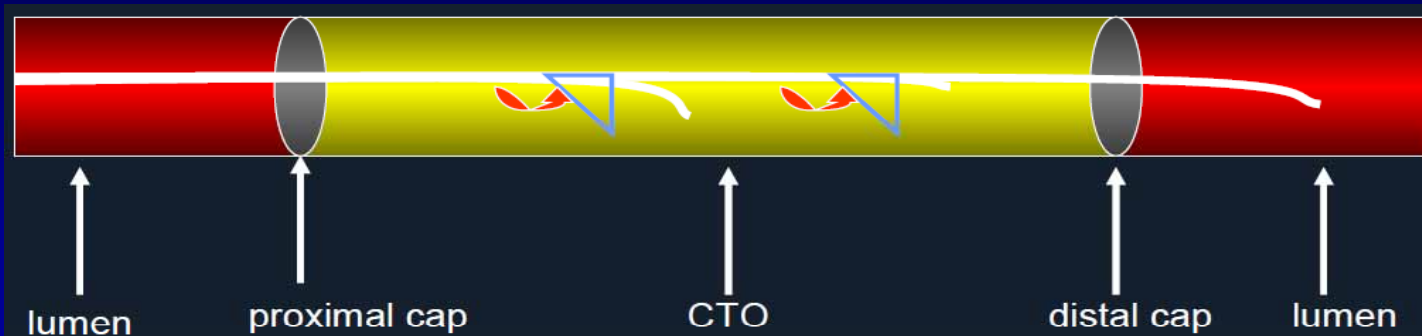
**Lubricious proximal coating**



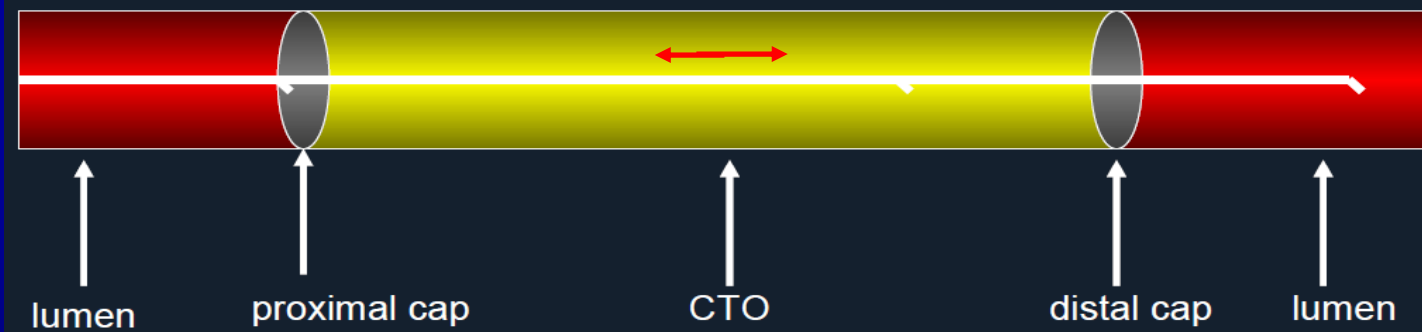
**Device compatibility**

# Chronic Total Occlusion (CTO)

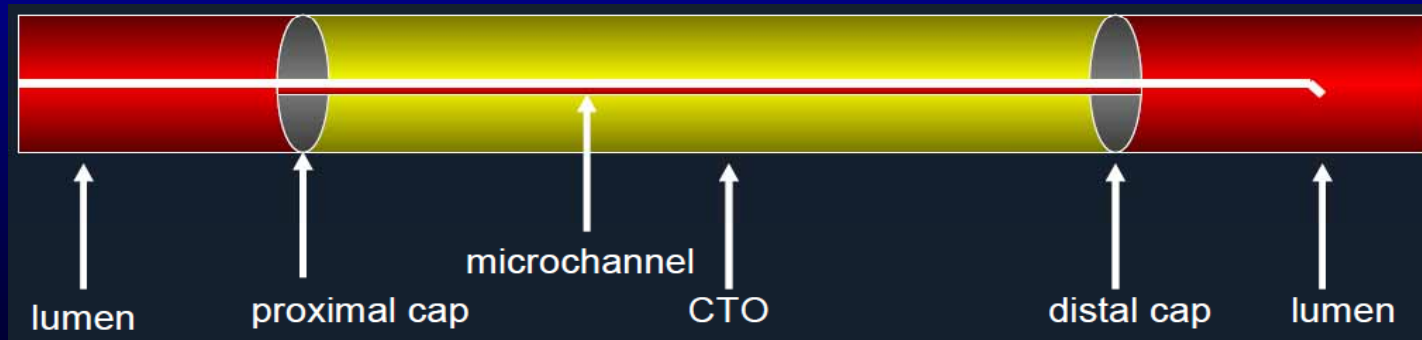
## *Antegrade CTO Wiring Technique*



*Controlled Drilling*



*Penetration Technique*



*Sliding Technique*

# **Advanced Techniques for Chronic Total Occlusion**

## *Japanese Specialized Technique*

- **Anchor balloon technique**
- **Mother-Child catheter technique**
- **Parallel wire**
- **IVUS guidance**
- **Retrograde approach**

# Retrograde Approach

- **Typically reserved for LAD or RCA CTOs via septal collaterals**
- **Three techniques:**
  - **Direct retrograde crossing**
  - **Kissing wire**
  - **Controlled Antegrade and Retrograde Technique (CART)**

# Concept of CART technique

*Controlled Antegrade and Retrograde Suboptimal Tracking*



# Support Catheters

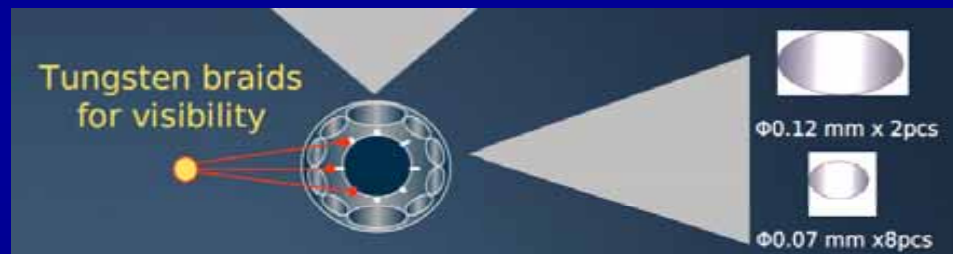
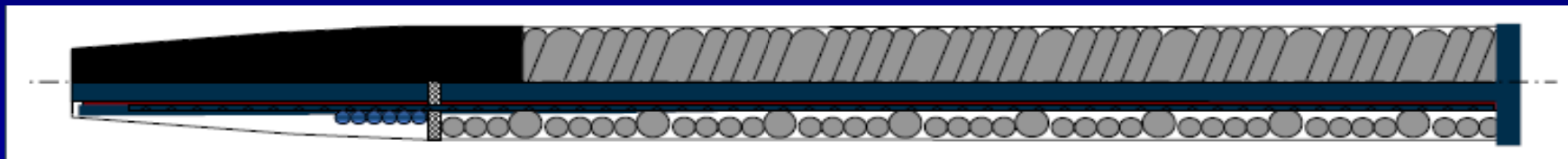


**Finecross**  
**1.5mm OTW Balloon**  
**Quick cross**  
**Minicross**  
**Corsair**

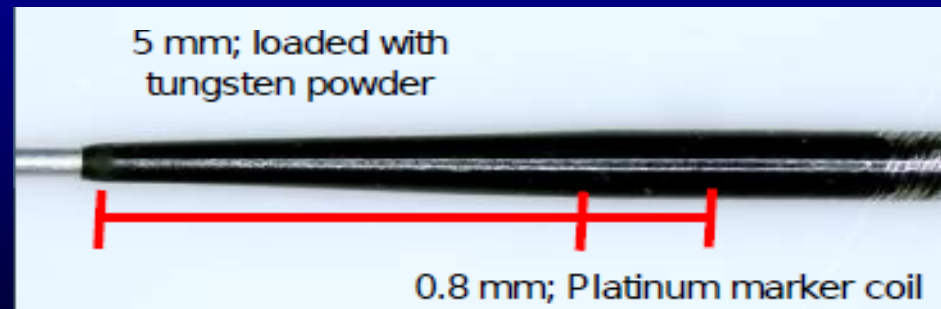
# Chronic Total Occlusion (CTO)

## *Corsair Micro-Catheter*

For crossing & dilating small vessels: SHINKA Shaft



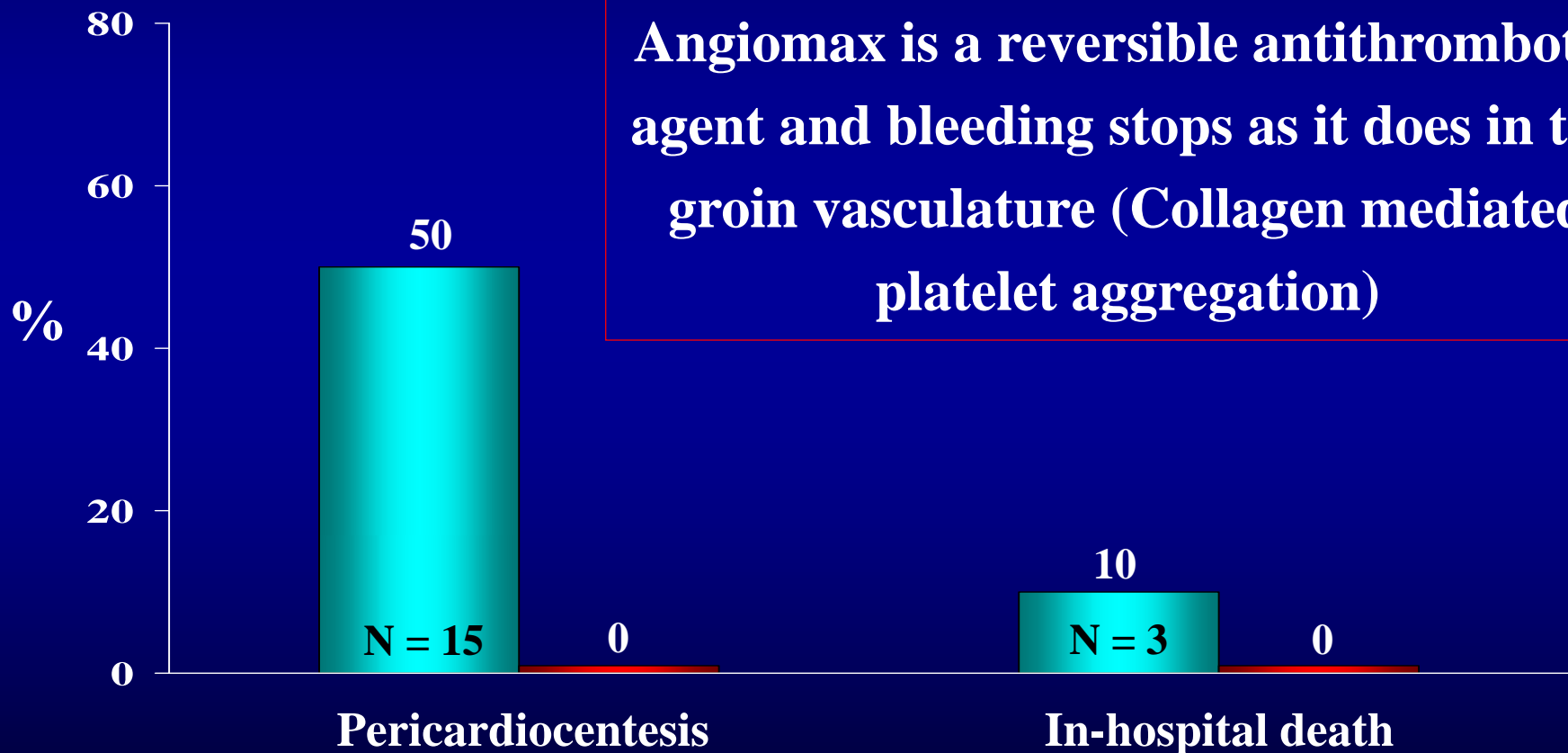
8 thin wires wound with 2 larger ones = pushability, trackability



# Wire Perforation during PCI

## Mount Sinai Experience

■ Heparin (n = 30)  
■ Angiomax (n = 20)



Angiomax is a reversible antithrombotic agent and bleeding stops as it does in the groin vasculature (Collagen mediated platelet aggregation)

# CTO PCI: Technical Considerations

- **Planned procedure** – not >1-2 in a day
  - Careful assessment of symptoms, and target site viability + ischemia based on the appropriateness criteria
- **Proper views**
  - Must visualize stump, collaterals and distal parent vessel beyond the CTO segment (consider contra-lateral injection)
- **Strong guiding catheter support**
  - 6-8 Fr, trans-femoral preferred
  - Long sheaths, short guides for retrograde
- **Bilateral angiography** from the outset in essentially ALL cases
- **Time limit of radiation exposure and contrast volume**
- **Initial floppy wire passage for distal or angulated CTOs**
- **Increasing stiffness of the wires**
- **Support/transit catheters or small OTW balloon**

# Appropriateness Criteria for Coronary Revascularization

Table 2. Patients Without Prior Bypass Surgery

Indication		Appropriateness Score (1-9)		
		CCS Angina Class		
		Asymptomatic	I or II	III or IV
22.	<ul style="list-style-type: none"> <li>Chronic total occlusion of 1 major epicardial coronary artery, without other coronary stenoses</li> <li>Low-risk findings on noninvasive testing</li> <li>Receiving no or minimal anti-ischemic medical therapy</li> </ul>	I <sub>(1)</sub>	I <sub>(2)</sub>	I <sub>(3)</sub>
23.	<ul style="list-style-type: none"> <li>Chronic total occlusion of 1 major epicardial coronary artery, without other coronary stenoses</li> <li>Low-risk findings on noninvasive testing</li> <li>Receiving a course of maximal anti-ischemic medical therapy</li> </ul>	I <sub>(1)</sub>	U <sub>(4)</sub>	U <sub>(6)</sub>
24.	<ul style="list-style-type: none"> <li>Chronic total occlusion of 1 major epicardial coronary artery, without other coronary stenoses</li> <li>Intermediate-risk findings on noninvasive testing</li> <li>Receiving no or minimal anti-ischemic medical therapy</li> </ul>	I <sub>(3)</sub>	U <sub>(4)</sub>	U <sub>(6)</sub>
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# Take Home Message: Techniques of For CTO PCI and DES

- ✓ Optimal techniques and strategy are crucial to avoid any potential complications in complex CTO, *Wires selection with graded stiffness*
- ✓ Requires long time and resources and hence should be carefully planned, *patience, patience, patience and second try*
- ✓ DES is preferred after successful recanalization