

**Dallas CVI**  
**December 7, 2013**

**Coronary Chronic Total Occlusion  
Interventions: state of the art 2013**

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## **ES Brilakis: Disclosures**

**Consulting/speaker honoraria: St Jude Medical, Terumo, Janssen, Sanofi, Bridgepoint Medical/Boston Scientific**

**Employment (spouse): Medtronic**

**Grants: NIH –1R01HL102442**

**VA - I01-CX000787-01**

**VA CSP#571 – DIVA**

# Outline

## 1. Definition – prevalence

## 2. Indications

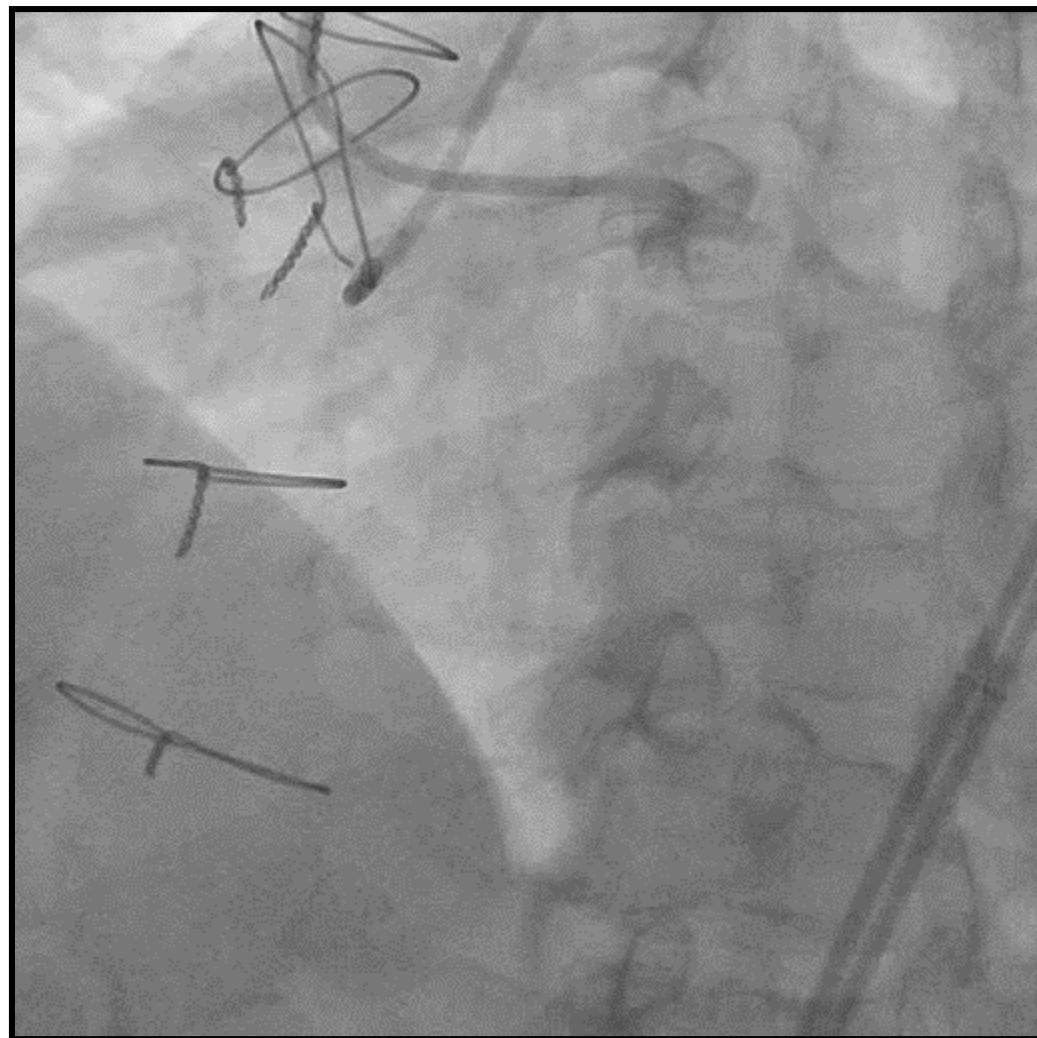
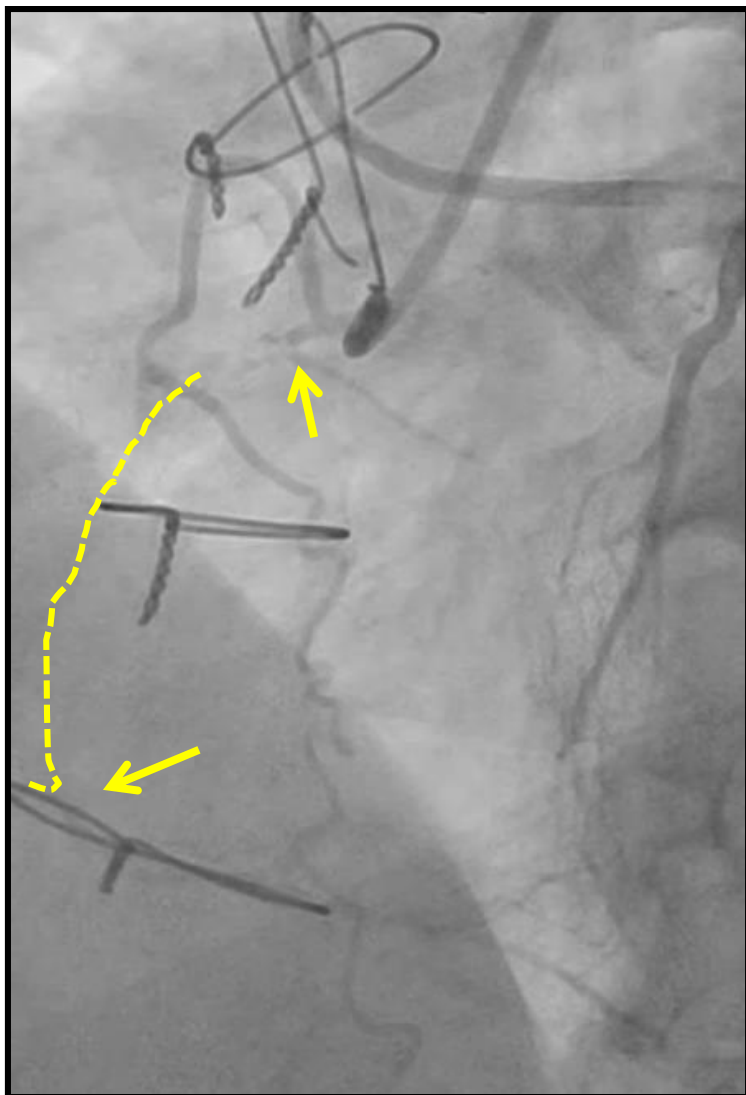
## 3. Technique

- **Wire crossing strategies**
- **Balloon Crossing**
- **Stents**

## 4. Complications



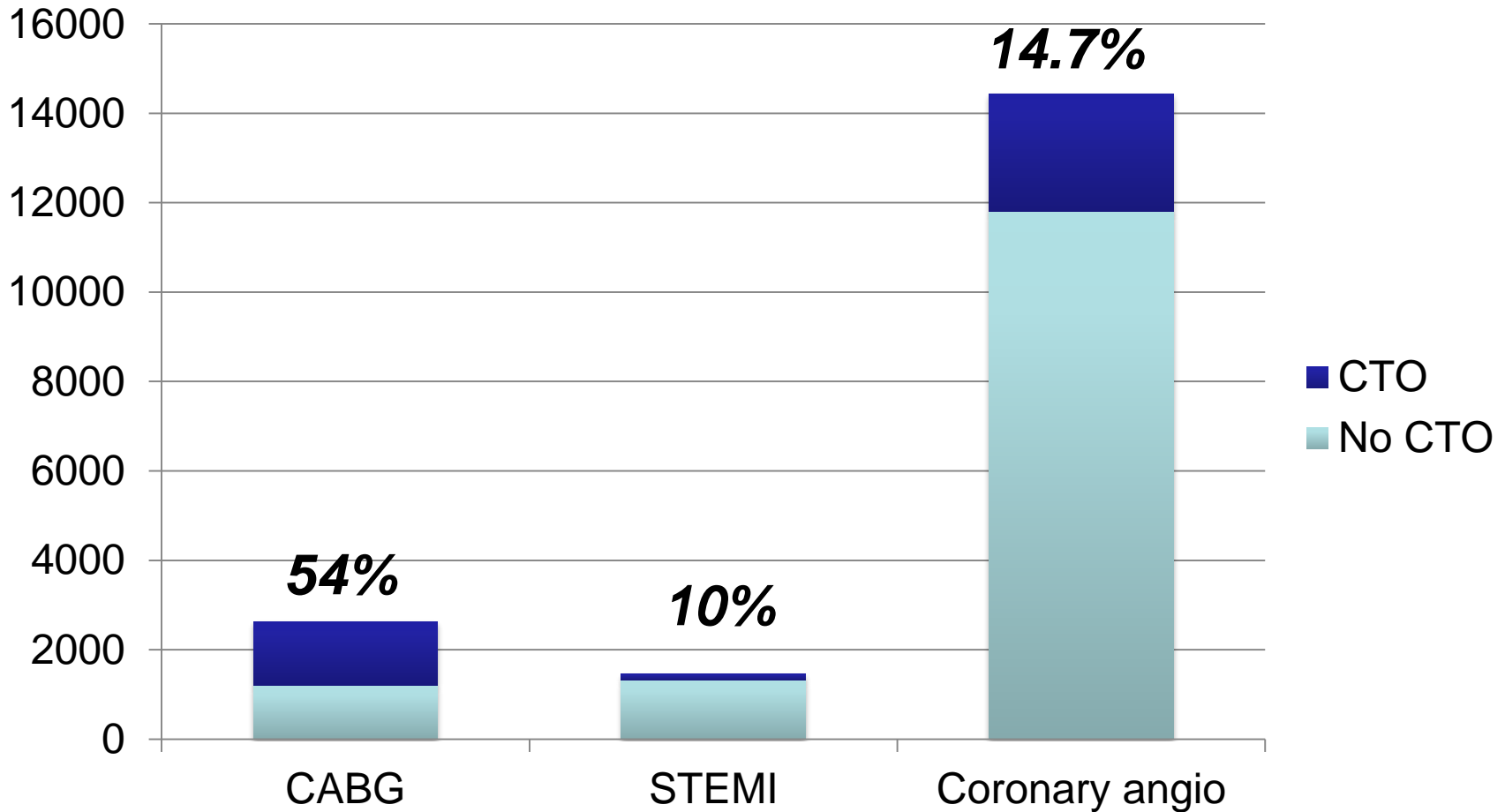
**CTO: occlusion in the coronary artery with  
TIMI 0 flow of  $\geq 3$  months duration**



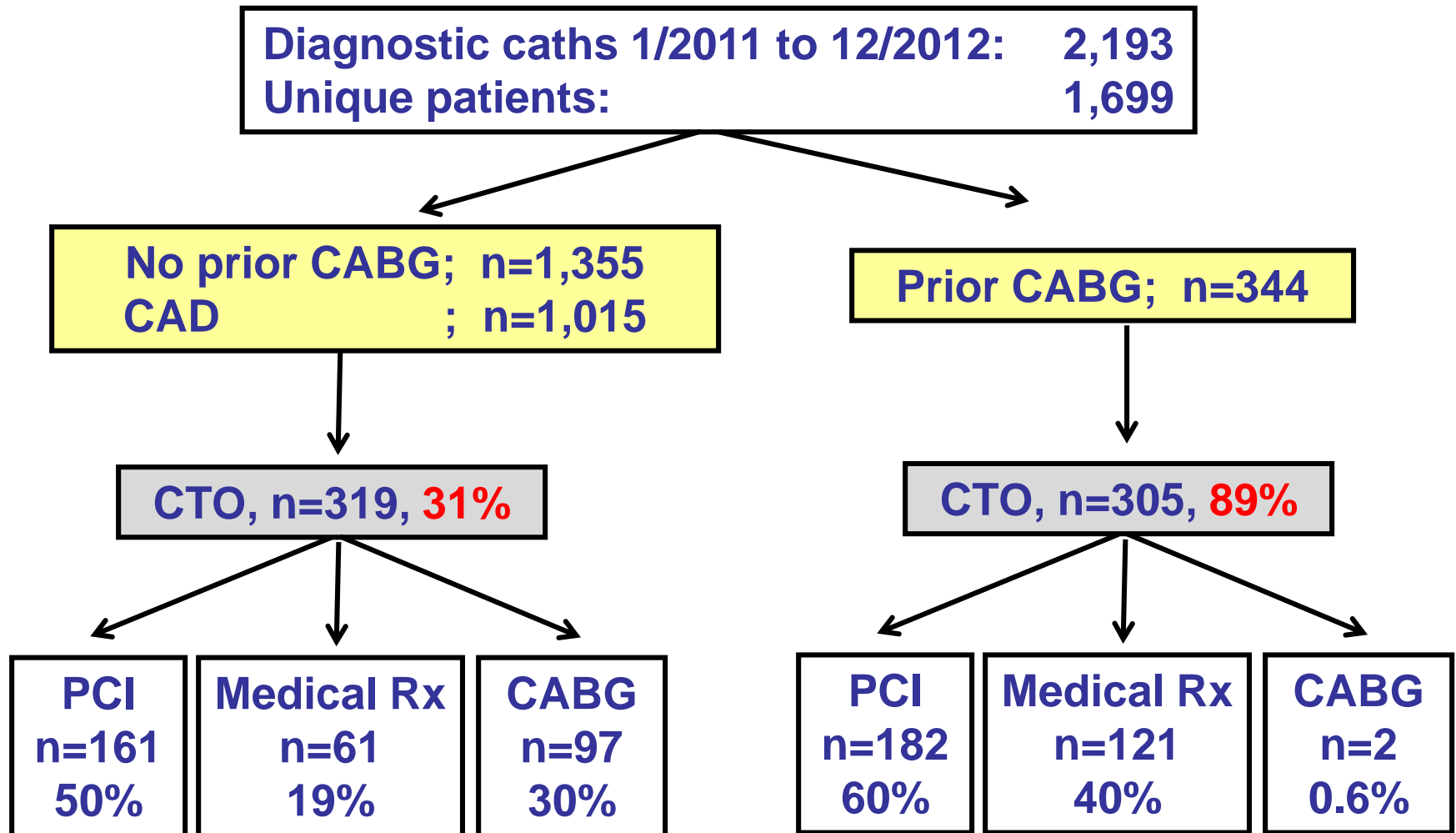
# CTO prevalence: Canadian registry

**18.4% among pts with CAD**

# of pts



# Prevalence of CTOs and choice of revascularization in Dallas VAMC



# Outline

**1. Definition – prevalence**

**2. Indications**

**3. Technique**

- **Wire crossing strategies**
- **Balloon Crossing**
- **Stents**

**4. Complications**

# **Patient testimonial after right coronary artery chronic total occlusion intervention**



# Why open a CTO?

## Patient

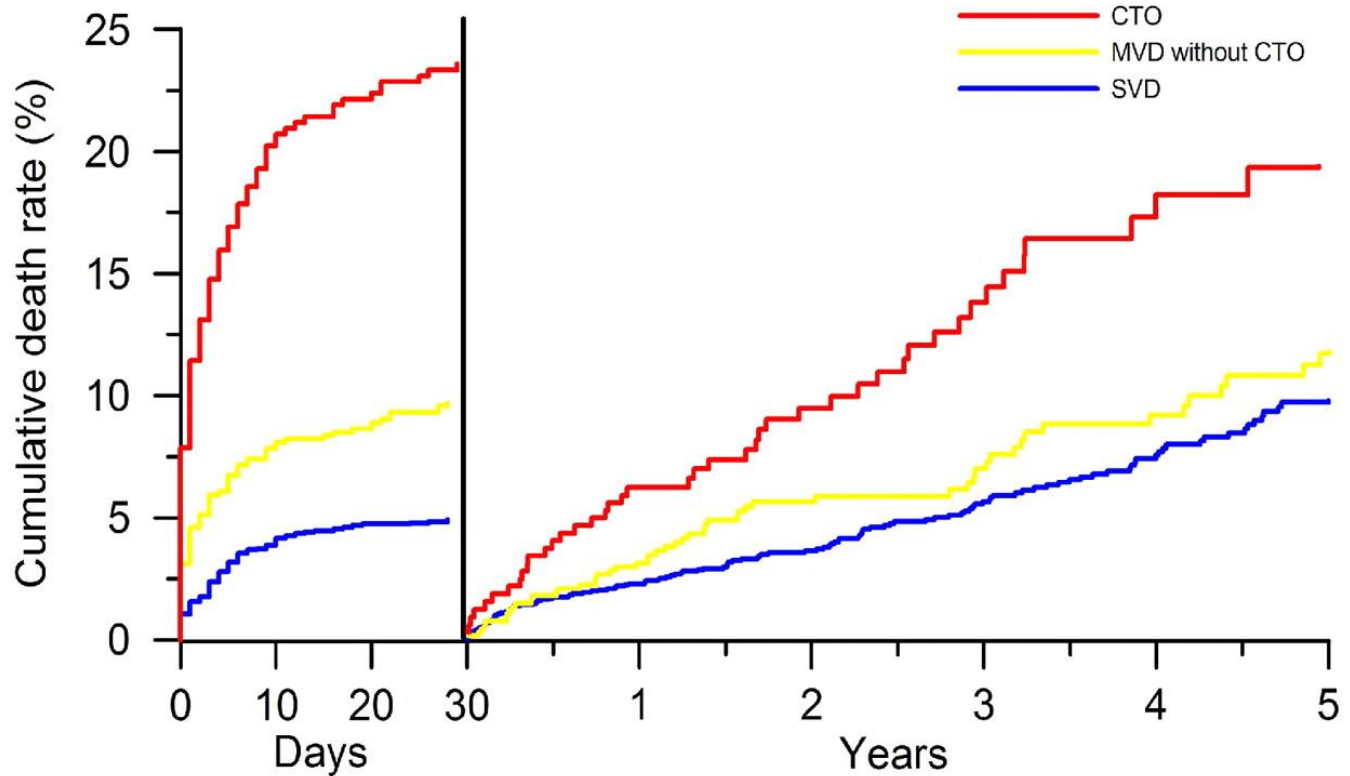
1. ↓ angina
2. ↑ LV function
3. ↓ consequences of future ACS
4. ↓ arrhythmias
5. ↓ CABG
6. ↓ nitrate use...

## Physician

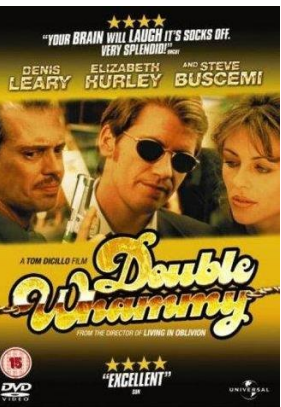
1. Help pts
2. Improve PCI skills
3. ↑ PCI volume



# Impact of CTO on outcomes post STEMI



	0	30	1	2	3	4	5
Number at Risk							
SVD	2114	2010	1852	1361	1010	665	436
MVD no CTO	741	669	617	419	320	240	184
CTO	420	320	285	196	138	89	61



**Claessen, B. E.P.M. et al. J Am Coll Cardiol Intv 2009;2:1128-1134**

# Complete vs incomplete revascularization

## 89,883 Patients

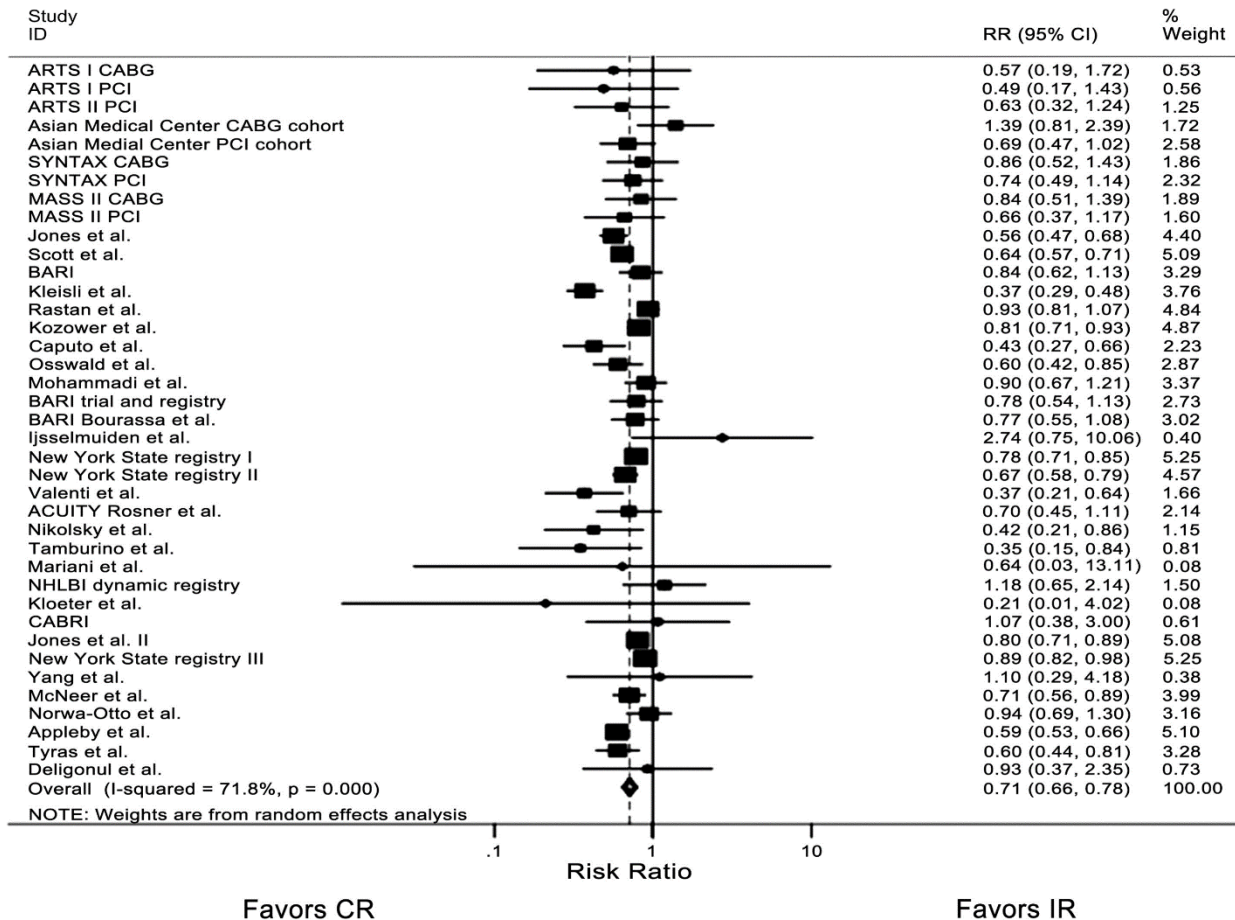
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12,259 out of 89,883  
(13%) died during follow  
up.

CR was associated with  
**reduced long-term  
mortality** relative to IR  
(risk ratio (RR):0.71; 95%  
[CI]:0.65-0.77, p<0.001

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.**



**RR = 0.71 [0.65-0.77], p<0.001**

Garcia, ..., Brilakis. *J Am Coll Cardiol.* 2013;62:1421-1431

# Outline

## 1. Definition – prevalence

## 2. Indications

## 3. Technique

- Wire crossing strategies
- Balloon Crossing
- Stents

## 4. Complications

# Getting Things ~~\_\_\_\_\_~~ DONE

The Art of  
Stress-Free  
Productivity



**David Allen**

author of *Ready for Anything*

"The personal productivity guru."  
—Fast Company



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# CTOs

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## 3. How?





2004-2007 The "early" years

2007-2010 "Crazy years"

2010- Moving on....

Catheterization and Cardiovascular Interventions 73:326-331 (2008)

**Case Reports**

**Successful Retrograde Treatment of a Mid Left Anterior Descending Artery Chronic Total Occlusion Using a Novel "Guide Parallel to Wire" Technique**

Emmanouil S. Brilakis,<sup>1</sup> MD, PhD, FSCAI and Subhash Banerjee, MD, FSCAI

**Abstract:** Adequate crossing of a chronic total occlusion adjacent to a large side branch may fail. We describe a patient in whom a chronic total occlusion of the proximal left anterior descending artery was successfully crossed retrogradely through an optical catheter after a failed antegrade crossing attempt. No balloon was long enough to reach the left anterior descending artery lesion retrogradely. A retrograde Whistler wire was snared through an antegrade left main guide catheter introduced via the radial approach. We were unable to reduce the wire via the radial guide catheter because of wire fracture during withdrawal. Externalization of the retrograde guidewire required use of a FrontRunner catheter and removal of the antegrade guide catheter. The balloon was predilated with a retrograde balloon inserted without a guide over the retrograde wire. A SF guide catheter was introduced next to the retrograde wire through the radial sheath (guide parallel to wire" technique) followed by successful antegrade crossing and stenting of the mid left anterior descending artery lesion. © 2008 Wiley-Liss, Inc.

**Key words:** percutaneous coronary intervention; heparin grafts; coronary new devices

Catheterization and Cardiovascular Interventions 75:109-113 (2010)

**Case Reports**

**Retrograde Recanalization of Native Coronary Artery Chronic Occlusions via Acutely Occluded Vein Grafts**

Emmanouil S. Brilakis,<sup>1,2</sup> MD, PhD, FSCAI, Subhash Banerjee,<sup>2</sup> MD, FSCAI, and William L. Lombardi,<sup>2</sup> MD, FSCAI

**Abstract:** Treatment of acutely occluded saphenous vein grafts may be challenging due to large thrombus burden and diffuse disease. We report two cases of thrombotic saphenous vein graft occlusion, in which other percutaneous attempts to recanalize the saphenous vein graft failed, the target native coronary artery chronic total occlusions were successfully treated using a retrograde approach. © 2010 Wiley-Liss, Inc.

**Key words:** percutaneous coronary intervention; coronary artery bypass grafts; thrombus

**Case Report**

**Hairpin-Trap: A Novel Stent Retrieval Technique**

Emmanouil S. Brilakis,<sup>1</sup> MD, PhD, FSCAI, Abdul-rahman R. Abdel-karim, MD, and Subhash Banerjee, MD, FSCAI

**Abstract:** We report a novel technique for retrieving lost stents or other equipment from the intravascular space. A hairpin is formed at the distal part of a 0.014 inch coronary guidewire, inserted through the Touhy valve, and used to "hook" the lost stent. The distal tip of the wire is then pulled back into the guiding catheter, when it is trapped by a balloon, forming a "hairpin-trap." The entire system is subsequently withdrawn. © 2010 Wiley-Liss, Inc.

**Key words:** stent loss; complications; percutaneous coronary intervention

Catheterization and Cardiovascular Interventions 00:000-000 (2010)

**Original Studies**

**Use of Drug-Eluting Stents for Chronic Total Occlusions: A Systematic Review and Meta-analysis**

Bilal Saeed,<sup>1</sup> MD, David E. Kandari,<sup>2</sup> MD, Pierfrancesco Agostoni,<sup>3</sup> MD, PhD, William L. Lombardi,<sup>2</sup> MD, Bavans V. Rangan,<sup>2</sup> MD, MCh, Subhash Banerjee,<sup>2</sup> MD, and Emmanouil S. Brilakis,<sup>2</sup> MD, PhD

**Abstract:** Aim: To perform a systematic review and meta-analysis of studies reporting outcomes after drug-eluting stent (DES) implantation in chronic total occlusions (CTOs). Methods: A review of publications and online databases in January 2010 reviewed 17 published studies that reported outcomes after DES implantation in CTOs after randomized studies, non-randomized comparative studies with bare-metal stents (BMS), or post-hoc analysis of a randomized trial, and one randomized trial. Data were pooled using random-effects meta-analysis models. Results: All published studies evaluated antithrombotic- or postdilatation-stents. All studies reporting comparative angiographic outcomes revealed less binary angiographic restenosis with DES implantation compared to BMS (odds ratio 0.15, 95% CI 0.06-0.38). Over a mean follow-up period of 18.3 ± 16.8 months, the cumulative incidence of death, myocardial infarction, or stent thrombosis was similar between DES and BMS in all studies. Target lesion recanalization (odds ratio 0.13, 95% CI 0.06-0.26) and target vessel revascularization (odds ratio 0.11, 95% CI 0.11-0.13) at 6-12 months were significantly lower among DES-treated patients. © 2010 Wiley-Liss, Inc.

Catheterization and Cardiovascular Interventions 76:391-394 (2010)

**Original Studies**

**Use of the Stingray® Guidewire and the Venture® Catheter for Crossing Flush Coronary Chronic Total Occlusions Due to In-Stent Restenosis**

Emmanouil S. Brilakis,<sup>1</sup> MD, PhD, FSCAI, William B. Lombardi,<sup>2</sup> MD, FSCAI, and Subhash Banerjee,<sup>2</sup> MD, FSCAI

**Abstract:** We report two cases of flush chronic total occlusion due to in-stent restenosis, in which percutaneous coronary intervention attempts via over-the-wire balloons and microcatheters failed to cross the lesion. Using the Venture® catheter for support and the Stingray® guidewire for enhanced penetration capability, both lesions were successfully crossed and stented. © 2010 Wiley-Liss, Inc.

**Key words:** chronic total occlusion; percutaneous coronary intervention; drug-eluting stent; devices

Catheterization and Cardiovascular Interventions 00:000-000 (2010)

**Original Studies**

**Use of the Venture Wire Control Catheter for the Treatment of Coronary Artery Chronic Total Occlusions**

Jose Miguel Harbe, MD, Abdul-Rahman R. Abdel-Karim, MD, Vijay M. Raju, MD, MD, Bavans V. Rangan, MD, MCh, Subhash Banerjee, MD, FSCAI, and Emmanouil S. Brilakis,<sup>1</sup> MD, PhD, FSCAI

**Abstract:** Background: The Venture catheter (St. Jude, Minneapolis, MN) has a defensible tip for negotiating wire crossing and a soft body. Both properties can be useful in percutaneous coronary interventions (PCI) of coronary artery chronic total occlusions (CTOs). Methods: We treated 20 consecutive patients in whom the Venture catheter was utilized during primary CTO PCI at our institution between May 2008 and September 2008. Results: Mean age was 68 ± 9 years and 90% of the patients were men. The CTO was previously treated in the right coronary artery (80%), left anterior descending artery (20%), circumflex (20%) or a subacute vein graft (0%). A prior attempt for CTO PCI had been done in 18%. The primary CTO PCI approach was antegrade in 18% and retrograde in 82%, but a retrograde approach was used in an additional 57% of the patients after antegrade approach failed. The Venture catheter was used to overcome vessel tortuosity (25%), for CTOs with side branches at the occlusion site (10%), to facilitate catheter branch entry during retrograde PCI (8%), and to provide wire support (8%). The overall CTO PCI success rate was 70%, and was 80% in patients with optimal Venture catheter use and in

ELSEVIER

Cardiovascular Revascularization Medicine 12 (2011) 170-176

**Contemporary outcomes of percutaneous intervention in chronic total coronary occlusions due to in-stent restenosis<sup>25</sup>**

Abdul-rahman R. Abdel-karim<sup>1</sup>, William B. Lombardi<sup>2</sup>, Subhash Banerjee<sup>2</sup>, Emmanouil S. Brilakis<sup>1,2</sup>

<sup>1</sup>VA North Texas Healthcare System and University of Texas Southwestern Medical Center, Dallas, Texas, USA  
<sup>2</sup>Department of Cardiology, St. Joseph's Hospital, Billingham, Washington, USA

Received 15 June 2010; received in revised form 4 August 2010; accepted 5 August 2010

Catheterization and Cardiovascular Interventions 78:395-399 (2011)

**Case Reports**

**"Ping-Pong" Guide Catheter Technique for Retrograde Intervention of a Chronic Total Occlusion Through an Ipsilateral Collateral**

Emmanouil S. Brilakis,<sup>1,2</sup> MD, PhD, FSCAI, J. Aaron Grantham,<sup>2</sup> MD, and Subhash Banerjee,<sup>2</sup> MD, FSCAI

**Abstract:** We report a novel technique for performing retrograde interventions on a coronary chronic total occlusion through an ipsilateral collateral. Two guiding catheters are used to engage the target coronary artery, one to advance to the retrograde guidewire and the other to externalize the retrograde guidewire and antegrade wiring. Engagement of the target coronary artery is alternating between the antegrade and the retrograde guide catheter in a "ping-pong" fashion, enabling lesion crossing and equipment delivery. © 2011 Wiley-Liss, Inc.

**Key words:** chronic total occlusion; percutaneous coronary intervention; technique

**Complex Case Intervention**

**"Bilateral Knuckle" Technique and Stingray Re-Entry System for Retrograde Chronic Total Occlusion Intervention**

Emmanouil S. Brilakis, MD, PhD, Neeraj Badhey, MD, Subhash Banerjee, MD

**Abstract:** We report a novel technique for retrograde chronic total occlusion intervention, in which the lesion is crossed by forming and advancing a "knuckle" in both the antegrade and retrograde guidewires, followed by reentry in the true lumen by using the Stingray re-entry system.

J INVASIVE CARDIOL 2011;23:E7-E9

**Key words:** chronic total occlusion; percutaneous coronary intervention; chronic total occlusion; stents

**Rapid Communication**

**Intravascular Ultrasound-Guided True Lumen Re-entry Successful Recanalization of Chronic Total Occlusions**

Subhash Banerjee, MD, Ryan Master, MD, Emmanouil S. Brilakis, MD, PhD

**Abstract:** We report a strategy of intravascular ultrasound-guided selection of the true lumen entry site from the subintimal space for predictable and successful re-entry, critical to successful recanalization of coronary chronic total occlusions.

J INVASIVE CARDIOL 2010;22:608-610

**Key words:** intravascular ultrasound, chronic total occlusion, stents

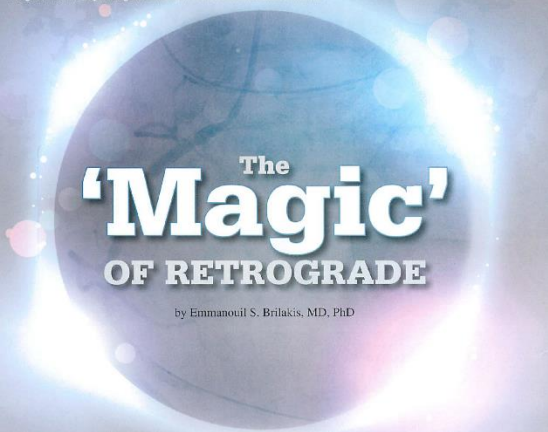
September, 2010

**Use of the Venture® Wire Control Catheter for Subintimal Coronary Dissection and Reentry in Chronic Total Occlusions**

Thu, 9/9/10 1:59pm | 0 Comments | 2949 reads

**Pages:** 445 - 448  
**Author(s):** Neeraj Badhey, MD, William L. Lombardi, MD, Craig A. Thompson, MD, MMSc, Emmanouil S. Brilakis, MD, PhD, FSCAI, Subhash Banerjee, MD, FSCAI





by Emmanouil S. Brilakis, MD, PhD

STATE-OF-THE-ART PAPER

**A Percutaneous Treatment Algorithm for Crossing Coronary Chronic Total Occlusions**

CME

Emmanouil S. Brilakis, MD, PhD,\* J. Aaron Grantham, MD,† Stéphane Rinfret, MD, SM,‡ R. Michael Wyman, MD,§ M. Nicholas Burke, MD,|| Dimitri Karpaliotis, MD,¶ Nicholas Lembo, MD,¶ Ashish Pershad, MD,‡ David E. Kandzari, MD,¶ Christopher E. Buller, MD,‡ Tony DeMartini, MD,‡ William L. Lombardi, MD,‡ Craig A. Thompson, MD, MMSc§§  
Dallas, Texas; Kansas City, Missouri; Torrance, California; Minneapolis, Minnesota; Atlanta, Georgia; Phoenix, Arizona; Quebec City, Quebec and Toronto, Ontario, Canada; Springfield, Illinois; Bellingham, Washington; and New Haven, Connecticut

**Retrograde Coronary Chronic Total Occlusion Revascularization**

**Procedural and In-Hospital Outcomes From a Multicenter Registry in the United States**

Dimitri Karpaliotis, MD,\* Tesfaldet T. Michael, MD, MPH,†† Emmanouil S. Brilakis, MD, PhD,†† Aristotelis C. Papayannis, MD,†† Daniel L. Tran, MSc,†† Ben L. Kirkland, BS,\* Nicholas Lembo, MD,\* Anna Kalynych, MD,\* Harold Carlson, MD,\* Subhash Banerjee, MD,†† William Lombardi, MD,§ David E. Kandzari, MD\*

Atlanta, Georgia; Dallas, Texas; and Bellingham, Washington

**Complications of Chronic Total Occlusion Angioplasty**

Emmanouil S. Brilakis, MD, PhD<sup>a,\*</sup>,  
Dimitri Karpaliotis, MD<sup>b</sup>, Vishal Patel, MD<sup>a</sup>,  
Subhash Banerjee, MD<sup>a</sup>



**THE ESSENTIAL EQUIPMENT for CTO Interventions**

by Emmanouil S. Brilakis, MD, PhD

IMAGES IN INTERVENTION

**Knuckle Wire and Stingray Balloon for Recrossing a Coronary Dissection After Loss of Guidewire Position**

Abelardo A. Martinez-Rumayor, MD, Subhash Banerjee, MD, Emmanouil S. Brilakis, MD, PhD  
Dallas, Texas

**Chronic Total Occlusions: Patient Selection and Overview of Advanced Techniques**

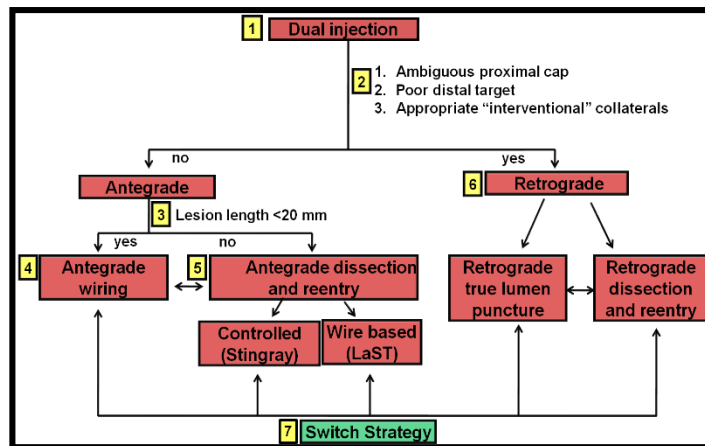
Santiago Garcia • Shuaib Abdullah • Subhash Banerjee • Emmanouil S. Brilakis

**Advances in Interventional Cardiology**

**Subintimal Dissection/Reentry Strategies in Coronary Chronic Total Occlusion Interventions**

Tesfaldet T. Michael, MD, MPH, Aristotelis C. Papayannis, MD, Subhash Banerjee, MD, Emmanouil S. Brilakis, MD, PhD

Received March 3, 2012; accepted July 12, 2012.  
From the VA North Texas Healthcare System and University of Texas Southwestern Medical Center, Dallas, TX.  
Corresponding to: Emmanouil S. Brilakis, MD, PhD, Dallas VA Medical Center (111A), 4500 South Lancaster Road, Dallas, TX 75216. E-mail: ebrilakis@psb.com  
(Circ Cardiovasc Interv: 2012;5:729-738).  
© 2012 American Heart Association, Inc.  
Circ Cardiovasc Interv is available at http://circinterventions.ahajournals.org DOI: 10.1161/CIRCINTERVENTIONS.112.969888



**Procedural Outcomes of Revascularization of Chronic Total Occlusion of Native Coronary Arteries (from a Multicenter United States Registry)**

Tesfaldet T. Michael, MD, MPH<sup>a,b</sup>, Dimitri Karpaliotis, MD<sup>a</sup>, Emmanouil S. Brilakis, MD, PhD<sup>a,b,c,d</sup>, Eric Fuh, MD<sup>a,b</sup>, Vishal G. Patel, MD<sup>a,d</sup>, Owen Mogabgab, MD<sup>a,d</sup>, Mohammed Alomar, MD<sup>a,b</sup>, Ben L. Kirkland, BS<sup>a</sup>, Nicholas Lembo, MD<sup>a</sup>, Anna Kalynych, MD<sup>a</sup>, Harold Carlson, MD<sup>a</sup>, Subhash Banerjee, MD<sup>a,b</sup>, William Lombardi, MD<sup>a</sup>, and David E. Kandzari, MD<sup>a</sup>

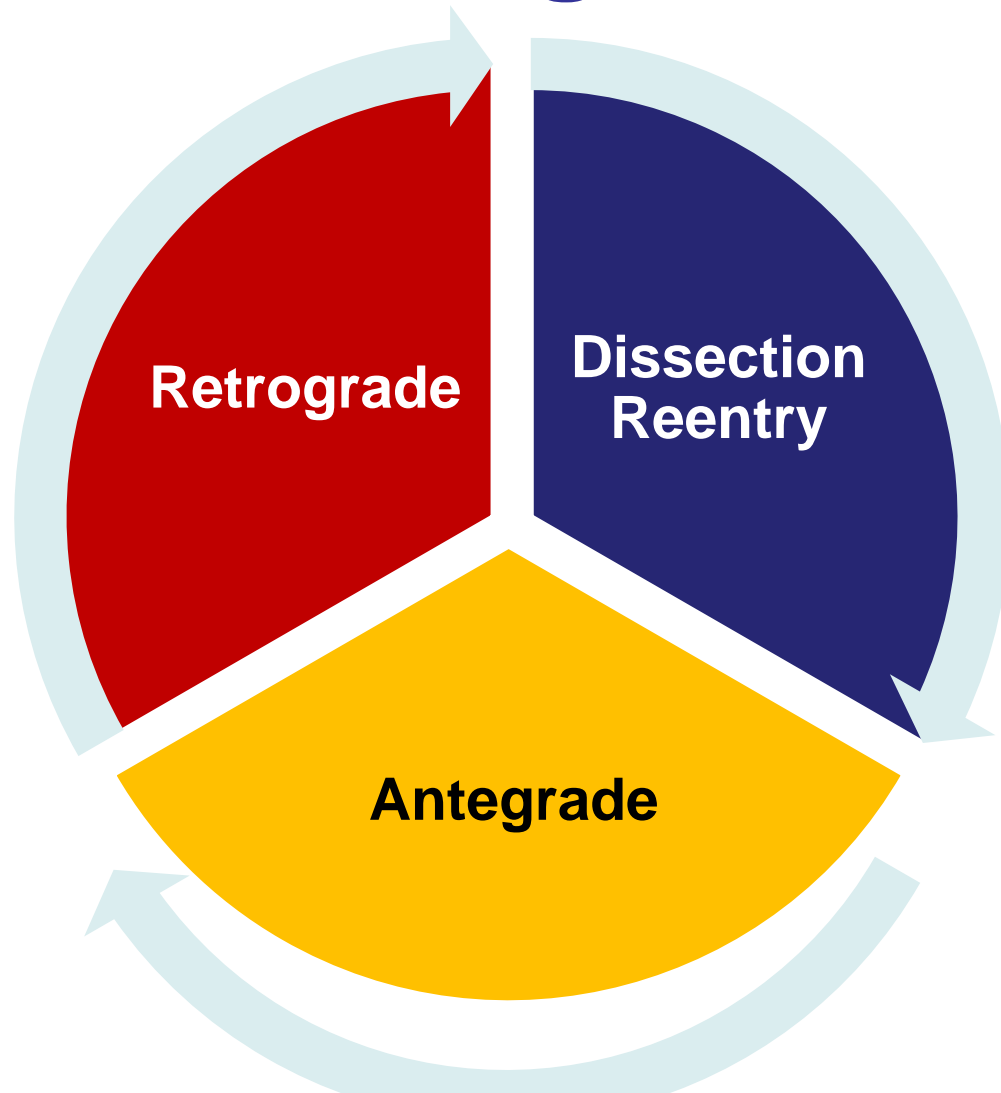
Percutaneous coronary intervention (PCI) of chronic total occlusions (CTOs) is a rapidly evolving area of interventional cardiology. We sought to examine the immediate procedural and in-hospital clinical outcomes of native coronary artery CTO PCI from a multicenter United States (US) registry. We retrospectively examined the procedural outcomes of 1,361 consecutive native coronary artery CTO PCIs performed at 3 US institutions from January 2006 to November 2011. Mean age was 65 ± 11 years, 85% of patients were men, 40% had diabetes, 37% had previous coronary artery bypass graft surgery, and 42% had previous PCI. The CTO target vessel was the right coronary artery (55%), circumflex (23%), left anterior descending artery (21%), and left main or bypass graft (1%). The retrograde approach was used in 34% of all procedures. The technical and procedural success rates were 85.5% and 84.2%, respectively. The mean procedure time, fluoroscopy time, and contrast utilization were 113 ± 61 minutes, 42 ± 29 minutes, and 294 ± 158 ml, respectively. In multivariate analysis, female gender, no previous coronary artery bypass surgery, and years since initiation of CTO PCI at each center were independent predictors of procedural success. Major complications occurred in 24 patients (1.8%). In conclusion, among selected US-based institutions with experienced operators, native coronary artery CTO PCI can be performed with high success and low major complication rates. Published by Elsevier Inc. (Am J Cardiol 2013;112:488–492)

ORIGINAL ARTICLE

**Impact of prior coronary artery bypass graft surgery on chronic total occlusion revascularisation: insights from a multicentre US registry**

Tesfaldet T Michael,<sup>1,2</sup> Dimitri Karpaliotis,<sup>3</sup> Emmanouil S Brilakis,<sup>1,2</sup> Shuaib M Abdullah,<sup>1,2</sup> Ben L Kirkland,<sup>3</sup> Katrina L Mishoe,<sup>4</sup> Nicholas Lembo,<sup>3</sup> Anna Kalynych,<sup>3</sup> Harold Carlson,<sup>3</sup> Subhash Banerjee,<sup>1,2</sup> William Lombardi,<sup>4</sup> David E Kandzari<sup>3</sup>

# CTO crossing techniques



# “Hybrid”

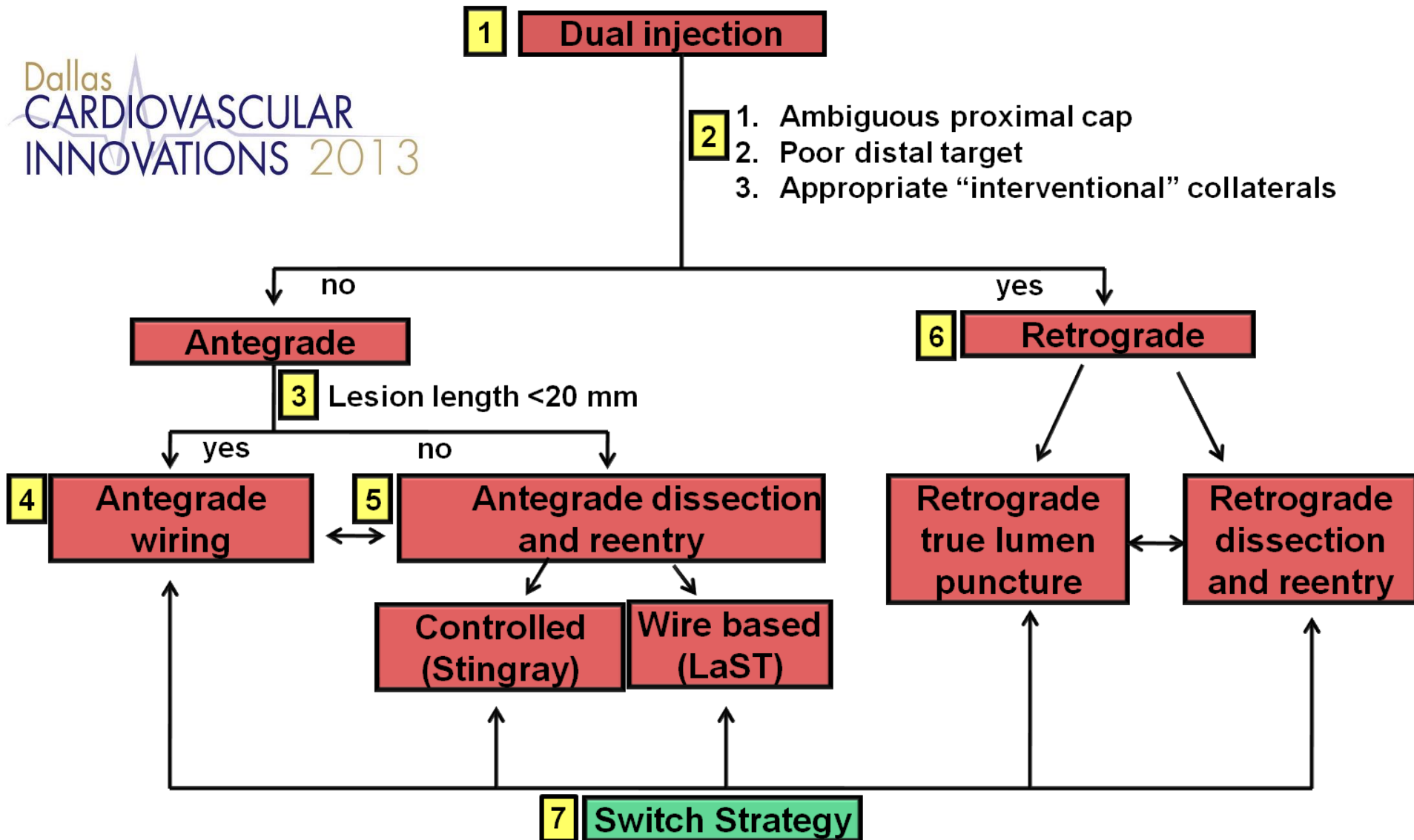
**an offspring resulting  
from cross-breeding**

**“Liger” –  
crossbreed  
for lion and  
tiger – bigger  
than either!**



# “Hybrid” CTO crossing algorithm

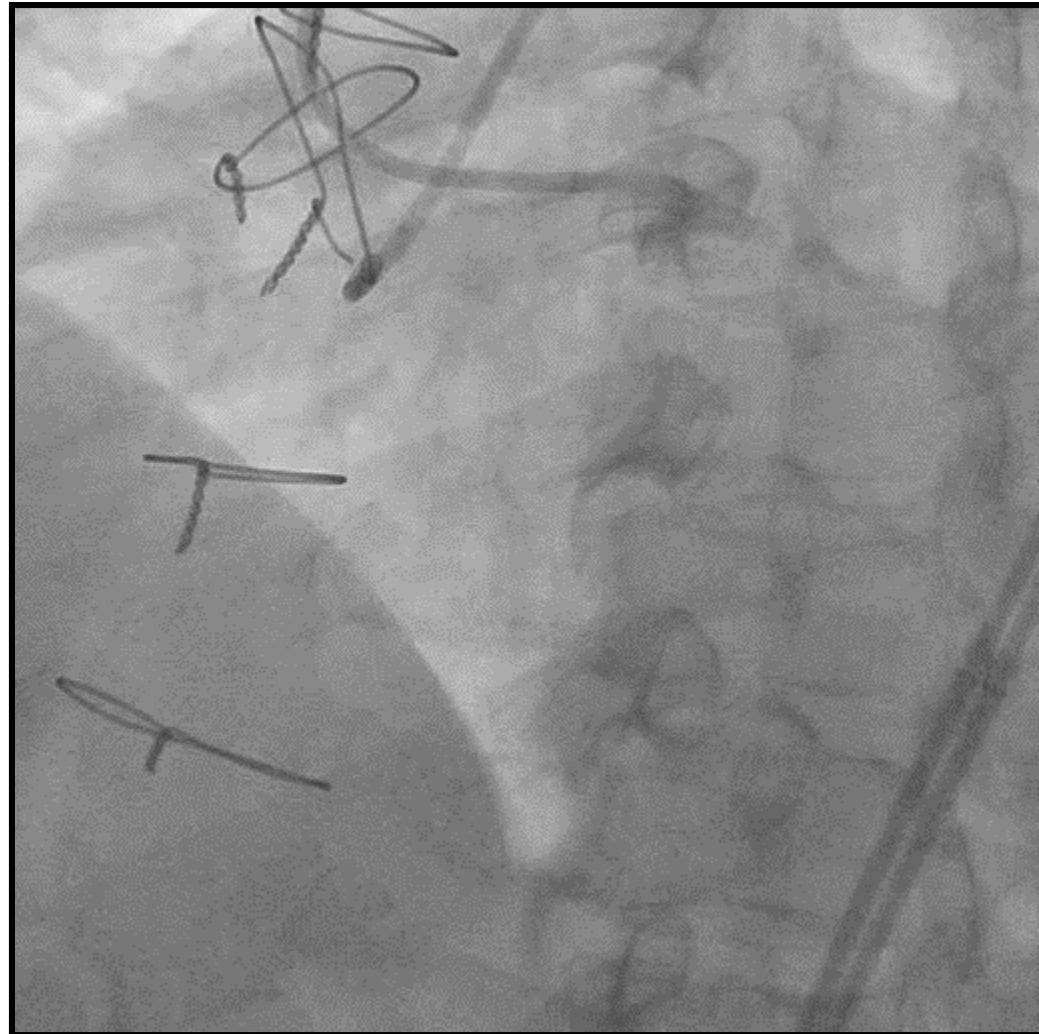
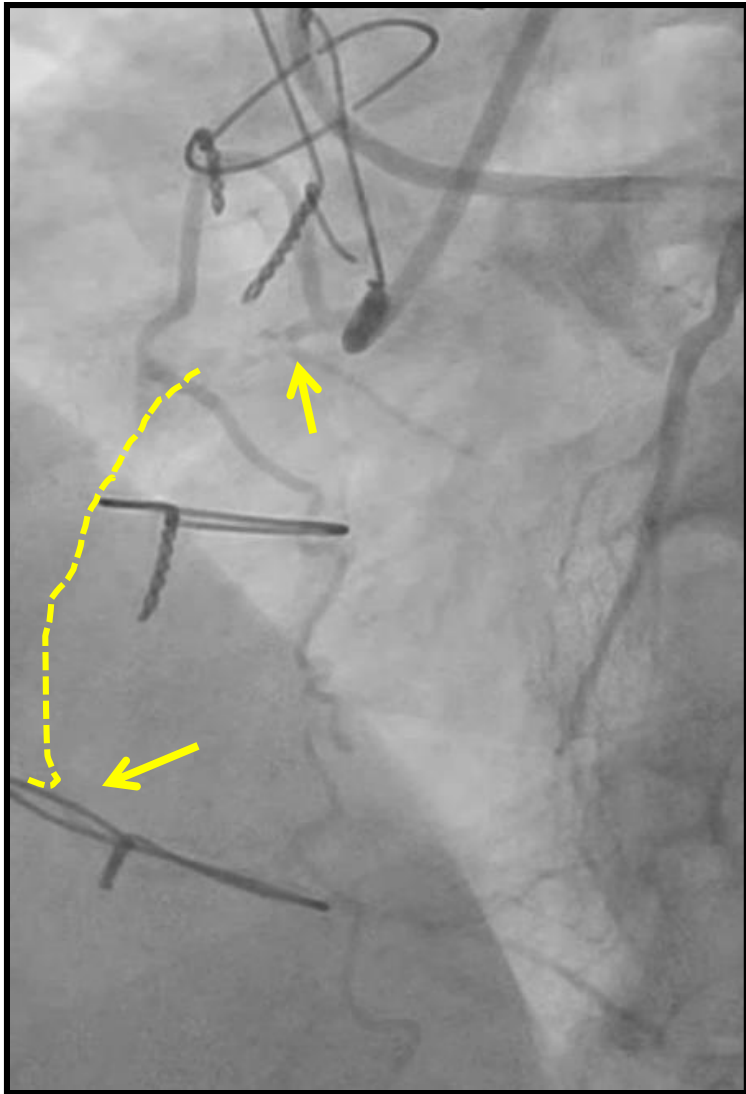
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*Brilakis, Grantham, Rinfret, Wyman, Burke, Karpaliotis, Lembo, Pershad, Kandzari, Buller, De Martini, Lombardi, Thompson. JACC Intv 2012*

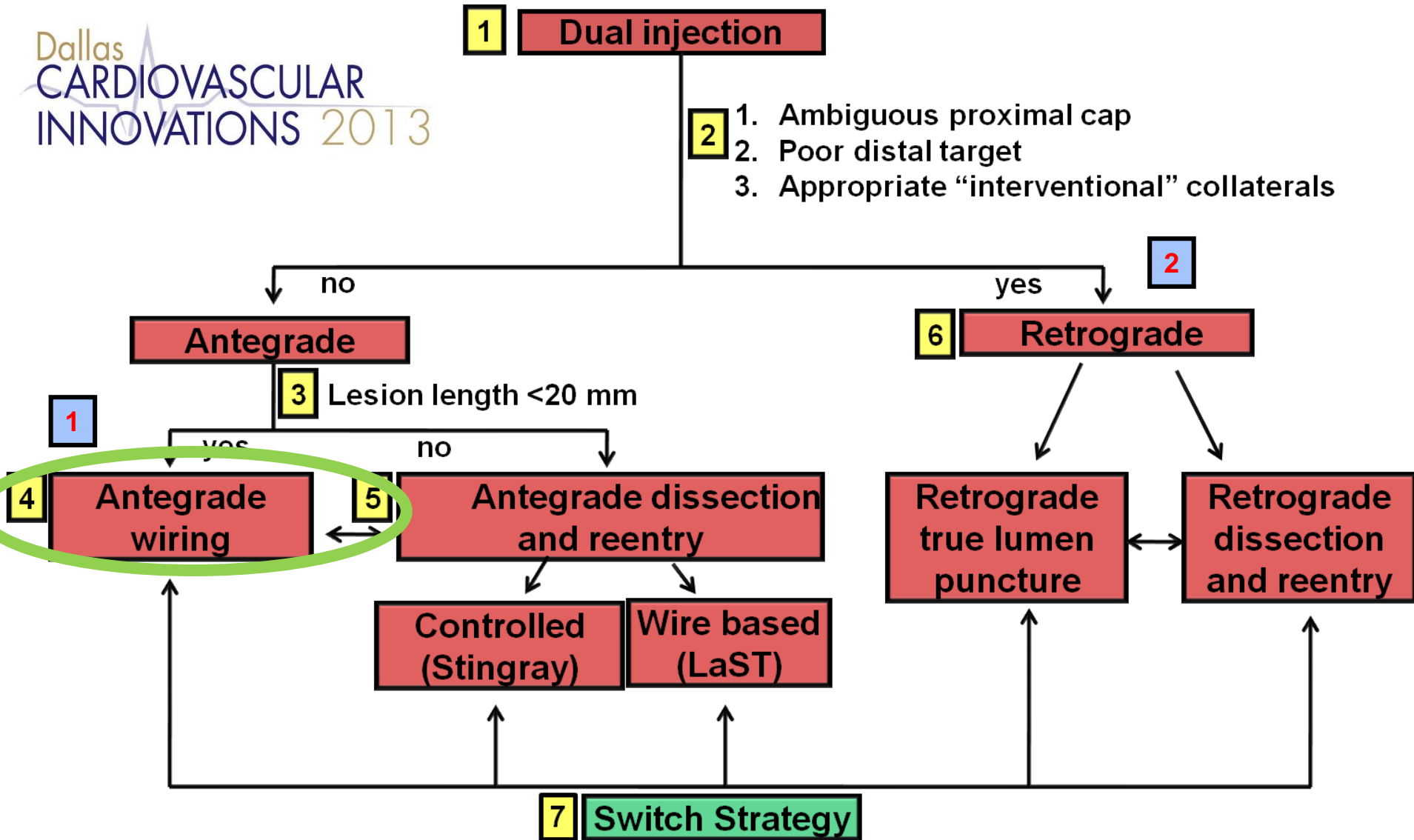


# Proximal RCA CTO – LAO view



# “Hybrid” CTO crossing algorithm

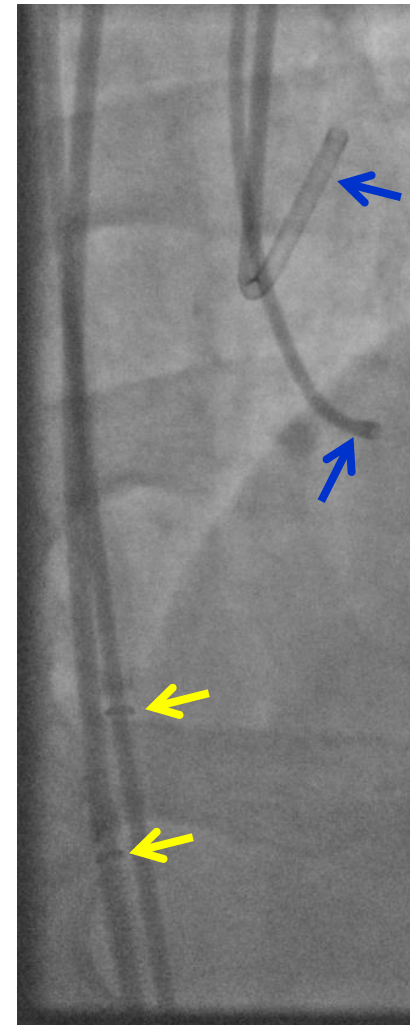
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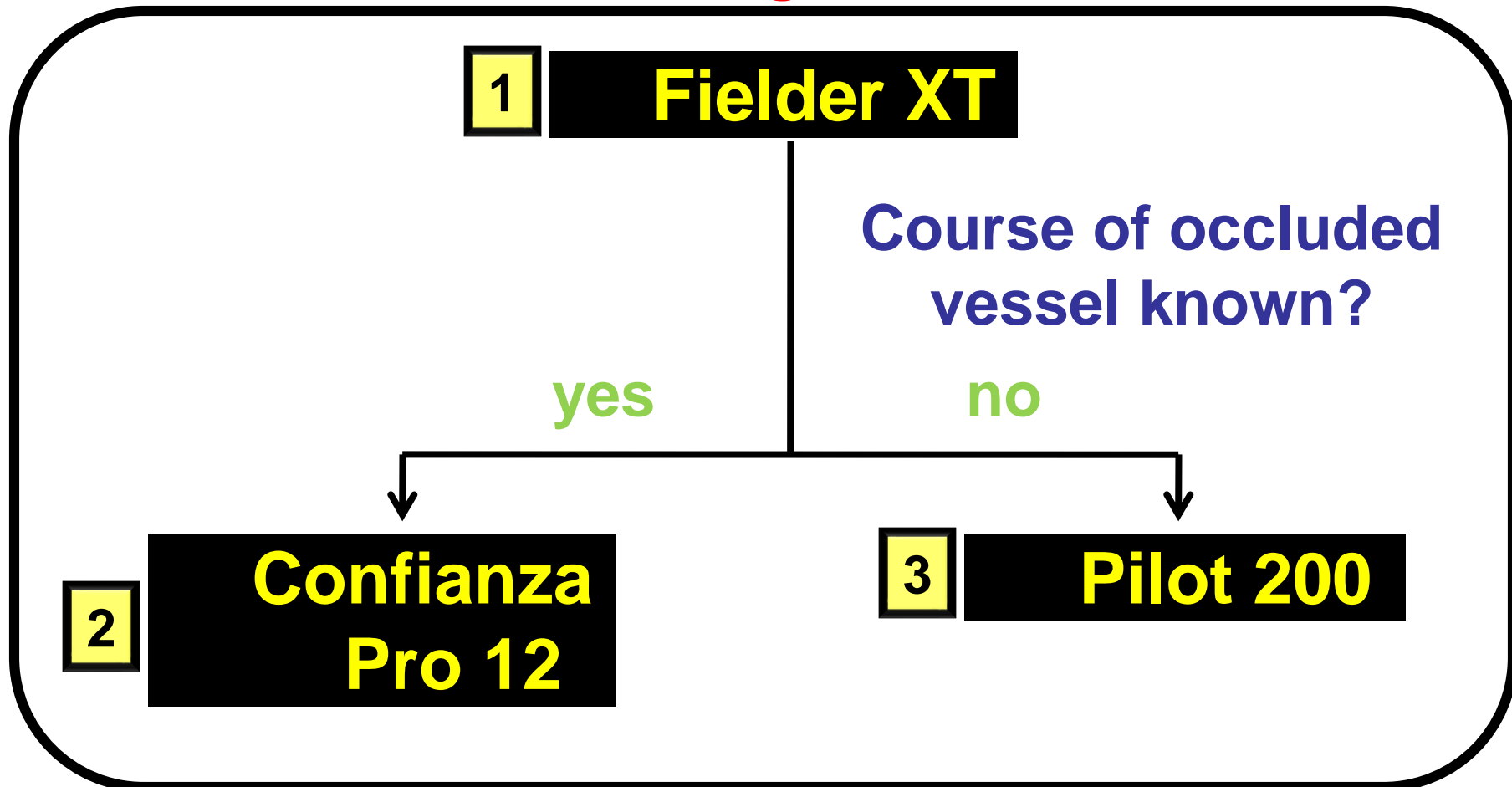
# CTO basics

1. Approach: femoral – consider **45 cm sheath**
2. Guide: **7 or 8 French** – support short/shortened **90 cm**
3. Virtually always: **dual injections**
4. Anticoagulation: **heparin**
5. Monitor radiation: **AK**
6. Ready to manage complications: **perforation - tamponade**



# Guidewire Selection Simplified

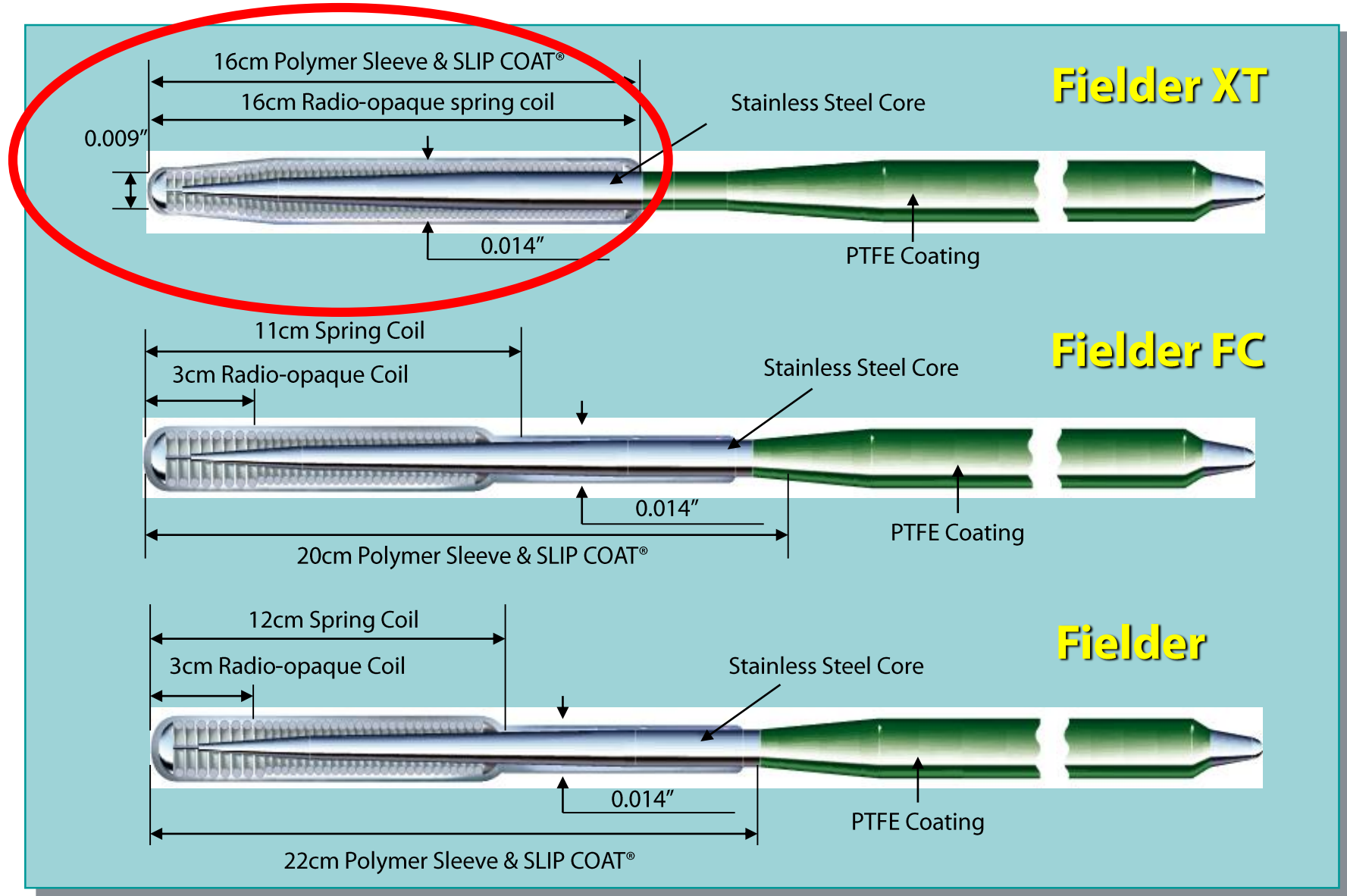
## Antegrade










## Retrograde

4 Sion

# ASAHI Fielder Guidewires



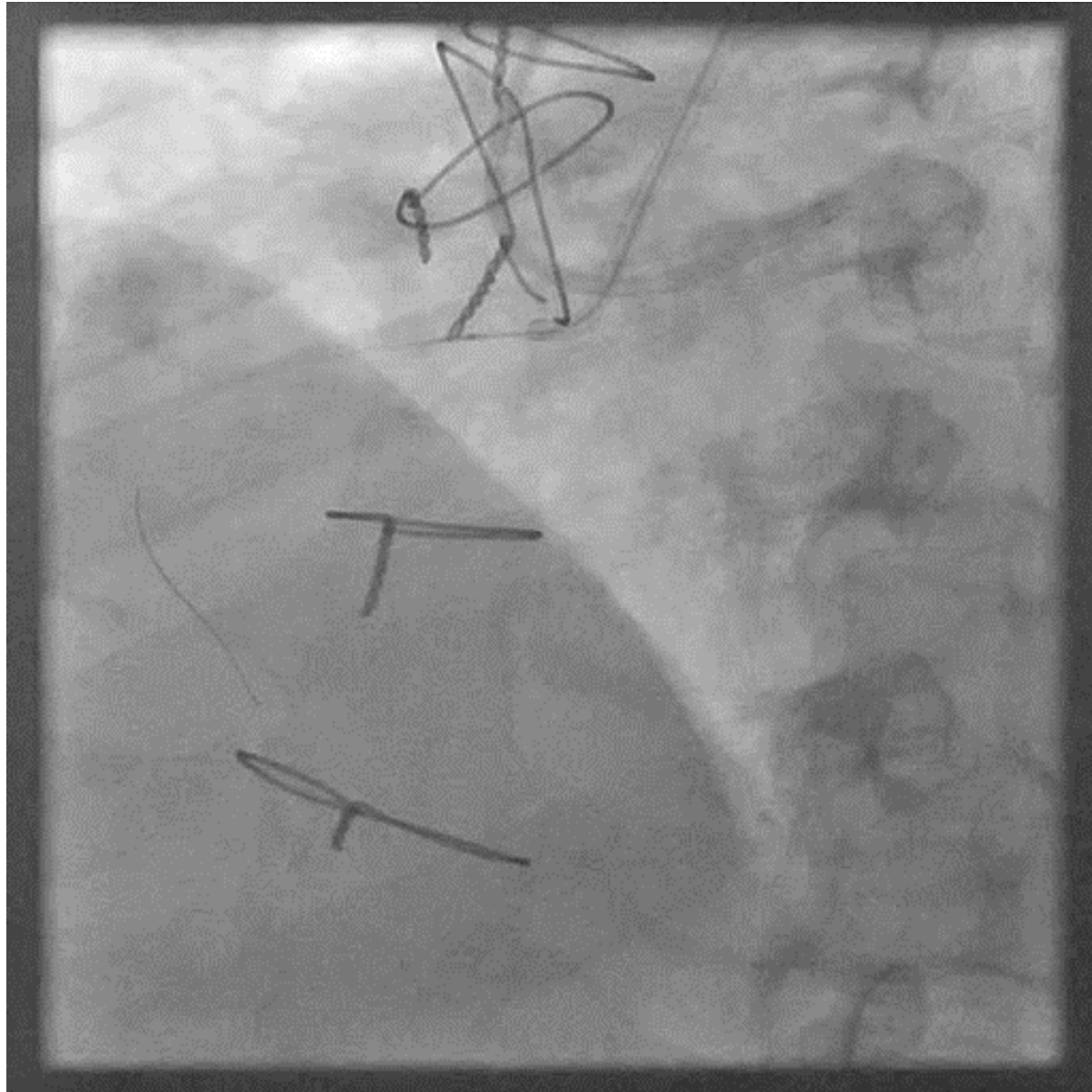
# Asahi Miracle wire family

<i>Straight Tip</i>	<i>Tapered Tip</i>
<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> <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><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> <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><b>ASAHI MIRACLEBROS™ 12</b></p> <ul style="list-style-type: none"> <li>• TIP LOAD: 12.0G</li> <li>• Radiopacity length: 11cm</li> <li>• Joint-less</li> </ul> 	This cell is empty in the original image, as the Confianza Pro 12 wire is shown in the previous row.

Increasing Support

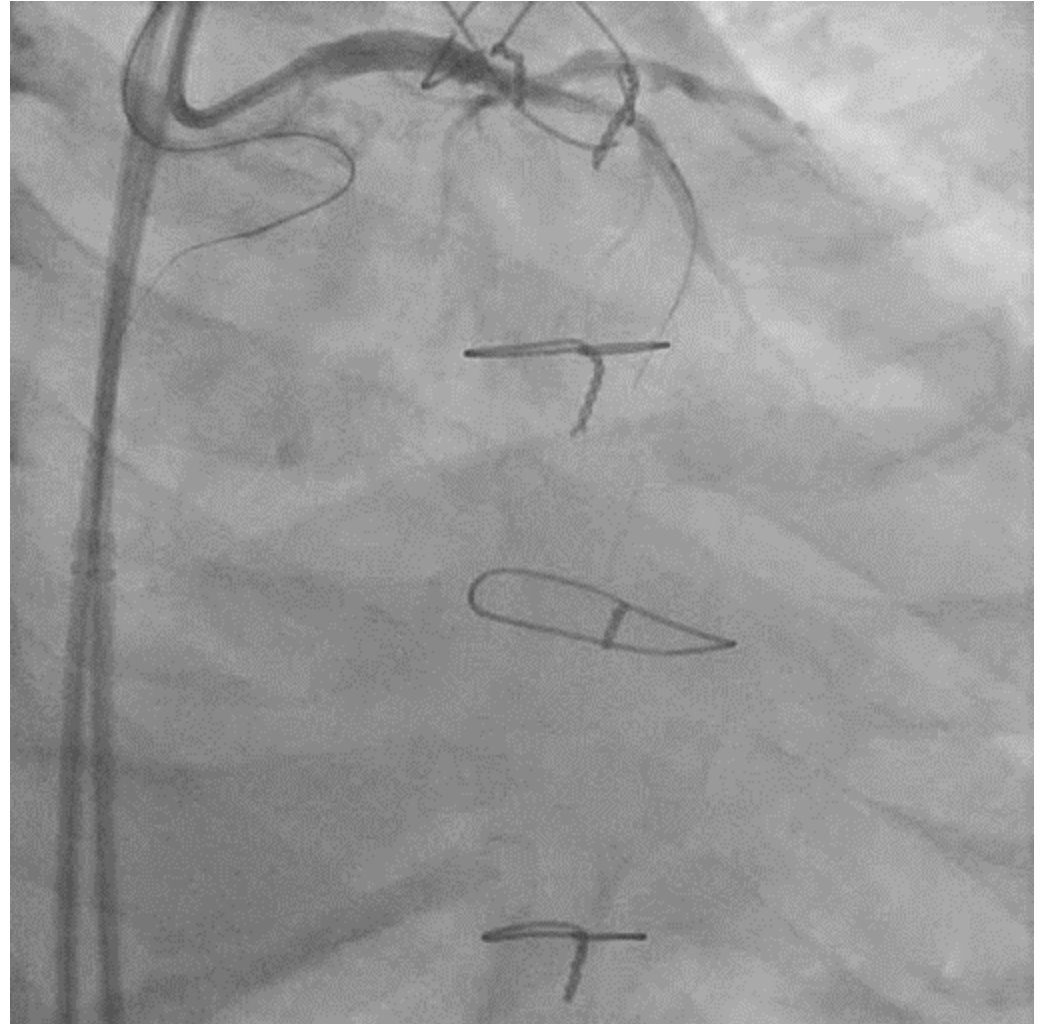
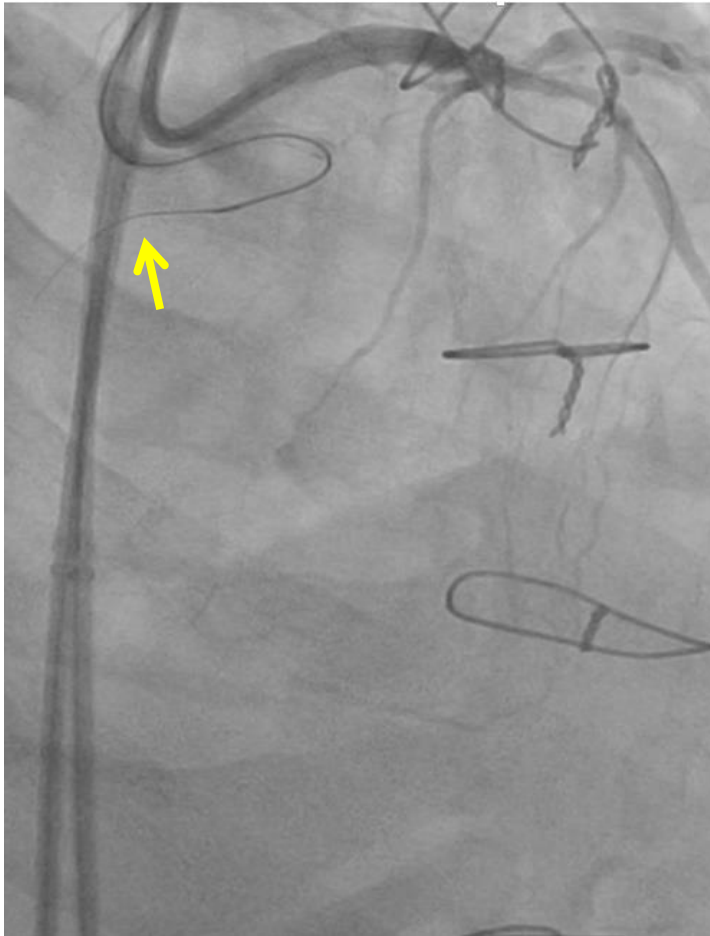
**Confianza** = tapered tip  
**Pro** = hydrophilic coating

# Antegrade attempt



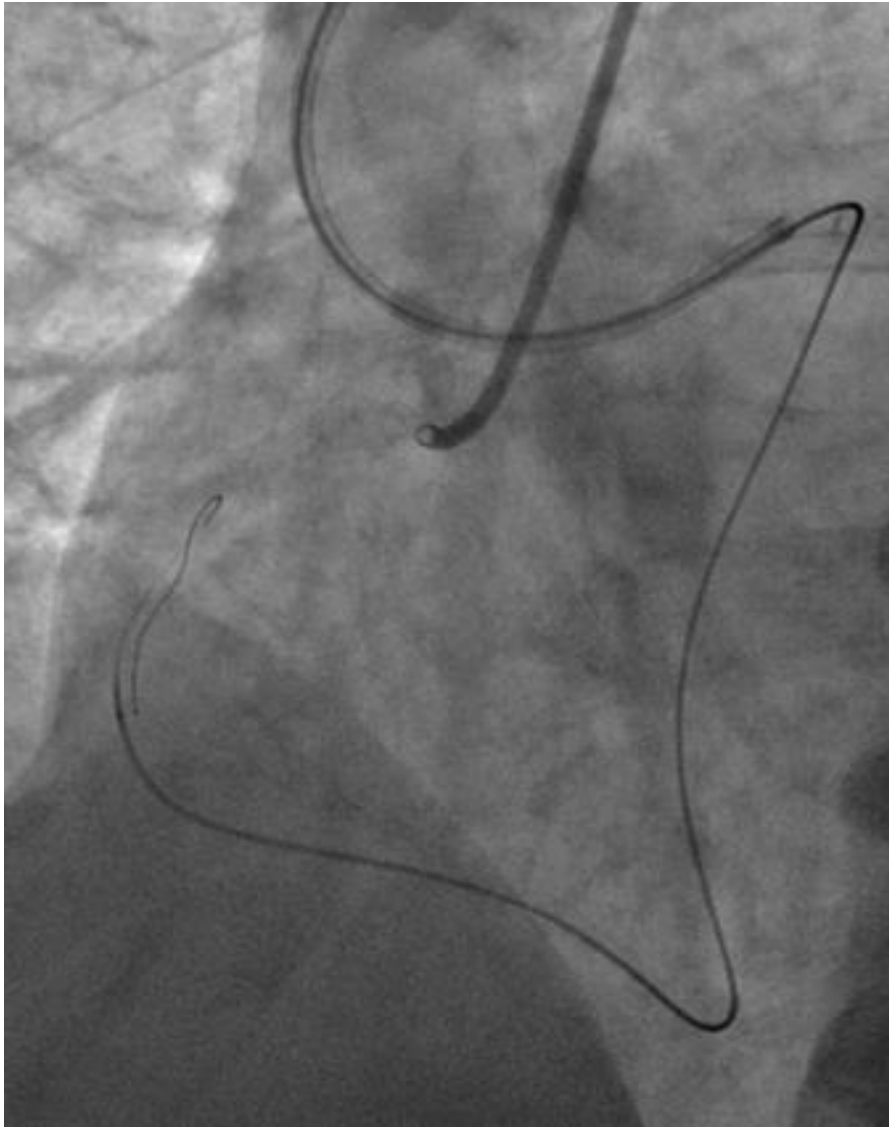


# Retrograde attempt





# The retrograde approach



## Retrograde Percutaneous Recanalization of Chronic Total Occlusion of the Coronary Arteries Procedural Outcomes and Predictors of Success in Contemporary Practice

Sudhir Rathore, MD, MRCP; Osamu Katoh, MD; Hitoshi Matsuo, MD; Mitsuyasu Terashima, MD; Nobuyoshi Tanaka, MD; Yoshihisa Kinoshita, MD; Masashi Kimura, MD, PhD; Etsuo Tsuchikane, MD, PhD; Kenya Nasu, MD; Mariko Ehara, MD; Keiko Asakura, MD; Yasushi Asakura, MD; Takahiko Suzuki, MD

**Background**—Retrograde approach through collaterals has been introduced for percutaneous recanalization of chronic total occlusion (CTO) of the coronary arteries. We investigated the safety and efficacy of retrograde approaches used for percutaneous recanalization of CTO in a consecutive series of patients.

**Methods and Results**—We studied 157 consecutive patients who underwent retrograde CTO recanalization between 2003 and 2008 at a single center. A total of 118 (75.2%) of these patients have had previously failed antegrade attempts. Septal, epicardial, and saphenous vein graft collaterals were used in 67.5%, 24.8%, and 7.6% of cases, respectively. Collateral channel was crossed by guide wire successfully in 115 (73.2%) cases, and the procedure was successful by retrograde approach in 103 (65.6%) cases. Collateral channels (CCs) were graded as follows: CC0, no continuous connection; CC1, continuous thread-like connection; and CC2, continuous, small sidebranch-like connection. CC1, collateral tortuosity  $<90^\circ$ , and angle with recipient vessel  $<90^\circ$  ( $P<0.0001$ ) were significant predictors of success. Epicardial channel use ( $P=0.01$ ), CC0, corkscrew channel ( $P<0.0001$ ), angle with recipient vessel  $>90^\circ$  ( $P=0.0007$ ), and nonvisibility of connection with recipient vessel were found to be significant predictors of procedural failure. The CC dissection was observed in 6 patients, with 1 needing coil embolization and others who were managed conservatively. The major adverse cardiac events were low, with 1 coronary artery bypass graft, 1 Q-wave myocardial infarction, 5 non-Q-wave myocardial infarctions, and no deaths in this group of patients.

**Conclusions**—The retrograde approach in CTO percutaneous coronary intervention is effective in recanalizing CTO. The success rate by retrograde approach was 65.6%, and final success was 85% in this group with acceptable overall adverse events. We have identified predictors of failure related to collateral morphology. (*Circ Cardiovasc Interv.* 2009;2:124-132.)

**Key Words:** chronic total occlusion ■ coronary angioplasty ■ retrograde approach ■ collateral circulation ■ coronary disease

Catheterization and Cardiovascular Interventions 79:3-19 (2012)

## CORONARY ARTERY DISEASE

### Core Curriculum

## The Retrograde Approach to Coronary Artery Chronic Total Occlusions: A Practical Approach

Emmanouil S. Brilakis,<sup>1\*</sup> MD, PhD, J. Aaron Grantham,<sup>2</sup> MD, Craig A. Thompson,<sup>3</sup> MD, MMSc, Tony J. DeMartini,<sup>4</sup> MD, Abhiram Prasad,<sup>5</sup> MD, FRCP, Gurpreet S. Sandhu,<sup>5</sup> MD, PhD, Subhash Banerjee,<sup>1</sup> MD, and William L. Lombardi,<sup>6</sup> MD

The retrograde approach has revolutionized the treatment of chronic total occlusions. Several retrograde techniques have recently been described. In this article, we present a practical review with step-by-step instructions on the indications for retrograde interventions, equipment and retrograde channel selection, and techniques for retrograde crossing and treatment of chronic total occlusions. © 2011 Wiley Periodicals, Inc.

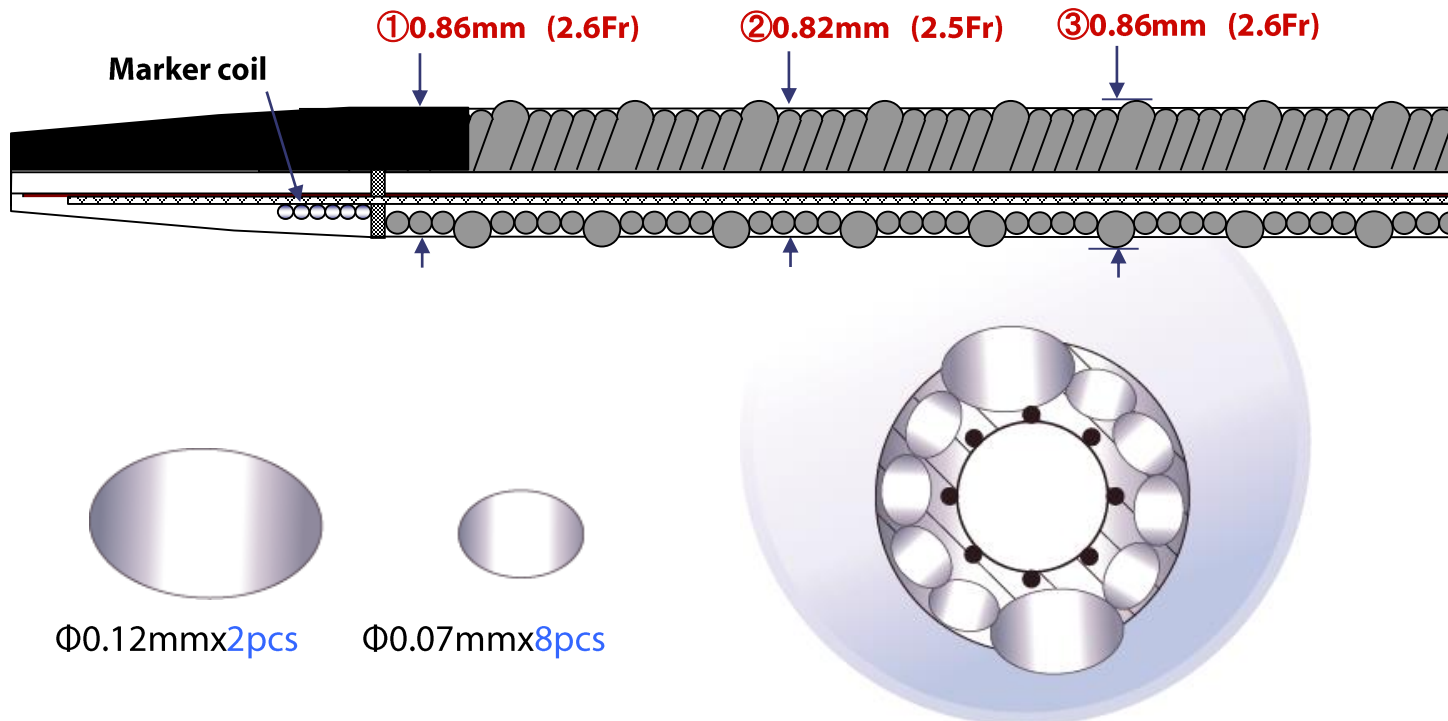
**Key words:** chronic total occlusions; percutaneous coronary intervention; retrograde coronary intervention

# ASAHI Corsair Microcatheter

## 20cm Screw Head Structure

For tip flexibility & vessel trackability

- By using 2pcs of thick stainless steel wires and 8pcs of thin stainless steel wires, ASAHI Corsair possesses screw head structure from the tip to 20cm. This structure enables the product to progress into the septal channels by just adding rotational movement which leads to superior vessel trackability.



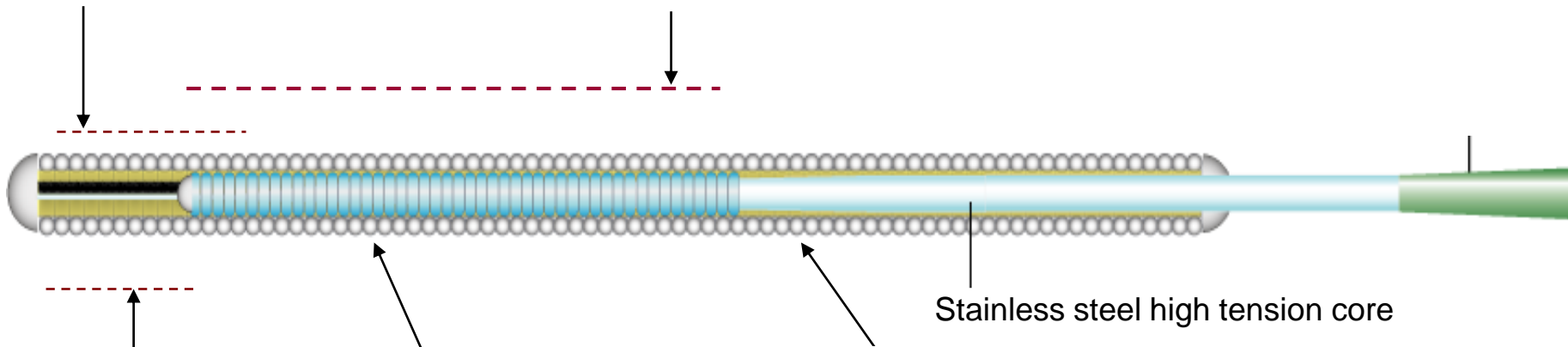
# ASAHI SION Guide Wire Design

## Composite Core (distal portion)

1. Flexible core
2. Twist wire

## Composite Core Technology (proximal portion)

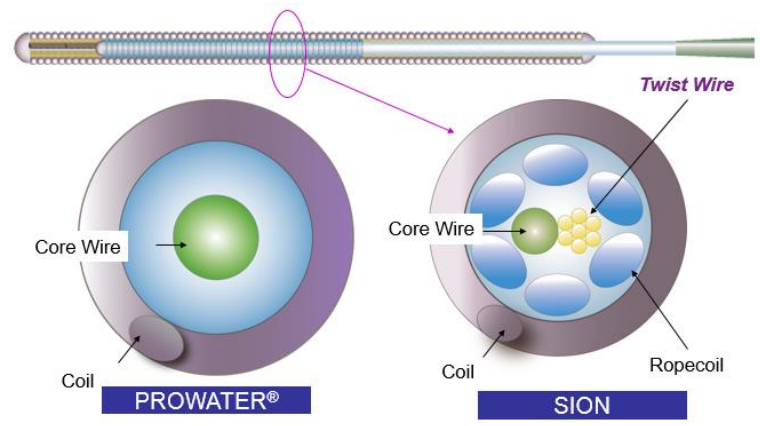
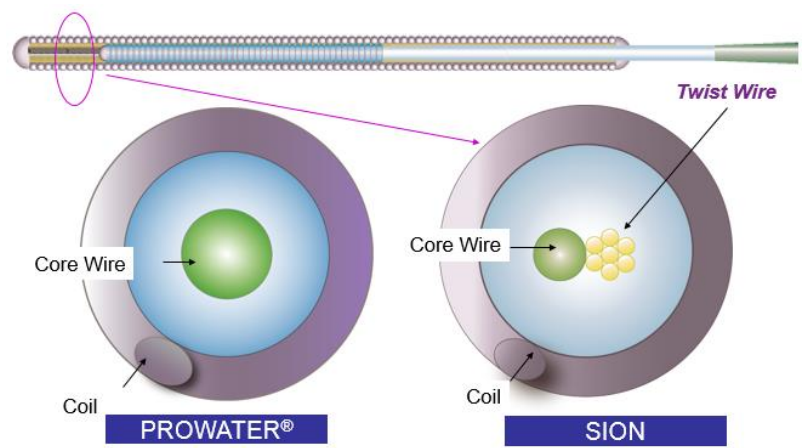
1. Rope Coil
2. Flexible core
3. Twist wire



**3 cm Radiopaque coils**

**Joint-less spring coil**

**SLIPCOAT™ hydrophilic coating coats entire working length of the wire (28 cm)**

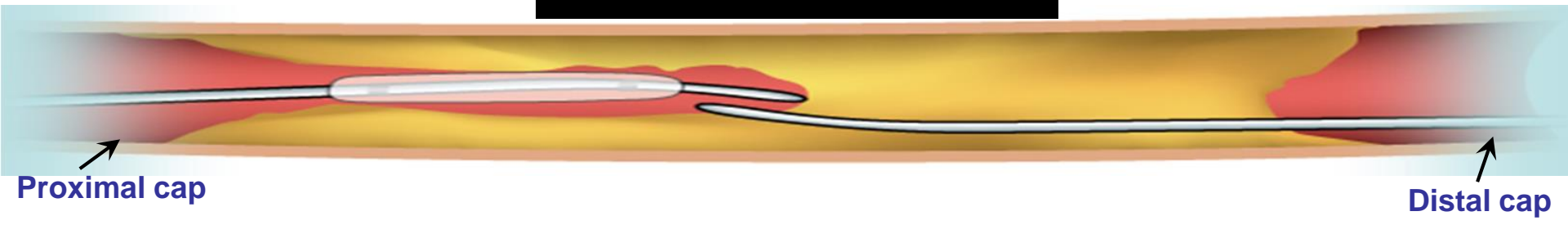


# Retrograde Dissection Techniques

## CART



## Reverse CART



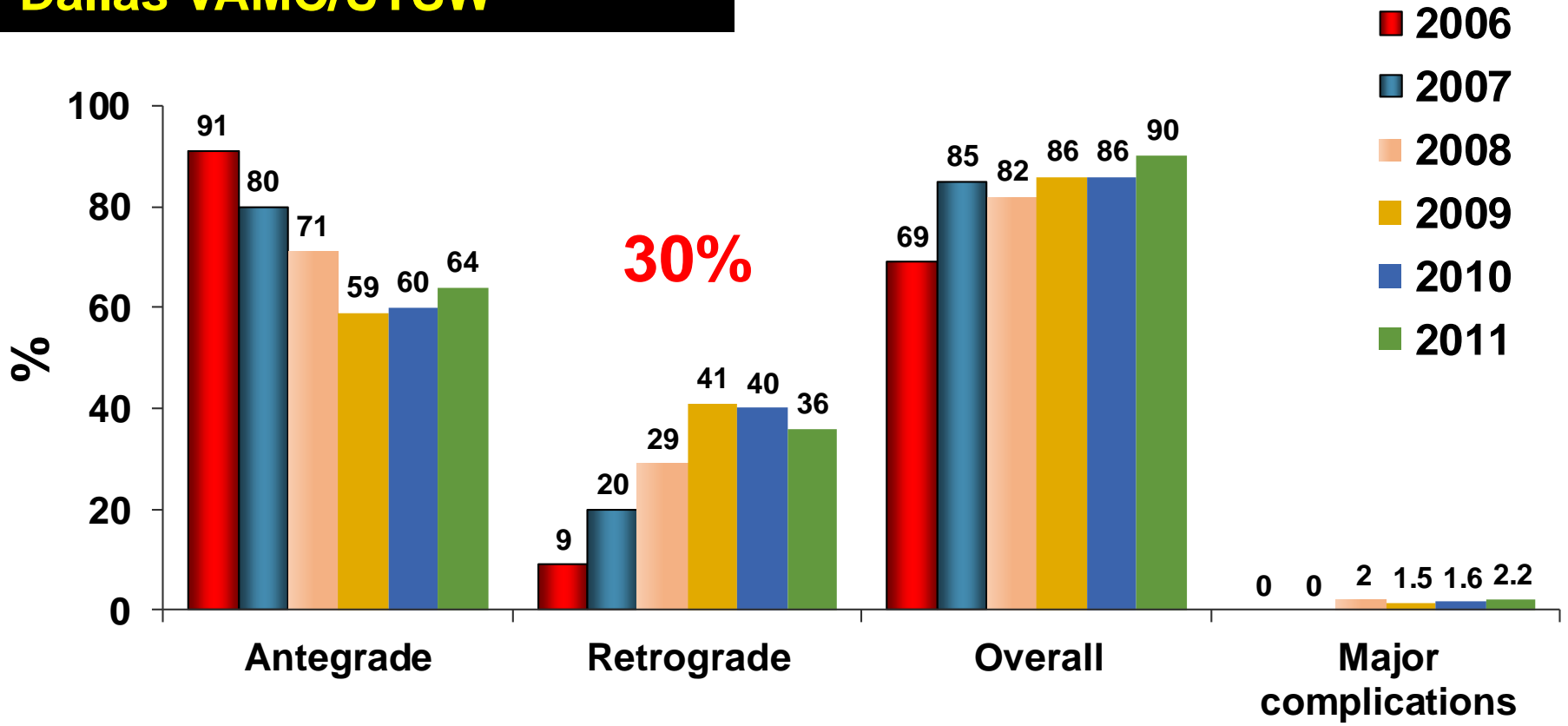
## Confluent balloon



# CTO PCI: success and complications

- Peacehealth Bellingham, WA
- Piedmont Atlanta, GA
- Dallas VAMC/UTSW

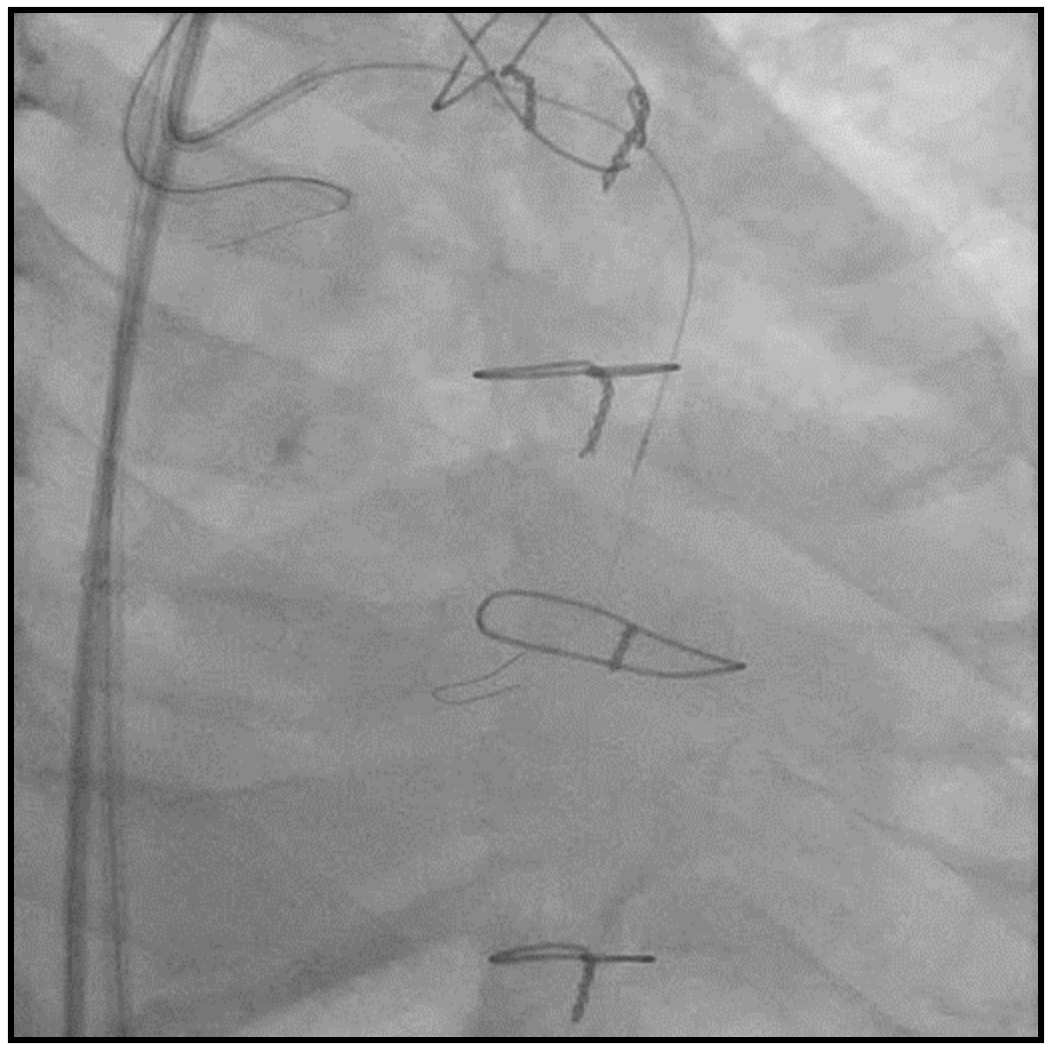
N=1,363



*Karmpaliotis, Michael, Brilakis, Lombardi, Kandzari et al. JACC Intv 2012;5:1273-9  
 Michael, Karmpaliotis, Brilakis, Lombardi, Kandzari et al. Am J Cardiol 2013;112:488-492*



# Retrograde crossing failed





# CTO dissection/re-entry strategies

**Antegrade**

**Retrograde**

**Dissection**

**Dissection**

**Knuckle wire  
CrossBoss**

**Knuckle wire**

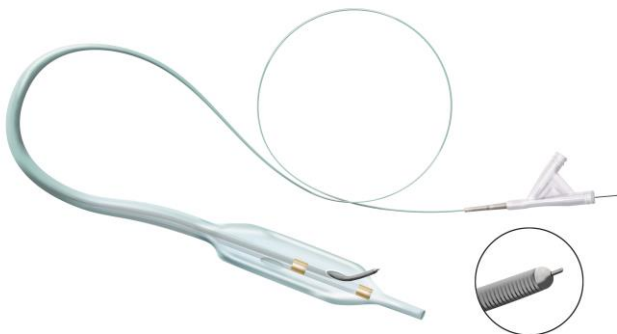
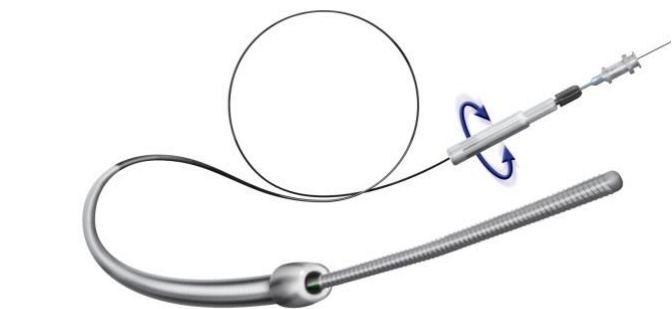
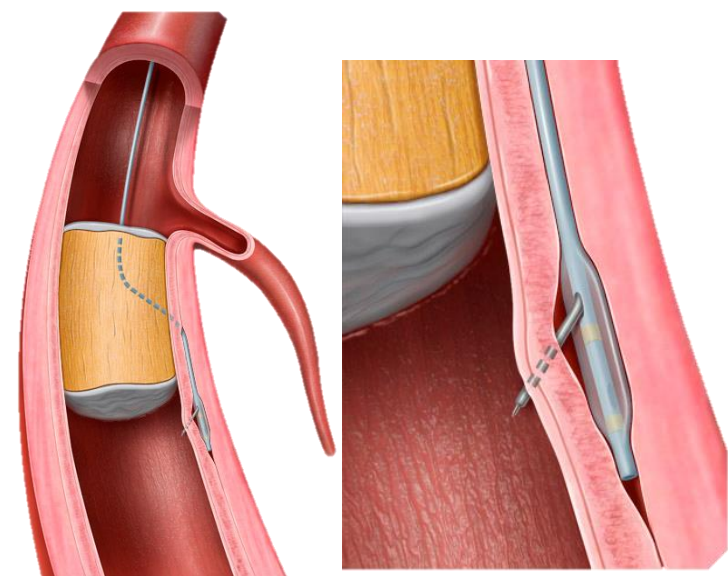
**Re-entry**

**Re-entry**

**•STAR  
•Contrast-guided STAR  
•mini-STAR  
•LAST  
•Stingray**

**CART  
Reverse CART**

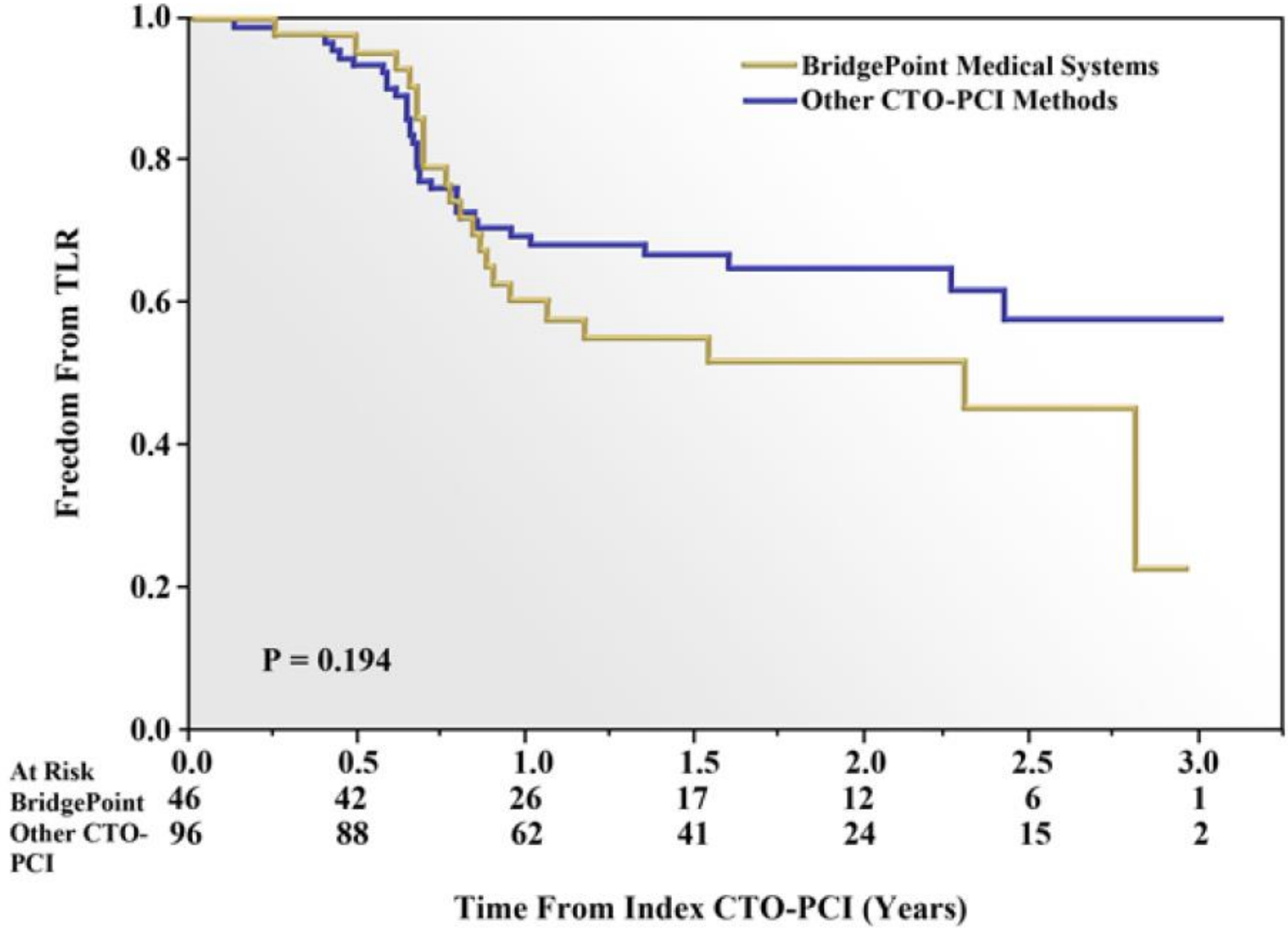
**Michael et al  
Circ Intv 2012**



# CrossBoss – Stingray mechanism of action

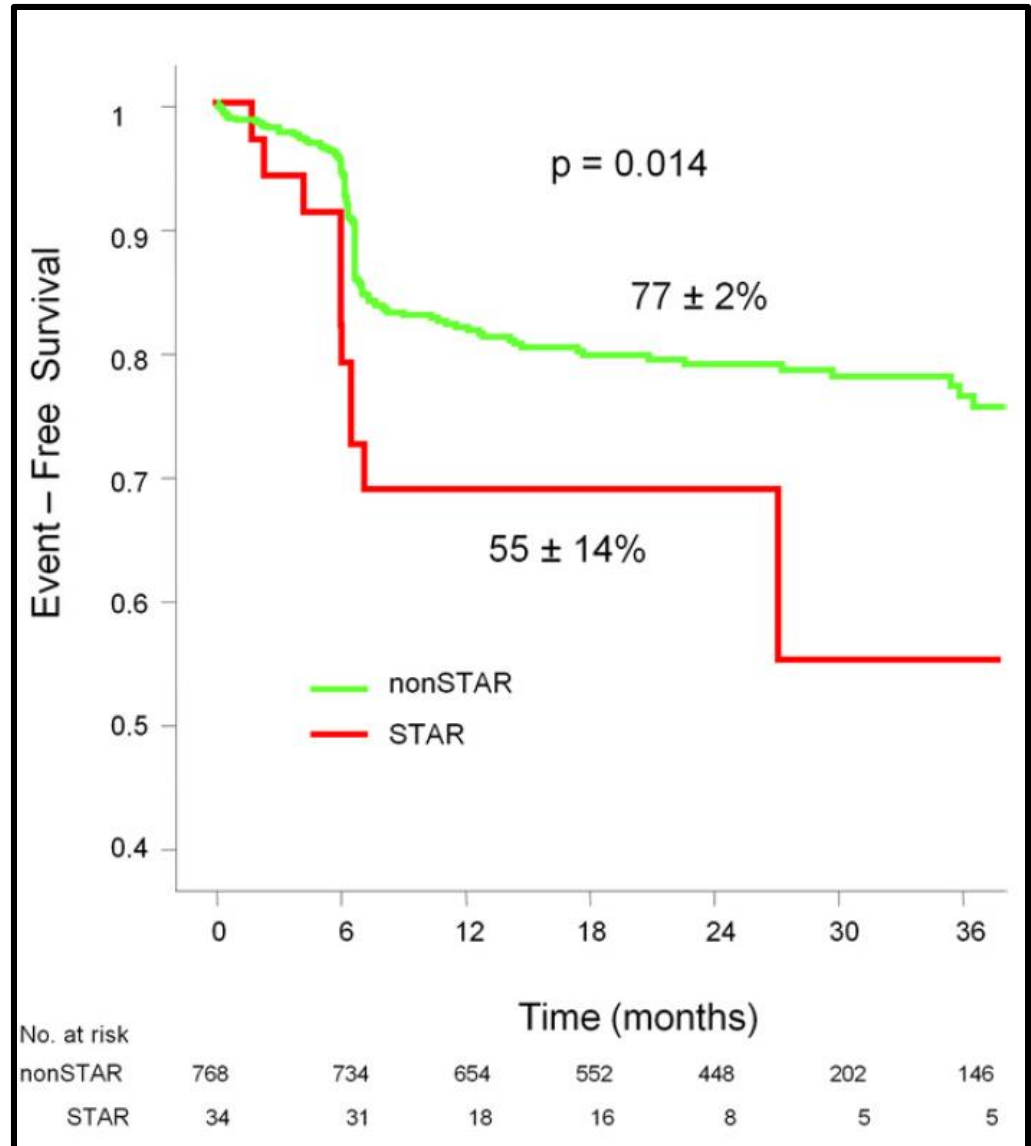


# Bridgepoint system: mid-term outcomes

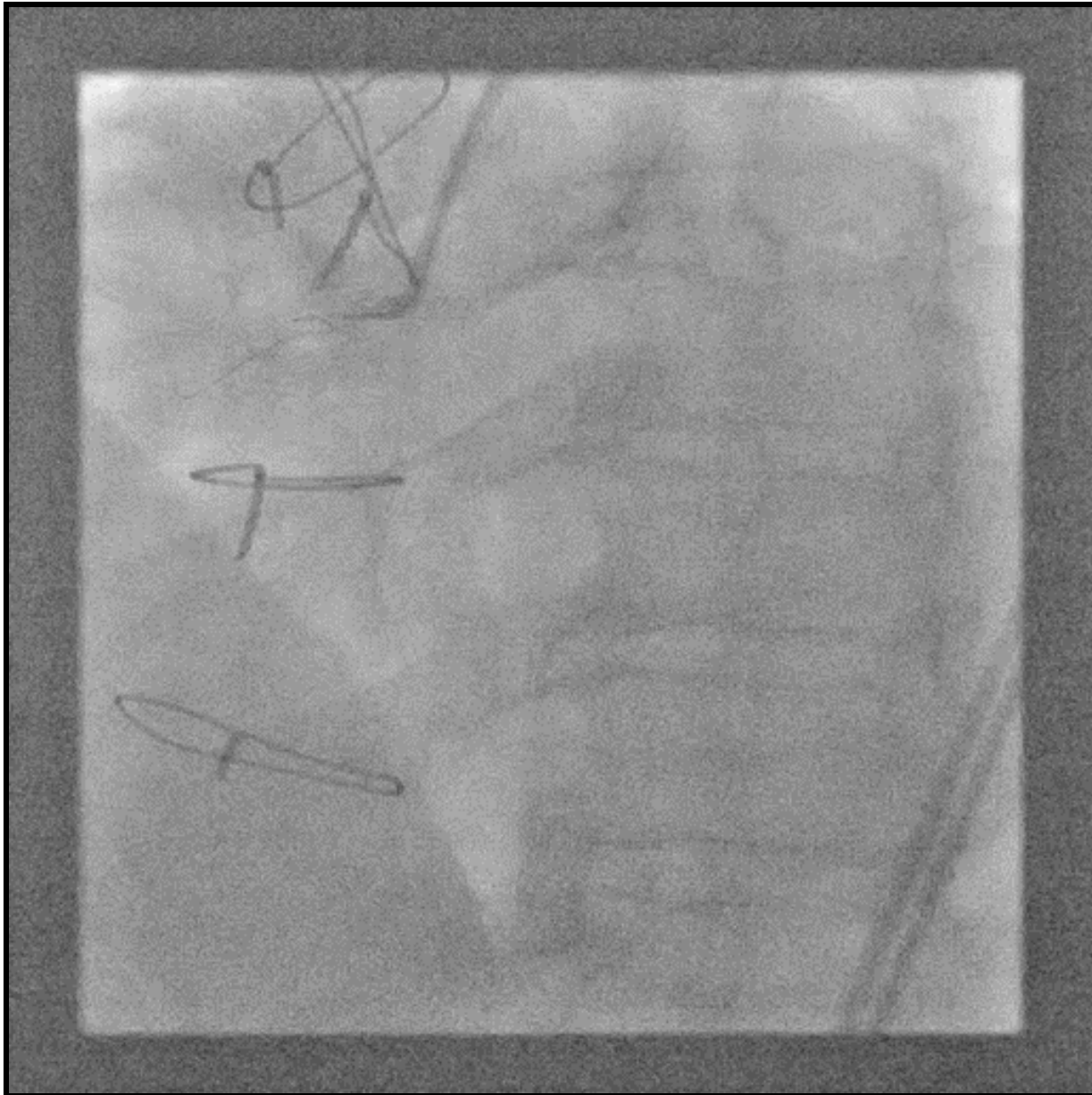


# STAR technique: long-term outcomes

- Florence CTO PCI registry
- 802 successful CTO PCI between 2003-2010
- 82% angiographic FU
- EES less reocclusion than 1<sup>st</sup> generation DES
- **STAR: 57% reocclusion rate (16/28)**

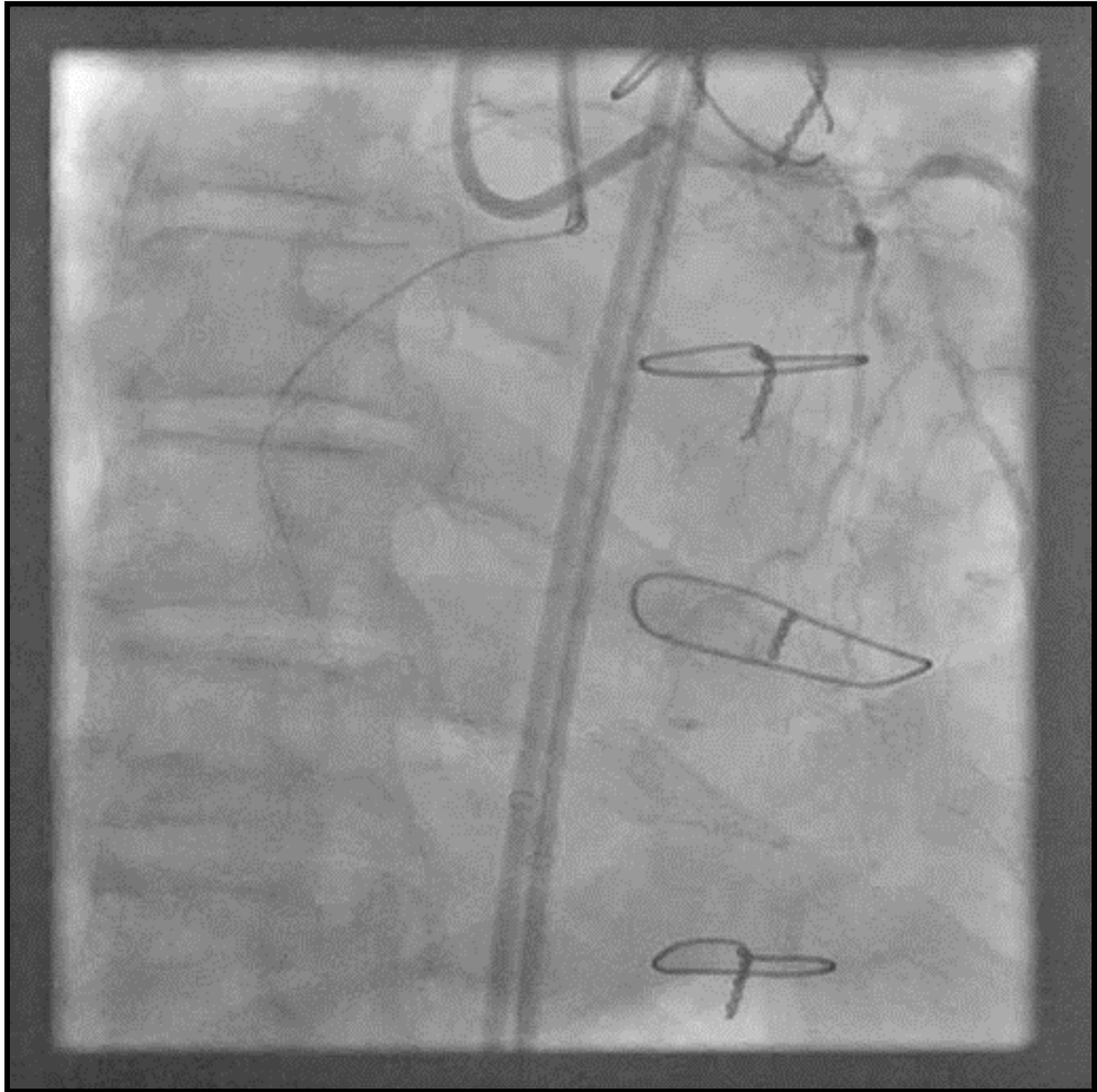


# Forming a knuckle

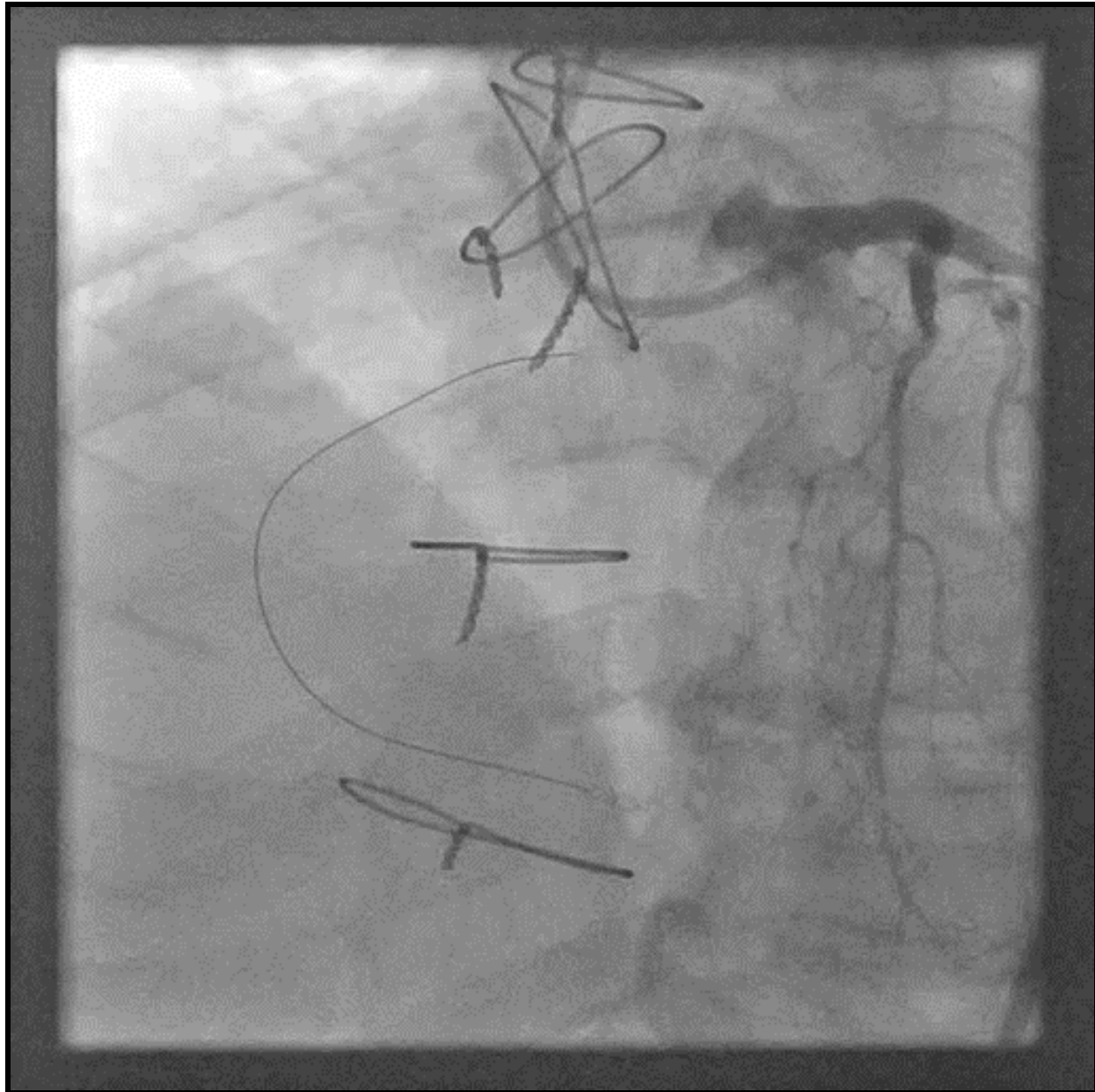




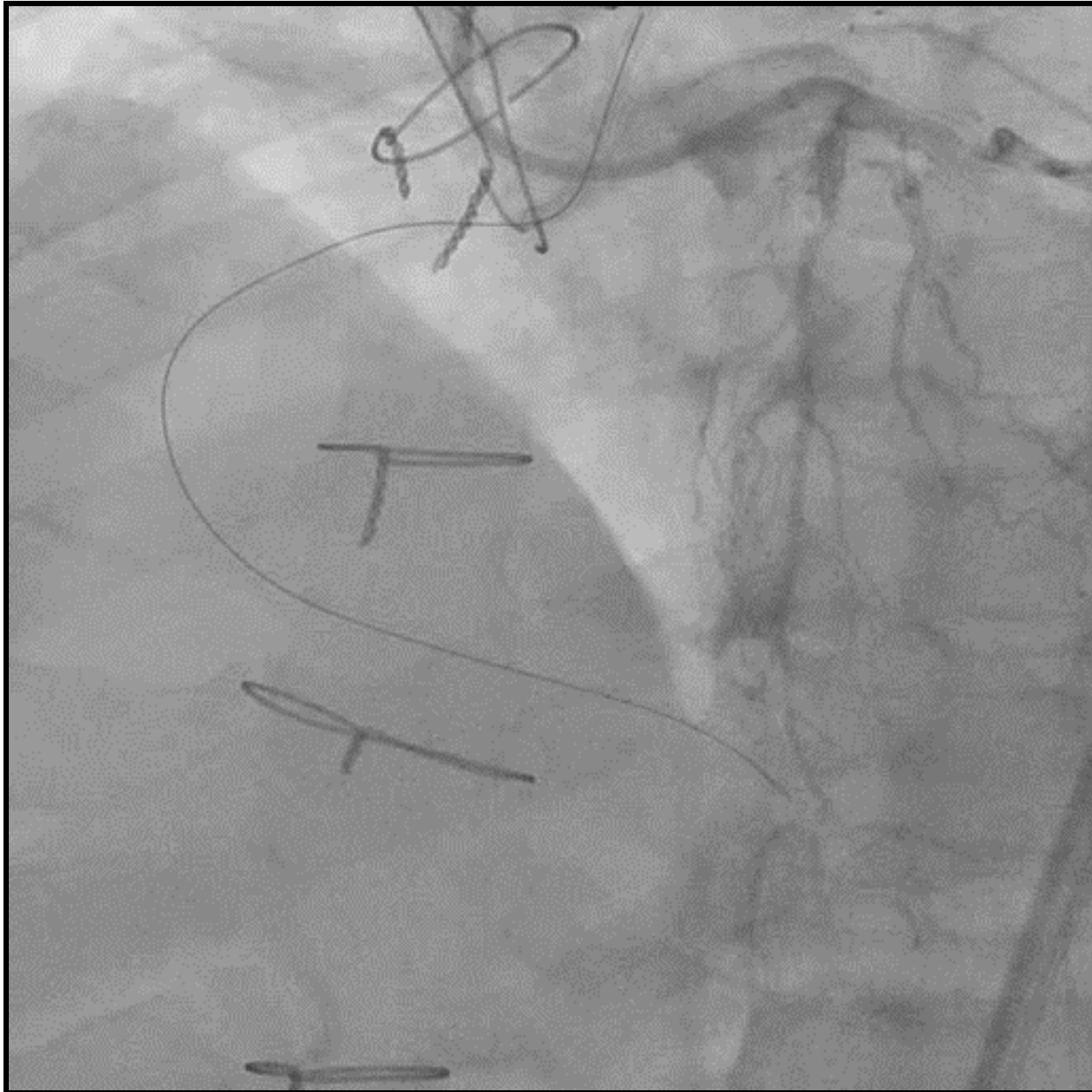
# The “dance”



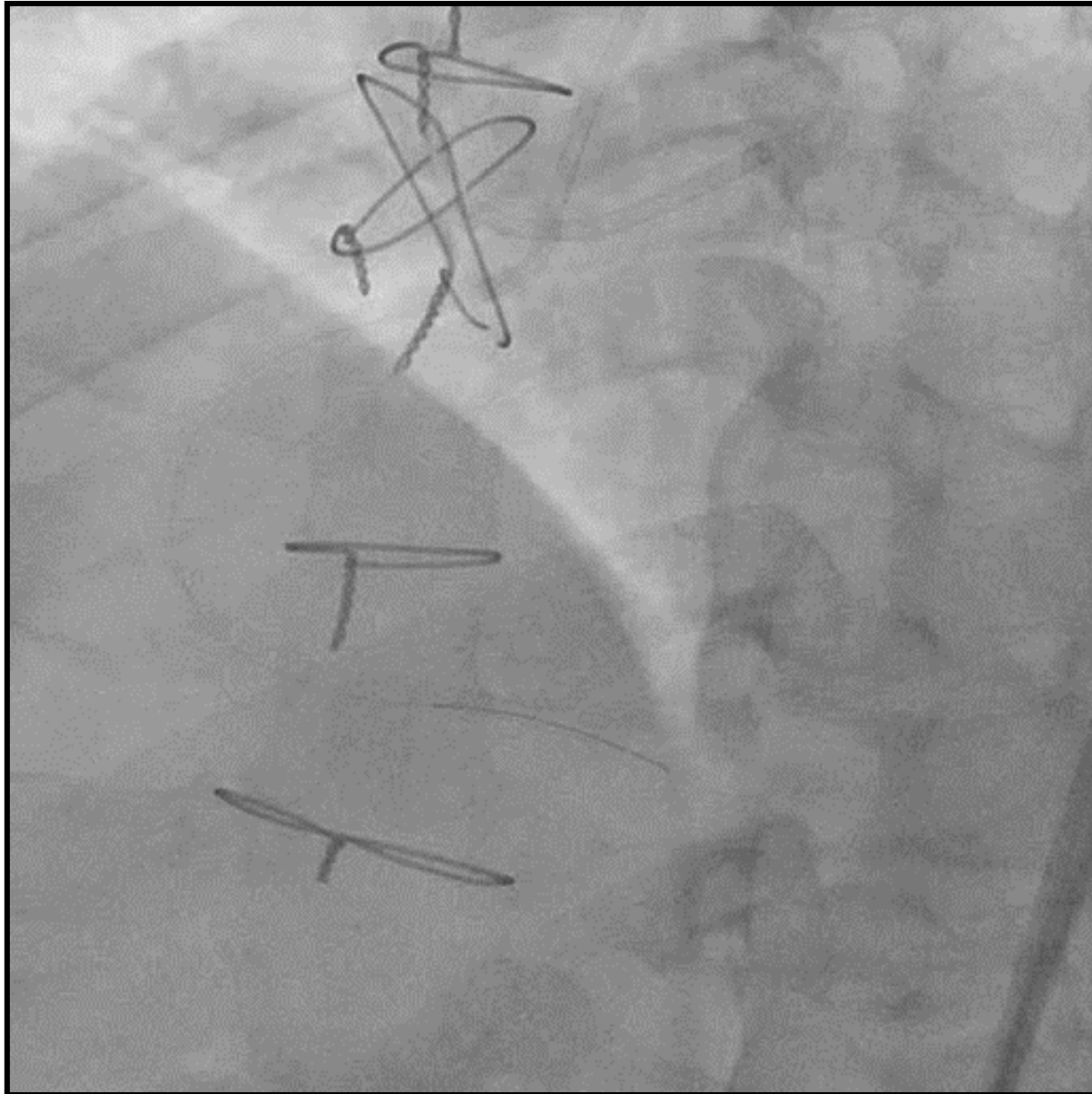
# Stingray



# Position confirmation

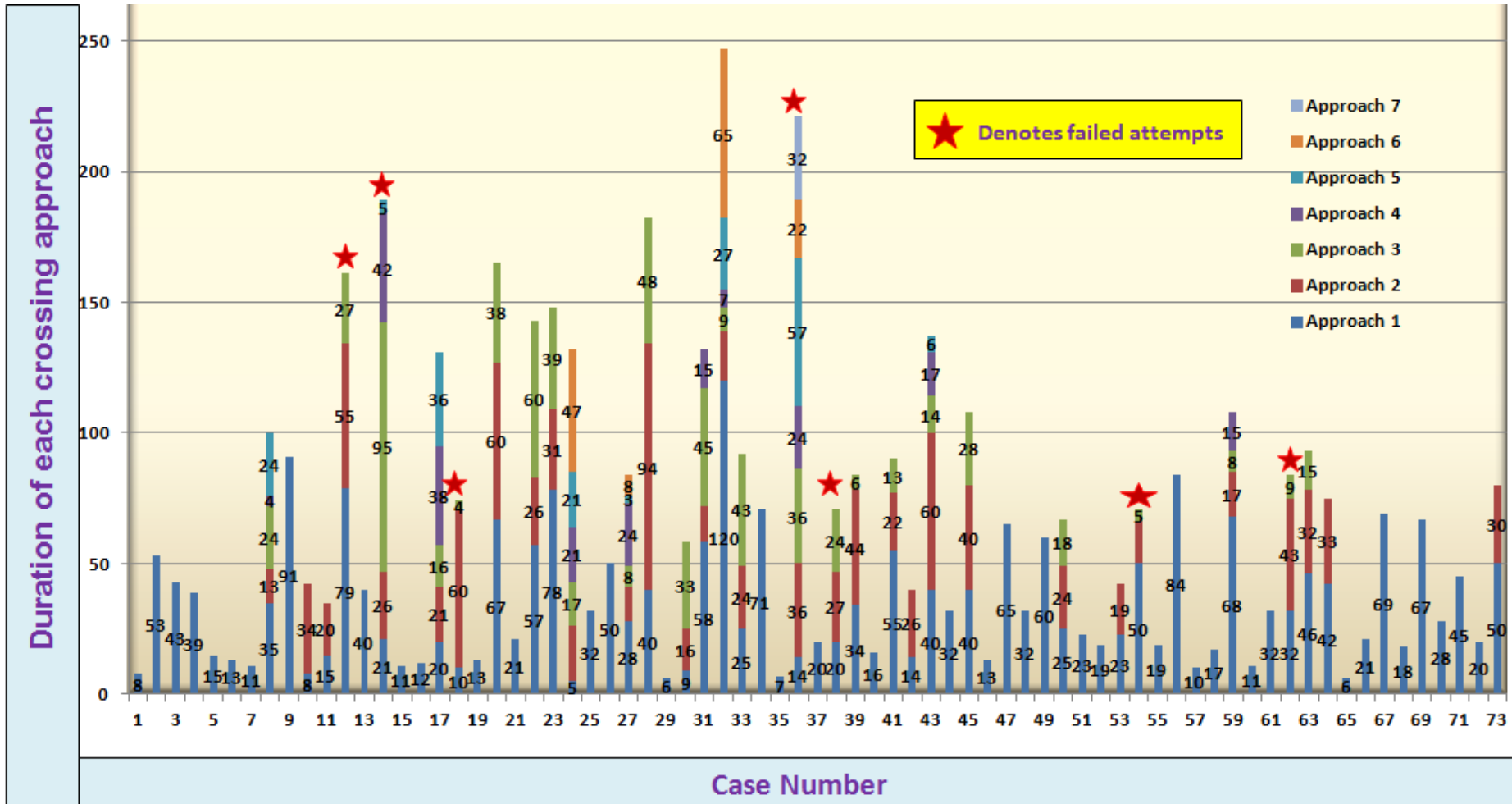


# Final result





# How often is “switch” needed?



**66/73 success rate (90.4%)**

**32 of 73 pts (44%) required 3.6±1.4 approach changes**

**Antegrade wire: 50.0%; antegrade diss/re-entry: 24.2% retrograde: 25.8%**





# US Multicenter CTO registry

- Appleton Cardiology, WI
- Dallas VAMC/UTSW
- Peaceheath Bellingham, WA
- Piedmont Heart Institute, GA
- St Luke's Mid America Heart Institute, MO

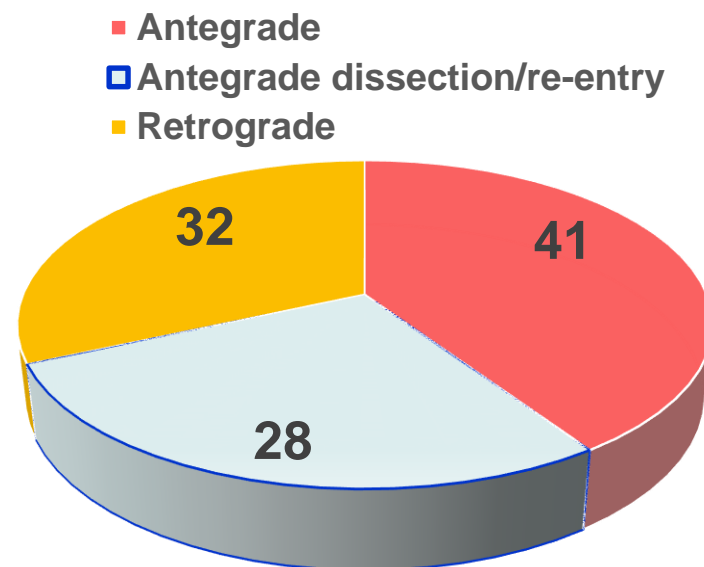
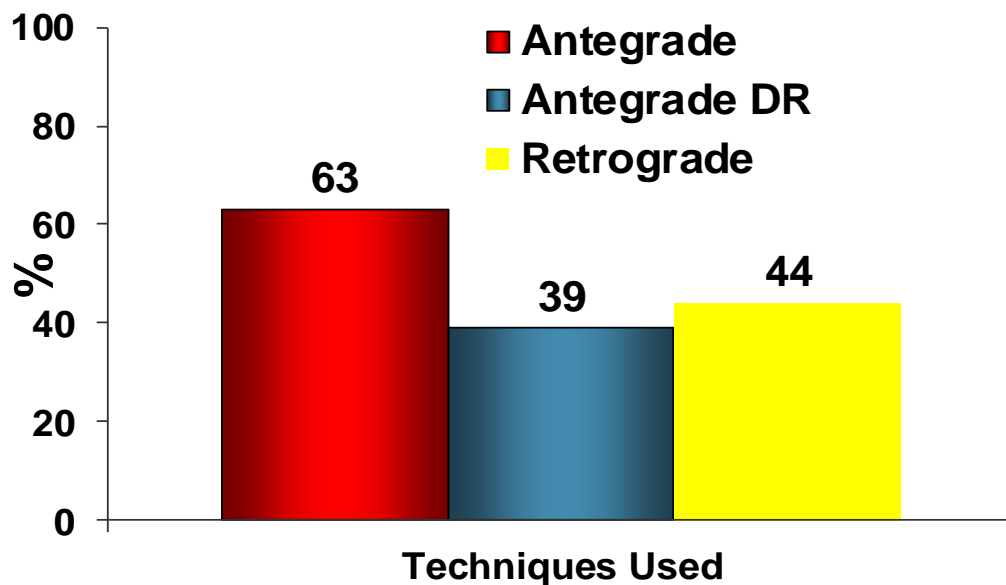
1/2012 to 8/2013

n=489

Technical success: **91.6%**

Major complications: **1.6%**

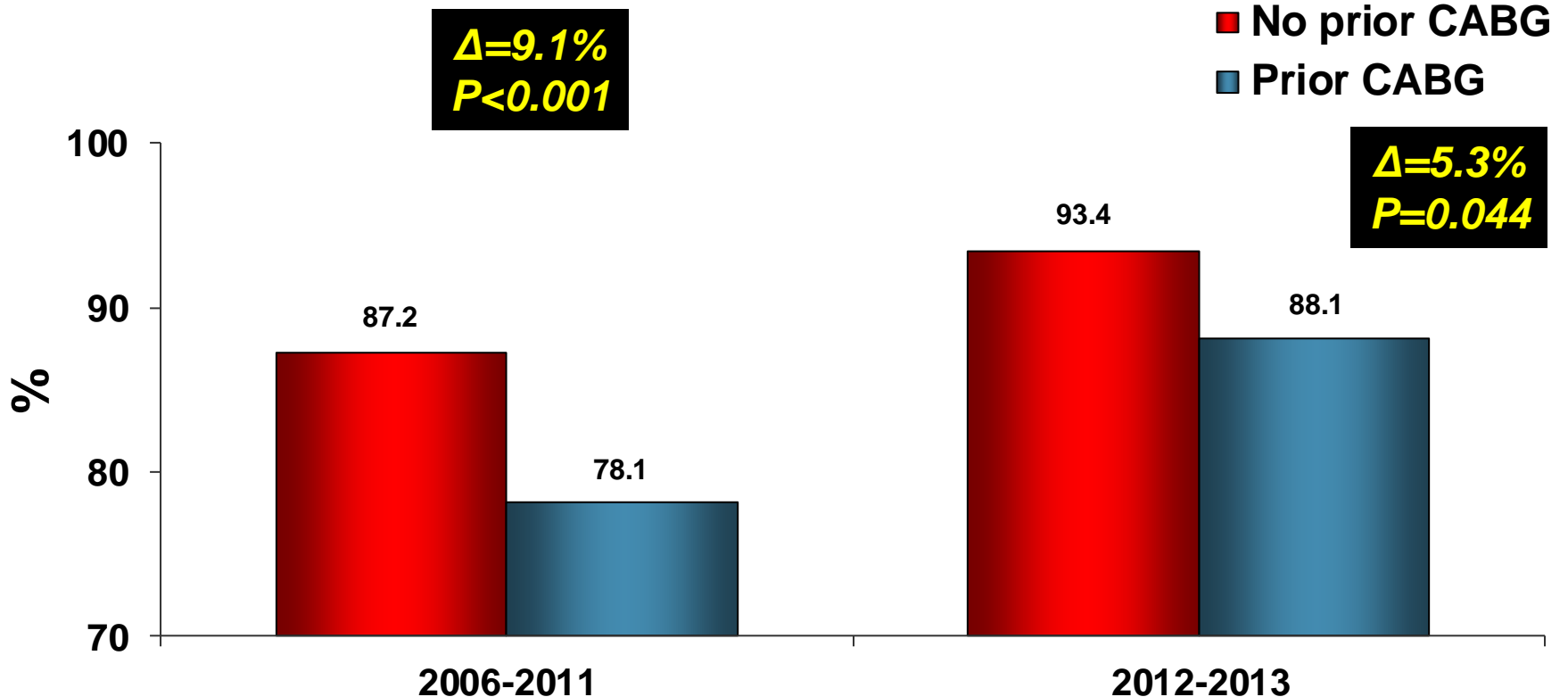
## Successful technique



# CTO PCI: success and prior CABG

Pre “Hybrid” era

“Hybrid” era



**N=1,363**

**3 US sites**

**Prior CABG: 37%**

**Complications: 1.5% vs. 2.1%**

**Retrograde: 27.1% vs. 46.7%**

*Michael, Karpaliotis, Brilakis, Lombardi,  
Kandzari et al. Heart 2013;99:1515-8*

**N=496**

**5 US sites**

**Prior CABG: 35%**

**Complications: 1.9% vs. 1.1%**

**Retrograde: 24% vs. 39%**

*Christopoulos, Menon, Karpaliotis, Alaswad,  
Lombardi, Grantham, Brilakis et al, submitted*

# Outline

**1. Definition – prevalence**

**2. Indications**

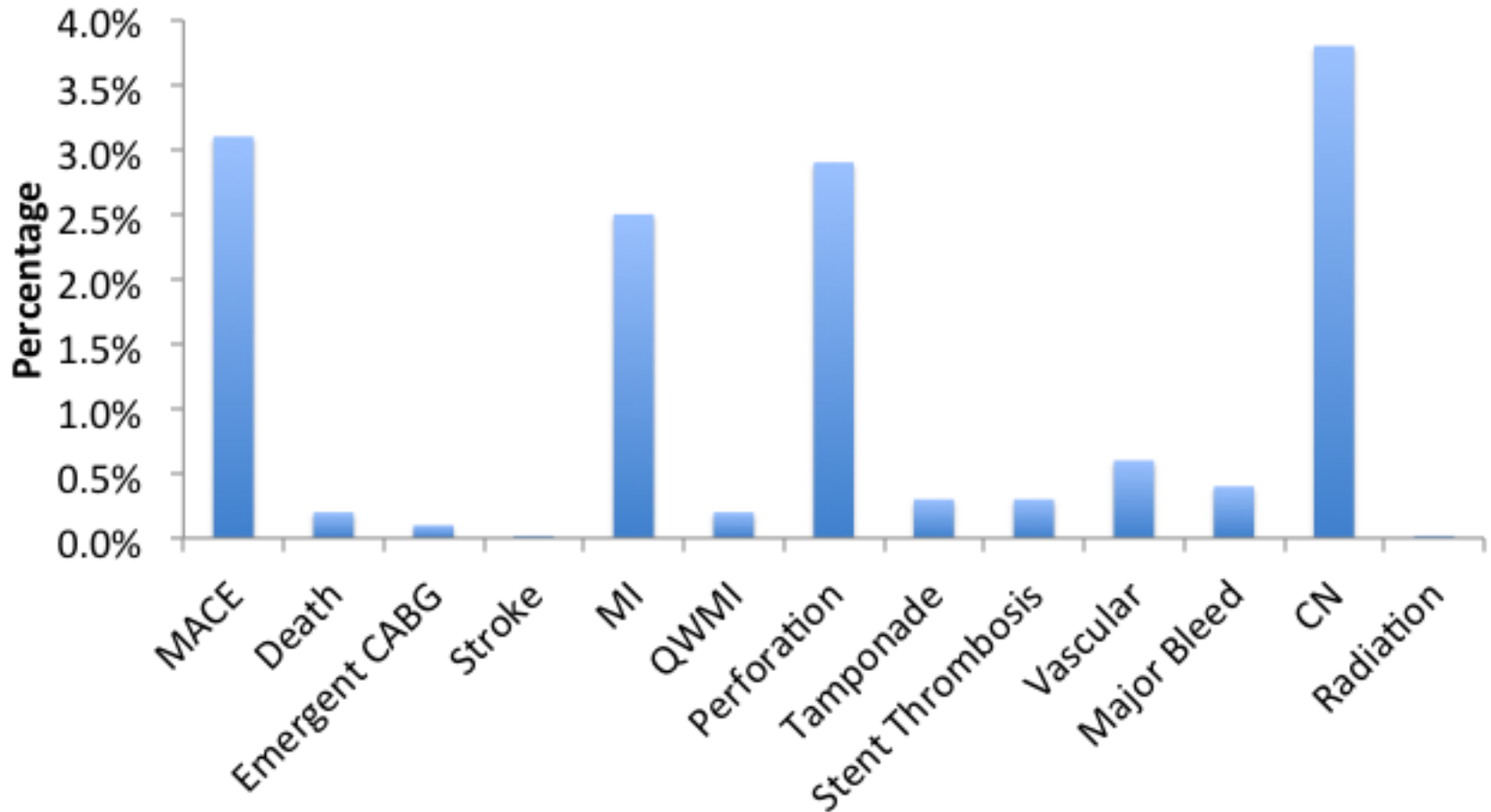
**3. Technique**

- **Wire crossing strategies**
- **Balloon Crossing**
- **Stents**

**4. Complications**

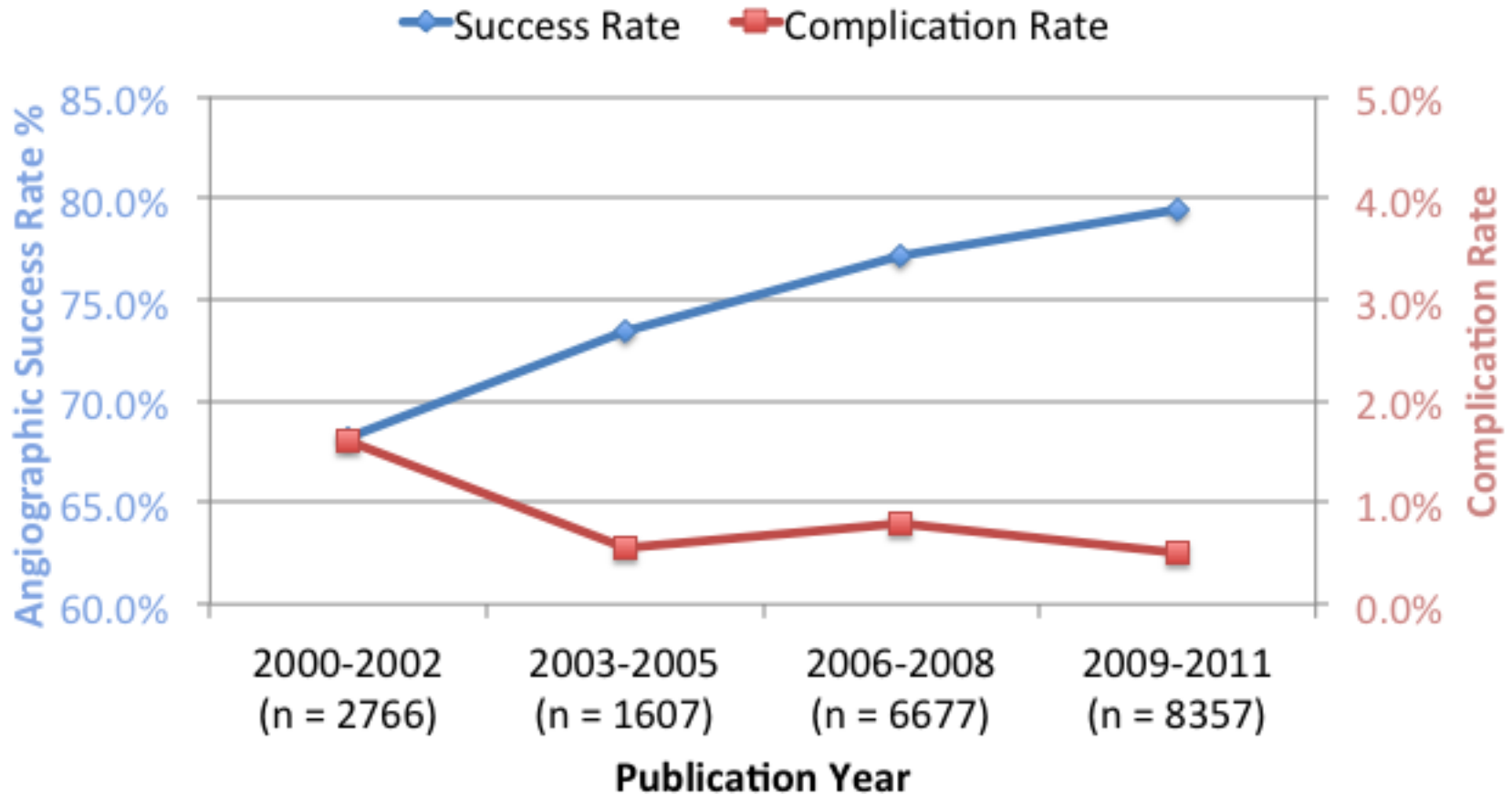
# Frequency of CTO complications

65 studies - 18,061 Patients



# Frequency of CTO complications

65 studies - 18,061 Patients



Patel V,....., Brilakis ES – JACC Intv 2013

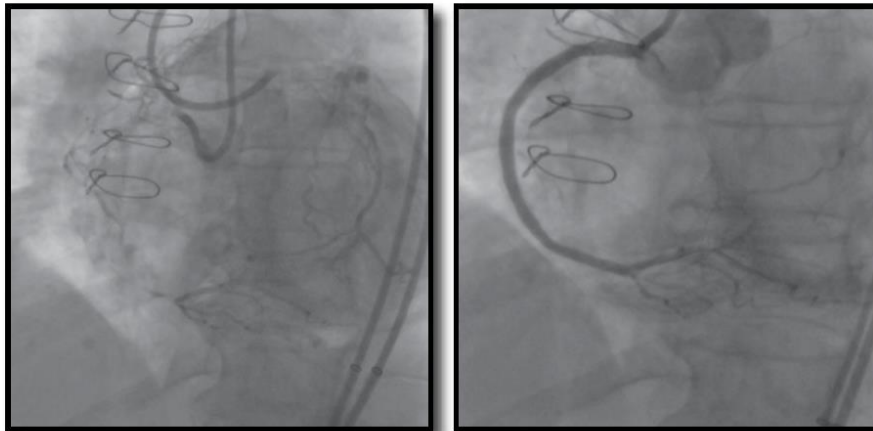


# Conclusions

- 1. CTOs are common**
- 2. CTO revascularization can provide significant clinical benefits**
- 3. CTO PCI can be achieved with high success and low complication rates and can be cost-effective**

# MANUAL OF CORONARY CHRONIC TOTAL OCCLUSION INTERVENTIONS

A STEP-BY-STEP APPROACH



EMMANOUIL BRILAKIS



**Released:  
TCT 2013**