# Clinical Indications of CTO Recanalization

Ramon Quesada, MD, FACP, FACC, FSCAI
Medical Director, Interventional Cardiology & Cardiac Research
Medical Director, Structural Heart and TAVR Program
Baptist Cardiac & Vascular Institute, Miami, Florida

Clinical Associate Professor of Medicine,
Florida International University
Herbert Wertheim School of Medicine

Baptist Cardiac & Vascular Institute
BAPTIST HOSPITAL OF MIAMI

# Disclosure Statement of Financial Interest

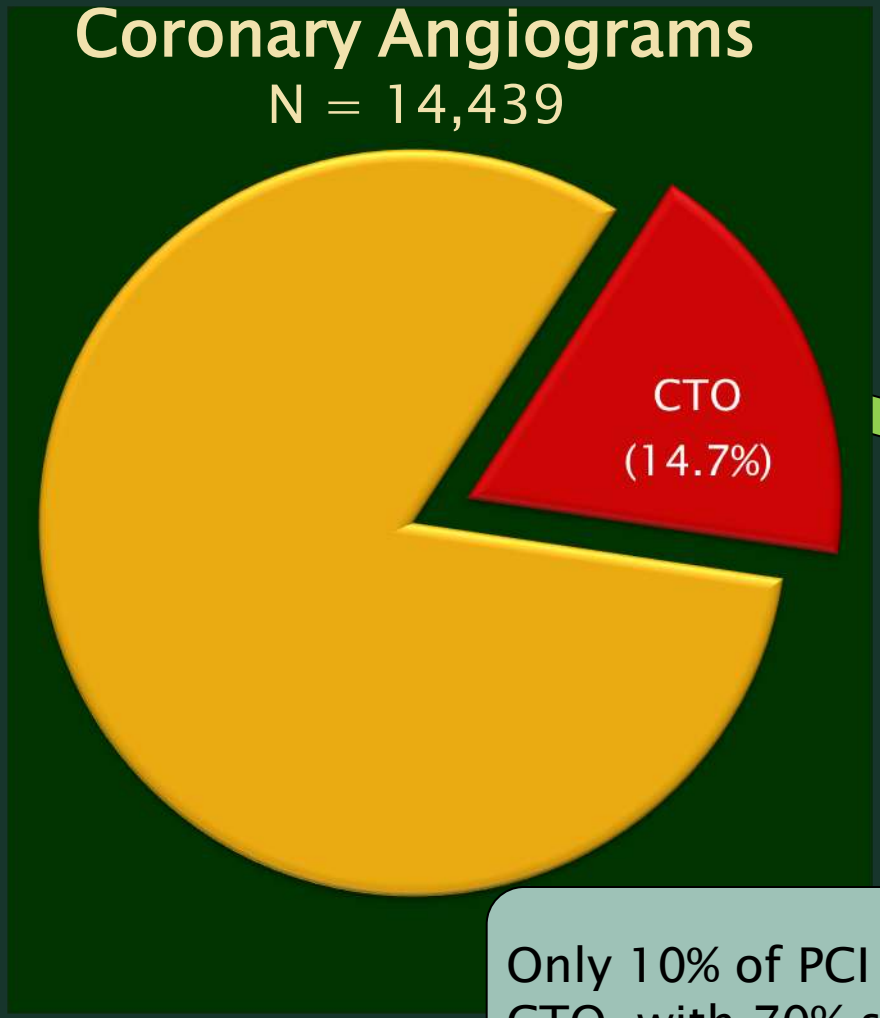
Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

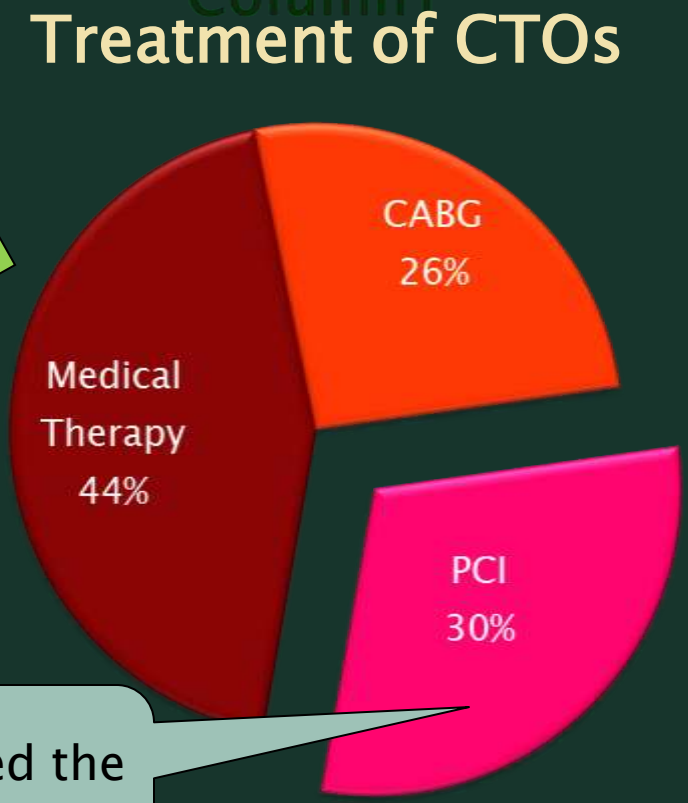
| Affiliation/Financial Relationship | Company |
| --- | --- |
| Grant/Research Support | None |
| Consulting Fees/Honoraria | Abbott, Cordis, St. Jude, W.L. Gore, Boston Scientific Corp. Terumo |
| Major Stock Shareholder/Equity | None |
| Royalty Income | None |
| Ownership/Founder | None |
| Intellectual Property Rights | None |
| Other Financial Benefit | None |

# CTO-PCI: The Final Frontier

- Dispel misconceptions
- Safe and suitable treatment option
- Reproducible and teachable

# CTO Prevalence and Treatment



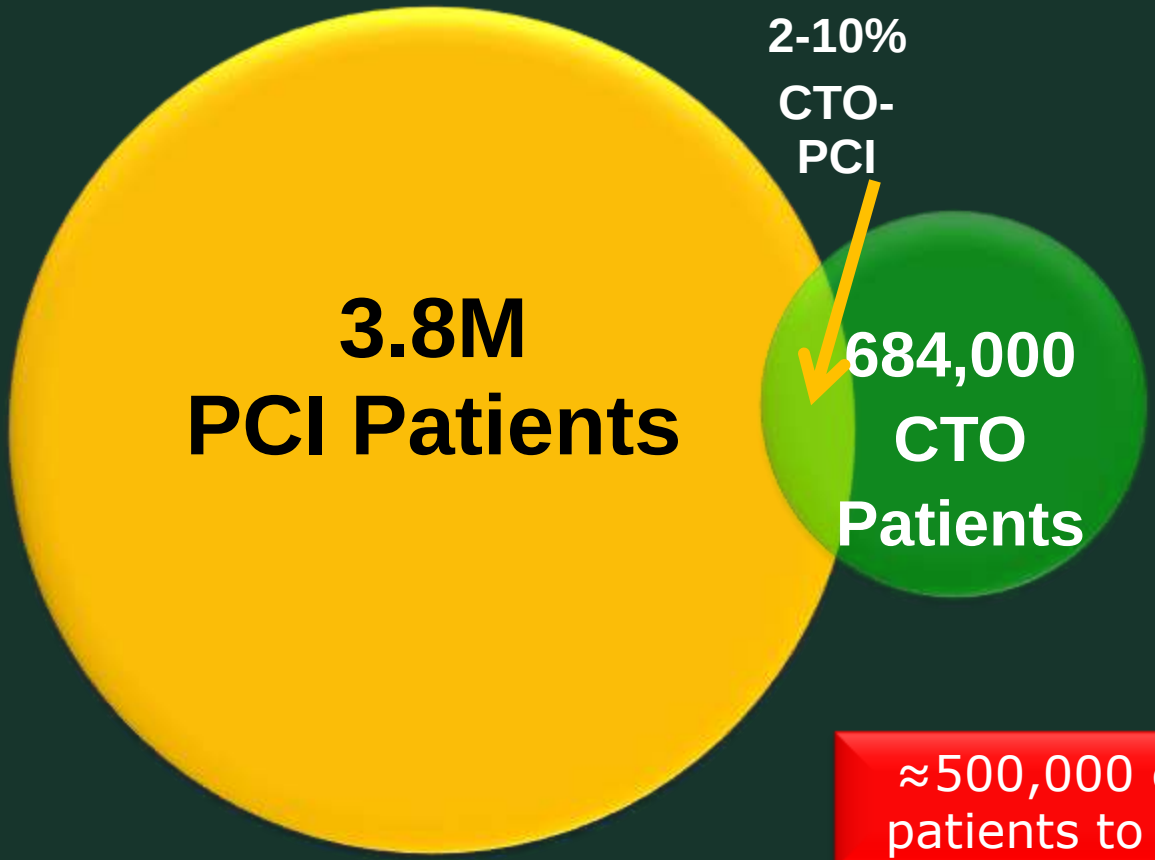




Only 10% of PCI involved the CTO, with 70% success rate!

Fefer et al. *JACC* 2012.

# CTO Prevalence and Treatment

## *Translating the results of the Canadian Registry*

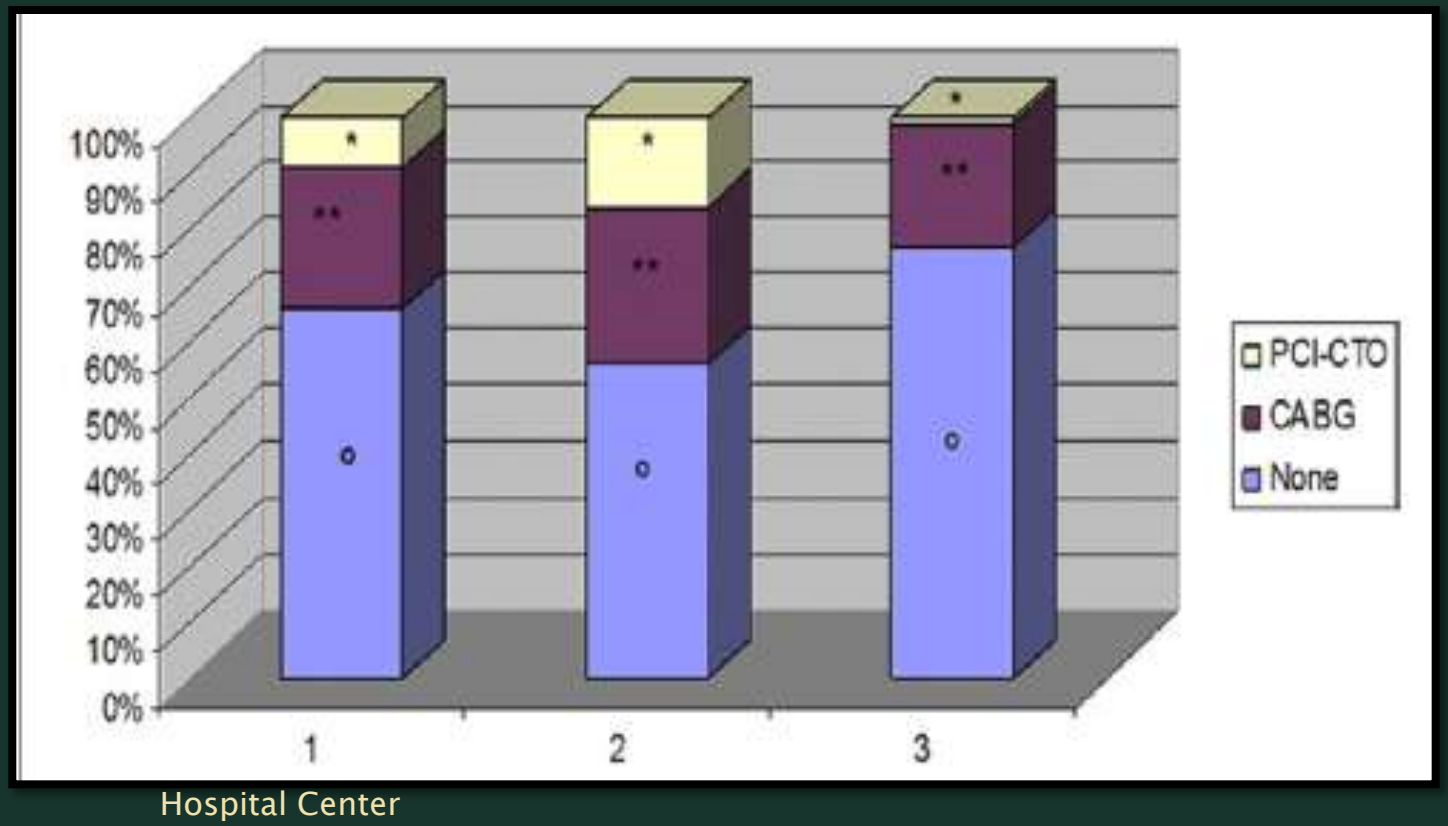



≈500,000 clinically eligible patients to receive CTO-PCI

Brilakis ES, et.al., *JACC Cardiovasc Interv* 2012. Fefer et. al.. *JACC* 2012. ARRIVE 1, ARRIVE 2, SCAR, eCypher real-world registries. Japan PCI CTO report.

# Variability in Current Treatment
## *CTO treatment strategies in 3 Canadian centers*

- CTO identified in 18.4% of 1,697 pts
- CTO-PCI attempt rate varied among hospitals from 1% to 16%

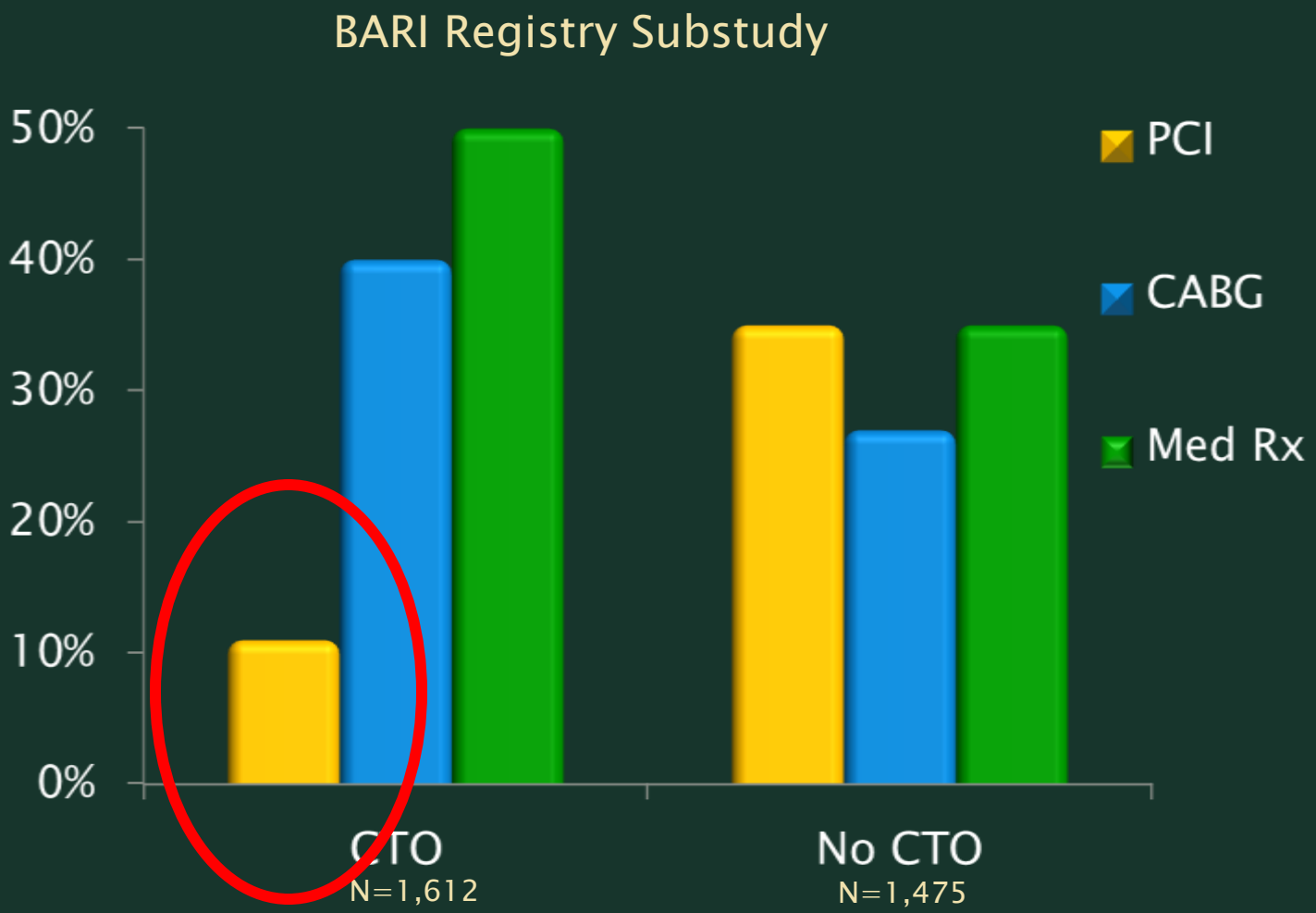



*p < 0.001; **p = NS; °p < 0.001.

Fefer et al. *JACC* 2012.

# CAD Treatment Strategies

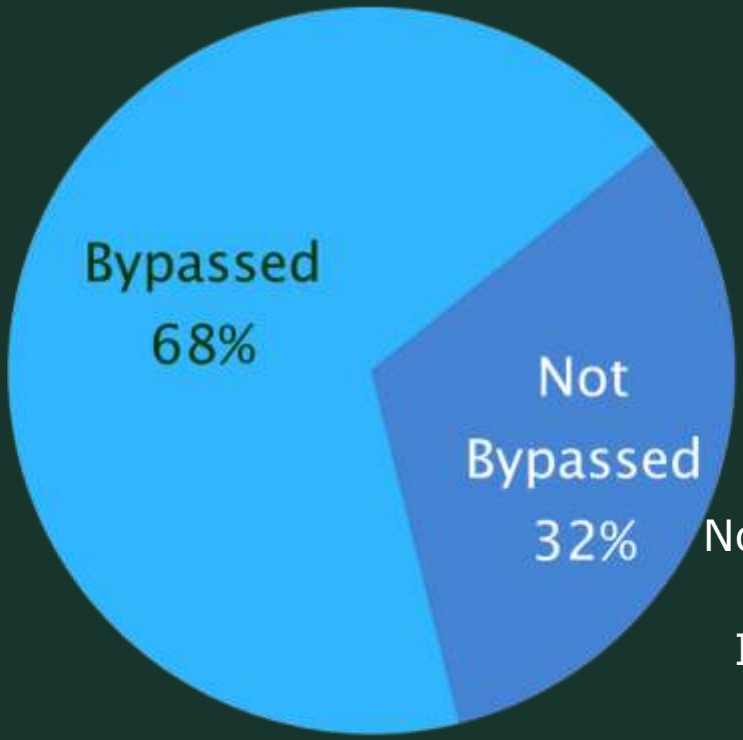
## *CTO-PCI disproportionately low*




Christofferson et al. *Am J Cardiol* 2005.

# CABG is Not Always an Option
## *SYNTAX CTO substudy*

266 CTO patients
randomized to receive CABG




**Reason not bypassed**:
Not intended to treat (n=12)
Diseased (n=11)
Inadequate conduit (n=2)
Too small (n=19)
Unable to find (n=1)
Other (n=36)

ITT, per lesion. 49.6% overall complete revascularization in CTO subset.
Courtesy Patrick Serruys, Syntax CTO substudy, TCT 2008.

# Why are CTO-PCI Attempt Rates So Low?
## *Common misconceptions*

- There is no clinical justification
- CTOs are stable and benign
- The procedure is too complex
- Success rates are low
- We don't have time for long procedures
- Results are not reproducible or teachable
- CTO-PCI is cost-prohibitive

"If you really want to do something, you'll find a way. If you don't, you'll find an excuse."

–Jim Rohn

There is No Clinical Justification

# Clinical Indications

## *Why open a chronically occluded coronary artery?*

- SYMPTOM CONTROL[1] and INCREASED QUALITY OF LIFE[2]
- IMPROVED LV FUNCTION[3]
- IMPROVED SURVIVAL[4]

[1] Grantham JA et al., Circulation: Cardiovascular Quality and Outcomes 2009.
[1-2] Safley D, Grantham JA, Jones P, and Spertus JA , ACC 2012
[3] Kirschbaum SW et al. American Journal of Cardiology 2008
[4] Hachamovitch et al Circulation. 2003; 107:2900-2907

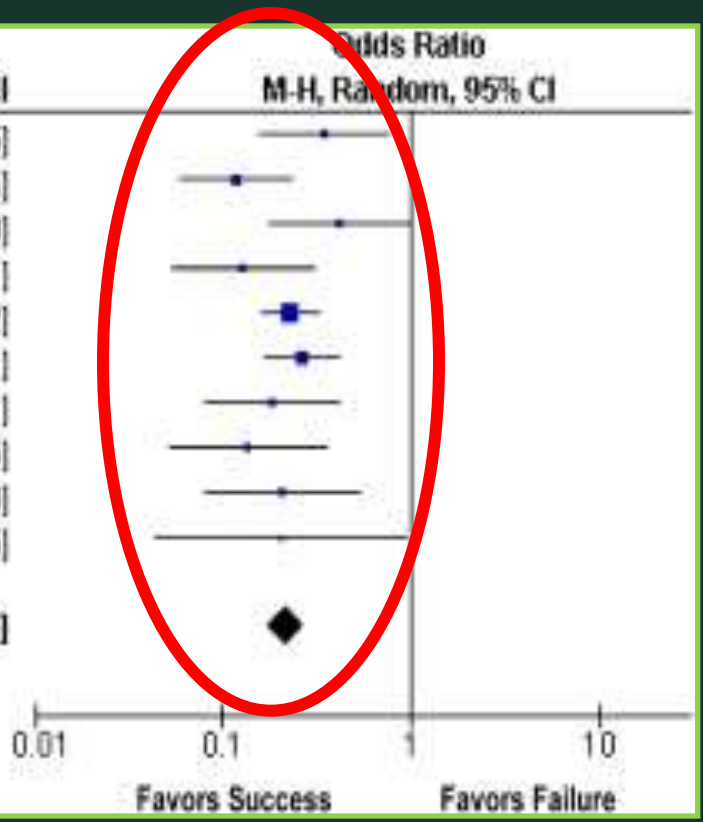
# Impact of Successful CTO-PCI: Angina

*Long-term angina benefit favors CTO-PCI success*

| Study or Subgroup | PCI success Events | Total | PCI failure Events | Total | Weight | Odds Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| Angioi et al. | 10 | 93 | 28 | 108 | 7.6% | 0.34 [0.16, 0.75] |
| Aziz et al. | 12 | 377 | 36 | 166 | 9.7% | 0.12 [0.06, 0.24] |
| Drozd et al. | 10 | 280 | 12 | 149 | 6.3% | 0.42 [0.18, 1.00] |
| Finci et al. | 7 | 100 | 37 | 100 | 6.2% | 0.13 [0.05, 0.31] |
| Hoye et al. | 71 | 567 | 117 | 304 | 30.9% | 0.23 [0.16, 0.32] |
| Ivanhoe et al. | 41 | 317 | 59 | 163 | 19.5% | 0.26 [0.17, 0.41] |
| Noguchi et al. | 9 | 134 | 26 | 92 | 7.0% | 0.18 [0.08, 0.41] |
| Olivari et al. | 7 | 286 | 13 | 83 | 5.2% | 0.14 [0.05, 0.35] |
| Valenti et al. | 7 | 344 | 13 | 142 | 5.4% | 0.21 [0.08, 0.53] |
| Warren et al. | 3 | 26 | 7 | 18 | 2.1% | 0.20 [0.04, 0.95] |
| **Total (95% CI)** | | **2524** | | **1325** | **100.0%** | **0.22 [0.17, 0.27]** |
| Total events | 177 | | 348 | | | |

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 9.90$, $df = 9$ ($P = .36$); $I^2 = 9\%$

Test for overall effect: $Z = 13.41$ ($P < .00001$)




Joyal D, Afilalo J, Rinfret S. *Am Heart J*, 2010.

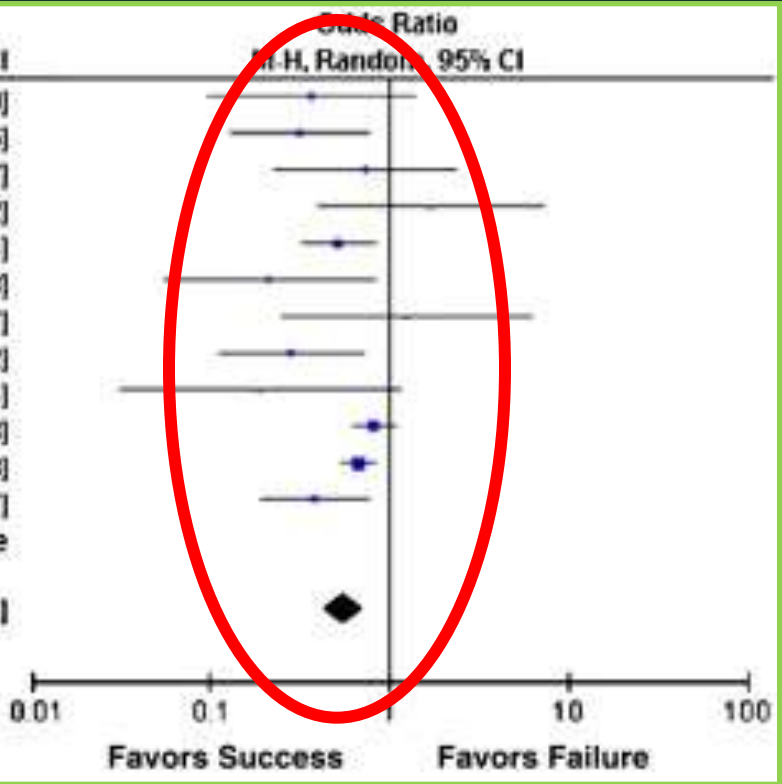
# Impact of Successful CTO-PCI: Mortality

*Long-term survival benefit favors CTO-PCI success*

| Study or Subgroup | PCI success Events | Total | PCI failure Events | Total | Weight | Odds Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| Angioi et al. | 3 | 93 | 9 | 108 | 3.4% | 0.37 [0.10, 1.40] |
| Aziz et al. | 9 | 377 | 12 | 166 | 6.7% | 0.31 [0.13, 0.76] |
| Drozd et al. | 7 | 280 | 5 | 149 | 4.3% | 0.74 [0.23, 2.37] |
| Finci et al. | 5 | 100 | 3 | 100 | 2.9% | 1.70 [0.40, 7.32] |
| Hoye et al. | 37 | 567 | 36 | 304 | 14.4% | 0.52 [0.32, 0.84] |
| Ivanhoe et al. | 3 | 317 | 7 | 163 | 3.2% | 0.21 [0.05, 0.83] |
| Labriolle et al. | 7 | 127 | 2 | 45 | 2.4% | 1.25 [0.25, 6.27] |
| Noguchi et al. | 7 | 134 | 15 | 92 | 6.1% | 0.28 [0.11, 0.72] |
| Olivari et al. | 2 | 286 | 3 | 83 | 1.9% | 0.19 [0.03, 1.14] |
| Prasad et al. | 229 | 914 | 101 | 348 | 21.6% | 0.82 [0.62, 1.08] |
| Suero et al. | 395 | 1491 | 180 | 514 | 23.8% | 0.67 [0.54, 0.83] |
| Valenti et al. | 17 | 344 | 17 | 142 | 9.3% | 0.38 [0.19, 0.77] |
| Warren et al. | 0 | 26 | 0 | 18 | | Not estimable |
| Total (95% CI) | | 5056 | | 2232 | 100.0% | 0.56 [0.43, 0.72] |
| Total events | 721 | | 390 | | | |

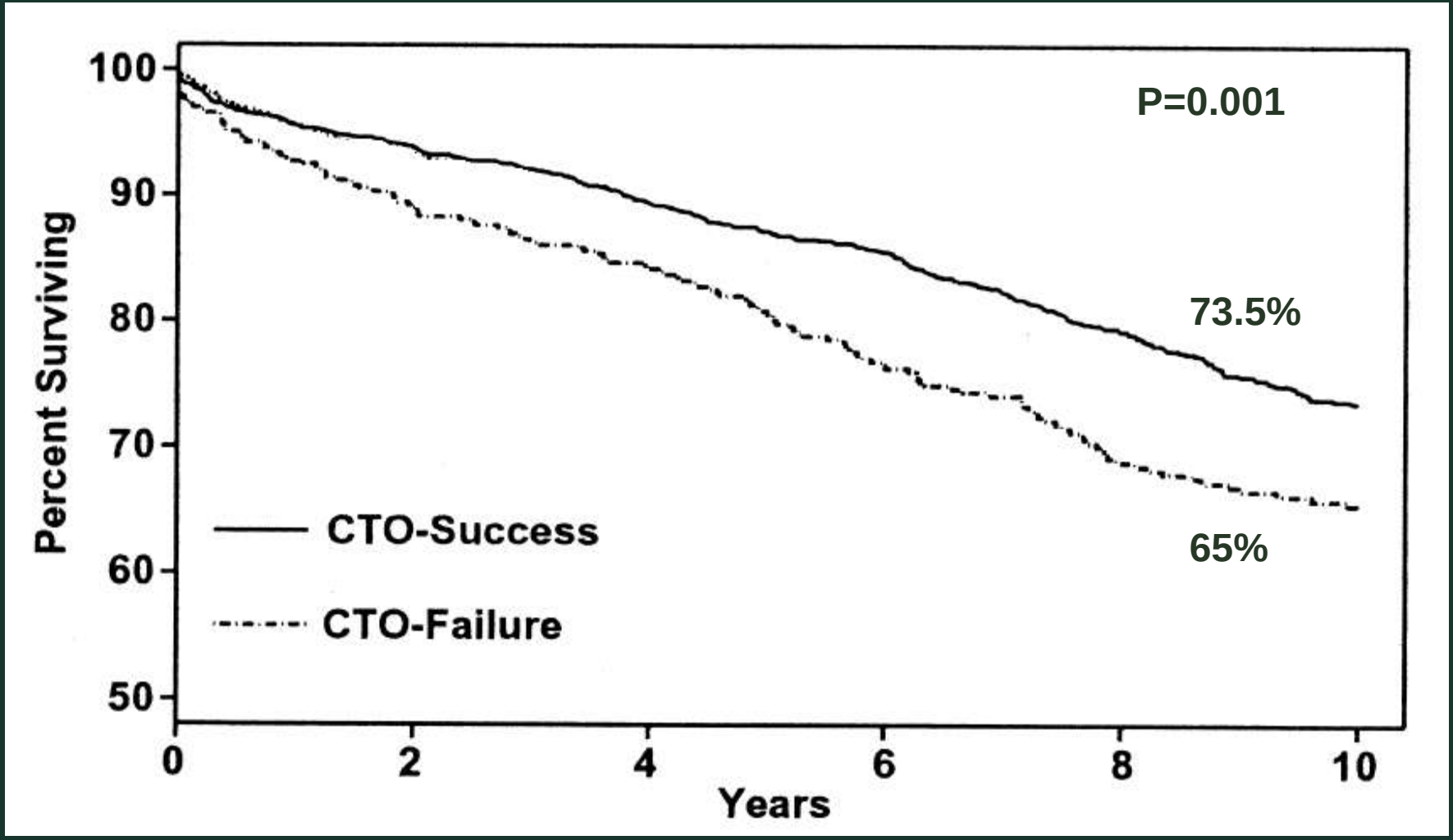
Heterogeneity: $Tau^2 = 0.06$; $Chi^2 = 18.74$, $df = 11$ ($P = .07$); $I^2 = 41\%$

Test for overall effect: $Z = 4.39$ ($P < .0001$)




Joyal D, Afilalo J, Rinfret S. *Am Heart J,* 2010.

# Re-opening of CTO: 20 years Experience

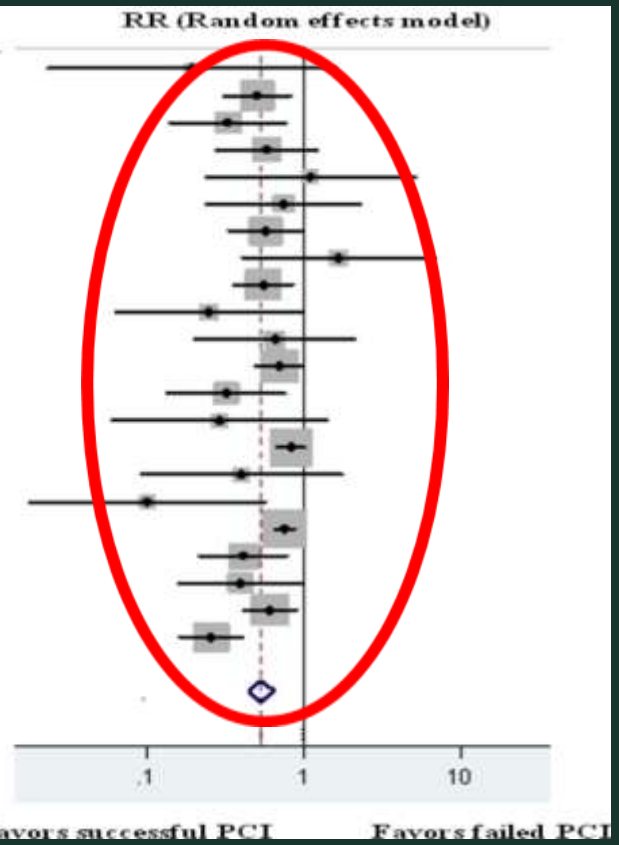



Suero, et al. JACC 2001;38:409-414

# Impact of Successful CTO-PCI on All Cause Mortality

| Study | PCI success n/N | PCI failure n/N | RR(95%CI) | %Weights |
|---|---|---|---|---|
| Angioi | 1/93 | 6/108 | 0.19(0.02-1.58) | 0.76 |
| Arslan | 9/117 | 37/115 | 0.50(0.31-0.82) | 6.77 |
| Aziz | 9/377 | 12/166 | 0.33(0.14-0.77) | 3.56 |
| Borgia | 19/237 | 9 /65 | 0.58(0.28-1.22) | 4.24 |
| de Labriolle | 7/127 | 2 /40 | 1.10(0.24-5.01) | 1.35 |
| Drozd | 7/280 | 5/149 | 0.74(0.24-2.31) | 2.28 |
| Jolicoeur | 22/213 | 24/133 | 0.57(0.34-0.98) | 6.20 |
| Finci | 5/100 | 3/100 | 1.67(0.41-6.78) | 1.58 |
| Hoye | 37/567 | 36/304 | 0.55(0.36-0.85) | 7.45 |
| Ivanhoe | 3/317 | 6/158 | 0.25(0.06-0.98) | 1.64 |
| Lee | 8/251 | 4 /82 | 0.65(0.20-2.11) | 2.14 |
| Mehran | 74/1226 | 49/565 | 0.70(0.49-0.98) | 8.75 |
| Noguchi | 7/134 | 15/92 | 0.32(0.14-0.76) | 3.49 |
| Olivari | 3/286 | 3 /83 | 0.29(0.06-1.41) | 1.28 |
| Prasad | 220/914 | 101/348 | 0.83(0.68-1.01) | 10.90 |
| Sathe | 3/116 | 4 /62 | 0.40(0.09-1.73) | 1.46 |
| Chen | 2/132 | 3/20 | 0.10(0.02-0.57) | 1.09 |
| Suero | 395/1491 | 179/514 | 0.76(0.66-0.88) | 11.58 |
| Valenti | 17/344 | 17/142 | 0.41(0.22-0.78) | 5.08 |
| Yang | 7/87 | 10/49 | 0.39(0.16-0.97) | 3.25 |
| YiX | 135/1202 | 24/130 | 0.61(0.41-0.90) | 8.05 |
| Jones | 26/582 | 44/254 | 0.26(0.16-0.41) | 7.12 |
| Warren | 0/26 | 0/18 | (Excluded) | |
| D+L pooled * RR | 1156/9219 | 593/3697 | 0.54(0.45-0.65) | 100.00 |

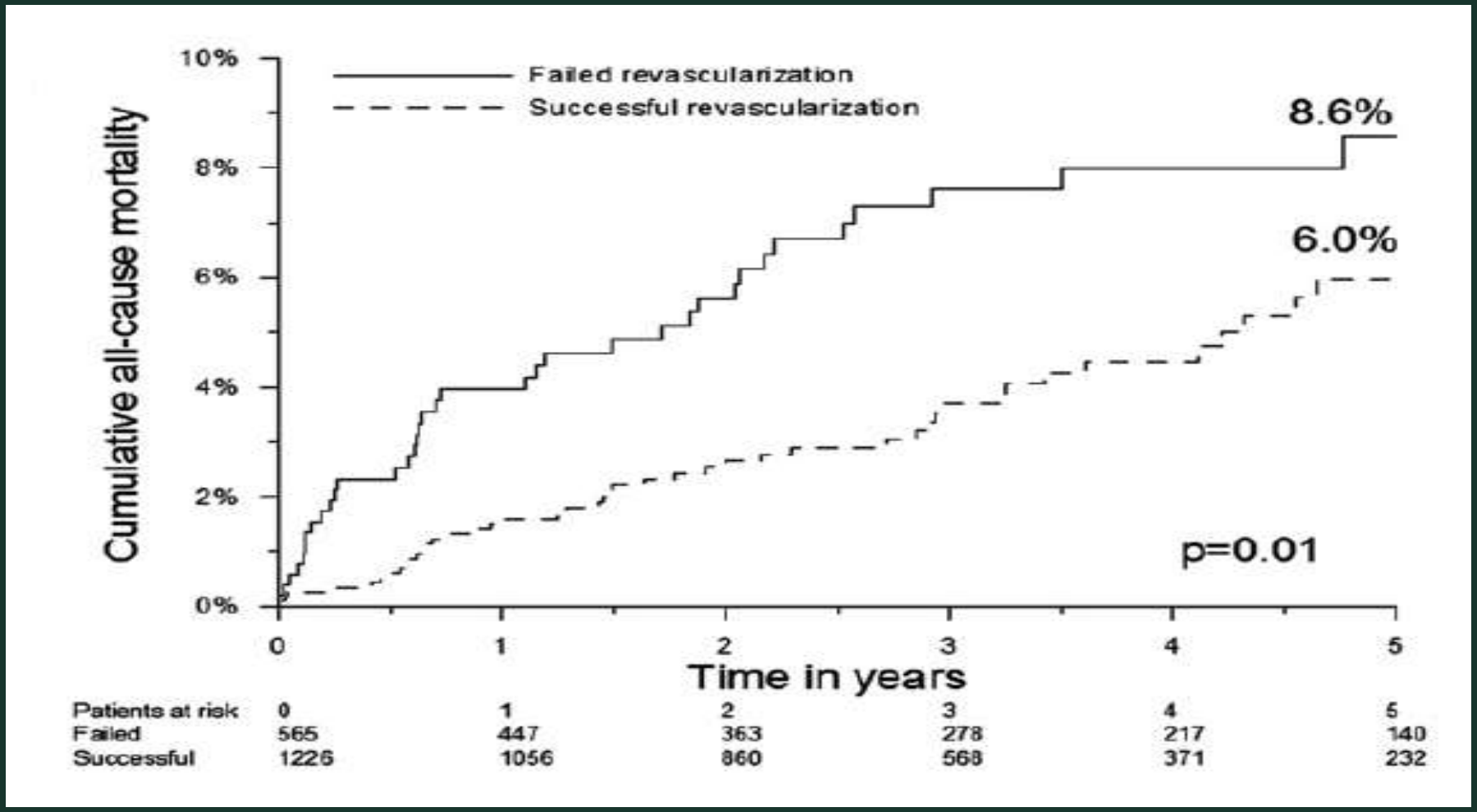
Heterogeneity chi-squared = 47.03 (d.f. = 21) p = 0.001
I-squared (variation in RR attributable to heterogeneity) = 55.3%
Estimate of between-study variance Tau-squared = 0.0745




Khan, et al. *Catheter Cardiovasc Intv.* 2013.

# Clinical Event Rates

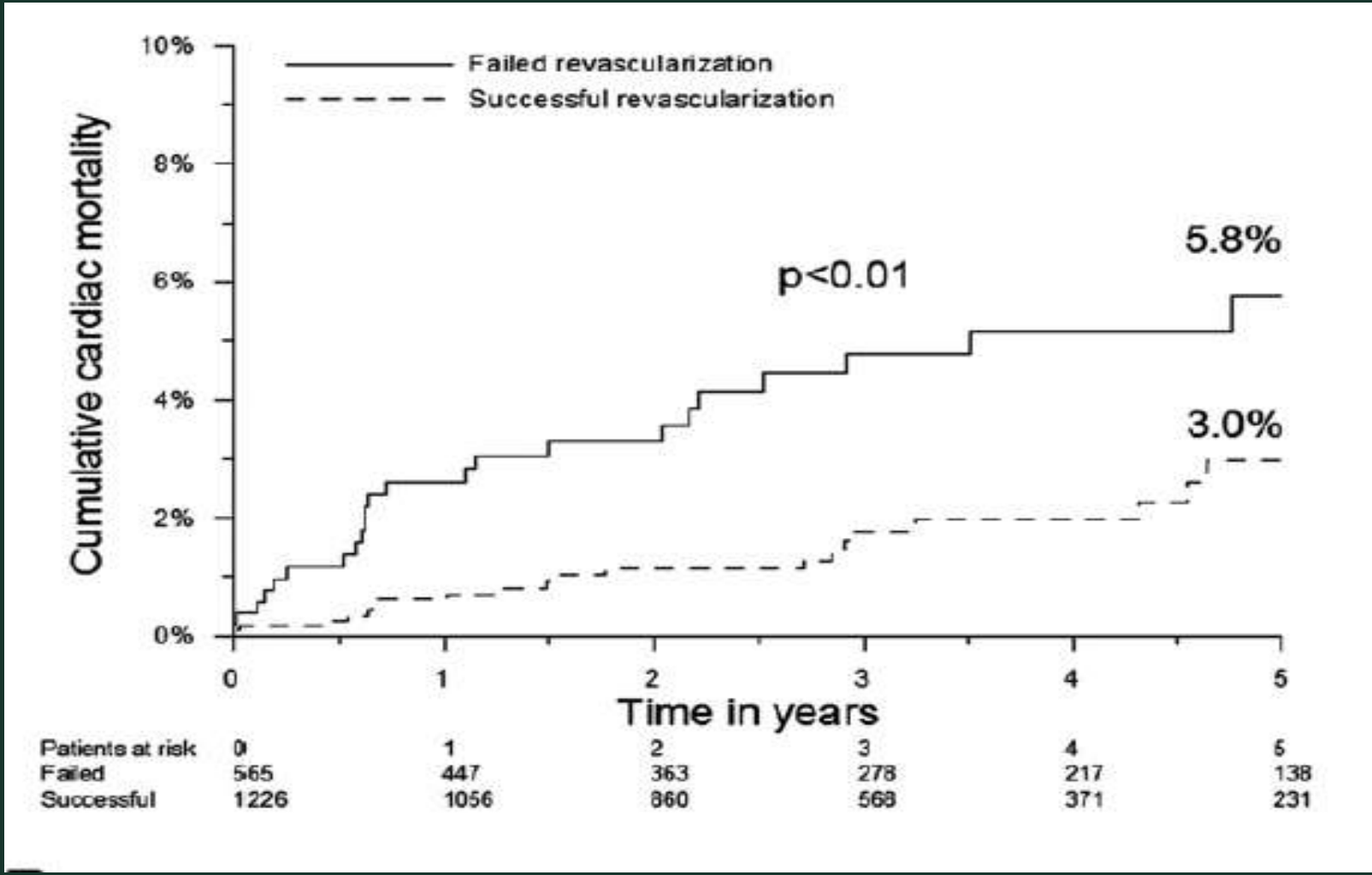
## All-cause Mortality for Successful versus Failed PCI of a CTO




Mehran, et al. *J Am Coll Cardiol Intv.*2011;4(9):952-961.

# Clinical Event Rates

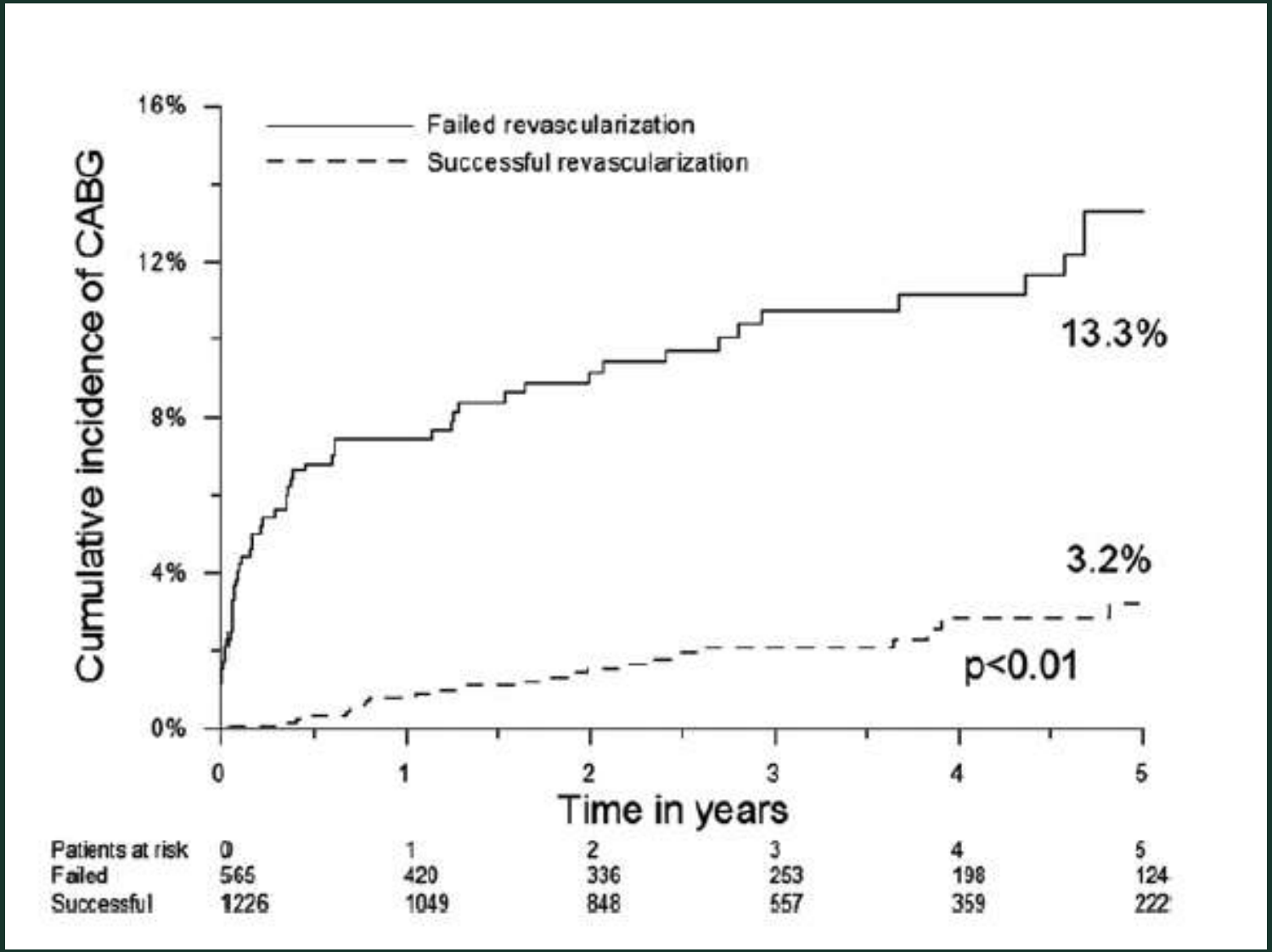
## Cumulative Cardiac Mortality for Successful versus Failed PCI of a CTO




Mehran, et al. *J Am Coll Cardiol Intv.*2011;4(9):952-961.

# Clinical Event Rates

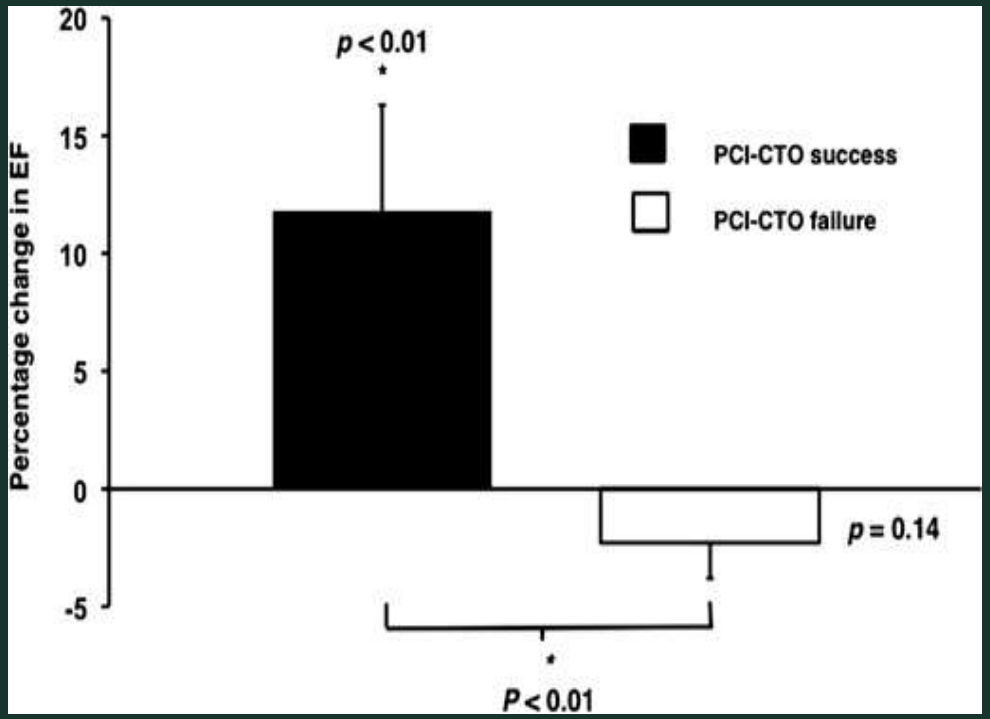
## Cumulative Incidence of CABG for Successful versus Failed PCI of a CTO



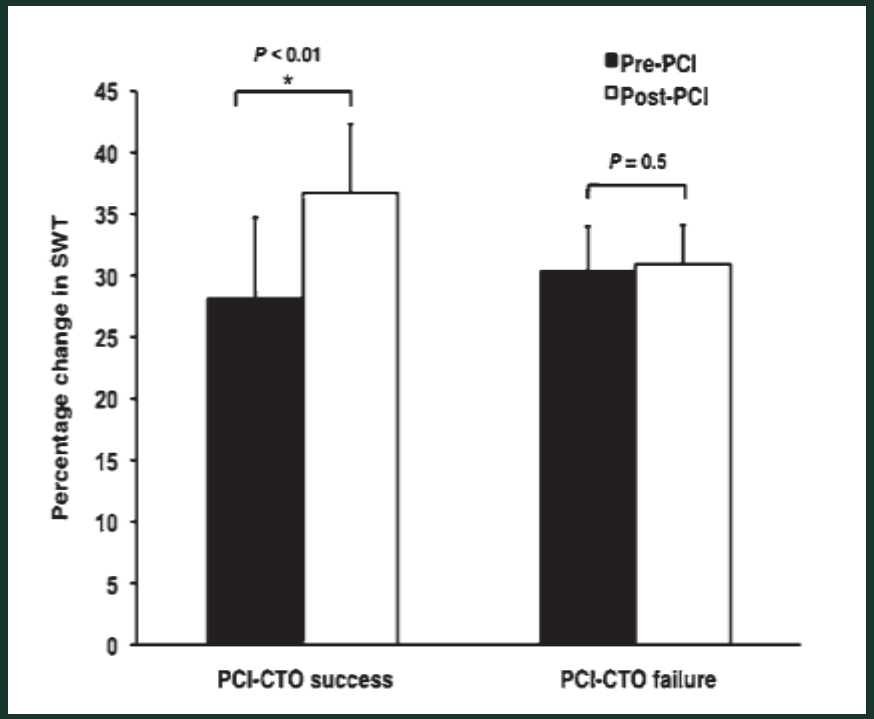

Mehran, et al. *J Am Coll Cardiol Intv.*2011;4(9):952-961.

# Improvement of LV function with CTO-PCI

Ejection Fraction (EF)



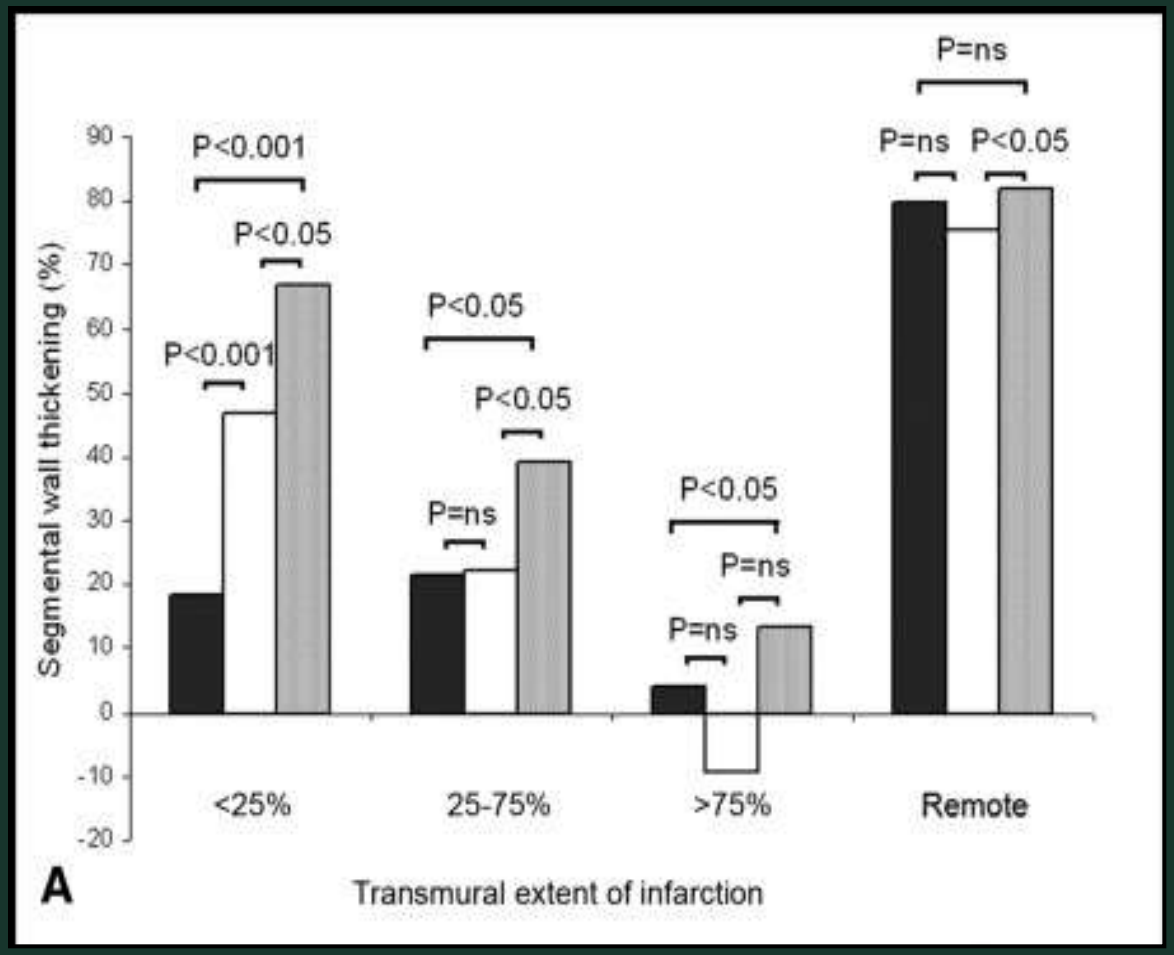

Segmental Wall Thickening (SWT)




MRI assessment at baseline and at 6 months shows an improvement in EF and SWT in patients who had successful CTO-PCI

Paul et al, *Heart* 2011.

# Long Term LV Function Improvement with CTO-PCI
## *<25% infarcted has most significant improvement*

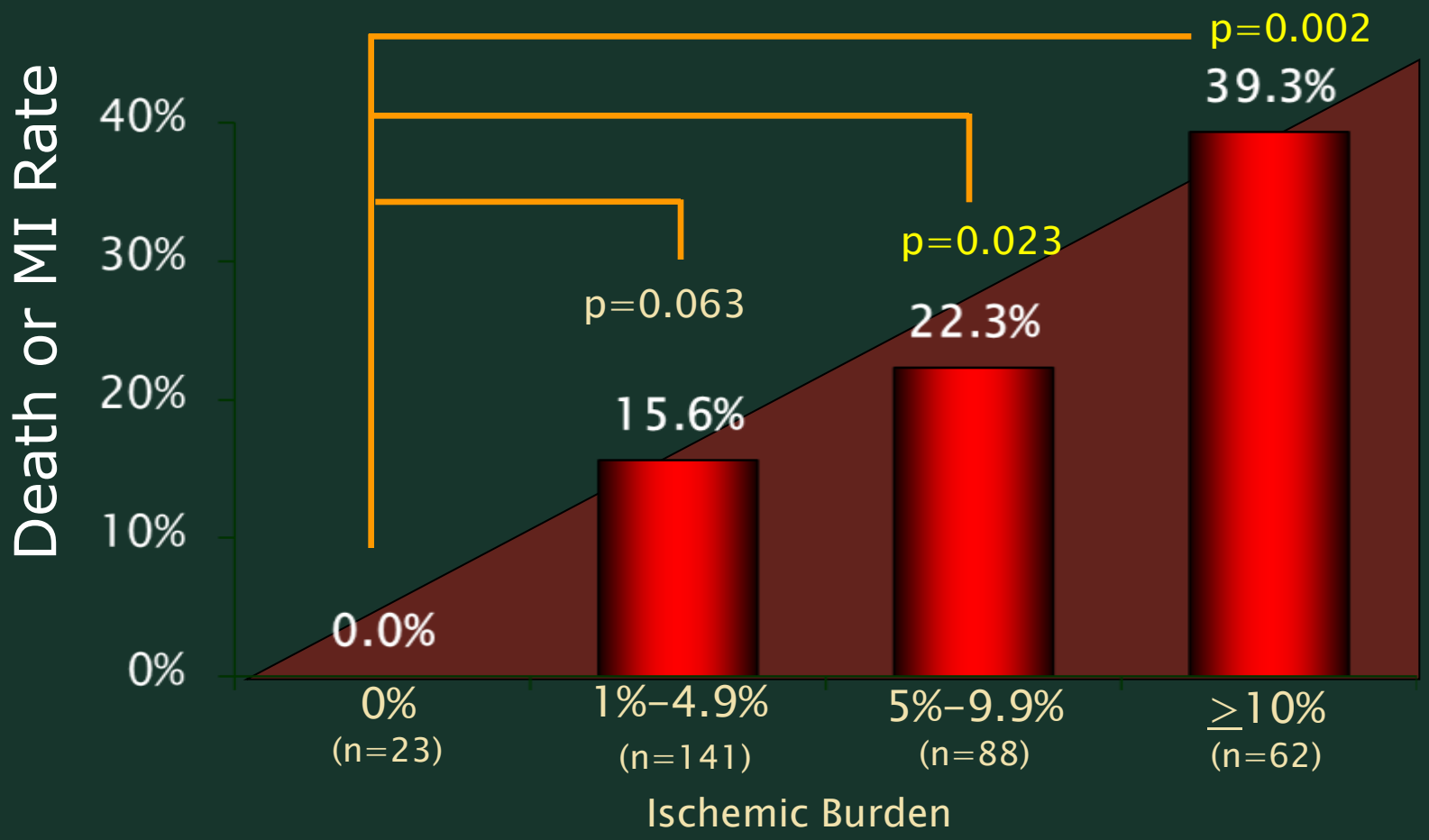



- Improvements in LV volume maintained at 3 years
- Degree of transmurality of scar by MRI

Kirschbaum SW et al. *American Journal of Cardiology* 2008

# Medical Therapy may not be enough!

## *Higher ischemic burden correlated to mortality*




Shaw et al, *Circulation* 2008;117

# When is CTO-PCI Appropriate?

## Single vessel CTO

Angina ↑ / Risk ↑

| | Class 0 | Class I/II | Class III/IV |
|---|---|---|---|
| High Risk Max Rx | U | A | A |
| Int Risk Max Rx | U | U | A |
| Low Risk Max Rx | U | U | A |

## 1 or 2 vessel disease
(No proximal LAD)

Angina ↑ / Risk ↑

| | Class 0 | Class I/II | Class III/IV |
|---|---|---|---|
| High Risk Max Rx | A | A | A |
| Int Risk Max Rx | U | A | A |
| Low Risk Max Rx | U | A | A |

CTO–PCI appropriateness is based on patient risk and angina, assuming maximum medical therapy

Modified from Patel et al *J Am Coll Cardiol* 2009;53:530–553

# But not all CTOs are appropriate

Single vessel CTO

| Risk | Class 0 | Class I/II | Class III/IV |
|---|---|---|---|
| High Risk No Rx | I | U | U |
| Int Risk No Rx | I | U | U |
| Low Risk No Rx | I | I | I |

Angina

1 or 2 vessel disease
(No proximal LAD)

| Risk | Class 0 | Class I/II | Class III/IV |
|---|---|---|---|
| High Risk No Rx | I | U | A |
| Int Risk No Rx | I | U | U |
| Low Risk No Rx | I | I | U |

Angina

If maximum medical therapy is absent, CTO-PCI may not be appropriate

Modified from Patel et al *J Am Coll Cardiol* 2009;53:530-553

# 2011 ACC CTO-PCI Guidelines

## Chronic Total Occlusions


PCI of a CTO in patients with appropriate clinical indications and suitable anatomy is reasonable when performed by operators with appropriate expertise.



Helping Cardiovascular Professionals Learn, Advance, Heal.

American Heart Association.

The Society for Cardiovascular Angiography and Interventions

# Controlled, randomized trial needed
## *OPEN CTO Registry Coming*

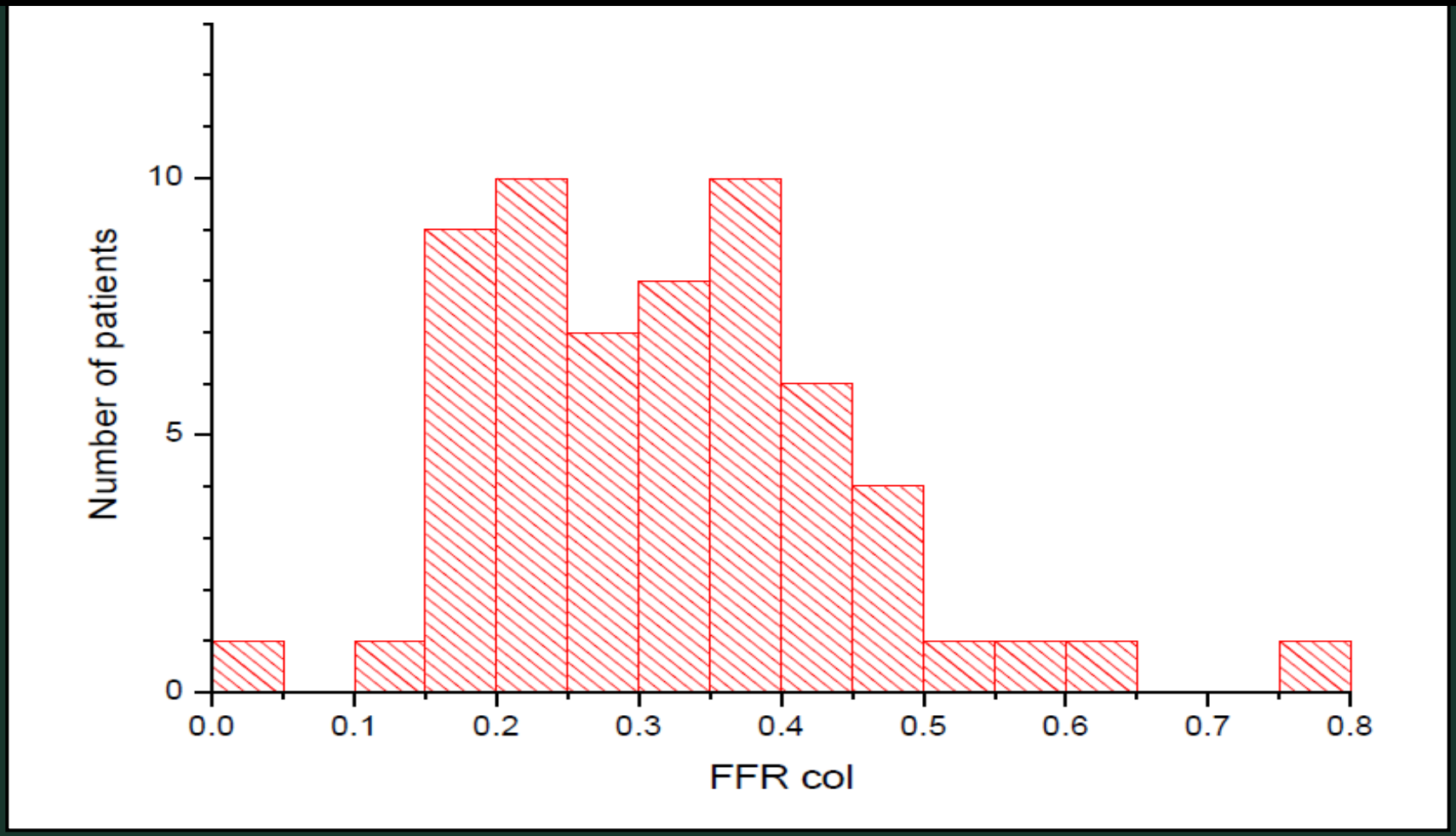

| | |
|---|---|
| **Primary Investigators** | • J. Aaron Grantham (PI)<br>• William L. Lombardi (Co-PI) |
| **Overview** | • 10 US sites<br>• 1000 patients<br>• Multi-center, prospective, single arm observational registry |
| **Aims** | • Safety, success, efficiency of hybrid approach<br>• Health status effects of CTO-PCI<br>• Indications and appropriateness of CTO-PCI<br>• Economic analysis |
| **Status** | • Enrolling 2014 |
| **Sponsorship** | • Saint Luke's Mid-America Heart Institute<br>• Investigator Sponsored Research trial made possible by a grant from Boston Scientific |

CTOs are St  le and Benign

# Ischemia in "Adequately Collateralized" CTOs

*No CTOs are adequately collateralized*

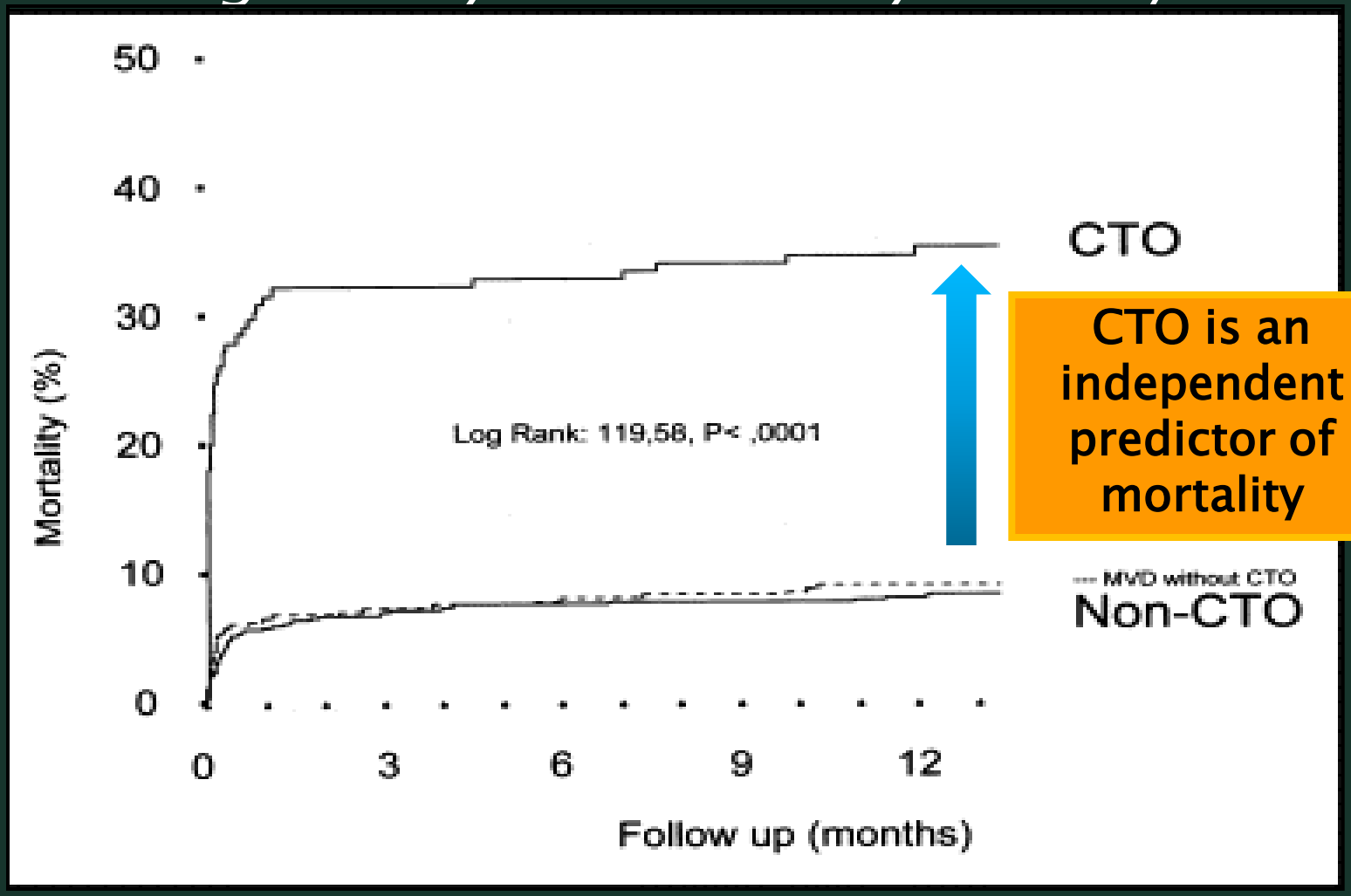
*FFR in 59 pts after successful wire crossing of a CTO*




Werner GS et al, *European Heart Journal* 2006.

# CTO Impact on Non-CTO vessel AMI Mortality

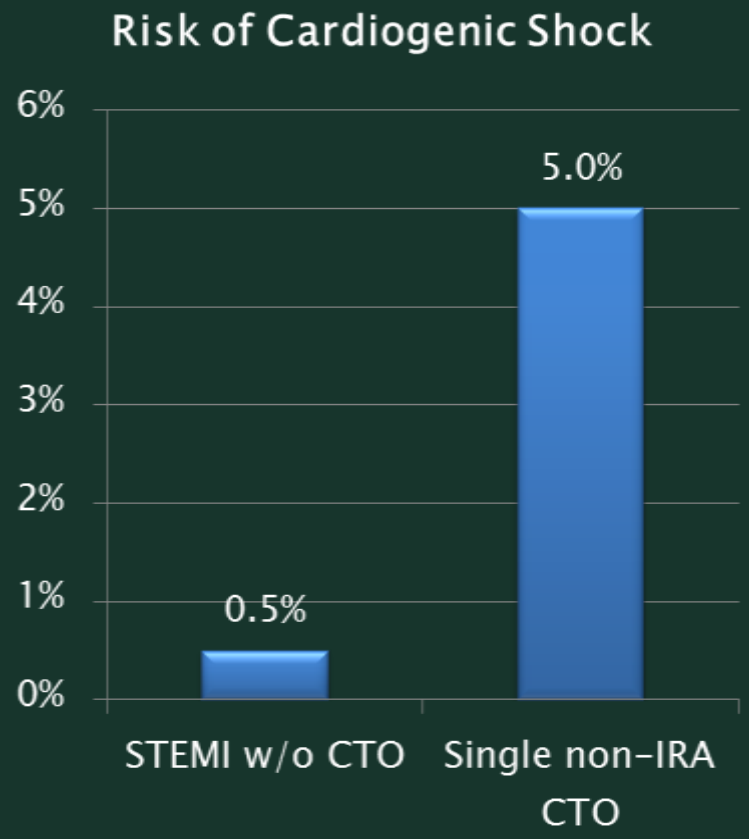
*Higher 1-year mortality rate w/ CTO*

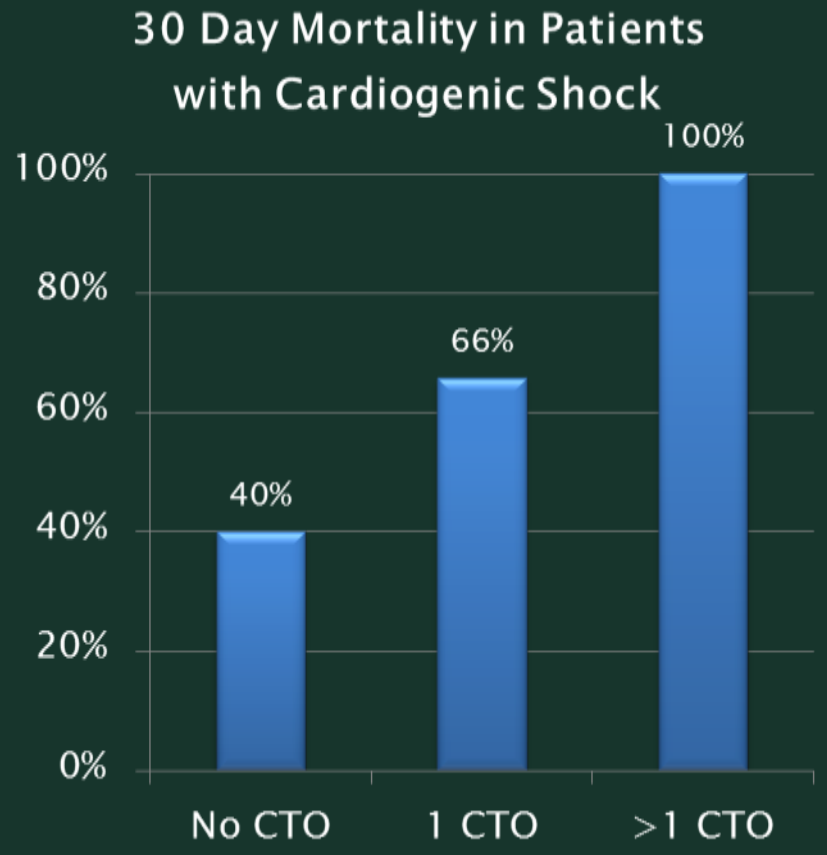



Van der Schaff RJ et al. *Am J Cardiol*

# CTO and Cardiogenic Shock

## *CTO is independent predictor of mortality*




Bataille Y, et al. *Am Heart J.* 2012.

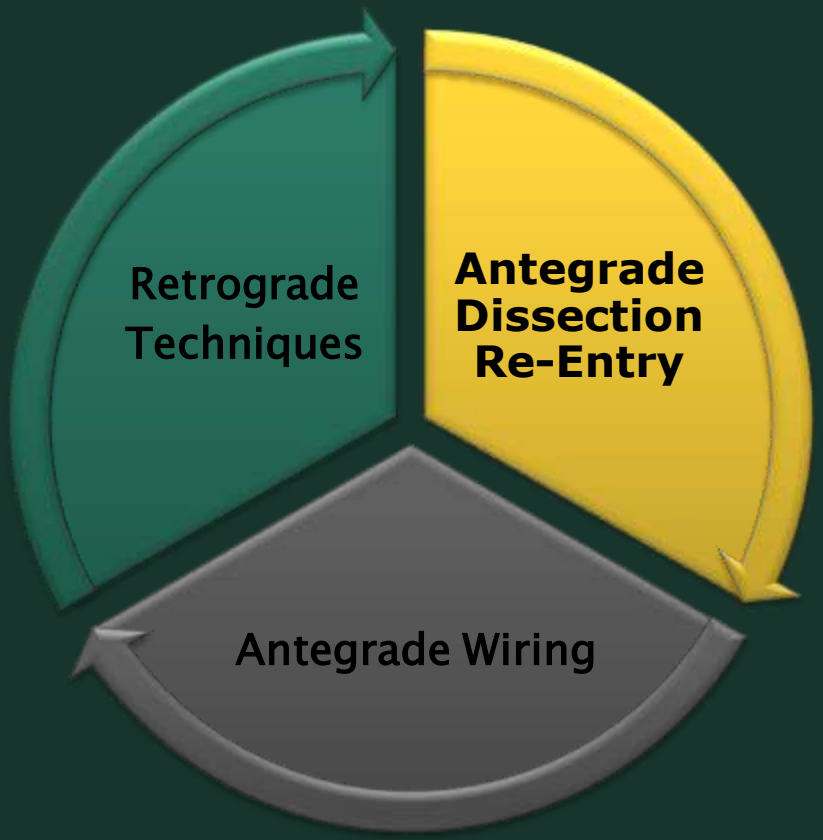
The Procedure Is Too Complex

# Evolution of CTO-PCI

*Increasing success rates related to technique evolution*

- 2004
  - Antegrade Wires and IVUS
- 2007
  - Rudimentary Retrograde
- 2010
  - Early Antegrade Dissection Re-Entry
- 2012
  - Hybrid

# New Approach to Treat CTOs
## *The Hybrid Strategy*



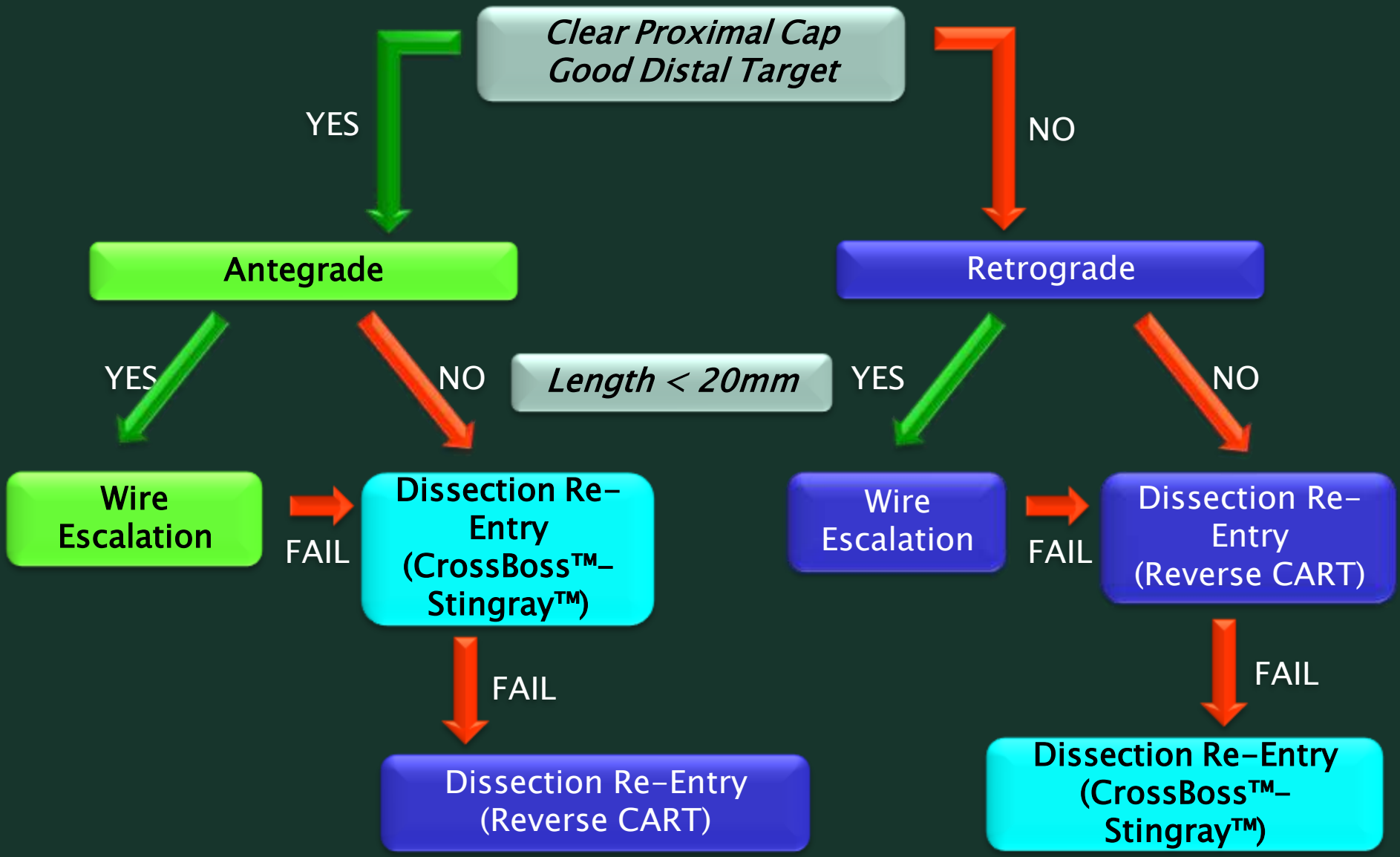

FOUR ANGIOGRAPHIC CHARACTERISTICS DICTATE STRATEGY

- Proximal cap ambiguity
- Lesion length
- Quality of distal target
- Suitability of "interventional" collaterals

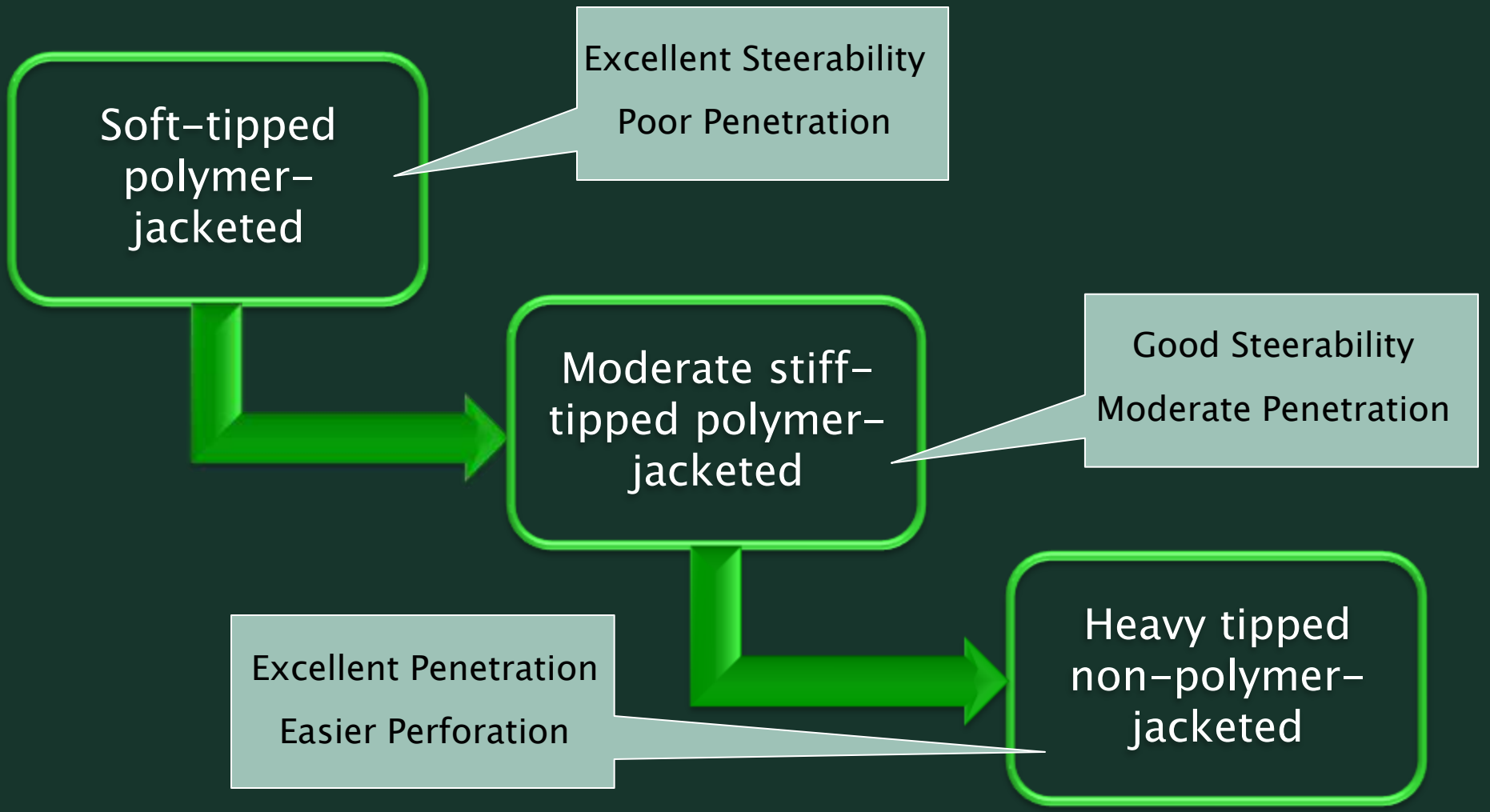
HYBRID STRATEGY PRINCIPLES

- Consistent evaluation approach
- Emphasizes procedural safety, success, and efficiency
- Minimizes radiation and contrast
- Quick transition to alternate plans when failure mode occurs

# The Hybrid Algorithm



# Antegrade Wire Escalation



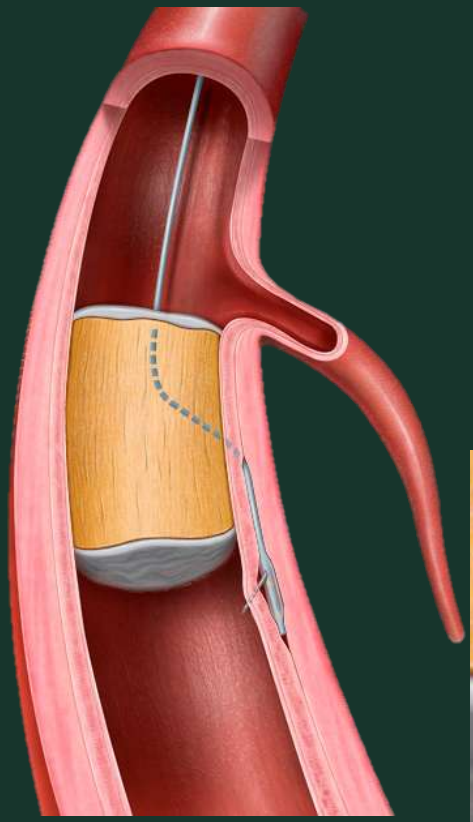
# Guidewire Selection

| Procedure | Guide-wire | Commercial name |
|---|---|---|
| Antegrade micro-channel or soft tissue probing | A hydrophilic and/or polymer-jacket 0.014-inch guidewire, low gram-force, with tapered 0.009-I | Fielder XT wire (Asahi Intecc, Nagoya, Japan) & Runthrough taper wire (Terumo Corporation, Tokyo, Japan) |
| Knuckle techniques | A hydrophilic and/or polymer-jacket 0.014-inch guidewire, low gram-force, with tapered 0.009-inch tip - Moderately high– gram-force (4 to 6 g), polymerjacket, nontapered 0.014-inch | Fielder XT wire (Asahi Intecc, Nagoya, Japan)<br><br>Fielder FC wire (Asahi Intecc) |
| Retrograde collateral channel crossing | Nontapered, polymer-jacket hydrophilic 0.014-inch guidewire | Fielder FC wire (Asahi Intecc) and Pilot 50 wire (Abbott Vascular, Santa Clara, California) |
| Complex lesion crossing | Moderately high–gram-force (4 to 6 g), polymerjacket, nontapered 0.014-inch High–gram-force 0.014-inch guidewire, with a tapered 0.009-inch nonjacketed tip | Pilot 200 guidewire (Abbott Vascular) *(for tortuous vessels)*<br><br>Confianza Pro 12 wire (Asahi Intecc)- *straight vessels* |
| Long lesions | Moderately high–gram-force (4 to 6 g), polymerjacket, nontapered 0.014-inch | Pilot 200 guidewire (Abbott Vascular) |
| Dissection/re-entry | Moderately high–gram-force (4 to 6 g), polymerjacket, nontapered 0.014-inch High–gram-force 0.014-inch guidewire, with a tapered 0.009-inch nonjacketed tip | Pilot 200 guidewire (Abbott Vascular)<br><br>Confianza Pro 12 wire (Asahi Intecc) |
| Penetration techniques | High–gram-force 0.014-inch guidewire, with a tapered 0.009-inch nonjacketed tip | Confianza Pro 12 wire (Asahi Intecc) |
| Cap puncture | High–gram-force 0.014-inch guidewire, with a tapered 0.009-inch nonjacketed tip | Confianza Pro 12 wire (Asahi Intecc) |

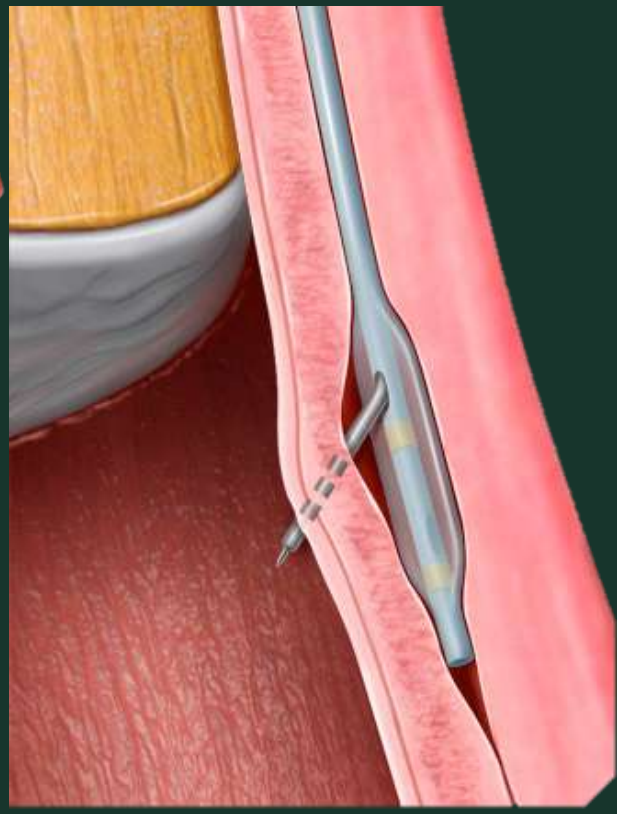
# Micro-catheters

- Corsair microcatheter- 2.7 Fr
- Small outer diameter, over-the-wire (OTW) microcatheters- V and Quickcross, finecross-2.6 to 1.8Fr
- Small OTW balloons for wire support and exchange- 1.0 to 1.5 balloons
- Tornus microcatheter

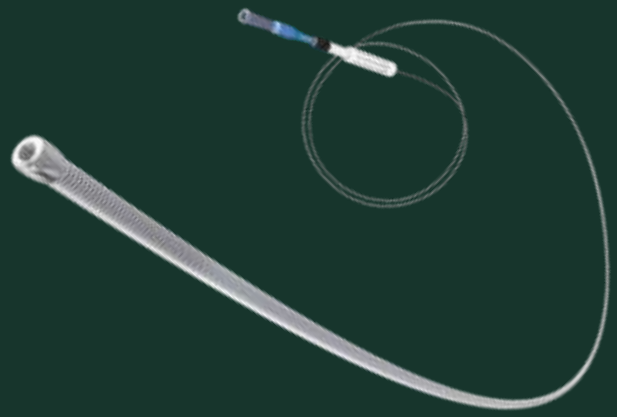
# Antegrade Dissection Re-Entry

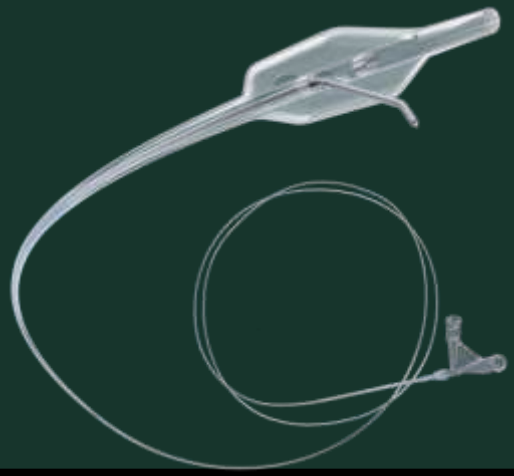
CTO crossing through the subintimal space, advancing across the occlusion, re-entering into the distal true lumen



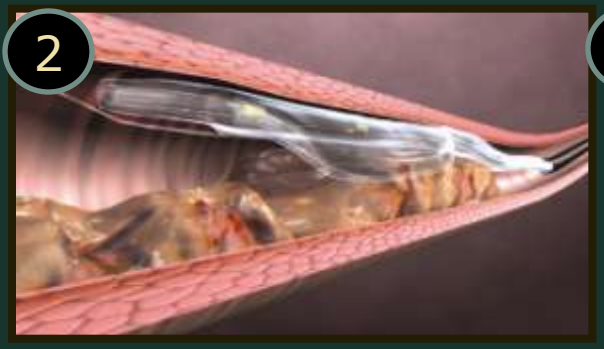
# Coronary CTO Crossing and Re-entry System



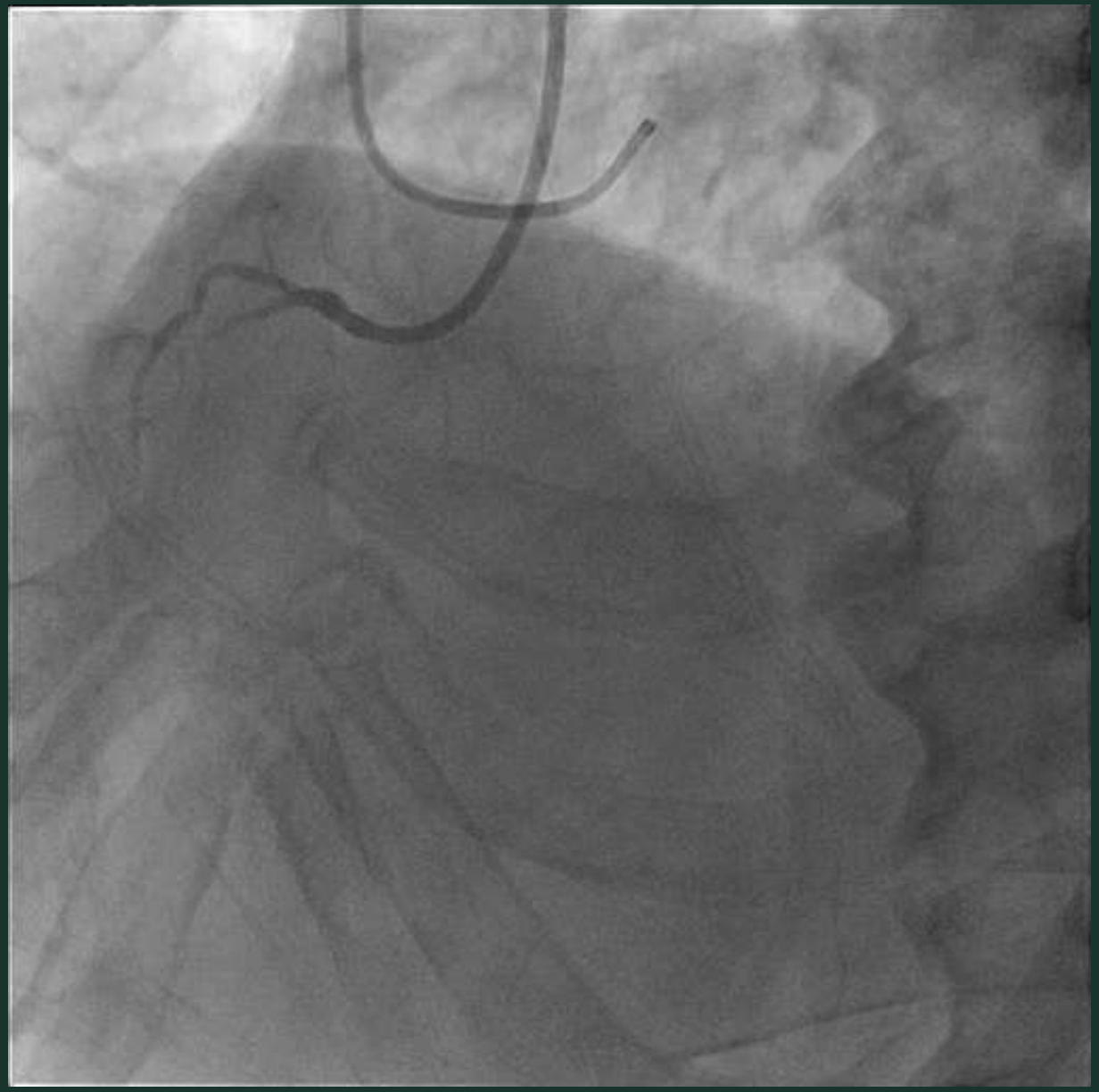
CrossBoss™ Catheter
Designed to quickly and safely deliver a guidewire via true lumen or subintimal pathways



Stingray™ Catheter
Designed to accurately target and re-enter the true lumen from a subintimal position

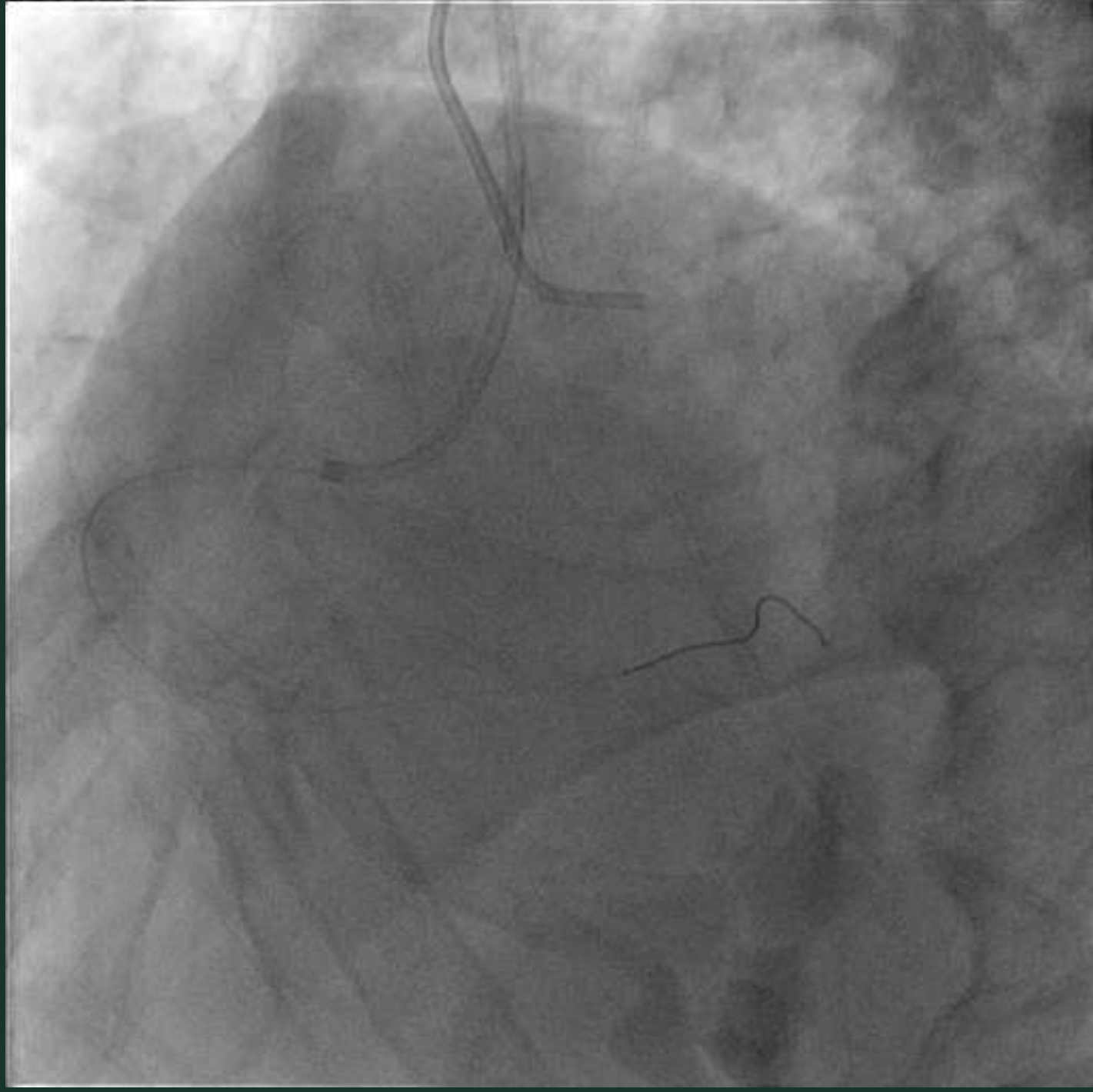




# Bilateral Transradial Access



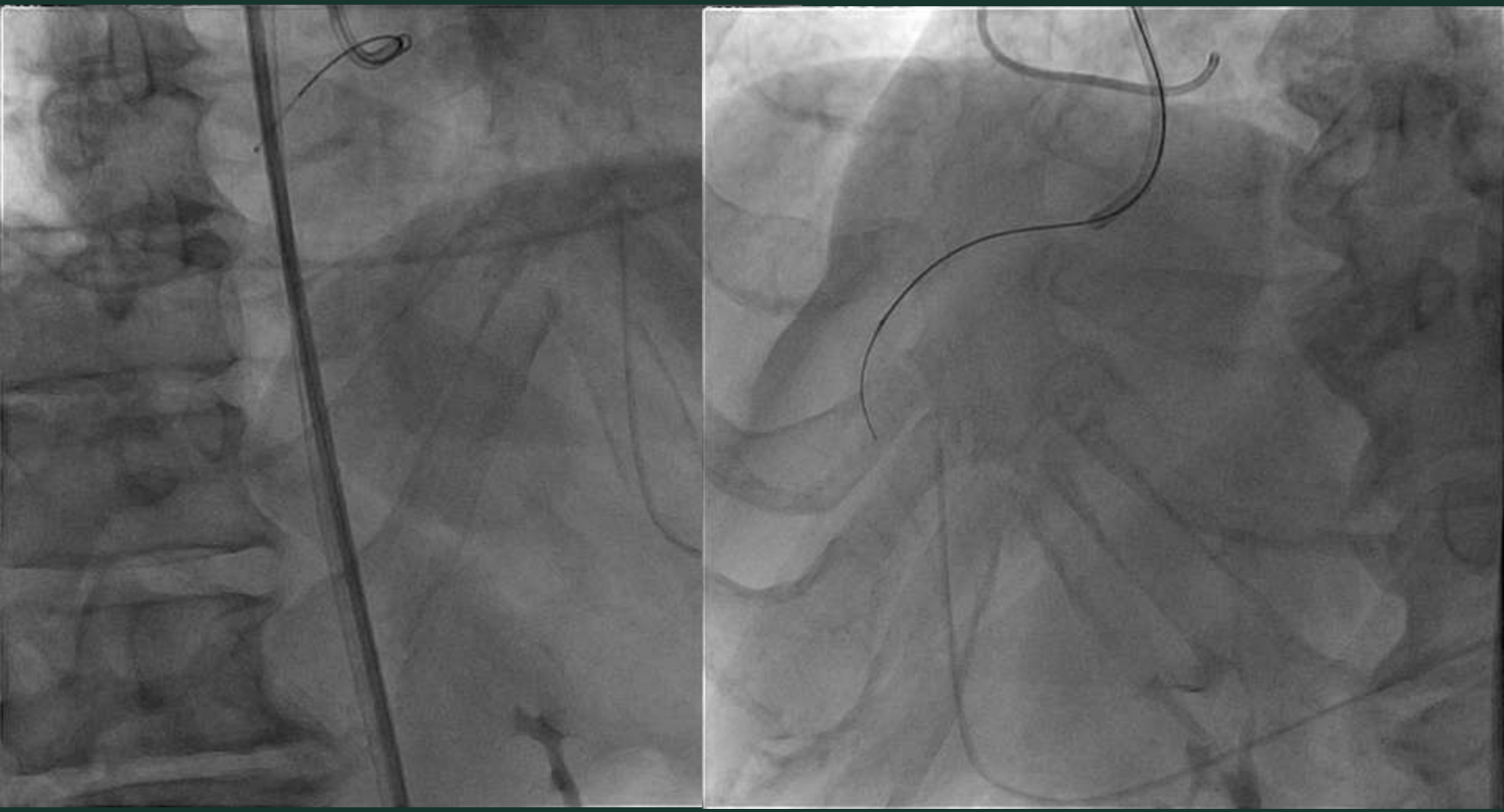
7 Fr JR Guide
RTRA
6 Fr Jackie LTRA

Post balloon angioplasty

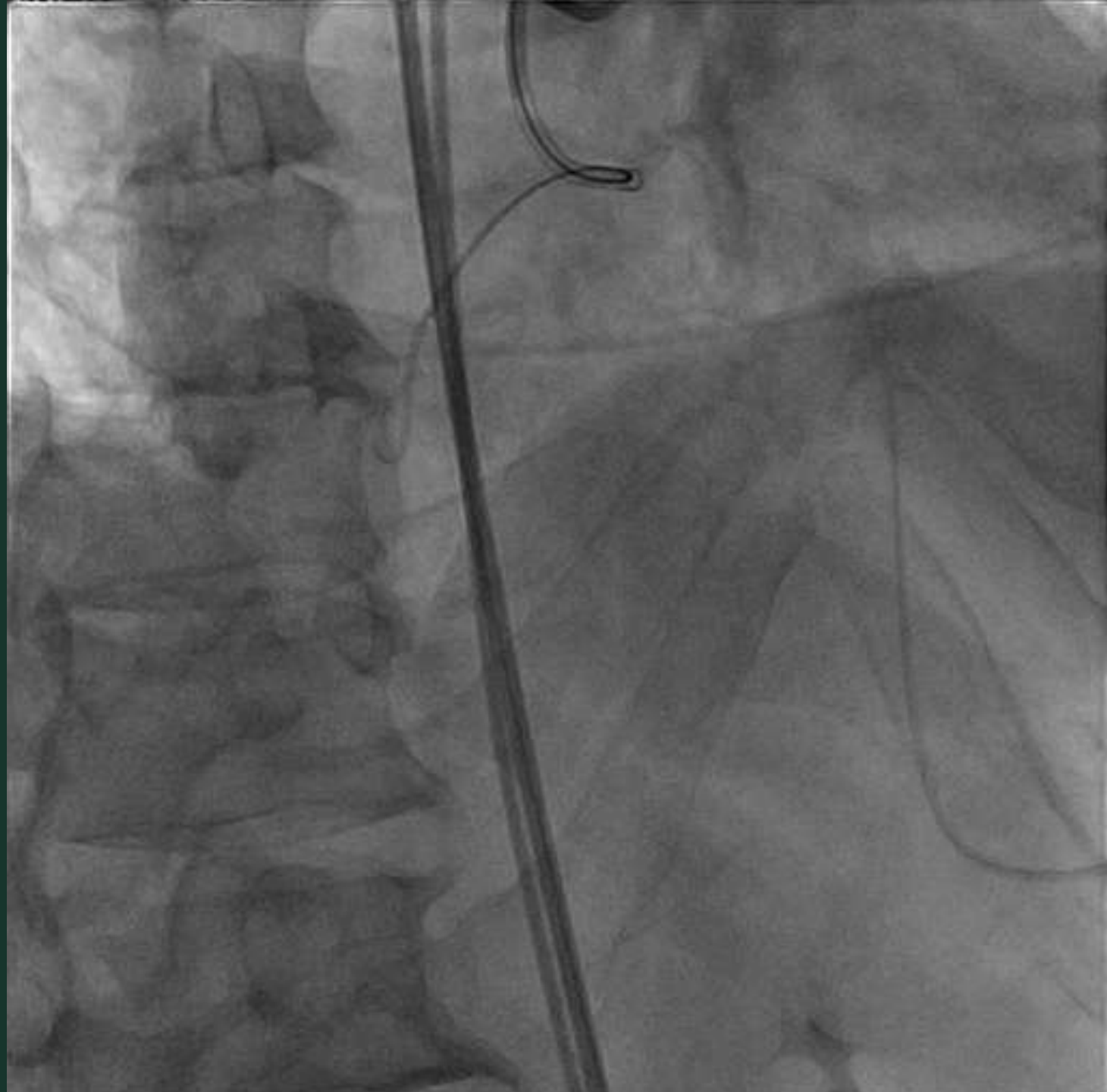


Final Angio
Patient sent home to return in 6-8 weeks

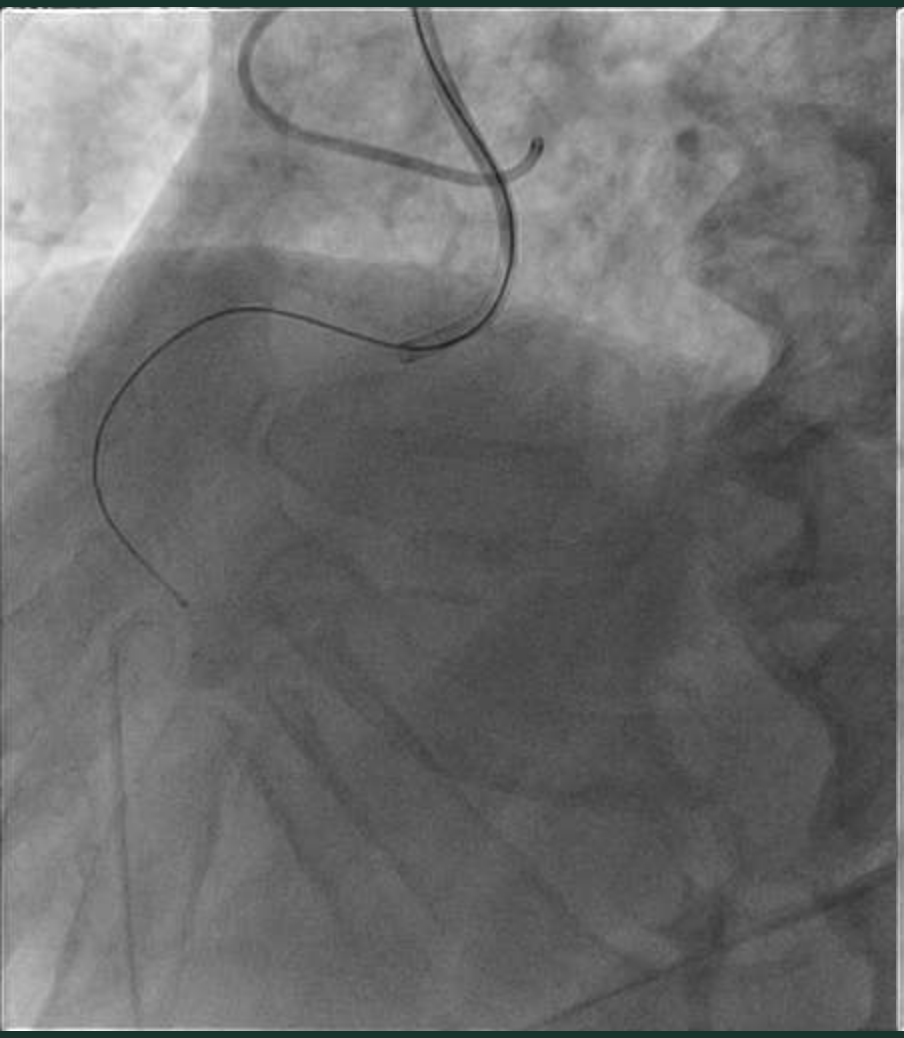
# RCA Crossbow with a Fielder XT Wire

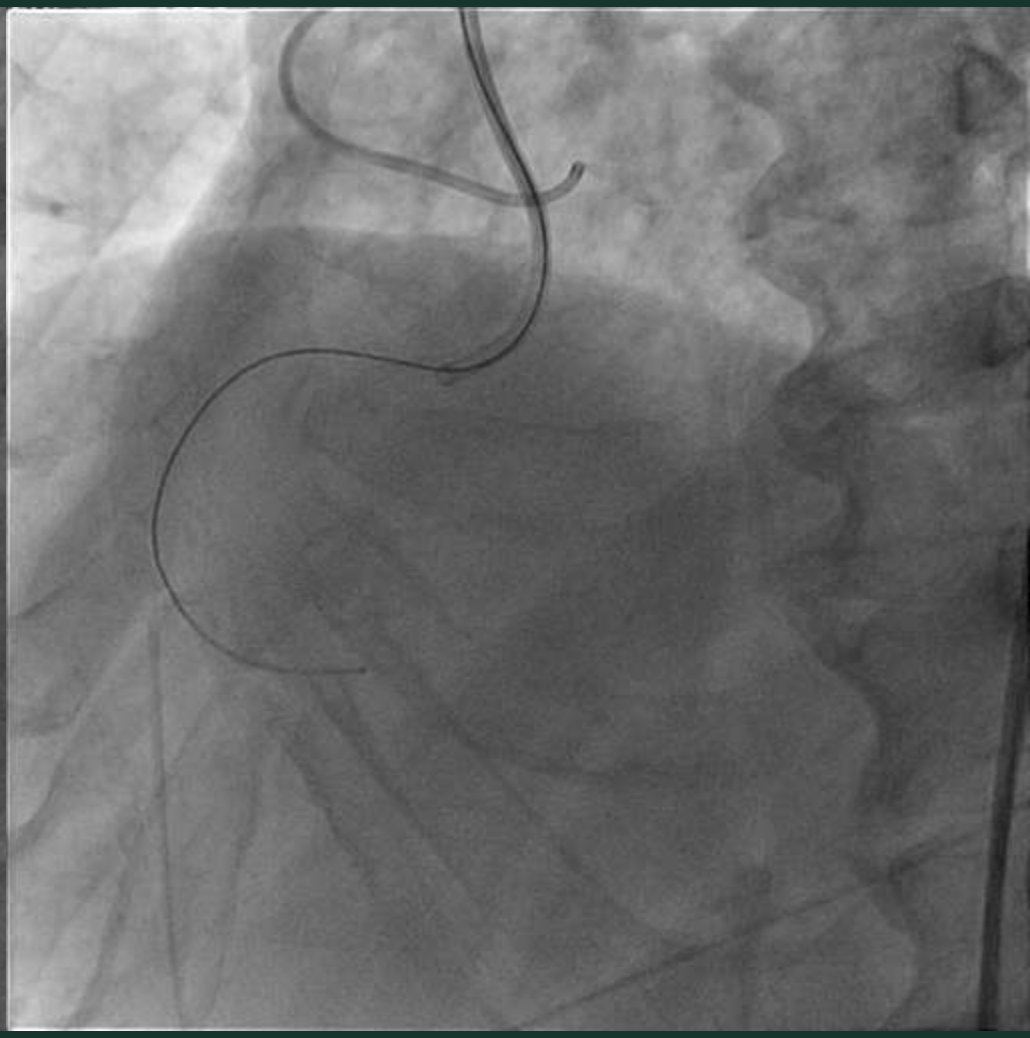


Crossbow redirect with a “knuckle” wire technique



# Mini-loop Subintimal

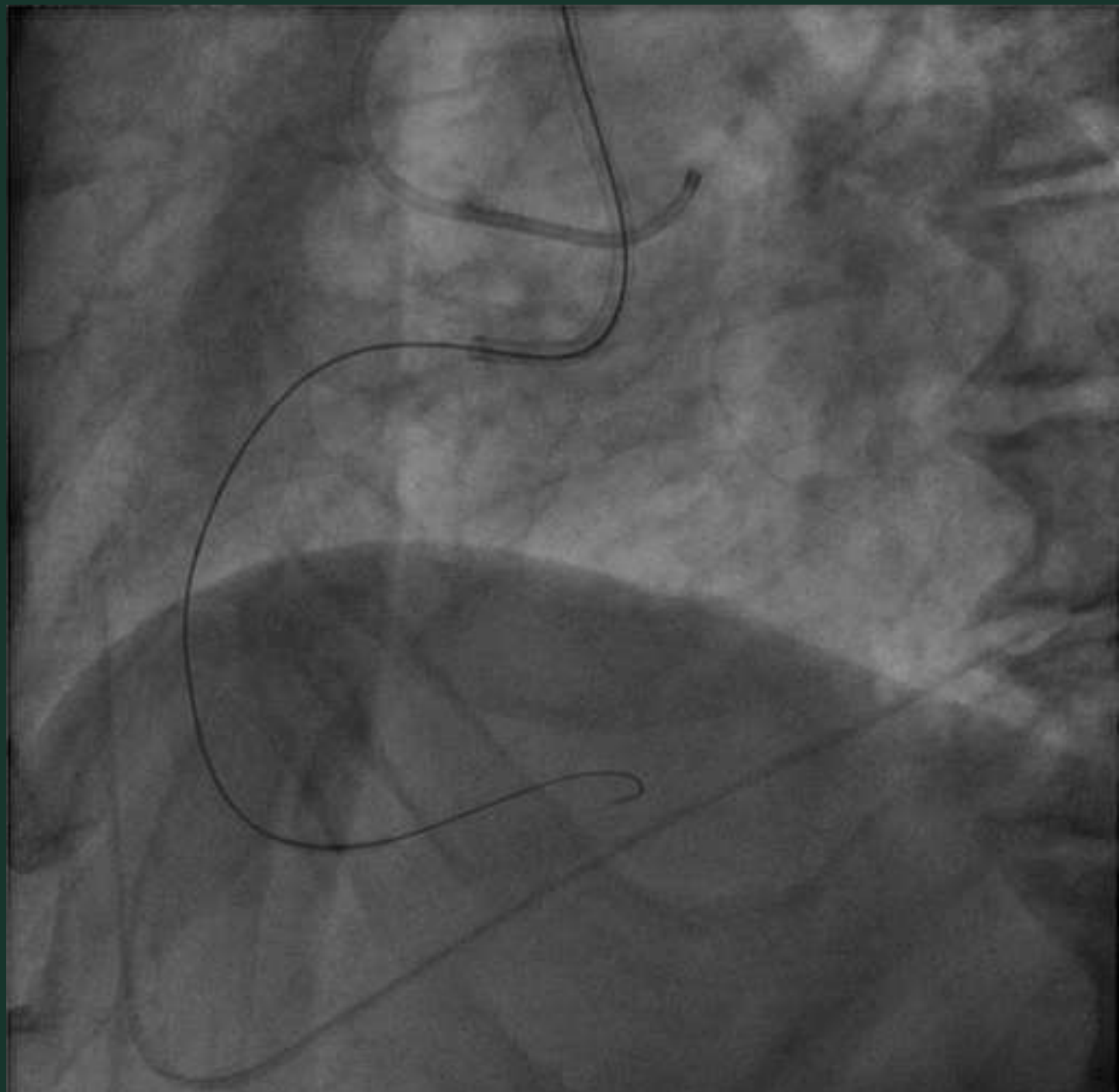




Verify the placement of Stingray catheter subintimally

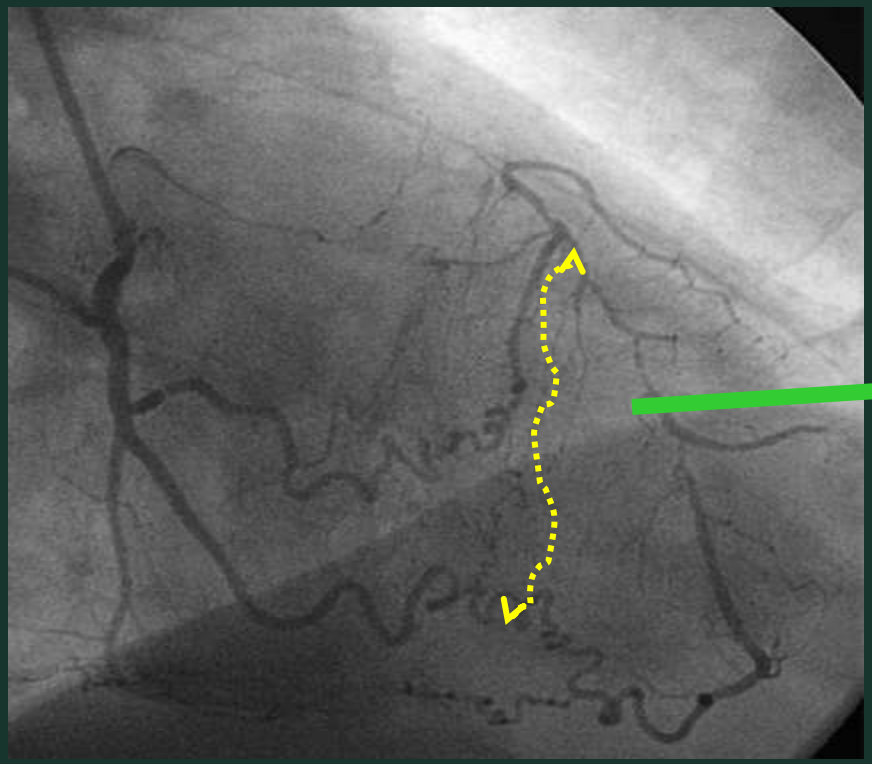
# Stingray Wire Crossing 2

Dilating Site of Re-entry



# Final Result

# Retrograde Techniques
## *Retrograde collateral wiring*

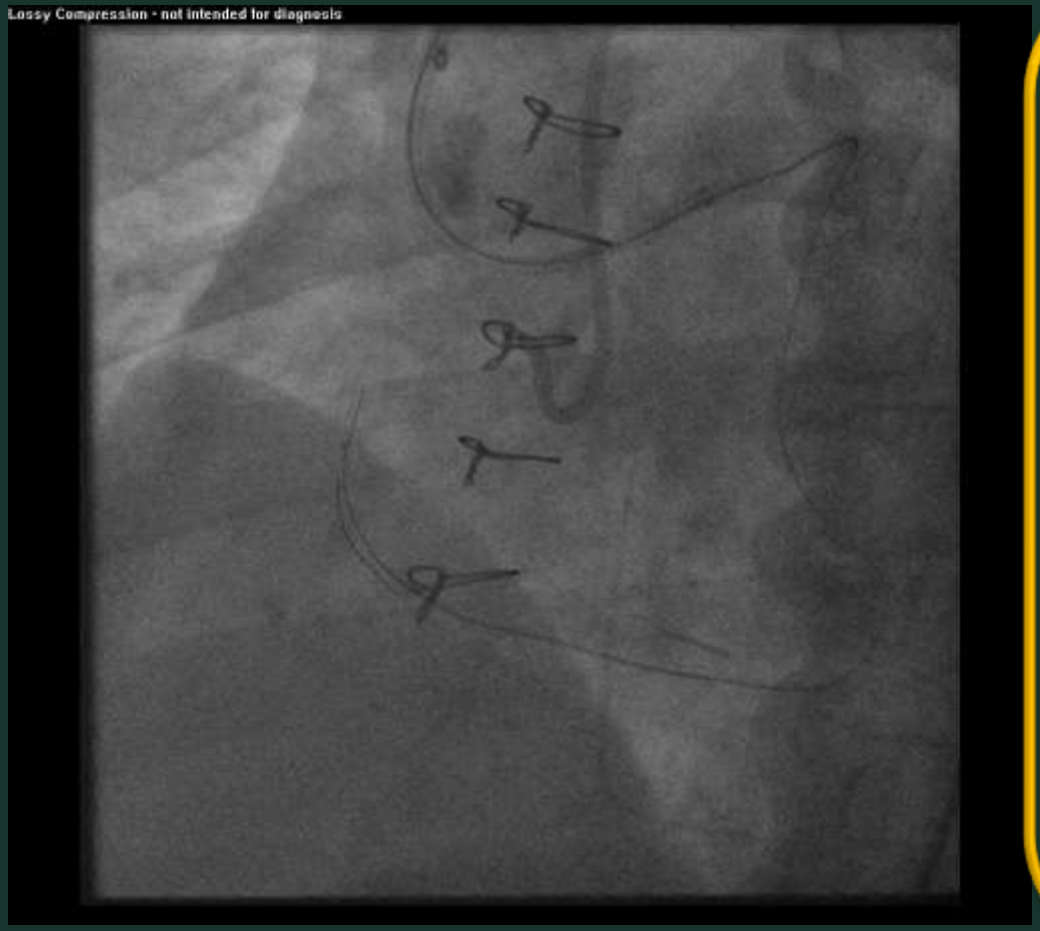


Essential tools for retrograde

1. Microcatheters
2. Wires

Illustration by Dr J C Spratt / VascularPerspectives

# Retrograde Techniques




Once septal collaterals allow access to distal cap...

↓

the distal cap should then be tackled like proximal cap.

↓

Follow the Hybrid approach.

# Retrograde Techniques

## *Dissection Re-Entry Techniques: Reverse CART*

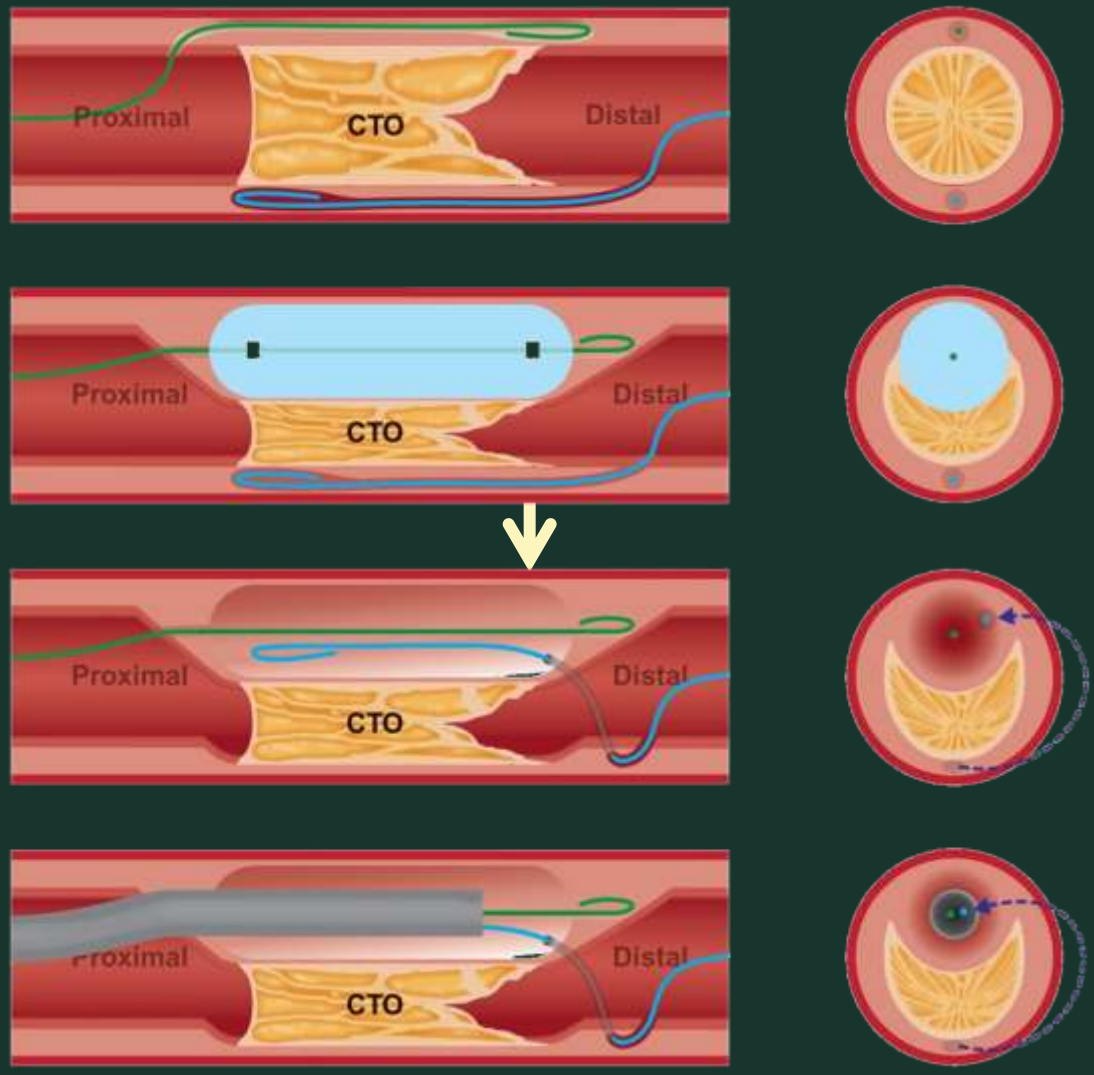
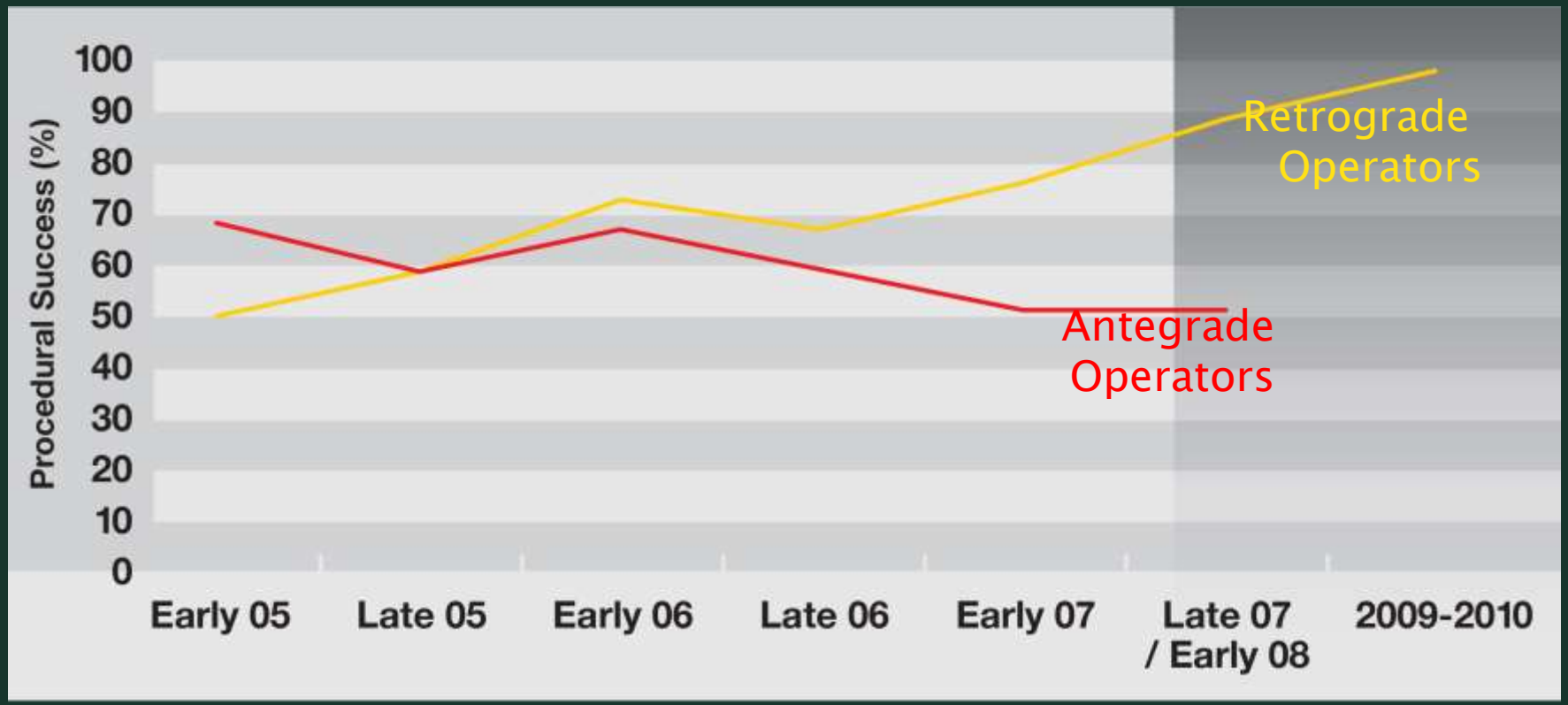



Illustration by Dr J C Spratt / VascularPerspectives

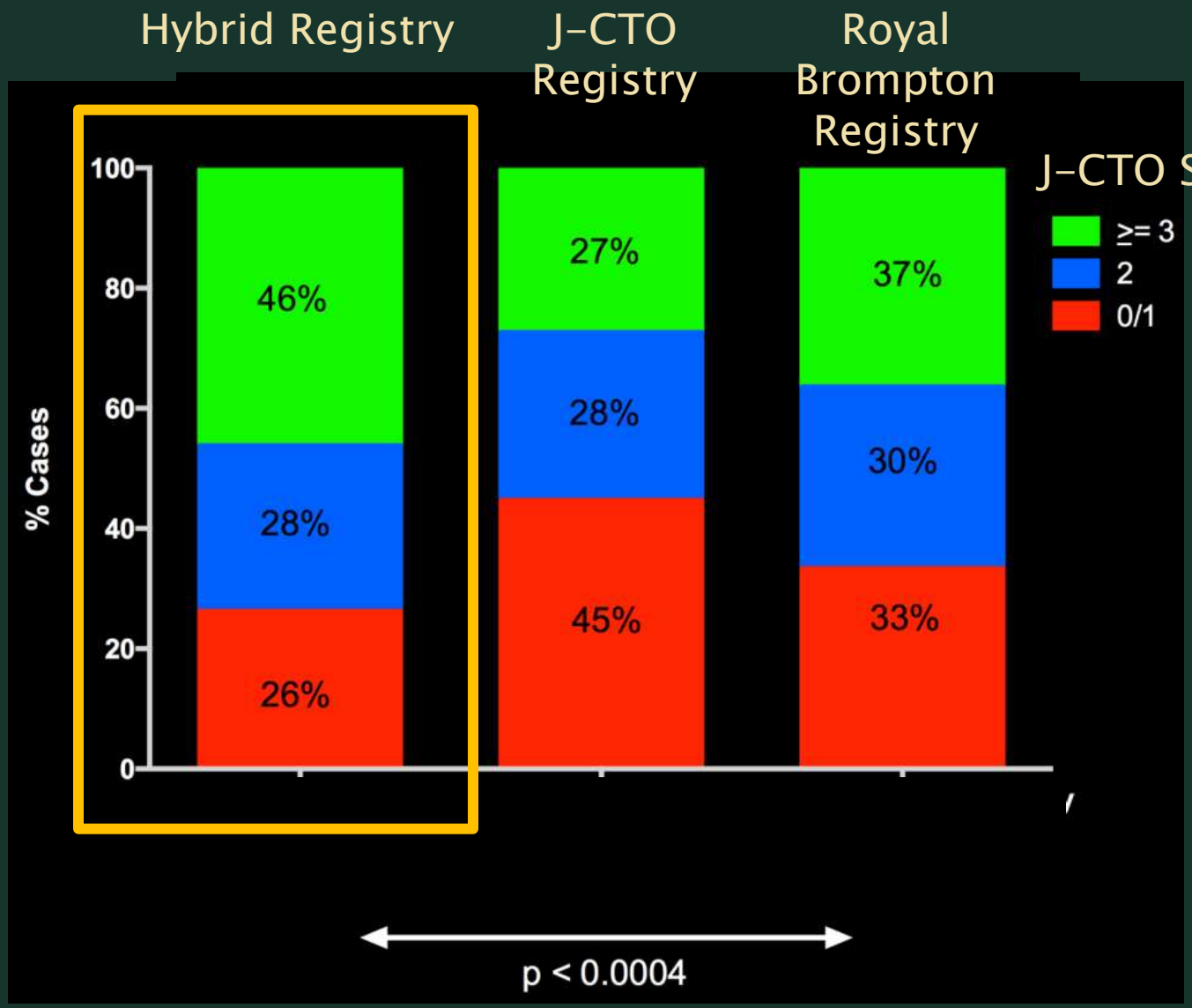
Success Rates are Low

# Procedural Success Rates Over Time
## *Operators with retrograde skills >90% success*




Dartmouth –North Cascade Multicenter CTO Registry, Thompson CA, Lombardi WL

# Hybrid CTO Registry Results
# More Complex Lesions Overall by J-CTO Score




Daniels D, CTO/LM Summit 2013

# J-CTO Score

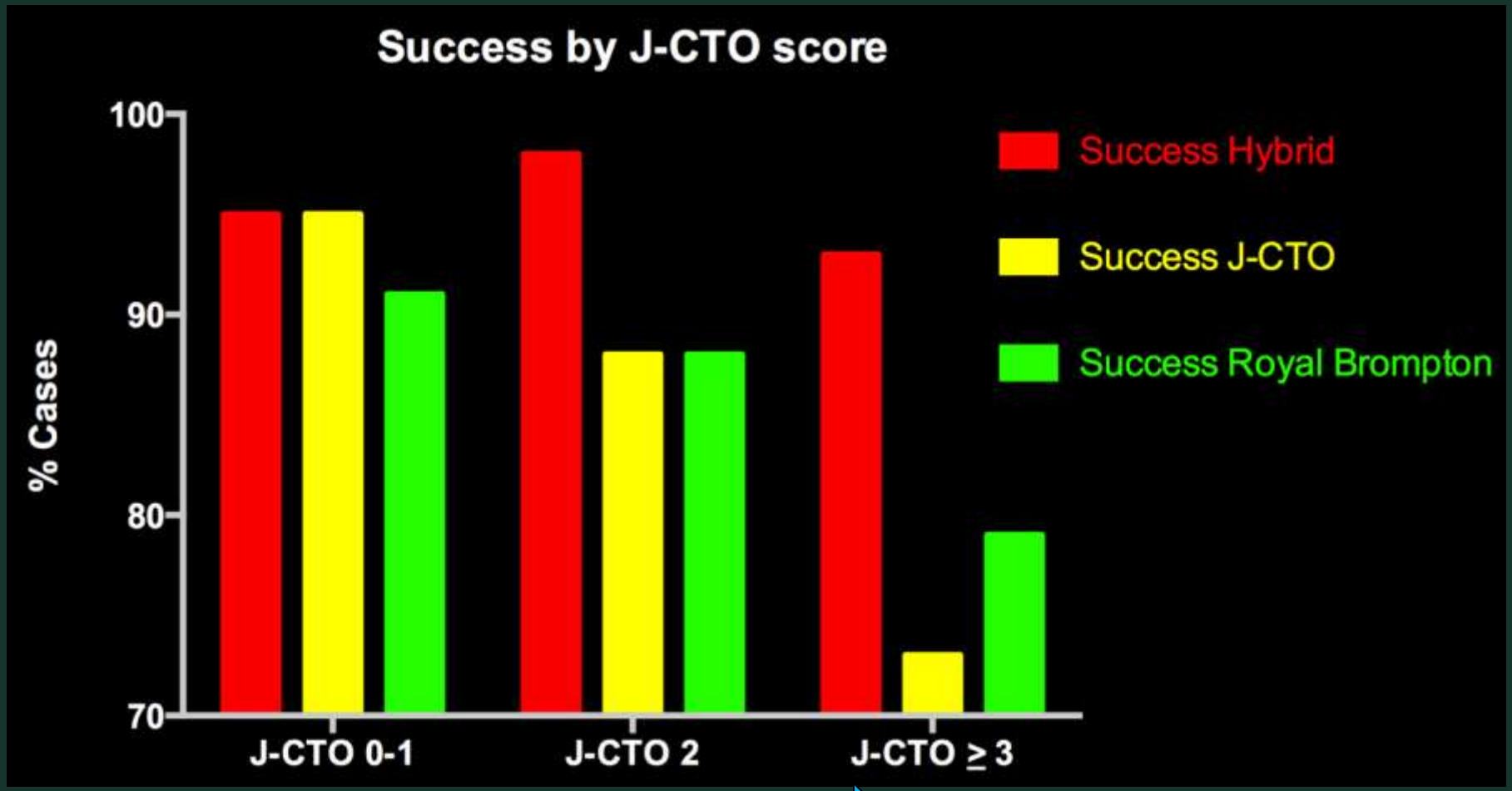

- Developed from the J-CTO registry
- Derivation and Validation
- Predictor of wiring time < 30 minutes
- Procedural success

***Morino et al. JACC CI 2011;4:213-21***

Source: Dave Daniels, MD; CTO/LM Summit 2013

# Hybrid CTO Registry Results

*Most successful strategy for complex lesions*

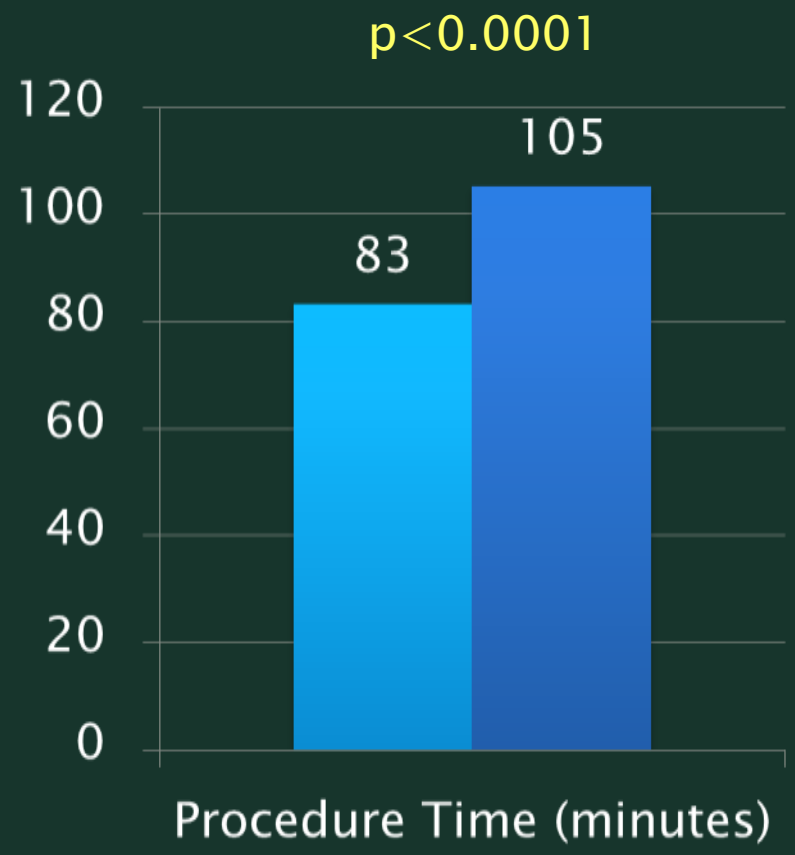


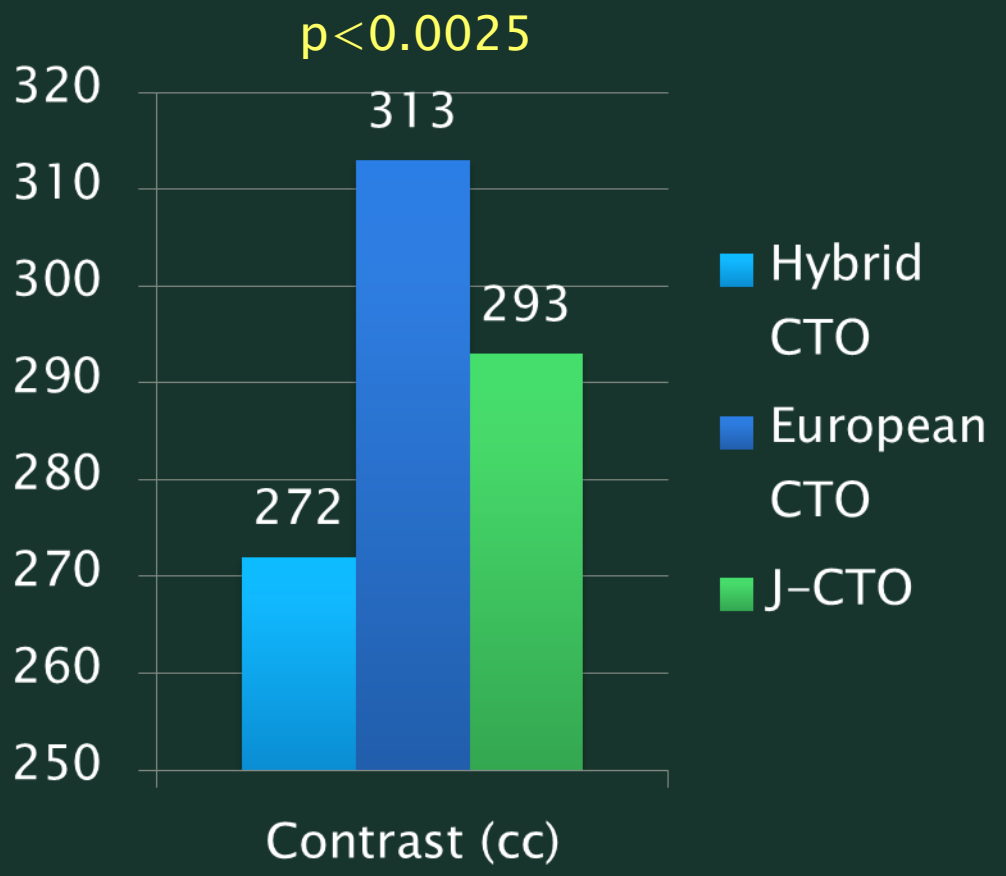

Daniels D, CTO/LM Summit 2013

CTO-PCI take too much time

# Procedural Efficiency

*Hybrid showed lowest procedure time and contrast used*



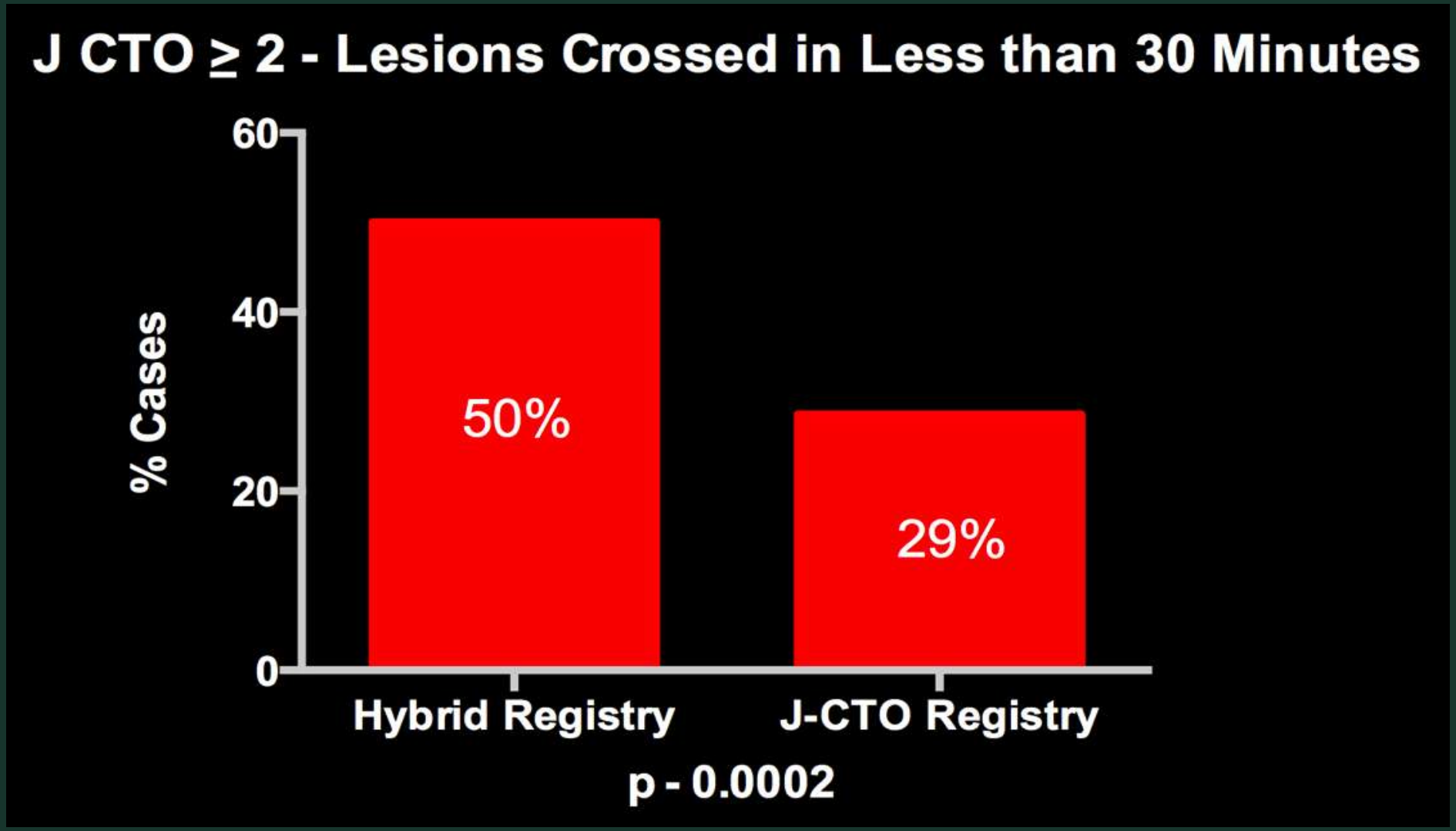

Data on procedure time from J-CTO was not published.

Presented by Daniels, D at TCT 2013

*Gallasi et al. Eurointervention 2011;7:472-49*

# Hybrid CTO Registry Results

## Complex Lesions Crossed Quickly in More Cases

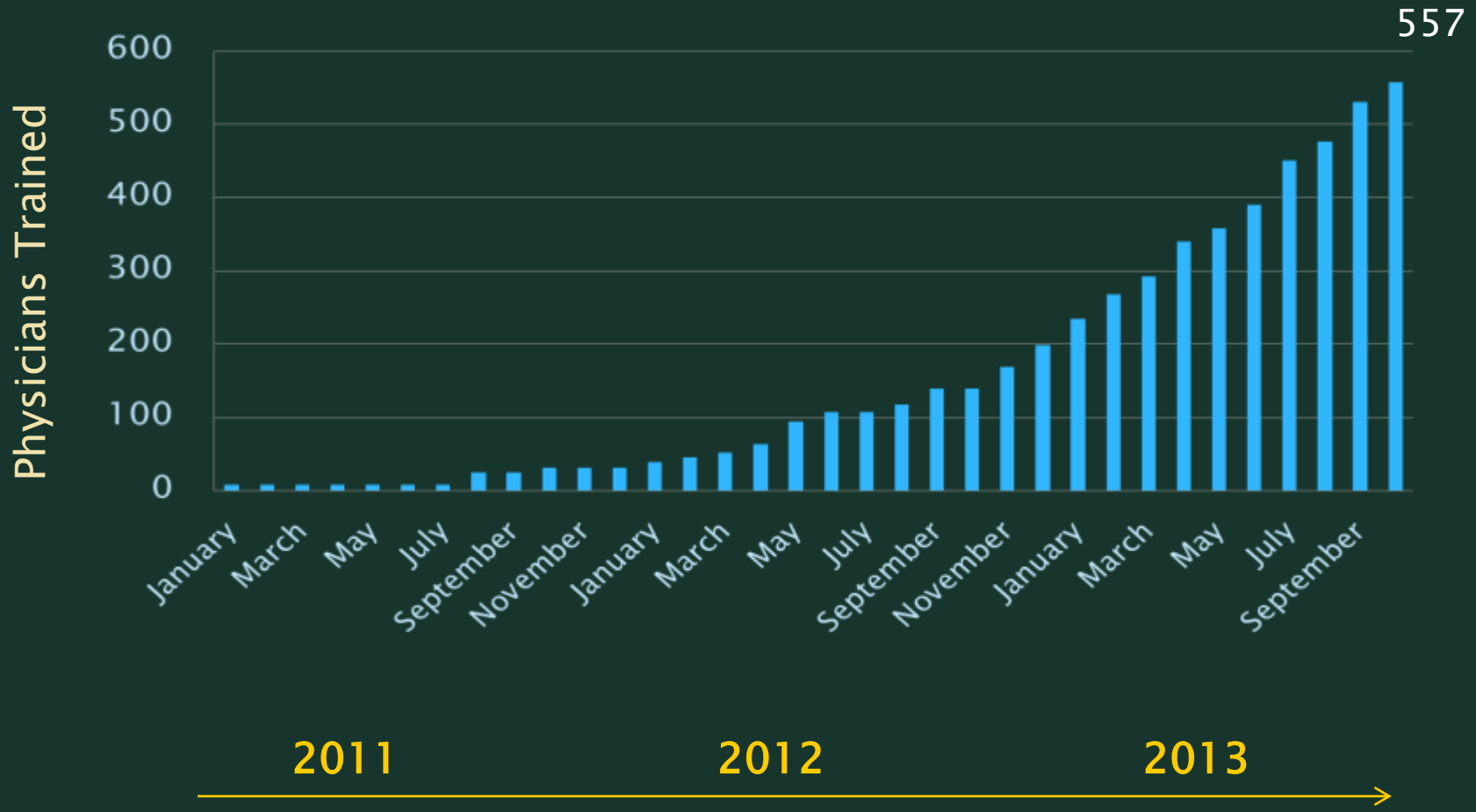



The procedure is not
reproducible or teachable

# Training & Education

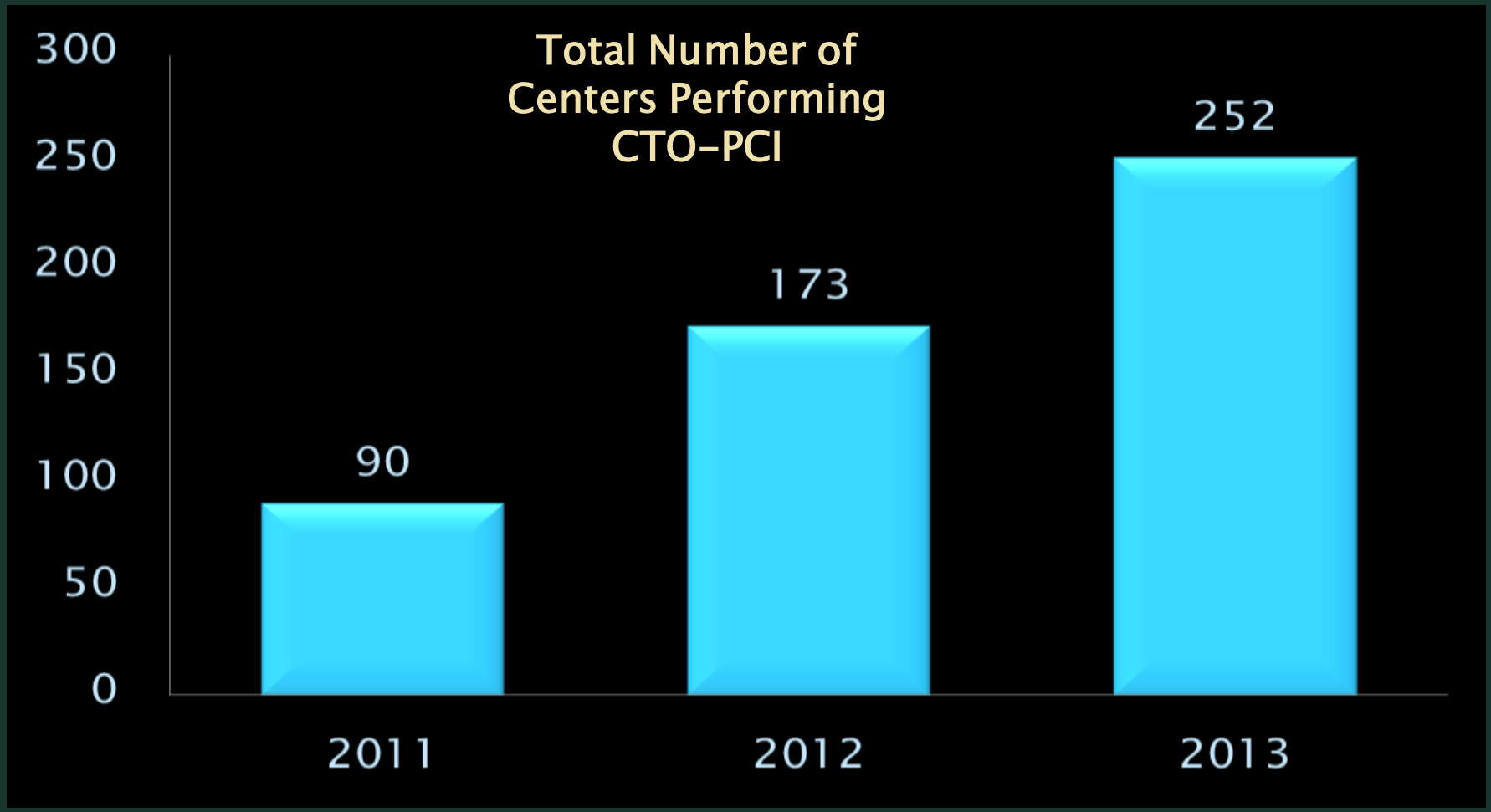

| Training | 2012 | 2013 |
|---|---|---|
| Training Sites | 5 | 11 |
| Physician Attendees | 167 | 359 |
| Proctors | 13 | 18 |
| Training Events | 14 | 18 |

# North America Training Course Participation




*Data does not include international training numbers

# CTO-PCI Adoption Curve



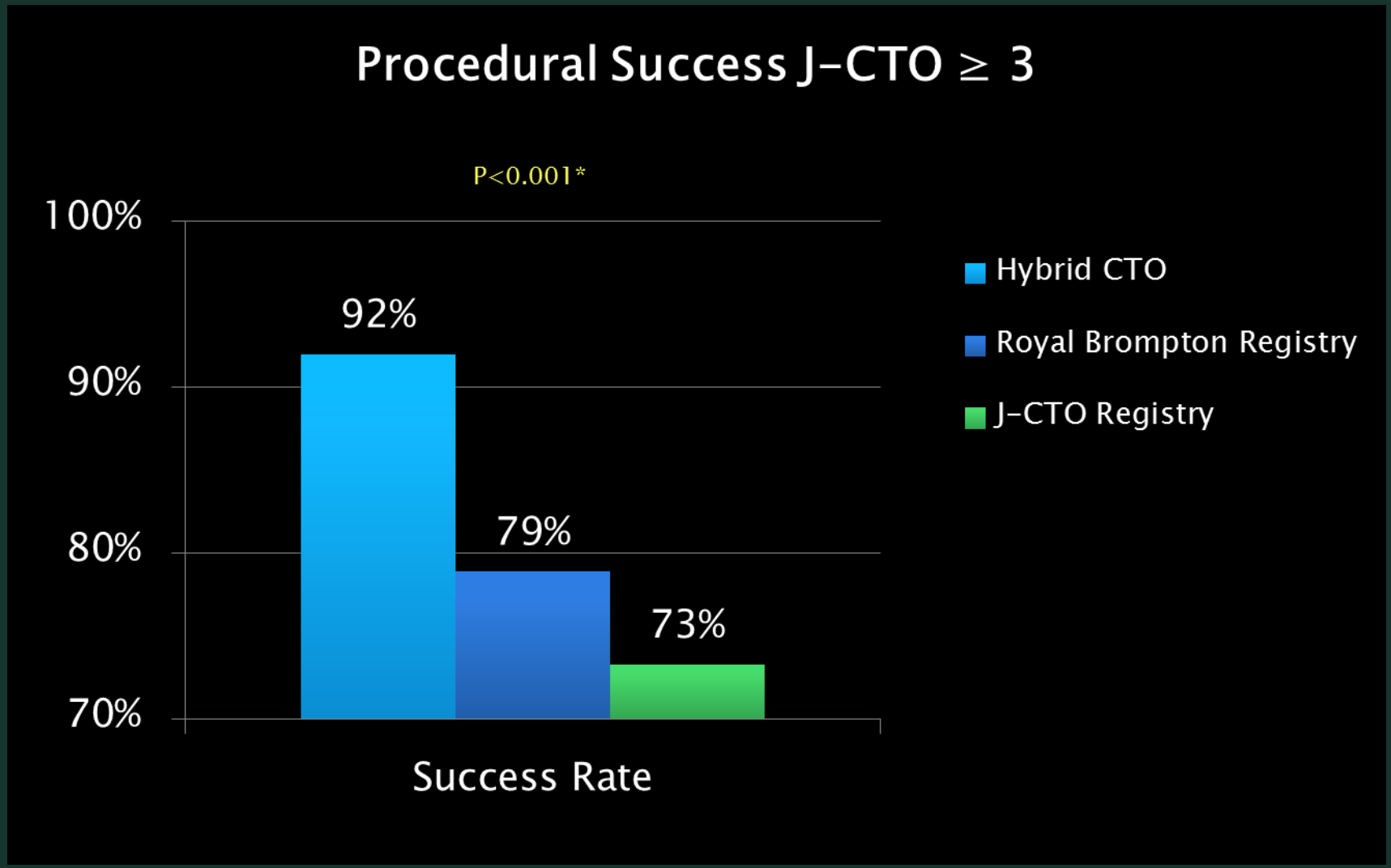

*Industry estimate. Data on file.

# Proctoring Success


*Hands-off proctoring

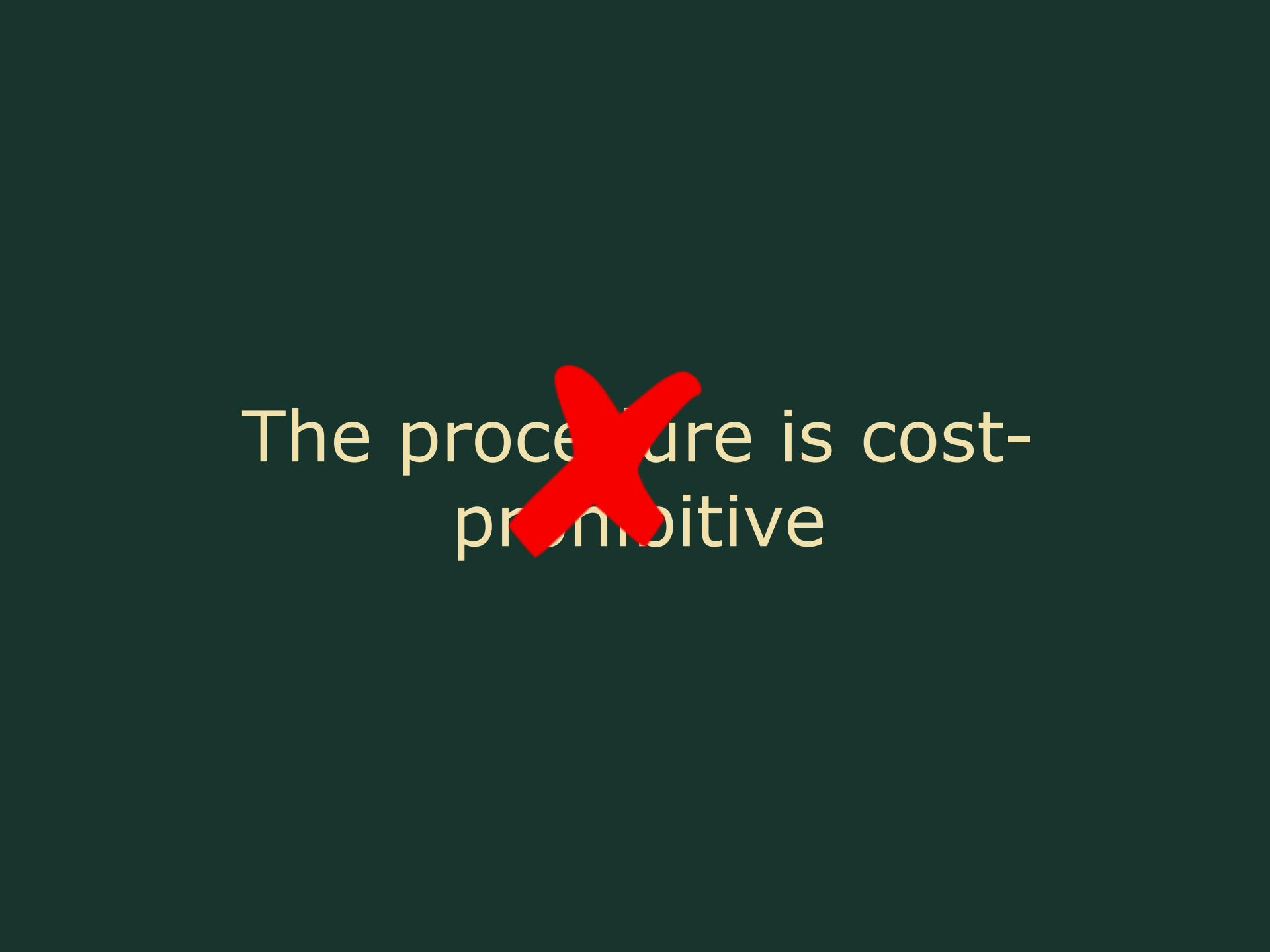
# Hybrid CTO Registry Results

## *Complex Lesions Crossed Quickly in More Cases*




Presented by Daniels, D at TCT 2013

* Hybrid vs. RBR and Hybrid vs. J-CTO


The procedure is cost-prohibitive

# CTO Health Economics & Reimbursement

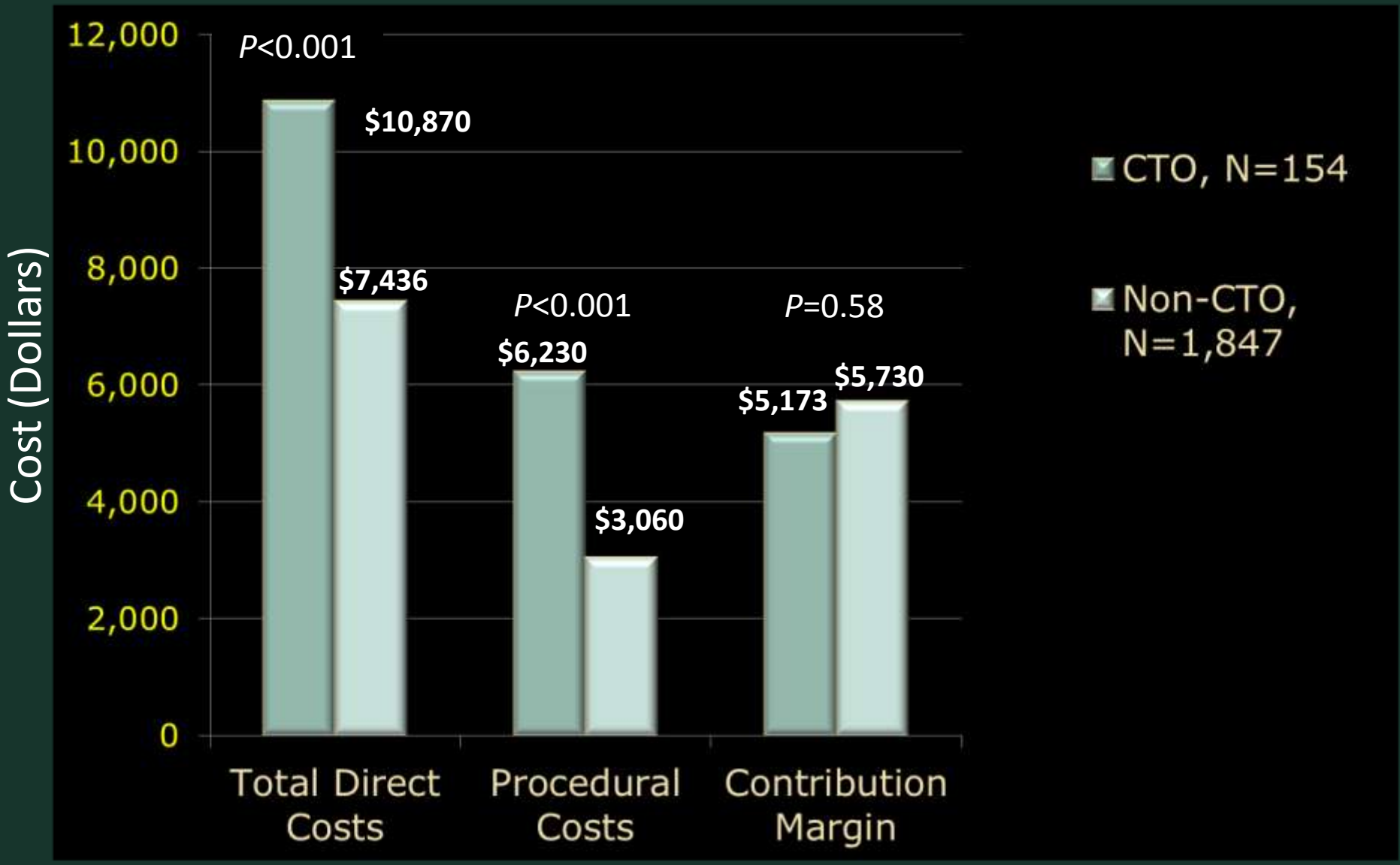
| | Physician Payment |
|---|---|
| Basic PTCA/Stenting Procedure | $604 |
| **CTO** | **$677** |
| AMI | $677 |
| SVG | $604 |
| Atherectomy | $676 |

The Piedmont Study on Economic Outcomes of CTOs showed that both charges and payments were higher in the CTO group, and overall hospital contribution margins were similar[1]

| | CTO | Non CTO |
|---|---|---|
| Reimbursement | $16,013 | $13,166 |
| Procedure Cost (non device related) | $4,640 | $4,376 |
| Device Cost | $6,230 | $3,060 |
| Contribution Margin | $5,173 | $5,730 |

*[1] Piedmont Study: CTO, n=154; non CTO, n=1847*

# CTO Revascularization: Economic Outcomes



# Why are CTO-PCI Attempt Rates So Low?
## *Common misconceptions*

- There is no clinical justification
- CTOs are stable and benign
- The procedure is too complex
- Success rates are low
- We don't have time for long procedures
- Results are not reproducible or teachable
- CTO-PCI is cost-prohibitive

- Quality of life benefit is indisputable
- Mortality benefit is a reasonable hypothesis being tested
- Underutilization exists and should be addressed
- Controlled, randomized trials are coming

# Why are CTO-PCI Attempt Rates So Low?
## *Common misconceptions*

- ~~There is no clinical justification~~
- ~~CTOs are stable and benign~~
- The procedure is too complex
- Success rates are low
- We don't have time for long procedures
- Results are not reproducible or teachable
- CTO-PCI is cost-prohibitive

- CTO is an independent predictor of mortality

# Why are CTO-PCI Attempt Rates So Low?
## *Common misconceptions*

- ~~There is no clinical justification~~
- ~~CTOs are stable and benign~~
- ~~The procedure is too complex~~
- Success rates are low
- We don't have time for long procedures
- Results are not reproducible or teachable
- CTO-PCI is cost-prohibitive

- Hybrid approach helps direct decision-making

# Why are CTO-PCI Attempt Rates So Low?
## *Common misconceptions*

- ~~There is no clinical justification~~
- ~~CTOs are stable and benign~~
- ~~The procedure is too complex~~
- ~~Success rates are low~~
- We don't have time for long procedures
- Results are not reproducible or teachable
- CTO-PCI is cost-prohibitive

- Historical CTO success rates are low
- Expert CTO operators have >90% success rates
- Hybrid algorithm is most successful strategy for complex lesions

# Why are CTO-PCI Attempt Rates So Low?
## *Common misconceptions*

- ~~There is no clinical justification~~
- ~~CTOs are stable and benign~~
- ~~The procedure is too complex~~
- ~~Success rates are low~~
- ~~We don't have time for long procedures~~
- Results are not reproducible or teachable
- CTO-PCI is cost-prohibitive

- Hybrid algorithm vs other CTO algorithm
  - >20% less time to treat CTOs
  - More complex lesions treated in under 30 minutes

# Why are CTO-PCI Attempt Rates So Low?
## *Common misconceptions*

- ~~There is no clinical justification~~
- ~~CTOs are stable and benign~~
- ~~The procedure is too complex~~
- ~~Success rates are low~~
- ~~We don't have time for long procedures~~
- ~~Results are not reproducible or teachable~~
- CTO-PCI is cost-prohibitive

- CTO-PCI training programs rapidly expanding pool of operators
- With dedicated training and proctoring on the Hybrid Approach, trainee success rates are >80%

# Why are CTO-PCI Attempt Rates So Low?
## *Common misconceptions*

- ✗ There is no clinical justification
- ✗ CTOs are stable and benign
- ✗ The procedure is too complex
- ✗ Success rates are low
- ✗ We don't have time for long procedures
- ✗ Results are not reproducible or teachable
- ✗ CTO-PCI is cost-prohibitive

- Contribution margin between CTO-PCI and standard PCI is not significant

# Thank You!