

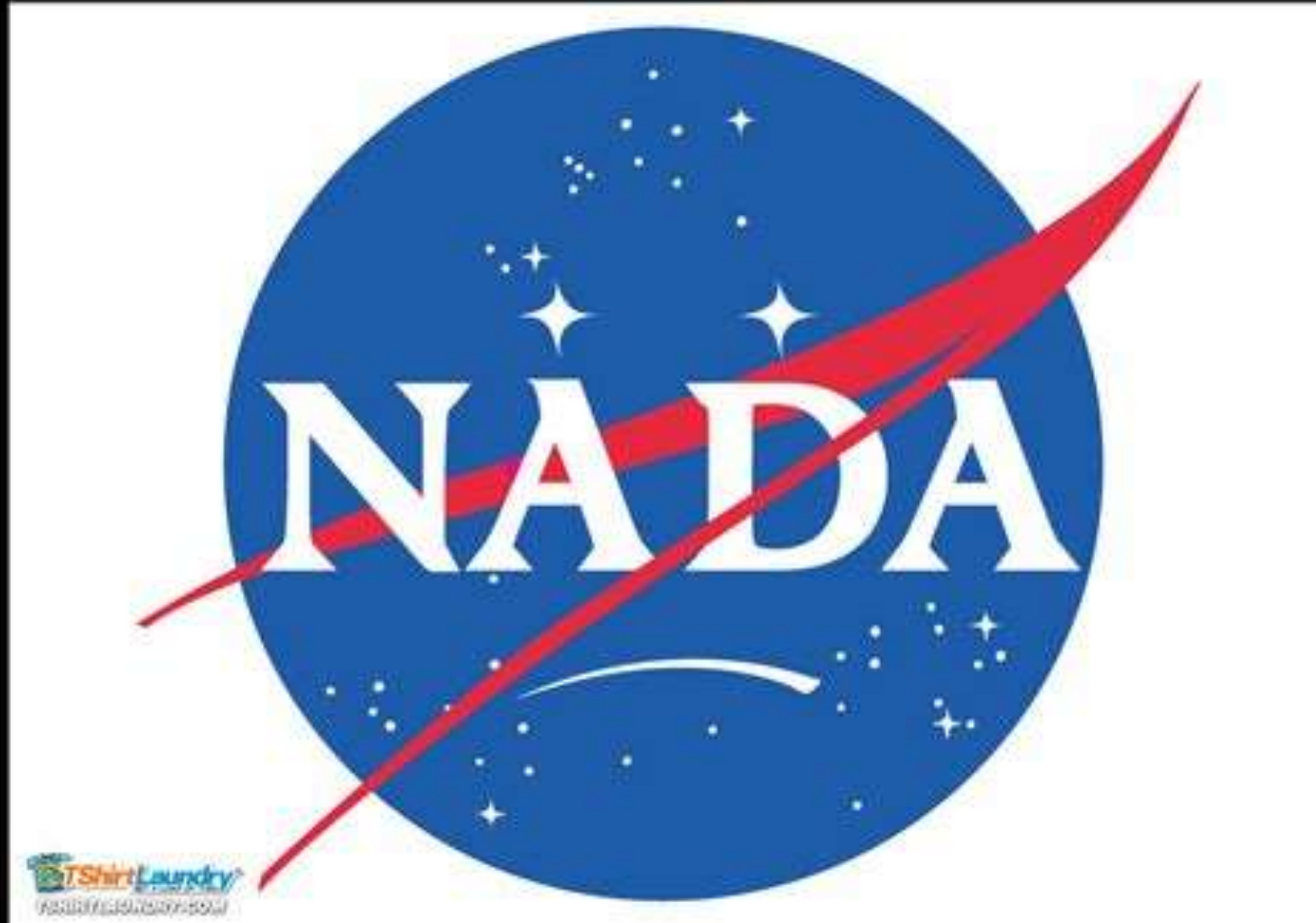
Chronic Total Occlusions

Hiding in Plain Sight

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Financial Disclosures



Learning Objectives

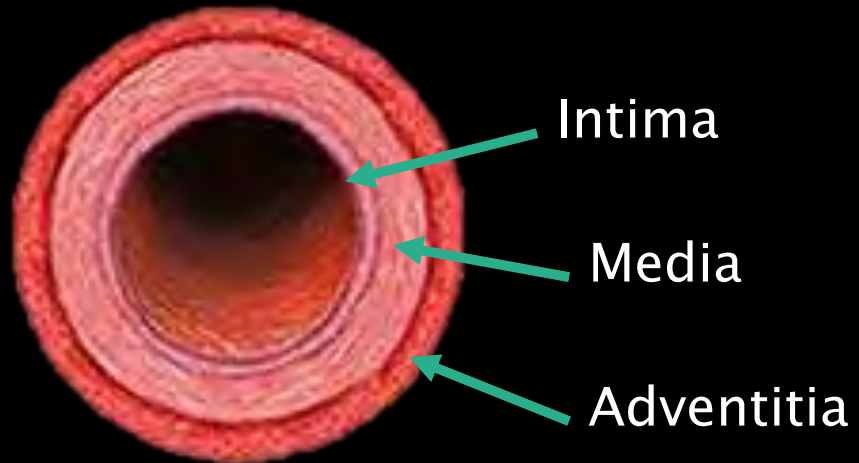
- Define and identify chronic total occlusion
- Know the impact of CTOs on your patients
- Know the treatment options

Get Comfortable being Uncomfortable

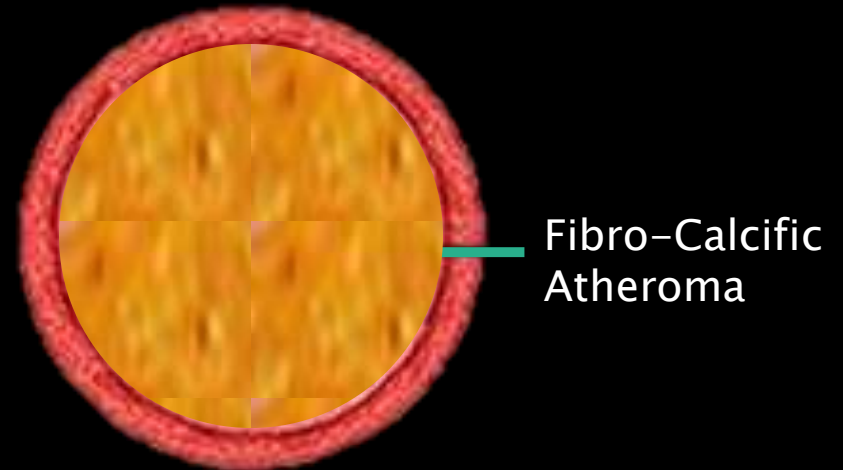


What is a CTO?

Normal Artery Cross Section



Chronic Total Occlusion





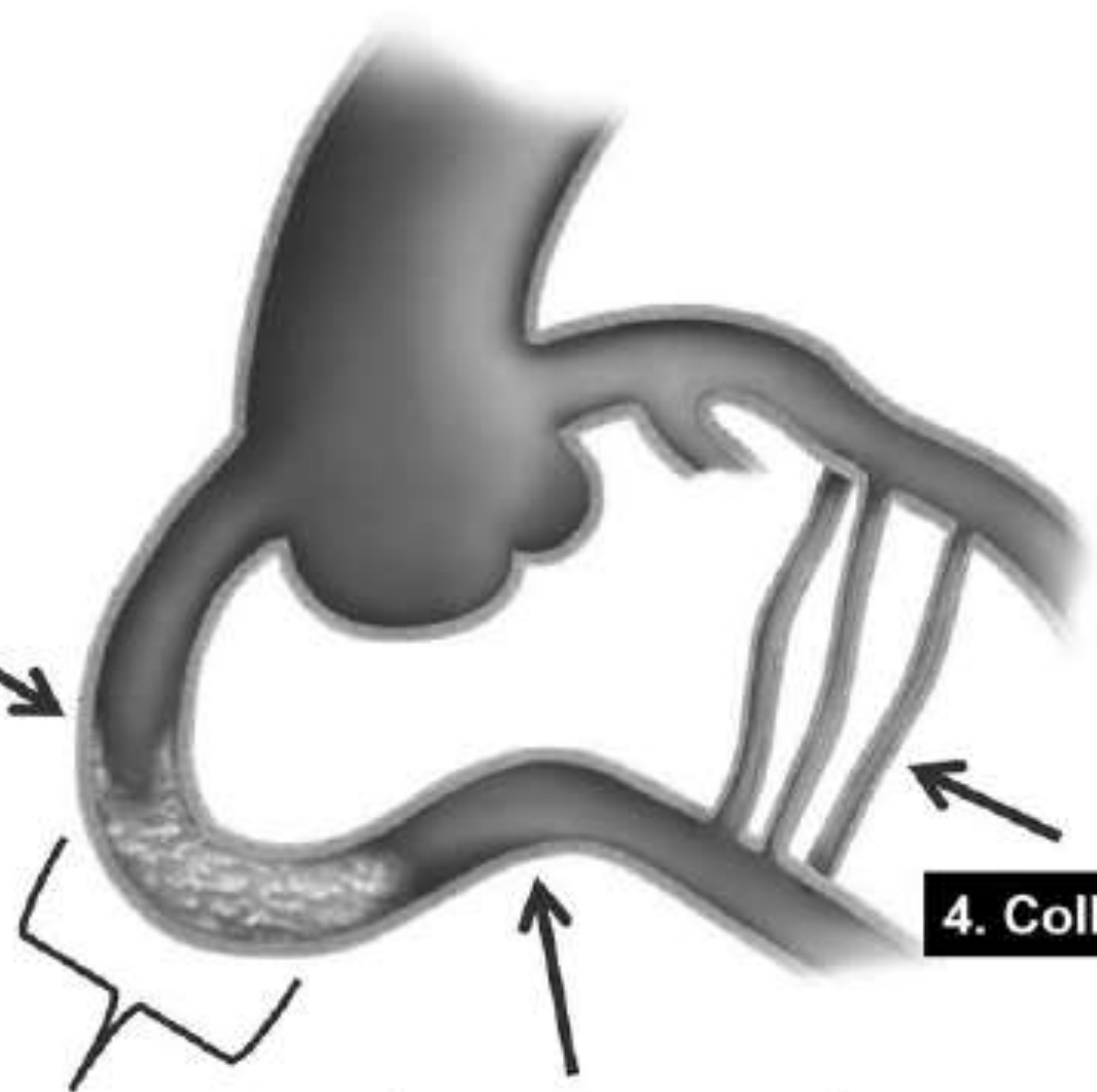


1. Proximal cap

2. Lesion length, course, and composition

3. Distal vessel

4. Collaterals

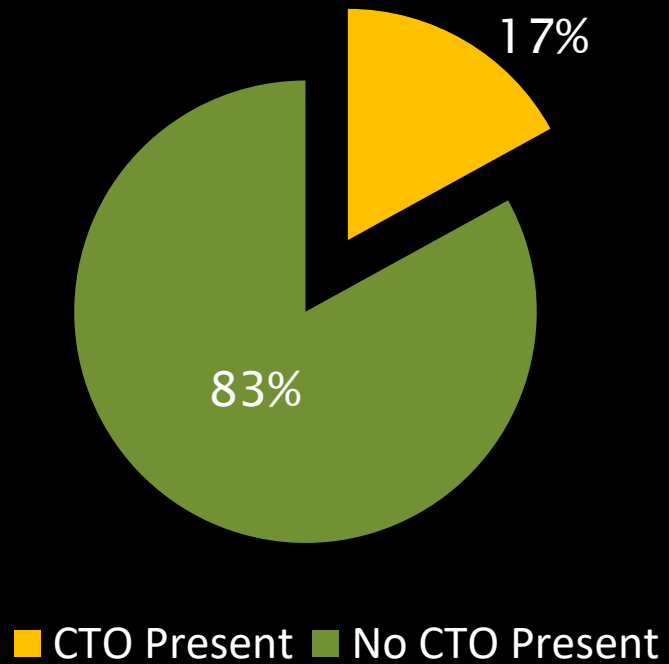


Prevalence

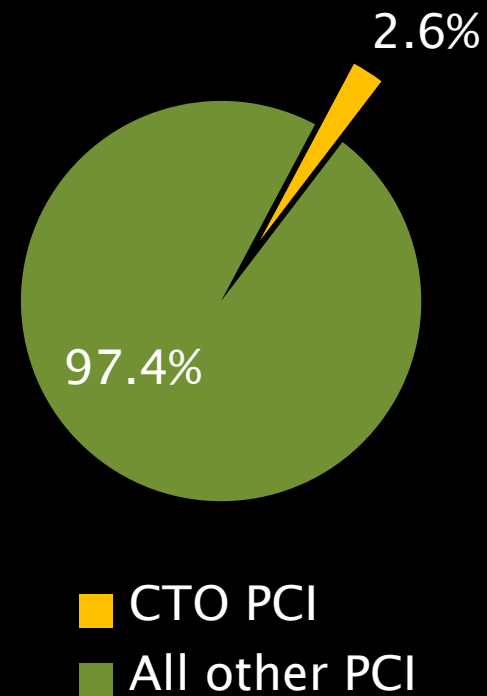
- 11.1 Million Americans have chronic stable angina
- 20% of all patients referred for coronary angiography
- 30-50% in those with known CAD
- 89% in CABG patients (VA population)
- Seen more frequently in older patients
 - 36.5% < 65 y/o
 - 39.1% 65-79 y/o
 - 40.7% \geq 80 y/o

How common are CTOs?

Overall CTO Prevalence



Real World CTO PCI



Manifestations of CTO

- Angina on maximal medical therapy
 - 7 item Seattle-Angina Questionnaire
- Shortness of breath
- Impaired quality of life
- Gradual reduction of level of activity
- Depression

Seattle Angina Questionnaire

1. The following is a list of activities that people often do during the week. Although for some people with several medical problems it is difficult to determine what it is that limits them, please go over the activities listed below and indicate how much limitation you have had **due to chest pain, chest tightness or angina over the past 4 weeks**.

Place an X in one box on each line.

Activity	Extremely limited	Quite a bit limited	Moderately Limited	Slightly limited	Not at all limited	Limited for other reasons or did not do the activity
a. Walking (indoors on level ground)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Gardening, vacuuming or carrying groceries	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Lifting or moving heavy objects (e.g. furniture, children)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2. Over the **past 4 weeks**, on average, how many times have you had **chest pain, chest tightness or angina**?

I have had **chest pain, chest tightness or angina**...

4 or more times per day	1-3 times per day	3 or more times per week but not every day	1-2 times per week	Less than once a week	None over the past 4 weeks
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. Over the **past 4 weeks**, on average, how many times have you had to take nitroglycerin (nitroglycerin tablets or spray) for your **chest pain, chest tightness or angina**?

I have taken nitroglycerin...

4 or more times per day	1-3 times per day	3 or more times per week but not every day	1-2 times per week	Less than once a week	None over the past 4 weeks
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

4. Over the **past 4 weeks**, how much has your **chest pain, chest tightness or angina** limited your enjoyment of life?

It has extremely limited my enjoyment of life	It has limited my enjoyment of life quite a bit	It has moderately limited my enjoyment of life	It has slightly limited my enjoyment of life	It has not limited my enjoyment of life at all
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. If you had to spend the rest of your life with your **chest pain, chest tightness or angina** the way it is right now, how would you feel about this?

Not satisfied at all	Mostly dissatisfied	Somewhat satisfied	Mostly satisfied	Completely satisfied
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Depression

TABLE 2 Health Status Comparison Between Depressed and Nondepressed Patients at Baseline and 1 Year, and Difference in Change in Health Status From Baseline to 1 Year Between Depressed and Nondepressed Patients Undergoing CTO PCI

Measurement	Depressed	Nondepressed	p Value
Baseline health status			
SAQ-PL	51.8 ± 25.0	71.0 ± 24.3	<0.001
SAQ-QL	32.1 ± 22.5	54.9 ± 26.1	<0.001
SAQ-AF	60.7 ± 27.7	73.5 ± 25.9	<0.001
SAQ Summary	48.5 ± 20.1	66.4 ± 21.4	<0.001
RDS	3.0 ± 1.2	1.9 ± 1.5	<0.001
1-yr health status			
SAQ-PL	91.0 ± 17.4	96.3 ± 11.3	<0.001
SAQ-QL	67.2 ± 26.3	83.0 ± 18.4	<0.001
SAQ-AF	87.6 ± 22.4	94.6 ± 15.6	<0.001
SAQ Summary	79.8 ± 19.3	90.6 ± 12.8	<0.001
RDS	1.9 ± 1.5	0.9 ± 1.2	<0.001
Change from baseline to 1 yr			
SAQ-PL	35.2 ± 24.1	23.5 ± 23.2	< 0.001
SAQ-QL	35.4 ± 29.1	28.0 ± 25.6	<0.001
SAQ-AF	26.9 ± 29.2	21.1 ± 25.1	0.007
SAQ Summary	31.4 ± 22.4	24.2 ± 20.0	<0.001
RDS	-1.2 ± 1.6	-1.0 ± 1.6	0.240

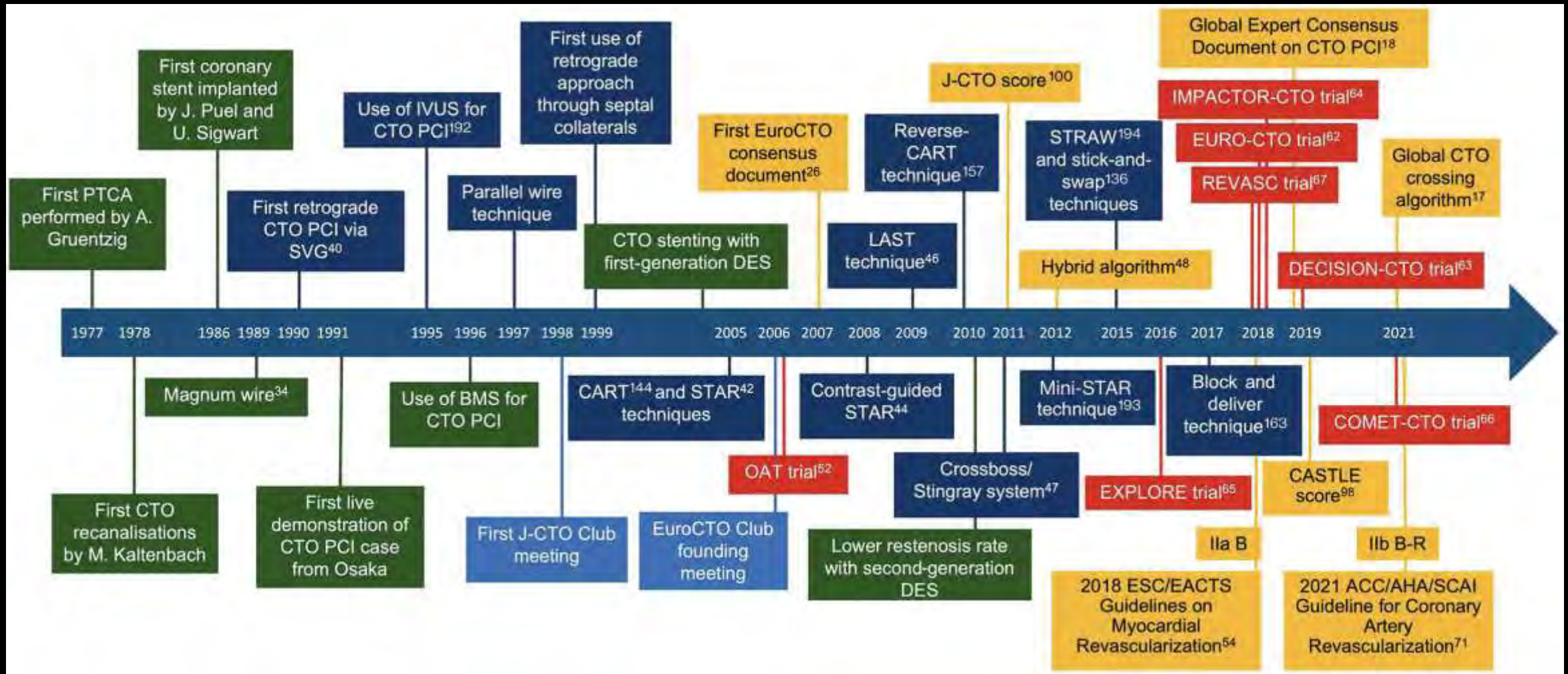
Values are mean ± SD.

AF — angina frequency; PCI — percutaneous coronary intervention; PL — physical limitation; QL — quality of life; RDS — Rose Dyspnea Scale; SAQ — Seattle Angina Questionnaire; other abbreviation as in Table 1.

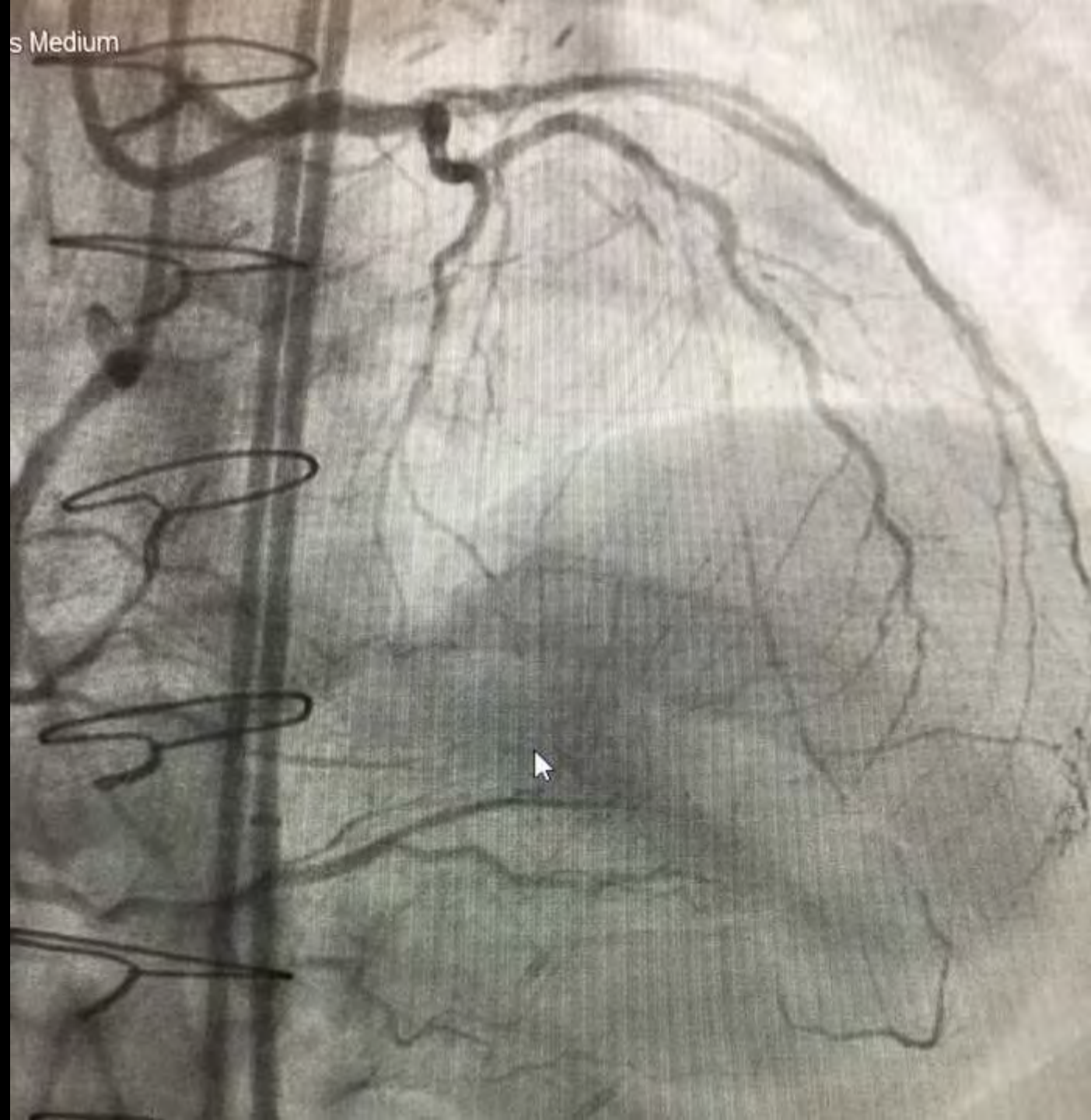
CTO Patient Profile

- Generally older
- More co-morbidities
 - DM
 - Smoking
 - HTN
 - Hypercholesterolemia
 - PAD
 - Previous MI

Timeline For CTO-PCI



s Medium



um





Collateral Circulation

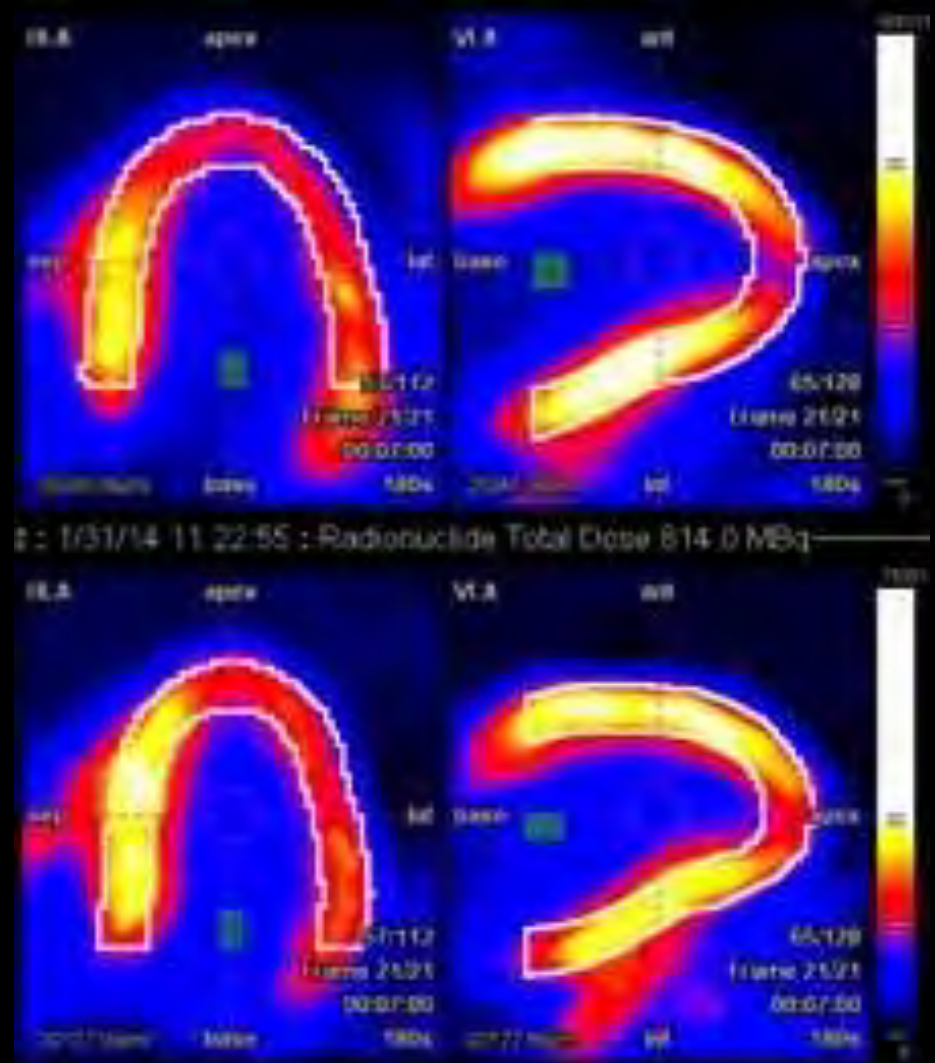
- Dual Injections is key
- Locations
 - Bridging collaterals
 - Septal
 - Epicardial
 - CABG grafts
- Werner Classification – size of vessel
 - CCO: no continuous connection
 - CC1: Threadlike connection
 - CC2: Side branch-like connection

Planning – Counselling Patient and Family

- Realistic expectations
- Patient
- Family
- Strategy
- Hemodynamic support
 - 4% of CTO cases

Assessment of Viability

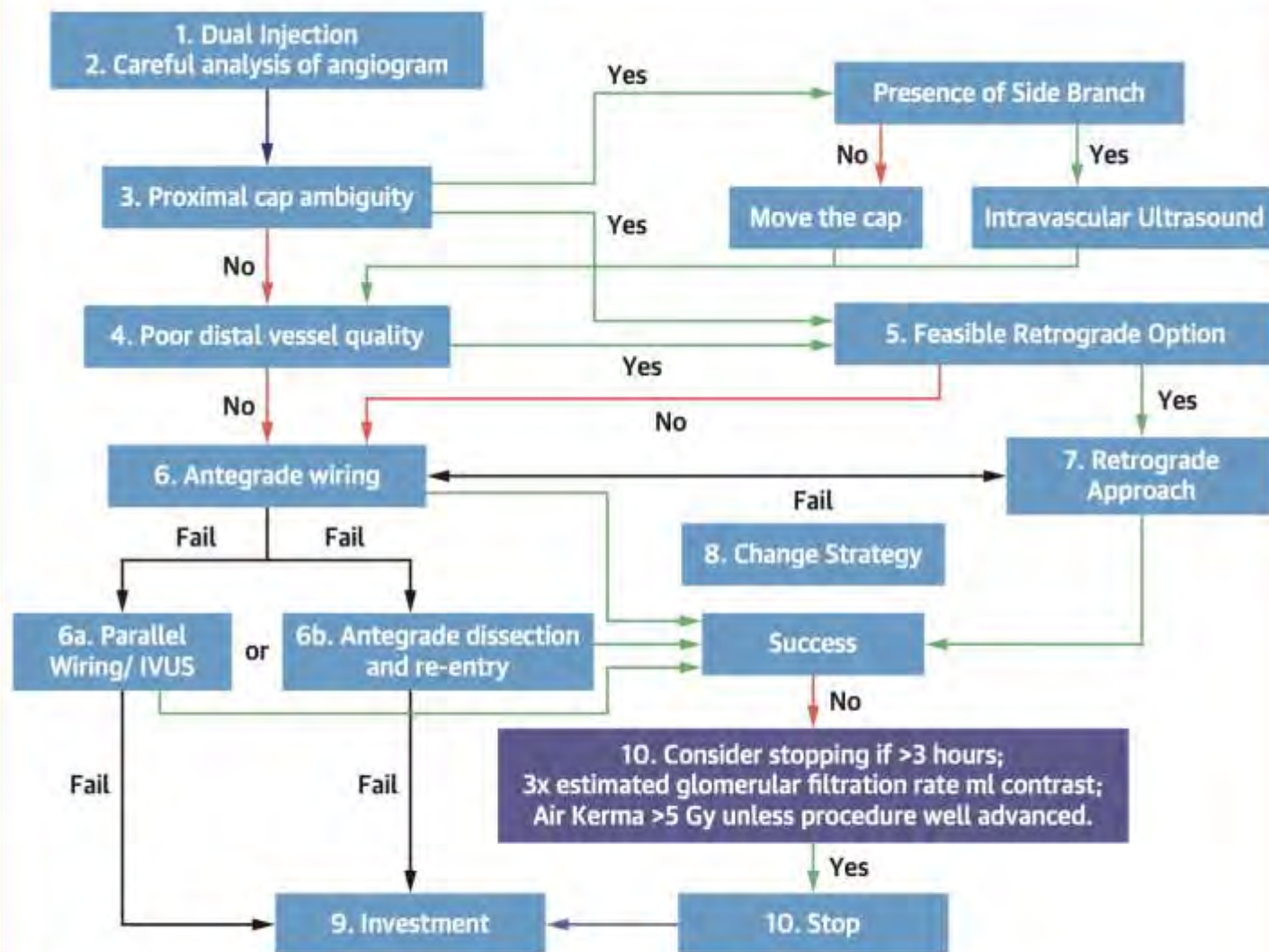
- PET
- Cardiac MRI
- Echocardiography



Global Chronic Total Occlusion Crossing Algorithm

JACC State-of-the-Art Review

CENTRAL ILLUSTRATION The Global Chronic Total Occlusion Crossing Algorithm



Wu, E.B. et al. *J Am Coll Cardiol.* 2021;78(8):840-853.

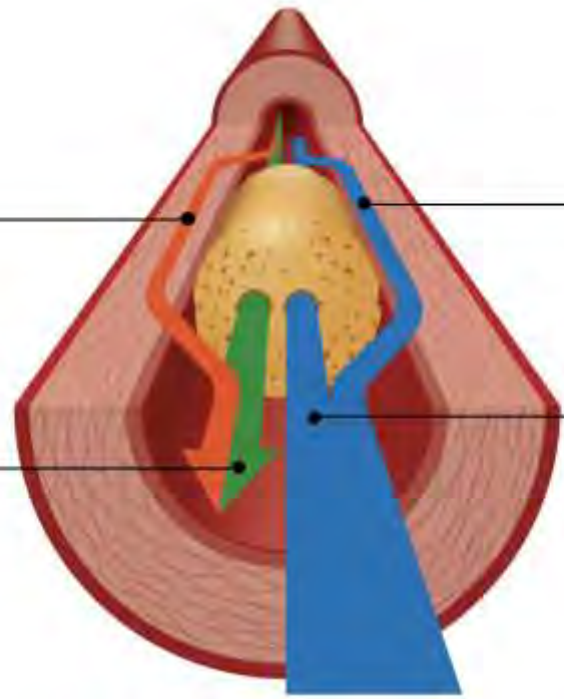
Flow of chronic total occlusion crossing procedure. Yes or presence of feature or success indicated by **green arrow**; no or absence of feature indicated by **red arrow**; failure indicated by **black arrow**; progression to next step indicated by **blue arrow**.

Antegrade Dissection Re-entry
ADR

Retrograde Dissection Re-entry
RDR

Antegrade Wire Escalation
AWE

Retrograde Wire Escalation
RWE



Dual injection

- 1. Ambiguous proximal cap
- 2. Poor distal target
- 3. Good interventional collaterals
- 4. Major side branch at distal cap

NO

YES

<20mm

Antegrade

>20mm

>20mm

Retrograde

<20mm

Antegrade wire escalation

Cross NO

Antegrade dissection re-entry

Cross NO

Cross NO

Retrograde dissection re-entry

Cross NO

Retrograde wire escalation

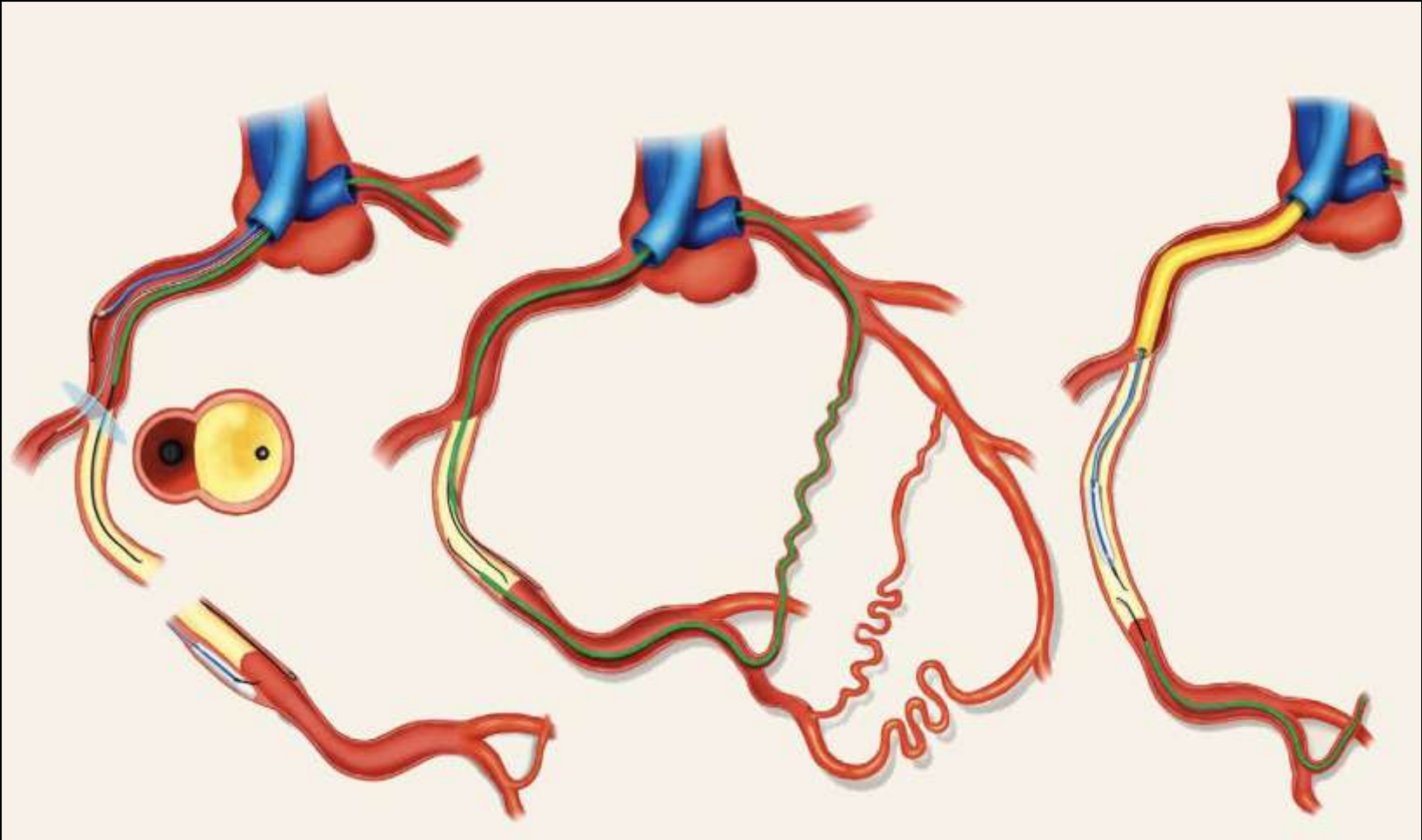
Cross YES

Cross YES

Cross YES

Cross YES

Antegrade and Retrograde Approaches

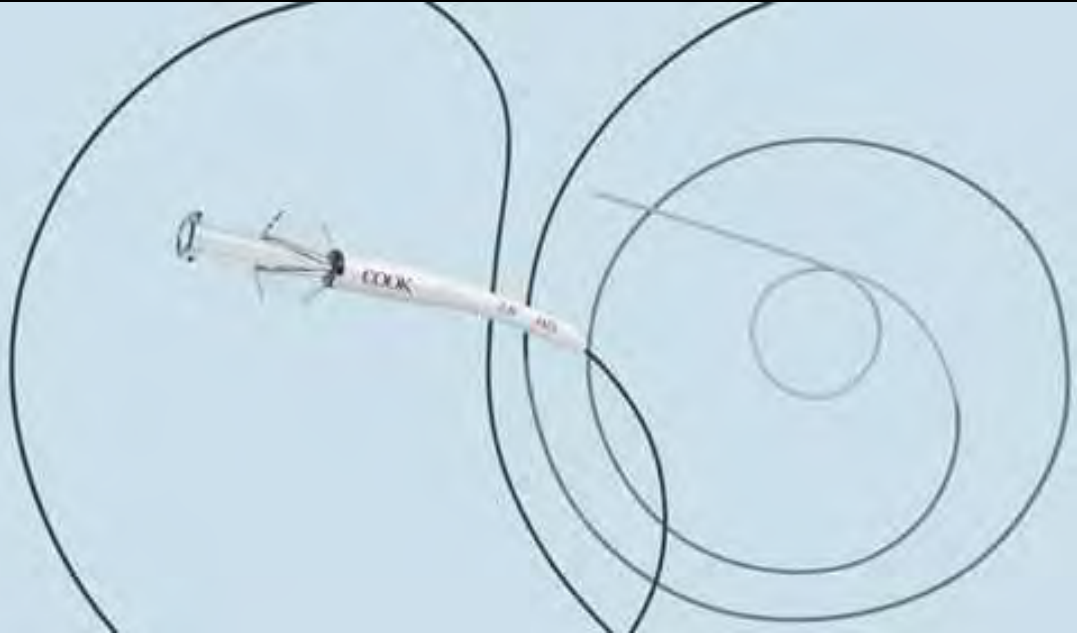


Guiding Principles for Chronic Total Occlusion Percutaneous Coronary Intervention

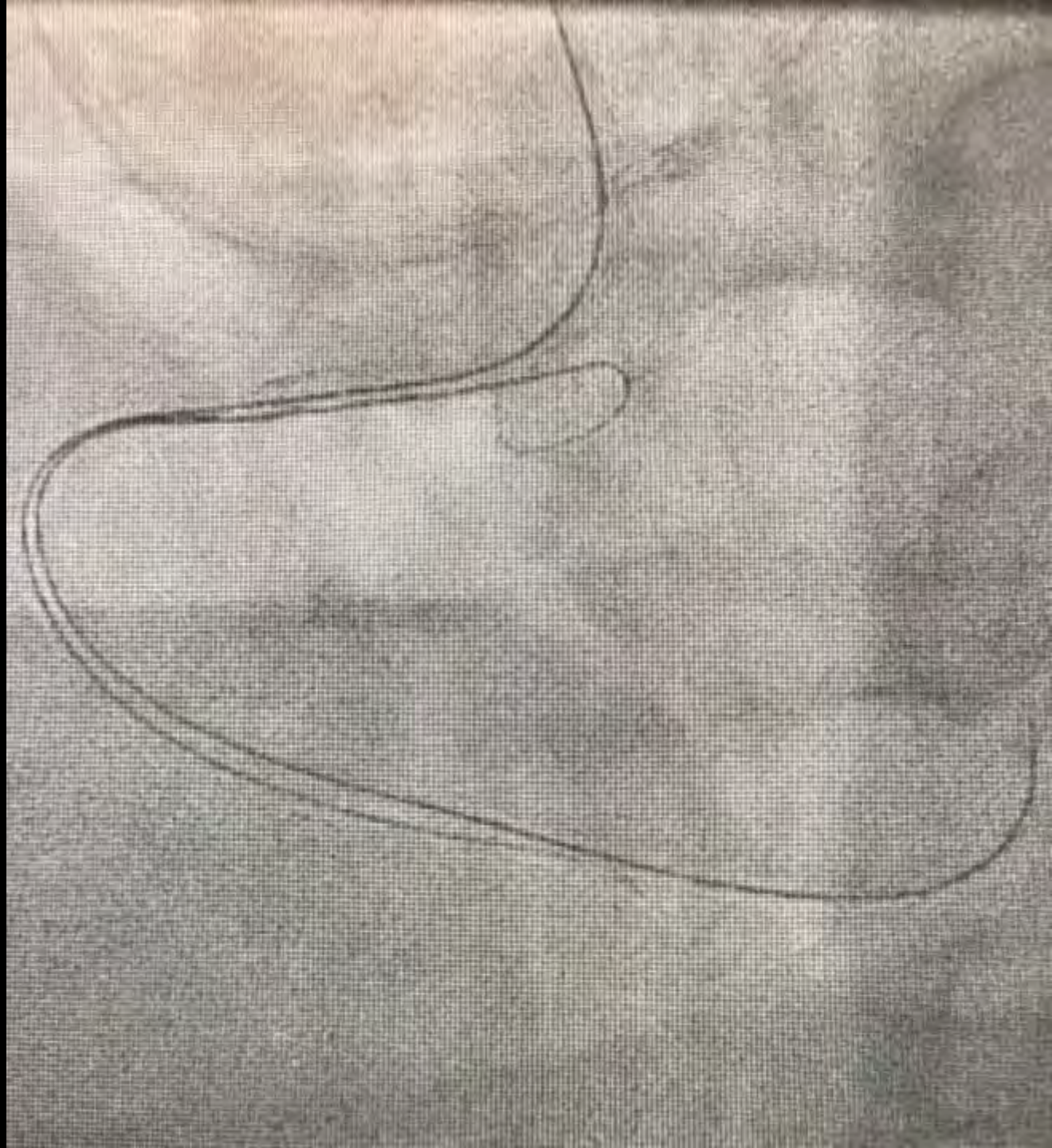
A Global Expert Consensus Document

1	The principal indication for CTO-PCI is to improve symptoms.
2	Dual coronary angiography and thorough, structured angiographic review should be performed in every case.
3	Use of a microcatheter is essential for guidewire support.
4	There are 4 CTO crossing strategies: antegrade wire escalation, antegrade dissection/reentry, retrograde wire escalation, and retrograde dissection/reentry.
5	Change of equipment and technique increases the likelihood of success and improves the efficiency of the procedure.
6	Centers and physicians performing CTO-PCI should have the necessary equipment, expertise, and experience to optimize success and minimize and manage complications.
7	Every effort should be made to optimize stent deployment in CTO PCI, including the frequent use of intravascular imaging.

CTO-PCI Specialty Equipment



Wire Properties	Examples	Function
Low-gram weight, tapered tip, polymer jacket	Fighter (Boston Scientific) Fielder XT, Fielder XTA, Fielder XTR (Asahi Intecc)	Palpate proximal cap, loose tissue tracking within CTO body. Knuckle wire
Medium-gram weight, polymer jacket	Pilot 200 (Abbott) Gladius (Asahi Intecc) Crosswire NT (Terumo) Raider (Teleflex)	Palpate proximal cap, tracking within more resistant CTOs. Knuckle wire. Less likely to exit in tortuosity and ambiguity
Medium-gram weight, no polymer jacket	Gaia 2, Gaia 3, Gaia Next (Asahi Intecc) Judo 3, Judo 6 (Boston Scientific)	Crossing CTO body in more mature resistant lesions. Tactile feedback and torque transmission help in understood anatomy
High-gram weight, tapered, no polymer jacket	Confianza Pro12, Astato 8/20 & 8/40 (Asahi Intecc) Pro Via 15 (Medtronic) Progress 200T (Abbott) Hornet 14 (Boston Scientific)	Penetration wires for focused crossing of highly resistant segments
Dedicated knuckle wire	Gladius MG (Asahi Intecc)	Crossing long segments efficiently using blunt dissection, with a low risk of perforation
Collateral crossing wires for retrograde procedures	Sion, Sion Black, Suoh03 (Asahi Intecc) Samurai RC (Boston Scientific)	Low tip load, highly torquable and flexible shafts to adapt to channel shapes





OPEN-AP

- Purpose: predict who has the greatest symptomatic benefit
- Variables
 - **Frequency of angina**
 - Frequency of NTG
 - Dyspnea when walking with others
 - # of antianginal medications
 - Presence of multiple CTO
 - Procedure for symptoms or not
 - Patient Health Questionnaire

Predictors of Decreased Success

- **Demographics**

- Prior MI
- Prior PCI
- CABG
- Prior stroke/TIA
- PVD

- **Angiographic**

- Non-LAD
- Multivessel CAD
- Bridging collaterals
- Moderate to severe calcification
- > 45 degree vessel bend
- Tortuous vessel
- Blunt stump
- Ostial lesions

Complications

- Stroke
- Contrast
- Radiation dermatitis
- CABG
- MACE
 - 4.1% vs 5% $p=0.04$
- Death -
 - 30-day mortality rate =1.3%
 - 1.2% vs 1.5% $p=0.51$

Complications

- Coronary artery perforation - 4.8%
 - 3.5% vs 2% $p=0.04$
- Cardiac tamponade
 - 0.8% vs 0.1% $p=0.001$
- Access site complication
- Donor vessel injury
- Arrhythmias

Indications

- 2011 ACC/AHA Revascularization Guideline
 - Class IIA level with evidence B
- 2021 ACC/AHA/SCAI Revascularization Guidelines
 - Class 2 b LOE B-R
 - *“In patients with suitable anatomy who have refractory angina on medical therapy, after treatment of non-CTO lesions, the benefit of PCI of a CTO to improve symptoms is uncertain.”*

Studies

- **EXPLORE**

- n= 302 STEMI patients with CTO in non-farct artery
- Nov 2007-April 2015
- 14 centers in Europe and Canada
- Early CTO-PCI (one week) vs. NO CTO-PCI
- Procedure success = 77% and 73%
- Mean LVEF and LVEDV at 4 months by MRI
- No difference between groups except LAD group
 - n=69 LAD vs n=211 non-LAD
 - LVEF = 47.2 vs 40.4 p=0.02

Studies

• CTO (EuroCTO)

- 3 year follow up
- 17.3% crossover rate (OMT->CTO_PCI)
- 396 patients randomized CTO-PCI vs OMT
 - 50% single vessel CAD
- No difference in CV death or MI
- MACE higher in OMT group (21.2%vs11.2%)
- At 12 months
 - Angina frequency at 12 months
 - 5.23, p=0.003
 - Quality of Life
 - 6.62, p=0.007

Studies

- IMPACTOR-CTO

- 94 patients with RCA CTO randomized to CTO-PCI vs OMT
- 72 isolated RCA CTOs (8 failed PCI, 14 failed compliance OMT)
- Procedure success = 83%
- Myocardial ischemic burden decreased at 12 months
 - 27.7+/- 8.5% -> 16.1+/- 8.6% (p<0.01) vs no significant improvement in OMT
- Six-minute walking test increased from 295m -> 430m vs no improvement in OMT group
- Improved QoL item in CTO-PCI group vs no improvement in OMT

Studies

- **REVASC**

- n=205 patients
- Stable CAD
- Success rate = 89%
- Assess LV function improvement
 - Primary end point not reached
- Reduced MACE at 12 months
 - Reduction in repeat PCI (16.3% vs 5.9%, p=0.02)

Studies

• **DECISION-CTO**

- N=815 patients (planned = 1284)
- Silent ischemia, stable angina, ACS
- Procedural success = 91%
- 4 year follow up
- Stopped early due to poor enrollment
- Most patients from a single center
- Most patients were poorly symptomatic
- Stroke 5 x higher in OMT
- Combined end points of mortality, MI, stroke, any revascularization at 4 yrs
 - 22.3% vs 22.4%, p=0.86
 - Low power and high crossover rates (18% in OMT arm, 15.5% of PCI treated with OMT)

Registries

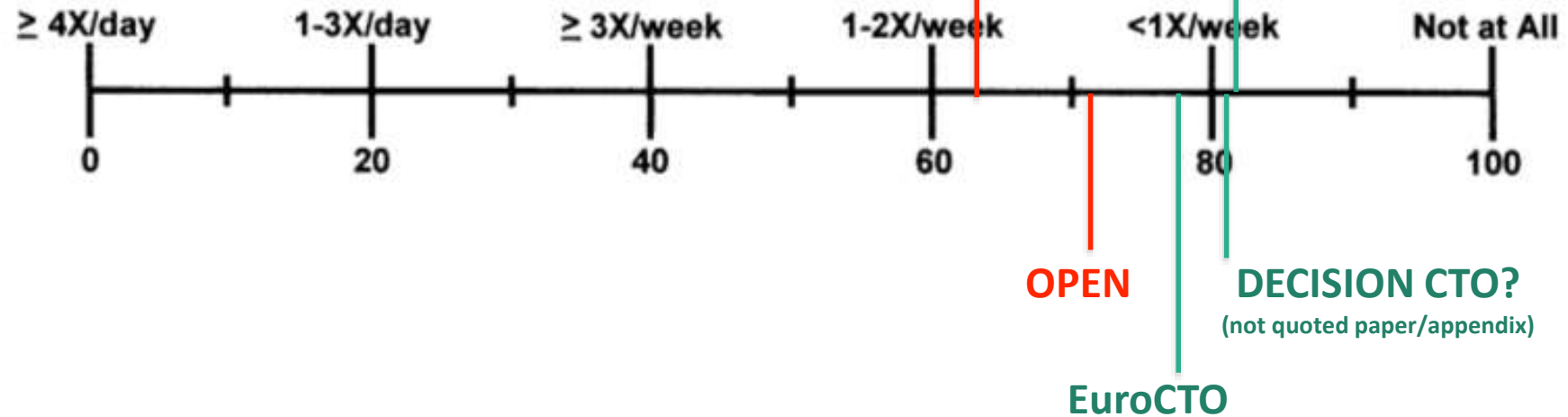
- PROGRESS-CTO
 - Prospective Global Registry for the Study of Chronic Total Occlusion Intervention
- OPEN-CTO
 - Outcomes, Patient Health Status and Efficiency In Chronic Total Occlusion Hybrid Procedures
 - 1,000 patients
 - 12 centers
 - NCDR Cath/PCI Registry
- Japanese Multicenter CTO Registry

Studies

- Gong et al. Observational Study
 - 592 patients
 - Significant improvement in cardiac death and MACE
 - Hazard ratio = 0.239
- Meta-Analysis
 - 25 studies
 - CTO-PCI vs failed CTO-PCI at 3 years
 - Lower mortality rate (OR =0.52), less residual ischemia(OR=0.38), lower stroke risk (OR =0.72), less need for subsequent CABG (OR=0.18)

SAQ Angina Frequency Scale

Over the past 4 weeks, how often have you had angina?



Strongly suggests symptomatic patients biased away from trials

Treatment Options

- Heart Team Approach
 - Evaluation
- Patient and Family/Care Giver Counseling
 - Shared Decision Making
 - Higher Risks
 - Greater benefits
- Medical Management
- CABG
- PCI

Outcomes

- Success rate
 - 85-90% in the best centers
 - 60-80% in the largest registries



Referral Process

- **CTO Clinic**
 - **402-559-8888**
- **Jess Anderson RN**
 - **CTO Coordinator**
- **Ed O'Leary MD**
 - **402-238-7834**



