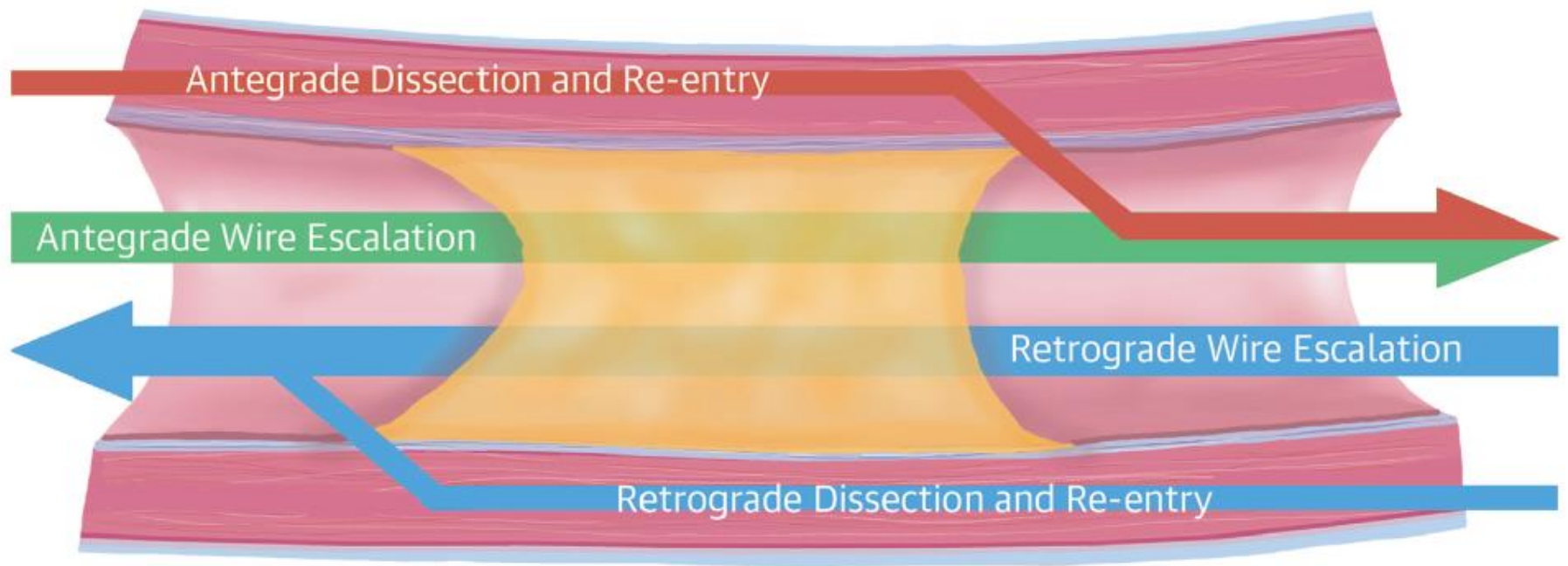


Summary of CTO technique for beginners: We Can Do It !

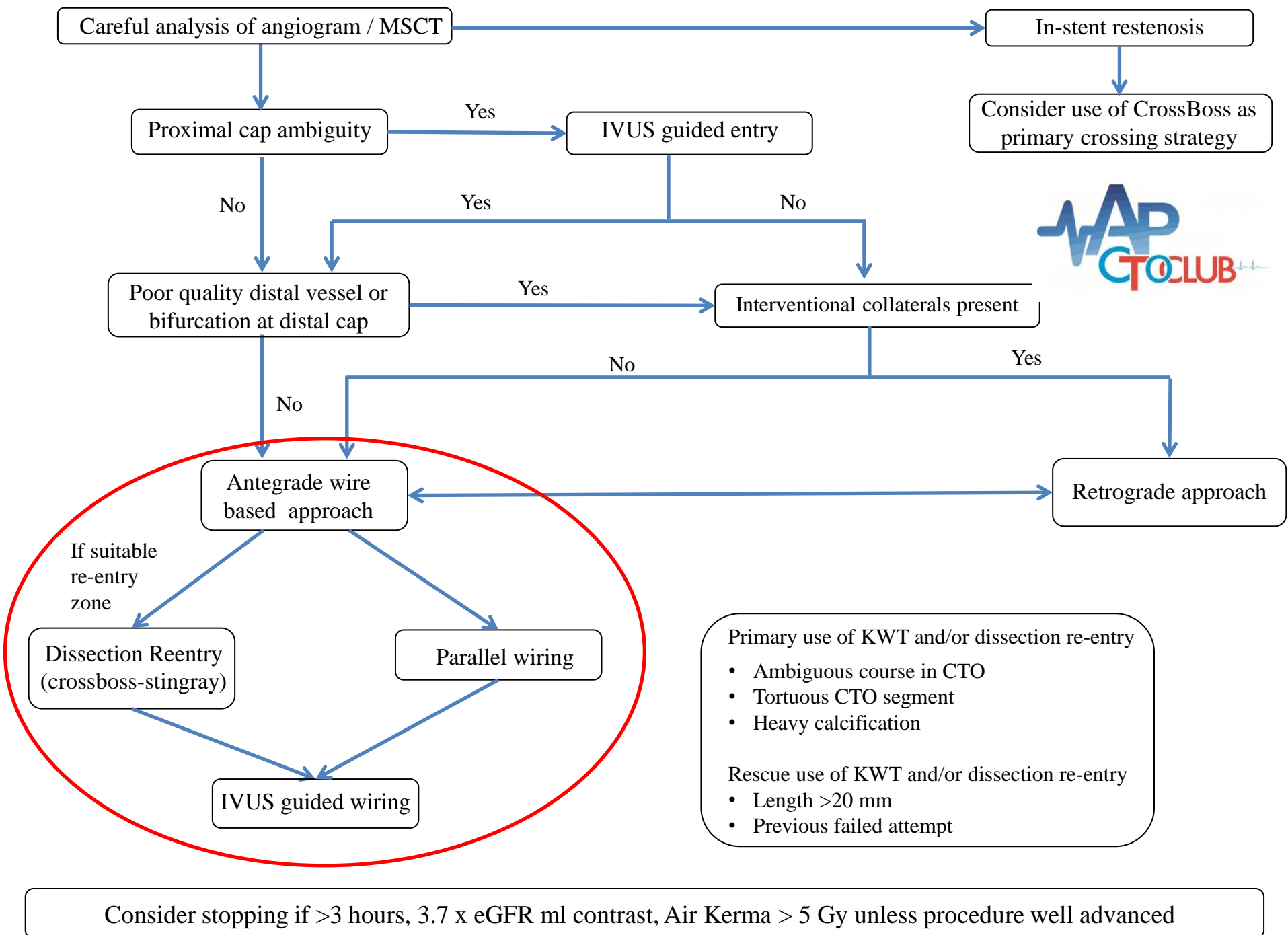
Seung-Whan Lee, MD, PhD

Asan Medical Center,
University of Ulsan College of Medicine, Seoul, Korea

Four strategies for CTO



J Am Coll Cardiol 2016;68:1958–70

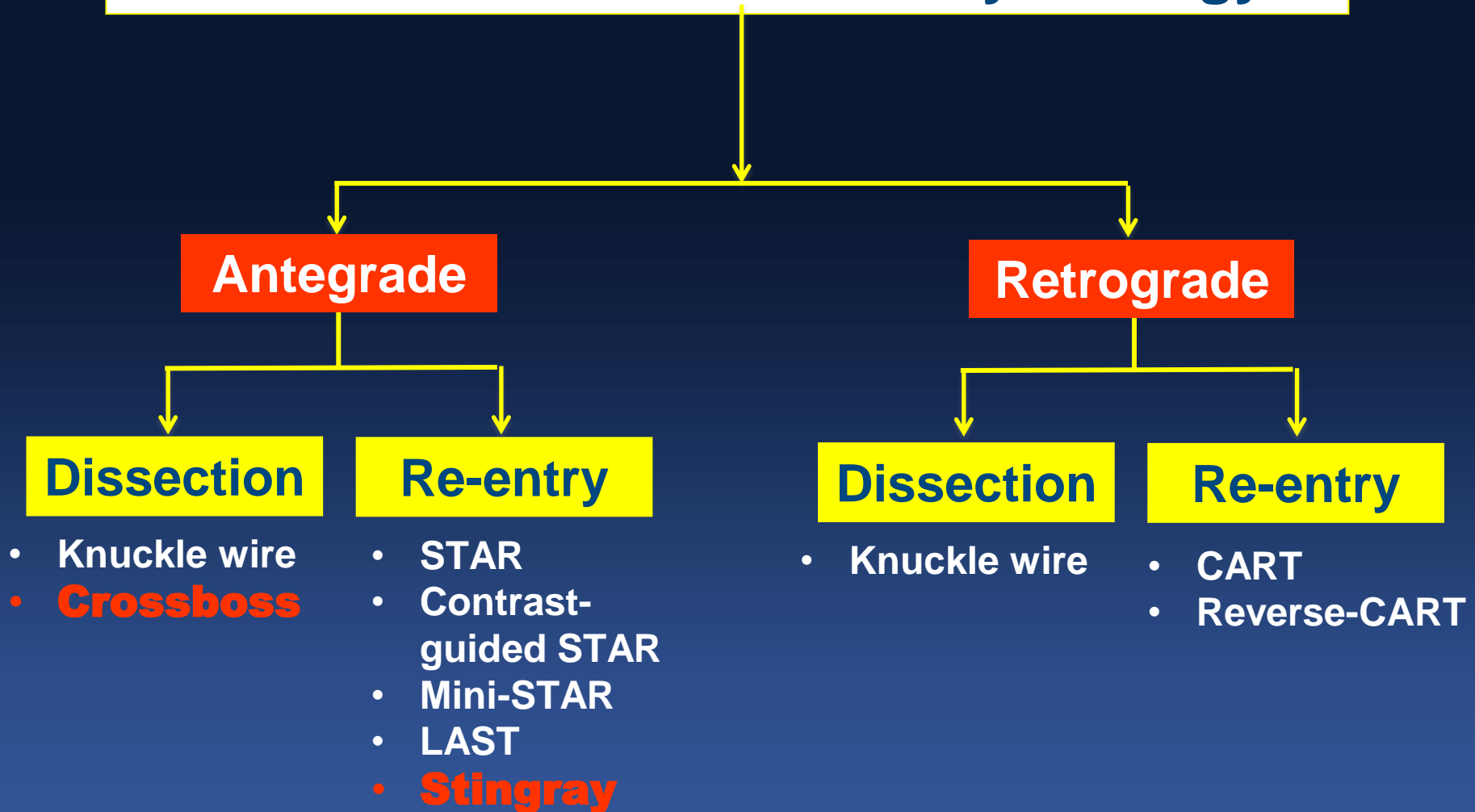


Antegrade approach

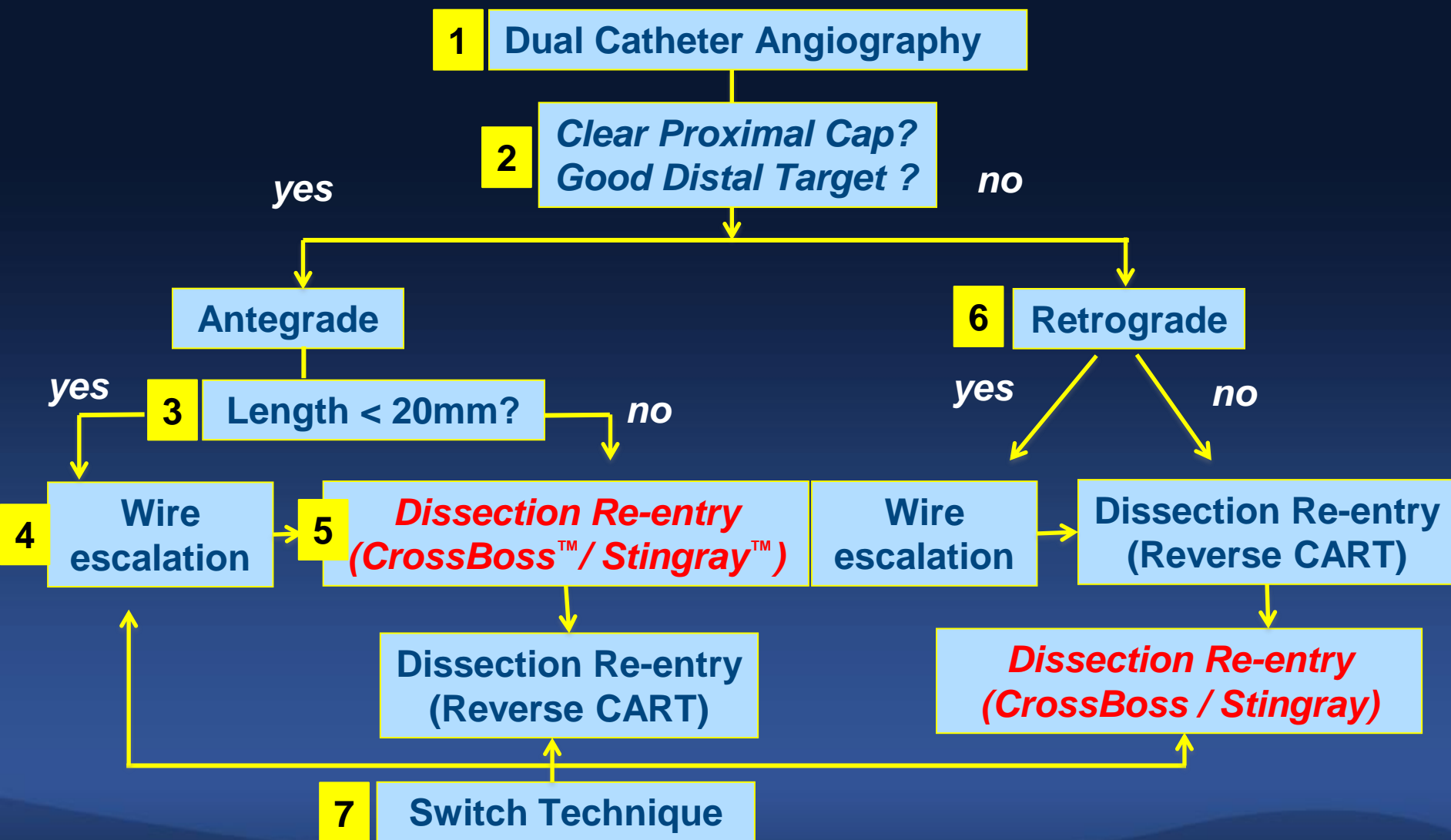
- Wire escalation
- Dissection reentry

In conjunction with
IVUS-guided approach

CTO dissection and Re-entry strategy



Hybrid Algorithm for CTO-PCI



CTO wires evolution

	Composite core (Dual coil)	Tip load (g)	Tip taper	Hydrophilic coating	Polymer jacket
Fielder FC	-	0.8	-	+	+
Fielder XT	-	0.8	+ (0.009")	+	+
Fielder XT-R	+	0.6	+ (0.010")	+	+
Fielder XT-A	+	1.0	+ (0.010")	+	+
SION	+	0.7	-	+	-
SION BLUE	+	0.5	-	+ (uncoated distal 15mm)	-
SION BLACK	+	0.8	-	+	+
Gaia 1st	+	1.5	+ (0.010")	+	-
Gaia 2nd	+	3.5	+ (0.011")	+	-
Gaia 3rd	+	4.5	+ (0.012")	+	-
Miracle	-	3,6,12	-	-	-
Conquest pro	-	9,12	+	+(uncoated tip)	-

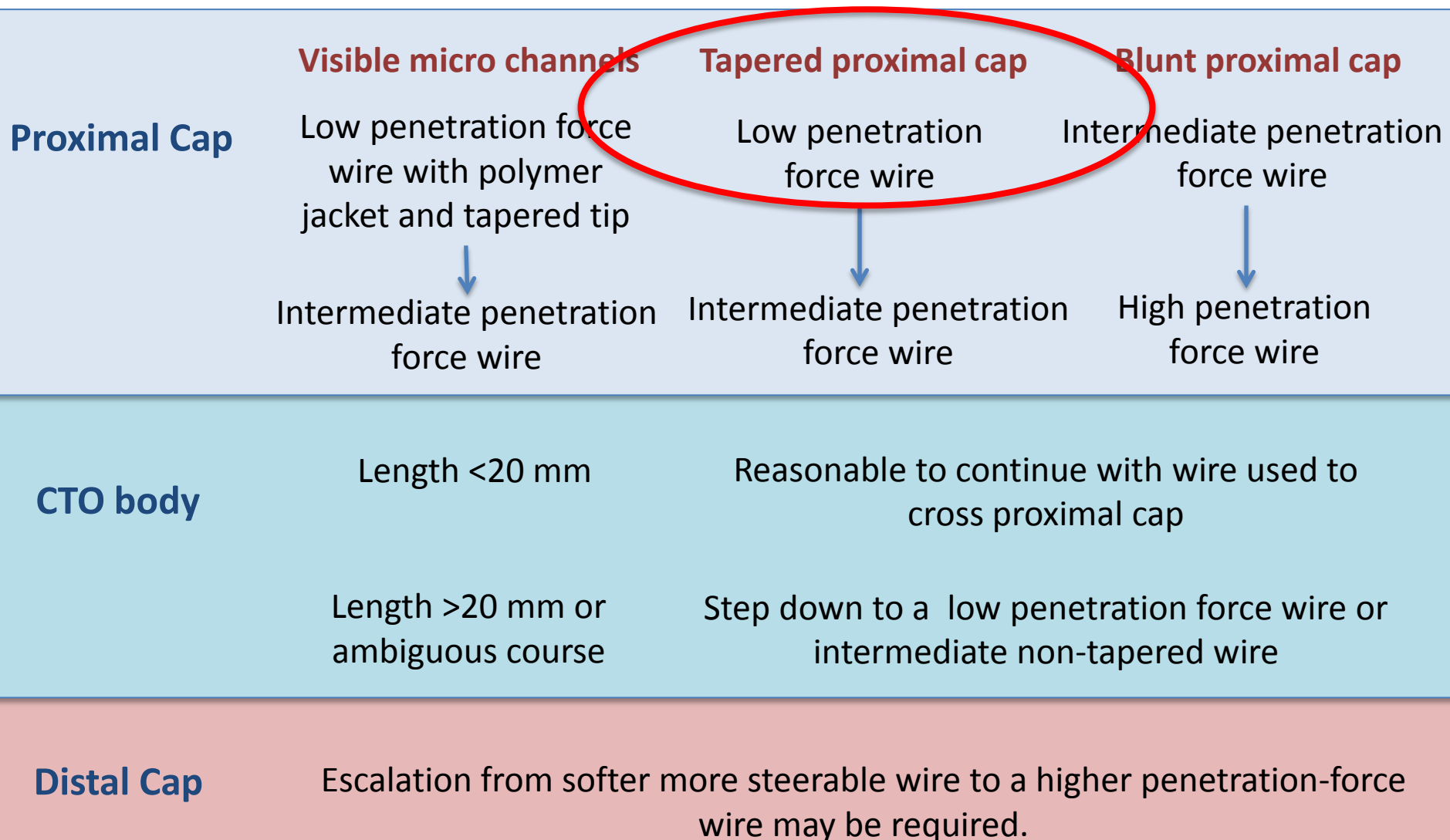
Antegrade wire based strategy



	Visible micro channels	Tapered proximal cap	Blunt proximal cap
Proximal Cap	<p>Low penetration force wire with polymer jacket and tapered tip</p> <p>↓</p> <p>Intermediate penetration force wire</p>	<p>Low penetration force wire</p> <p>↓</p> <p>Intermediate penetration force wire</p>	<p>Intermediate penetration force wire</p> <p>↓</p> <p>High penetration force wire</p>
CTO body	<p>Length <20 mm</p> <p>Length >20 mm or ambiguous course</p>	<p>Reasonable to continue with wire used to cross proximal cap</p> <p>Step down to a low penetration force wire or intermediate non-tapered wire</p>	
Distal Cap	<p>Escalation from softer more steerable wire to a higher penetration-force wire may be required.</p>		

Single wire technique

Antegrade wire based strategy

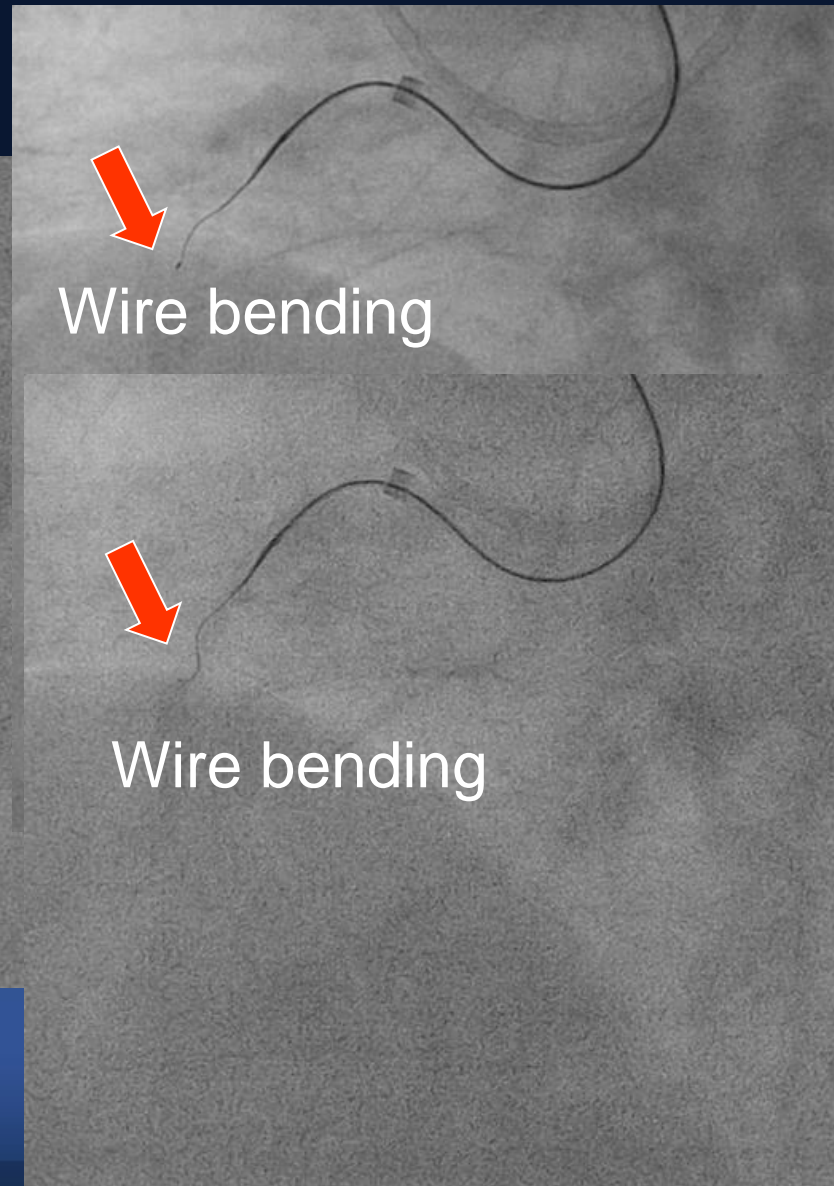
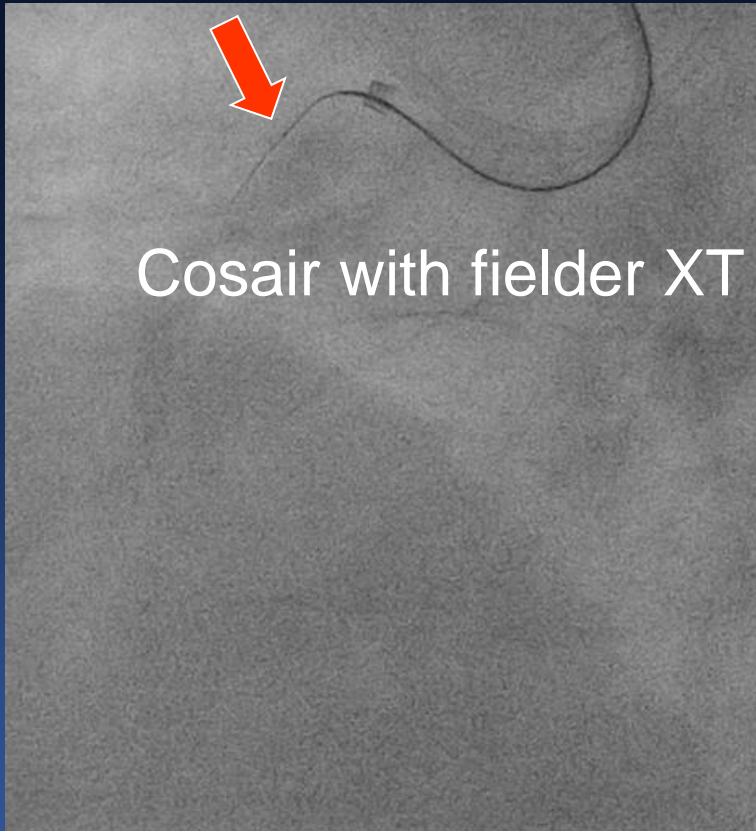


60/M, Long CTO with tapered cap

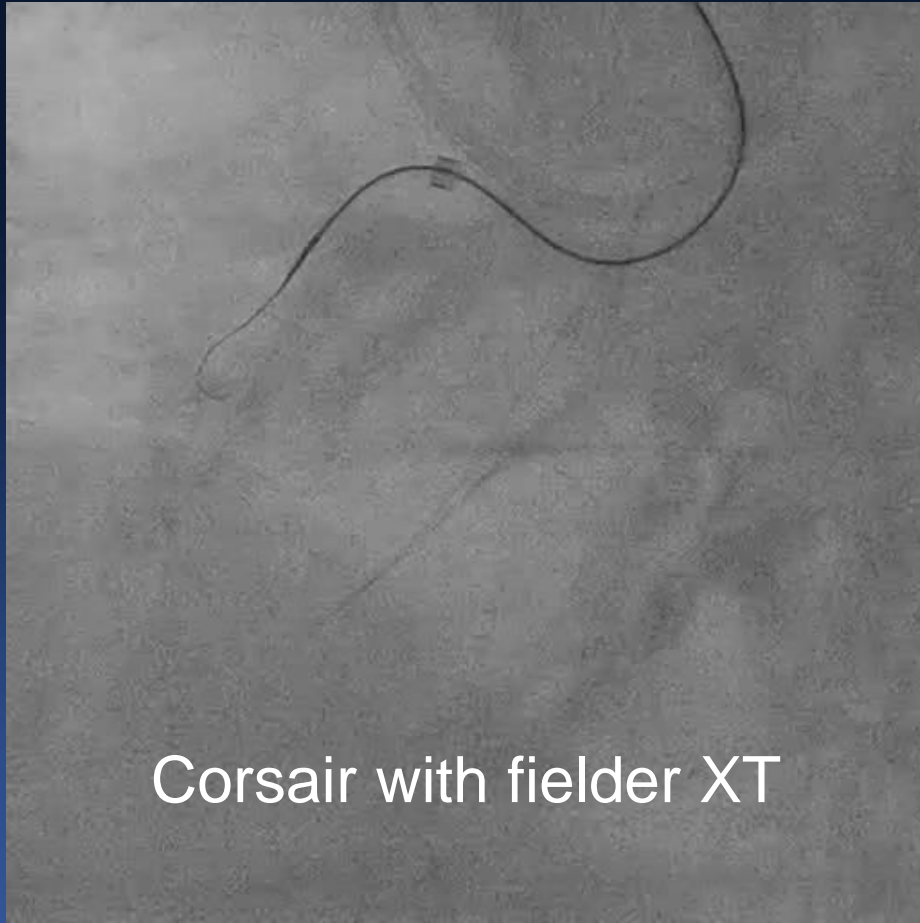
Poor distal target with good interventional collateral



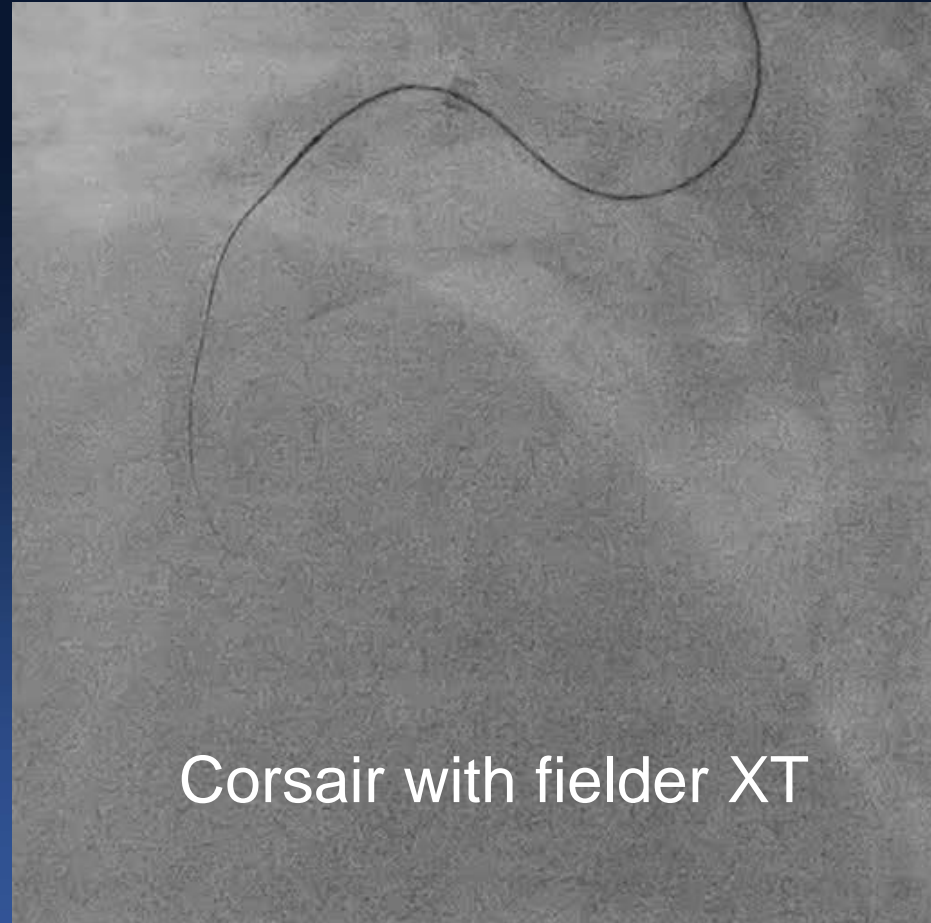
Long CTO with tapered cap



Long CTO with tapered cap



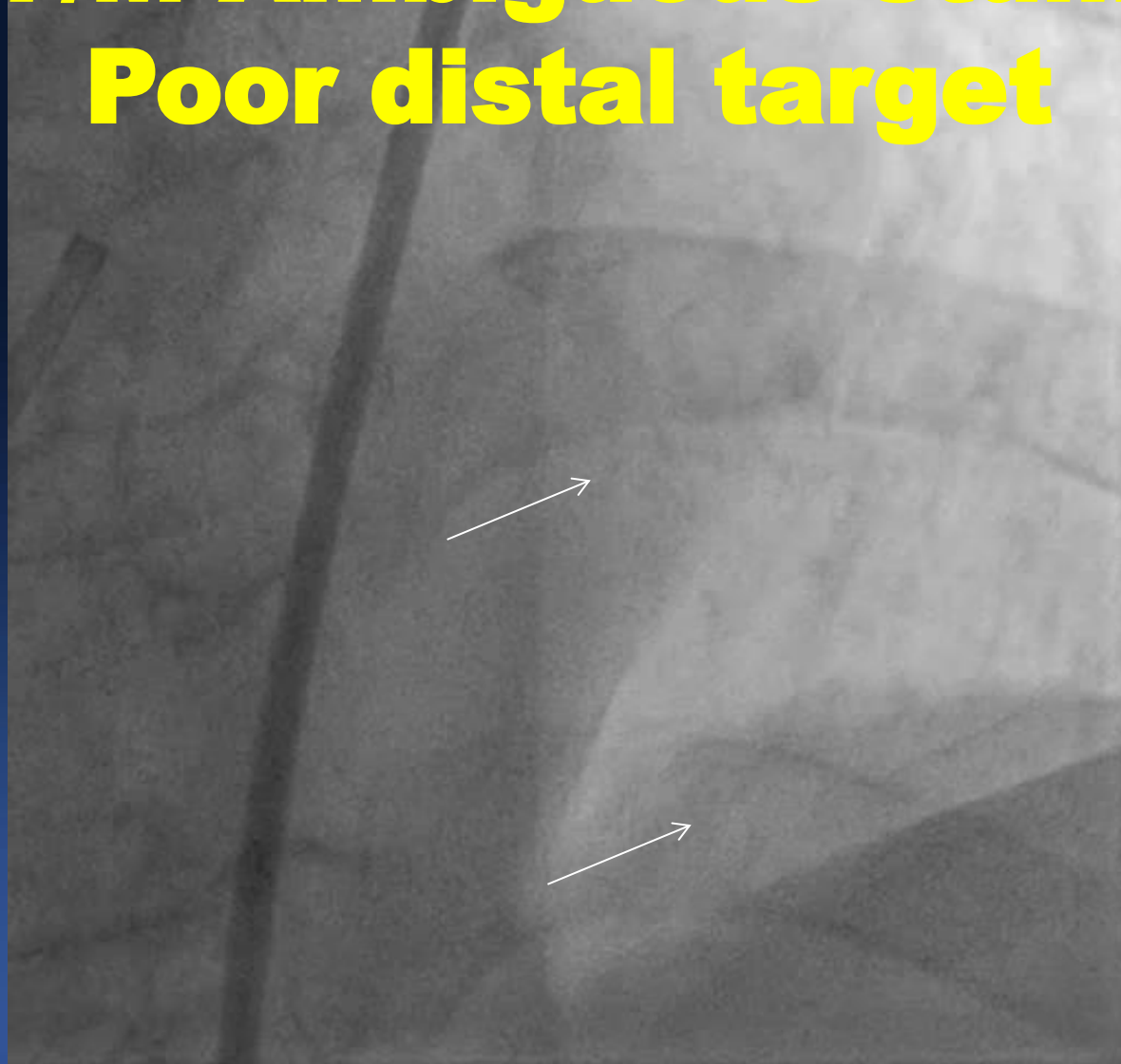
Corsair with fielder XT

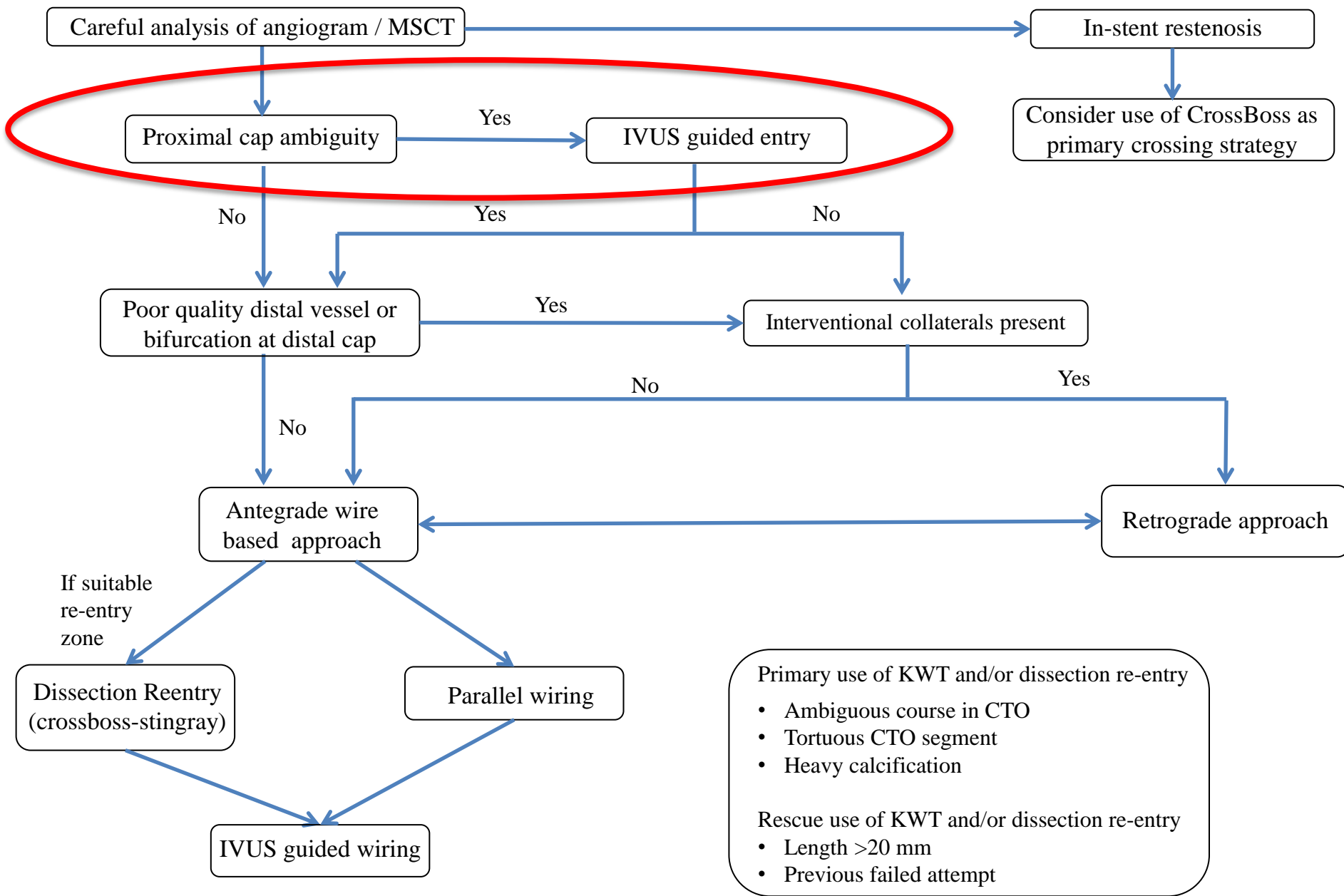


Corsair with fielder XT

67/M Ambiguous stump

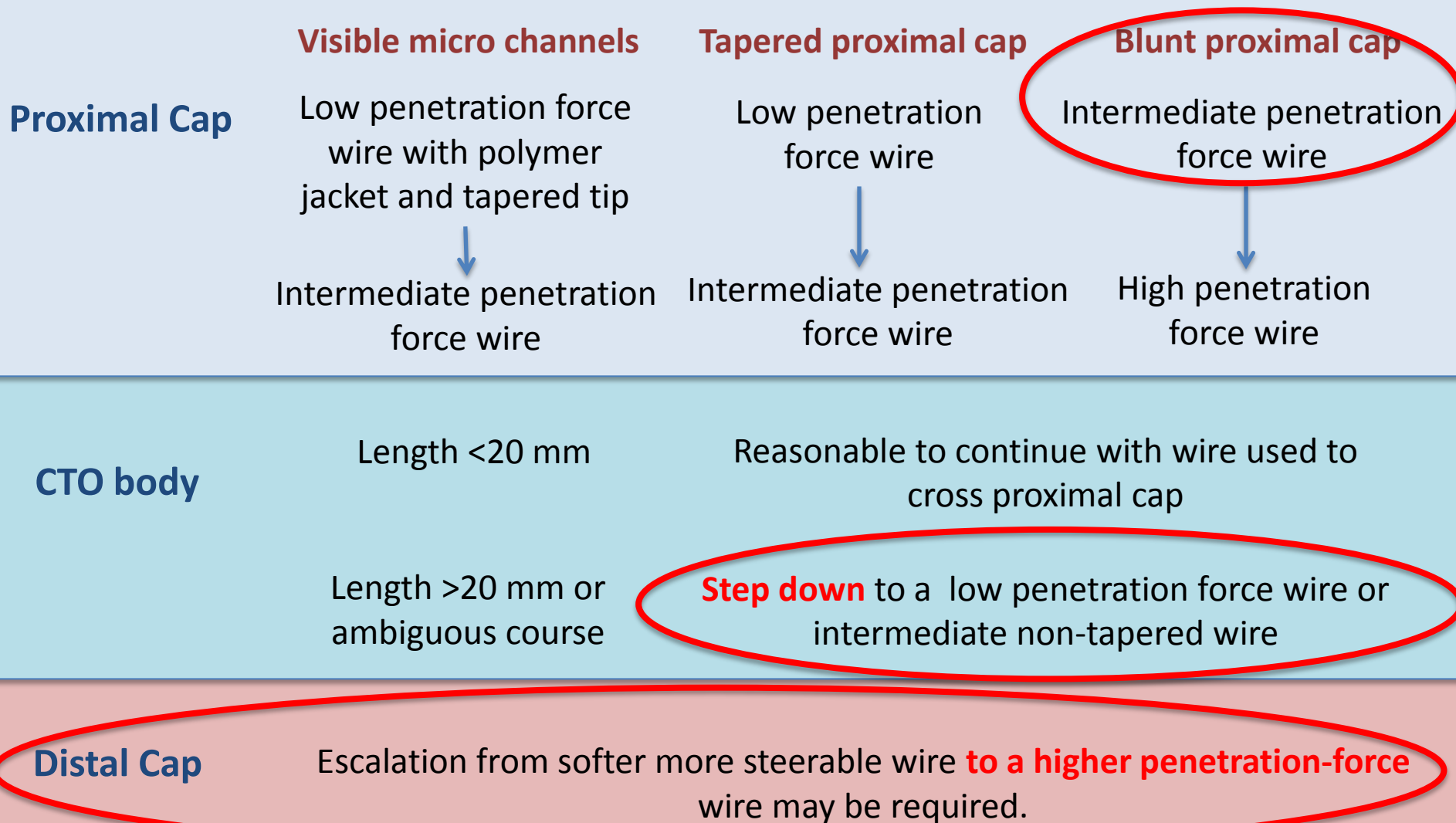
Poor distal target



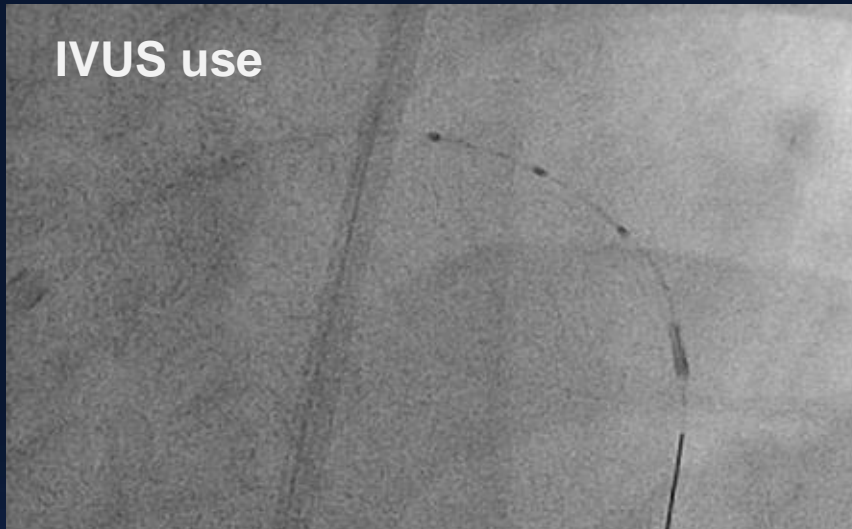


Consider stopping if >3 hours, 3.7 x eGFR ml contrast, Air Kerma > 5 Gy unless procedure well advanced

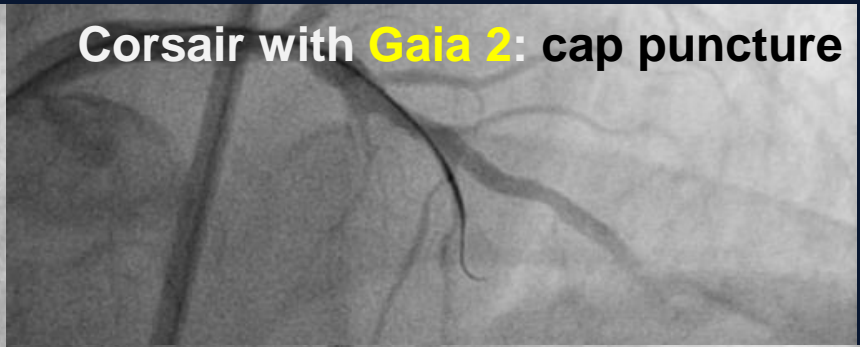
Antegrade wire based strategy



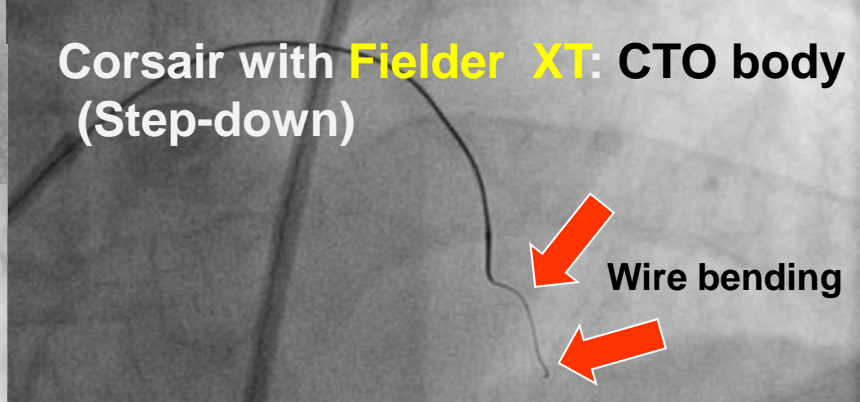
IVUS use



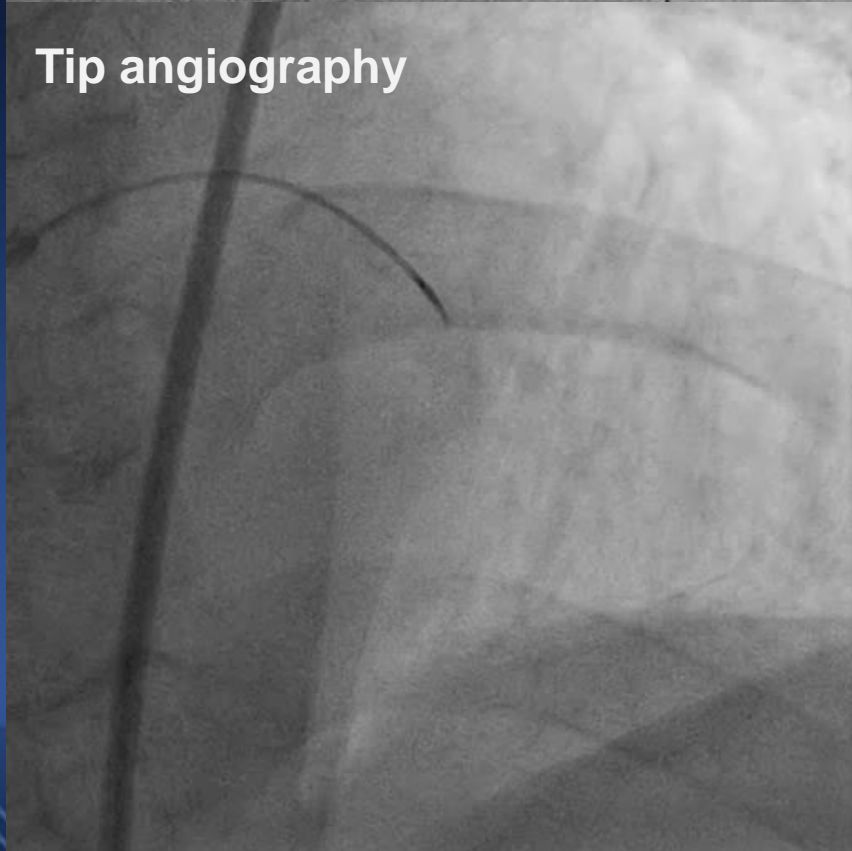
Corsair with **Gaia 2**: cap puncture



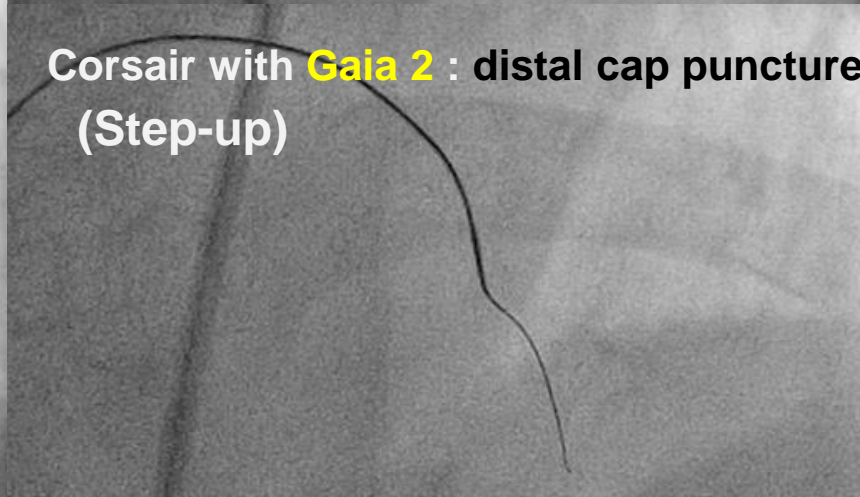
Corsair with **Fielder XT**: CTO body (Step-down)

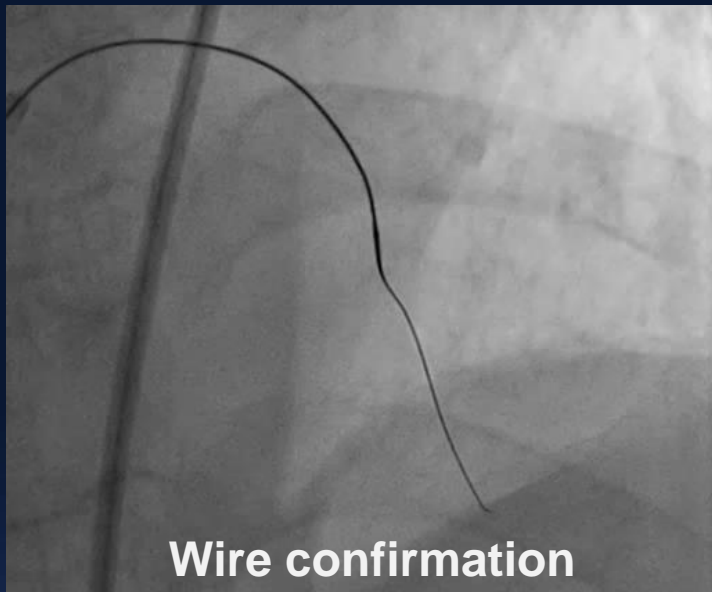


Tip angiography

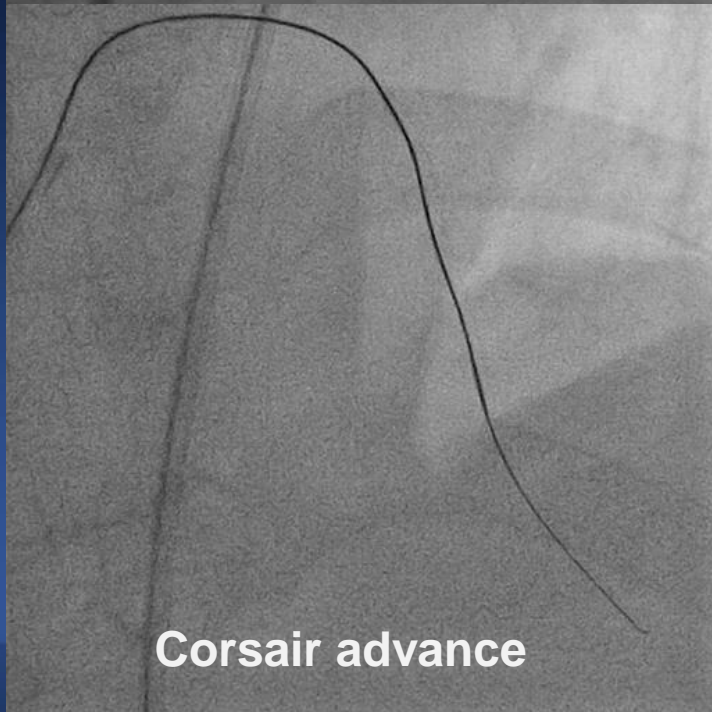


Corsair with **Gaia 2** : distal cap puncture (Step-up)

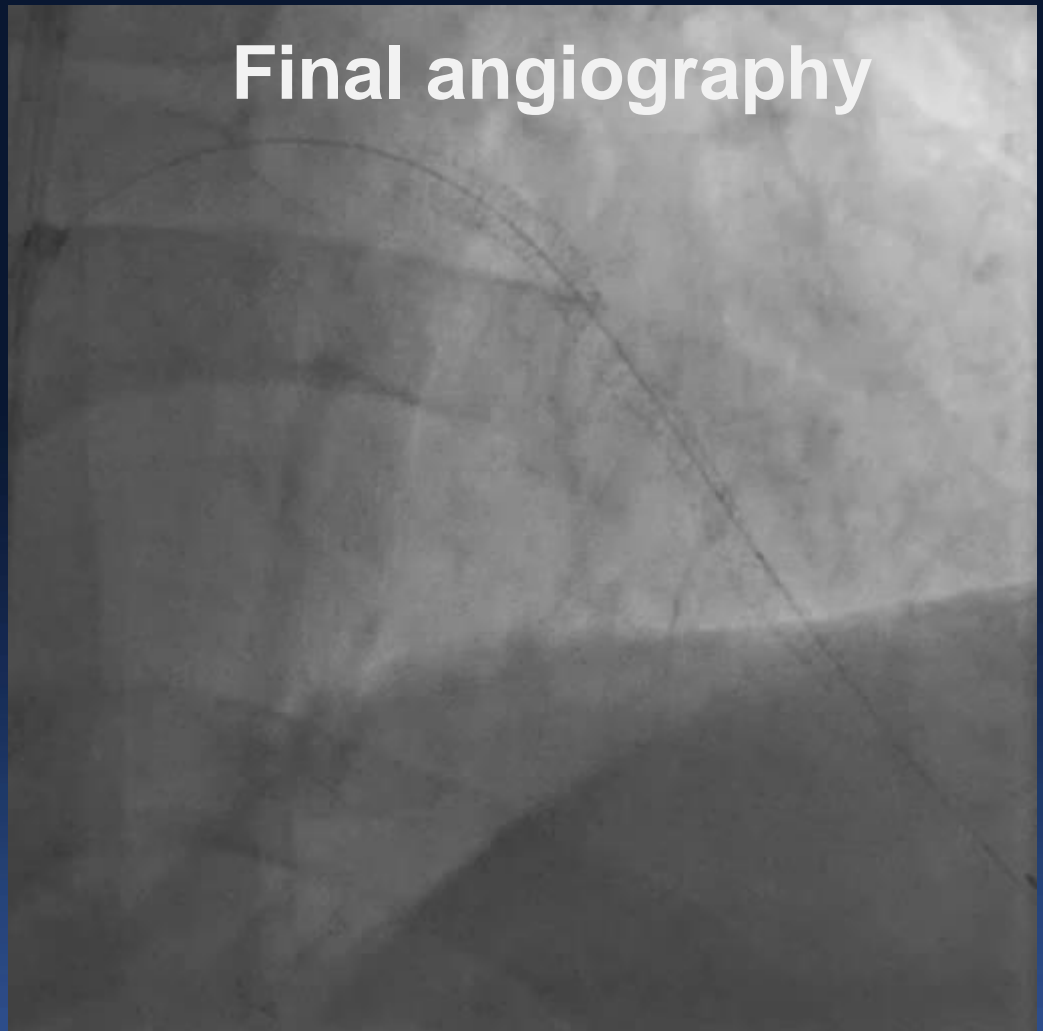




Wire confirmation

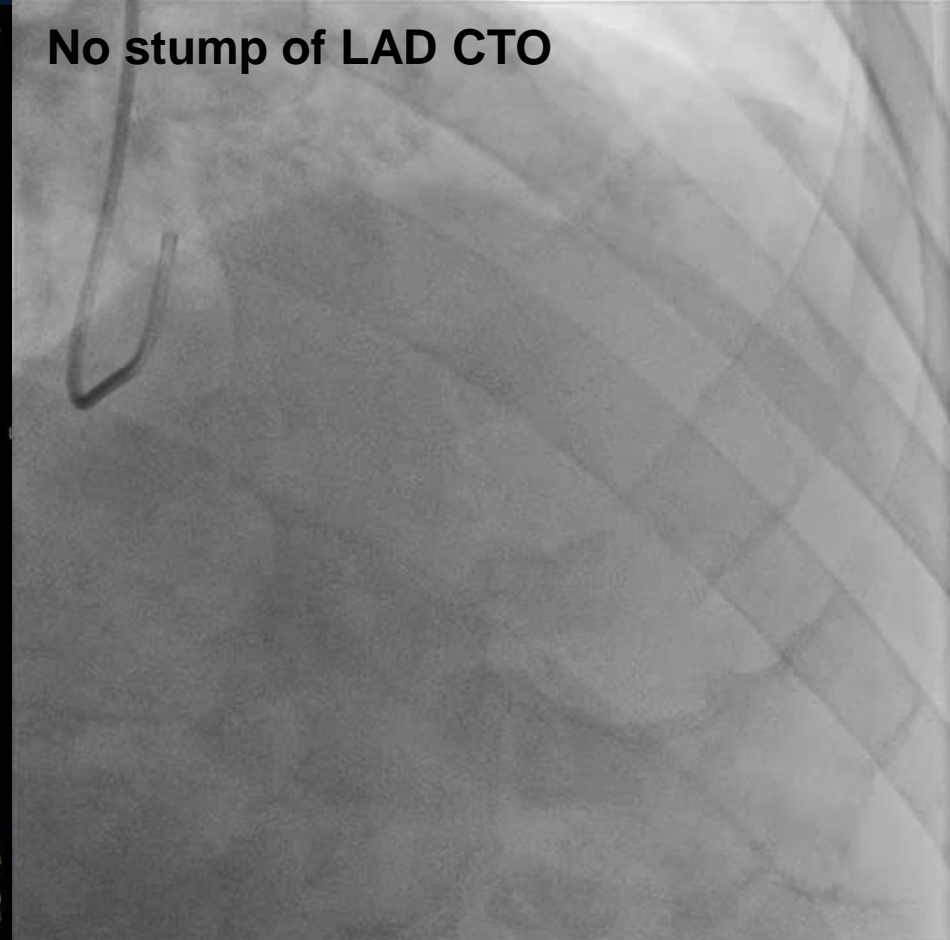
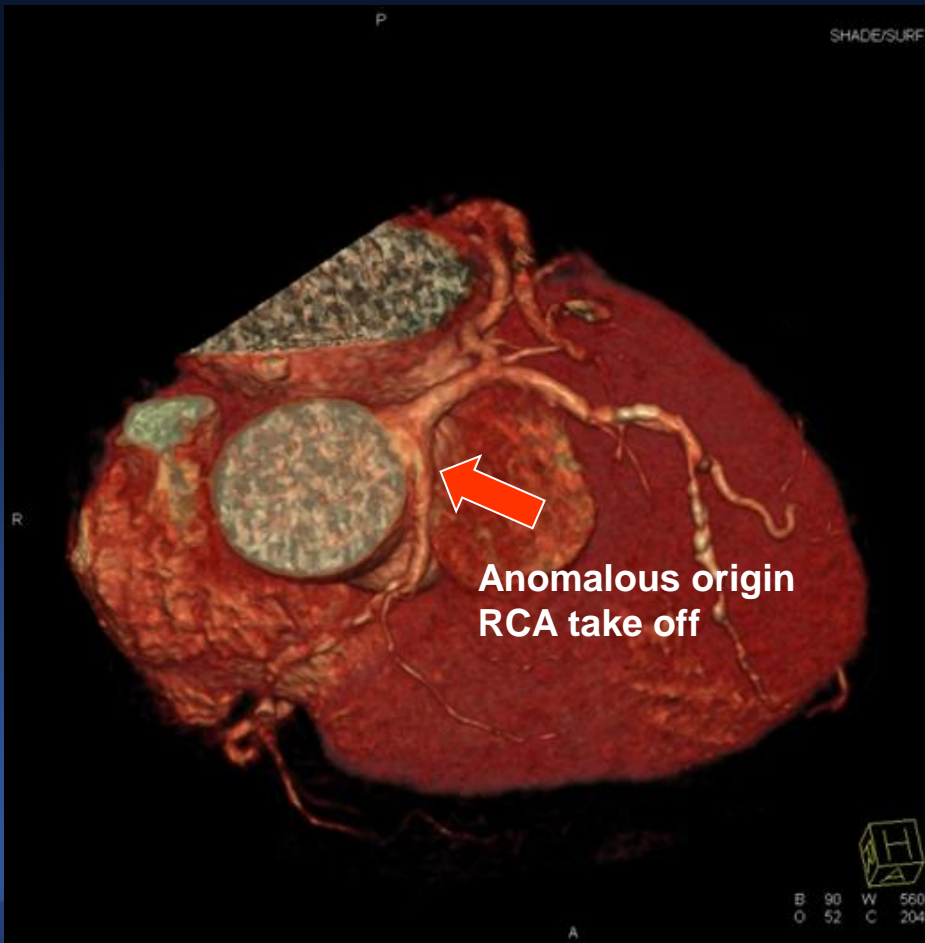


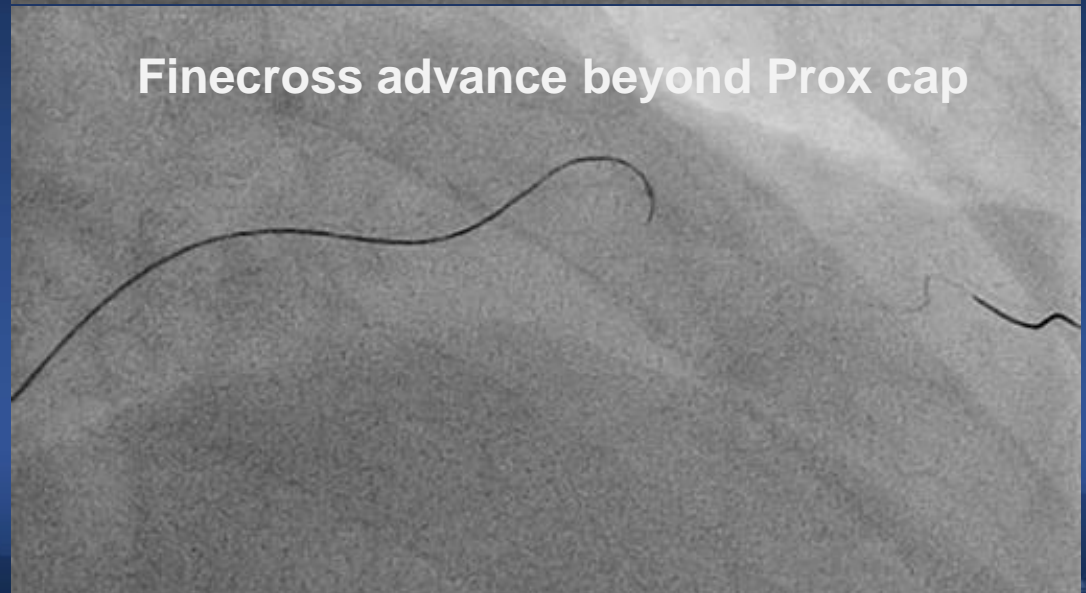
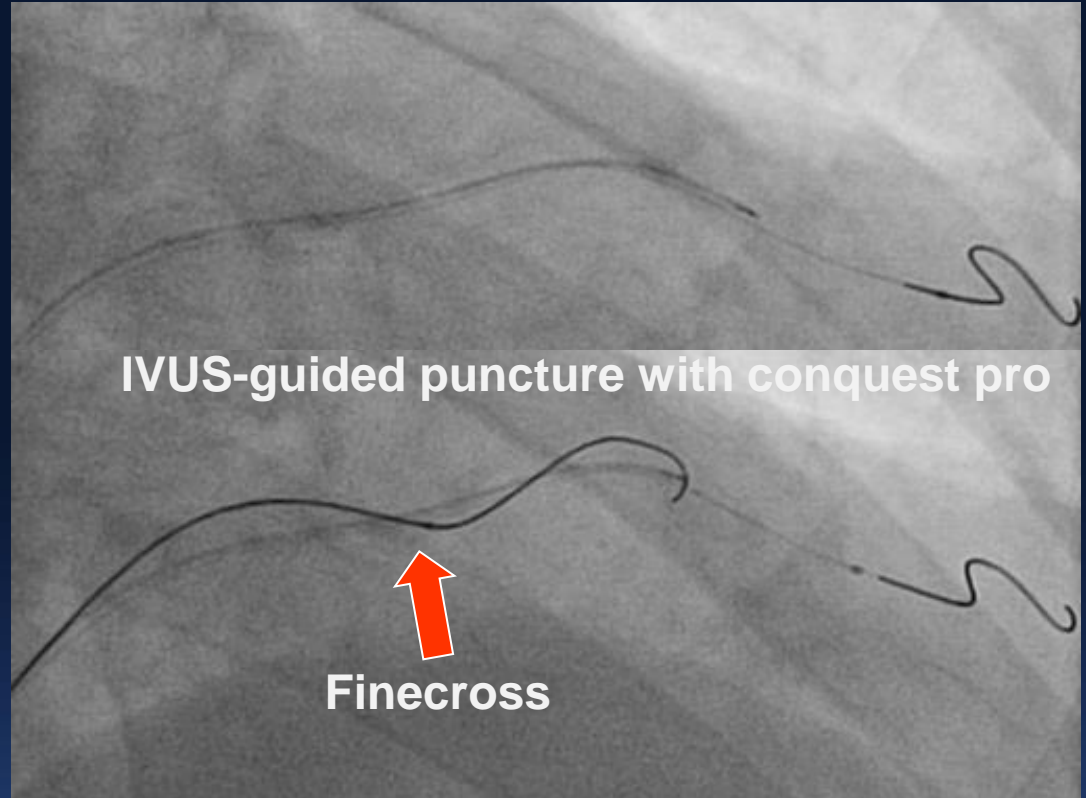
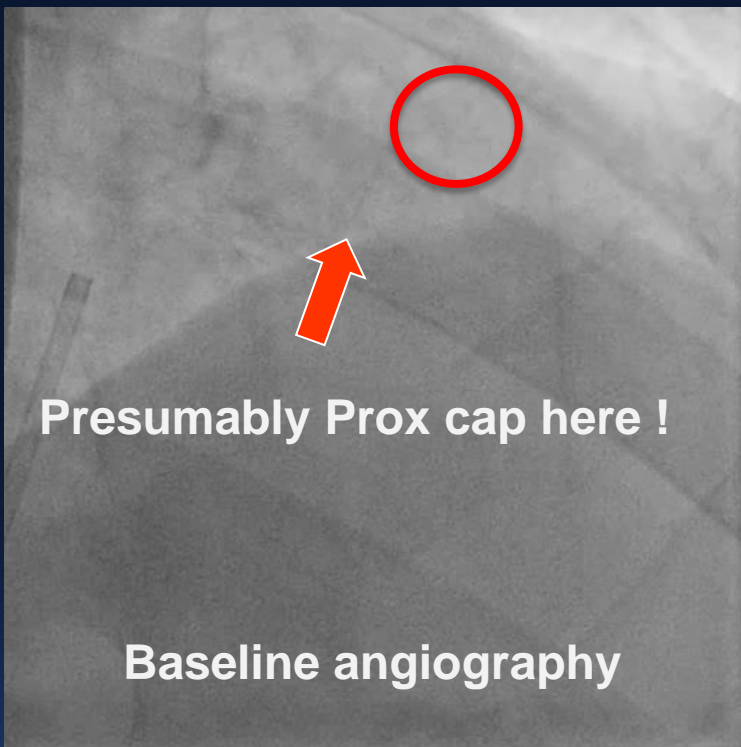
Corsair advance



Final angiography

LAD CTO with anomalous origin RCA CTO







Fielder XT (step down)



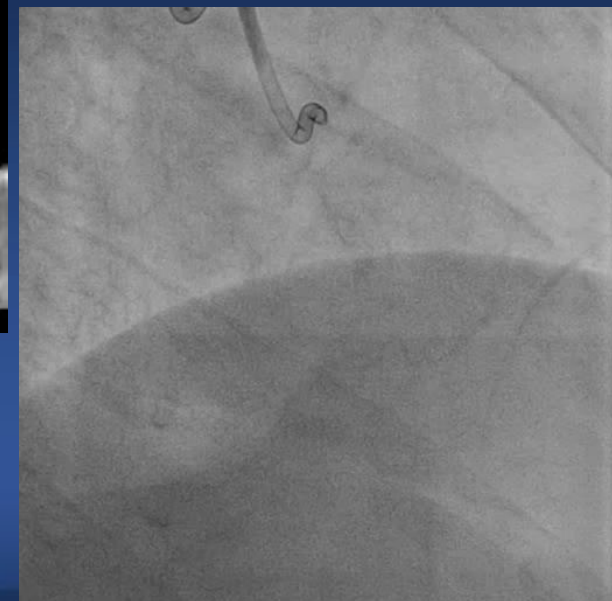
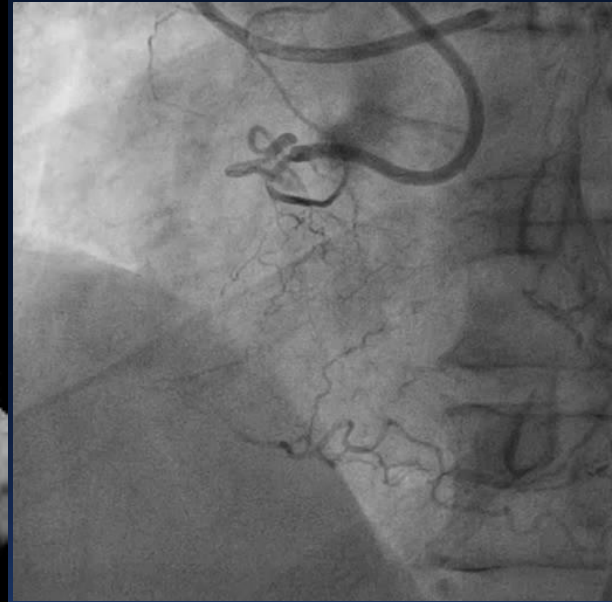
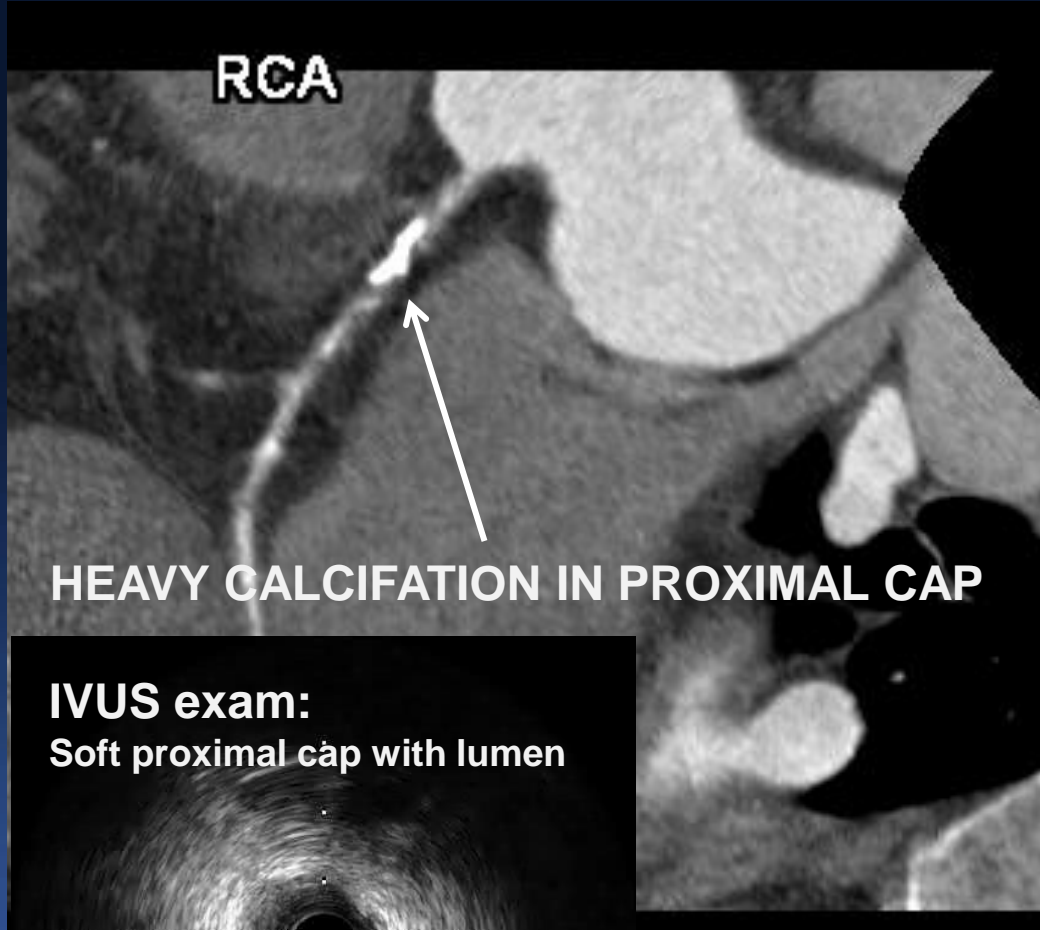
Tip angiography



Final angiography

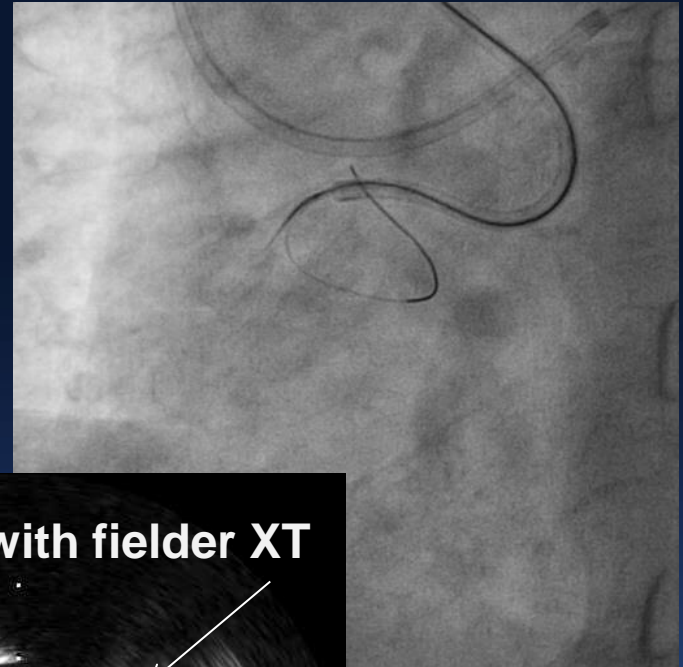
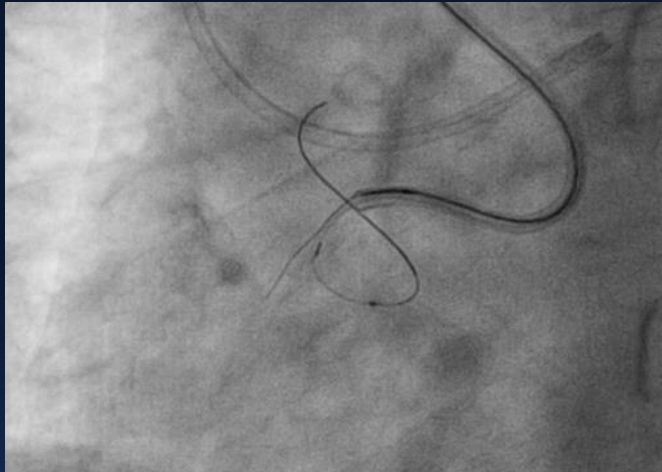
Distal true lumen wiring with fielder XT

56/M, Long RCA CTO with no stump



IVUS-guided Fielder XT

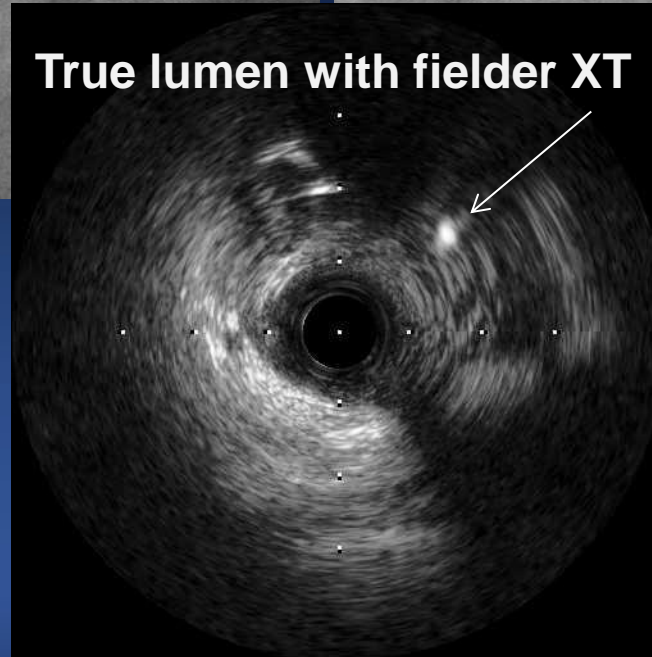
Corsair advance



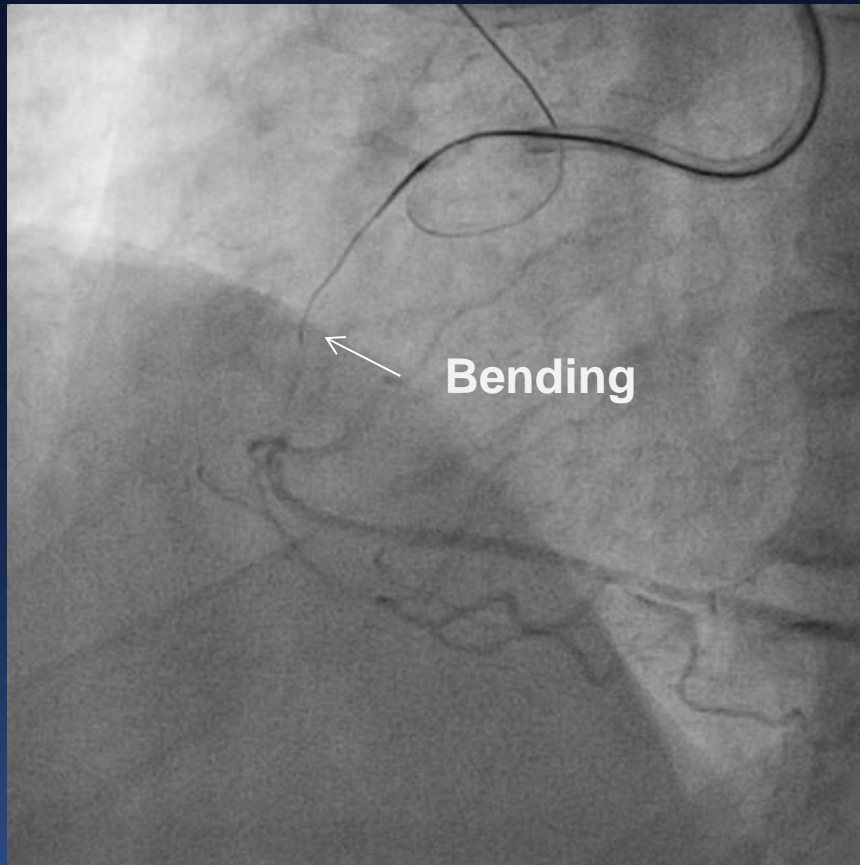
**IVUS exam:
Soft proximal cap with lumen**



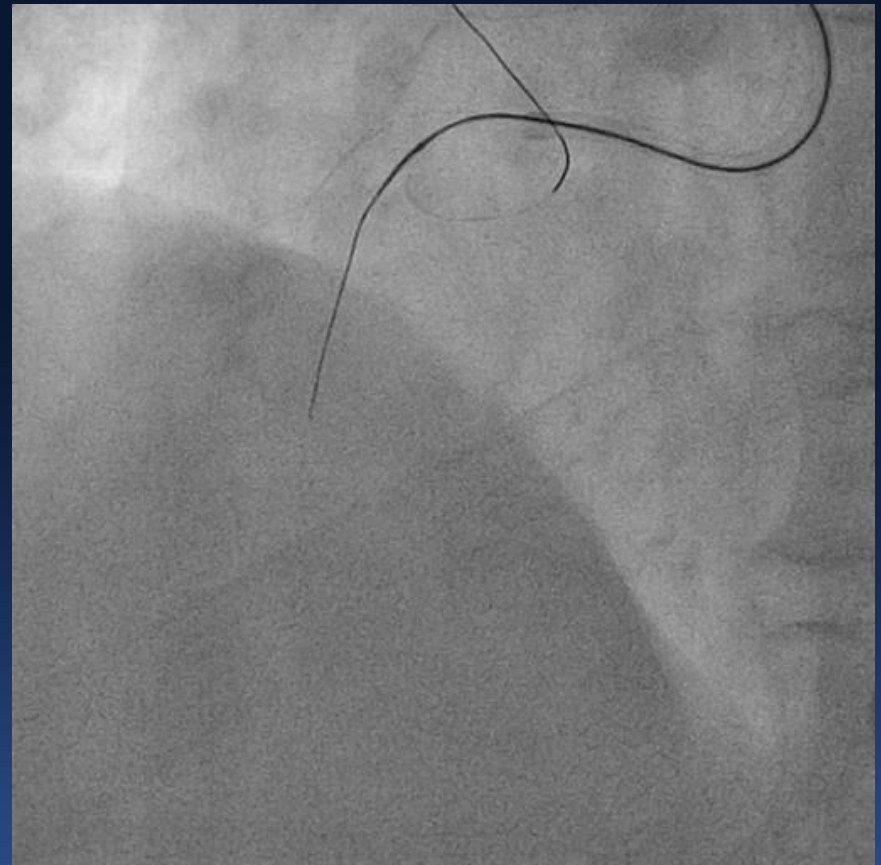
True lumen with fielder XT



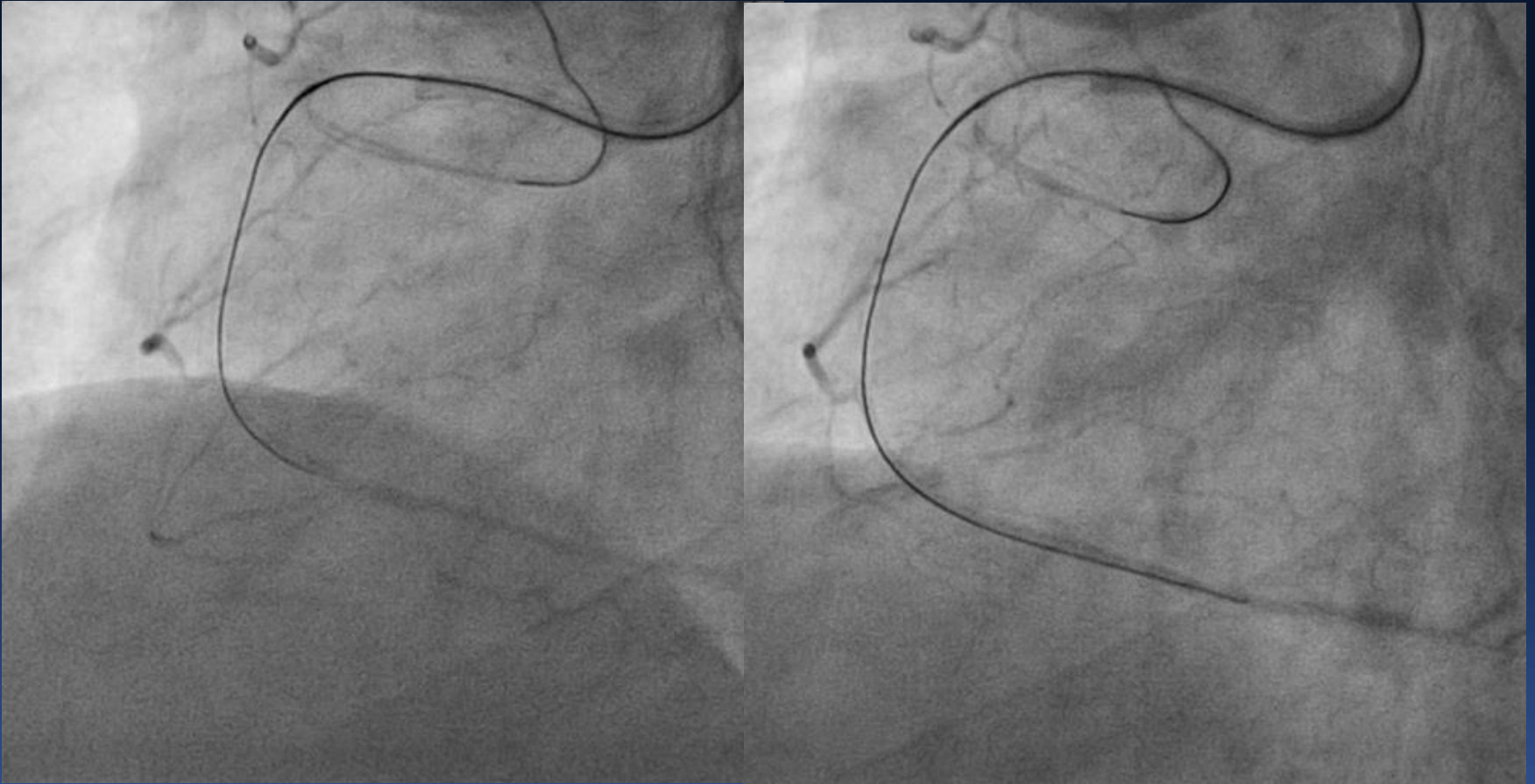
Fielder XT



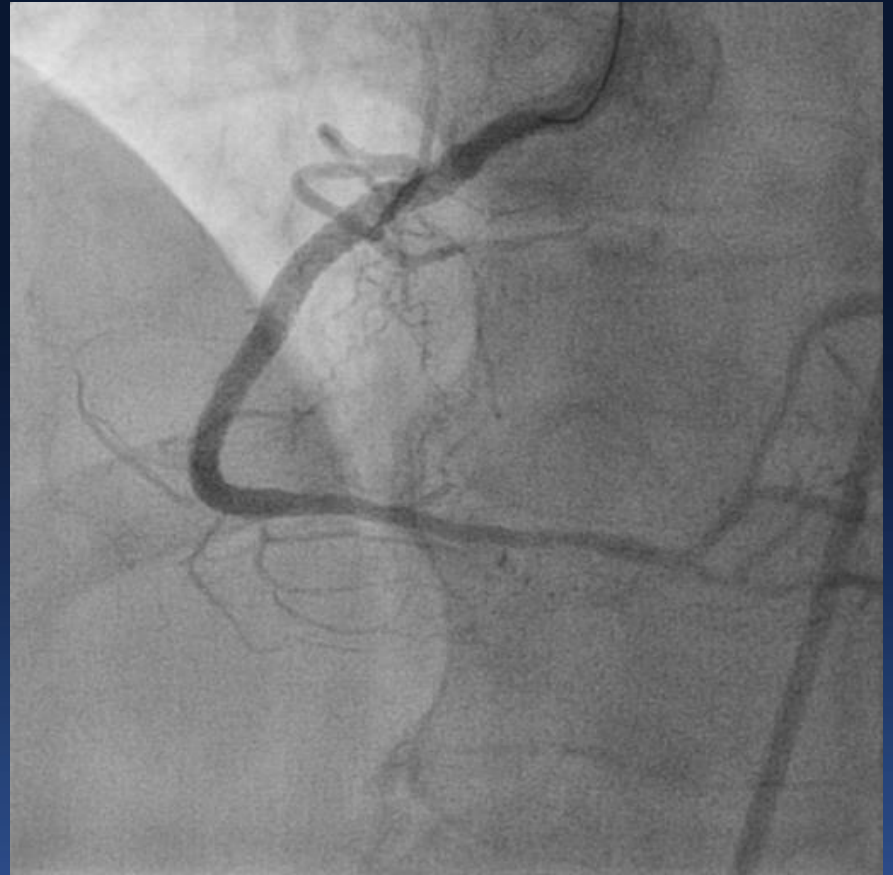
Gaia 2 (step-up escalation)



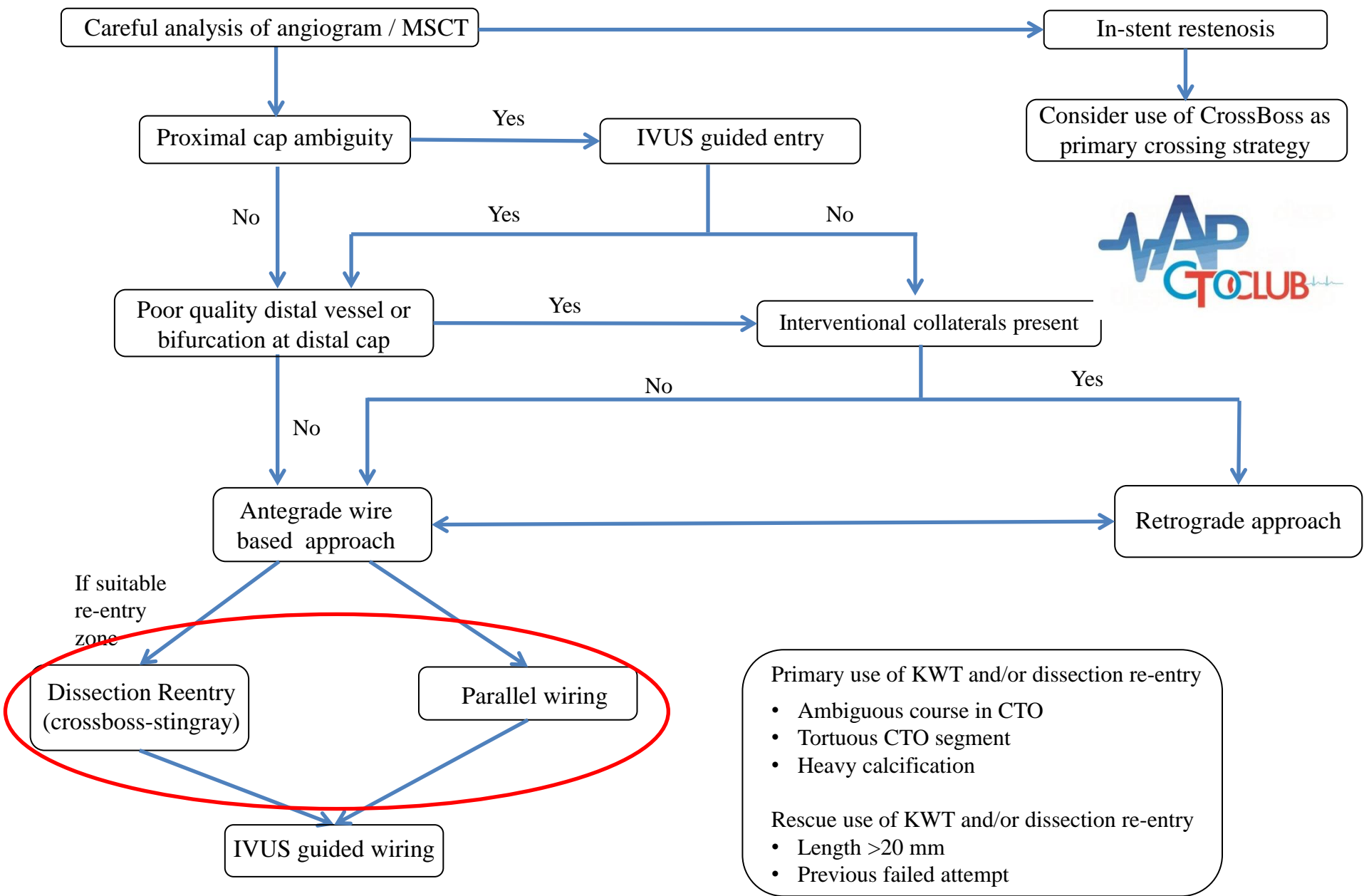
Gaia 2 : Advance into true lumen



Final angiography



Parallel wire technique



Consider stopping if >3 hours, 3.7 x eGFR ml contrast, Air Kerma > 5 Gy unless procedure well advanced

Selection of crossing strategy

- **Feature favoring use of stingray**

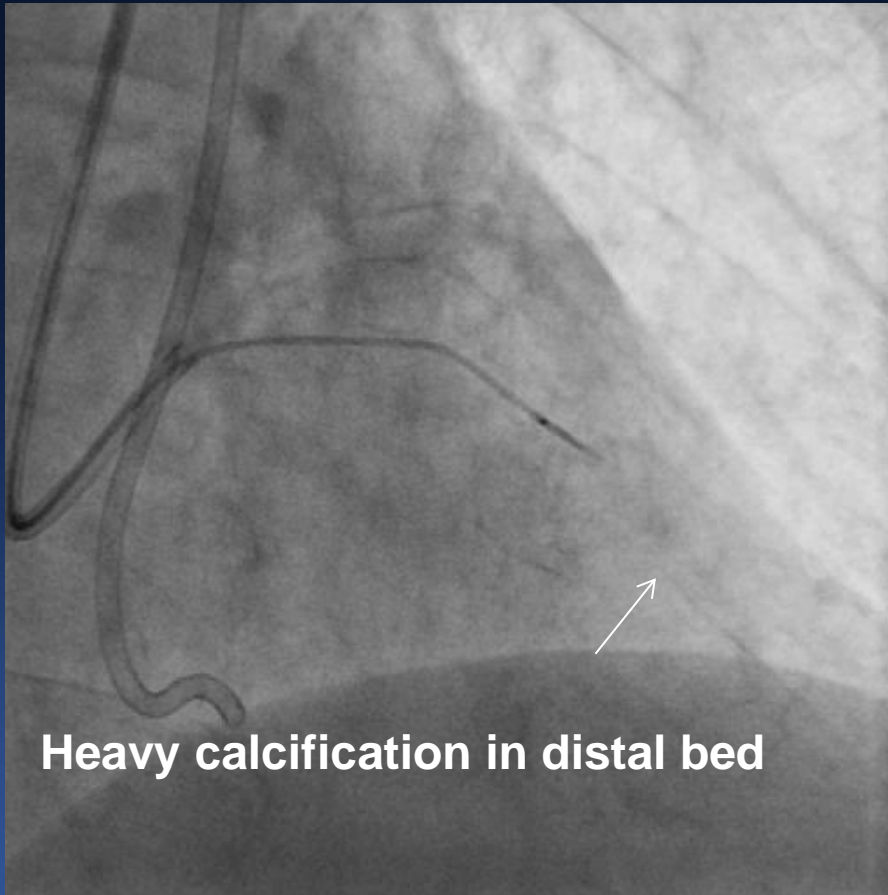
- Ambiguous vessel course
- Long, calcified, tortuous CTO lesion
- If wire is in subintimal at the proximal cap
- Good landing zone without major side branch and calcification

- **Feature favoring use of parallel wiring**

- Identified wire deflection point into sub-intimal space
- Heavy calcification and/or diffuse diseased distal bed
- Important side branch near distal cap

Use of parallel wiring and stingray is not interchangeable

Feature favoring use of parallel wiring

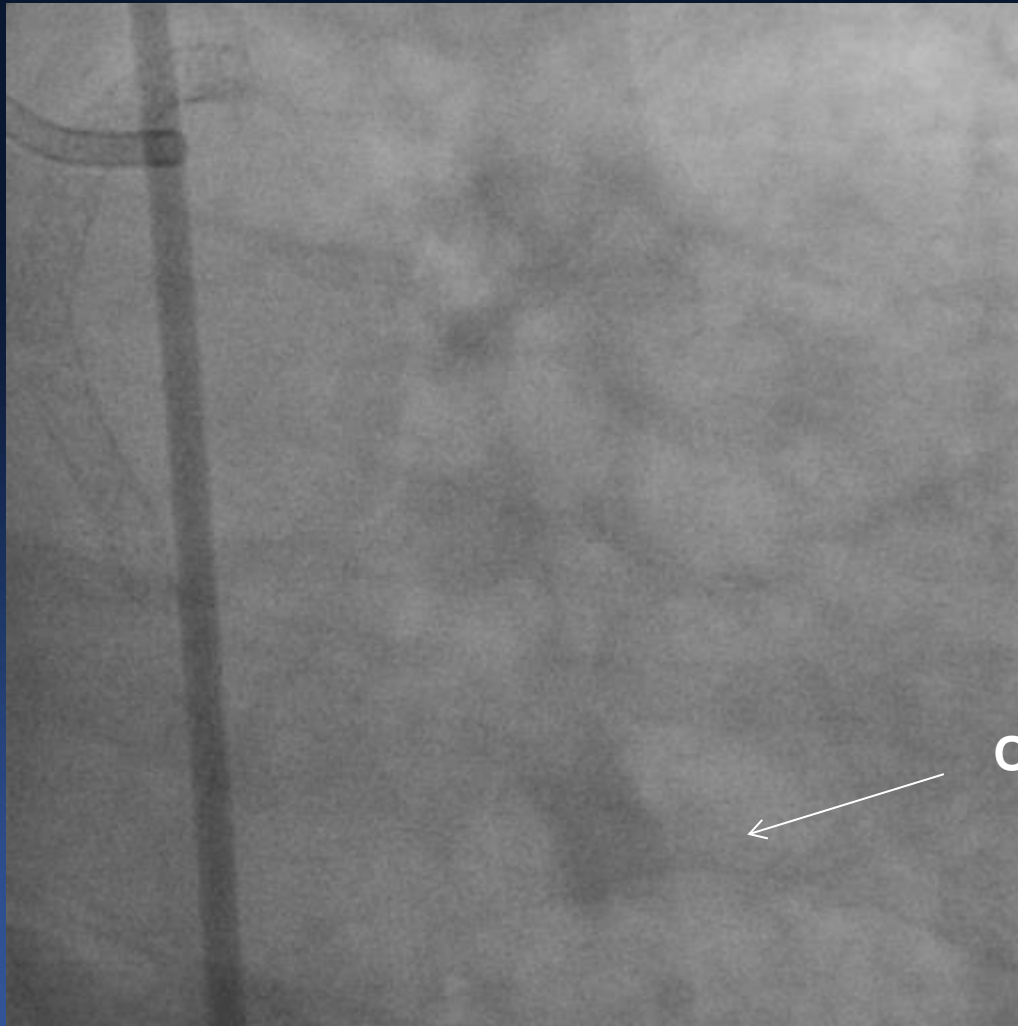


Heavy calcification in distal bed



OM branch near distal cap area

Feature favoring use of parallel wiring



OM branch near distal cap area

RAO caudal

RAO caudal

Possible
deflection point

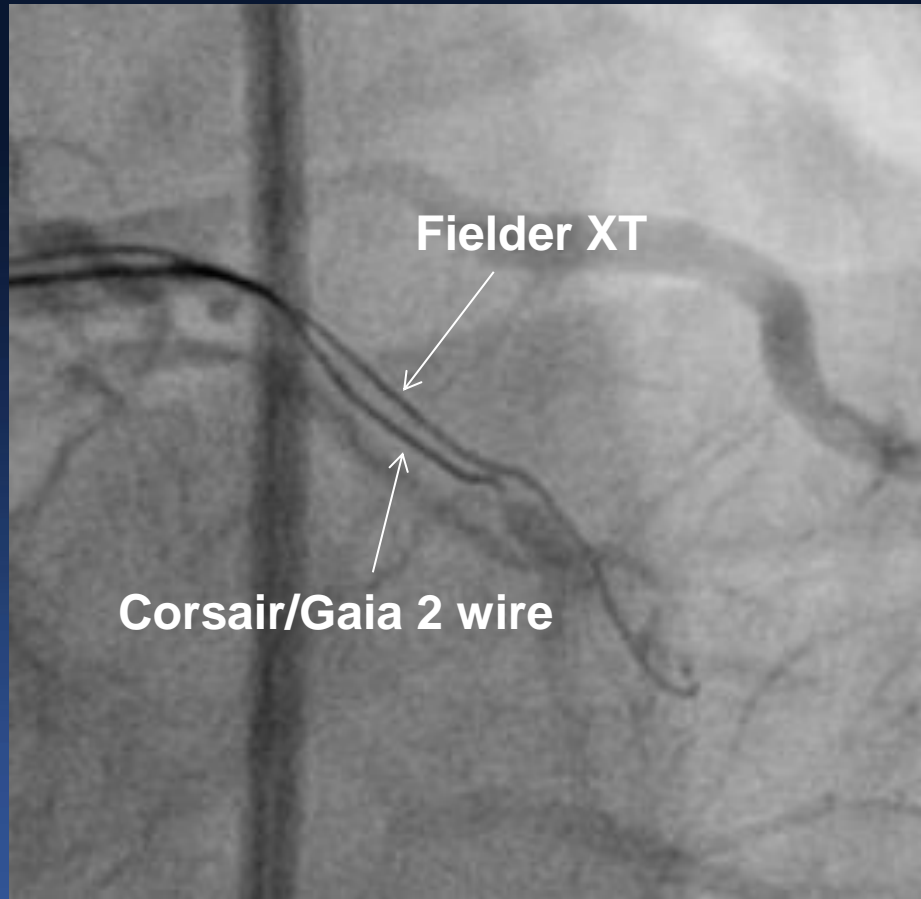


Corsair/fielder XT

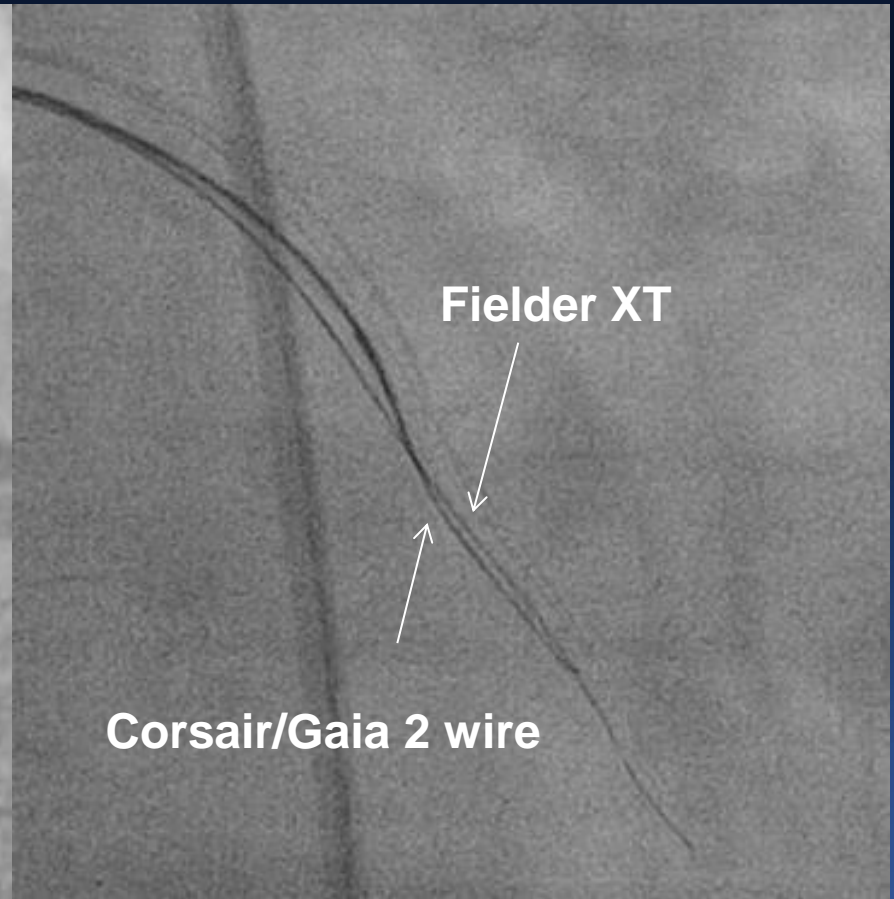
Fielder XT in Subintimal space

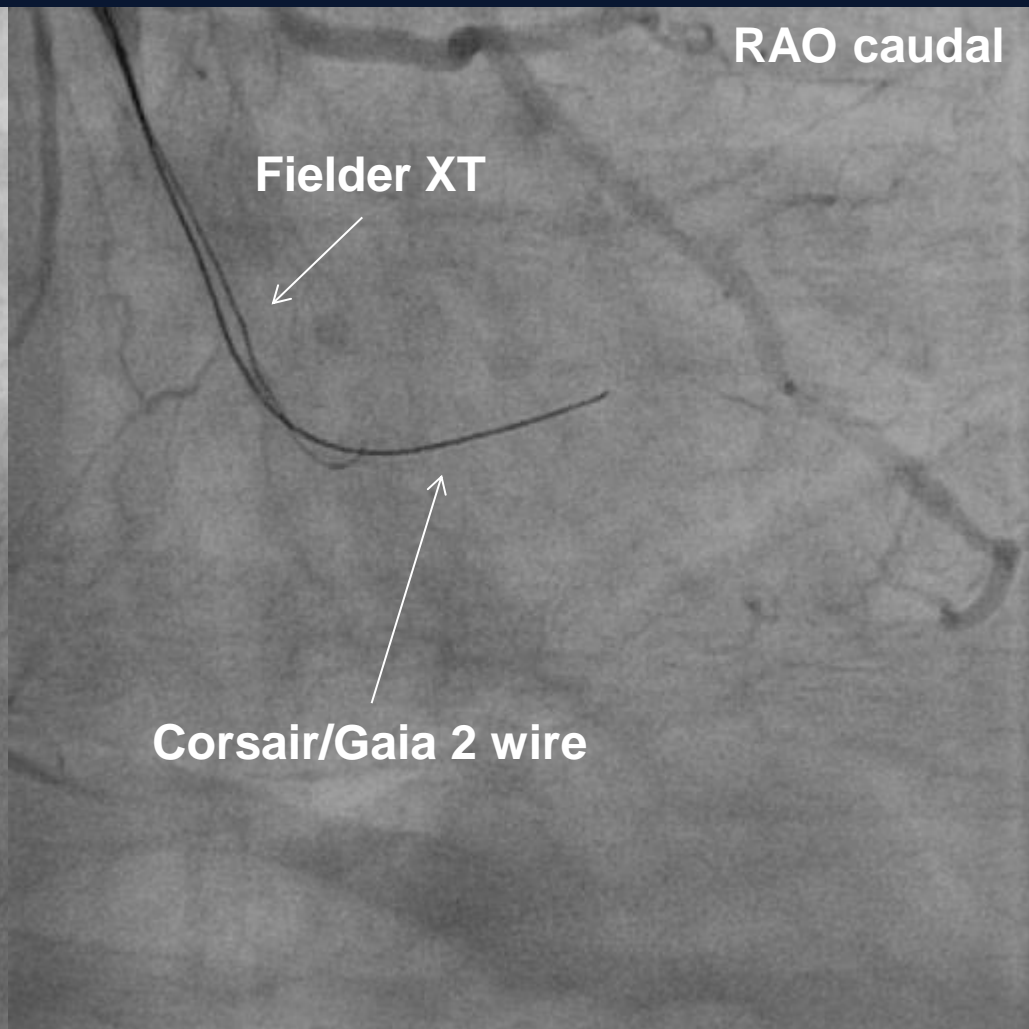
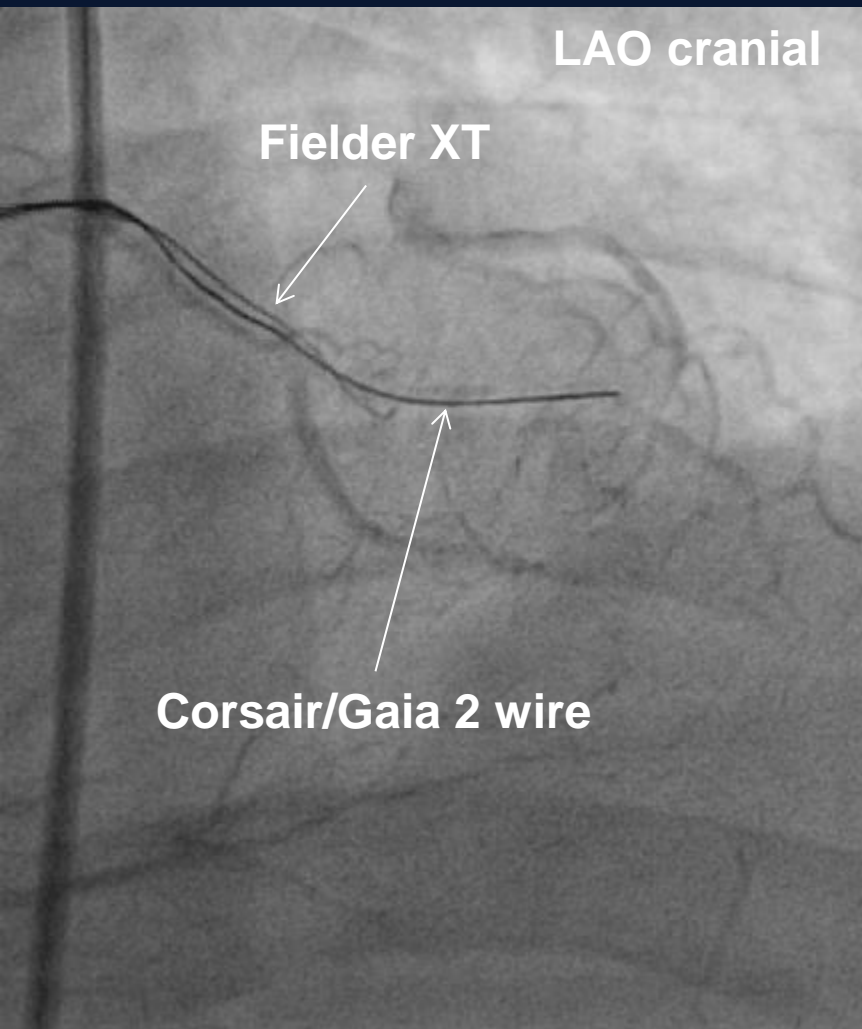
LAO cranial

LAO cranial



RAO caudal



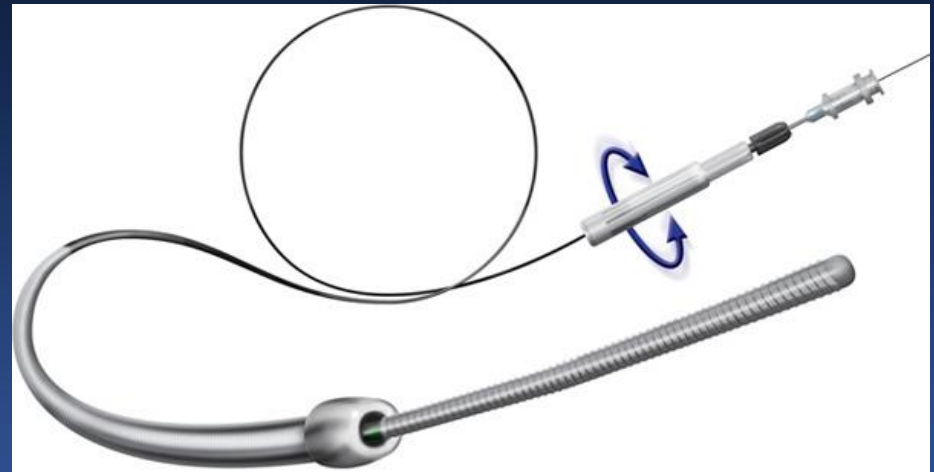
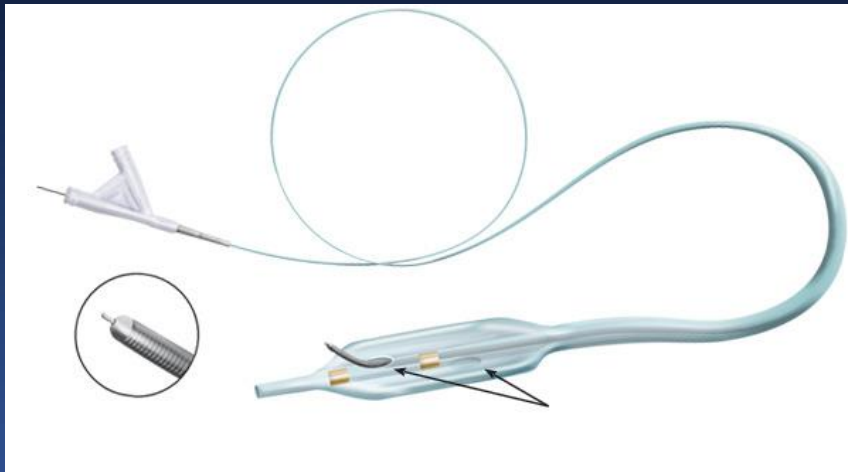


Antegrade wire escalation

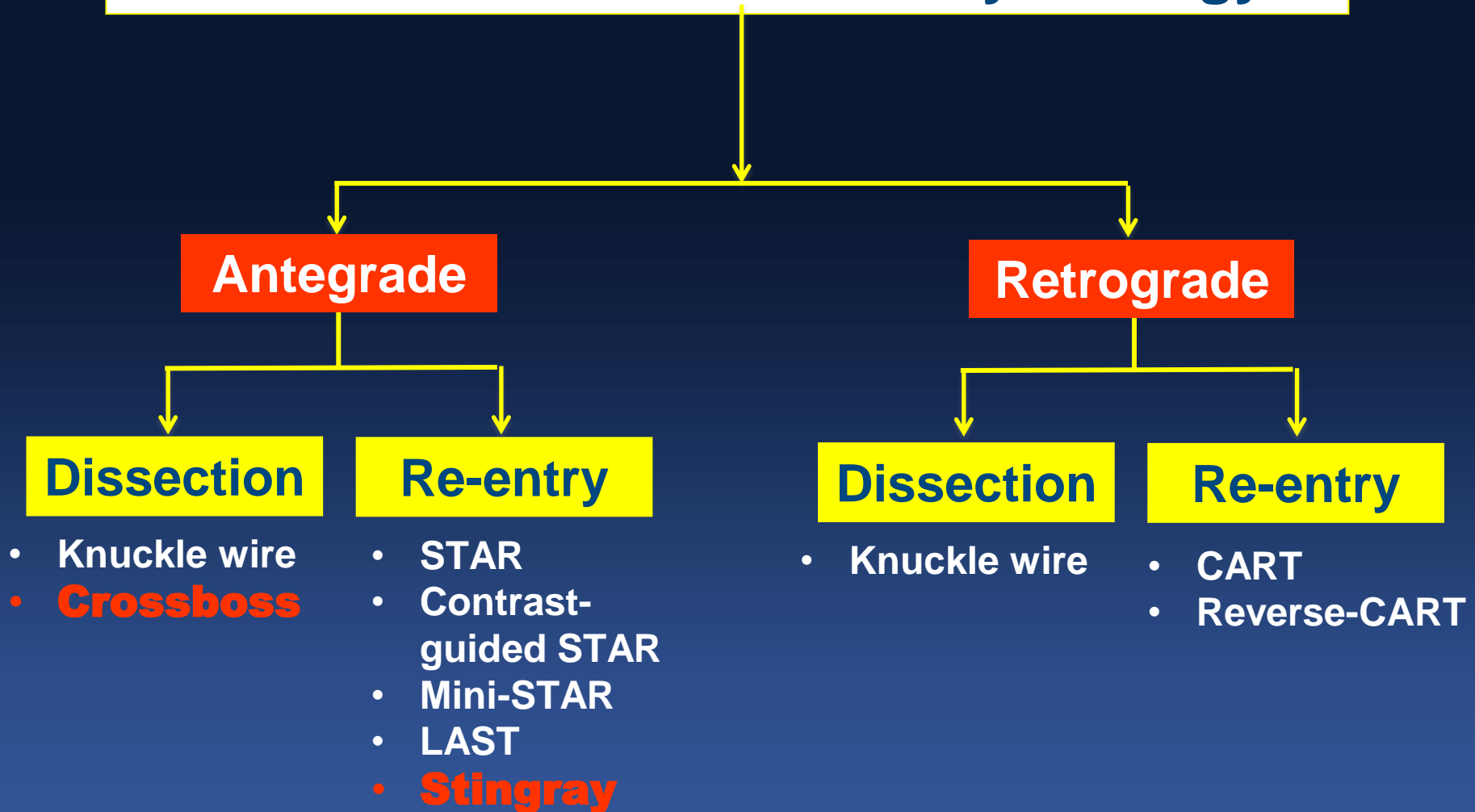
Up & down escalation

- Proximal cap: image guidance or morphology
- CTO body: image guidance or resistance
- Distal cap: image guidance or resistance

Dissection reentry

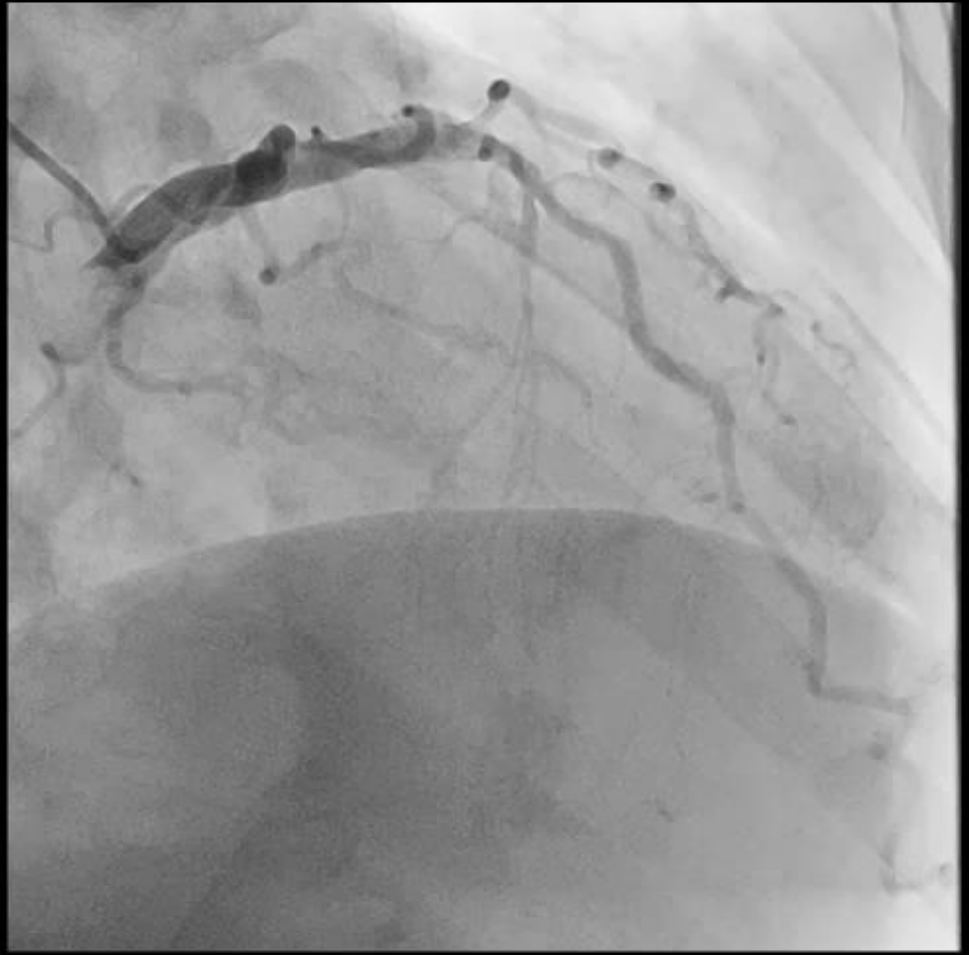
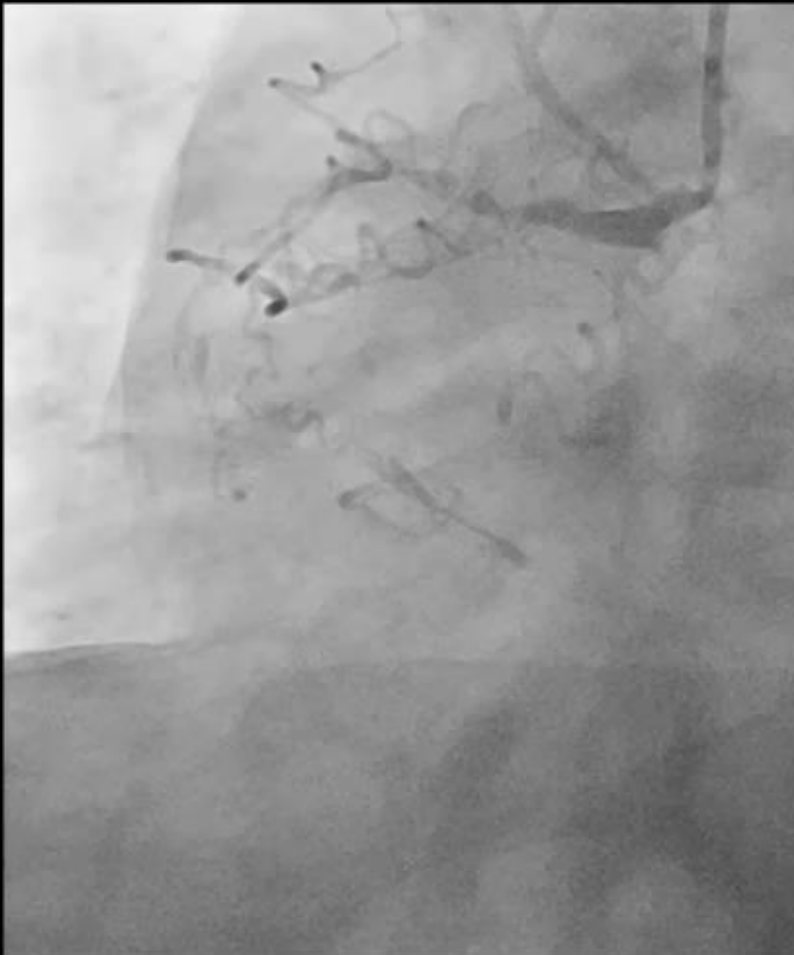


CTO dissection and Re-entry strategy

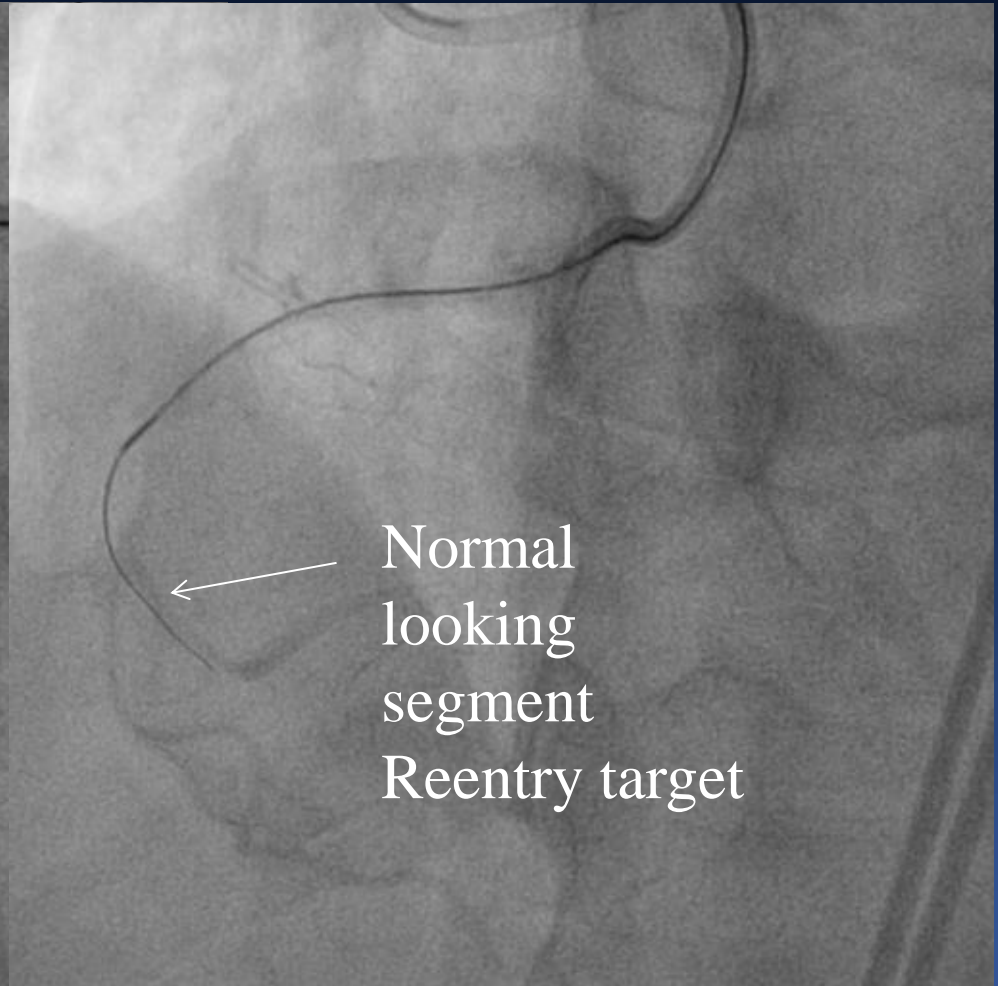
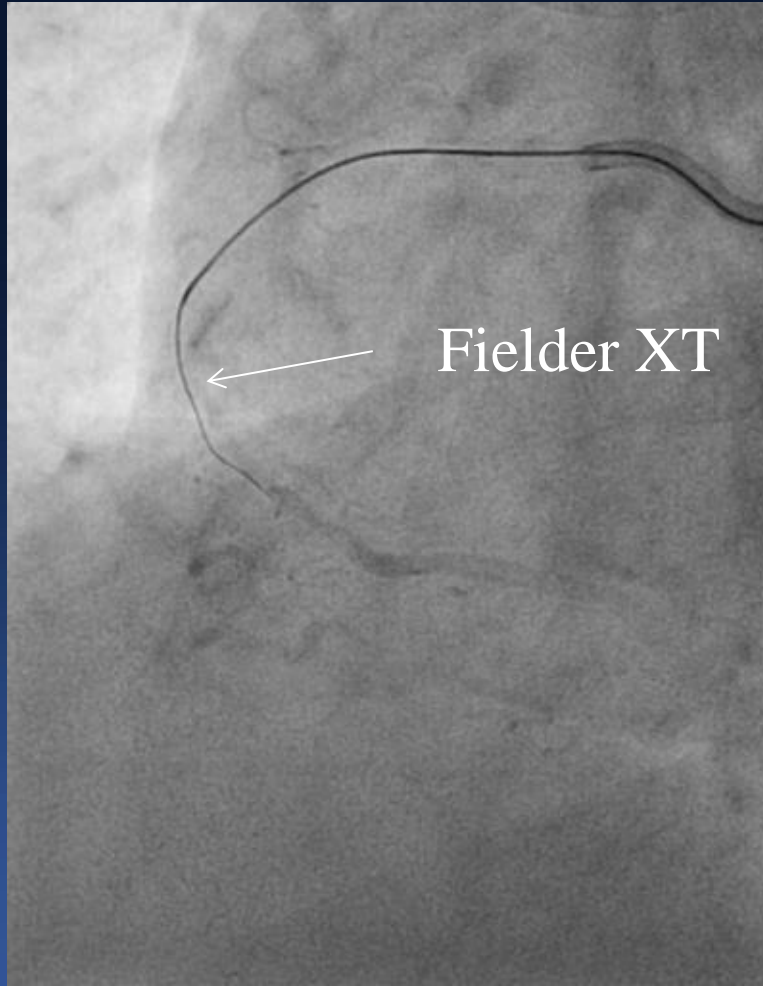


Baseline angiography

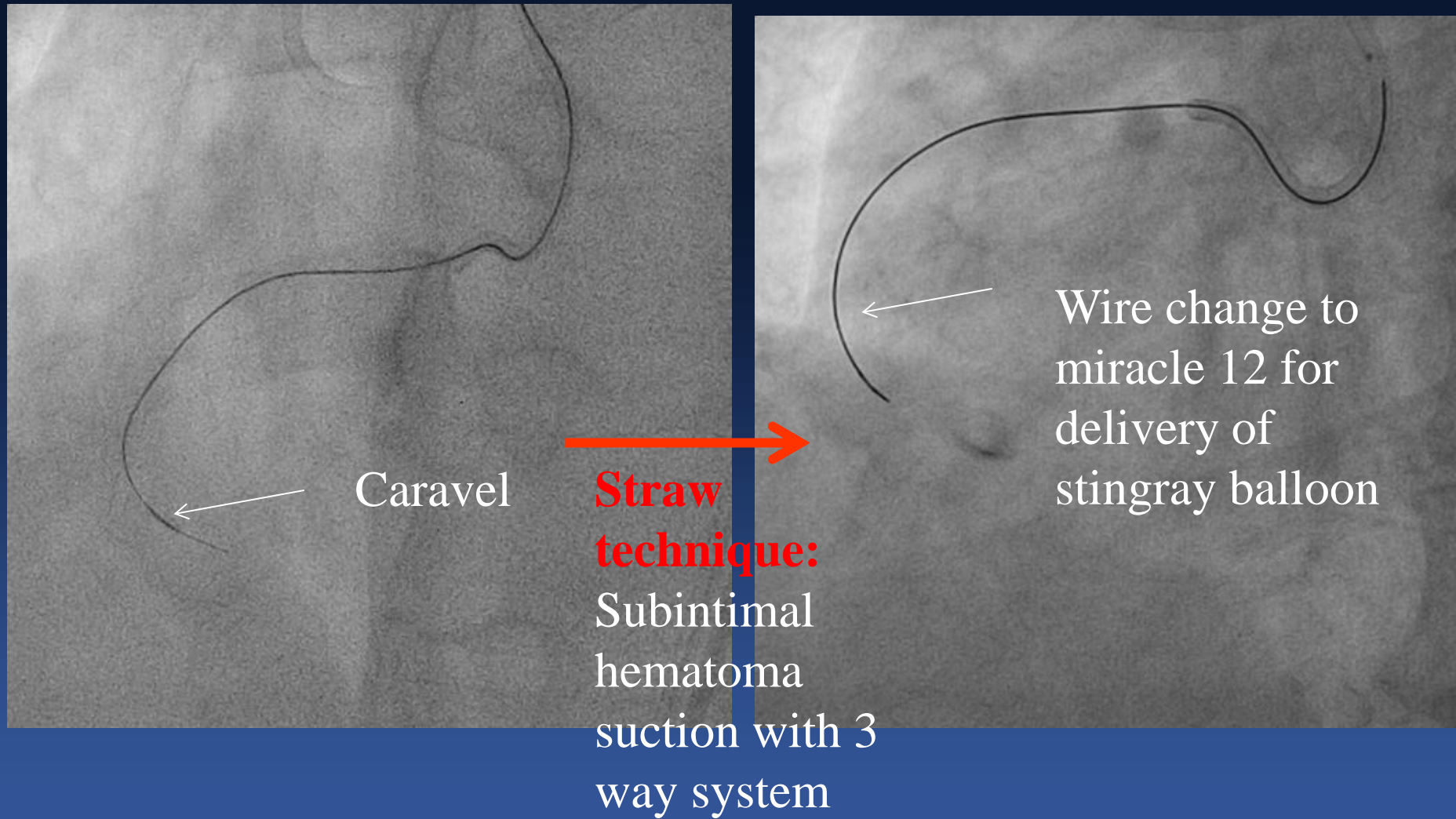
Good interventional collateral



Subintimal wiring with caravel



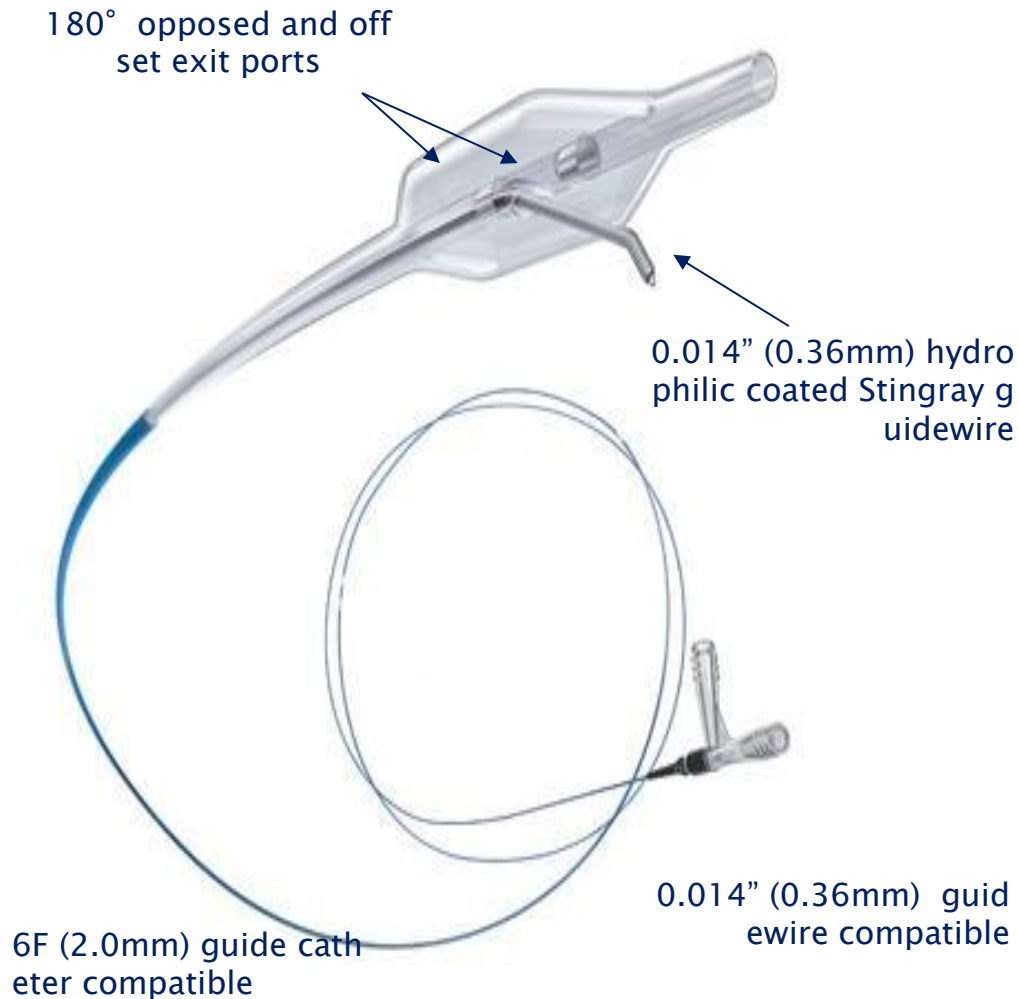
Microcatheter advance and wire exchange



Wire removal and straw technique balloon positioning by angiography

**Straw technique
again through
stingray balloon:**
Subintimal
hematoma suction
with 3 way system

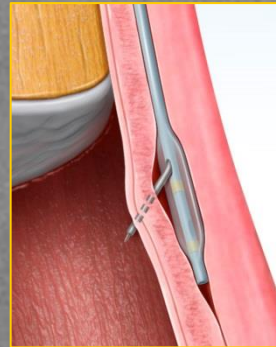




- Flat balloon
- One exit port on each side.
- 3.2F shaft
- Stingray Guidewire's angled tip and distal probe
- 2 radiopaque marker bands for exact placement
- 0.014" G/W compatible
- 6F G/C compatible

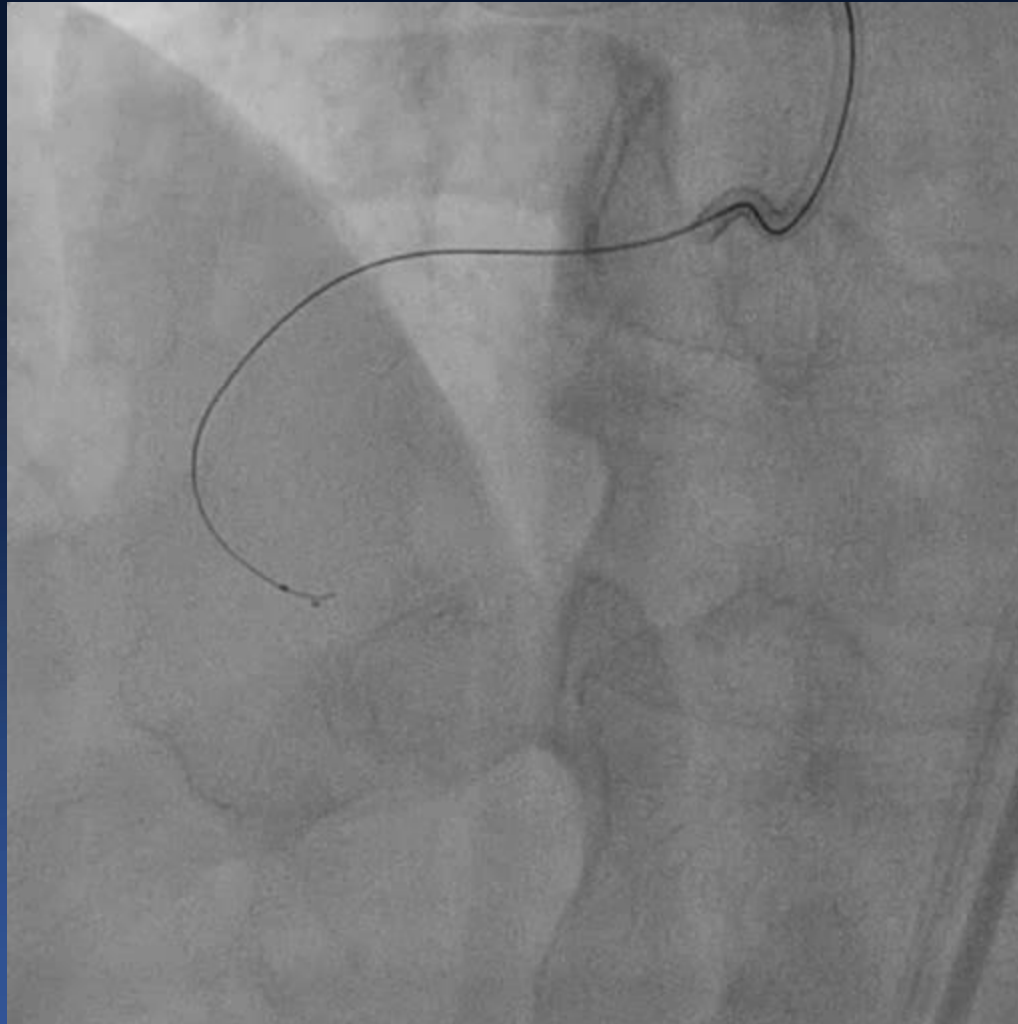
Reentry using Stingray wire

Balloon inflation 2-3 atm

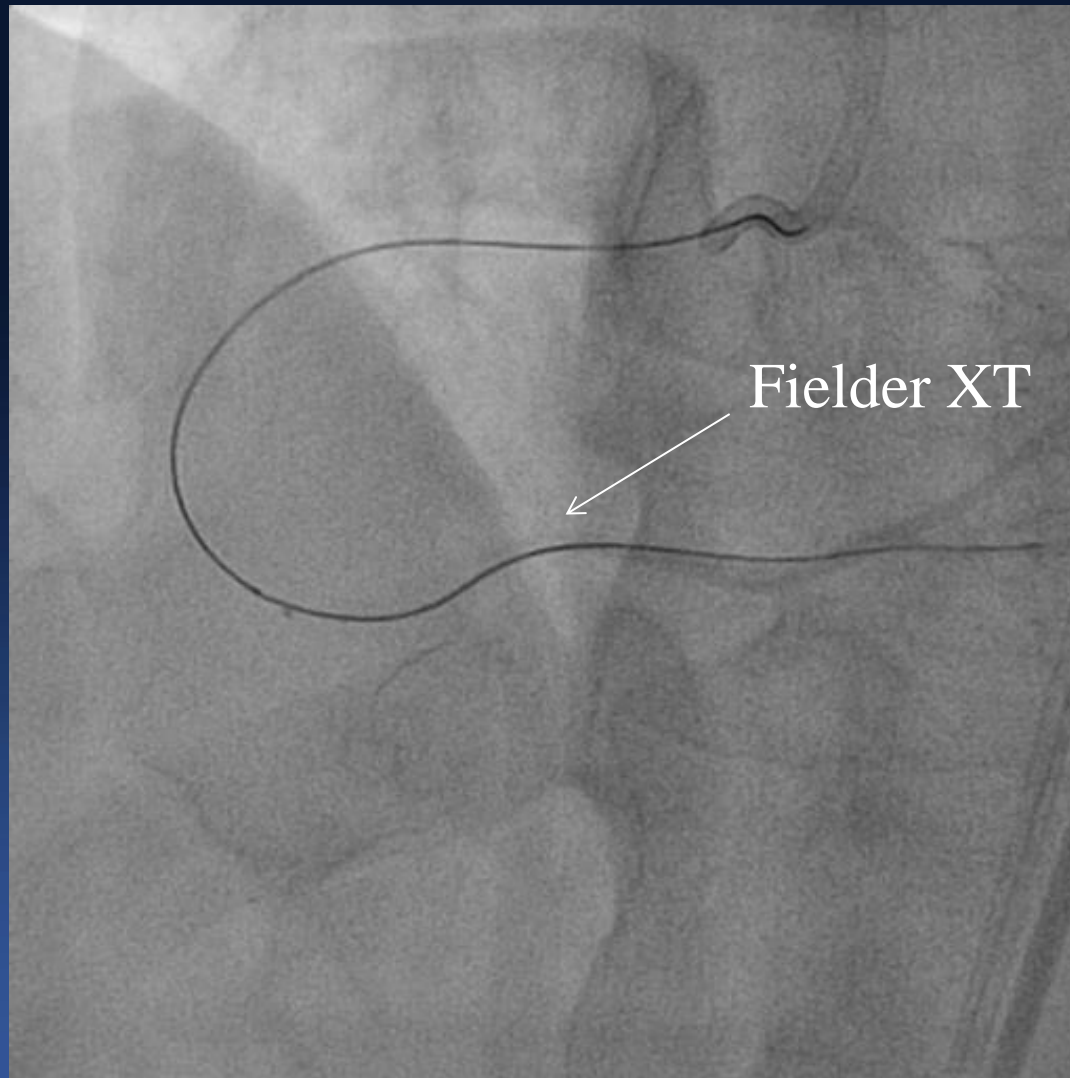


←
Angulation:
concern for vessel
damage with
stingray wire

Stick and Swab using Fielder XT wire



Wire position confirmed



Final angiography

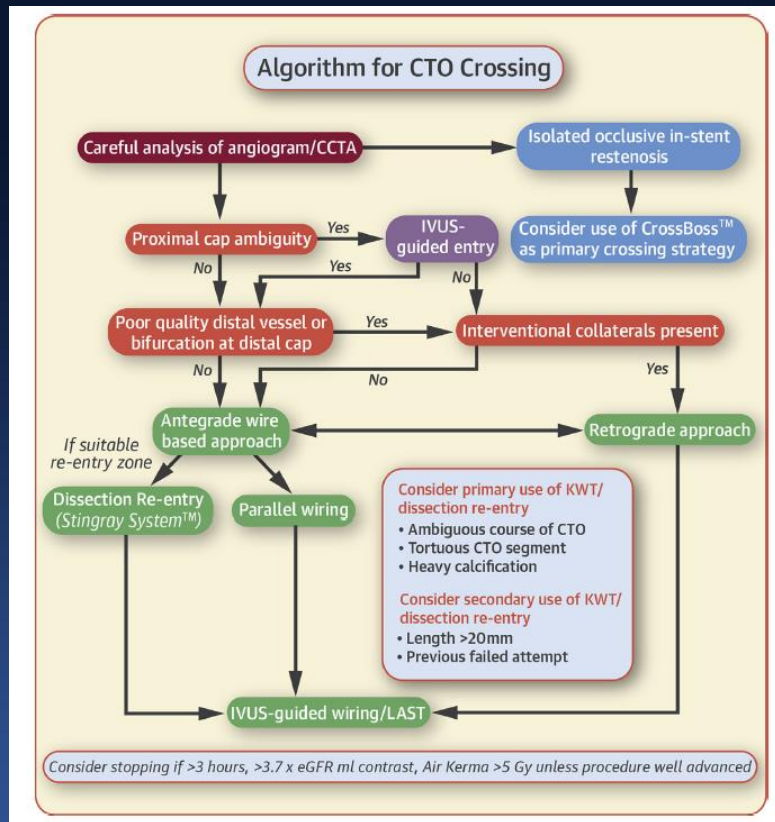


Retrograde approach

- Wire escalation
 - Dissection reentry
- } In conjunction with IVUS-guided approach

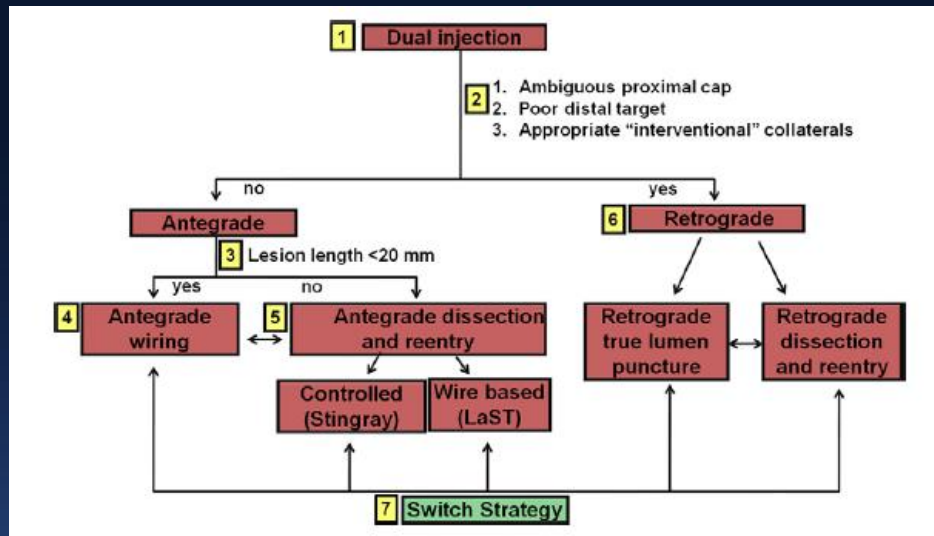
Indication for the retrograde approach

AP-CTO



J Am Coll Cardiol Interv 2017;10:2135–43

Hybrid

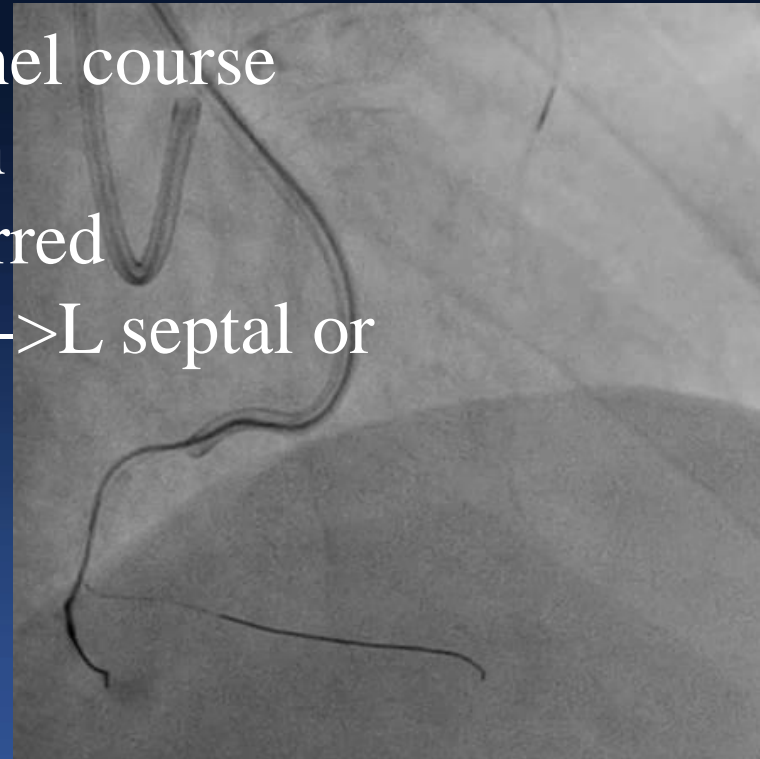


JACC Cardiovasc Interv 2012;5(4):367-79

- Ambiguous proximal cap
- Poor distal target
- Interventional collaterals

Selective angiography

- Not necessary for all cases
- Necessary for ambiguous channel course
- Confirm for blood regurgitation
- Proximal channel portion preferred
- Caution for channel damage (R->L septal or epicardial channel)



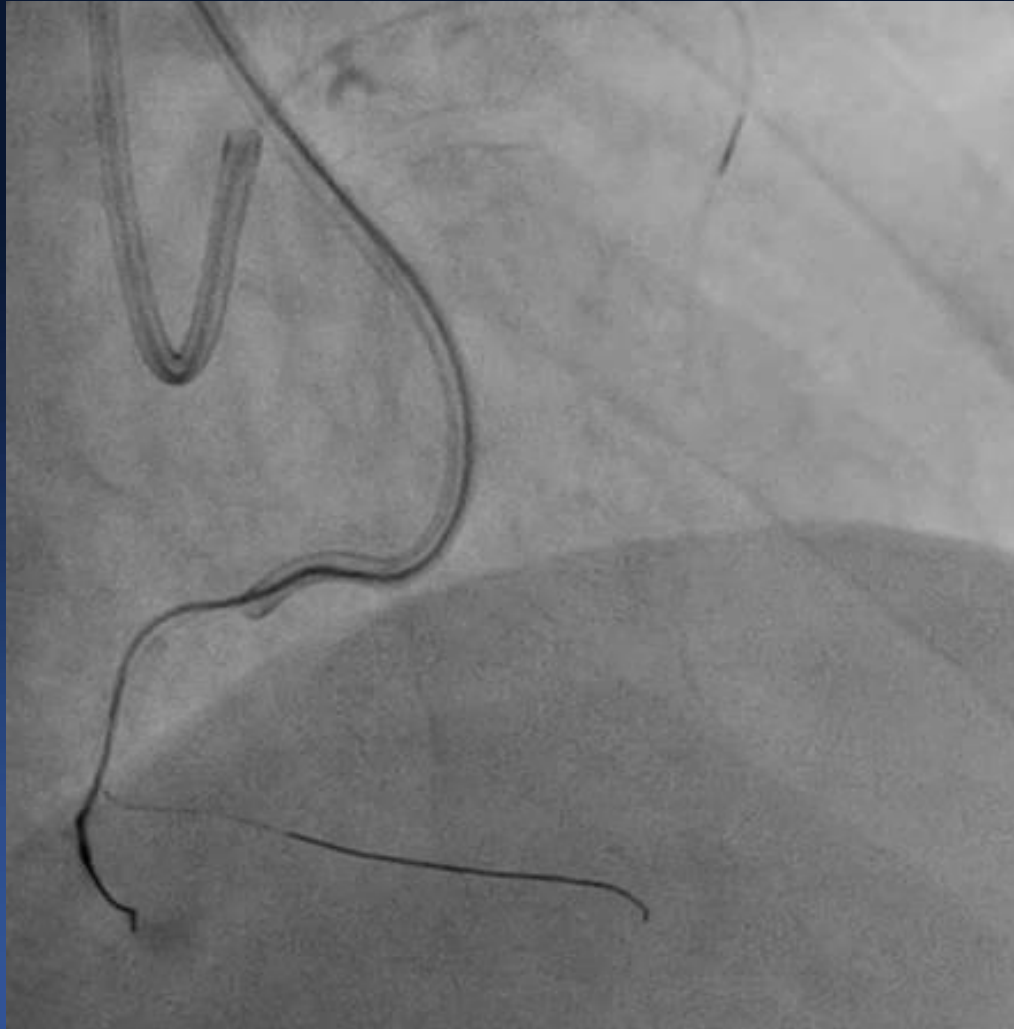
Collateral channel wiring

- Initial wire: Sion
- Tortuous channel: Souh03 or Sion black
- Small channel: Fielder XT-R

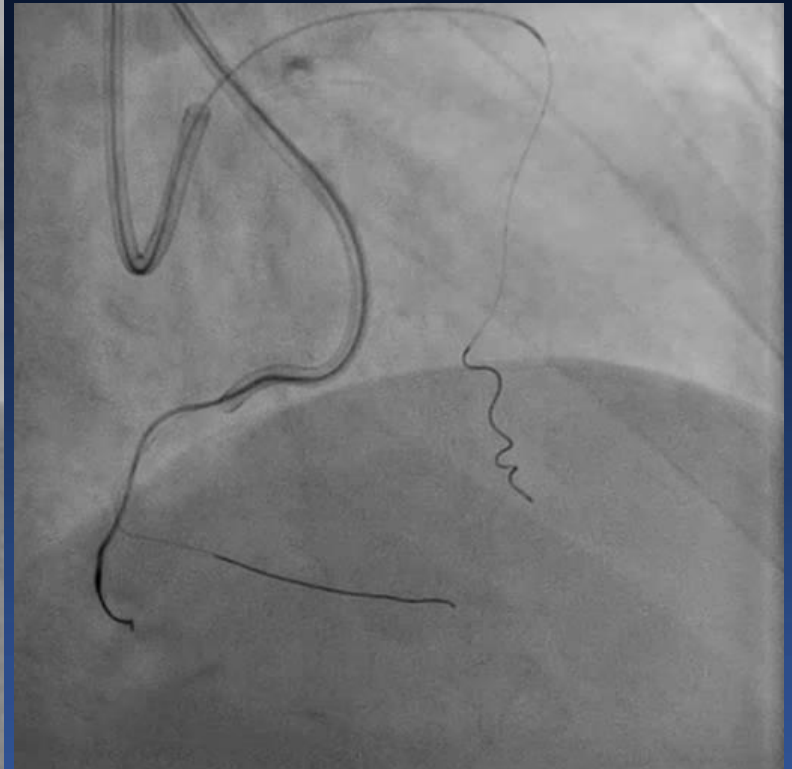
Table 2. Tips for channel crossing.

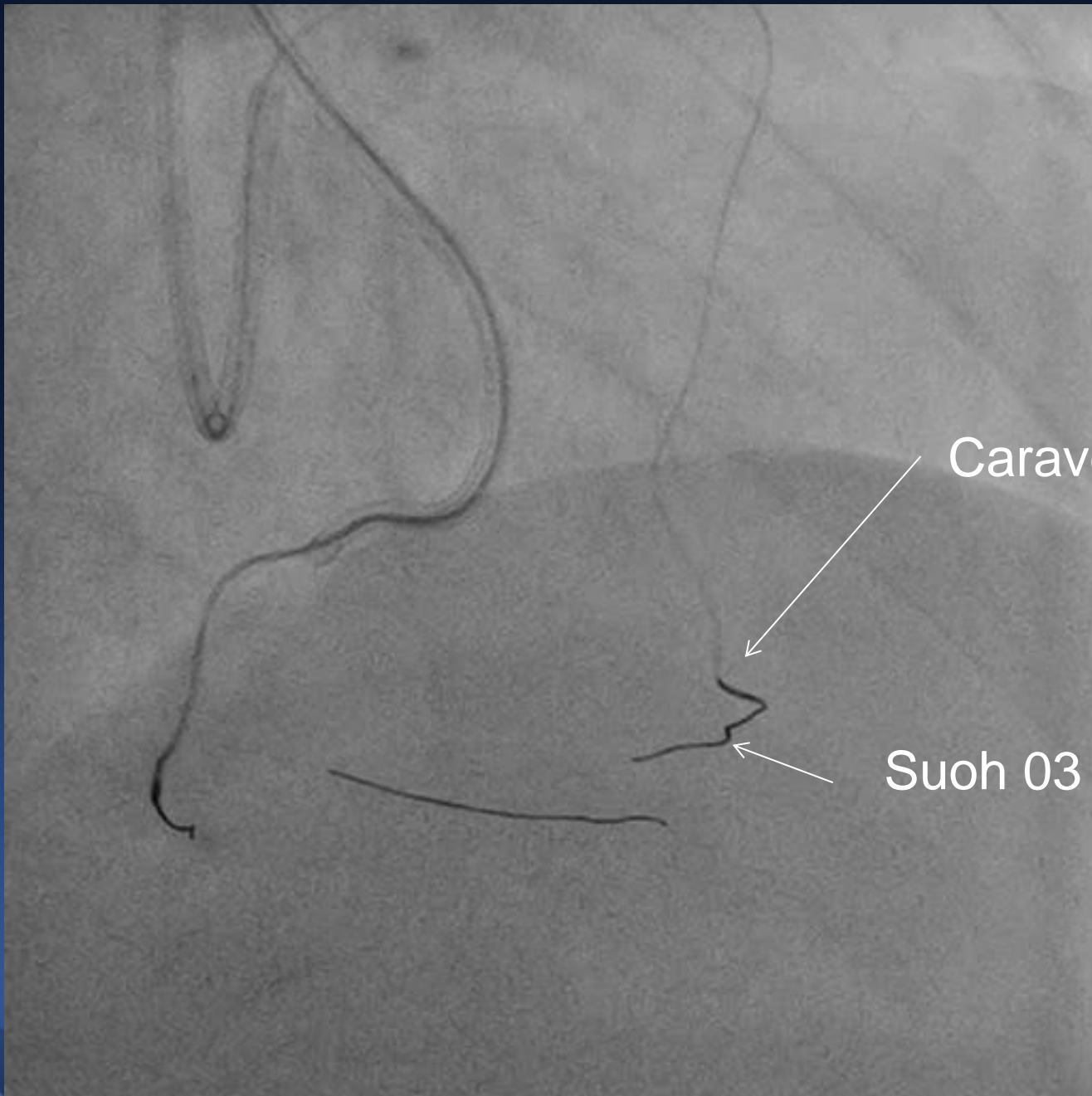
Channel	Angio	Tips	First wire	Second choice small channel	Second choice for tortuous channel	Third choice for tortuous channel
L → R septals	Selective injection*	Further distal selective injection with rotational angiogram	SION	XT-R	SUOH 03	SION black
R → L septals	Non-selective injection (or via twin lumen)	Twin lumen catheter to overcome retroflex ostium	SION	XT-R	SUOH 03	SION black
Epicardial	Selective injection*	Microcatheter follows the wire technique	SUOH 03	XT-R/SION	SION/XT-R	SION black if large epicardial channel
* Selective angiography should be performed with biplane or rotational angiography.						

Tortuous septal channel (Suoh 03)



Caravel/Sion wire: failed





Caravel

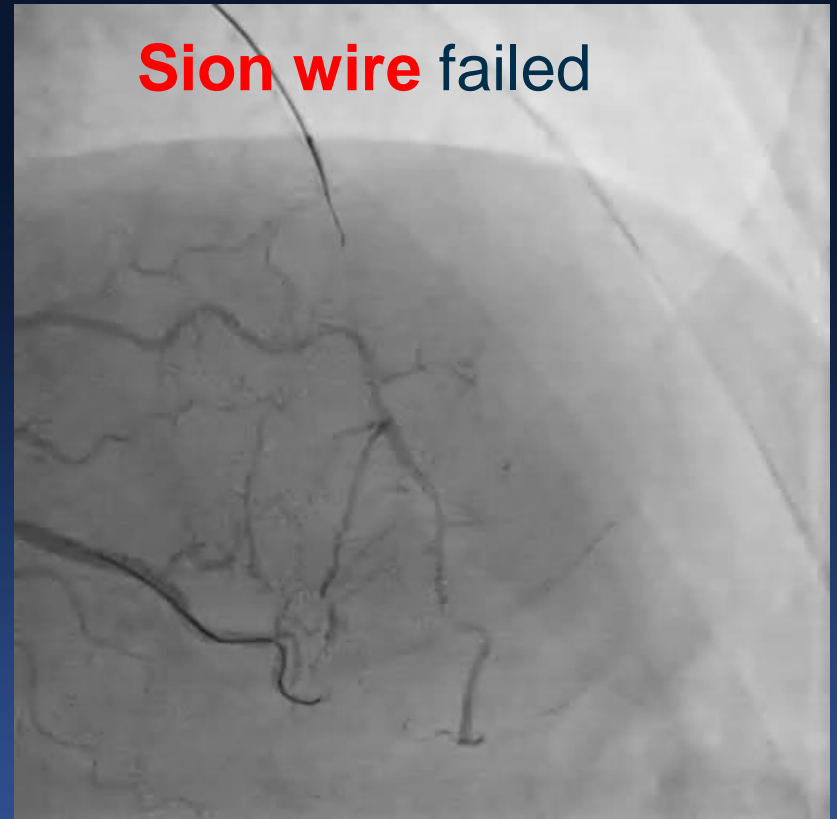
Suoh 03 wire

Tortuous septal channel

Tip angiography



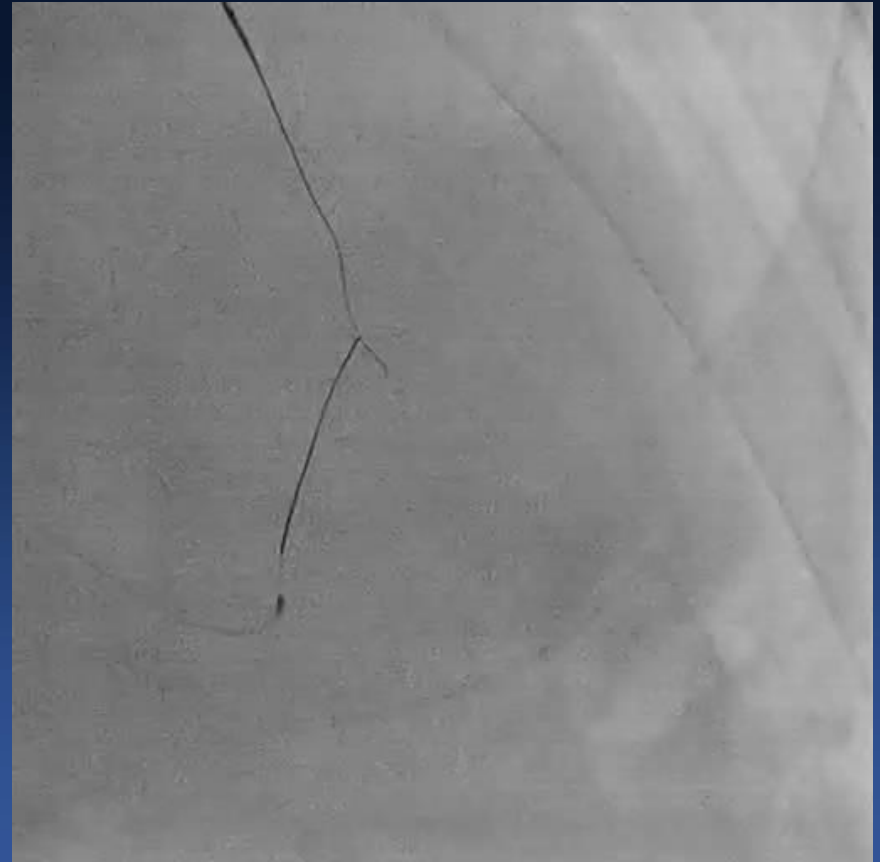
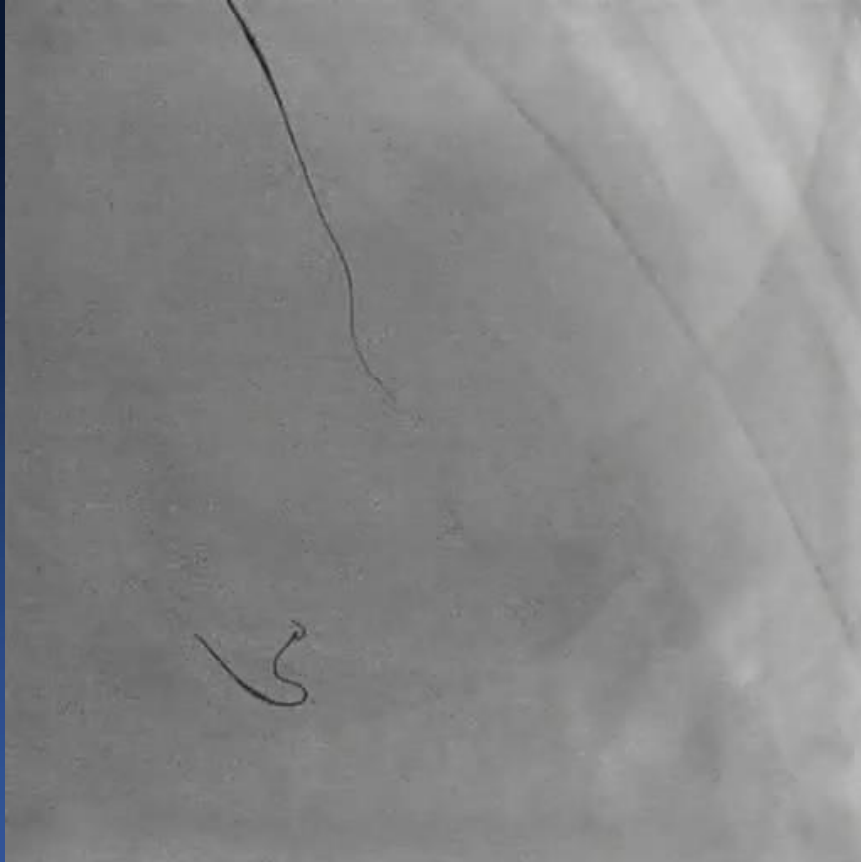
Sion wire failed



Tortuous septal channel

Suoh03 wire failed:

poor forward power → **Sion black** succeed



Mid LAD CTO

Septal to septal channel



Corsair, fielder XT: failed



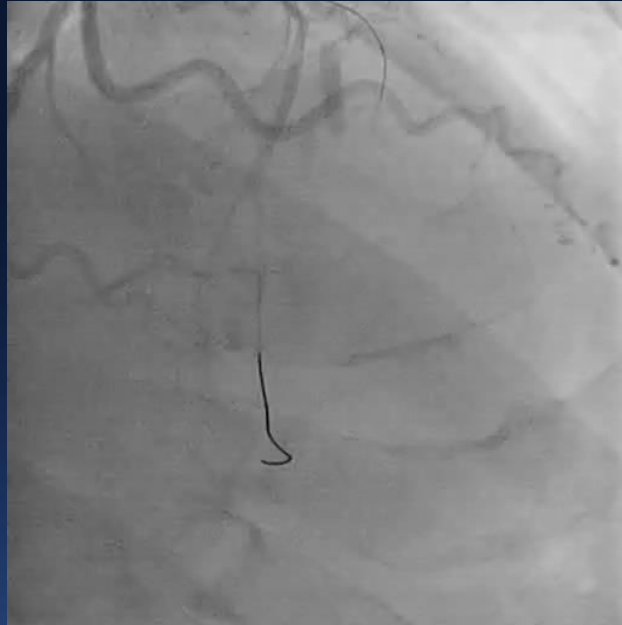
Caravel: Tip angiography



Sion/Suoh03 failed



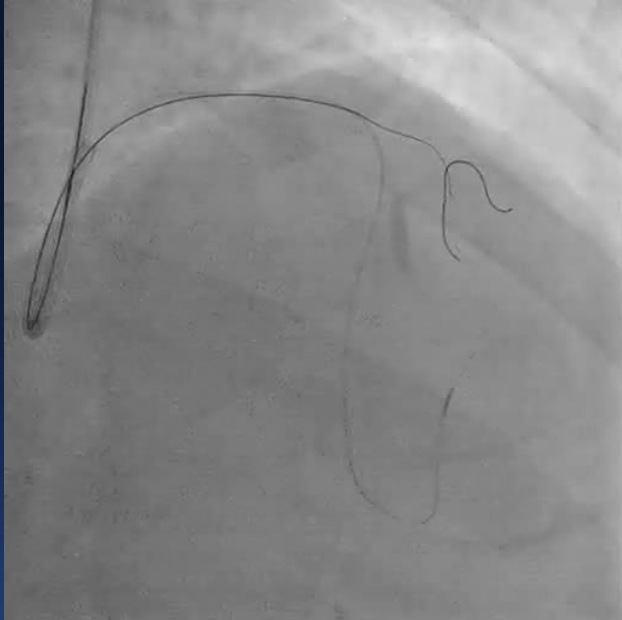
Sion black/blue failed



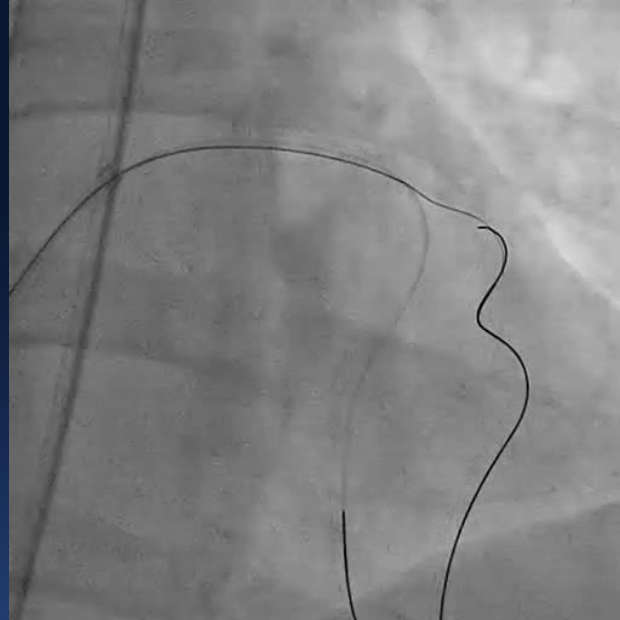
Suoh 03 success



Caravel advance



Retrograde direct Wiring: UB3 wire



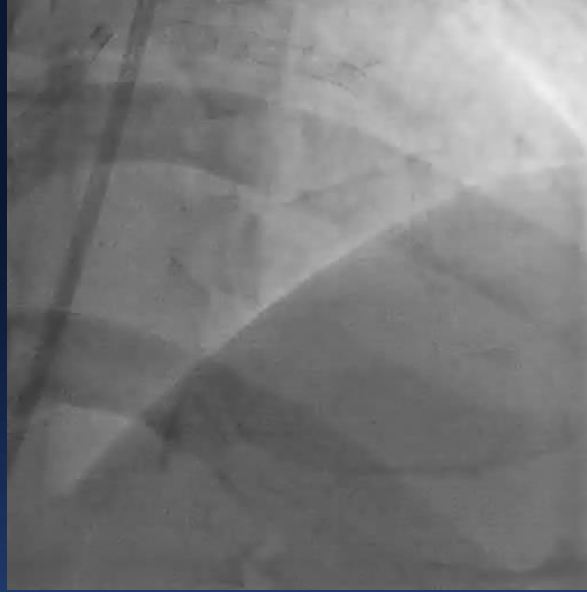
Contralateral guiding Wiring (pingpong guiding)



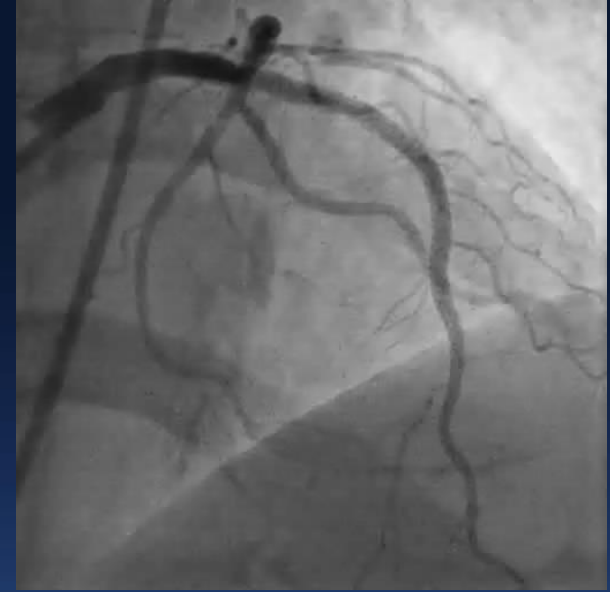
**Caravel advance
To contralateral guiding**



Post stenting



Septal perforation



No pericardial effusion

Microcatheter thru channel

- Initial MC: Corsair, Finecross, Caravel
- Next: Turnpike LP
- 3rd option: 1.0 or 1.25 mm balloon
- 4th option: anchor balloon or Guide extension

Table 3. Tips for crossing microcatheter through channel.

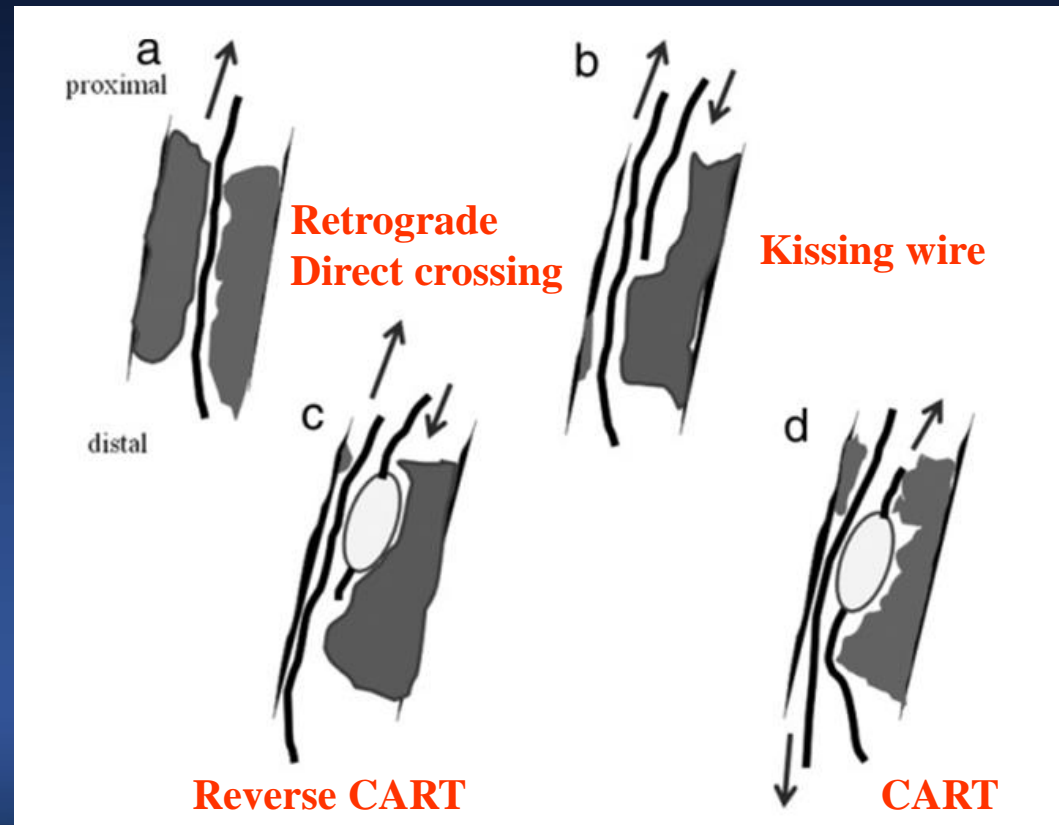
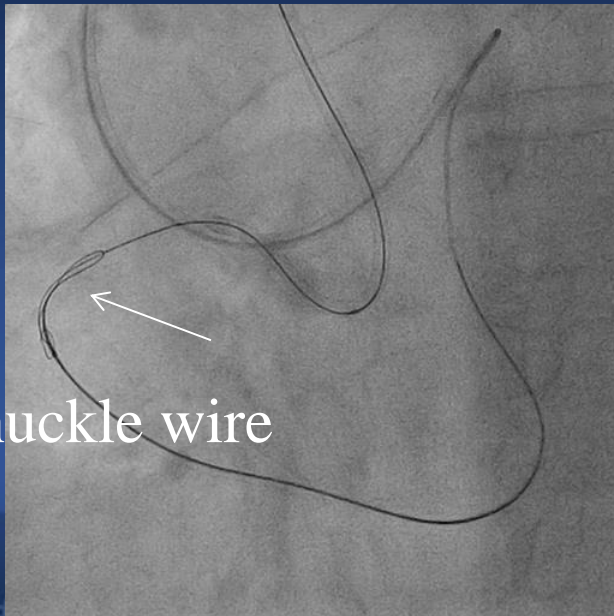
Channel	Corsair/Turnpike will not cross	Switched microcatheter will not cross	Failure to cross after balloon dilatation
L → R septal	Switch to Caravel/Turnpike LP*	1.25 mm balloon to dilate channel	Side branch anchor balloon
R → L septal			Beware too tortuous PDA to septal channel angle
Epicardial		Switch to Finecross	Beware too small channel
* If septal ostium stented → dilate septal ostium with small balloon.			

Retrograde CTO passing techniques

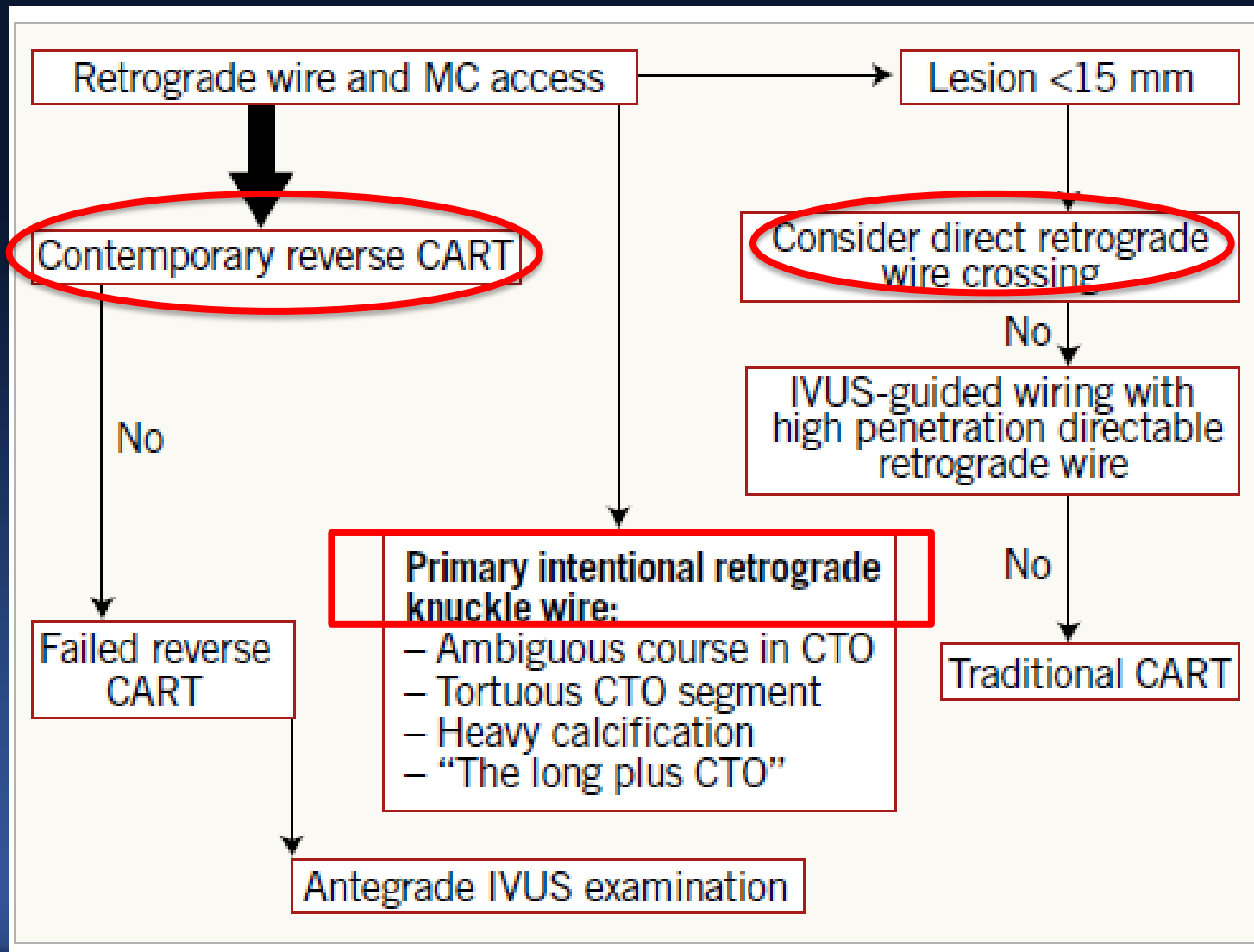
- **Retrograde direct wire crossing**: short lesion length (< 15 mm) (a)
- **Kissing wire technique**: bidirectional wiring (b)
- **Knuckle wire**: long, calcific, tortuous, unknown course
- **CART technique**: rarely used currently (d)
- **Reverse CART**: for bidirectional wire connection (c)

Conventional
Contemporary (directed)
Modified (extended)

Knuckle wire

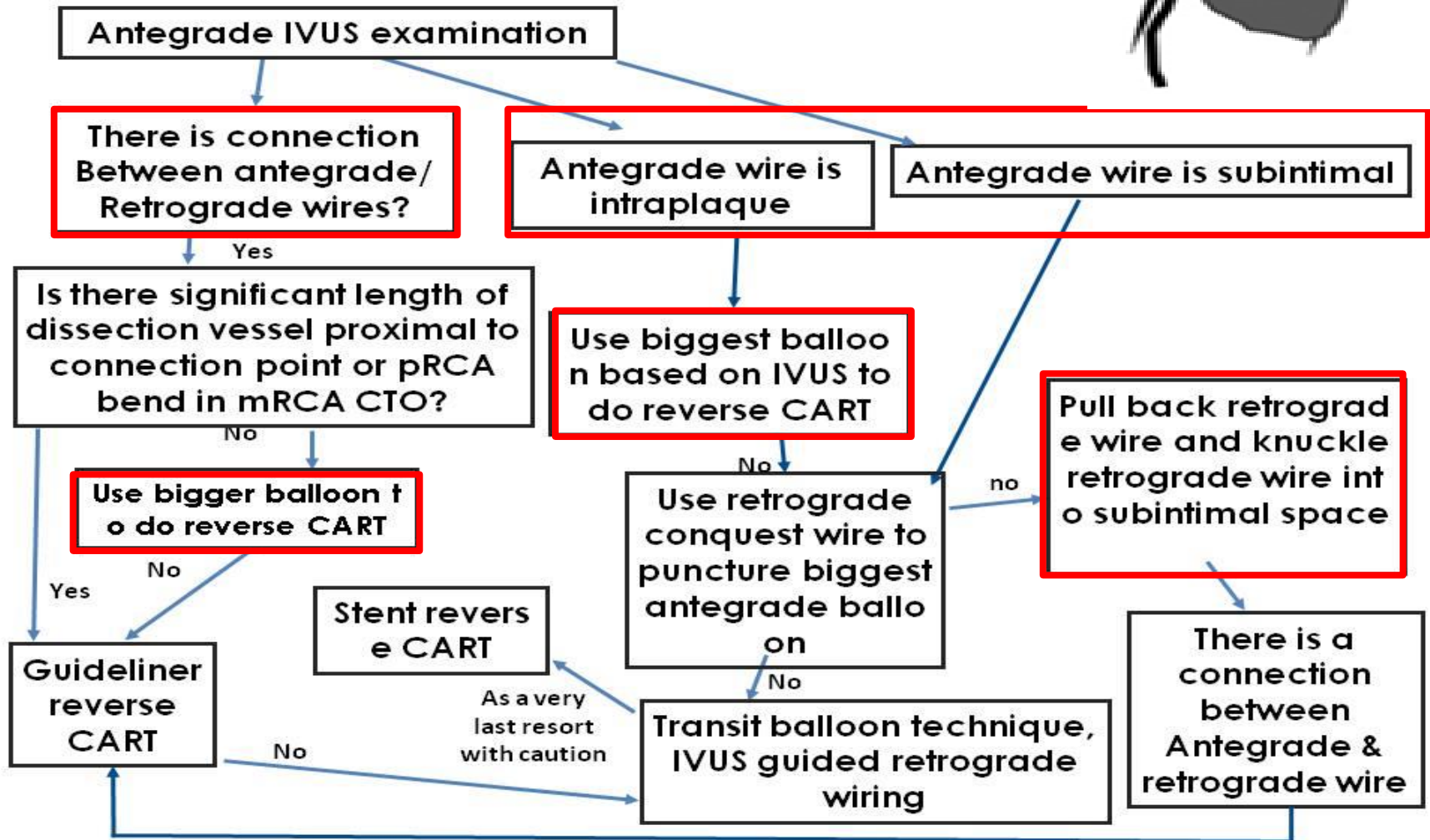


Algorithm for crossing a CTO lesion via the retrograde approach



APCTO club Sub-algorithms for Retrograde Approach

IVUS guided r-CART



Retrograde approach

- Basically bidirectional wiring
- If microcatheter did not cross the channel: **wire mark technique for antegrade wiring**
- Retrograde WIRE escalation under guidance of antegrade wire or ballooning with/without IVUS.
- Retrograde knuckle: unknown, long, calcific, or tortuous CTO segment.

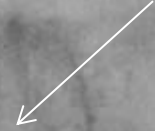
PROXIMAL LAD CTO

Epicardial channel

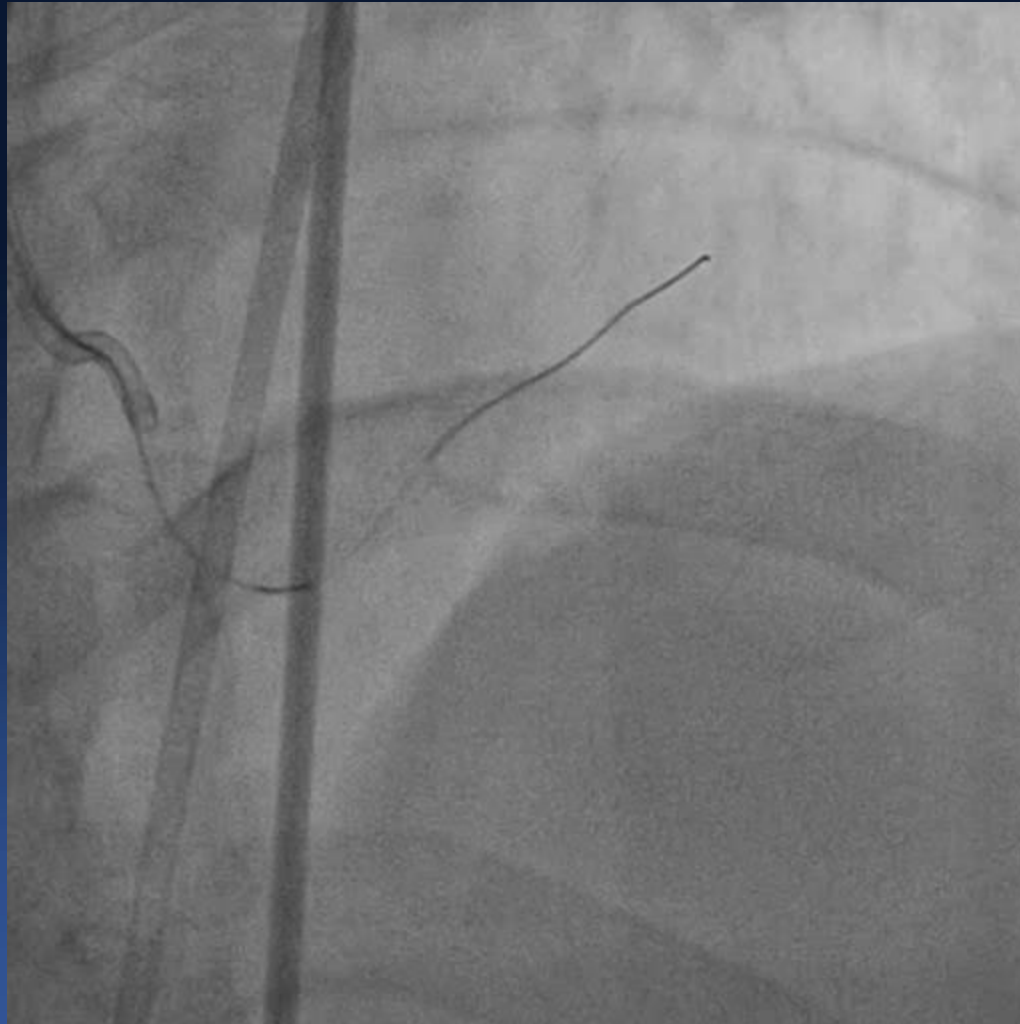


Prox LAD, CTO

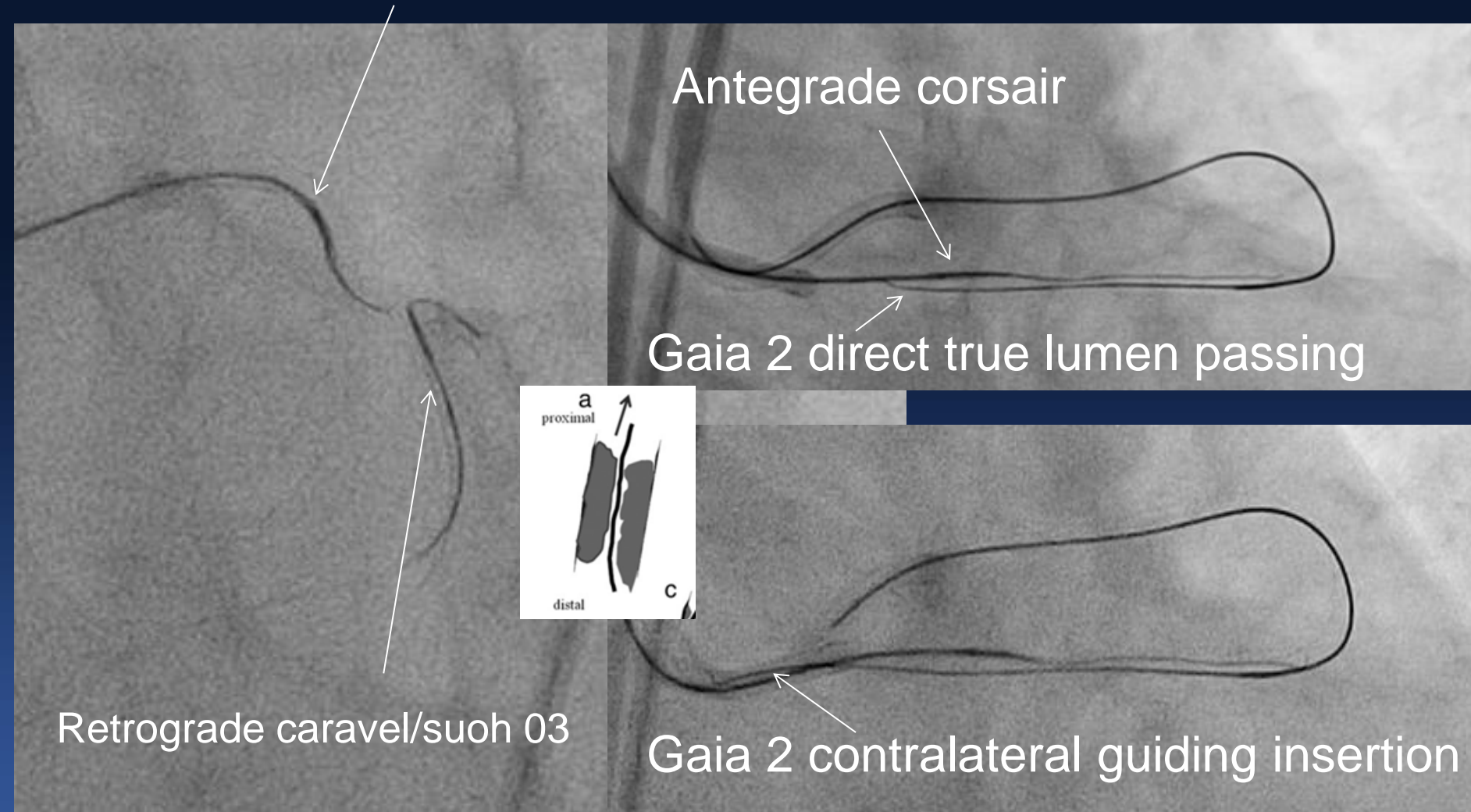
Failed antegrade wiring



Retrograde caravel/suoh 03 wire via epicardial channel

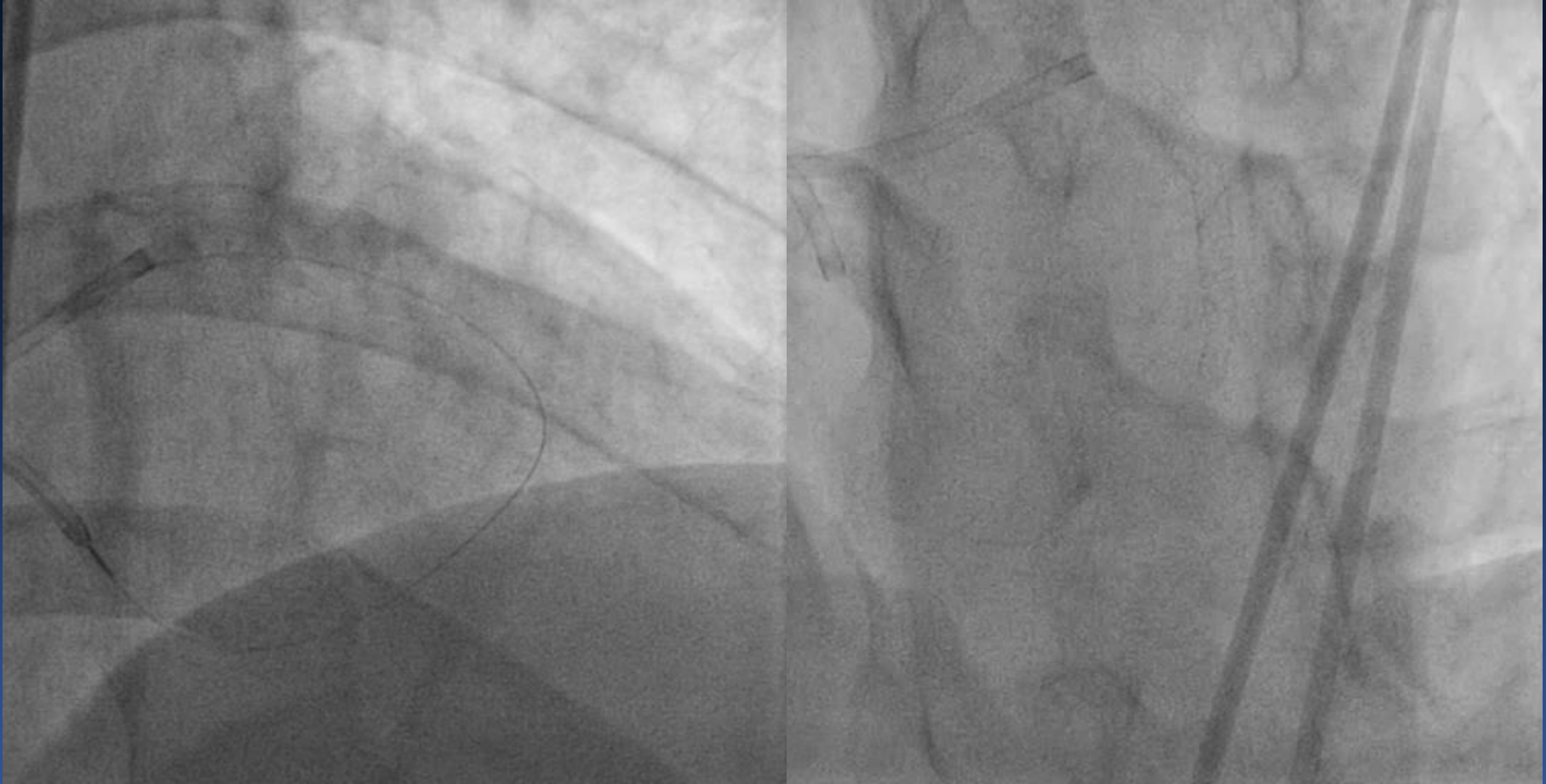


Antegrade corsair/Fielder XT wire

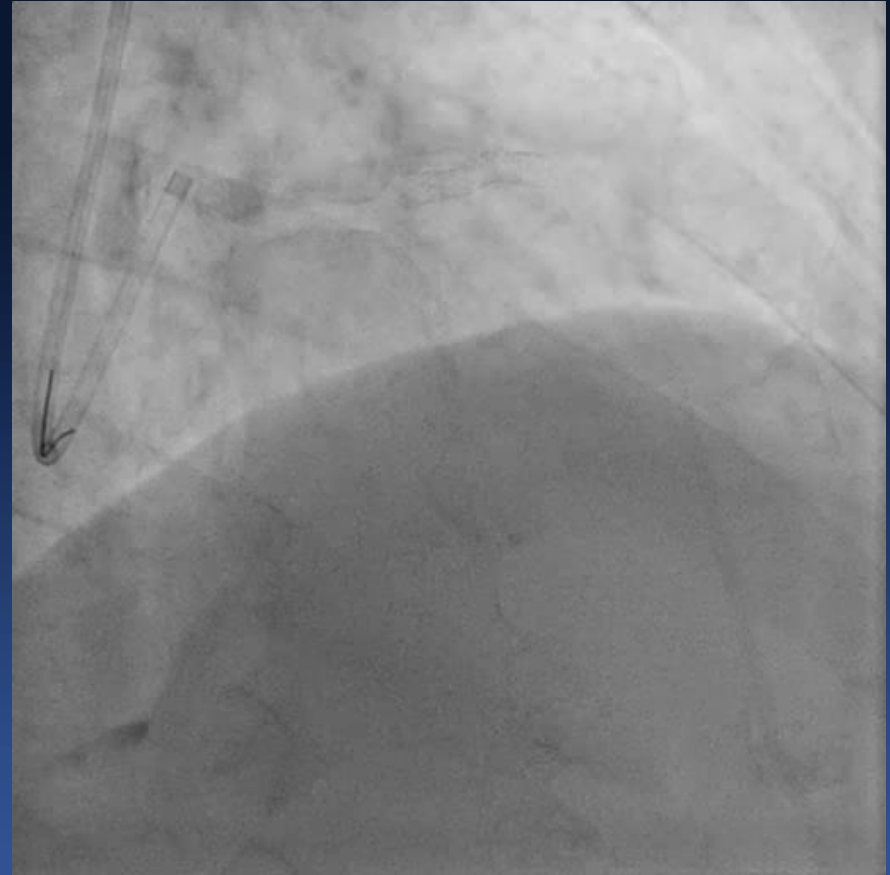


Final angiography

Wire externalization

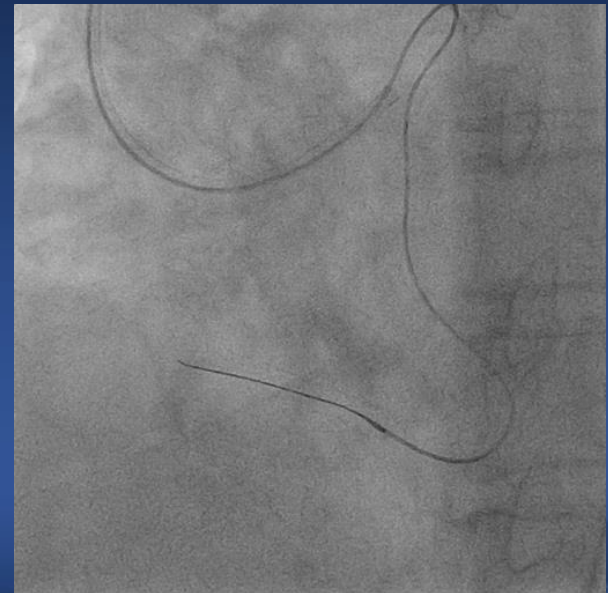
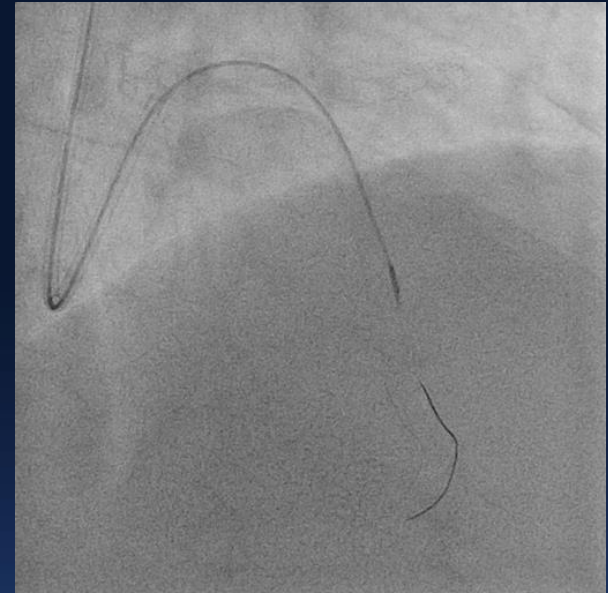
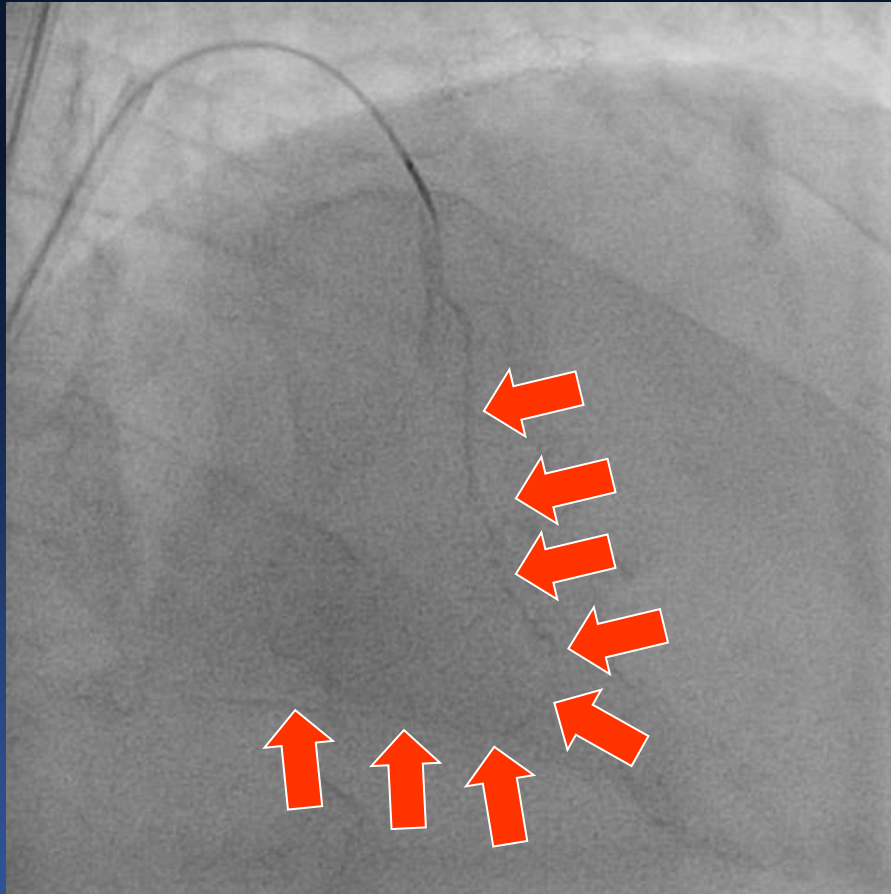


Long RCA CTO

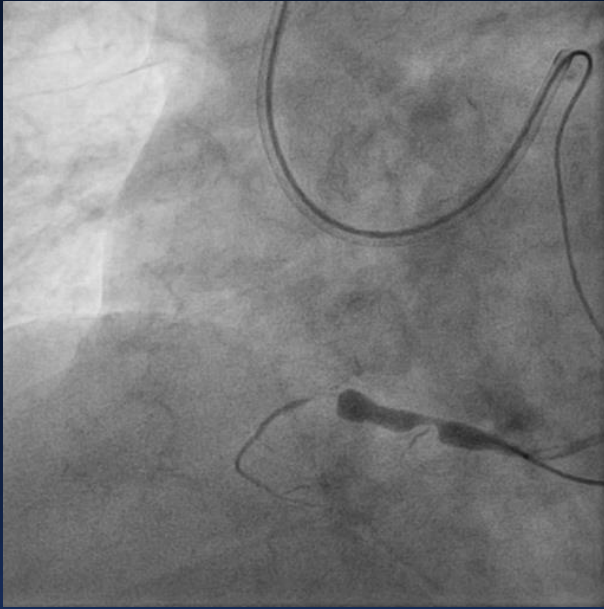


Wiring with sion wire

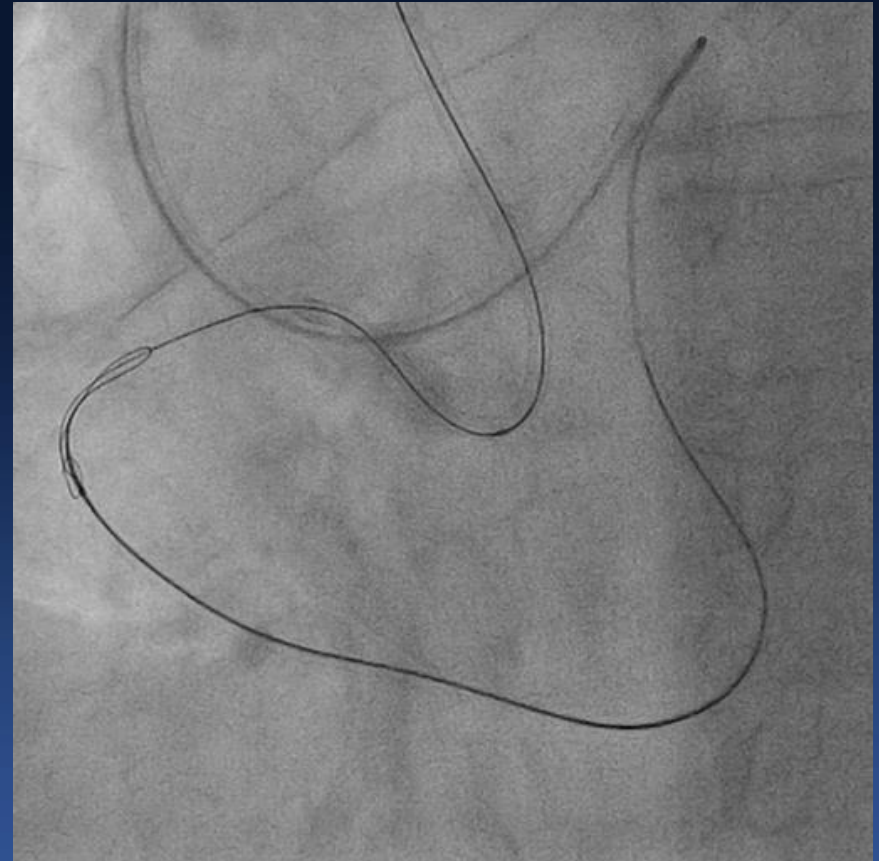
Tip angiography



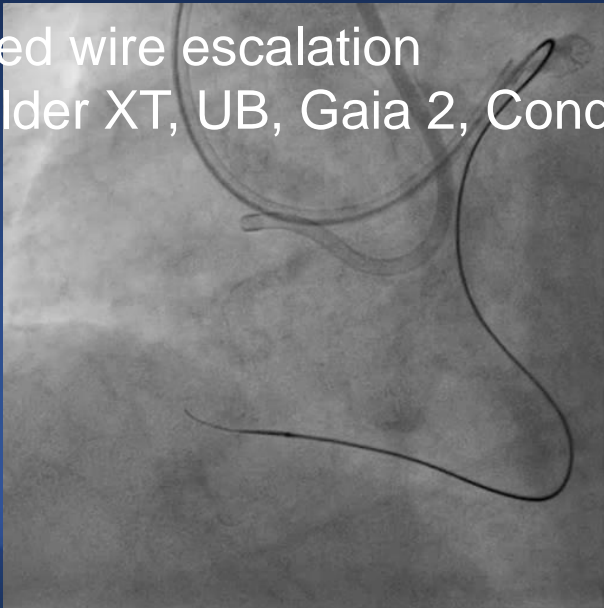
Tip angiography



Knuckle wire with fielder XT

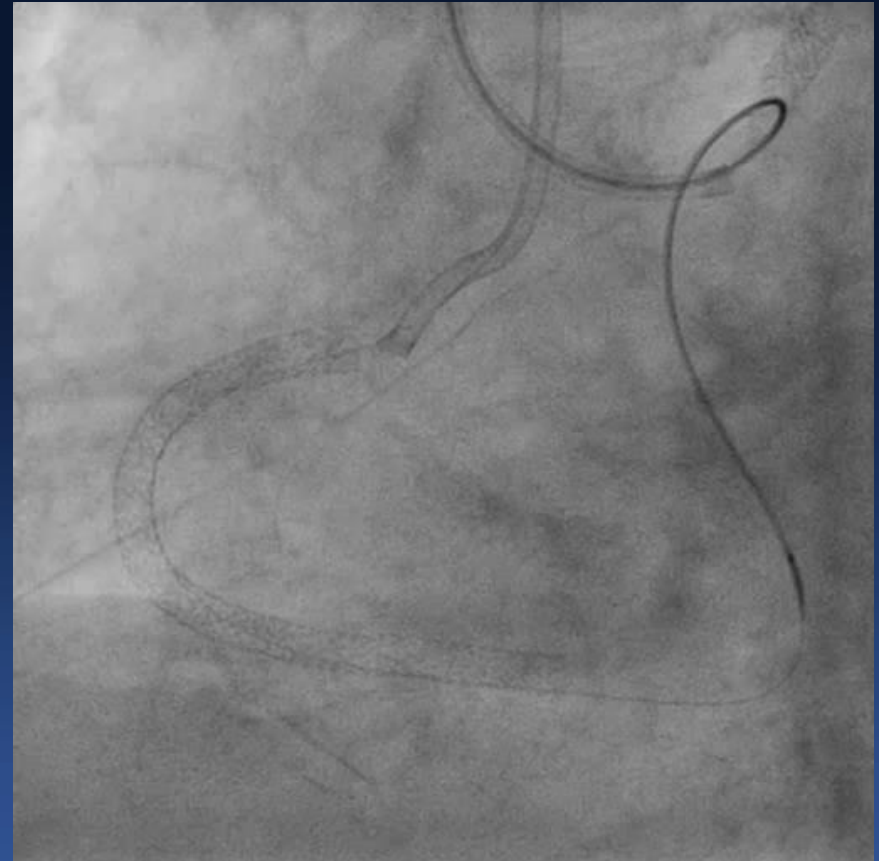
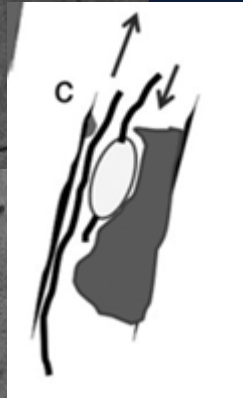
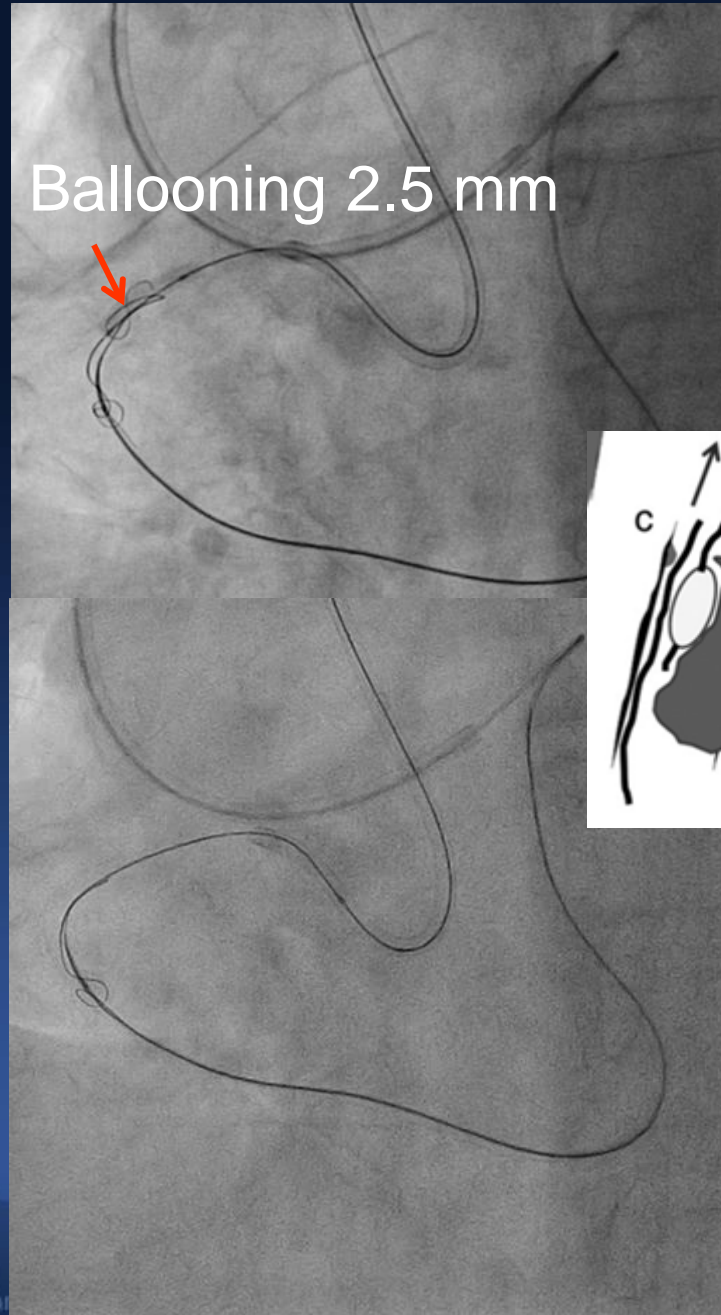


Failed wire escalation (Fielder XT, UB, Gaia 2, Conquest)



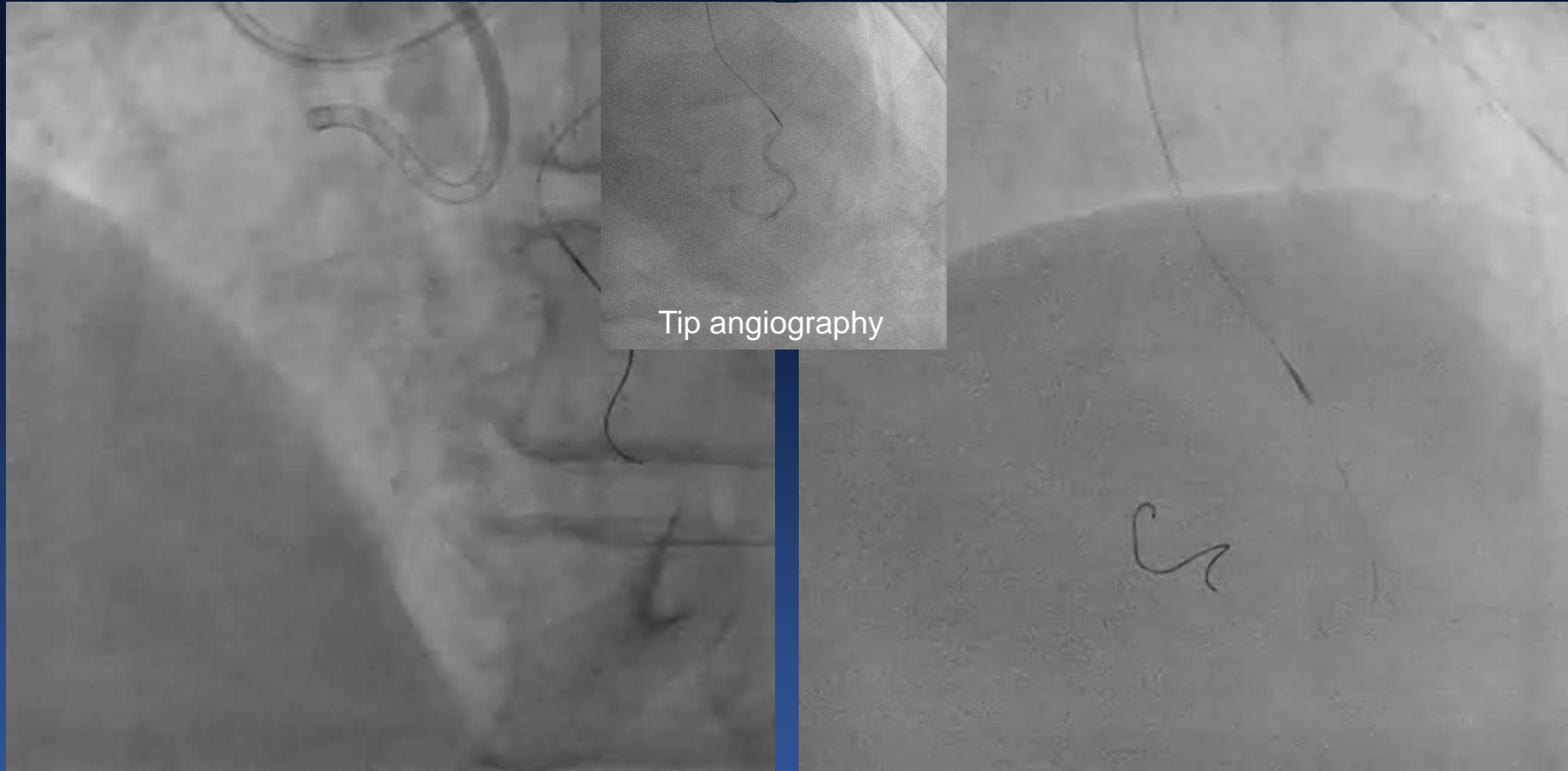
Knuckle wiring with reverse CART

Final angiography



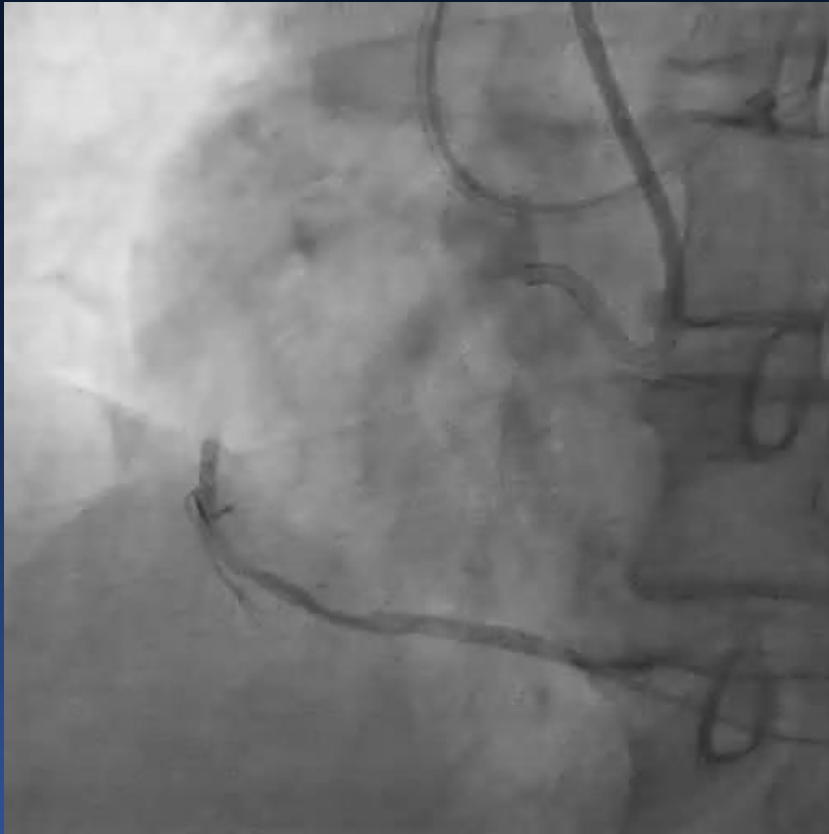
Proximal RCA CTO ***(epicardial channel LAD apex to PDA)***

Caravel with Suoh03 wire

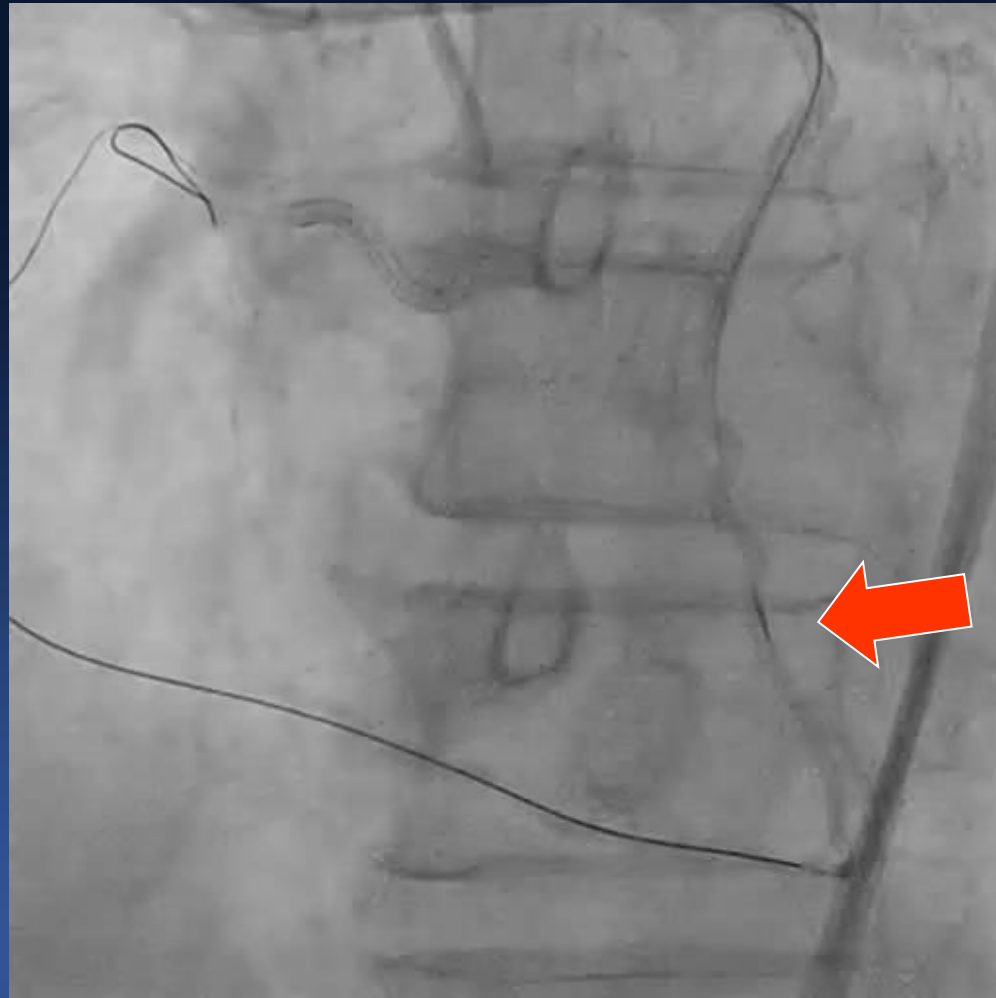


Retrograde wiring/fielder XT

Tip angio for distal Cap

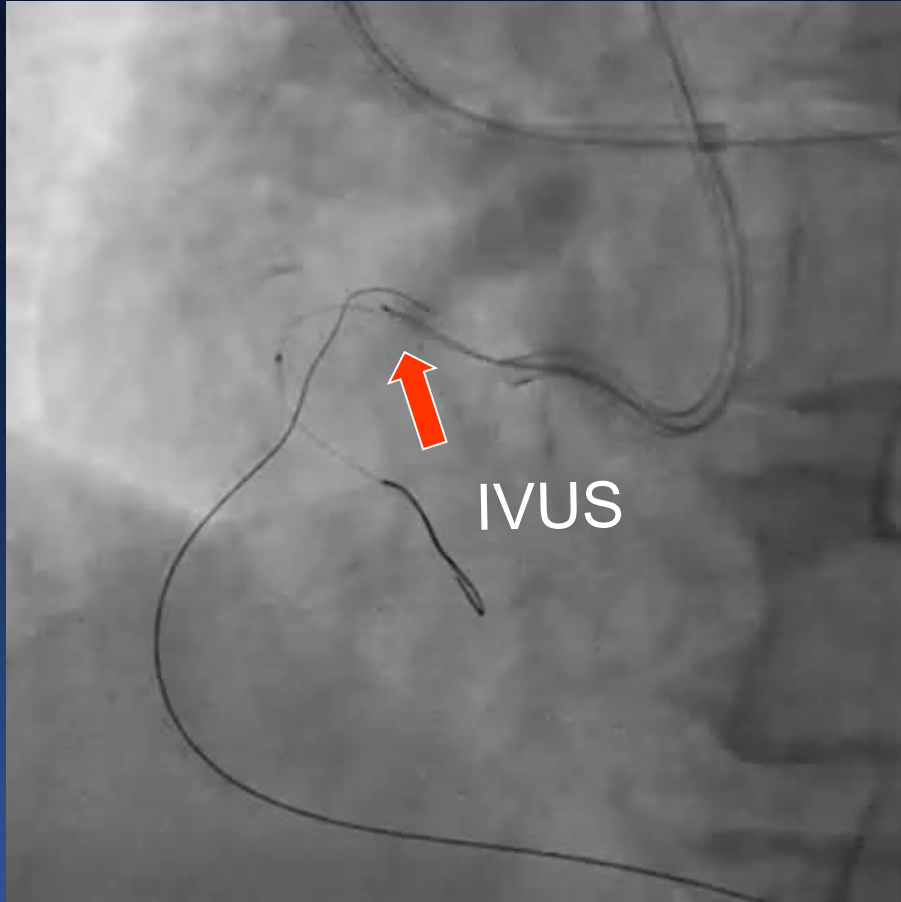


ST elevation/hypotension during wiring
---- pull back caravel to LAD with keeping the wire

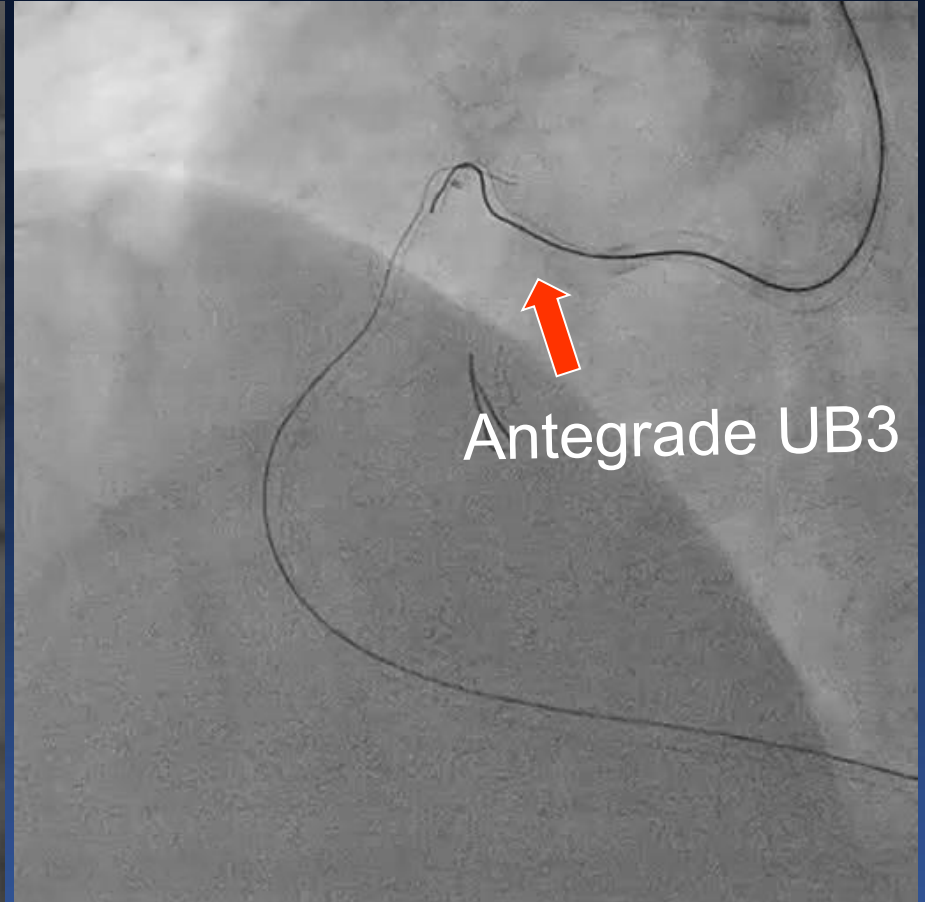


Caravel MC

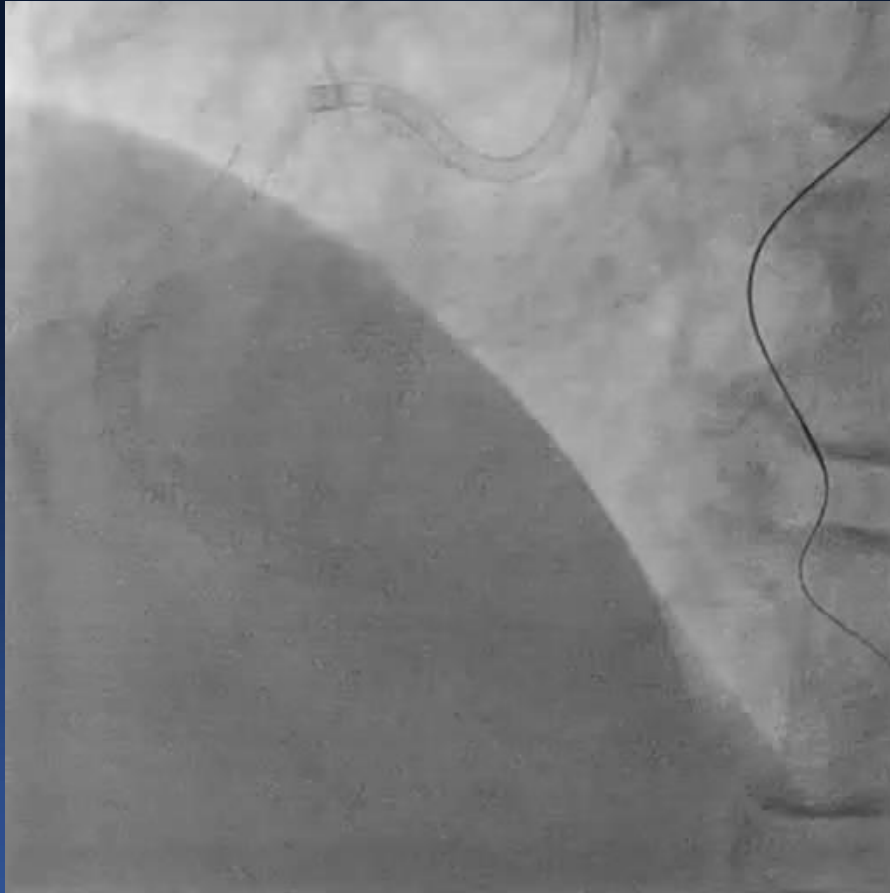
IVUS use for wire position
(Retro wire is in the true lumen)



Antegrade wiring (wire mark)
(Double lumen catheter/UB3 wire)



Final angiography



Check for channel damage



Failure mode of contemporary techniques from APCTO registry

Antegrade app (N=11)

Inability to wire to true lumen despite advanced antegrade wiring technique for example, parallel wiring or IVUS guided wiring: **wire passage failure (N=10, 90%)**.

Retrograde app (N=20)

Wire collateral channel passage failure; **6 (30%)**

Failed reverse CART; **6 (30%)**

Retrograde MC CTO passage failure: **6 (30 %)**

Procedure complications: **4 (20%)**

Conclusion

- **Bidirectional angiography**
- **Careful angiography (with CCTA) review**
- **Antegrade app First: (single or parallel wire or ADR** based on the lesion morphology) under selective guidance of IVUS (entry or rewiring)
- **Retrograde channel cross: selective angiography and retrograde wire channel cross** (Sion, Sion black, Suoh03, Fielder XT-R) and **Microcatheter channel cross** (Finecross, Corsair, Caravel, Turnpike LP)
- **Retrograde CTO cross tech: (Wire mark technique, Retrograde direct wiring** for short length CTO, **Kissing wire, reverse CART/CART)** under selective guidance of IVUS for wire position

**There is an easy-looking CTO, but
there is no easy CTO to open. You must
always do your best.**

Thank you for your attention