Antegrade algorithm from APCTO Club
What has changed in practice and unmet needs

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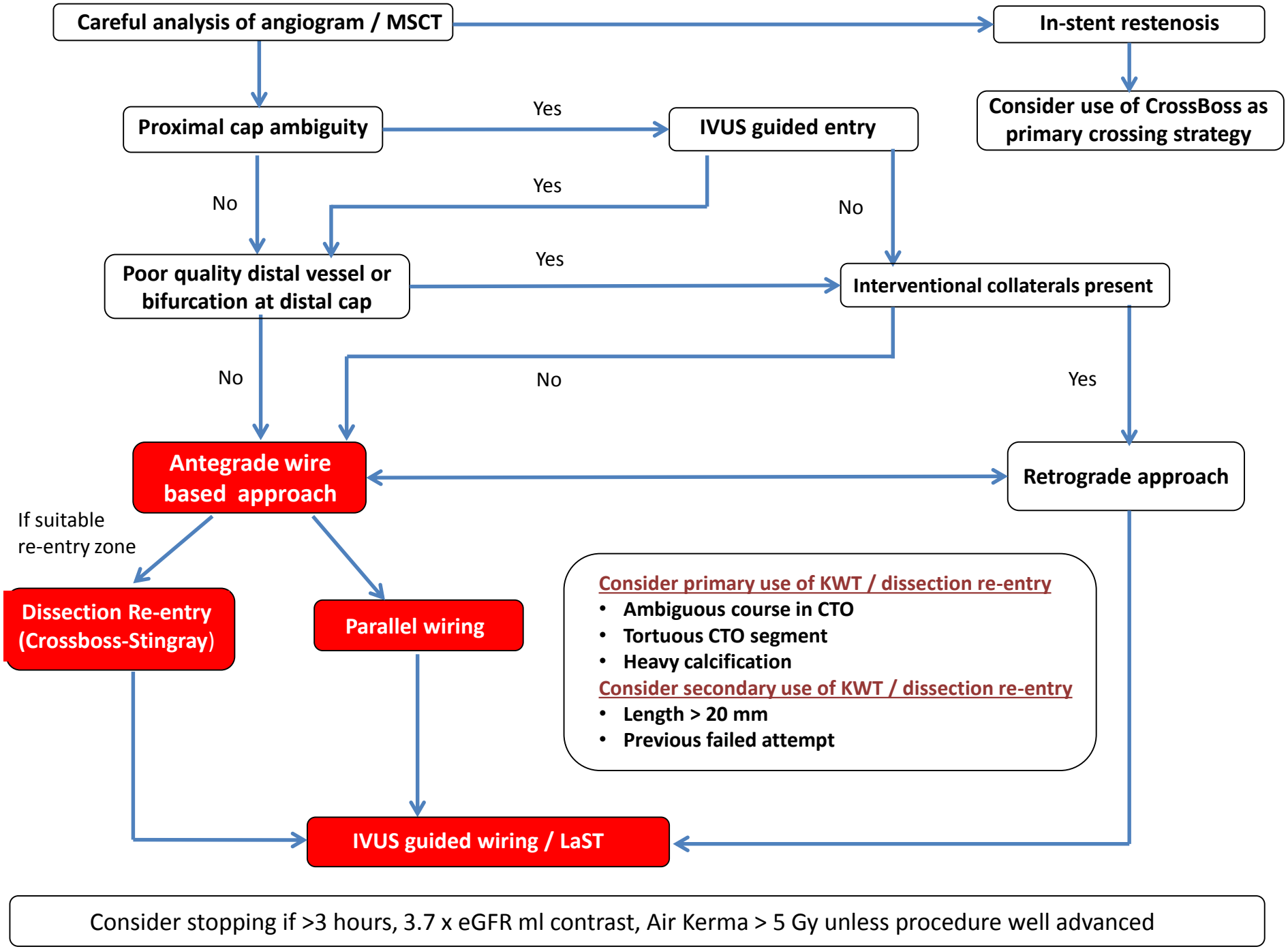
Disclosure Statement of Financial Interest

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

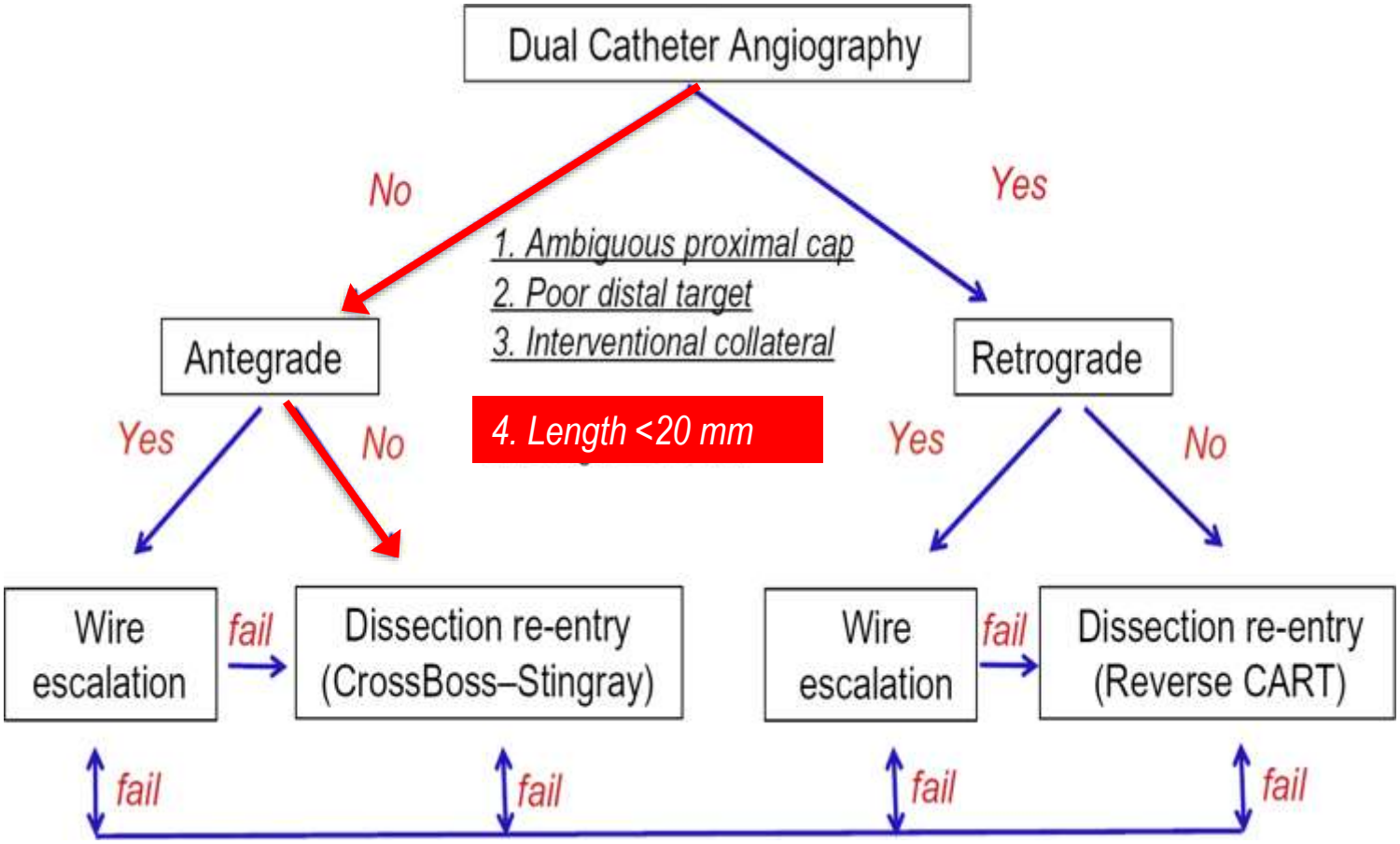
Affiliation/Financial Relationship	Company
• Grant/Research Support	• Asahi Intecc
• Consulting Fees/Honoraria	• Abbott Vascular, Boston Scientific, Asahi Intecc, Medtronic


Careful analysis of angiogram / MSCT
In-stent restenosis
Consider use of CrossBoss as primary crossing strategy
Proximal cap ambiguity
Yes
IVUS guided entry
No
Yes
No
Poor quality distal vessel or bifurcation at distal cap
Yes
Interventional collaterals present
No
No
Yes
Antegrade wire based approach
Retrograde approach
If suitable re-entry zone
Dissection Re-entry (Crossboss-Stingray)
Parallel wiring
Consider primary use of KWT / dissection re-entry
• Ambiguous course in CTO
• Tortuous CTO segment
• Heavy calcification
Consider secondary use of KWT / dissection re-entry
• Length > 20 mm
• Previous failed attempt
IVUS guided wiring / LaST
Consider stopping if >3 hours, 3.7 x eGFR ml contrast, Air Kerma > 5 Gy unless procedure well advanced

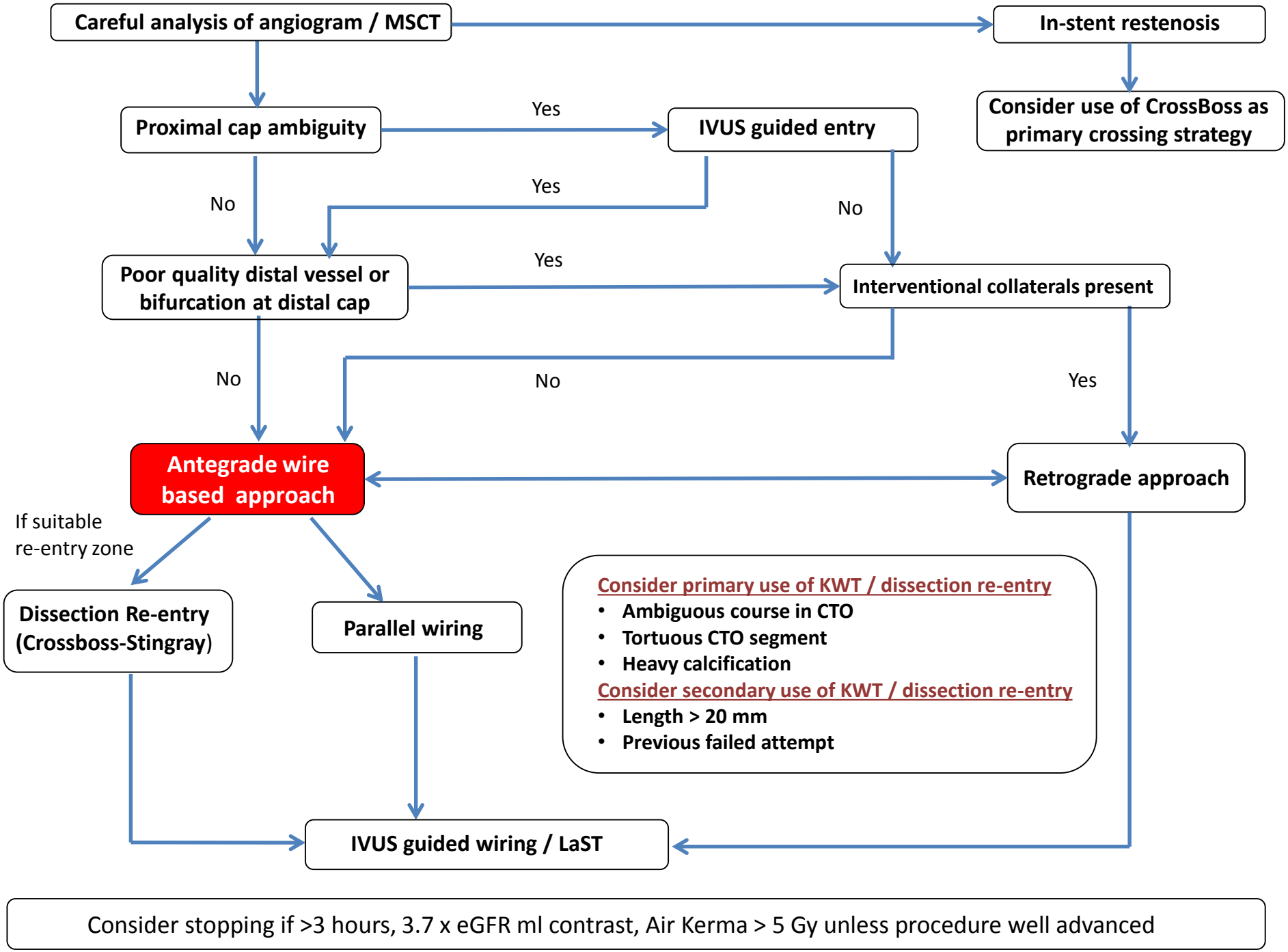
What has changed in practice?

- CTO length >20 mm doesn't = ADR even for hybrid operators
- New wires
- New techniques – dual lumen catheters for proximal cap puncture and parallel wiring
- Evidence base for ADR
- Contemporary approach to ADR

The Hybrid Algorithm



Chronic Total Occlusion Percutaneous Coronary Intervention: Evidence and Controversies, Volume: 7, Issue: 2, DOI: (10.1161/JAHA.117.006732)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The Hybrid Algorithm for Treating Chronic Total Occlusions in Europe

The RECHARGE Registry

Joren Maeremans, MSc,[a,b] Simon Walsh, MD,[c] Paul Knaapen, MD, PhD,[d] James C. Spratt, MD,[e] Alexandre Avran, MD,[f] Colm G. Hanratty, MD,[c] Benjamin Faurie, MD, PhD,[g] Pierfrancesco Agostoni, MD,[h,i] Erwan Bressollette, MD,[j] Peter Kayaert, MD,[k] Alan J. Bagnall, MD, PhD,[l,m] Mohaned Egred, MD,[l,m] Dave Smith, MD,[n] Alexander Chase, MD, PhD,[n] Margaret B. McEntegart, MD, PhD,[o] William H.T. Smith, MB, BChir, PhD,[p] Alun Harcombe, MD,[p] Paul Kelly, MD,[q] John Irving, MD,[r] Elliot J. Smith, MD,[s] Julian W. Strange, MD,[t] Joseph Dens, MD, PhD[a,b]

Lesion Length ≥20 mm in 59%

AWE was the primary strategy in 77%!

PROspective Global REgiStry for the Study of CTO interventions

WELLINGTON CARDIOLOGY

Application and outcomes of a hybrid approach to chronic total occlusion percutaneous coronary intervention in a contemporary multicenter US registry☆

Georgios Christopoulos [a], Dimitri Karmpaliotis [b], Khaldoon Alaswad [c], Robert W. Yeh [d,m], Farouc A. Jaffer [e], R. Michael Wyman [e], William L. Lombardi [f], Rohan V. Menon [a], J. Aaron Grantham [g], David E. Kandzari [h], Nicholas Lembo [h], Jeffrey W. Moses [b], Ajay J. Kirtane [b], Manish Parikh [b], Philip Green [b], Matthew Finn [b], Santiago Garcia [i,n], Anthony Doing [j], Mitul Patel [k,o], John Bahadorani [k,o], Muhammad Nauman J. Tarar [a], Georgios E. Christakopoulos [a], Craig A. Thompson [l], Subhash Banerjee [a], Emmanouil S. Brilakis [a,*]

Lesion Length was ≥20 mm in 75%

AWE was the primary strategy in 66%!

Christopoulos G et al. International Journal of Cardiology 198 (2015) 222–228

Early Procedural and Health Status Outcomes After Chronic Total Occlusion Angioplasty

A Report From the OPEN-CTO Registry (Outcomes, Patient Health Status, and Efficiency in Chronic Total Occlusion Hybrid Procedures)

Mean lesion Length was 29.1 ± 23.8 mm

AWE was the primary strategy in 54.7%

JACC Cardiovascular Interventions

Proximal Cap	**Visible micro channels**	**Tapered proximal cap**	**Blunt proximal cap**
	Low penetration force wire with polymer jacket and tapered tip ↓ Intermediate penetration force wire	Low penetration force wire ↓ Intermediate penetration force wire	Intermediate penetration force wire ↓ High penetration force wire
CTO body	If a high penetration-force wire has been used to the puncture proximal cap step down to a lower penetration-force wire unless occlusion short with unambiguous course.		
Distal Cap	Escalation from softer more steerable wire to a higher penetration-force wire may be required.		

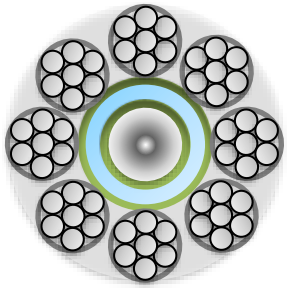
New Wires: GAIA Next Family

Designed for intentional intimal tracking

Key features:

- High torque response
- Deflection control – due to combination of flexibility and penetration force

XTRAND coil



- ✓ Decreased breakage risk within the occlusion
- ✓ Improved resistance in case of trapping into the lesion
- ✓ Increased torque via counter clockwise rotation

ASAHI Gaia Next 1	2.0gf0.36mm/0.27mm
ASAHI Gaia Next 2	4.0gf0.36mm/0.30mm (0.014inch/0.012inch)
ASAHI Gaia Next 3	6.0gf0.36mm/0.30mm (0.014inch/0.012inch)

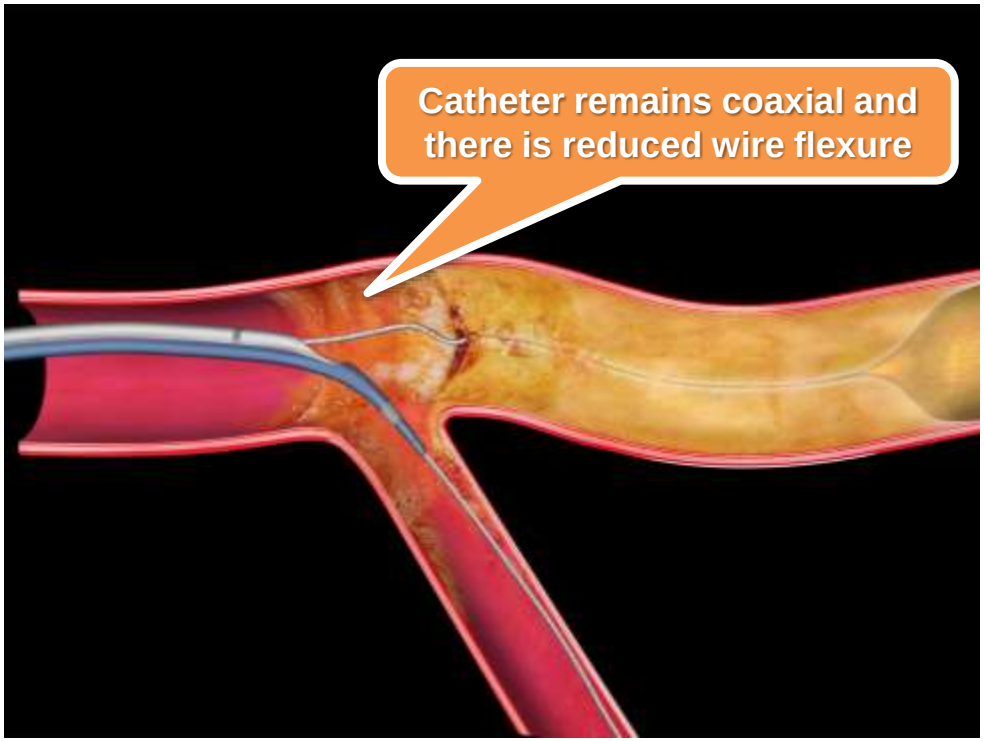
New Wires: HORNET™ Family

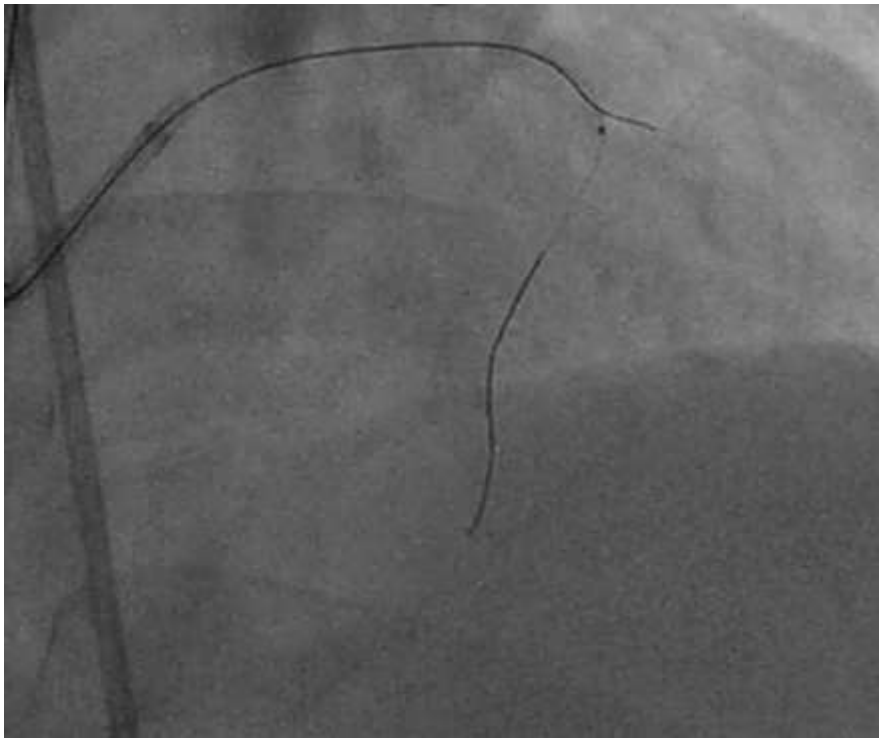
Closest Comparators:
HORNET: ASAHI Gaia® First
HORNET 10: ASAHI CONFIANZA PRO®, ASAHI CONFIANZA PRO® 12
HORNET 14 : ASAHI CONFIANZA PRO® 12

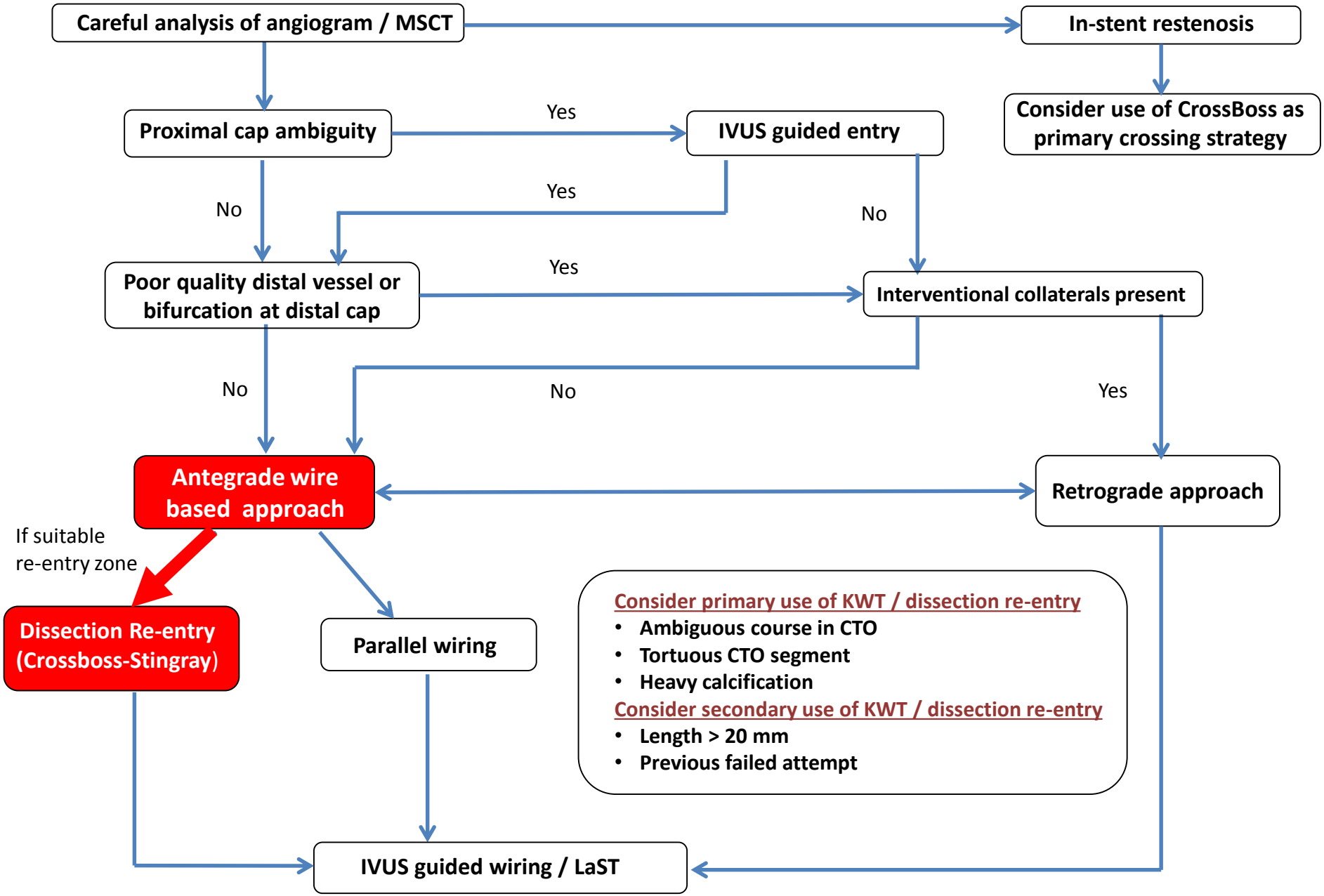
Key Features
Tapered tip: lowest tip profile on market (.008”)
Hornet 14: highest tip load on market
Hornet 10 & 14: highest penetration force on market
Hydrophilic coating

Name	Coil Diameter (inch)	Tip Diameter (inch)	Total Length (cm)	Coil Length (cm)	Radiop-aque (cm)	Tip Load (gf)	Penetration Force (gf/mm²)	Core Material	Tip Shape	Coating
HORNET	0.014	0.008	190 300	15	3.5	1	31	Stainless Steel	Straight	Hydrophilic
HORNET 10	0.014	0.008	190 300	15	3.5	10	308	Stainless Steel	Straight	Hydrophilic
HORNET 14	0.014	0.008	190 300	15	3.5	14	432	Stainless Steel	Straight	Hydrophilic

Dual lumen microcatheter puncture for flush occlusion of proximal cap



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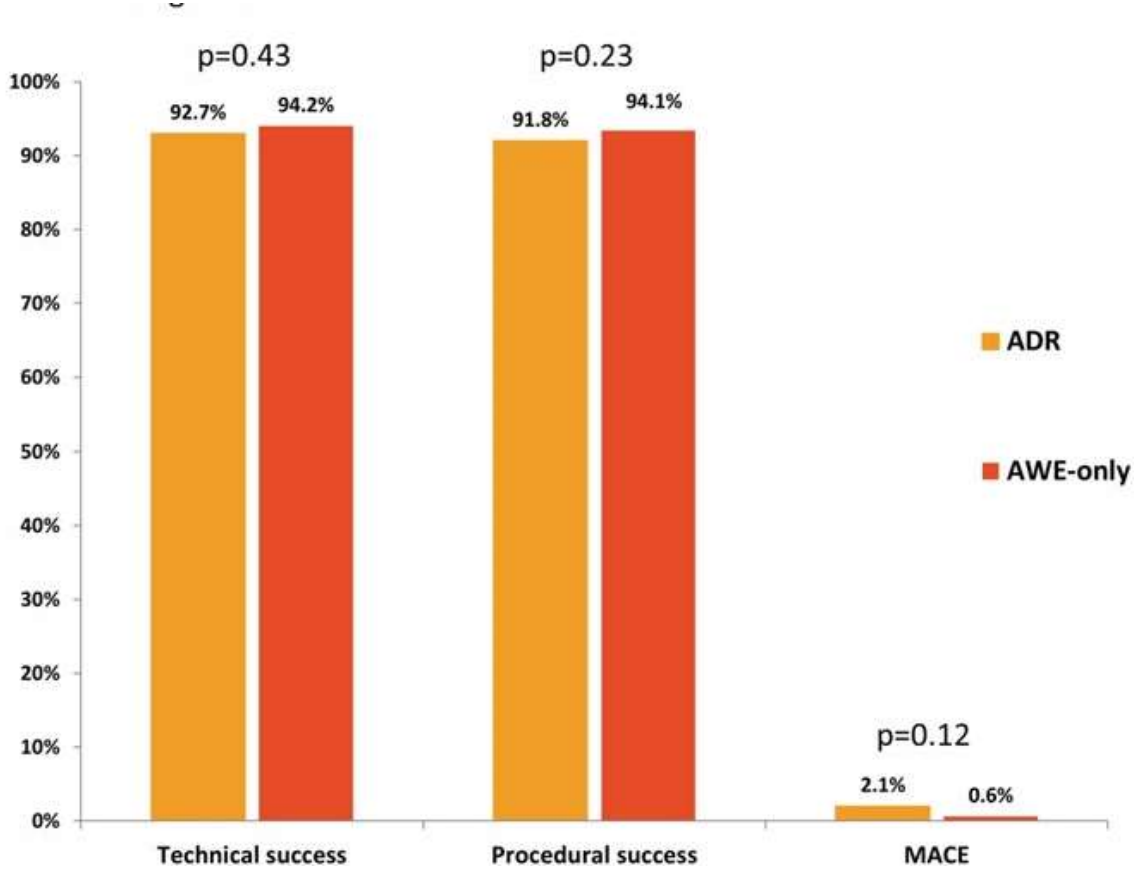
Growing evidence base for ADR

Antegrade procedures, technical success, procedural success and MACE according to use of AWE or ADR



458 ADR procedure in 1313 CTO PCIs performed at 11 US centers

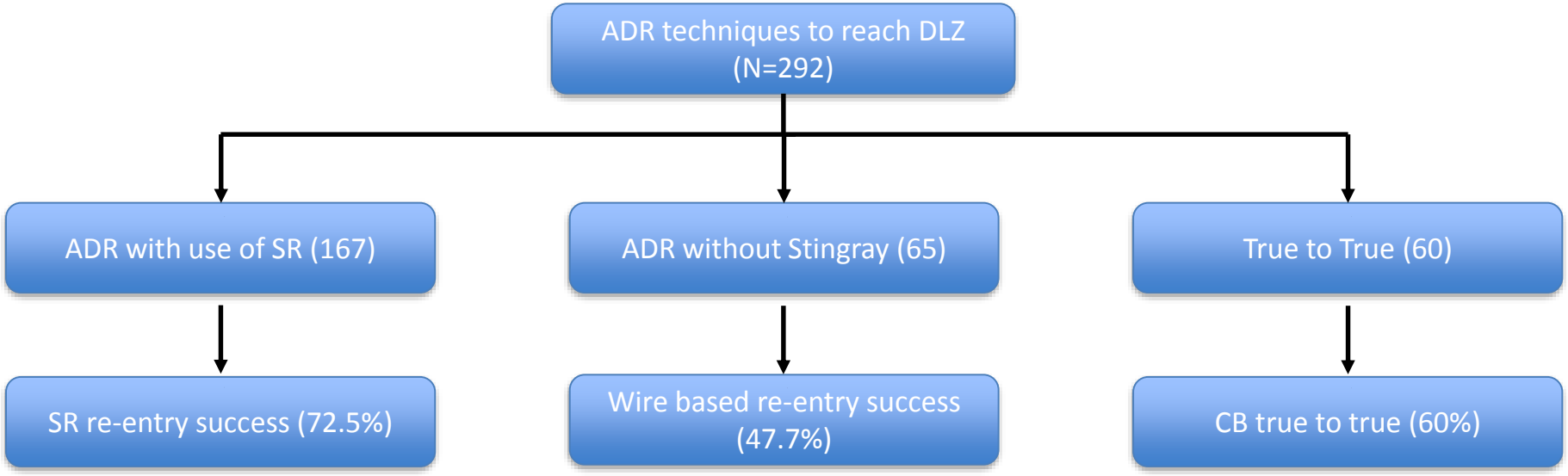
*MACE = In-hospital death, MI, urgent repeat TVR, tamponade or CVA

Danek B et el. International Journal of Cardiology 2016;214:428–437

Antegrade Dissection and Reentry as Part of the Hybrid Chronic Total Occlusion Revascularization Strategy

A Subanalysis of the RECHARGE Registry (Registry of CrossBoss and Hybrid Procedures in France, the Netherlands, Belgium and United Kingdom)

Joren Maeremans, Jo Dens, James C. Spratt, Alan J. Bagnall, Wynand Stuijfzand, Alexander Nap, Pierfrancesco Agostoni, William Wilson, Colm G. Hanratty, Simon Wilson, Benjamin Faurie, Alexandre Avran, Erwan Bressollette, Mohaned Egred, Paul Knaapen, Simon Walsh, and on behalf of the RECHARGE Investigators, Dave Smith, Alexander Chase, ... Show all Authors



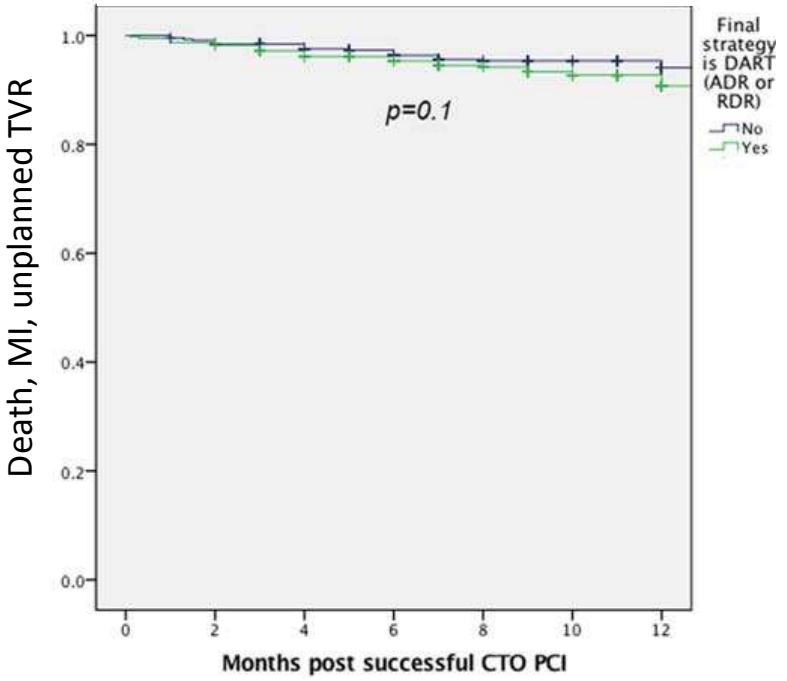
In Hospital ADR-associated major events occurred in 3.4% (n=10/292).

Maeremans et al. Circ Cardiovasc Interv. 2017

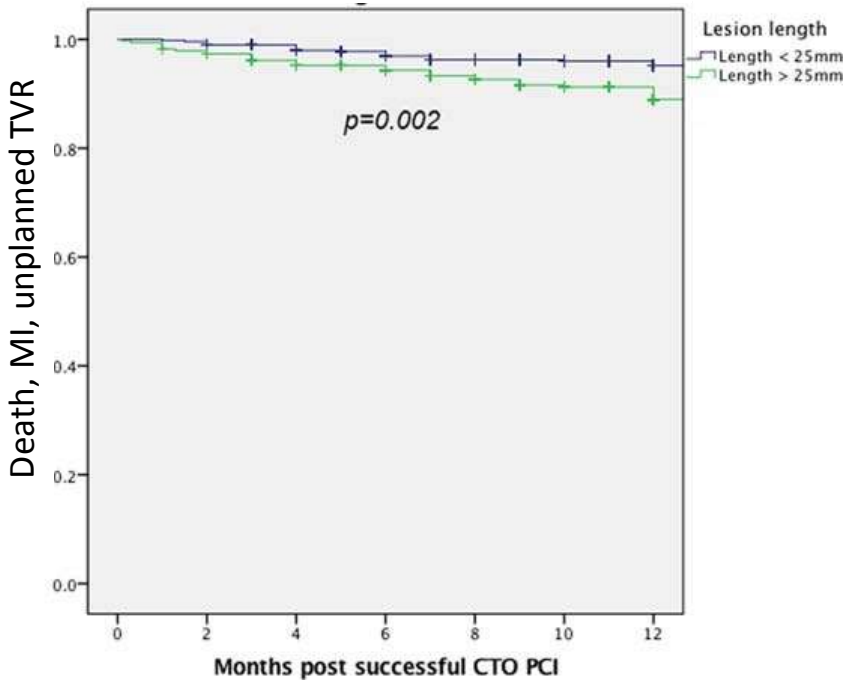
One-Year Outcomes After Successful Chronic Total Occlusion Percutaneous Coronary Intervention: The Impact of Dissection Re-Entry Techniques

W. M. Wilson,[1] MBBS, FRACP, S.J. Walsh,[2] MD, FRCP, A. Bagnall,[3,4] MBCHB, PhD, FRCP, A.T. Yan,[5] MD, FRCPC, C.G. Hanratty,[2] MD, FRCPI, M. Egred,[3,4] BSC (HONS), MBCHB, MD, FRCP, E. Smith,[6] BSC, MBBS, MD, K.G. Oldroyd,[7] MBCHB, MD (HONS), FRCP, M. McEntegart,[7] MD, PhD, J. Irving,[8] MBCHB, MD, FRCPEDIN, H. Douglas,[2] MB, BCH, J. Strange,[9] MBCHB, MRCP, MD, and J.C. Spratt,[10*] BSC, MBCHB, MD, FRCP

Wire based vs. DART as final strategy



Lesion length <25mm vs >25 mm



W Wilson et al. CCI 2017;90:703–712

Dissection & Re-entry: 12 month outcomes

TABLE VI. Multivariate Analysis (Cox Regression Models)

	Model 1		Model 2		Model 3		Model 4	
Variable	Odds ratio	*P* value	Odds ratio	*P* value	Odds ratio	*P* value	Odds ratio	*P* value
Final Approach								
AWE	1							
ADR	0.66 (0.3–1.5)	0.32						
RWE	0.68 (0.16–2.9)	0.61						
RDR	1.1 (0.53–2.2)	0.83						
DART (any)			0.74 (0.4–1.4)	0.35				
ADR (any)					0.67 (0.35–1.3)	0.23		
RDR (any)							1.3 (0.67–2.4)	0.47
Lesion length >25 mm	2.5 (1.3–4.8)	0.007	2.9 (1.5–5.6)	0.002	2.6 (1.5–4.8)	0.001	2.3 (1.2–4.3)	0.01
Stent length >50 mm	0.85 (0.4–1.8)	0.85	0.85 (0.4–1.7)	0.65	0.85 (0.41–1.7)	0.66	0.79 (0.39–1.6)	0.52
Disease distal (moderate or severe)	1.6 (0.82–2.9)	0.17	1.67 (0.85–3)	0.15	1.6 (0.83–3.0)	0.17	1.6 (0.86–3.1)	0.16
Bifurcation	1.2 (0.8–2.2)	0.36	1.3 (0.8–2.2)	0.3	1.3 (0.7–2.2)	0.36	1.3 (0.8–2.2)	0.34
Diabetes	1.4 (0.8–2.4)	0.3	1.4 (0.8–2.4)	0.28	1.4 (0.8–2.4)	0.18	1.3 (0.8–2.4)	0.31
In-stent restenosis	1.5 (0.6–3.6)	0.4	1.3 (0.6–3.1)	0.64	1.4 (0.6–3.3)	0.23	1.4 (0.6–3.5)	0.47

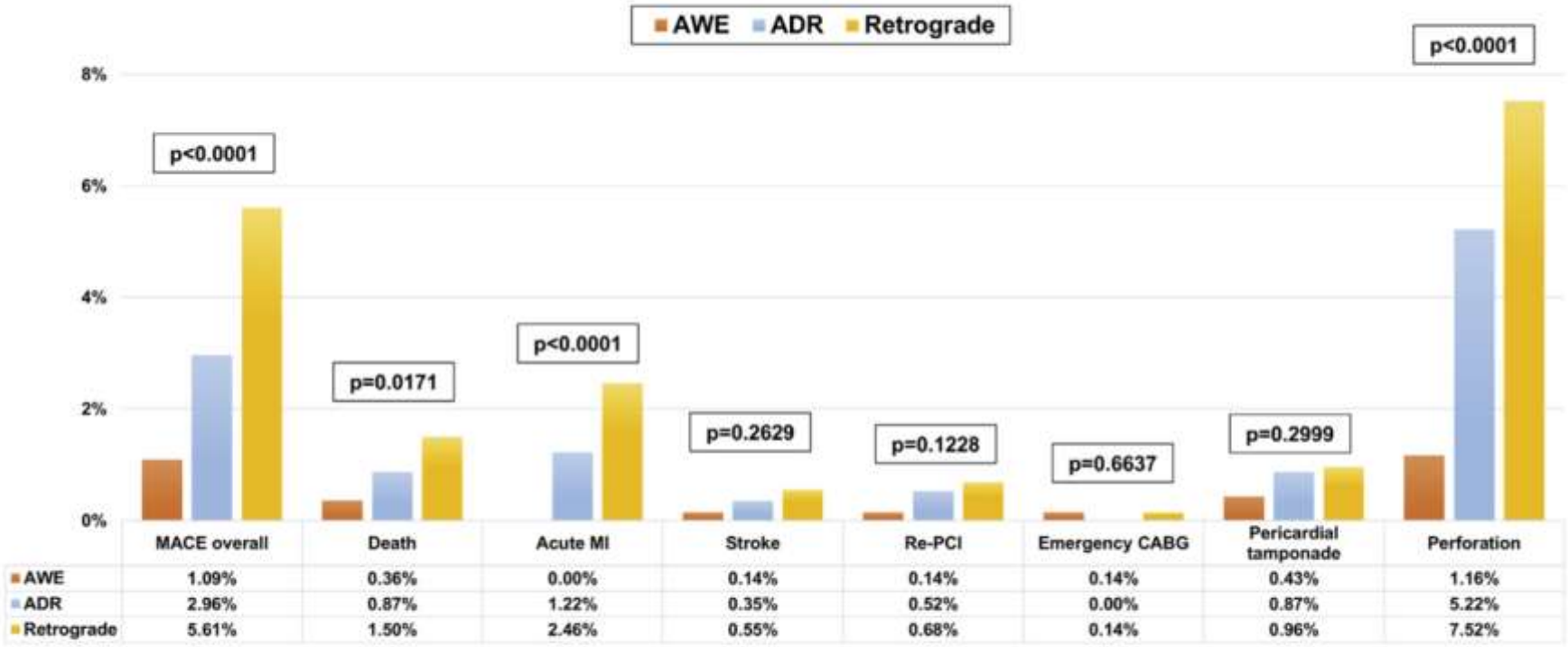
Presented as Hazard ratio (95% confidence interval) and *P* value.

AWE: Antegrade wire escalation; ADR: Antegrade dissection re-entry; RWE: retrograde wire escalation; RDR: retrograde dissection re-entry; DART: dissection and re-entry.

W Wilson et al. CCI 2017;90:703–712

Complications with various techniques

FIGURE 4 In-Hospital Major Complications Classified According to Final Successful Crossing Strategy



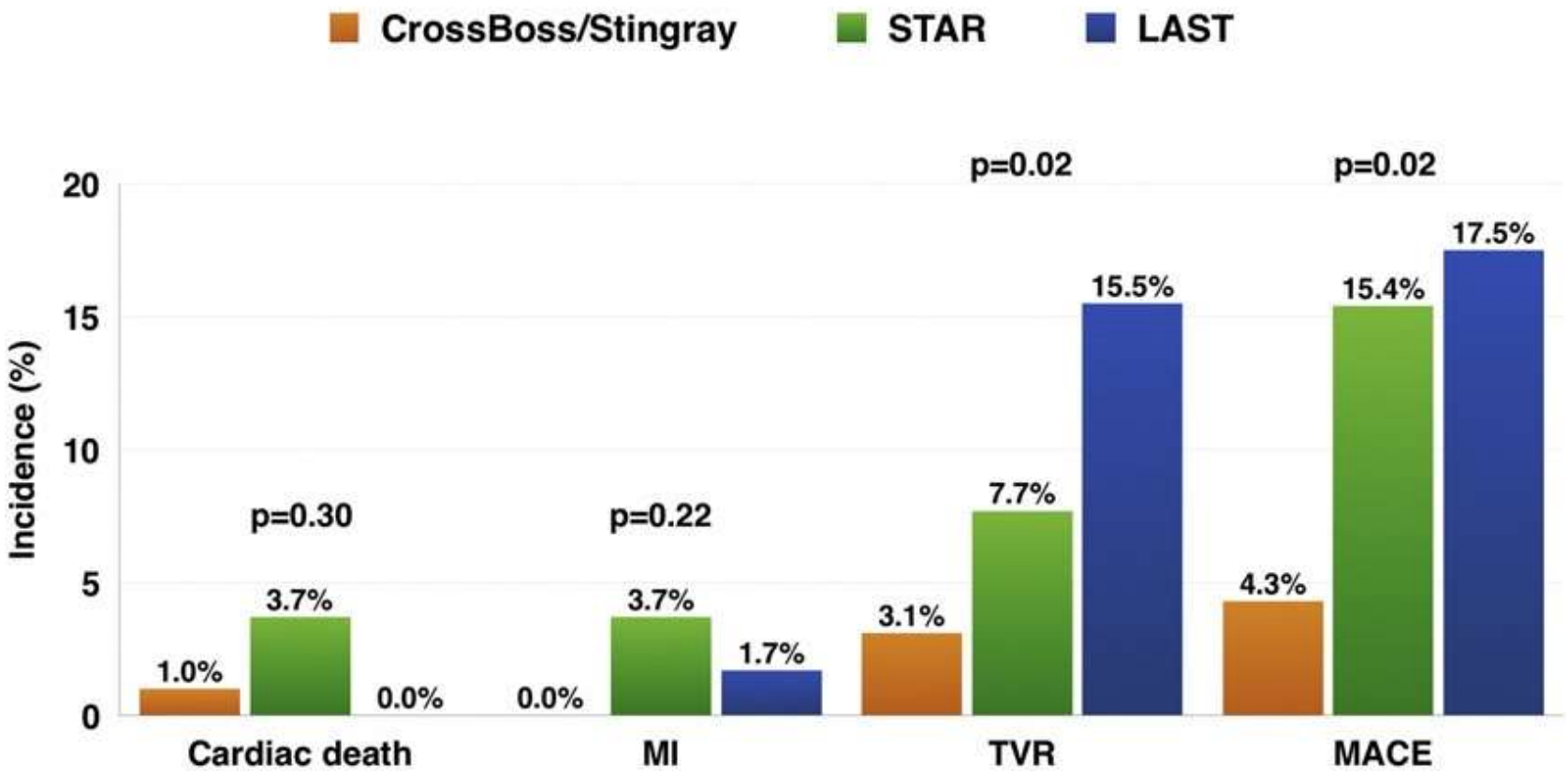
	MACE overall	Death	Acute MI	Stroke	Re-PCI	Emergency CABG	Pericardial tamponade	Perforation
AWE	1.09%	0.36%	0.00%	0.14%	0.14%	0.14%	0.43%	1.16%
ADR	2.96%	0.87%	1.22%	0.35%	0.52%	0.00%	0.87%	5.22%
Retrograde	5.61%	1.50%	2.46%	0.55%	0.68%	0.14%	0.96%	7.52%

Use of the retrograde approach was associated with higher overall in-hospital major adverse cardiac events (MACE) and risk for perforation. ADR = antegrade dissection and re-entry; AWE = antegrade wire escalation; CABG = coronary artery bypass graft; MI = myocardial infarction; PCI = percutaneous coronary intervention.

>3000 patients from PROGRESS Registry

Tajti P et al. JACC CI 2018;11:1325-35

We should avoid uncontrolled or wire based ADR

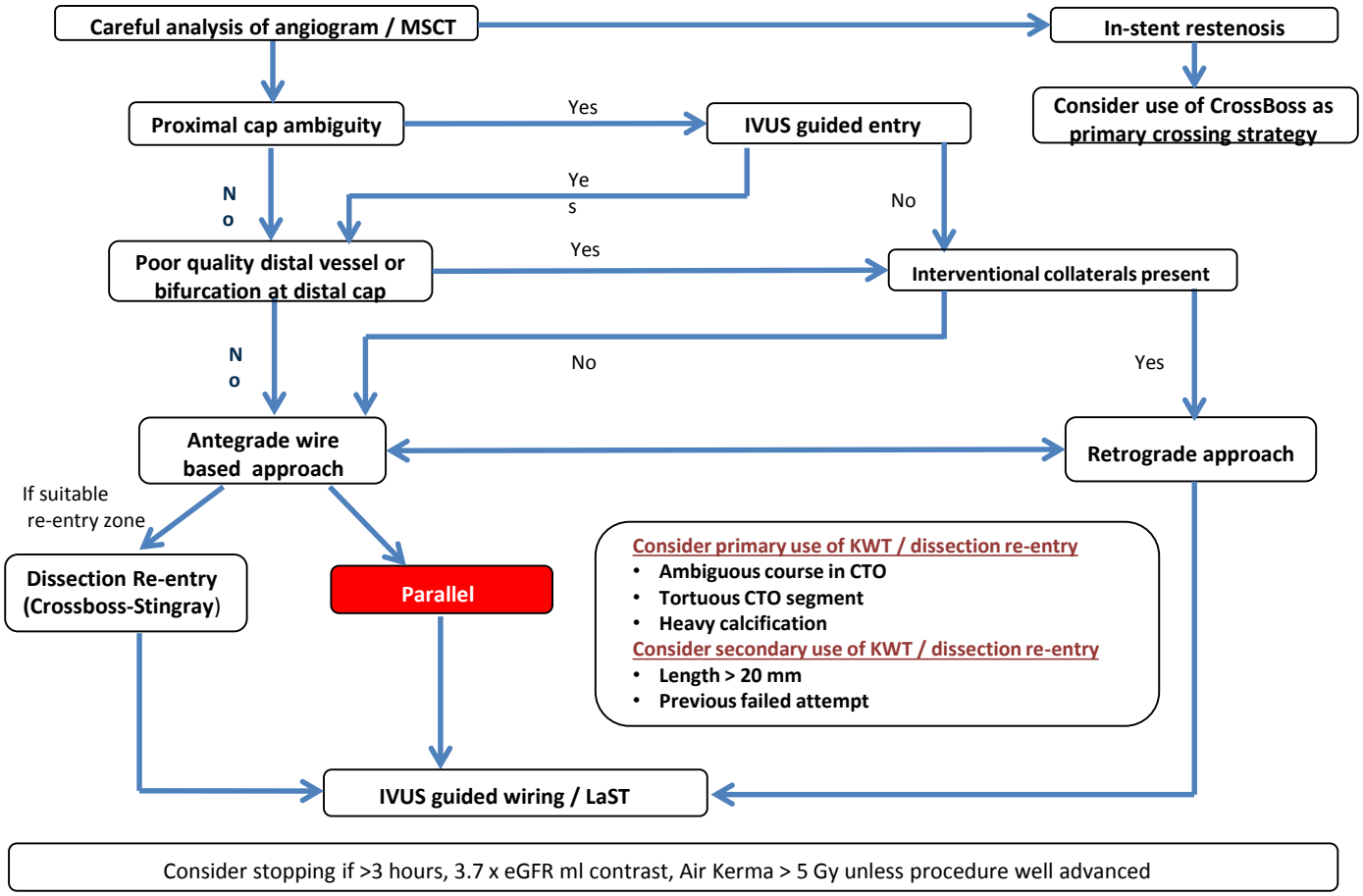


Azzalini L et al. International Journal of Cardiology 231 (2017) 78–83

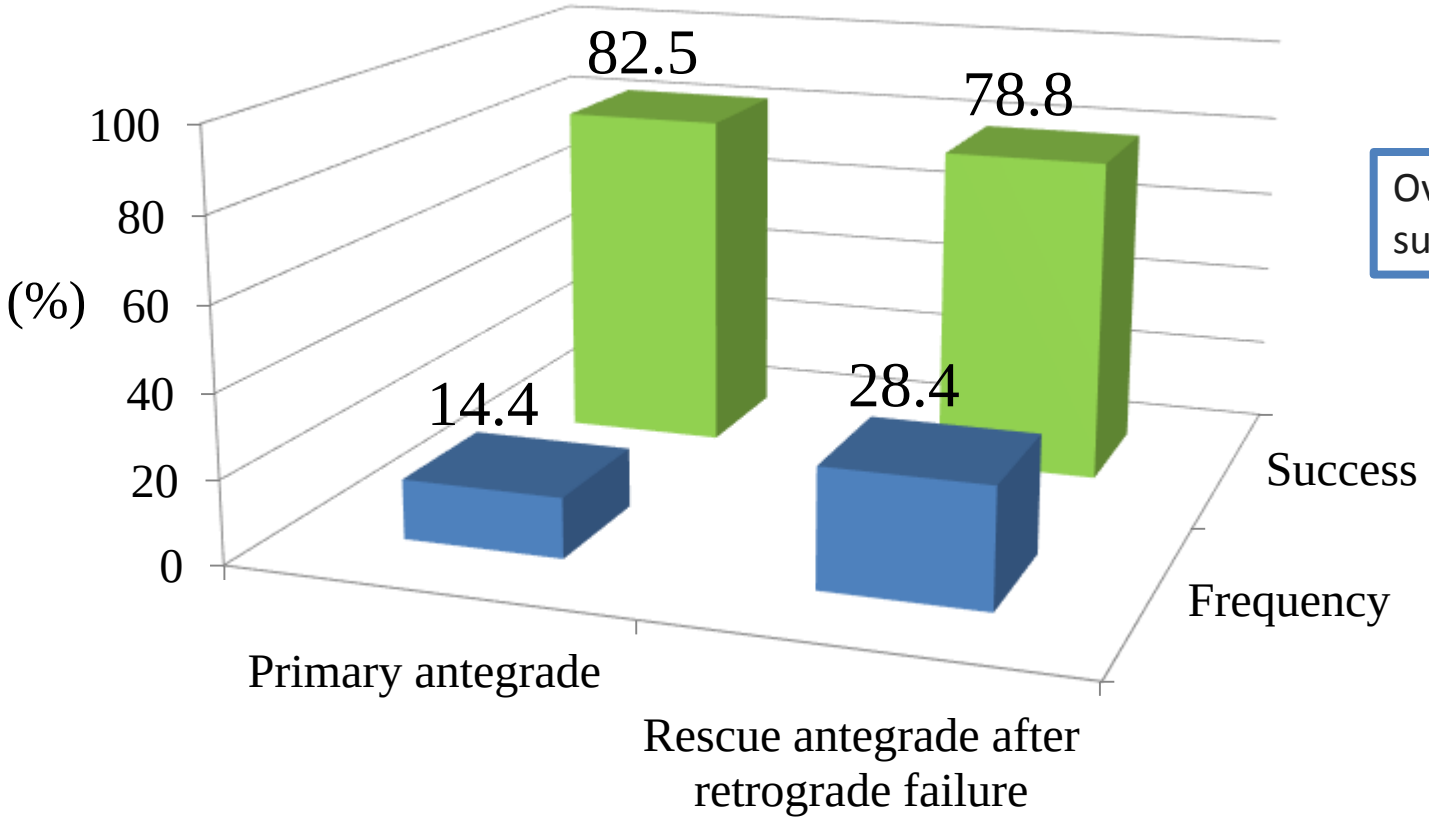
Contemporary approach to ADR

	Classic ADR 2011	Contemporary ADR 2018
Set up	8Fr Femoral with supportive guides AL0.75/EBU 3.5	Compatible with radial access 7Fr with 7F Trapliner or 6Fr without guide extension
Initial Microcatheter	CrossBoss	Start with wire and microcatheter Finish with CrossBoss to limit dissection in re-entry zone
Re-entry catheter	Stingray	Stingray LP
Re-entry wire	Stingray wire	Stingray /Astato 20/Hornet 14/ GAIA 3rd Next
Re-entry Technique	Stick and go	Stick and swap with Pilot 200
Hematoma Management	STRAW- if loss of visualization of distal vessel	Active management with Trapliner upfront and preemptive STRAW

What has changed in practice?



Parallel wiring use and success in Japanese expert registry



Overall technical success 81.3%

Suzuki Y, et al. J Am Coll Cardiol Intv 2017;10:2144–54

Parallel wiring vs. Stingray

Major features favouring use of stingray

- Vessel course ambiguity
- If wire subintimal at the proximal cap
- Good distal landing zone

Major features favouring use of parallel wiring

- Diffuse disease and calcification of the distal vessel
- CTO course is unambiguous
- Stingray not available or financial restraints

Remaining challenges

- Antegrade failure
- Calcium
- Under utilization of ADR in Asia Pacific
- Patient selection
- Bridging the gap

Why do we fail antegrade?

Why do we fail antegrade wiring?

- Ambiguity of the proximal cap or course
- Tortuosity
- Calcium

Why do we fail at controlled ADR?

- Failure to reach the distal landing zone (ambiguous proximal cap or calcium)
- Failure to re-enter at the distal landing zone (haematoma, diffuse disease or calcium)

Calcification

Multivariate predictors of failure from the Japanese Expert Registry

TABLE 5 Multivariate Analyses Investigating Possible Predictors of Failed CTO-PCIs

	Overall			PAA			PRA		
	OR	95% CI	p Value	OR	95% CI	p Value	OR	95% CI	p Value
Prior CABG	1.47	0.765-2.715	0.219	1.677	0.780-3.604	0.186			
Prior PCI	1.276	0.928-1.756	0.134	1.135	0.759-1.696	0.588			
Diabetes	1.12	0.850-1.476	0.421	1.429	0.995-2.052	0.053			
eGFR >60 ml/min/1.73 m^2	0.764	0.576-1.012	0.061	0.818	0.565-1.184	0.288			
Reattempt	1.131	0.811-1.577	0.469	0.906	0.552-1.487	0.697			
Target (LAD)	1.26	0.878-1.808	0.211	0.207	0.041-1.052	0.058			
CTO length ≥20 mm	1.42	1.036-1.946	0.029	1.262	0.850-1.874	0.249			
Severe calcification	3.101	2.057-4.675	<0.001	2.837	1.622-4.963	<0.001	3.264	1.739-6.125	<0.001
Tortuosity of CTO lesion	1.972	1.438-2.703	<0.001	1.992	1.365-2.907	<0.001	1.699	1.075-2.686	0.023
Dyslipidemia							0.535	0.322-0.889	0.016
Side branch at proximal cap							2.399	1.524-3.776	<0.001

Suzuki Y, et al. J Am Coll Cardiol Intv 2017;10:2144–54

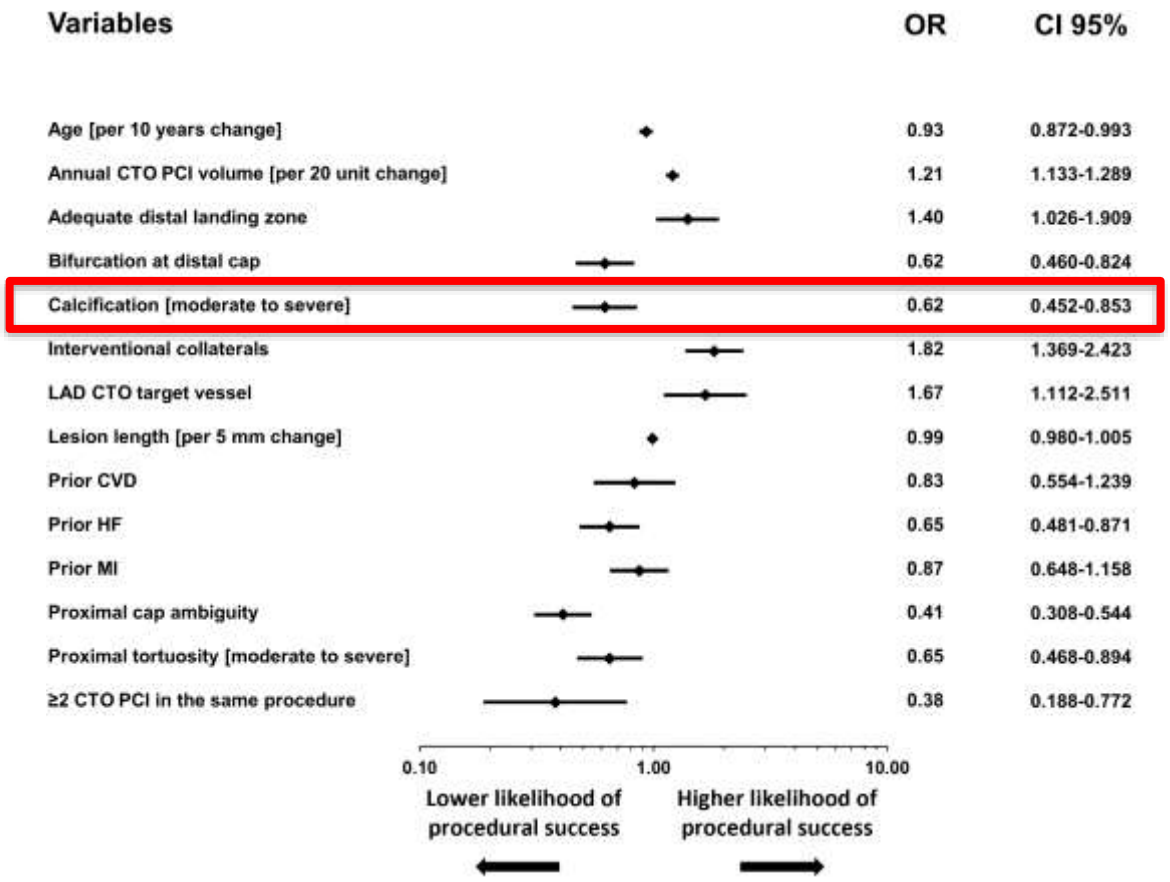
Calcification

Balloon-uncrossable lesions present in 10.6% of CTO

Balloon-undilatable lesions present in 11.1% of CTO

Calcification consistent predictor of failure

Highlights the need for CTO operators to have experience in calcium modification techniques and new device to help us.

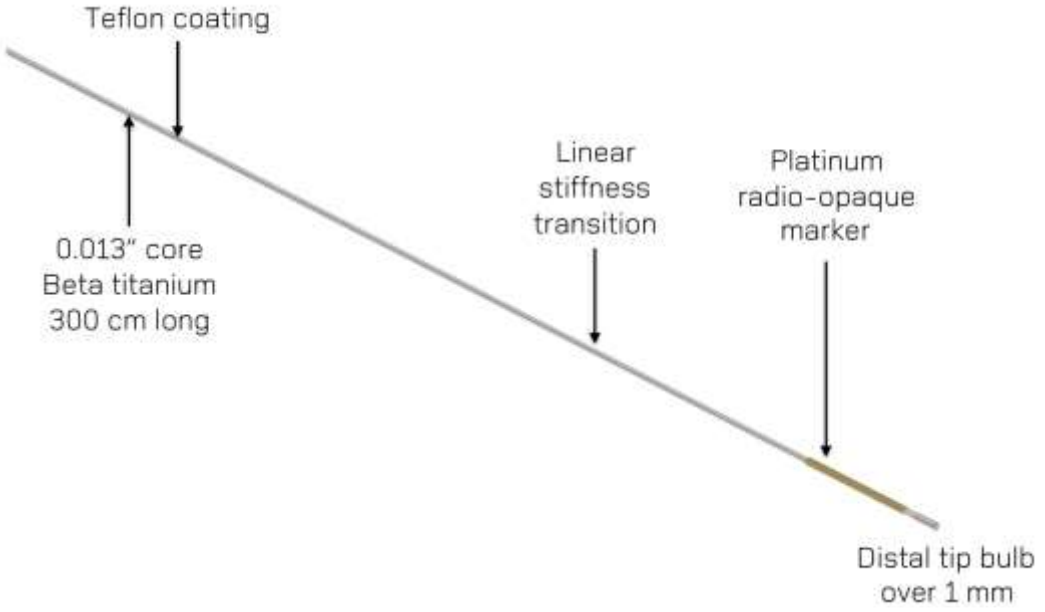


Tajti P et al. JACC CI 2018;11:1325-35

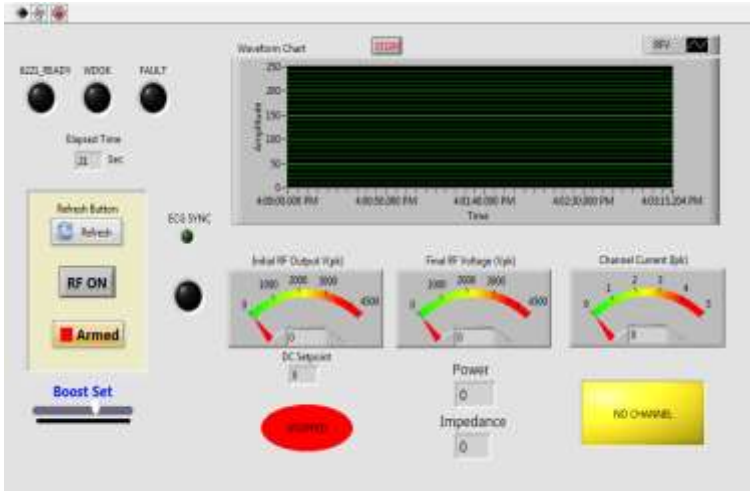
SoundBite Crossing System

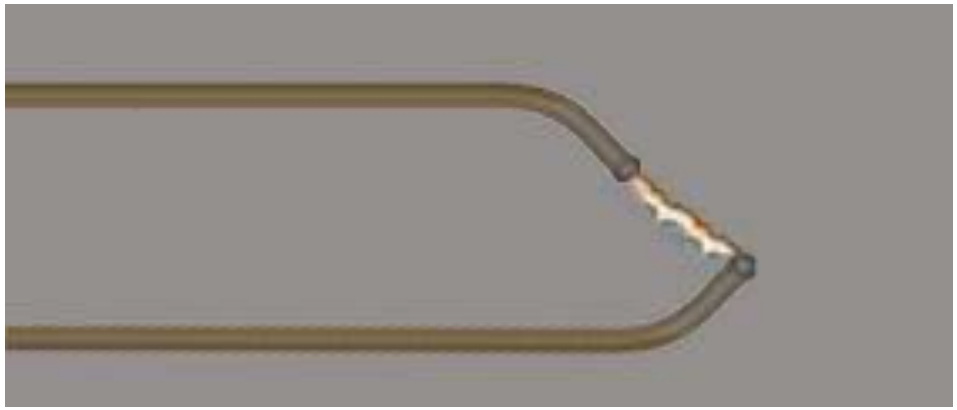
Steerable Active Wire energized by shockwaves generated by a bedside console: Jackhammer effect

Console



PlasmaWire System





- The PlasmaWire System consists of an RF Generator (RFG), Connector Cable and two 0.014” RF wires (PlasmaWire).
- Two, independently steerable PlasmaWires act as electrodes to form a bipolar arrangement for precise directional ablation.
- RF energy is delivered to the PlasmaWire in “packets” of short pulses to minimize tissue injury while creating plasma between the two wire tips.

Under utilization of ADR in Asia Pacific

	APCTO	J-CTO	PROGRESS	RECHARGE	OPEN CTO
	N=447	N=498	N=1036	N=1253	N=1000
Retrograde attempted	48%	27.3%	41.6%	34%	-
Retrograde successful strategy	41.7%	20.7%	26.4%	20.8%	35%
% retrograde success	86.4%	75.7%	63%	67%	-
ADR attempted	2%	0%	36%	23%	-
ADR successful strategy		0%	26%	15%	24.3%
% ADR success		-	72%	66%	-
Contrast dose (ml)	250 (200-320)	293 (53–1,097)	260 (200–360)	250 (180-340)	262 ± 140
Fluoroscopy time (minutes)	48 (29-73)	45 (1–301)	44 (27–72)	35 (21-55)	50 ± 34
Procedure time (minutes)	100 (60-140)	-	119 (82–175)	90 (60-120)	120 ± 64
Technical success rate	95%	87%	91%	86%	86%

Strategy and outcomes by registry

Why do these difference exist?

Potential barriers to use of ADR in Asia Pacific:

- Availability → Becoming more widely available in Asia
- ~~8F access~~
- Cost
- Training and skills
- Differences in populations
- ~~Lack of long term outcome data~~
- ~~Safety~~

Patient selection

What did we learn from the randomized controlled trials to date?

- Patients with no or low symptom burden and small amount of ischaemic myocardium can be managed medically
- Symptomatic patients derive significant benefit from CTO PCI
- Role of CTO PCI in asymptomatic patients with moderate or large area of ischaemia controversial and unproven

Complications are higher in CTO PCI and are predicted by lesion complexity (J-CTO score)

The patients age, frailty and co-morbidities are important determinants of there ability to benefit

We must use this knowledge to weight the potential risks and benefits of CTO PCI and select appropriate patients - Not every CTO needs opening

Bridging the Gap

Registries report success rates around 90% for CTO PCI with expert operators. However, contemporary studies encompassing a broader range of centres and operators demonstrated substantially lower success rates.

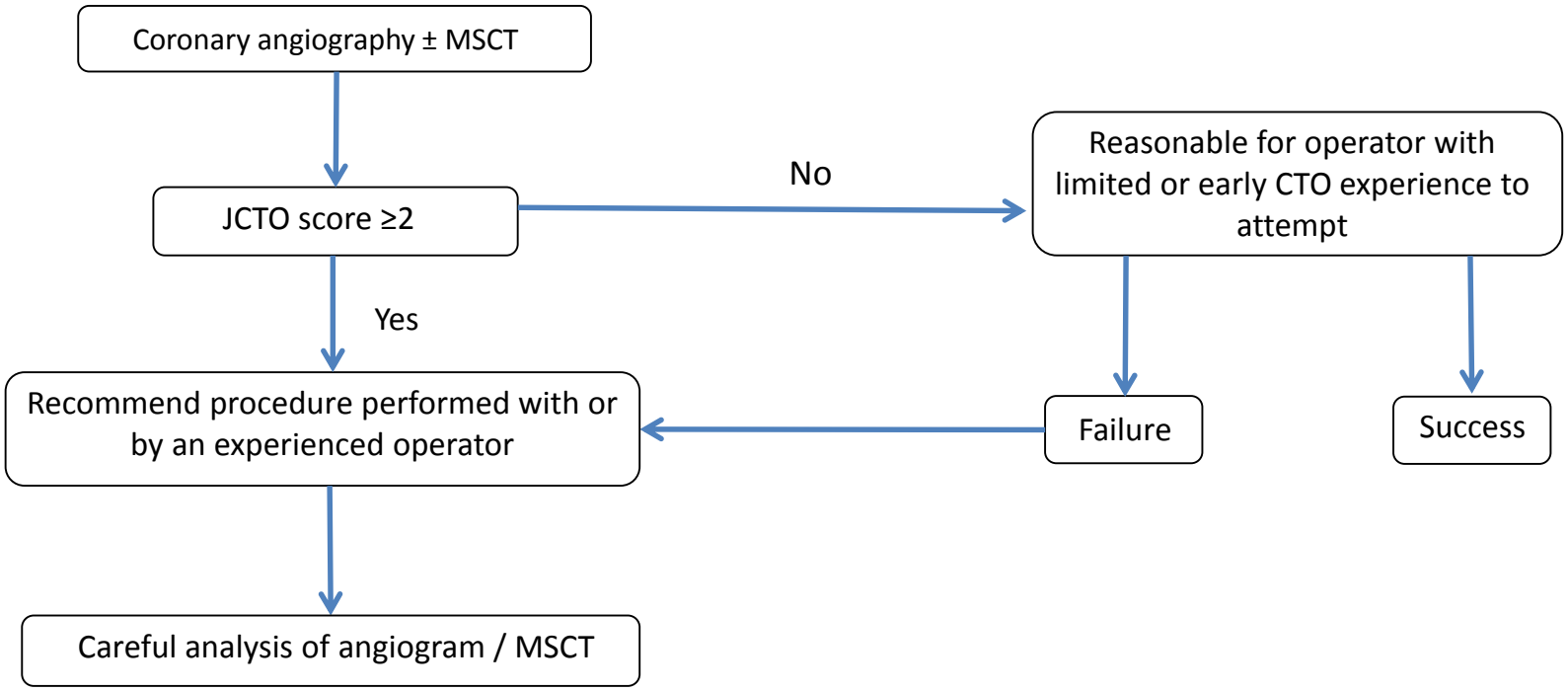
Strategies to bridge this gap:

Dissemination of knowledge

- Papers
- Proctoring
- Mentoring

Acceptance that not everyone can be an expert CTO operator and referral of appropriate cases

Bridging the Gap



Conclusions

- Antegrade wire escalation remains the most frequently used and safest crossing strategy
- The ADR technique is evolving and there is evidence that this is safe and effective
- We should be using controlled ADR with the Stingray system and avoid wire based ADR
- Ongoing education, training and proctorship/mentor programs are needed to disseminate knowledge
- Calcification remains problematic and new tools are needed