CTO Current Technique and Approaches

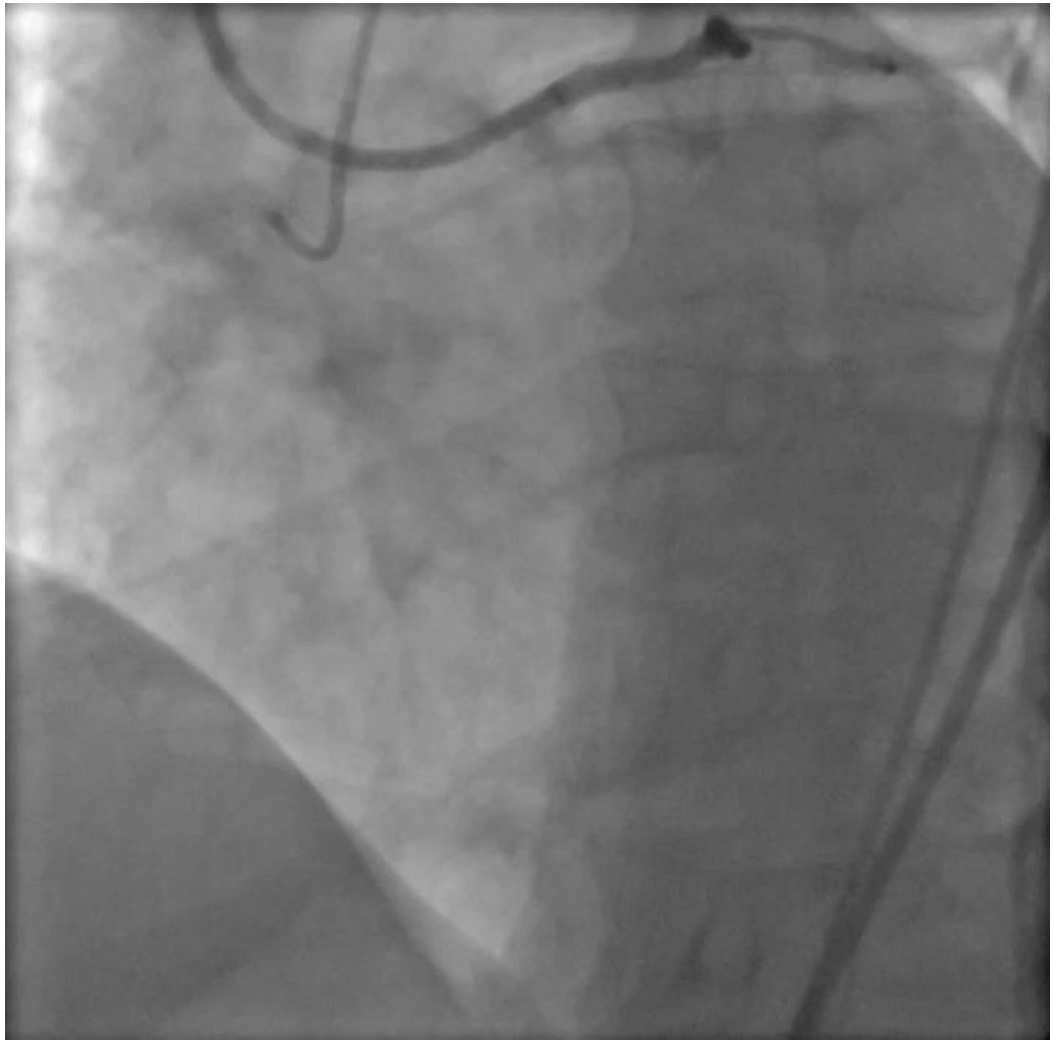
WELLINGTON CARDIOLOGY

Professor Scott Harding
Department of Cardiology
Wellington Hospital

Doing the basics right is key

WELLINGTON CARDIOLOGY

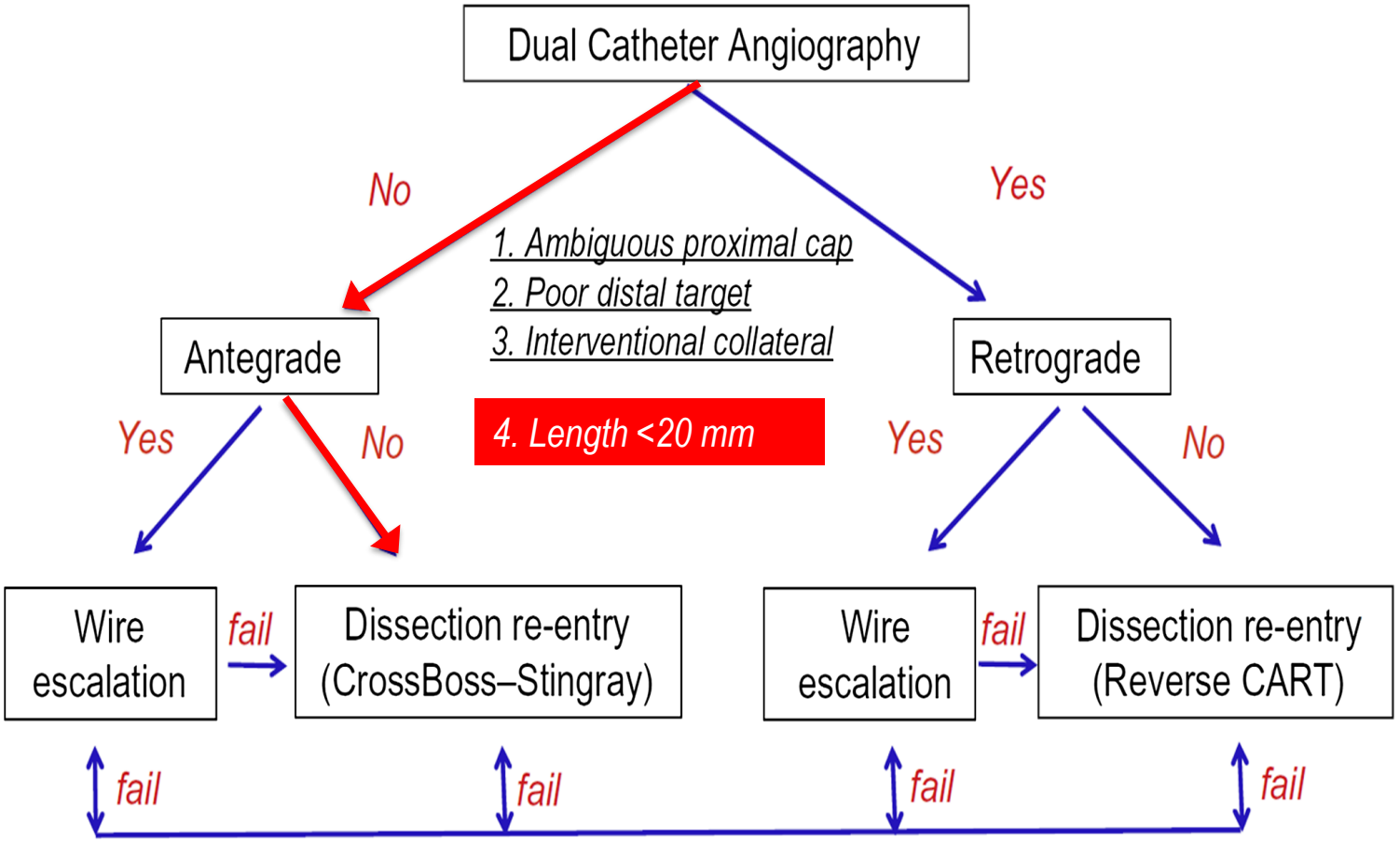
- Patient selection
- Avoid ad-hoc procedures
- Routine dual injections
- Careful analysis of the angiogram
- Routine use of microcatheters
- Have the equipment you need to succeed
- Have the equipment you need to deal with complications



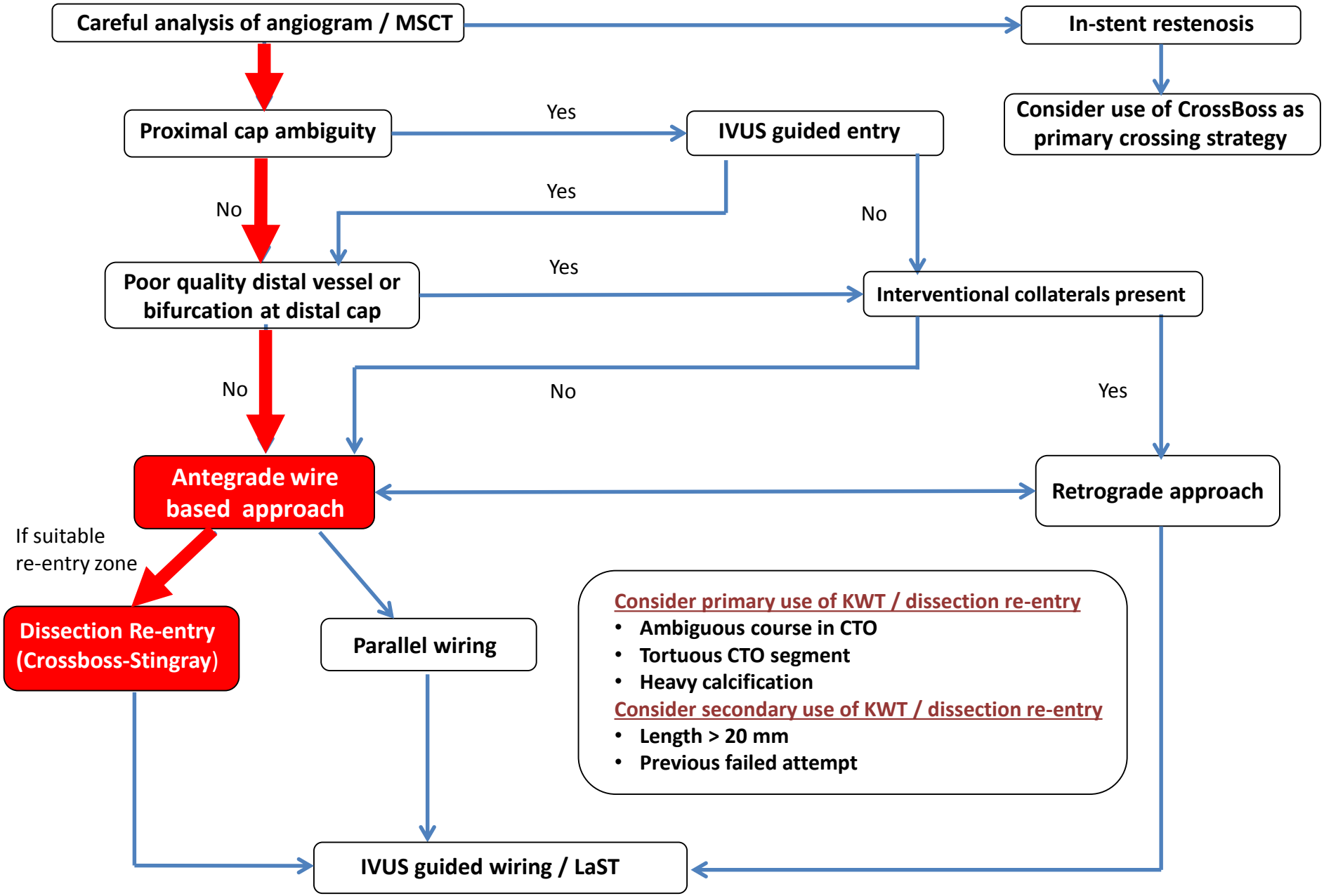
Antegrade wire escalation remains the most commonly used strategy

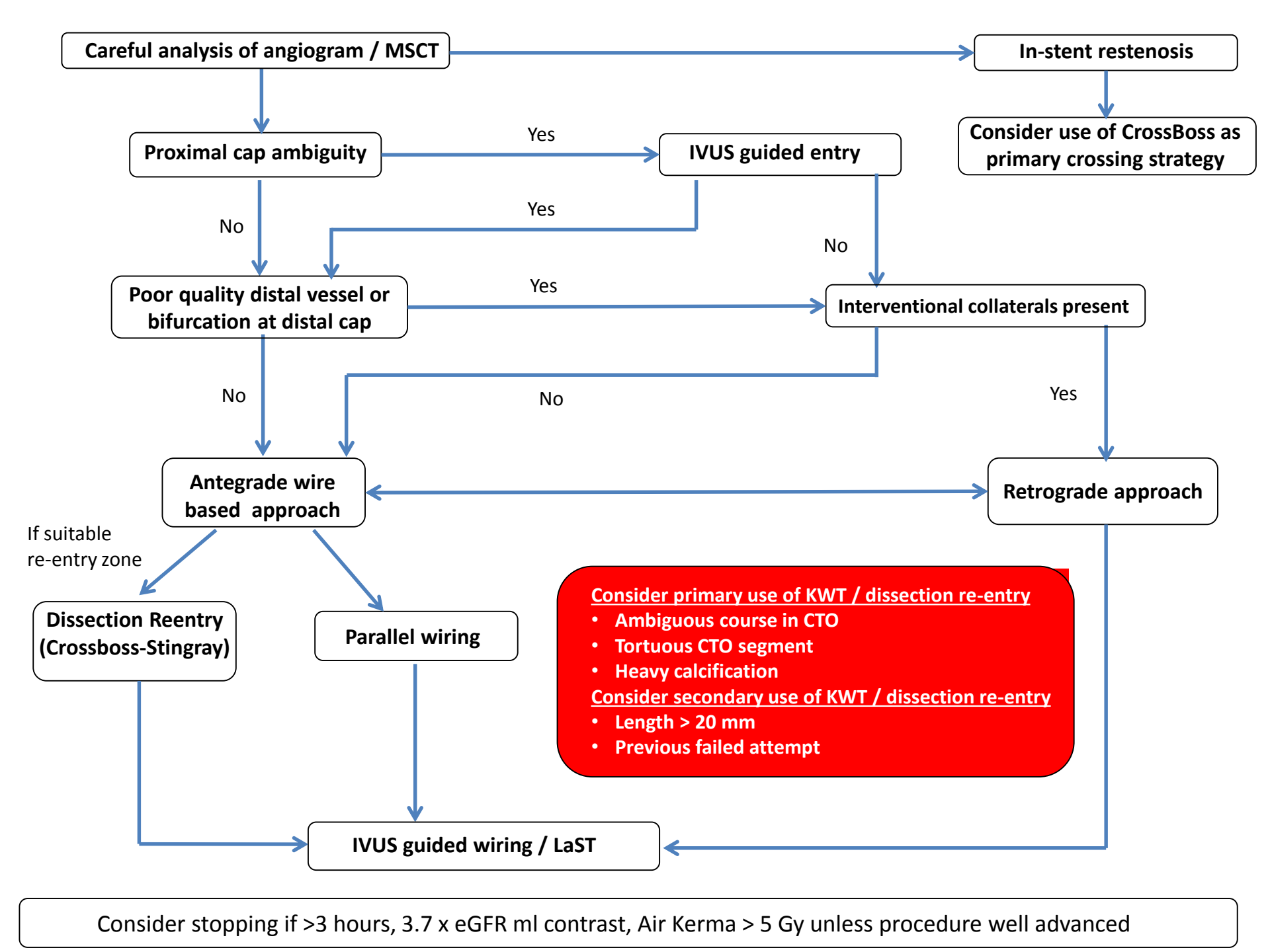
Authors	Acronym	Study Period	Cases	AWE first strategy	AWE Final Success Strategy
Konstantinidis et al.[89]	EURO-CTO registry	2008-2015	17,626	64.6%	—
Tajti et al.[60]	PROGRESS-CTO	2012–2017	3,055	75%	52%
Suzuki et al.[31]	Japanese CTO-PCI Expert Registry	2014–2015	2,846	72%	56%
Maeremans et al.[61]	RECHARGE	2014–2015	1,253	77%	58%
Sapontis et al.[3]	OPEN-CTO	2013–2017	1,000	55%	40.8%

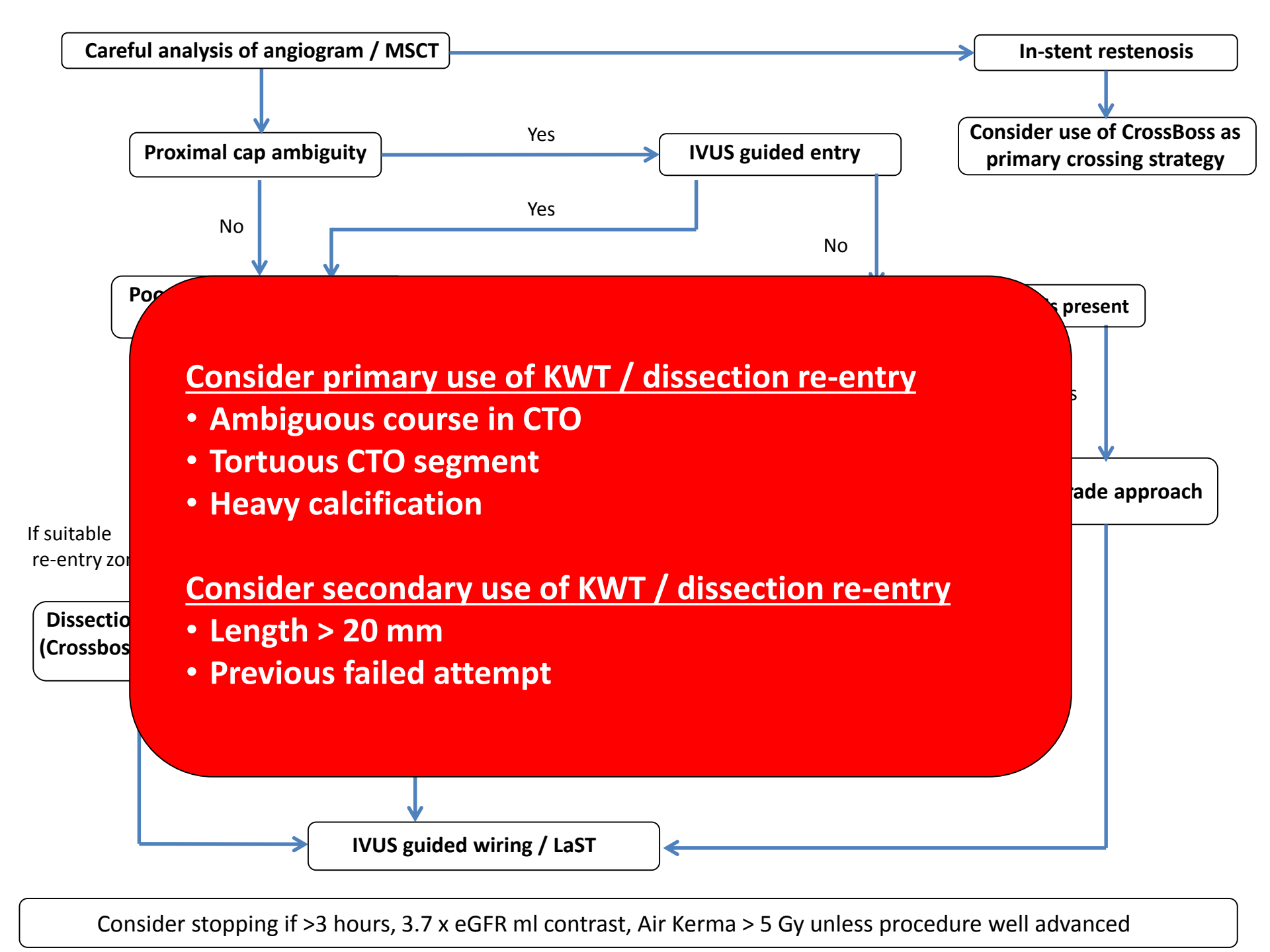
The Hybrid Algorithm



Chronic Total Occlusion Percutaneous Coronary Intervention: Evidence and Controversies, Volume: 7, Issue: 2, DOI: (10.1161/JAHA.117.006732)


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


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 Reentry (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


Careful analysis of angiogram / MSCT
In-stent restenosis
Proximal cap ambiguity
Yes
IVUS guided entry
Consider use of CrossBoss as primary crossing strategy
No
Yes
No
present
Consider primary use of KWT / dissection re-entry
• Ambiguous course in CTO
• Tortuous CTO segment
• Heavy calcification
ade approach
If suitable
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

WELLINGTON CARDIOLOGY

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)

WELLINGTON CARDIOLOGY

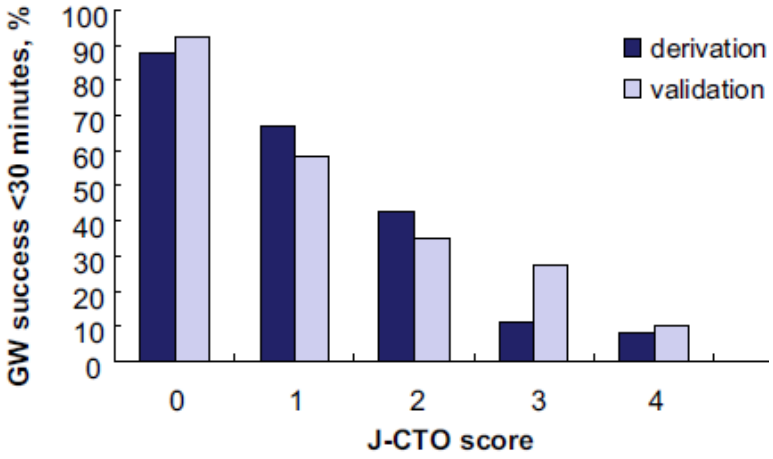
Mean lesion Length was 29.1 ± 23.8 mm

AWE was the primary strategy in 54.7%

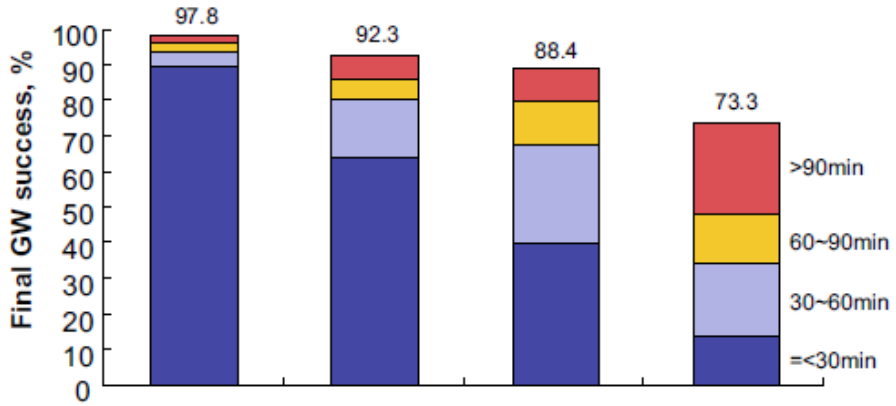
JACC Cardiovascular Interventions

Failure of AWE is linked to lesion complexity

WELLINGTON CARDIOLOGY



Patient number						
	329	65	82	92	63	24
	165	26	48	46	33	10

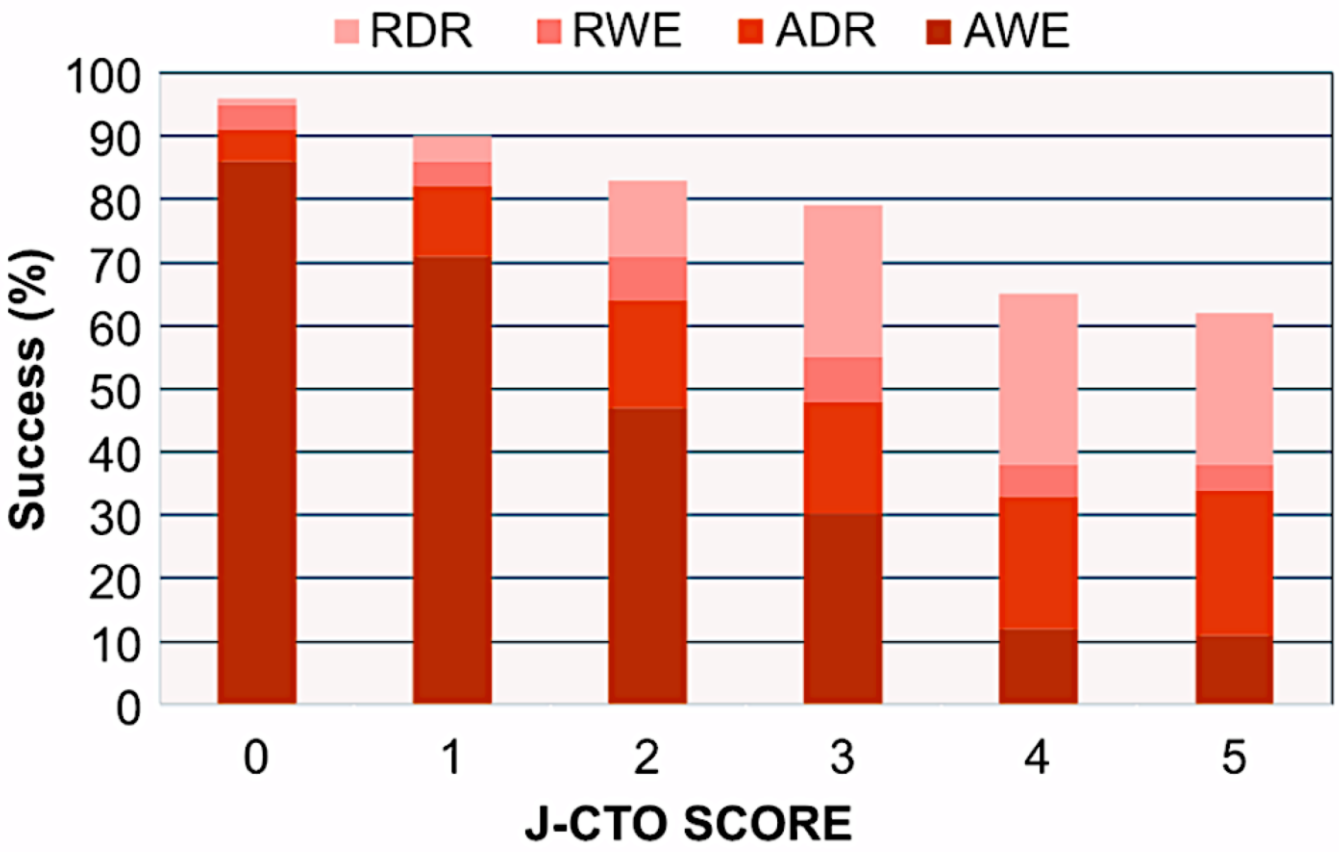


Risk groups:	Easy	Intermediate	Difficult	Very difficult
J-CTO score:	0	1	2	>=3
Patient number	494	91	130	138	135

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

Crossing Strategy Success by J-CTO Score

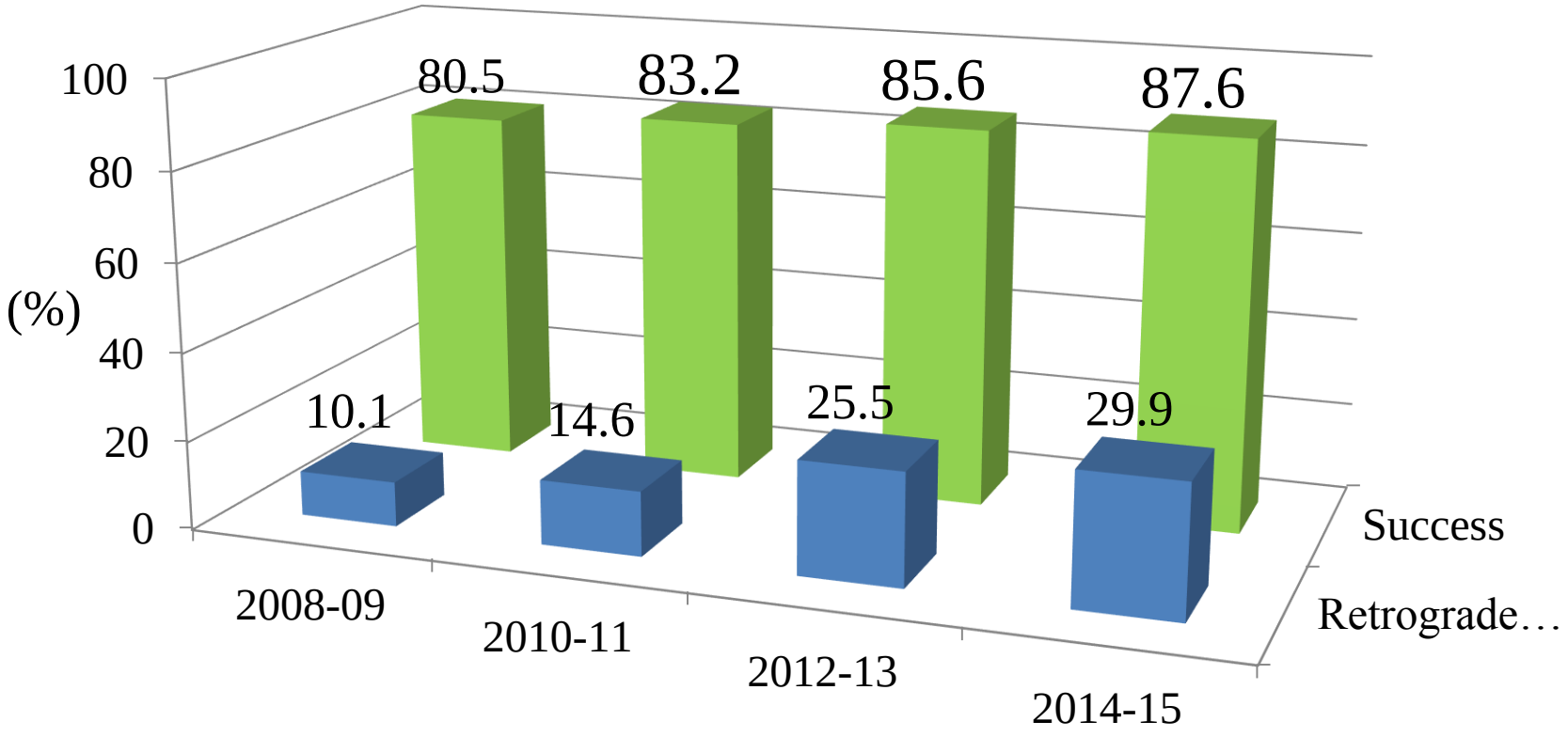
UK Hybrid Registry



As complexity increases use of dissection re-entry (antegrade *or* retrograde) techniques increases

Wilson WM, et al. Heart 2016;102:1486–1493.

Retrograde use and success rates European CTO Registry



Konstantinidis NV, et al. *Circ Cardiovasc Interv.* 2018

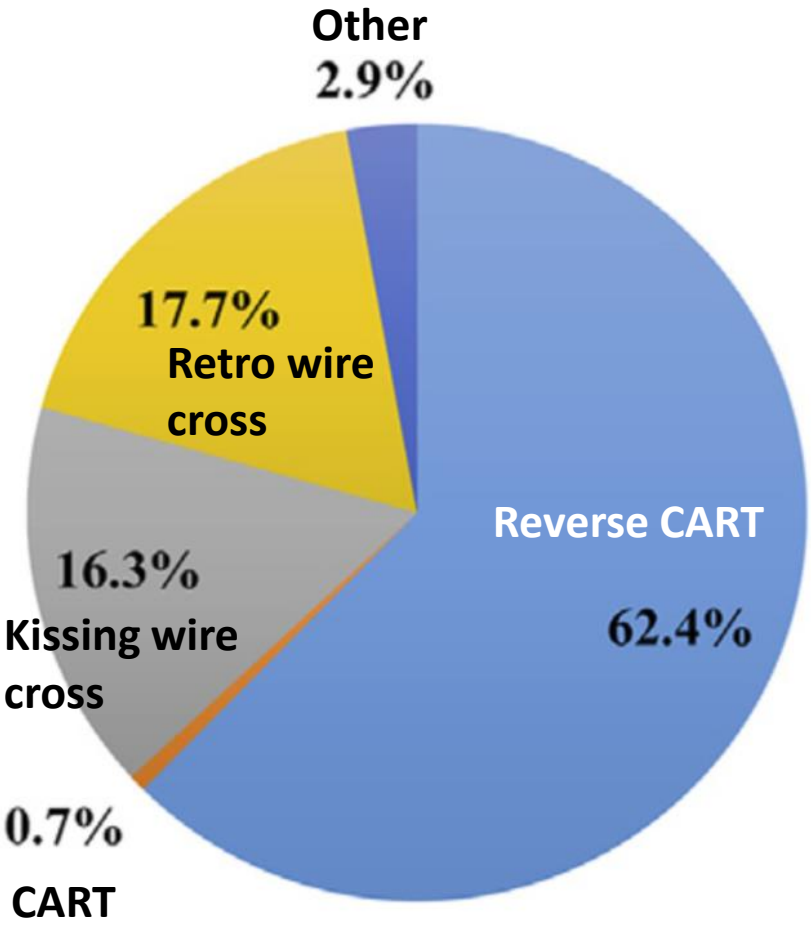
Frequency and success of Retrograde approach

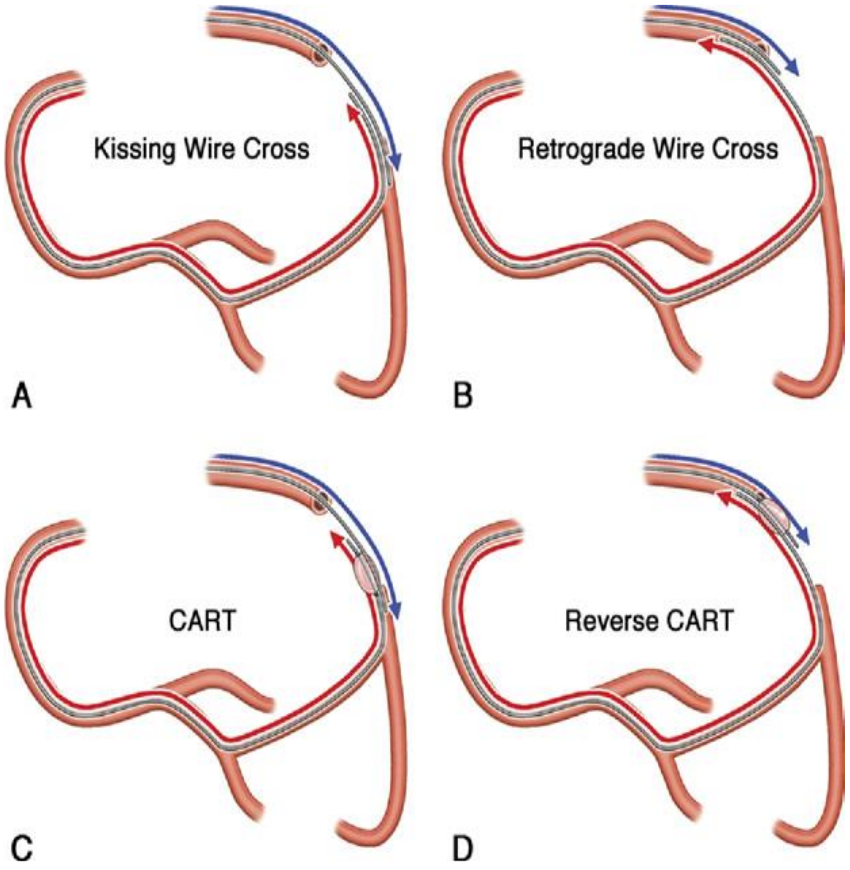
WELLINGTON CARDIOLOGY

	APCTO	Japanese Expert	PROGRESS	RECHARGE	OPEN CTO
	N=447	N=2596	N=1036	N=1253	N=1000
Retrograde attempted	48%	46%	42%	34%	-
Retrograde successful strategy	42%	33	26%	21%	35%
% retrograde success	86.4%	72%	63%	67%	-
ADR attempted	2%	3%*	36%	23%	-
ADR successful strategy	-	2%	26%	15%	24.3%
% ADR success	-	78%	72%	66%	-
Contrast dose (ml)	250 (200-320)	231 ± 106	260 (200–360)	250 (180-340)	262 ± 140
Fluoroscopy time (min)	48 (29-73)	-	44 (27–72)	35 (21-55)	50 ± 34
Procedure time (min)	100 (60-140)	160 ± 90	119 (82–175)	90 (60-120)	120 ± 64
Technical success rate	95%	90%	91%	86%	86%

*This represents IVUS guided wire re-entry

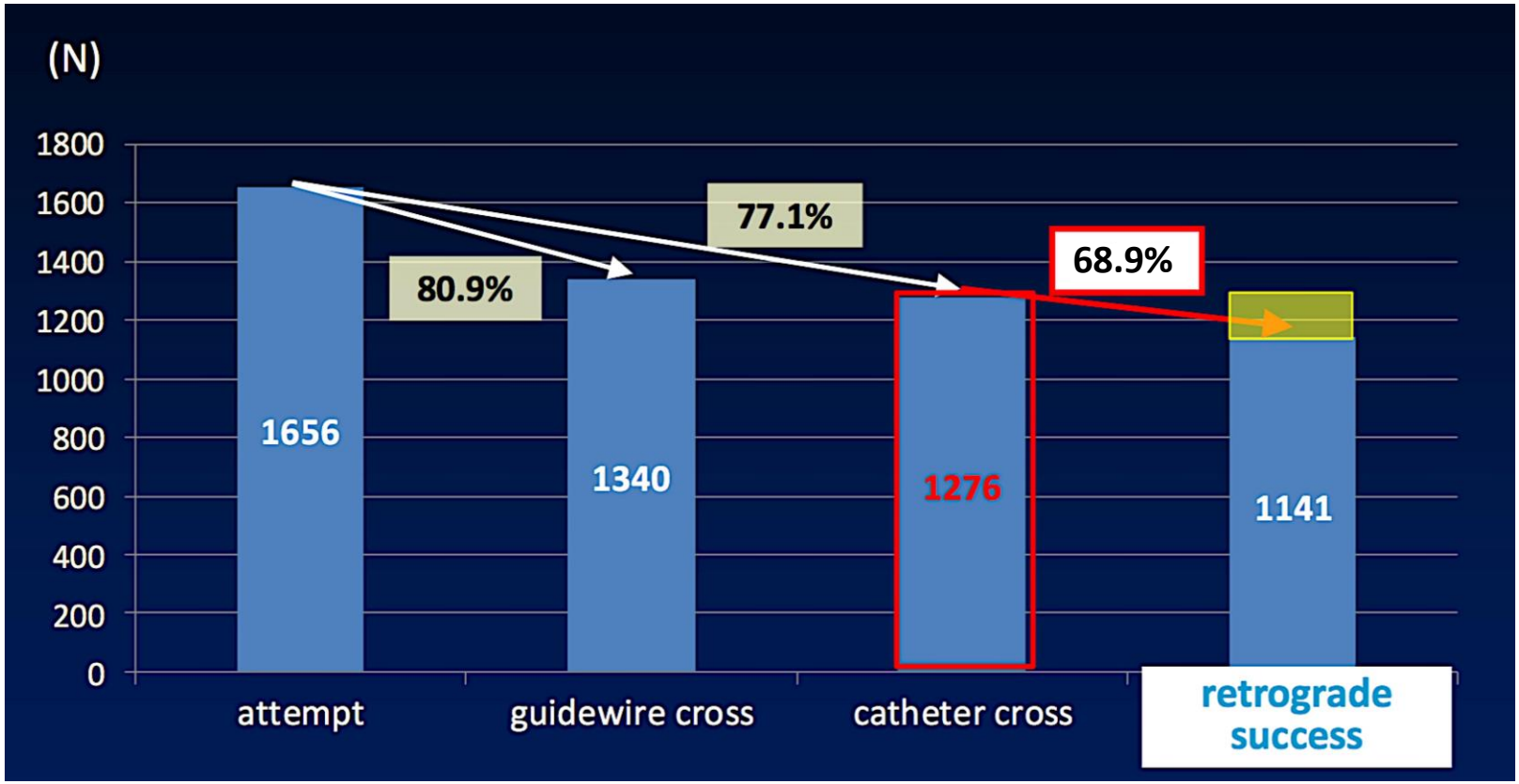
Use of Retrograde strategies





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

Why do we need ADR?

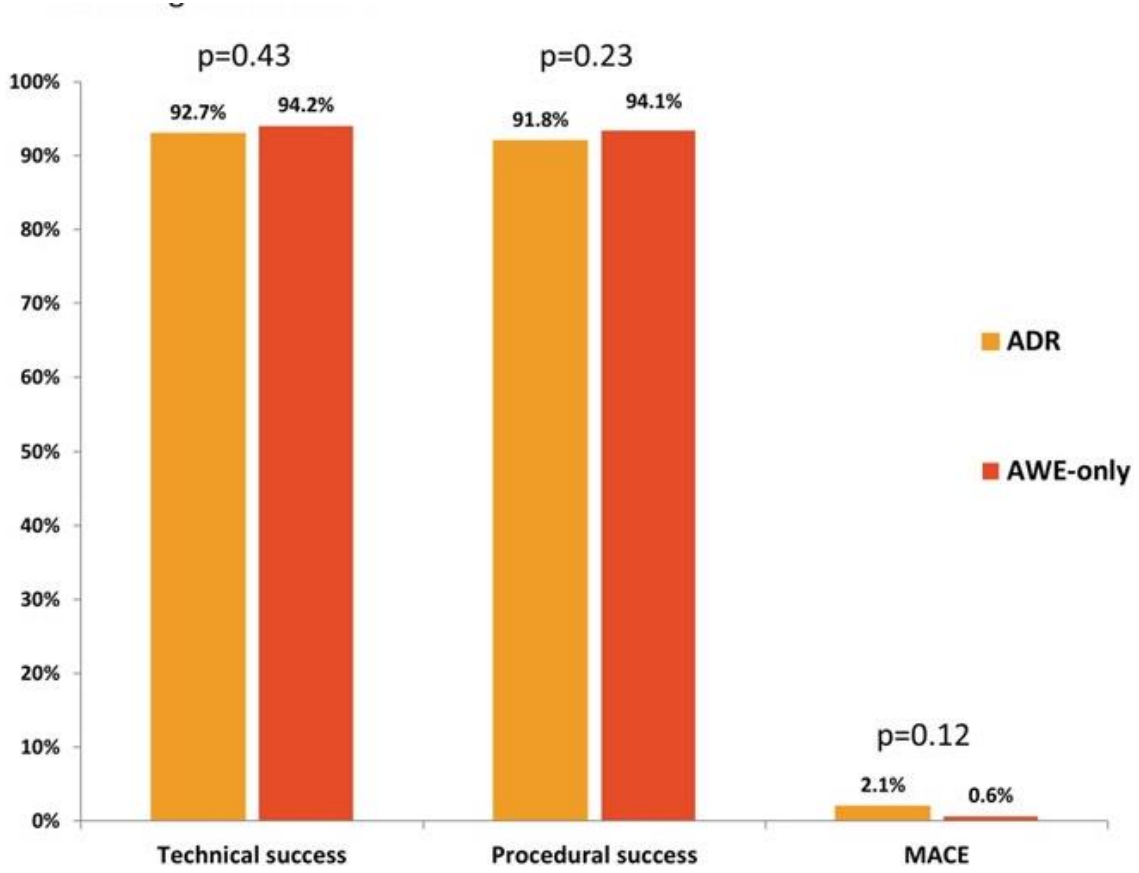


Retrograde channels are not always available and can't always be crossed

Japanese Registry Data from Retrograde Summit 2009-2012. Dr Tsuchikane TCT 2015

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

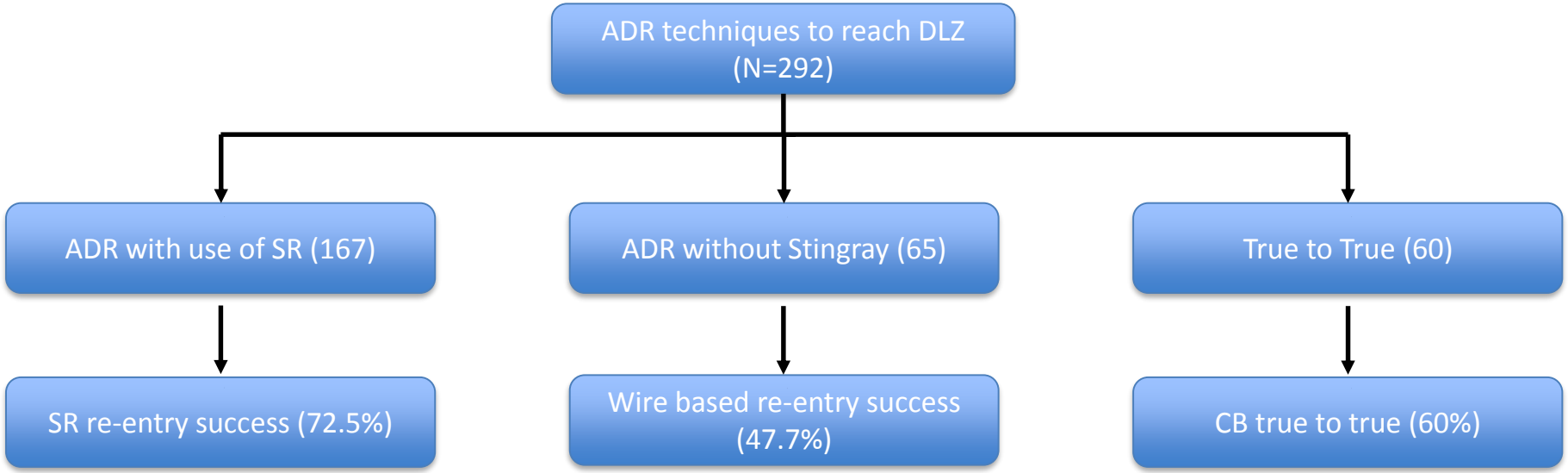
*MACE = In-hospital death, MI, urgent repeat TVR, tamponade or CVA

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



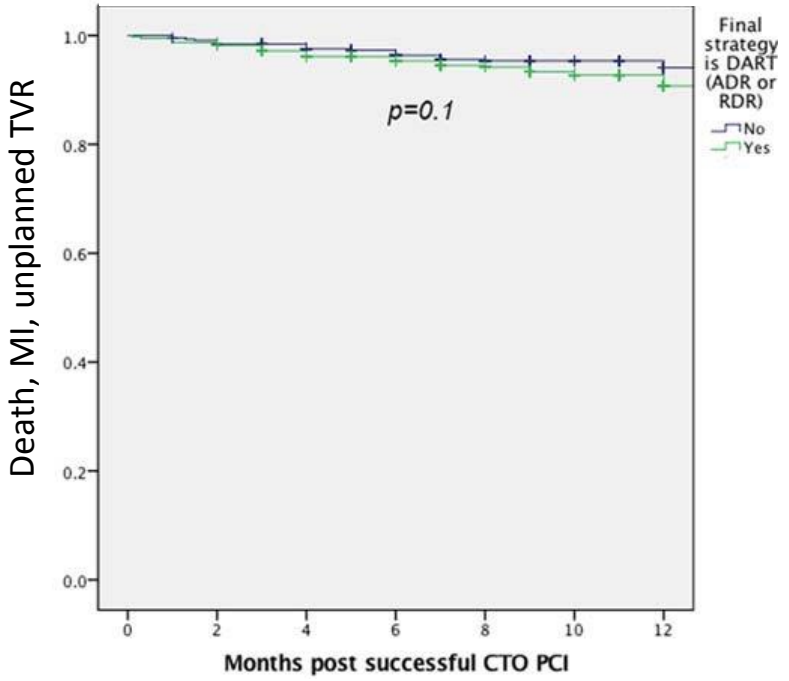
In Hospital ADR-associated major events occurred in 3.4% (n=10/292).

Maeremans et al. Circ Cardiovasc Interv. 2017

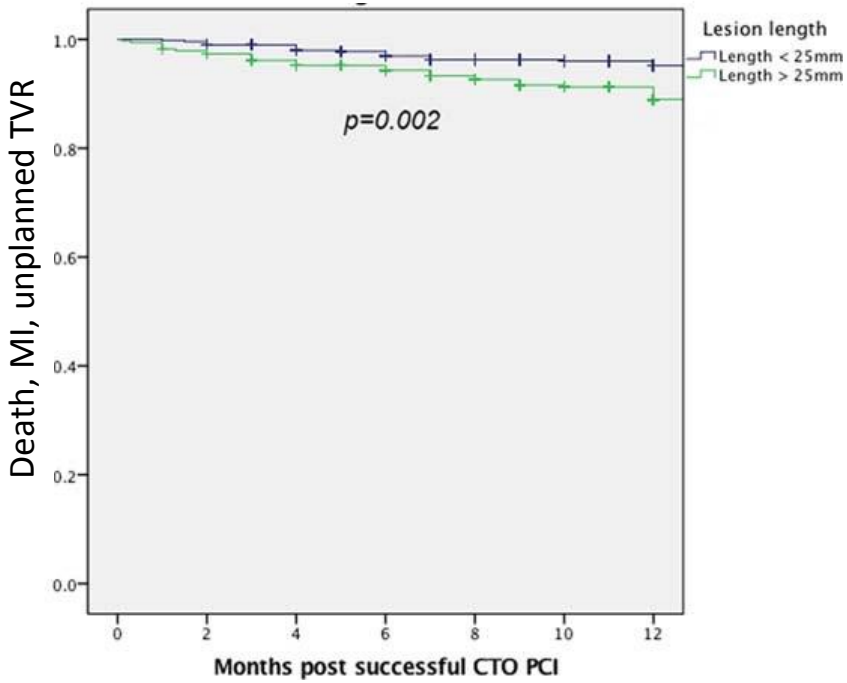
One-Year Outcomes After Successful Chronic Total Occlusion Percutaneous Coronary Intervention: The Impact of Dissection Re-Entry Techniques

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

WELLINGTON CARDIOLOGY

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.

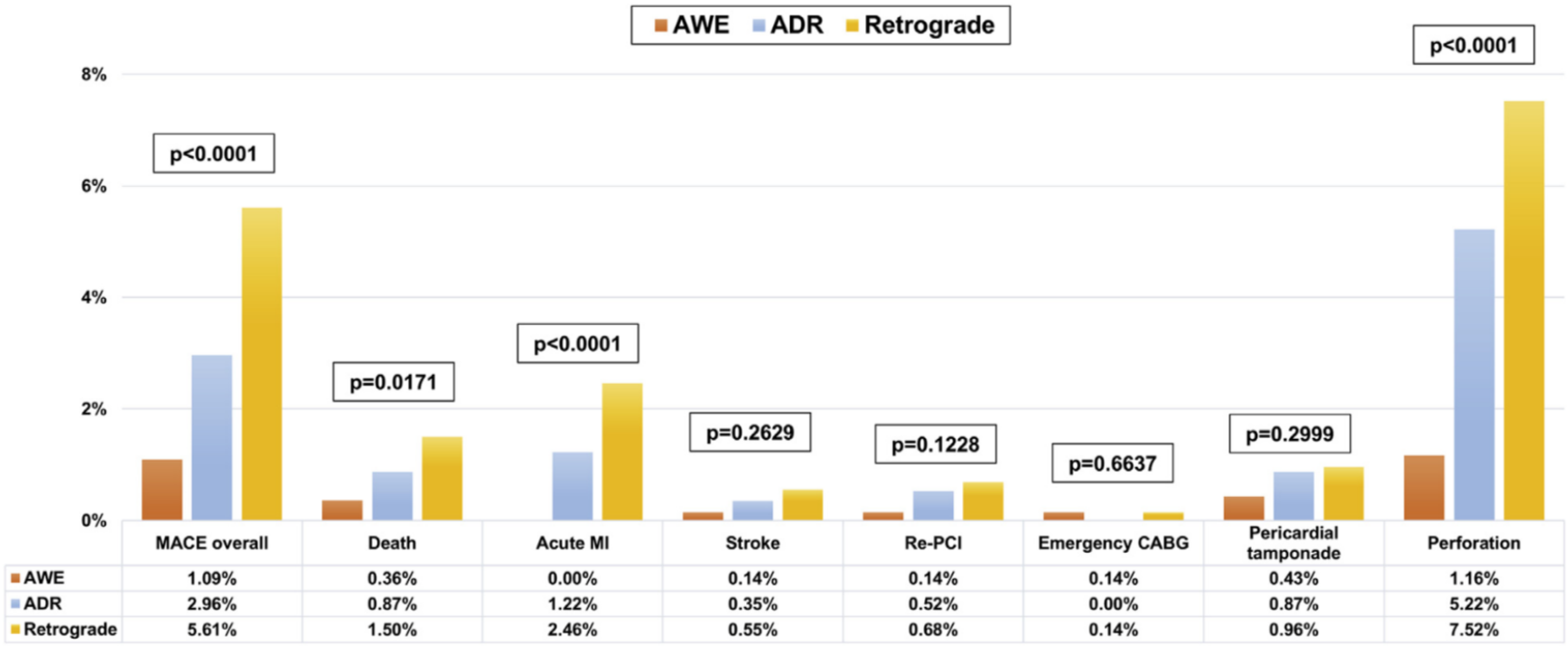
AWE: Antegrade wire escalation; ADR: Antegrade dissection re-entry; RWE: retrograde wire escalation; RDR: retrograde dissection re-entry; DART: dissection and re-entry.

W Wilson et al. CCI 2017;90:703–712

Complications with various techniques

WELLINGTON CARDIOLOGY

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



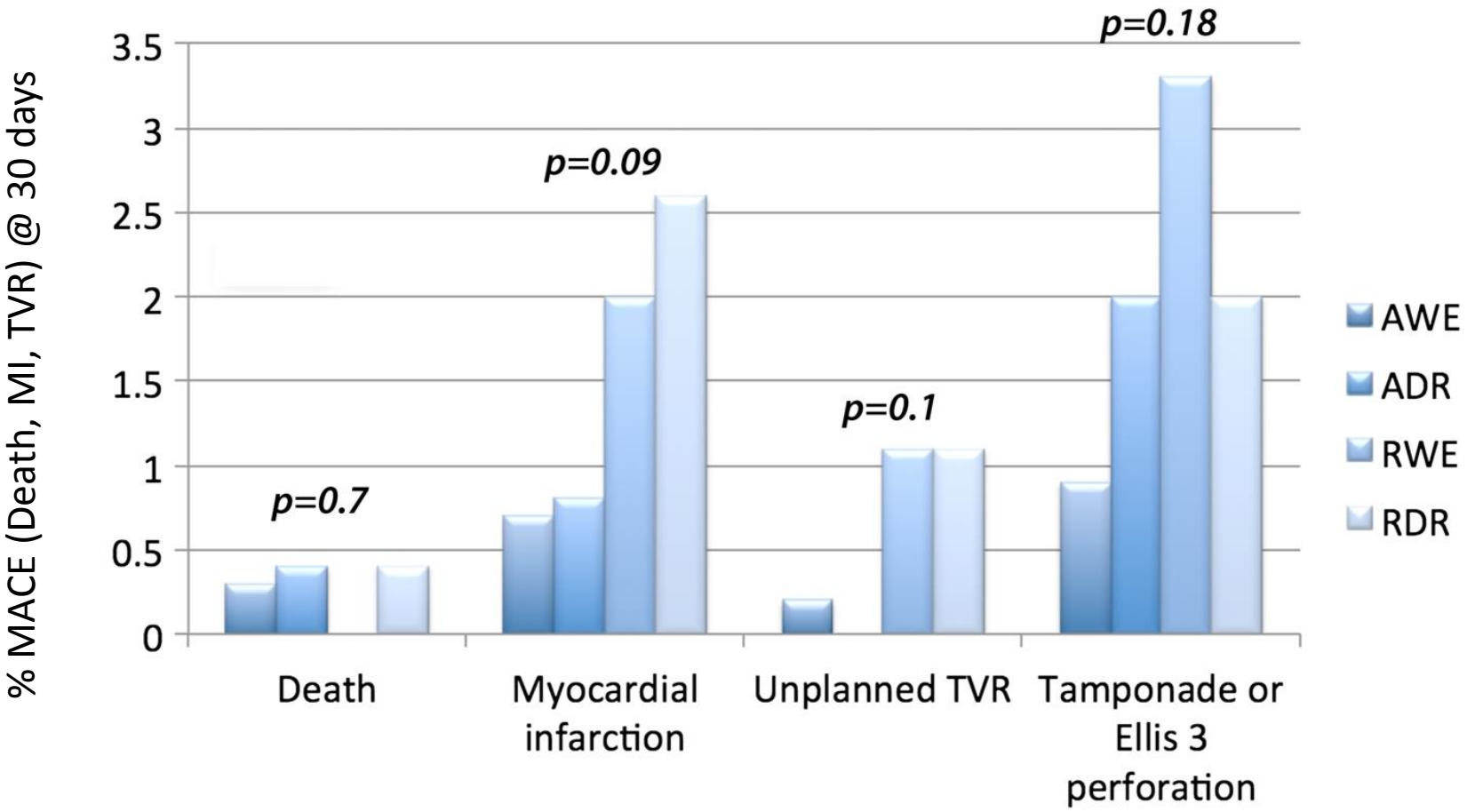
	MACE overall	Death	Acute MI	Stroke	Re-PCI	Emergency CABG	Pericardial tamponade	Perforation
AWE	1.09%	0.36%	0.00%	0.14%	0.14%	0.14%	0.43%	1.16%
ADR	2.96%	0.87%	1.22%	0.35%	0.52%	0.00%	0.87%	5.22%
Retrograde	5.61%	1.50%	2.46%	0.55%	0.68%	0.14%	0.96%	7.52%

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

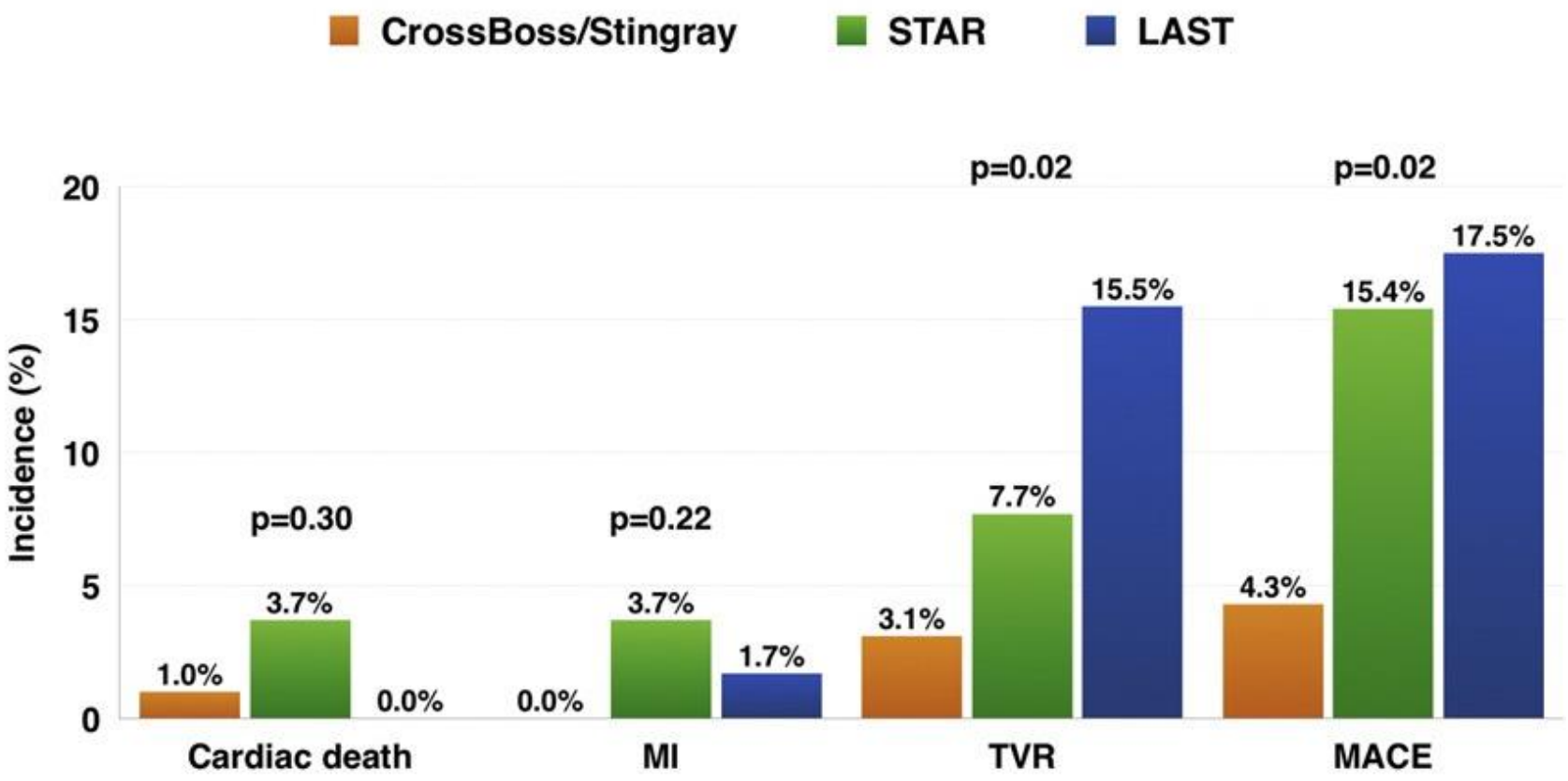
Tajti P et al. JACC CI 2018;11:1325-35

Complications with various techniques



Wilson WM, et al. Heart 2016;102:1486–1493

We should avoid uncontrolled or wire based ADR



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

Contemporary approach to ADR

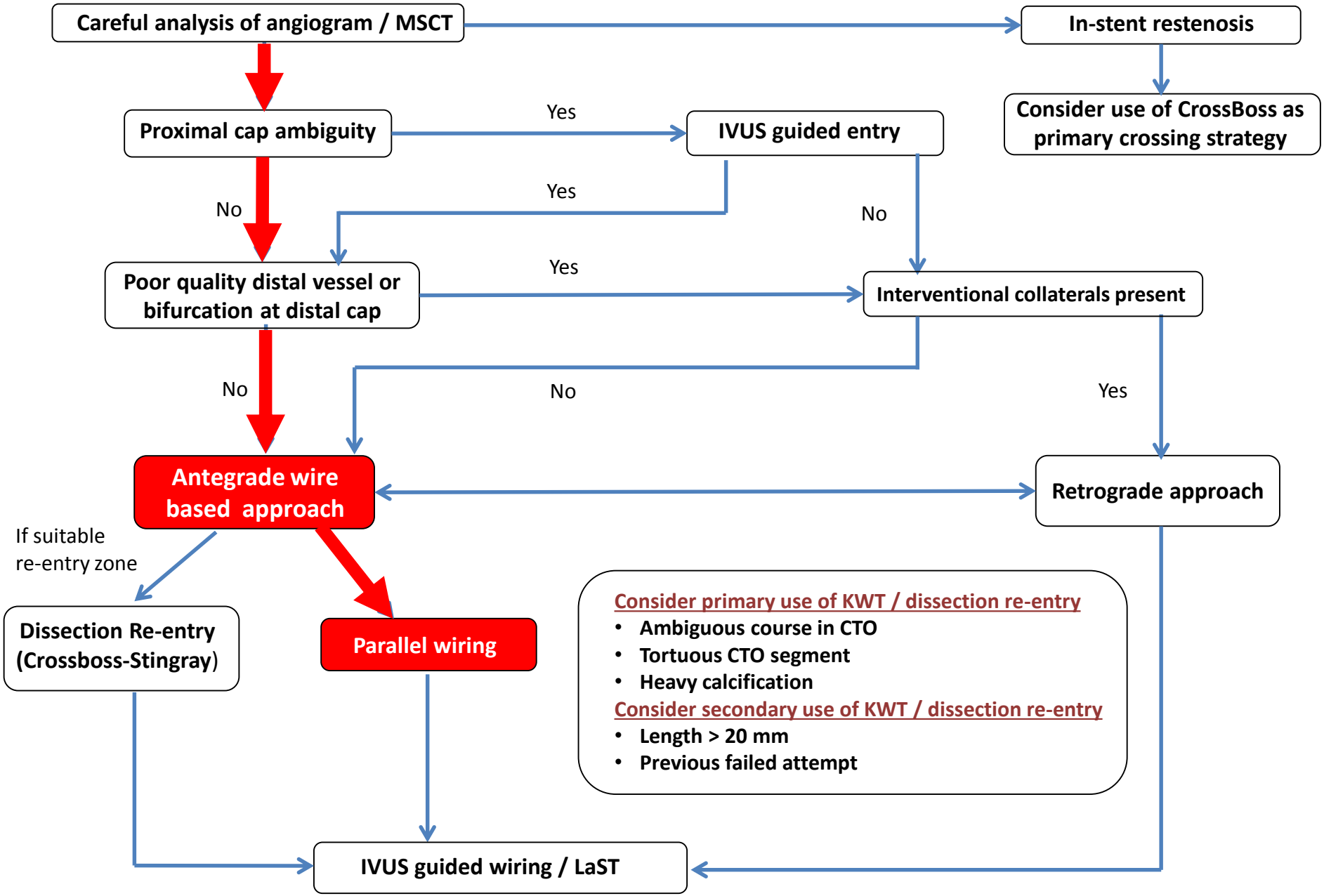
WELLINGTON CARDIOLOGY

	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

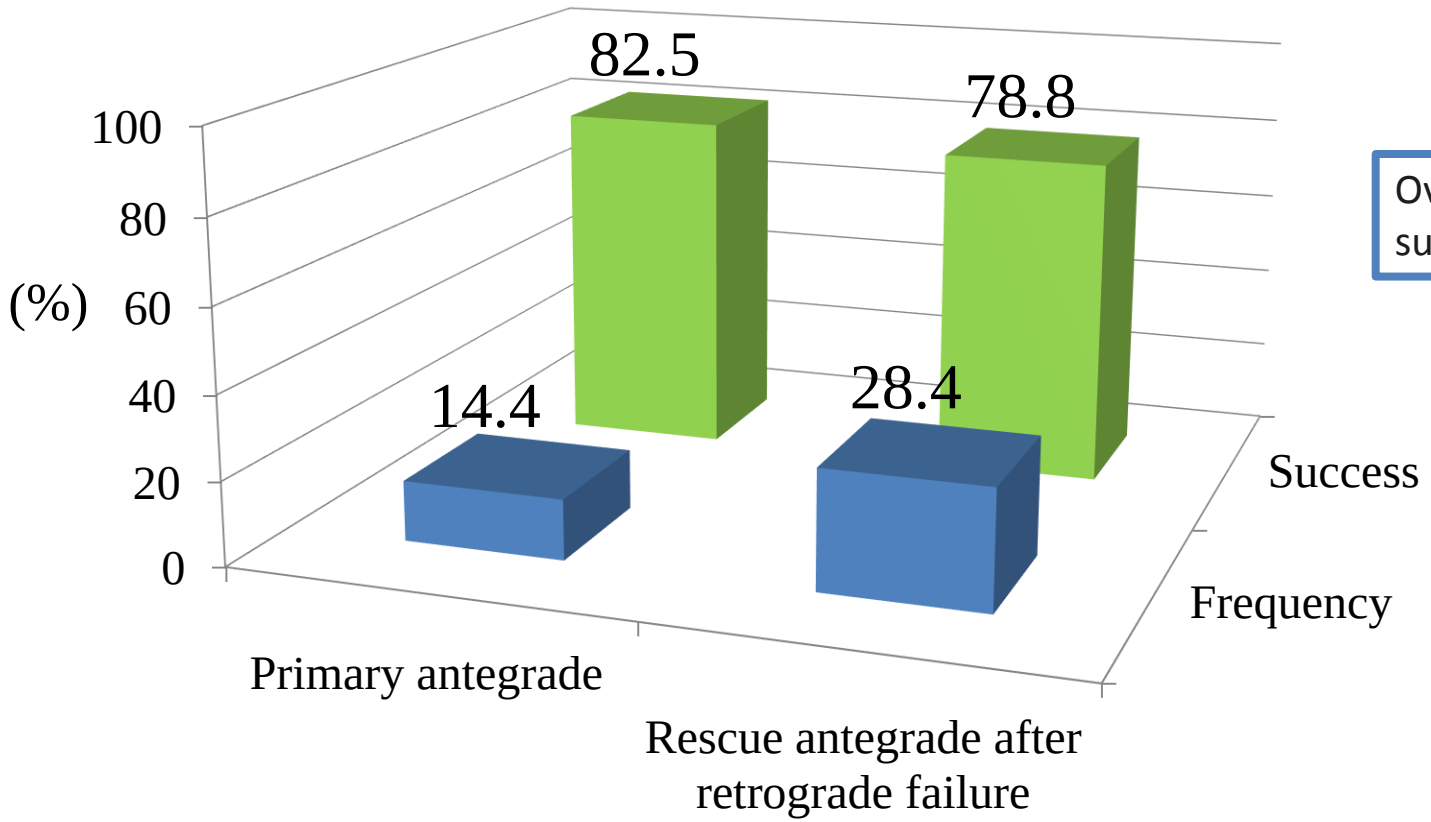
Frequency and success of ADR

	APCTO	Japanese Expert	PROGRESS	RECHARGE	OPEN CTO
	N=447	N=2596	N=1036	N=1253	N=1000
Retrograde attempted	48%	46%	42%	34%	-
Retrograde successful strategy	42%	33	26%	21%	35%
% retrograde success	86.4%	72%	63%	67%	-
ADR attempted	2%	3%*	36%	23%	-
ADR successful strategy	-	2%	26%	15%	24.3%
% ADR success	-	78%	72%	66%	-
Contrast dose (ml)	250 (200-320)	231 ± 106	260 (200–360)	250 (180-340)	262 ± 140
Fluoroscopy time (min)	48 (29-73)	-	44 (27–72)	35 (21-55)	50 ± 34
Procedure time (min)	100 (60-140)	160 ± 90	119 (82–175)	90 (60-120)	120 ± 64
Technical success rate	95%	90%	91%	86%	86%

*This represents IVUS guided wire re-entry


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

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

WELLINGTON CARDIOLOGY

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

Global Consensus Statement

WELLINGTON CARDIOLOGY

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/re-entry, retrograde wire escalation, and retrograde dissection/re-entry
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

Brilakis et al, Circulation 2019

Conclusions

WELLINGTON CARDIOLOGY

- Antegrade wiring, antegrade dissection and re-entry and the retrograde approach are all complementary and necessary crossing strategies.
- Antegrade wiring is the most common initial technique, while retrograde and antegrade dissection and re-entry are often required for more complex CTOs.
- There is an increasing body of data demonstrating the safety and effectiveness of targeted ADR with the Stingray system
- Wire based ADR strategies should be avoided as they are associated with higher in-hospital and long-term outcomes