Predictors and Clinical Outcomes of Successful Recanalization in Native Coronary Chronic Total Occlusion: The B-CTO (Busan Single-Center CTO Registry) Data

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Topics

1. Predictors of CTO Opening
2. Long-term Outcomes

Review PCI Guidelines

- **CTO-PCI is holding a Class II recommendation in current guidelines.**

CTOs Recommendations	Class	Level
2011 AHA		
PCI of a CTO in patients with appropriate clinical indications and suitable anatomy is reasonable when performed by operators with appropriate expertise	IIa	B
2014 ESC		
Percutaneous recanalization of CTOs should be considered in patients with expected ischemia reduction in a corresponding myocardial territory and/or angina relief.	IIa	B
Retrograde recanalization of CTOs may be considered after a failed anterograde approach or as the primary approach in selected patients.	IIb	C

Levine GN, et al. J Am Coll Cardiol 2011.
Kolh P, et al. Eur J Cardiothorac Surg 2014.

However…

- **It is less attempted, due to:**

1. Historically low procedural success rate (51-74%);
2. More complexity (GC support, dedicated devices: micro-catheter, GWs, IVUS, “hybird” technique, balloon/stent delivery);
3. High risk of complication (myocardial injury, perforation, tamponade, contrast induced nephropathy).

Abbott JD, et al. Am J Cardiol 2006.
Brilakis ES, et al. JACC Cardiovasc Interv 2015.

CTO Meta-analysis

- **Successful CTO opening may be benefit for:**

1. Angina symptom improvement;
2. LV function improvement;
3. Survival improvement;
4. Reduce subsequent MI.

Khan MF, et al. Catheter Cardiovasc Interv 2015;85:781-794.
Christakopoulos GE, et al. Am J Cardiol 2015;115:1367-1375.

What the Critical for CTO Opening Success?

1. **Pre-procedure Evaluation**, e.g.

   - clinical presentation, CTO lesion characteristics;

2. **Dedicated CTO devices** (e.g. **GWs**, micro-catheter)

3. **Operators' Skills**

Brilakis ES, et al. JACC Cardiovasc Interv 2015.

What the Critical for CTO Opening Success?

- **Pre-procedure Evaluation is major critical.**

  ➢ **Like J-CTO Score…**

Japanese Multicenter CTO Registry (J-CTO) Score

- As well known, J-CTO score was widely used as a tool for assessment of lesion severity and prediction of successful guidewire crossing within 30 min.

Table 4. Difficulty Score for CTO Lesions (J-CTO Score): 5 Selected Independent Predictors Identified by the Forward/Backward Procedure

Variables	Odds Ratio (95% CI)	Beta Coefficient	Point
Previously failed lesion	0.39 (0.15–0.97)	0.93	1
Blunt stump type	0.32 (0.18–0.55)	1.14	1
Bending	0.34 (0.20–0.58)	1.09	1
Calcification	0.26 (0.15–0.44)	1.36	1
Occlusion length ≥20 mm	0.19 (0.09–0.39)	1.65	1

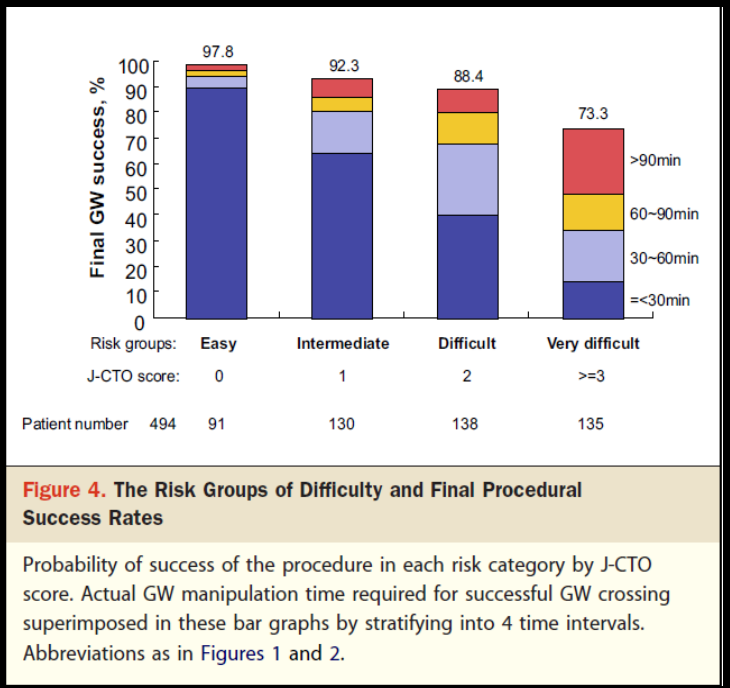


Figure 4. The Risk Groups of Difficulty and Final Procedural Success Rates

Probability of success of the procedure in each risk category by J-CTO score. Actual GW manipulation time required for successful GW crossing superimposed in these bar graphs by stratifying into 4 time intervals. Abbreviations as in Figures 1 and 2.

Morino Y, et al. JACC: Cardiovasc interv 2011;4:213-221.

However…

- **J-CTO score limitations:**

  1) Only use angiographic parameters;

  2) Did not predict the final technique success.

Brilakis ES, et al. JACC Cardiovasc Interv 2015

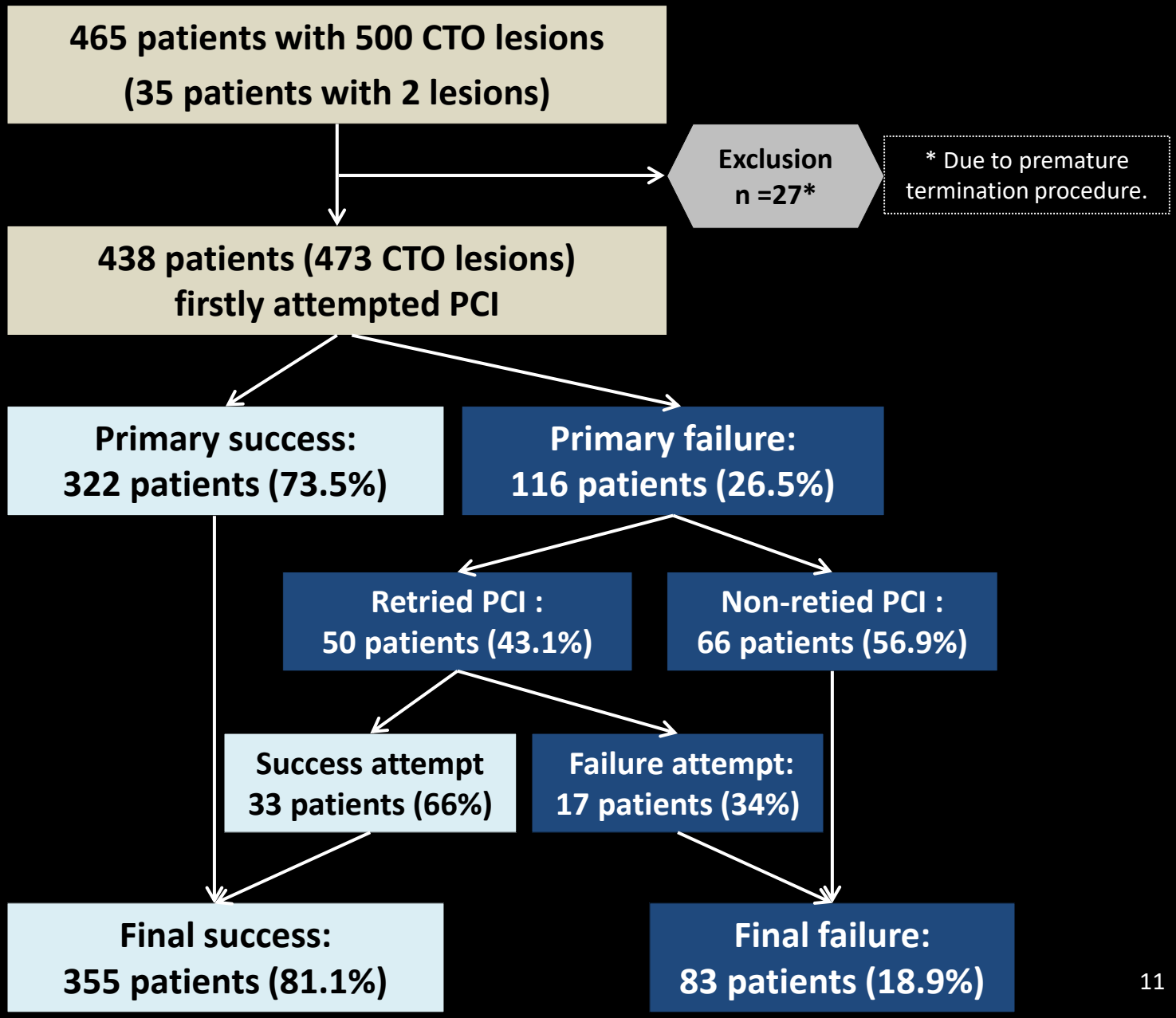
Objective

- Whether J-CTO score is suitable for Korean CTO cases?

  If not,

- We aim to make and validate a novel scoring system called the B-CTO score, which takes into account clinical and angiographic predictors in Busan CTO Registry.

Patient flow and overall study design



Study Criteria

- **Inclusion criteria**
  - Patients were first-attempted CTO-PCI.
- **Exclusion criteria**
  - Early terminated procedure.
  - Patients presented AMI within 4 weeks.
  - High risk of bleeding
  - Severe kidney dysfunction.
  - Cancer, life expectancy <3 years.

Study Definitions

- Chronic Total Occlusion (CTO): TIMI flow 0 with >3-month duration.
- Angiographic success: <20% of final residual stenosis with TIMII grade ≥2 flow on visual assessment.
- Hard major clinical events:
  - HMACE: composite of CV death, non-fatal MI and stroke.

Sianos G, et al. EuroIntervention 2012;8:139-145.
Godino C, et al. Int J Cardiol 2013;168:1402-1409.

Statistical Analysis

- **PASW Statistics (version 18.0; SPSS Inc., Chicago, IL, USA)**
  - Continuous variables: Independent-samples t-test (or Mann-Whitney test)
  - Categorical variables: Chi-square statistics or Fisher's exact test.
  - **Multivariate logistic regression, Hosmer-Lemeshow test.**
  - **ROC curves comparison analysis.**
- **SAS software (version 9.4, SAS Institute, Cary, NC, USA)**
  - Integrated discrimination improvement (**IDI**) and net reclassification improvement (**NRI**).

Results

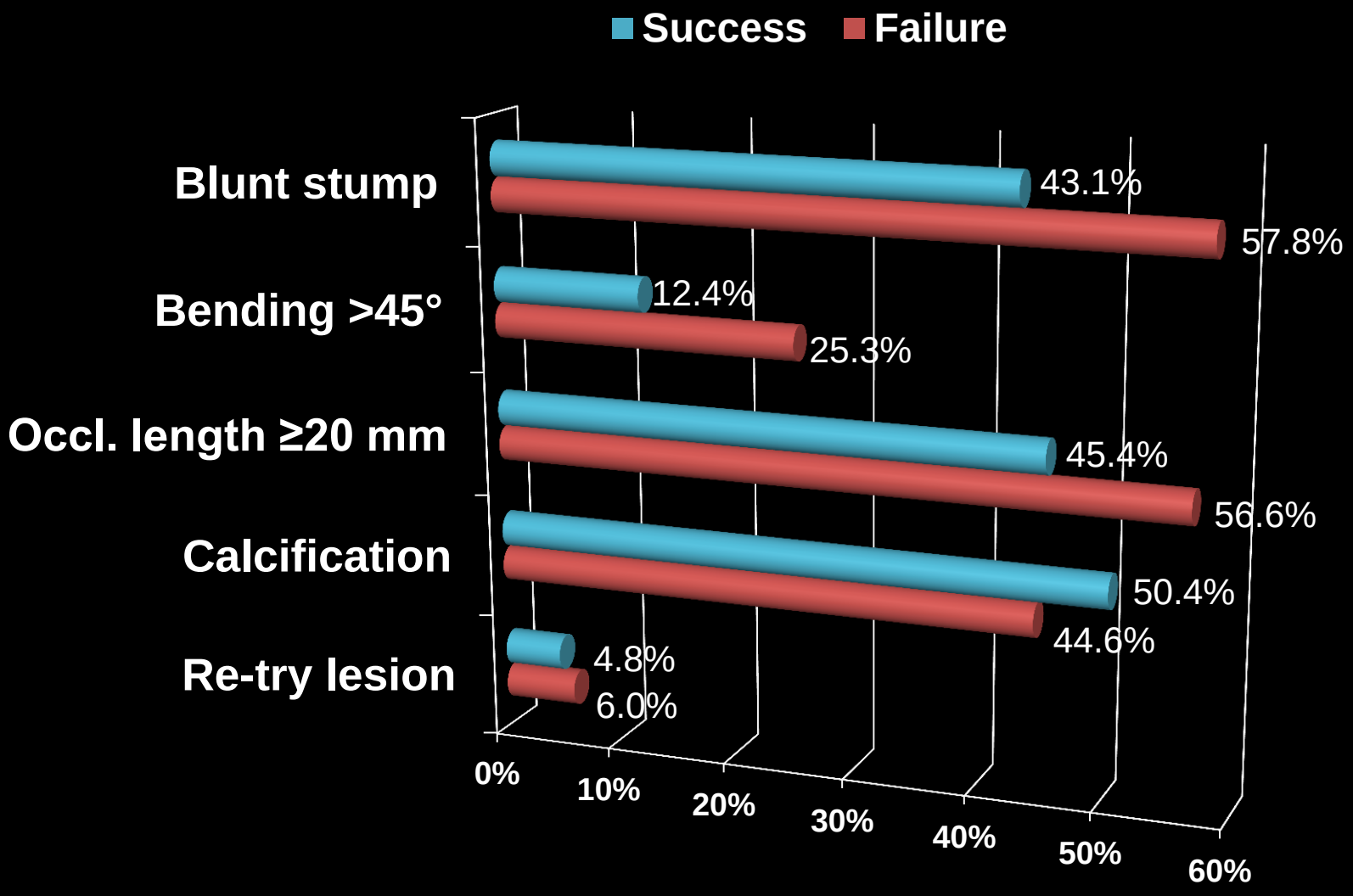
Results (1) Baseline clinical data

Variables	Failure (n =83)	Success (n =355)	P value
Age, years	62±10	61±10	0.250
≥75, n (%)	14 (16.9)	36 (10.1)	0.083
Male gender, n (%)	56 (67.5)	278 (78.3)	0.037
BMI, kg/m^2	24.9±3.4	25.0±3.3	0.926
Cardiovascular risk factor, n (%)			
Hypertension	48 (57.8)	194 (54.6)	0.600
Diabetes	29 (34.9)	130 (36.6)	0.774
Dyslipidemia	16 (19.3)	59 (16.6)	0.563
Current Smoking	20 (24.1)	91 (25.6)	0.772
Previous disease, n (%)			
Prior MI	9 (10.8)	55 (15.5)	0.280
Prior PCI	20 (24.1)	112 (31.5)	0.188
Prior CABG	1 (1.1)	6 (1.7)	>0.999
Clinical presentation, n (%)			0.431
Stable angina	30 (36.1)	114 (32.1)	
Unstable angina	30 (36.1)	156 (43.9)	
Current MI	23 (27.8)	85 (24.0)	
LVEF, %	50±12	51±12	0.982
LVEF <40%, n (%)	14 (16.9)	68 (19.2)	0.631

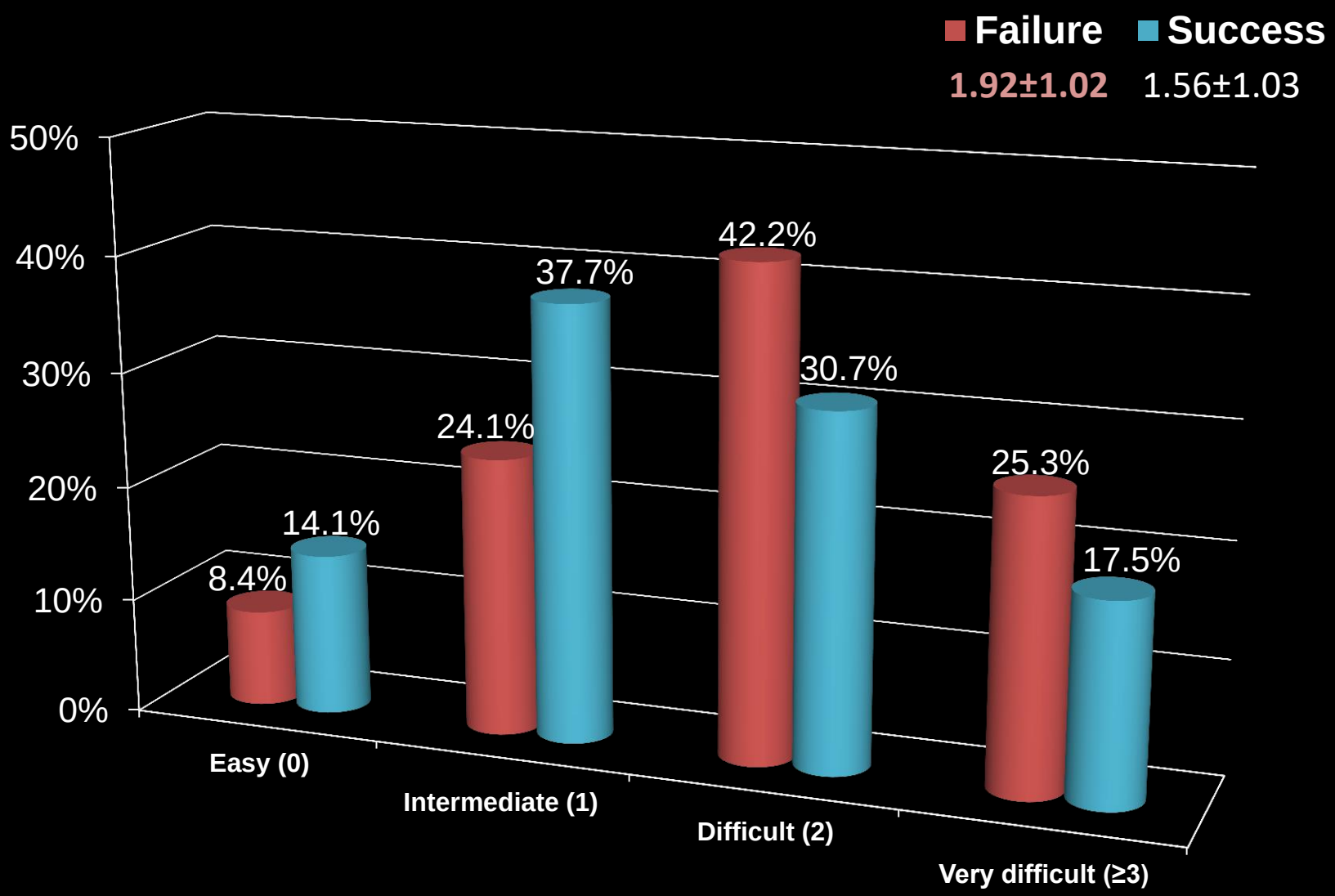
Results (2) Angiographic data

Variables	Failure (n =83)	Success (n =355)	P value
Multi-vessel, n (%)	59 (71.1)	262 (73.8)	0.614
CTO lesion location, n (%)			0.457
Proximal	43 (51.8)	158 (44.5)	
Mid	26 (31.3)	122 (34.3)	
Distal	14 (16.9)	75 (21.1)	
Target CTO artery, n (%)			0.039
LAD	27 (32.5)	151 (42.5)	
LCX	8 (9.6)	53 (14.9)	
RCA	48 (57.8)	151 (42.5)	

Results (3) J-CTO score members

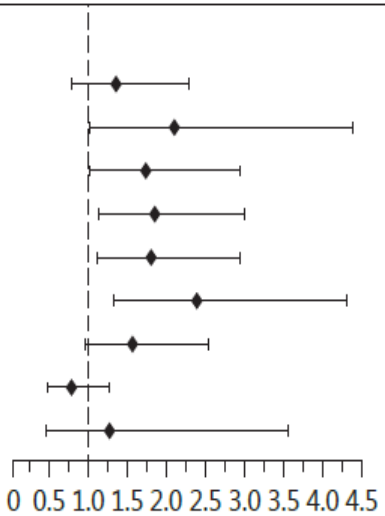


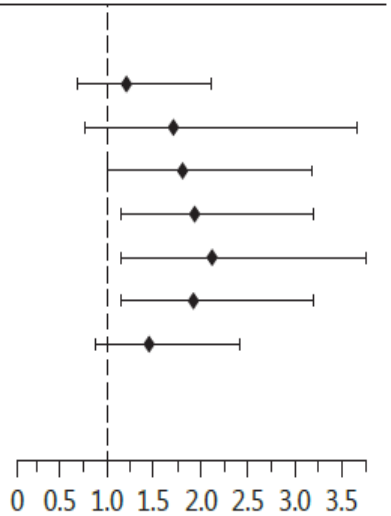
Results (4) J-CTO score points



Results (5) Multivariate Logistic Regression

Predictors	Crude OR (95% CI)	*p* value	Adjusted OR (95% CI)	*p* value
Age <60 years	Reference			
Age 60 – 74 years	1.36 (0.80 – 2.29)	0.252	1.21 (0.69 – 2.11)	0.507
Age ≥75 years	2.11 (1.02 – 4.38)	0.045	1.70 (0.78 – 3.67)	0.180
Female gender	1.74 (1.03 – 2.94)	0.038	1.80 (1.02 – 3.18)	0.042
CTO located in RCA	1.85 (1.14 – 3.01)	0.012	1.93 (1.16 – 3.20)	0.011
Blunt stump	1.81 (1.12 – 2.94)	0.016	1.92 (1.15 – 3.20)	0.012
Bending >45°	2.39 (1.33 – 4.31)	0.004	2.12 (1.16 – 3.90)	0.015
Occlusion lesion ≥20 mm	1.57 (0.97 – 2.55)	0.065	1.45 (0.88 – 2.41)	0.145
Calcification	0.79 (0.49 – 1.28)	0.338	–	–
Retry lesion	1.28 (0.46 – 3.56)	0.643	–	–





OR ref.	Points*
≥1.2, <1.5	1
≥1.5, <2.4	2
≥2.5, <3.4	3
≥3.5, <4.4	4

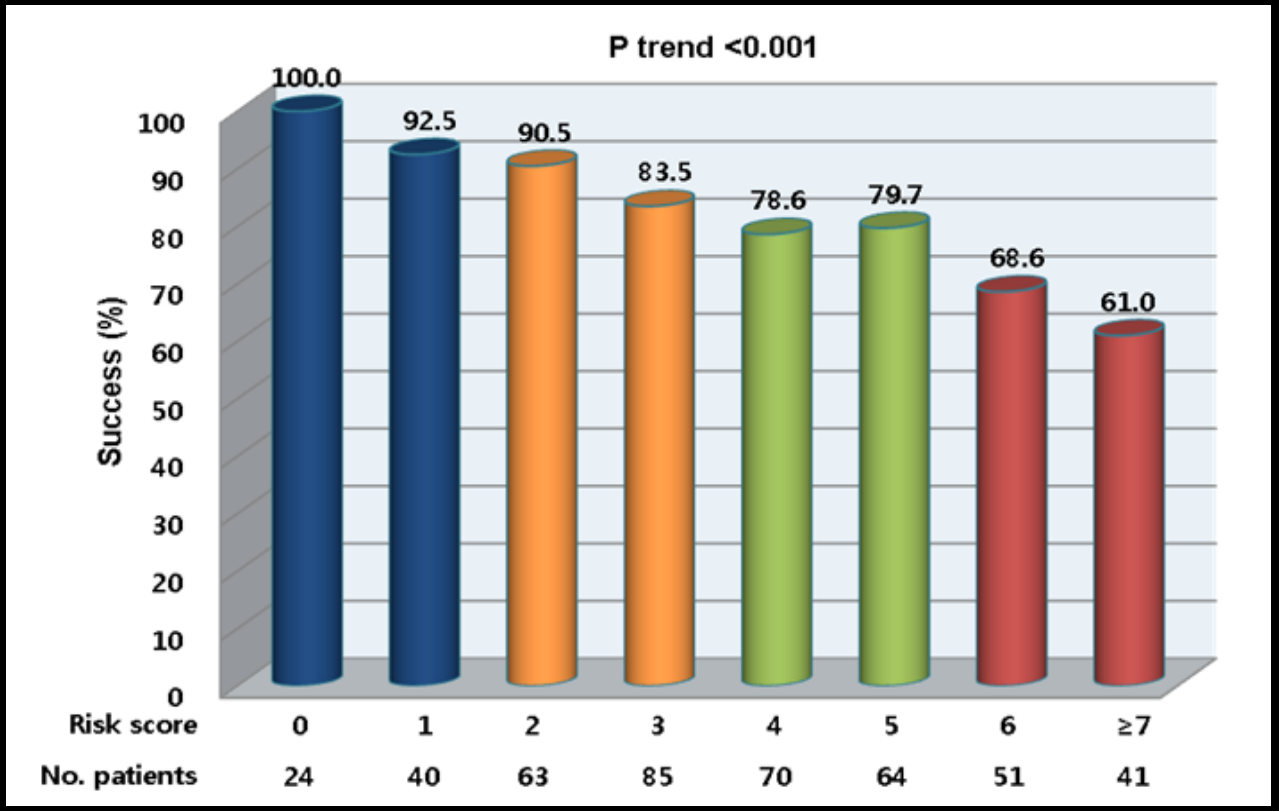
- *Points were assigned using the method described by Charlson (1987).*

Charlson ME, et al. J Chronic Dis 1987; 40:373-383.
Steyerberg E, et al. Clinical prediction models. New York: Springer; 2009

B-CTO Score points assignment

Vaviable	Adjusted OR	Points
Age 60-74	1.21(0.69 – 2.11)	1
Age ≥75 years	1.70(0.78 – 3.67)	2
Female gender	1.80(1.02 – 3.18)	2
CTO located at RCA	1.93(1.16 – 3.20)	2
Blunt stump	1.92(1.15 – 3.20)	2
Bending >45°	2.12(1.16 – 3.90)	2
Occlu. lesion ≥20mm	1.45(0.88 – 2.41)	1

Results (6) B-CTO Score and Technique Success



Results (7)
Comparison of Predictive Models for CTO Opening

Models	AUC	△AUC	P Value	IDI	Category-free NRI
Base Model: (J-CTO)	0.598	-	-	-	-
Model 1	0.620	0.022 (-0.023-0.068)	0.336	-0.037 (-0.186-0.111)	0.129 (-0.085-0.343)
Model 2 (B-CTO)	0.681	0.083 (0.025-0.141)	0.005	0.042 (0.023-0.062)	0.560 (0.349-0.772)
Base Model: (Model 1)	0.620	-	-	-	-
Model 2	0.681	0.061 (0.017-0.104)	0.006	0.034 (0.019-0.049)	0.418 (0.204-0.632)

AUC = area under the receiver operating characteristic curve;

IDI = integrated discrimination improvement; NRI = net reclassification improvement.

△AUC was indicated as AUC differences in predictive models.

Base model = J-CTO score model;

Model 1 = Clinical-based model (additional adjustment for age and gender);

Model 2 = B-CTO score model (Busan Single-Center CTO Registry).

Results (8). Clinical F/U data (Median 40 months)

Events	Failure (n =83)	Success (n =355)	HR (95% CI)	P value
Hard MACE*	5 (6.0)	11 (3.1)	0.47 (0.16-1.35)	0.162
Cardiac death	1 (1.2)	1 (0.3)		
Non-fatal MI	3 (3.6)	4 (1.1)		
Stroke	1 (1.2)	6 (1.7)		

* HMACE: hard major clinical events: composite of cardiac death, non-fatal MI and stroke.

Summary

1. Present study is the first to predict CTO opening success by combining clinical characteristics and angiographic parameters.
2. The B-CTO scoring system can be successfully applied for improved stratification and discrimination specifically in Korean patients.
3. Successful CTO opening did not further improve hard MACE, CV death, non-fatal MI and stroke.

Study limitations

1. It is a single-center, observational study and relative small proportion of failure cases (n =85, 19%).
2. We mainly applied antegrade (92.7%), B-CTO scoring system was not validated for retrograde approach.
3. CTO interventional era bias. Data collection suffered from a prolonged duration (over 15 years).
4. The operators' skill, as well as new CTO devices. which also influence on success or not.

Conclusion

- B-CTO score is an improved tool for predicting successful CTO opening, which has been designed and validated in Busan CTO Registry. Wider application remains to be explored.

- The risk of Hard MACE was minimal, do not depend on the procedure success. Further study is warranted to validate the present results with large population.

Contents lists available at ScienceDirect

Cardiovascular Revascularization Medicine

Original research

Long-term clinical outcomes after successful and failed native chronic Total occlusion: Insights from the Busan occlusion (B-CTO) Registry☆

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ABSTRACT

Objective: To assess hard major adverse clinical ev
coronary intervention for chronic total occlusion (P
Background: There are limited data regarding long-t
Methods: First-time PCI was performed in 438 cons
procedural success (n = 355; 378 CTO lesions) and f
40 months (7–77 months range). We compared H
infarction (MI), and stroke) dependent on the succe
Results: The incidence of HMACE was low, with a tot
[0.16–1.35; p = 0.162] dependent on the success of
0.22; CI [0.01–3.50]; p = 0.283}, non fatal MI {1.1%
strokes {1.7% vs.1.2%, RR = 1.32; CI [0.16–10.99], p
Conclusions: The risks of HMACE after PCI-CTO over
the procedure success. This unexpected finding sor
and should be confirmed in the adequately powered

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Predicting Successful Recanalization in Patients with Native Coronary Chronic Total Occlusion: The Busan CTO Score

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Keywords
Predictors · Chronic total occlusion · Recanalization · Registry · Korean patients

Abstract
Background: The optimal strategy to manage chronic total occlusion (CTO) remains unclear. The Japanese CTO multicenter registry (J-CTO) score is an established tool for predicting successful recanalization. However, it does not take into account nonangiographic predictors for final technique success. In the present study, we designed and tested a scoring model called the Busan single-center CTO registry (B-CTO) score combining clinical and angiographic characteristics to predict successful CTO recanalization in Korean patients. ***Methods:*** Prospectively enrolled CTO patients (n = 438) undergoing coronary intervention (1999–2015) were assessed. The B-CTO score comprises 6 independent predictors: age 60–74 years and lesion length ≥20 mm were assigned 1 point each, while age ≥75 years, female gender, lesion location in the right coronary artery, blunt stump, and bending >45° were assigned 2 points each. For each predictor, the points assigned were based on the associated odds ratio by multivariate analysis. The lesions were classified into 4 groups according to the summation of points scored to assess the probability of successful CTO recanalization: easy (score 0–1), intermediate (score 2–3), difficult (score 4–5), and very difficult (score ≥6). CTO opening was designated as the primary endpoint regardless of the interventional era or the skill of the operator. ***Results:*** The final success rate for B-CTO was 81.1%. The probability of successful recanalization for patient groups classified as easy (n = 64), intermediate (n = 148), difficult (n = 134), and very difficult (n = 92) was 95.3, 86.5, 79.1 and 65.2%, respectively (p for trend <0.001). When compared to the J-CTO, the B-CTO score demonstrated a significant improvement in discrimination as indicated by the area under the receiver-operator characteristic curve (AUC 0.083; 95% CI 0.025–0.141), with a positive integrated discrimination improvement of 0.042 and a net reclassification improvement of 56.0%. ***Conclusions:*** The B-CTO score has been designed and validated in Korean patients with native coronary CTO and is an improved tool for predicting successful recanalization. Wider application of the B-CTO score remains to be explored.

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Thanks For Your Listening!

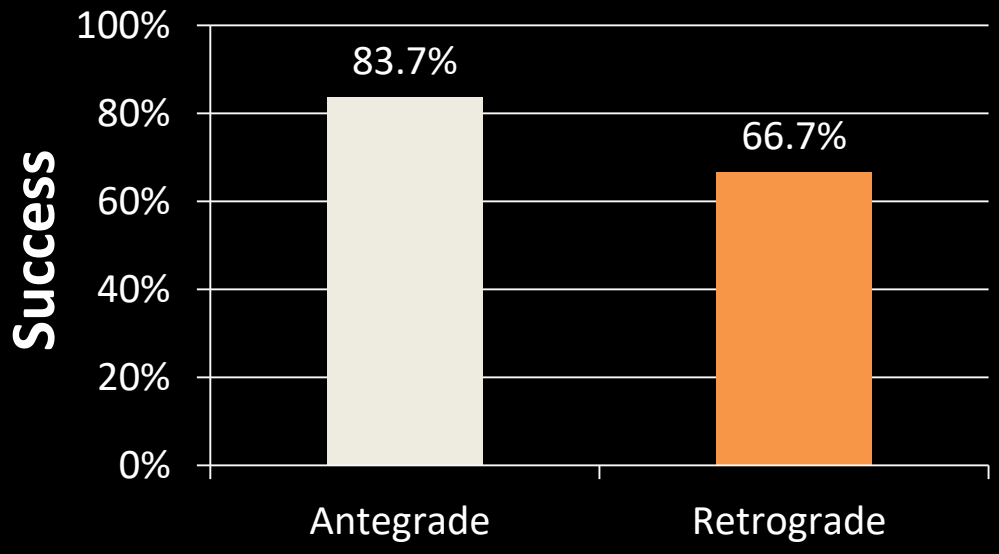
Backup slides

Table S. Guidewire crossing technique

	Failure (n =83)	Success (n =355)	P value
Antegrade GW technique			0.004
Single	55 (66.3)	272 (76.6)	
Parallel	25 (30.1)	54 (15.2)	
Retrograde GW technique			0.354
Retrograde GW cross (Rendezvous)	0 (0)	13 (3.7)	
Kissing GW cross	1 (1.2)	6 (1.7)	
CART	0 (0)	0 (0)	
Reverse CART	2 (2.4)	10 (2.8)	
IVUS-guided re-entry	3 (3.6)	5 (1.4)	NA

Table S. Guidewire crossing technique

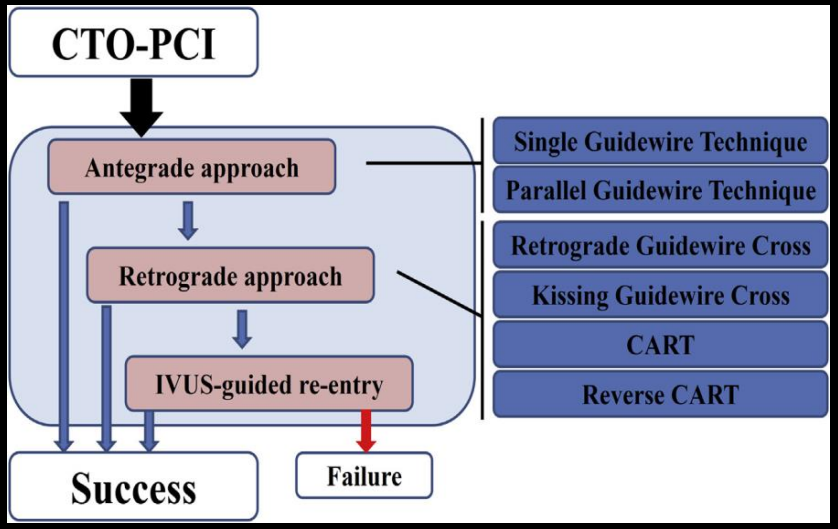
	Antegrade (N=369)	Retrograde (N=69)	P value
Success rate	309 (83.7)	46 (66.7)	0.001



B-CTO scoring model validation

	r	95% CI	P value
1. Correlation	0.595	0.531-0.652	<0.001
	X^2		P value
2. Calibration	2.14		0.829
	AUC	95% CI	P value
3. Discrimination	0.681	0.635-0.724	<0.001

CTO GW-crossing technique

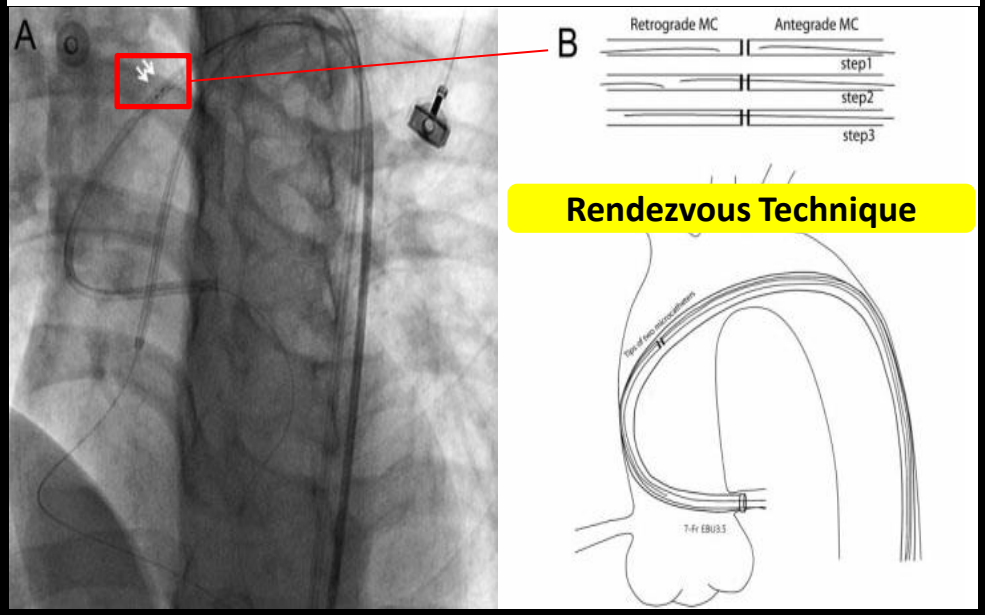


Sumitsuji S, et al. J Am Coll Cardiol 2011.

A New Retrograde Wiring Technique for Chronic Total Occlusion

Moo Hyun Kim,[1*] MD, FACC, Long Hao Yu,[1] MD, and Kazuaki Mitsudo,[2] MD

To improve the success rate of percutaneous coronary intervention for coronary chronic total occlusion (CTO), different strategies of retrograde approach were introduced in recent years. The aim of this report is to describe a new retrograde wiring technique for CTO, the "Bridge or Rendezvous method." This new technique saves time, reduces cost, as well as reduces procedure-related complications. © 2009 Wiley-Liss, Inc.



Kim MH, et al. Catheter Cardiovasc Interv 2010.

Study Definitions

- Periprocedural myocardial injury (PMI): cardiac troponin (cTn) >5x99th percentile URL post-PCI 48 hours.
- Contrast induced nephropathy (CIN): creatinine increase >0.5mg/dl or 25% baseline value within 48 hours after contrast administration.

Sianos G, et al. EuroIntervention 2012;8:139-145.
Godino C, et al. Int J Cardiol 2013;168:1402-1409.

Result (8)
Complication & In-hospital Adverse Events

Variables	Failure (n =83)	Success (n =355)	P value
Peri-procedural complication	6 (7.2)	13 (3.7)	0.225
Collateral channel injury	4 (4.8)	6 (1.7)	
Coronary perforation	1 (1.2)	2 (0.6)	
Cardiac tamponade	1 (1.2)	3 (0.8)	
Side branch occlusion	0 (0)	2 (0.6)	
PMI	11 (13.3)	31 (8.7)	0.208
CIN	1 (1.2)	8 (2.3)	
In-hospital cardiac events	1 (1.2)	2 (0.6)	0.468
Cardiac death	1 (1.2)	1 (0.3)	
Non-fatal MI	0 (0)	1 (0.3)	

Results (8). Clinical F/U data (Median 40 months)

Events	Failure (n =83)	Success (n =355)	HR (95% CI)	P value
MACCEs†	23 (27.7)	45 (12.7)	0.47 (0.28-0.79)	0.004
Hard MACE*	5 (6.0)	11 (3.1)	0.47 (0.16-1.35)	0.162
Cardiac death	1 (1.2)	1 (0.3)		
Non-fatal MI	3 (3.6)	4 (1.1)		
Stroke	1 (1.2)	6 (1.7)		
Repeat revascularization‡	16 (19.3)	30 (8.5)	0.47 (0.25-0.86)	0.015
Repeat PCI	3 (3.6)	21 (5.9)		
CABG	13 (15.7)	4 (1.1)		

† MACCEs: composite of cardiac death, non-fatal MI, repeat revascularization and stroke.
* HMACE: hard major clinical events: composite of cardiac death, non-fatal MI and stroke.
‡ Repeat revascularization included interventional or surgical target vessel revascularization.