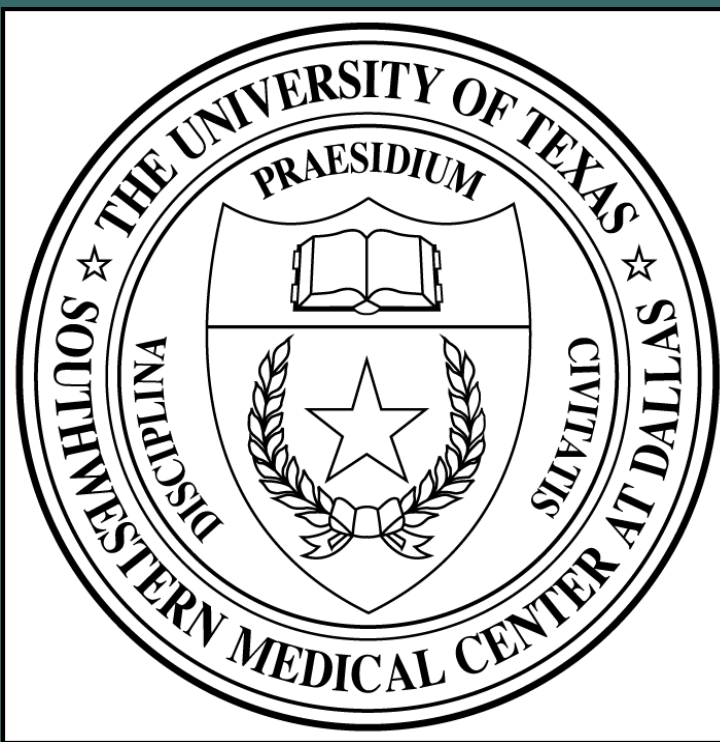




Application of the “Hybrid Approach” to Chronic Total Occlusions in a Contemporary Multicenter US Registry

Rohan V. Menon, BS¹, Georgios Christopoulos, MD¹, Dimitrios Karpaliotis, MD², Khaldoon Alaswad, MD³, William Lombardi, MD⁴, J. Aaron Grantham, MD⁵, Katrina L. Mishoe, BS⁴, Vishal G. Patel, MD¹, Bavana V. Rangan, BDS, MPH¹, Anna P. Kotsia, MD¹, Nicholas Lembo, MD², David Kandzari, MD², James Lee, MD², Anna Kalynych, MD², Harold Carlson, MD², Santiago Garcia, MD⁶, Subhash Banerjee, MD¹, Craig A. Thompson, M.D., MMSc⁷, Emmanouil S. Brilakis, MD, PhD¹

¹ VA North Texas Healthcare System and UT Southwestern Medical Center, Dallas, TX, ² Piedmont Hospital, Atlanta, GA, ³ Appleton Cardiology, Appleton, WI, ⁴ PeaceHealth Cardiology, Bellingham, WA, ⁵ Mid America Heart Institute, Kansas City, MO, ⁶ Minneapolis VA Healthcare System and University of Minnesota, Minneapolis, Minnesota, USA, ⁷ Yale University School of Medicine, New Haven, CT

ABSTRACT

Background: The “hybrid” approach to coronary chronic total occlusion (CTO) crossing was developed to optimize procedural efficacy, efficiency, and safety. Current strategies of crossing CTOs include antegrade wire escalation, antegrade dissection re-entry, and the retrograde approach. The “hybrid” approach is an algorithm that, based on angiographic characteristics of the lesion, streamlines the selection of the optimal technique for crossing the CTO. The goal of this study was to analyze the impact of the “hybrid” approach to CTO percutaneous coronary intervention on procedural workflow and outcomes at five high-volume US centers.

Methods: We examined the procedural techniques and outcomes of 489 consecutive CTO cases performed using the “hybrid” approach between 2012 and 2013 at 5 US centers from cities including Appleton WI, Atlanta GA, Bellingham WA, Kansas City MO, and Dallas TX.

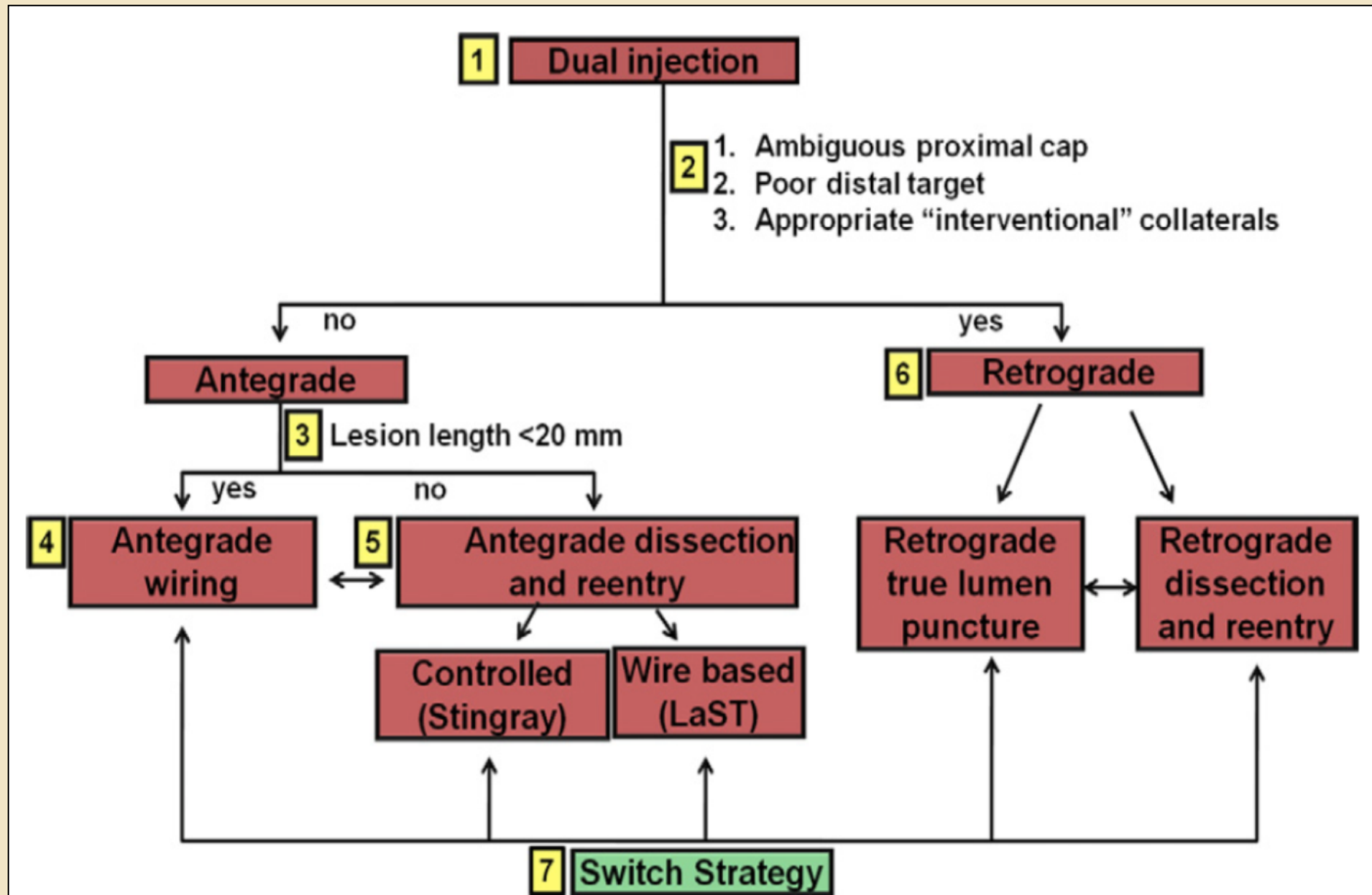
Results: Mean age was 63.8 ± 9.8 years and 86.9% of the patients were men, with high prevalence of diabetes mellitus (41.7%) and prior coronary artery bypass graft surgery (35.7%). Most target CTOs were located in the right coronary artery (61.5%), followed by the left anterior descending artery (20.9%) and left circumflex (16.8%). Dual injection was used in 73.3%. Overall, antegrade wire escalation was used in 62.8%, antegrade dissection re-entry in 38.9% and retrograde in 44.2%. Among successful cases, the final successful crossing technique was antegrade wire escalation in 40.6%, antegrade dissection and re-entry in 27.5%, and retrograde in 31.9%. The initial crossing strategy was successful in 62.0% of the patients, whereas 35.8% required an additional 1 to 4 crossing strategies. Technical success was achieved in 91.6% and major procedural complications occurred in 1.6%. Mean contrast volume, fluoroscopy time, and air kerma radiation exposure were 297.6 ± 154.7 ml, 48.9 ± 31.4 min, 4.4 ± 3.8 Gray, respectively.

Conclusion: Application of the “hybrid” approach to CTO crossing resulted in high success and low complication rates among a varied operator group and hospital structure, further supporting the value of the “hybrid” approach in crossing these challenging coronary lesions.

INTRODUCTION

- Successful percutaneous coronary intervention (PCI) of chronic total occlusions (CTOs) can provide significant clinical benefits, but can be challenging to perform
- Current broad groups of CTO crossing techniques include antegrade wire escalation, antegrade dissection/re-entry, and the retrograde approach
- Selecting the optimal technique for each CTO lesion can be challenging, but has recently been streamlined with the introduction of the “hybrid” CTO crossing algorithm
- Goal: To examine the impact of the “hybrid” approach to CTO PCI on procedural workflow and outcomes at five high-volume US centers

Figure 1. “Hybrid” algorithm for CTO crossing
(JACC Cardiovasc Interv. 2012;5:367-79)



MATERIALS AND METHODS

- Procedural techniques and outcomes were examined for 489 consecutive CTO PCIs performed using the “hybrid” approach between January 2012 and July 2013
- Data was collected from 5 US centers: Appleton Cardiology, Appleton Wisconsin; Piedmont Heart Institute, Atlanta, Georgia; St. Joseph Medical Center, Bellingham Washington; St. Luke’s Health System’s Mid-America Heart Institute, Kansas City, Missouri; and VA North Texas Health Care System, Dallas, Texas
- Descriptive statistics were used to report the angiographic measurements, clinical characteristics, and in-hospital outcomes
- Categorical variables were compared using the chi-square test and expressed as percentages. Continuous variables were compared using the t-test and expressed as means with standard deviations. All statistical analyses were performed with JMP 9.0 (SAS Institute, Cary, North Carolina). Two-sided *p*-values of <0.05 were considered statistically significant.

RESULTS

- Technical success and procedural success were achieved in 91.6% and 90.8% of the cases, respectively
- Among successful cases (n=448), the final successful crossing technique was antegrade wire escalation in 40.6%, antegrade dissection and re-entry in 27.5%, and retrograde in 31.9%
- The initial crossing approach was antegrade wire escalation in 58.9%, antegrade dissection/re-entry in 18.8%, and retrograde in 22.3%. The initial crossing approach was successful in 303 cases (62.0%) while subsequent crossing strategies were utilized in 35.8% (n=175)
- The failed CTO PCI procedures had a higher number of approach changes than the successful ones

Table 1. Clinical and angiographic characteristics of the study patients, classified to according to whether technical success was achieved.

Clinical Characteristics	Overall (n=489)	Technical Success (n=448)	Technical Failure (n=41)	p
Age (years)*	64.7±9.9	64.7±10.0	65.2±9.6	0.75
Men (%)	86.9	86.4	92.7	0.218
Hypertension (%)	90.7	90.5	92.7	0.641
Dyslipidemia (%)	94.9	94.4	100.0	0.104
Diabetes (%)	41.7	43.0	26.8	0.039
Heart failure (%)	25.8	25.6	26.8	0.313
Previous MI (%)	35.5	34.5	46.3	0.330
Previous CABG (%)	35.7	34.5	48.8	0.072
Previous PCI	60.4	58.5	80.5	0.014
Previous stroke (%)	9.0	8.5	14.6	0.403
Peripheral arterial disease (%)	17.5	17.3	19.5	0.790
Angiographic characteristics				
CTO target vessel				0.529
RCA (%)	61.5	61.1	65.9	
PDA (%)	0.4	0.5	0.0	
LCX (%)	16.8	15.9	26.8	
LAD (%)	20.9	22.0	7.3	
LM (%)	0.4	0.5	0.0	
Moderate/severe calcification (%)	56.6	55.8	65.0	0.287
Moderate/severe tortuosity (%)	31.5	29.3	56.4	0.003
Prior failed attempt for CTO PCI (%)	17.7	16.6	29.3	0.056
In-stent restenosis (%)	11.7	11.3	16.7	0.457
J-CTO score*	2.7 ± 1.2	2.6 ± 1.2	3.4 ± 1.0	<0.001

* mean ± standard deviation
CABG, Coronary artery bypass graft surgery; CTO, chronic total occlusion; LAD, left anterior descending artery; LCX, left circumflex artery; LM, left main; MI, myocardial infarction; PCI, percutaneous coronary intervention; PDA, posterior descending artery; RCA, right coronary artery

Table 2. Crossing techniques utilized in the study patients, classified according to whether or not technical success was achieved.

Crossing techniques	Overall (n=489)	Technical Success (n=448)	Technical Failure (n=41)	p
Dual injection (%)	73.3	72.4	84.0	0.186
Antegrade wire escalation (%)	62.8	62.7	63.4	0.930
Antegrade dissection/re-entry (%)	38.9	36.6	63.4	0.001
Retrograde (%)	44.2	41.3	75.6	<0.001
Primary Approach				0.324
Antegrade wire escalation (%) (n=288)	58.9	59.4	53.7	
Antegrade dissection/re-entry (%) (n=92)	18.8	19.2	14.6	
Retrograde (%) (n=109)	22.3	21.4	31.7	
Initial approach successful (%) (n=303)	62.0	67.6	NA	NA
Antegrade wire escalation (%) (n=166)		37.0	NA	
Antegrade dissection/re-entry (%) (n=59)		13.2	NA	
Retrograde (%) (n=78)		17.4	NA	
Initial antegrade followed by other approaches (%) (n=119)	24.3	22.5	43.9	0.004
Initial antegrade dissection/re-entry followed by other approaches (%) (n=31)	6.3	6.0	9.8	0.379
Initial retrograde followed by other approaches (%) (n=25)	5.1	4.0	17.1	0.003
Number of approach changes for all patients (n=489)*	0.52±0.80	0.46±0.78	1.10±0.80	<0.001
No. of approach changes for those in who strategy switch was needed (n=175)*	1.44±0.69	1.43±0.72	1.50±0.51	0.515
Final successful CTO crossing Technique	NA	100.0	NA	NA
Antegrade wire escalation (%) (n=182)		40.6		
Antegrade dissection/re-entry (%) (n=123)		27.5		
Retrograde (%) (n=143)		31.9		

* mean ± standard deviation; CTO, chronic total occlusion

Table 3. Outcomes among study patients, classified according to whether technical success was achieved.

Outcomes and equipment utilization	Overall (n=489)	Technical Success (n=448)	Technical Failure (n=41)	p
Technical success	91.6	100.0	NA	NA
Procedural success	90.8	98.7	NA	NA
Total procedure time (min)*	122.1±67.8	117.1±65.5	182.0±67.3	<0.001
Total fluoroscopy time (min)*	48.9±31.4	46.8±30.8	72.8±27.9	<0.001
Total air kerma radiation exposure (Gray)*	4.4±3.8	4.3±3.9	5.8±2.5	0.002
Total contrast volume (ml)*	297.6±154.7	289.7±149.0	384.3±188.5	0.004
Number of stents used*	NA	2.6±1.1	NA	NA
Overlapping stents (%)	NA	98.0	NA	NA

* mean ± standard deviation.

Figure 2. Final Crossing Technique Among Successful Cases (n=448)

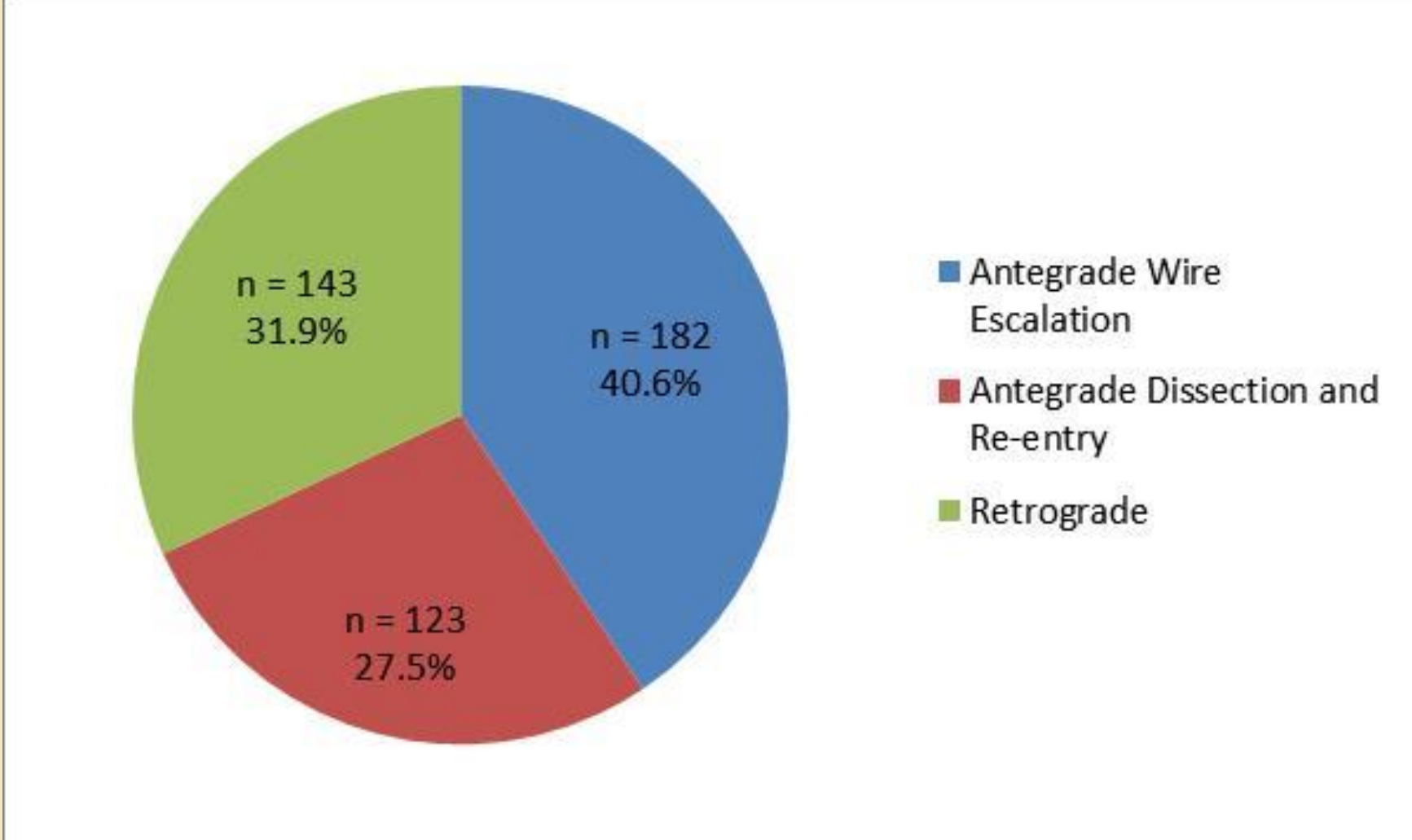


Figure 3. Initial Crossing Technique Used (n=489)

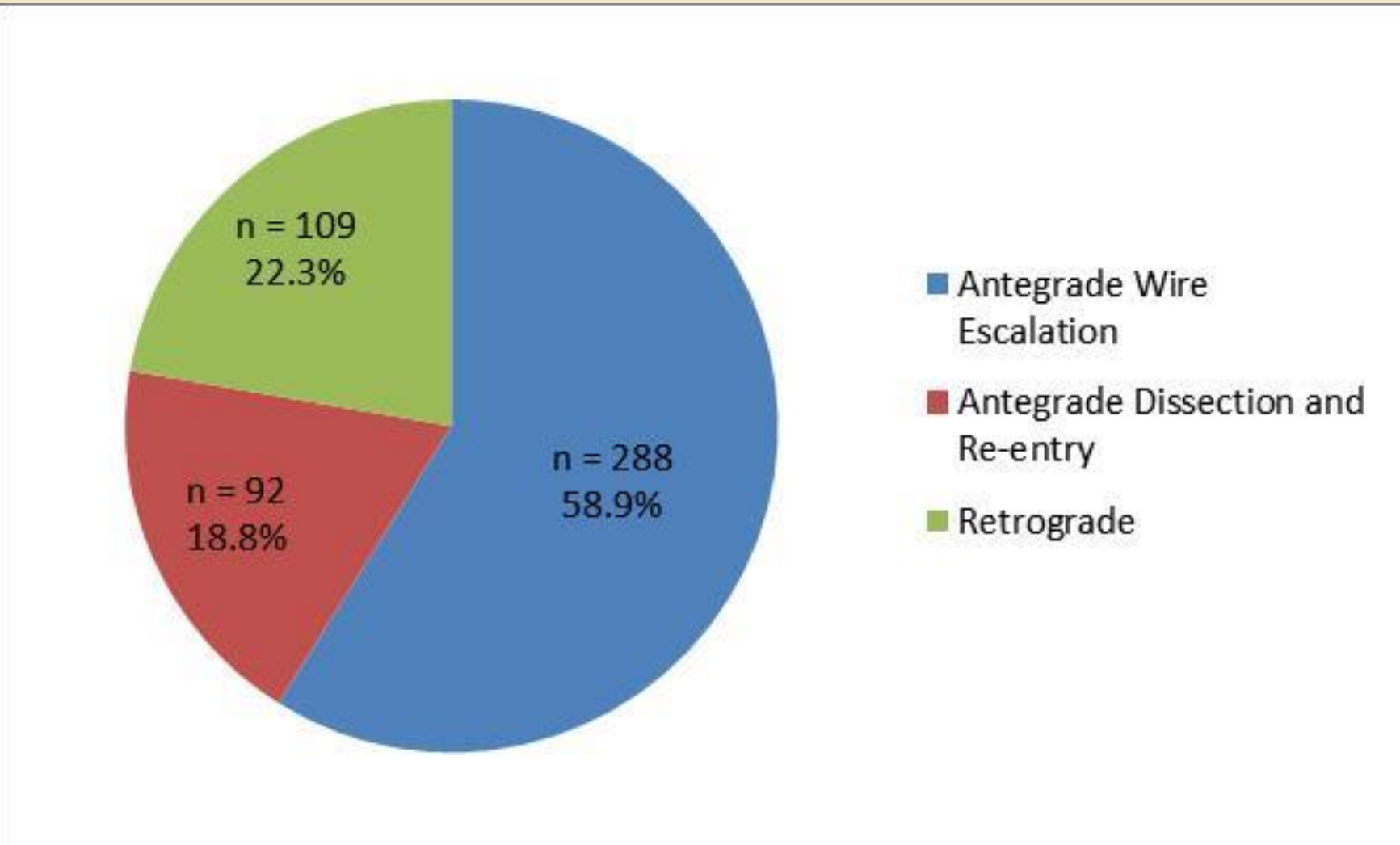
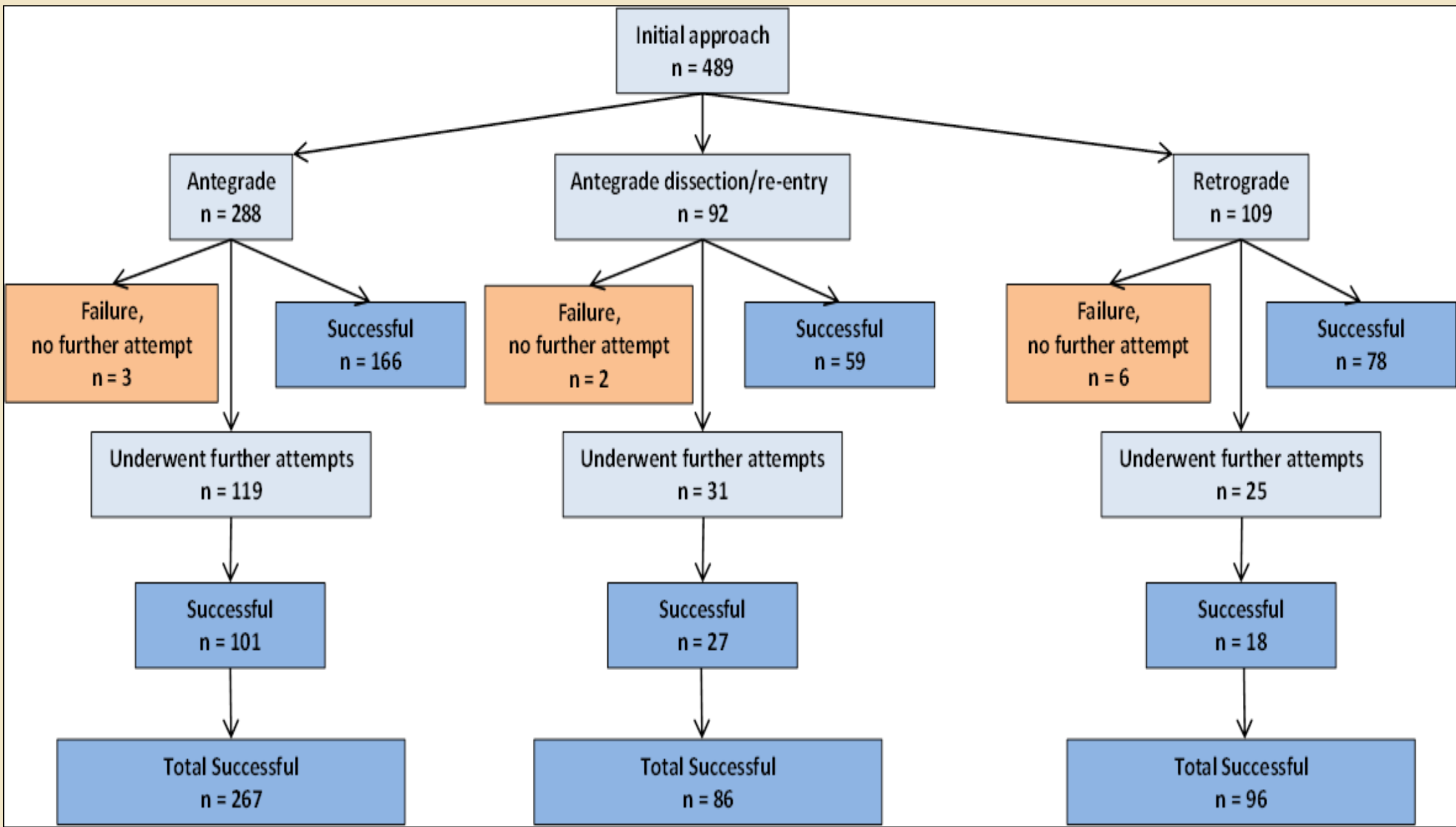


Figure 4. Flow chart depicting the crossing strategies utilized in the study patients.



Limitations

- Data data from more patients and sites would further add to the generalizability of our findings
- Efficiently applying the “hybrid approach” to CTO PCI requires extensive training and expertise in all three major CTO crossing strategies, which necessitates both didactic, but most importantly, practical experience
- Successful execution of the “hybrid approach” requires significant preparation prior to the start of the PCI, such as studying the case obtaining appropriate equipment, and planning for subsequent steps should the initial crossing attempt fail
- The study focused on acute procedural outcomes and did not evaluate long-term events after CTO PCI

CONCLUSION

The application of the “hybrid approach” to CTO crossing provided high success and low complication rates among various patient populations, operators, and hospitals, supporting its expanded use in CTO PCI