International Journal of Cardiology 198 (2015) 222–228

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

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

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ARTICLE INFO

Article history:
Received 14 May 2015
Accepted 22 June 2015
Available online 27 June 2015

Keywords:
Chronic total occlusion
Percutaneous coronary intervention
Techniques
Outcomes

ABSTRACT

Background: A hybrid approach to chronic total occlusion (CTO) percutaneous coronary intervention (PCI) prioritizing and combining all available crossing techniques was developed to optimize procedural efficacy, efficiency, and safety, but there is limited published data on its outcomes.
Methods: We examined the procedural techniques and outcomes of 1036 consecutive CTO PCIs performed using a hybrid approach between 2012 and 2015 at 11 US centers.
Results: Mean age was 65 ± 10 years and 86% of the patients were men, with a high prevalence of diabetes mellitus (43%) and prior coronary artery bypass graft surgery (34%). Most target CTOs were located in the right coronary artery (59%), followed by the left anterior descending artery (23%) and the circumflex (19%). Dual injection was used in 71%. Technical success was achieved in 91% and a major procedural complication occurred in 1.7% of cases. The final successful crossing technique was antegrade wire escalation in 46%, antegrade dissection/re-entry in 26%, and retrograde in 28%. The initial crossing strategy was successful in 58% of the lesions, whereas 39% required an additional approach. Overall, antegrade wire escalation was used in 71%, antegrade dissection/re-entry in 36%, and the retrograde approach in 42% of procedures. Median contrast volume, fluoroscopy time, and air kerma radiation dose were 260 (200–360) ml, 44 (27–72) min, and 3.4 (2.0–5.4) Gray, respectively.
Conclusion: Application of a hybrid approach to CTO crossing resulted in high success and low complication rates across a varied group of operators and hospital practice structures, supporting its expanding use in CTO PCI.
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☆ All authors herein take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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http://dx.doi.org/10.1016/j.ijcard.2015.06.093
0167-5273/Published by Elsevier Ireland Ltd.

1. Introduction

Successful percutaneous coronary intervention (PCI) of chronic total occlusions (CTOs) can provide significant clinical benefits [1–4]. However, it can be challenging to perform, with the inability to cross the occlusion being the main mode of failure [5]. Three broad categories of CTO crossing techniques are currently utilized [6]: antegrade wire escalation [7], antegrade dissection/re-entry [8–11], and the retrograde approach [12–14], all of which have contributed to improved procedural success rates [15–19]. Selecting the optimal technique for each CTO lesion can be challenging, but this process has recently been streamlined with the introduction of a hybrid CTO crossing algorithm (Fig. 1) [20]. The hybrid algorithm assesses four key angiographic characteristics to determine the optimal initial and subsequent crossing strategies [20]. The term hybrid refers to (a) sequential use of CTO crossing techniques if the initially attempted technique fails and (b) unification of all 3 currently available CTO crossing techniques under a single algorithm [19–26]. The goal of the present study was to examine the impact of a hybrid approach on procedural workflow and outcomes of CTO PCI in a multicenter, contemporary CTO PCI registry [27].

2. Methods

2.1. Patient population

We examined the procedural techniques and outcomes of 1036 consecutive CTO PCIs (1019 patients) performed using a hybrid approach between January 2012 and March 2015 at 11 US centers: Appleton Cardiology, Appleton Wisconsin; Columbia University, New York, New York; Massachusetts General Hospital, Boston, Massachusetts; Medical Center of the Rockies, Loveland, Colorado; Piedmont Heart Institute, Atlanta Georgia; St. Joseph Medical Center, Bellingham Washington; St. Luke's Health System's Mid-America Heart Institute, Kansas City, Missouri; Torrance Memorial Center, Torrance, California; VA Minneapolis Healthcare System, Minneapolis, Minnesota; VA North Texas Health Care System, Dallas, Texas, and VA San Diego Healthcare System, San Diego, California. All procedures were performed by operators with expertise in CTO PCI using a hybrid approach. Data collection was performed both prospectively and retrospectively and recorded in a dedicated CTO database (PROGRESS CTO, Clinicaltrials.gov Identifier: NCT02061436). The study was approved by the institutional review board of each site.

2.2. Definitions

Coronary CTOs were defined as coronary lesions with thrombolysis in myocardial infarction (TIMI) grade 0 flow of at least 3 month duration. Estimation of the occlusion duration was based on first onset of anginal symptoms, prior history of myocardial infarction in the target vessel territory, or comparison with a prior angiogram.

Calcification was assessed by angiography as mild (spots), moderate (involving ≤50% of the reference lesion diameter) and severe (involving >50% of the reference lesion diameter). Moderate proximal vessel tortuosity was defined as the presence of at least 2 bends >70° or 1 bend >90° and severe tortuosity as 2 bends >90° or 1 bend >120° in the CTO vessel. Technical success of CTO PCI was defined as successful CTO revascularization with achievement of <30% residual diameter stenosis within the treated segment and restoration of TIMI grade 3 antegrade flow. Procedural success was defined as achievement of technical success with no in-hospital major adverse cardiac events (MACE). In-hospital MACE included any of the following adverse events prior to hospital discharge: death, acute myocardial infarction, urgent repeat target vessel revascularization with PCI or coronary artery bypass graft surgery (CABG), tamponade requiring either pericardiocentesis or surgery, and stroke. Major bleeding was defined as bleeding resulting in transfusion, requiring surgical intervention, or causing hemoglobin drop ≥3 g/dL.

2.3. Statistical analysis

Descriptive statistics were used to report the angiographic measurements, clinical characteristics, and in-hospital outcomes. All procedures were categorized based on technical success or technical failure and compared in terms of baseline clinical characteristics, angiographic characteristics and procedural data. Categorical variables were expressed as percentages and compared using the chi-square test or Fischer's exact test. Continuous variables were presented as mean ± standard deviation or median (interquartile range) and were compared using the t-test, one-way analysis of variance or Wilcoxon rank-sum test, as appropriate. All statistical analyses were performed with JMP 11.0 (SAS Institute, Cary, North Carolina). Two-sided p-values < 0.05 were considered statistically significant.

3. Results

3.1. Patient characteristics

The mean age was 65 ± 10 years. Most patients (86%) were men, with a high prevalence of diabetes mellitus (43%), dyslipidemia (96%), hypertension (90%), peripheral arterial disease (17%), prior PCI (67%), and prior CABG (34%) (Table 1). Compared with patients in whom CTO PCI was successful, patients in whom CTO PCI failed were more likely to have had a history of myocardial infarction (58% vs. 40%, p = 0.001), CABG (46% vs. 33%, 0.013), PCI (78% vs. 65%, p = 0.015) or stroke (17% vs. 11%, p = 0.048).

3.2. Angiographic and procedural characteristics

The most common CTO target vessel was the right coronary artery (59%), followed by the left anterior descending artery (23%) and the circumflex (19%). Moderate to severe calcification and moderate to severe tortuosity were present in 56% and 33% of the CTO lesions,

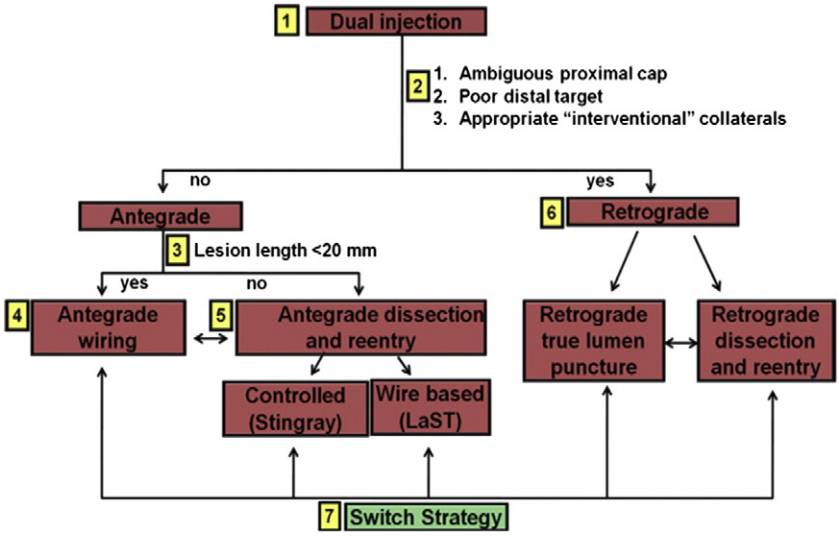

Fig. 1. A hybrid algorithm for CTO crossing (reproduced with permission from reference 20). The initial crossing strategy selection depends on several angiographic characteristics, such as proximal cap ambiguity, size and calcification of the distal target vessel, lesion length and presence of appropriate collaterals. Strategy switch is recommended if the initially selected strategy fails.