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Use of antegrade dissection re-entry in coronary chronic total occlusion percutaneous coronary intervention in a contemporary multicenter registry

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ABSTRACT

Background: We assessed efficacy and safety of chronic total occlusion (CTO) percutaneous coronary intervention (PCI) using antegrade dissection re-entry (ADR).
Methods: We examined outcomes of ADR among 1313 CTO PCIs performed at 11 US centers between 2012–2015.
Results: 84.1% of patients were men. Prevalence of prior coronary artery bypass graft surgery was 34.3%. Overall technical and procedural success were 90.1% and 88.7%, respectively. In-hospital major adverse cardiovascular events (MACE) occurred in 31 patients (2.4%).
ADR was used in 458 cases (34.9%), and was the first strategy in 169 cases (12.9%). ADR cases were angiographically more complex than non-ADR cases (mean J-CTO score: 2.8 ± 1.2 vs. 2.4 ± 1.2, $p < 0.001$). ADR was performed using the CrossBoss catheter in 246 of 458 (53.7%) and the Stingray system in 251 ADR cases (54.8%). Compared with non-ADR cases, ADR cases had lower technical (86.9% vs. 91.8%, $p = 0.005$) and procedural success (85.0% vs. 90.7%, $p = 0.002$), but similar risk for MACE (2.9% vs. 2.2%, $p = 0.42$). ADR was associated with longer procedure and fluoroscopy time, and higher patient air kerma dose and contrast volume (all $p < 0.001$). After excluding retrograde cases, ADR and antegrade wire escalation (AWE) had similar technical success (92.7% vs. 94.2%, $p = 0.43$), procedural success (91.8% vs. 94.1%, $p = 0.23$), and MACE (2.1% vs. 0.6%, $p = 0.12$).
Conclusions: ADR is used relatively frequently in contemporary CTO PCI, especially for challenging lesions and after failure of other strategies. ADR is associated with similar success rates and risk for complications as compared with AWE, and is important for achieving high procedural success.

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1. Introduction

Antegrade dissection and re-entry (ADR) for chronic total occlusion (CTO) percutaneous coronary intervention (PCI) was first described 10 years ago [1] and has since evolved to an indispensable technique [2]. In the hybrid approach to CTO PCI, ADR is recommended as the initial crossing strategy in CTOs with unambiguous proximal cap and

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good quality distal vessel, when the occlusion length is estimated to be ≥20 mm [3,4]. ADR is also commonly used after other crossing strategies fail [2]. Antegrade dissection can be achieved with either a knuckled guidewire or the CrossBoss catheter (Boston Scientific, Nattick, Massachusetts) and antegrade re-entry can be achieved either using guidewires or with the Stingray system (Boston Scientific) [5–8]. We examined a contemporary, multicenter CTO PCI registry to determine the current role of ADR and the associated outcomes.

2. Methods

2.1. Study population

We examined the clinical and angiographic records of patients who underwent CTO PCI between May 2012 and October 2015 at 11 US centers experienced in CTO PCI: Appleton Cardiology, Appleton, Wisconsin; Columbia University, New York, New York; Henry Ford Hospital, Detroit, Michigan; Massachusetts General Hospital, Boston, Massachusetts; Medical Center of the Rockies, Loveland, Colorado; Piedmont Heart Institute, Atlanta Georgia; PeaceHealth 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 North Texas Health Care System, Dallas, Texas, and VA San Diego Healthcare System, San Diego, California. Data collection was performed prospectively and retrospectively and recorded in a dedicated CTO database (PROGRESS CTO, Clinicaltrials.gov Identifier: NCT02061436) [9–16]. Some centers only enrolled patients during part of the study period due to participation in other studies. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki and 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 months duration. Estimation of the duration of occlusion was clinical, based on the first onset of angina, 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. Interventional collaterals were defined as collaterals considered amenable to crossing by a guidewire and a microcatheter by the operator. Procedures in which antegrade dissection or antegrade re-entry or both were used at any time were classified as ADR procedures. A procedure was considered to be "primary ADR" if the first attempted crossing strategy was subintimal dissection with subsequent lumen re-entry distal to the lesion. A procedure was considered "secondary ADR" if ADR was performed after failure of another CTO crossing strategy. A procedure was considered "tertiary ADR" if ADR was used after two other failed crossing strategies. A procedure was considered retrograde if an attempt was made to cross the lesion through a collateral vessel supplying the target vessel distal to the lesion. AWE-only procedures were those that used an exclusively intimal antegrade approach, with no entry into the subintimal space. A procedure was considered "antegrade-only" if no retrograde crossing attempts were made.

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 the combination 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, myocardial infarction, recurrent symptoms requiring urgent repeat target vessel revascularization with PCI or coronary artery bypass graft surgery (CABG), tamponade requiring either pericardiocentesis or surgery, and stroke. Myocardial infarction (MI) was defined using the Third Universal Definition of Myocardial Infarction (type 4 MI) [17].

2.3. Statistical analysis

Categorical variables were expressed as percentages and compared using Pearson's chi-square test or Fisher's exact test. Continuous variables were presented as mean ± standard deviation or median (interquartile range) and were compared using the *t*-test or Wilcoxon rank-sum test, as appropriate. Multivariable logistic regression analysis was performed to assess the association of baseline clinical and angiographic characteristics with technical success in the entire study population and with the use of ADR in the antegrade-only population. Variables associated with technical success and use of ADR, respectively, with $p < 0.10$ were included in the multivariate models. All statistical analyses were performed with JMP 12.0 (SAS Institute, Cary, North Carolina). A two-sided *p*-value of 0.05 was considered statistically significant.

3. Results

3.1. Baseline clinical and angiographic characteristics

A total of 1313 CTO PCIs performed in 1288 patients were included in the present analysis. ADR was used in 458 procedures (34.9%). Mean age of the study patients was 65.5 ± 10.2 years, and 84.1% were men with high prevalence of hypertension (89.5%), hyperlipidemia (94.3%) and diabetes mellitus (45.0%) (Table 1). Patients in whom ADR was used were significantly more likely to be men (88.0% vs. 82.0%, $p = 0.005$), and have a history of heart failure (31.4% vs. 26.2%, $p = 0.05$), prior CABG (38% vs. 32.3%, $p = 0.04$), and prior CTO PCI failure (20.7% vs. 16.0%, $p = 0.04$).

Compared with lesions attempted only with AWE and/or retrograde crossing, lesions attempted with ADR were more likely to be located in the right coronary artery (64.3% vs. 53.0%, $p < 0.001$), have longer length [median length: 30 (22–50) mm vs. 28 (18–40) mm, $p < 0.001$], and moderate or severe tortuosity (39.6% vs. 33.0%, $p = 0.02$). They were also less likely to have interventional collaterals (54.4% vs. 63.9%, $p = 0.004$) and more likely to have a higher J-CTO score (2.8 ± 1.2 vs. 2.4 ± 1.2, $p < 0.001$) (Table 1).

3.2. Procedural outcomes

Technical and procedural success among all 1313 cases was 90.1% and 88.7%, respectively. Use of ADR was associated with lower technical (86.9% vs. 91.8%, $p = 0.005$) and procedural (85.0% vs. 90.7%, $p = 0.002$) success (Fig. 1A). Intravascular ultrasonography (IVUS) was used more commonly in cases involving ADR (50.2% vs. 30.8%, $p < 0.001$), which also required more stents per lesion (2.9 ± 1.1 vs. 2.3 ± 1.0, $p < 0.001$) (Table 2). ADR was associated with longer procedure time, longer fluoroscopy time, higher patient air kerma (kinetic energy released per unit mass) dose, and higher contrast volume ($p < 0.001$ for all) (Table 2).

We performed multivariate analysis in the full study cohort ($n = 1313$) to assess the impact of strategy selection on technical outcome. Variables associated with technical success in univariate analysis with $p < 0.10$ were included in the multivariate model (Fig. 2A). The following were independent predictors of technical outcome (technical success or failure): prior MI (odds ratio [OR] 0.51, 95% CI: 0.29–0.87, $p = 0.013$), the presence of interventional collaterals (OR 3.31, 95% CI: 1.88–5.90, <0.001) and use of the retrograde approach (OR 0.48, 95% CI: 0.26–0.89, $p = 0.020$). Although technical success was lower with use of ADR in this cohort (Fig. 1A), multivariate analysis demonstrated that use of ADR was not independently associated with technical failure.