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Impact of antegrade dissection and re-entry technique on coronary percutaneous interventions for chronic total occlusion: the LATAM Chronic Total Occlusion registry

Impacto da técnica de dissecção/reentrada anterógrada nas intervenções coronárias percutâneas para oclusão crônica: registro *LATAM Chronic Total Occlusion*

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ABSTRACT - Background: The newest techniques of percutaneous coronary interventions for chronic total occlusion may improve technical success. The objectives were to describe safety and efficacy of antegrade dissection and reentry technique as initial revascularization strategy. **Methods**: A multicenter registry from Latin American countries (LATAM Chronic Total Occlusion). Baseline characteristics and outcomes of cases using antegrade dissection and reentry as primary strategy or bailout of antegrade wire escalation were analyzed. Retrograde approach cases were excluded. Physicians used conventional antegrade dissection and reentry technique. **Results**: Out of 1,875 patients analyzed, 50 were planned primary antegrade dissection and reentry and 1,825 planned primary antegrade wire escalation. Primary antegrade dissection and reentry was preferred in older patients, with a history of revascularization (coronary artery bypass graft: primary antegrade dissection and reentry in 33.3% and primary antegrade wire escalation in 13.4%; p<0.001; percutaneous coronary interventions in 66.6% and 48.8%, respectively; p=0.012). Longer chronic total occlusions (30mm [22-41] and 21mm [15-30]; p<0.001), moderate or severe calcification (62% and 42.6%; p=0.008) were associated with the selection of primary antegrade dissection and reentry, instead of primary antegrade wire escalation. There was a significant correlation between increasing J-CTO score (X^2=37, df=5; p<0.001), and use of primary antegrade dissection and reentry. Primary antegrade wire escalation had a success rate of 88.4%, and primary antegrade dissection and reentry of 76.7%. For primary antegrade wire escalation and bailout antegrade dissection and reentry, the use of the CrossBoss® device was related to the highest rates of success (92.3% and 82.7%, respectively). Short-term outcomes were similar in both groups. **Conclusion**: In Latin America, antegrade dissection and reentry was safe and effective, both as primary or bailout strategy, even when used for higher complexity lesions. The use of dedicated devices was related to a higher success rate.

Keywords: Coronary occlusion; Percutaneous coronary intervention; Dissection

RESUMO - Introdução: As mais novas técnicas de intervenção coronária percutânea em oclusões crônicas podem melhorar o sucesso técnico. Os objetivos deste estudo foram descrever a segurança e a eficácia da técnica de dissecção/reentrada anterógrada como estratégia inicial de revascularização. **Métodos**: Registro multicêntrico de países latino-americanos (*LATAM Chronic Total Occlusion*). Analisamos as características iniciais e os desfechos dos casos em que foi empregada dissecção/reentrada anterógrada como estratégia primária ou de resgate após escalonamento de fios por via anterógrada. Foram excluídos os casos de abordagem retrógrada. Os médicos usaram dissecção anterógrada convencional e técnica de reentrada. **Resultados**: Dos 1.875 pacientes analisados, em 50 foi planejada a dissecção/reentrada anterógrada, e, em 1.825, foi planejado o escalonamento de fios por via anterógrada primário. Deu-se preferência à dissecção/reentrada anterógrada em pacientes mais idosos e com história de revascularização (revascularização

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do miocárdio: dissecção/reentrada anterógrada em 33,3% e escalonamento de fios por via anterógrada primário em 13,4%, com p<0,001; intervenções coronárias percutâneas em 66,6 e 48,8%, respectivamente, com p=0,012). Oclusões crônicas mais longas (30mm [22-41] e 21mm [15-30], p<0,001) e calcificações moderadas ou graves (62 e 42,6%, com p=0,008) foram associadas à seleção da dissecção/reentrada anterógrada primária, ao invés do escalonamento de fios por via anterógrada primário. Houve correlação significativa entre o aumento do escore J-CTO (X^2=37, df=5; p<0,001) e o uso da dissecção/reentrada anterógrada. O escalonamento de fios por via anterógrada primário teve taxa de sucesso de 88,4%, e a dissecção/reentrada anterógrada, de 76,7%. Para o escalonamento de fios por via anterógrada primário e dissecção/reentrada anterógrada de resgate, o uso do dispositivo CrossBoss® foi relacionado às maiores taxas de sucesso (92,3% e 82,7%, respectivamente). Os desfechos a curto prazo foram semelhantes nos grupos. **Conclusão**: Na América Latina, a técnica de dissecção/reentrada anterógrada foi segura e efetiva, tanto como estratégia primária quanto de resgate, mesmo quando utilizada em lesões de maior complexidade. O uso de dispositivos específicos foi relacionado a uma maior taxa de sucesso.

Descritores: Oclusão coronária; Intervenção coronária percutânea; Dissecção

INTRODUCTION

Chronic total occlusion (CTO) represents a common entity in patients with ischemic heart disease, with a prevalence of approximately 30%.[1,2] Percutaneous coronary intervention (PCI) has evolved rapidly in the past years due to the development of new techniques and dedicated devices and catheters, achieving a high success rate.[3] To pass through the occlusion, three main techniques have been proposed: antegrade wire escalation (AWE), antegrade dissection and re-entry (ADR), and retrograde approach. AWE is the most widespread and used strategy, and the ADR represents an important alternative when other strategies (such as AWE) fail.[4] This technique is usually employed in cases in which the proximal cap is complex and the occlusion is long (>20mm), but with good visibility of the distal segment, and in vessels with a good caliber and poor collateral channels.

The ADR has been evolving since it was initially proposed. At first, the subintimal tracking and re-entry (STAR) technique was applied, followed by the use of the limited antegrade subintimal tracking (LAST) technique.[5,6] Unfortunately, these techniques share the limitation that true lumen distal entering site is unpredictable. This can generate long subintimal routes beyond the occlusion and large vessel hematomas, which may require extensive stenting with potential side branch loss, thus being a determinant of target vessel revascularization (TVR) and major adverse cardiac events (MACE) at follow up.[6-8]

Currently, ADR can be facilitated by dedicated devices, including Crossboss® catheter and Stingray® balloon. By combining both devices, a controlled and safer anterior dissection is achieved, which facilitates re-entry to the distal lumen at the selected site.[6] There is substantial data reporting results of the different CTO strategies in Japan, United States, and Europe,[9-11] but information in Latin America is scarce, especially in relation to the use of ADR as the primary strategy.

The aim of this study was to describe the safety and efficacy of the ADR as an initial CTO recanalization strategy, compared to the use of AWE with ADR as a rescue technique.

METHODS

Patients included in this study were submitted to CTO PCI in a participating center of the LATAM Chronic Total Occlusion (LATAM CTO) registry an international initiative developed to gather data in the region, as previously described.[12] Participating centers were invited and/or volunteered to participate. There was no specific requirement regarding CTO PCI volume for center acceptance. The inclusion criteria were age above 18 years and the presence of a CTO with PCI attempt, as indicated by the attending physician. The definition of CTO was a 100% lesion in a major coronary artery, known or estimated to exist for at least 3 months. Local institutional review boards approved the study. The authors are solely responsible for design and performance of the study, statistical analysis, drafting and editing of the paper, and approval of its final contents.

Data collection

Investigators inserted CTO PCI data in an online platform, and access to the database was available via Research Electronic Data Capture (REDCap),[13] a secure and free-access web application developed by Vanderbilt University. All investigators received standardized instructions to enter data in REDCap, including an instructions' manual for completing electronic data collection sheets. The training focused on the purposes of registration, clarification of the data collection process and storage. The centers received online support for questions regarding inclusion or completion of cases, and monthly feedbacks for missing data and discrepant values. The centers were asked to address queries, and internal audits were performed to maintain the quality of the database.

Definitions

Moderate/large ischemia was defined as the presence of a perfusion defect by scintigraphy, stress echocardiography or magnetic resonance ≥10%. Moderate/severe calcification was defined as a >50% involvement of the vessel by angiography, and moderate/severe tortuosity was the presence of at least two bends >70°, or one bend >90° in the proximal vessel. Blunt stump was defined as lack of tapering at the proximal cap. Interventional collateral vessels were side branches considered amenable to crossing by a guidewire and a microcatheter, by the operator. The J-CTO, PROGRESS, CL and ORA scores[14-18] were calculated by study investigators as previously described,[12] using the angiographic information reported by the centers.

The following strategies were generally considered for CTO PCI. Antegrade wire escalation consisted of stepwise attempt to directly cross the occluded segment employing different guidewires. Antegrade dissection and re-entry was defined as an antegrade PCI, during which the operator intentionally used the subadventitial space to, partially or totally, overcome the CTO segment with gears, reentering into the true lumen distally to the CTO. Conventional ADR was utilized by physicians, including double access site for simultaneous angiography, and equipment like guidewires, balloons, and microcatheters. A retrograde procedure was defined as an attempt to cross the lesion through a collateral vessel supplying a segment distal to the target CTO. We defined technical success as successful CTO revascularization within the treated segment, and restoration of Thrombolysis in Myocardial Infarction (TIMI) antegrade flow grade 3. Procedural success was the achievement of technical success without MACE.

Outcomes

In-hospital MACE before hospital discharge included all-cause mortality, myocardial infarction (MI) and stroke. MI was defined using the universal definition of MI (type 4a MI). Stroke was defined as a new focal neurological deficit of sudden onset, of presumably cerebrovascular irreversible cause (or resulting in death) within 24 hours, and not caused by any other easily identifiable cause.

Procedural complications included major bleeding, coronary perforation, cardiac tamponade and urgent revascularization with PCI or coronary artery bypass graft (CABG). Major bleeding was defined as any bleeding causing reduction in hemoglobin >3g/dL or bleeding requiring transfusion or surgical intervention. Coronary perforation was defined as any contrast extravasation beyond the artery wall. Cardiac tamponade was defined as a hemodynamic compromise caused by acute accumulation of blood in the pericardial space.

Statistical analysis

Three different analyses were performed. The first analysis compared the cases selected for primary AWE or primary ADR by physicians. The second analysis was the success rate using diverse approaches (excluding retrograde techniques), and the third analysis was a comparison of procedural and clinical outcomes between ADR cases (primary ADR *versus* AWE-bailout ADR), and stratified by the use of dedicated devices for dissection and re-entry, or knuckle wire technique.

Dichotomic variables are described as numbers and their percentages, and continuous variables are described as mean (± standard deviation) or median (interquartile range), as per their distribution type. X^2 and Fisher's tests were used for comparisons between categorical variables, while for comparisons between continuous variables, the Student's *t* test or Mann-Whitney U test were used according to the Gaussian or non-Gaussian distribution of the results. Bartlett's test was used to determine the normality of data distribution of the continuous variables. No imputations were made in cases of missing data. Since this study is a result of a continuous multicenter registry, no sample size calculation was possible for the main outcomes. In order to avoid biases, biostatisticians played no role in database organization, data entry, and were not in direct contact with local investigators. The Epi Info™, version 7.0 software was used and a p-value of <0.05 was considered significant. The LATAM CTO registry was funded by educational grants from the *Sociedade Brasileira de Hemodinâmica e Cardiologia Intervencionista* (SBHCI) and Boston Scientific®. However, the funders played no role in the design, development, or publication of this analysis, which was performed solely by the investigators. For this study, the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations were followed.[19]

RESULTS

A total of 2,228 cases were included in the database from January 2013 to August 2020. Figure 1 shows the

pADR: primary antegrade dissection reentry; pAWE: primary antegrade wire escalation; ADR: antegrade dissection and reentry; bADR: bailout antegrade dissection and re-entry.

Figure 1. Decision making process for antegrade dissection and re-entry. Stratification flowchart.

Table 1. Clinical and angiographic characteristics according to the initial planned strategy

	Antegrade (n=1,875)	pADR (n=50)	pAWE (n=1,825)	OR	95%CI	p-value
Clinical profile						
Age	64.2±10	67.1±9	64.1±10			0.054
Female sex	415 (22.13)	11 (22)	403 (22.1)			NS
Diabetes	722 (38.5)	21 (42.8)	701 (38.4)			NS
Dyslipidemia	1,348 (71.9)	35 (69.3)	1,312 (71.9)			NS
Hypertension	1,641 (87.5)	43 (85.7)	1,597 (87.5)			NS
Smoking (active)	351 (18.7)	5 (10.2)	347 (19)	0.48	0.19-1.23	0.13
Previous CABG	261 (13.9)	17 (33.3)	245 (13.4)	3.23	1.74-5.98	<0.001
Previous PCI	911 (48.6)	33 (66.6)	891(48.8)	2.15	1.17-3.96	0.012
Previous MI	846 (45.1)	23 (46.8)	821 (45)			NS
Previous PAD	201 (10.7)	6 (12.5)	193 (10.6)			NS
Previous stroke	64 (3.4)	0	65 (3.55)			NS
Previous heart failure	251 (13.4)	7 (14.5)	245 (13.4)			NS
Stable angina	1,392 (74.3)	35 (69.4)	1,356 (74.4)			NS
Angina CCS 3 or 4	699 (37.3)	19 (38.1)	683 (37.4)			NS
LVEF, %	53.5±11.8	56.5±13.6	53.5±11.8			0.089
Angiographic profile						
CTO vessel						<0.001
All LAD	675 (36)	9 (18)	691 (37.9)			
LAD, proximal	276 (14.7)	2 (4)	274 (15)			
LAD, medial	379 (20.2)	6 (12)	372 (20.4)			
All RCA	750 (40.0)	35 (70.0)	712 (39.0)			
RCA, proximal	262 (14.0)	25 (50.0)	235 (12.9)			
RCA, medial	339 (18.1)	8 (16.0)	331 (18.1)			
All LCx	375 (20.0)	6 (12.0)	399 (21.9)			
LCx, proximal	130 (7.0)	5 (10.0)	124 (6.8)			
LCx, medial	162 (8.6)	1 (2.0)	161 (8.8)			
Others	75 (4.0)	3 (6.0)	274 (15)			
Blunt proximal cap	857 (45.7)	41 (81.2)	818 (44.8)	5.34	2.57-11.09	<0.001
Calcification	825 (44)	31 (62)	777 (42.6)	2.2	1.23-3.92	0.008
Previous CTO attempt	251 (13.4)	13 (26.5)	238 (13)	2.41	1.26-4.61	0.010
Lesion length, mm	21 [15-30]	30 [22-41]	21 [15-30]			<0.001
Ambiguity	546 (29.1)	31 (61.2)	516 (28.3)	4.00	2.23-7.18	<0.001
Tortuosity	347 (18.5)	10 (20.3)	336 (18.4)			NS
Ostial lesion	334 (17.8)	13 (26.5)	319 (17.5)	1.69	0.88-3.23	0.10
Reference vessel diameter, mm	2.85 (0.4)	3.09 (0.4)	2.84 (0.4)			<0.001
Side branch near proximal cap	911 (48.6)	26 (52.1)	885 (48.5)			NS
Bifurcation	617 (32.9)	15 (29.1)	604 (33.1)			NS
In-stent CTO	178 (9.5)	9 (18.0)	166 (9.1)	2.19	1.04-4.59	0.032
Total occlusion (*versus* functional)	1,588 (84.7)	46 (91.8)	1,542 (84.5)	2.05	0.73-5.76	0.16
Good re-entry zone	1,337 (71.3)	30 (60.4)	1,307 (71.6)	0.60	0.33-1.08	0.09
Distal cap blunt (*versus* tapered)	767 (40.9)	37 (74.4)	728 (39.9)	4.37	2.25-8.49	<0.001
LMCA stenosis	142 (7.6)	4 (8.1)	139 (7.6)			NS
Number of diseased vessels	1.77±0.9	1.78±1.03	1.77±0.9			NS

Results expressed as mean ± standard deviation, n (%) or median [range].
pADR: primary antegrade dissection reentry; pAWE: primary antegrade wire escalation; NS: non-significan; CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention; MI: myocardial infarction; PAD: peripheral artery disease; LVEF: left ventricle ejection fraction; CTO: chronic total occlusion; LAD: left anterior descending artery; RCA: right coronary artery; LCx: left circumflex artery; LMCA: left main coronary artery.

algorithm of selection of cases for each analysis. The first analysis was a comparison of characteristics of cases where the first planned strategy was ADR or AWE. After excluding procedures with a planned retrograde approach (n=124), and missing information (n=229), 1,875 cases remained for the first analysis. Among them, 50 patients were treated with a planned primary ADR, and 1,825 patients were treated by a planned primary AWE.

Table 1 describes the clinical and angiographic characteristics of the study patients. There was a trend for selection of pADR in older patients, with no gender differences. pADR was preferred in patients with a history of revascularization by CABG or PCI. Most pADR procedures were performed in right coronary artery (RCA) lesions – 70% compared to 39.2% in pAWE; p=0.001. The mean reference vessel diameter (3.09mm [0.4] and 2.84mm [0.45]; p<0.001) and mean lesion length (30mm [22-41] and 21mm [15-30]; p<0.001) were greater in patients treated by pADR when compared to pAWE.

The selection of pADR was also more common in patients with in-stent CTO (18.8% and 9.1%, respectively; OR=2.19, 95%CI 1.04-4.59; p=0.032), moderate or severe calcified CTO (62% and 42.6%, OR=2.2, 95%CI 1.23-3.92; p=0.008), ambiguous caps (61.2% and 28.3%, respectively, OR=4.0, 95%CI 2.23-7.18; p<0.001), blunt proximal caps (81.2% e 44.8%, OR=5.34, 95%CI 2.57-11.09; p<0.001), and blunt distal caps (74.4% and 39.9%, OR 4.37, 95%CI 2.25-8.49; p<0.001) when compared to pAWE. When the specific CTO scoring systems were analyzed, we found a significant correlation between higher scores and the use of pADR for J-CTO (X^2=37, df=5; p<0.001), CASTLE (X^2=37; df=6; p<0.001), and CL scores (X^2=85, df=14; p<0.001) (Figure 2).

For the second analysis we removed all cases in whom a retrograde approach was performed at some point (n=327), and 1,901 (85.3%) cases remained for comparison of different approaches regarding success rates. pAWE had a success rate of 88.4%, and pADR of 76.7%. Femoral access was the most used (Table 2) and for a second access, bifemoral compared to femoral-radial was 61 (39%). Figure 3 shows the procedural success rates of specific antegrade approaches: when ADR cases were gathered (pADR and pAWE + bailout ADR), the success rate was 82.6%. For pAWE and bailout ADR, the use of CrossBoss® device was related to the highest rates of success (92.3% and 82.7%, respectively). However, when Stingray® was employed for re-entry, the rates of success were 62.5% and 77.5%, respectively.

In the third analysis, 236 cases in whom ADR was performed were included and primary and bailout ADR were compared. Most of the procedural and outcomes variables

AWE: antegrade wire escalation; ADR: antegrade dissection reentry.

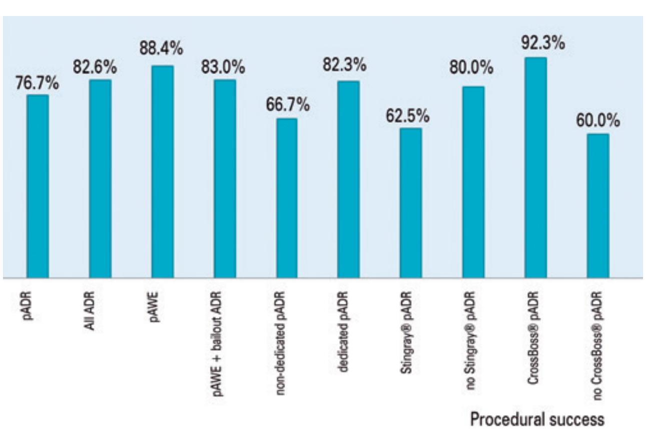
Figure 2. Scoring systems for chronic total occlusions stratified by primary antegrade dissection and reentry *versus* primary antegrade wire escalation. (A) Proportion of J-CTO score strata in planned primary antegrade wire escalation *versus* antegrade dissection and reentry. (B) J-CTO score for the whole group. (C) Proportion of Progress score strata in planned primary antegrade wire escalation *versus* antegrade dissection and reentry. (D) Progress score for the whole group. (E) Proportion of CASTLE score strata in planned primary antegrade wire escalation *versus* antegrade dissection and reentry. (F) CASTLE score for the whole group. (G) Proportion of CL score strata in planned primary antegrade wire escalation *versus* antegrade dissection and reentry. (H) CL score for the whole group. (I) Proportion of ORA score strata in planned primary antegrade wire escalation *versus* antegrade dissection and reentry. (J) ORA score for the whole group.

were similar in the groups. We found that primary ADR cases required a higher rate of femoral access, greater caliber (>8F), and had significantly more minor bleeding rate than pAWE with bailout ADR (Table 2). Figure 4 displays the differences in the main outcomes between our registry and other international registries, while figure 5 summarizes the key findings of the study.

Table 2. Procedural characteristics and angiographic outcomes of primary antegrade dissection reentry *versus* bailout antegrade dissection and re-entry

	AWE (no ADR attempt, n=1,281)	bADR (n=201)	pADR (n=27)	OR (bADR *versus* pADR, 95%CI)	p-value
Dedicated	NA	62 (30.8)	18 (66.6)	4.4 (1.8-10)	<0.001
CrossBoss®	NA	42 (21.1)	14 (51.8)	4.0 (1.74-9.2)	<0.001
Stingray®	NA	38 (18.7)	8 (29.6)	1.82 (0.74-4.51)	0.18
Success	1,133 (88.4)	164 (81.7)	23 (84.6)	1.23 (0.40-3.79)	1
Procedure duration, minutes	126±66	125±66	130±62		0.74
Contrast volume, mL	293±132	290±135	307±106		0.54
Femoral access	1,003 (78.3)	153 (76)	25 (92)	3.79 (0.86-16)	0.07
8F (*versus* smaller)	242 (18.9)	35 (17.3)	10 (37)	2.80 (1.18-6.64)	0.015
Fluoroscopy, minute	52±28	51±28	59±35		0.20
Radiation, Air Kerma	3,235 [1,846-5,509]	3,150 [1,771-5,532]	3,456 [1,847-5,218]		0.76
Perforation, any	81 (6.3)	15 (7.4)	0		0.22
Final dissection	154 (12.0)	25 (12.5)	5 (18.5)		0.44
Distal slow flow	100 (7.8)	18 (9.0)	0		0.23
Collateral damage	15 (1.2)	2 (1)	1 (3.7)		0.04
Donor thrombosis	11 (0.9)	2 (1)	0		1
Donor dissection	0	0	1 (3.7)		0.11
Side branch occlusion	89 (6.9)	14 (7.1)	1 (3.7)		1
Tamponade	11 (0.9)	2 (1)	0		1
Heart failure	35 (2.7)	5 (2.5)	3 (11.8)	1.5 (0.16-13)	0.53
Minor bleeding	38 (3.6)	6 (3)	3 (11)		0.02
Retroperitoneal (femoral access related)	0	0	0		
Required transfusion	17 (1.3)	3 (1.5)	1 (3.7)		0.39
Pacing	17 (1.3)	2 (1)	2 (7.4)		0.069
Shock	23 (1.8)	4 (2)	1 (3.7)		0.47
Dialysis	6 (0.4)	1 (0.5)	1 (3.7)		0.22
Death	6 (0.4)	1 (0.5)	0		0.5
Stroke	0	0	0		
New MI	25 (2.0)	3 (1.6)	0		1
PCI at follow-up	31 (2.4)	4 (2.2)	1 (3.7)		0.5
Angina at follow-up	38 (3)	4 (2)	3 (9)		0.11

Results expressed as n (%), mean ± standard deviation or median [interquartile range].
AWE: antegrade wire escalation; ADR: antegrade dissection and reentry; bADR: bailout antegrade dissection and re-entry; pADR: primary antegrade dissection and re-entry; NA: not applicable; MI: myocardial infarction; PCI: percutaneous coronary intervention.



pADR: primary antegrade dissection and reentry; ADR: antegrade dissection and reentry; pAWE: primary antegrade wire escalation.
Figure 3. Procedural success rate of each strategy. Dedicated antegrade dissection and reentry refers to the use of CrossBoss® or Stingray® or both devices.

DISCUSSION

In this report from a multicenter, multinational CTO PCI registry that gathered data from a region mainly composed of developing countries, the main findings were that ADR was selected for the most complex CTO, both antegrade techniques had acceptable procedural outcomes, and the use of dedicated devices contributed to the highest procedural success rates.

Antegrade techniques for CTO have evolved in the last years. New devices have been developed, strict planning of procedures has received greater attention, and the learning curve is also a related key factor. A focal, functionally occluded, and recent CTO may easily be treated with an initial AWE approach and, in our registry, these cases had a success rate near 90%. On the other hand, complex CTO usually require complex techniques; therefore, it is expected that ADR procedures may have a lower success rate.

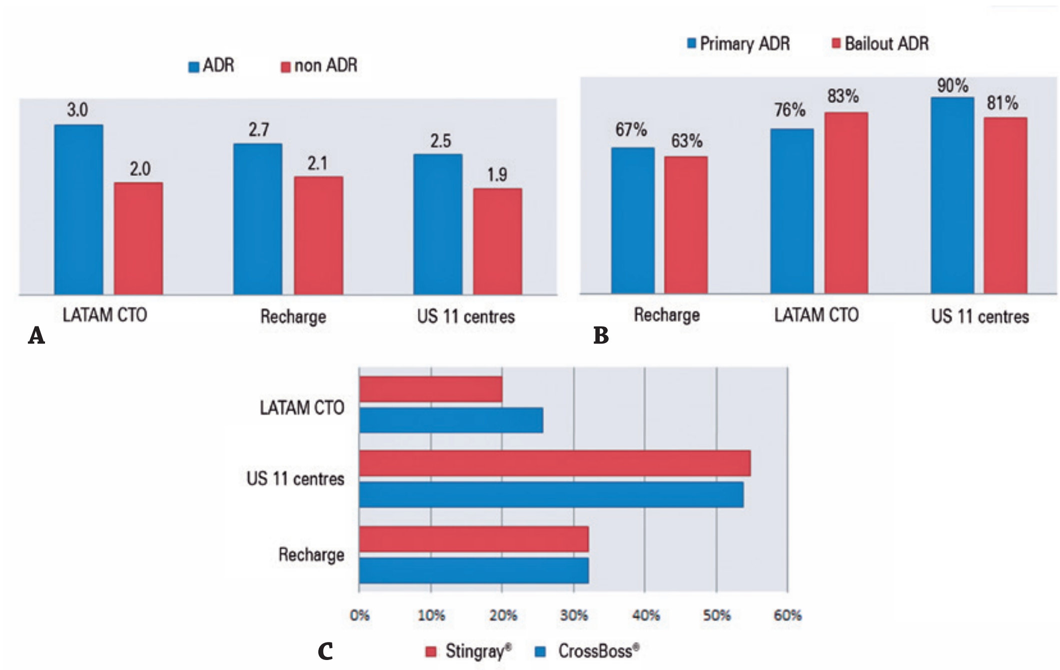
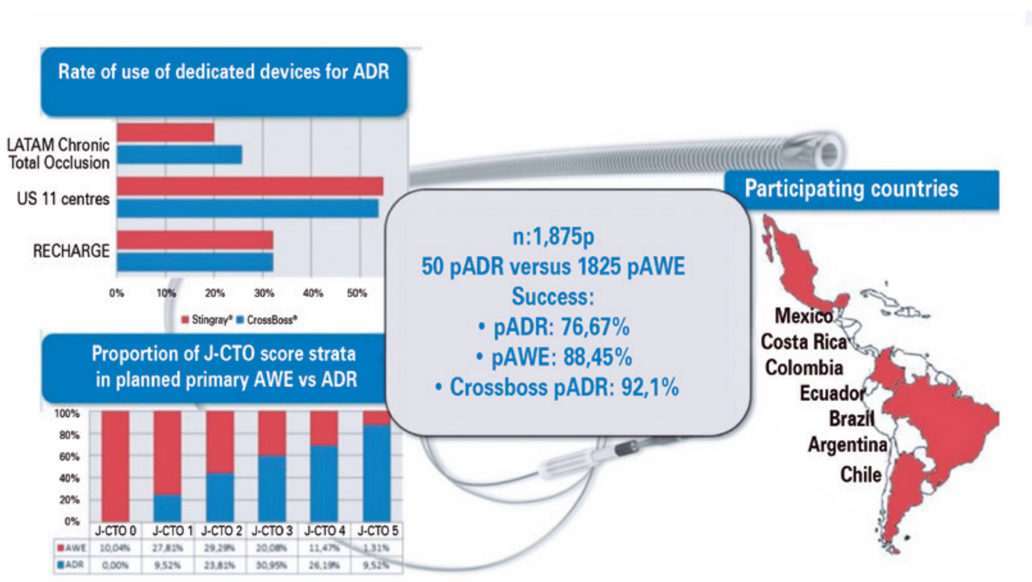


Figure 4. Comparison of key outcomes between LATAM Chronic Total Occlusion and other international chronic total occlusion registries. (A) J-CTO score in LATAM Chronic Total Occlusion, Recharge and United States registry. (B) Success rate of primary or bailout antegrade dissection and reentry. (C) Rate of use of dedicated devices for antegrade dissection and reentry.



ADR: antegrade dissection and re-entry; AWE: antegrade wire escalation; pADR: primary antegrade dissection and re-entry; pAWE: primary antegrade wire escalation.
Figure 5. Key findings of antegrade chronic total occlusion approach from LATAM Chronic Total Occlusion registry.

That said, success rates of 76% in all ADR cases and 92% using the CrossBoss® device, seem encouraging. Although performed at experienced centers, this information shows that complex CTO can be treated in most cases with an antegrade approach. Of note, these success rates seem higher than those described in the European registry RECHARGE (67% for pADR and 63% for bailout ADR).[11]

Regarding the history of CABG (not referring to the CTO of a bypass but to the native vessels), the greater use of ADR would be related to the greater anatomical complexity that these patients have (more calcification and tortuosity, longer lesion length, more frequently a blunt cap, and even more cases involving right coronary artery). Those factors were also related to ADR in our study. In turn, in these patients the success of the procedure is lower, and they have a higher MI rate.[20] The United States multicentric registry showed that prior CABG was related to technical failure in antegrade methods (OR=0.63; p=0.007).[10] On the other hand, for in-stent CTO cases, unlike patients with CABG, the complexity of the occlusion is lower, lesions are less calcified and have a lower J-CTO score, as described in a previous publication from our group.[21]

Planning is a very important aspect when an interventionist engages in CTO PCI. Other registries from Europe and the Unites States[10,11] consider a hybrid approach and take in consideration the scoring systems. Compared with these registries, our cohort had a higher J-CTO score for ADR procedures (Figure 4A). As mentioned above, in the present report increasing values of J-CTO, CL, and CASTLE scores were associated with the choice of ADR as the primary technique. However, even considering that issue, most primary CTO PCI were performed with AWE technique. That may be related to prior training by physicians and a more recent knowledge of ADR, such as knuckle wire, and even more recent introduction of dedicated devices. In our study, the use of bailout ADR helped physicians achieve a success rate of 83% (Figure 4B). Of note, these results are in cases where retrograde approaches were not intended or available.

This is the first continent-wide description of the use of dedicated devices for ADR from a region of developing countries. One out of four (25.6%; n=57) ADR procedures used the CrossBoss® device for antegrade dissection, and the success rate of the cases using it was the highest. Good planning and simpler techniques may have influenced physicians to use the abovementioned device. On the other hand, re-entry with Stingray® device was used in only 44 cases (20%), and its success rate was low. Possible reasons for this low use and low success rate may include the learning curve and adverse anatomic features of patients. In European and North American registries, the rate of use of these devices was higher than in this cohort (Figure 4C), probably due to the later arrival of those devices in Latin American countries due to regulations and costs, as well as a later proctor-based learning curve offered by the manufacturer of devices.

Limitations

Angiographies were not analyzed by a central core laboratory, and local investigators adjudicated the outcomes, therefore variability between observers may have occurred. Some variables had missing data, however no claims were made. The relatively low number of ADR procedures may have caused measurement bias on some of the sensitive outcomes, like MI rates. As strengths, these data come from a multicenter, prospective study, performed at academic centers.

Scalability and generalization

The information provided here may help increase the uptake of the ADR approach by practicing physicians, including direct data for comparison to newer techniques, such as parallel wiring.[22] We are facing an era of increased survival of coronary events and aging of population. In that sense, it is possible that, in the near future, we will have an increased number of patients suitable for CTO-PCI, which raises the importance of information provided in this study, reflecting current success rates of antegrade techniques in experienced centers, and bringing information for a specific pre-procedural planning. An uptake of dedicated devices, especially CrossBoss®, is another factor that may increase success rates.

CONCLUSION

In this first Latin American registry of percutaneous coronary interventions for chronic total occlusion, most cases achieved a successful percutaneous coronary intervention with antegrade techniques, which were safe. Primary antegrade dissection and re-entry were selected for the most complex lesions, and the use of dedicated devices contributed to a high success rate. Using antegrade techniques and novel devices for percutaneous coronary intervention, most chronic total occlusions can be treated, with reasonable low rates of complications. Technical characteristics and J-CTO score may be associated with the choice of antegrade dissection and re-entry, or antegrade wire escalation.

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CONFLICTS OF INTEREST

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CONTRIBUTION OF AUTHORS

Conception and design of the study: SPP and MOB; data collection: GJ, LM, AM, FG, LTP, JT and ASC; data interpretation: SPP, MOB and EJZ; text writing: SPP and EJZ; approval of the final version to be published: MOB, LCS, LTP, JT, PPO and ASQ.

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