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Case Report

Carlino to the Rescue: Use of Intralesion Contrast Injection for Bailout Antegrade and Retrograde Crossing of Complex Chronic Total Occlusions

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Percutaneous coronary intervention (PCI) of coronary chronic total occlusions (CTO) can be challenging. Although several crossing techniques are available, in some cases their application fails to cross the occlusion. Carlino et al. have pioneered the technique of hydraulic microdissection by contrast injection through a microcatheter inserted into the lesion. We report two CTO PCI cases in which the use of the Carlino technique enabled success after other crossing strategies failed to cross the occlusion.

Key words: coronary artery disease; primary PCI; balloon angioplasty

INTRODUCTION

Failure to cross a coronary chronic total occlusion (CTO) with a guidewire is the most common cause for failure of CTO percutaneous coronary intervention [1]. Several crossing techniques are currently available, including antegrade wiring, antegrade dissection/re-entry, and the retrograde approach [2–6].

In 2005, Antonio Colombo was the first to report the use of guidewire-based antegrade dissection/re-entry to cross coronary CTOs, the subintimal tracking and re-entry (STAR) technique [7]. In 2008, Mauro Carlino modified the technique by using contrast injection through a microcatheter advanced as far as possible into the occlusion, which he named "the microchannel technique" [8,9]. The contrast travels through intraluminal microchannels to illuminate the remainder of the vessel, visualizing a pathway for the guidewire to follow and penetrate the lesion [9]. Recanalization was achieved in 19 of 32 CTOs in that study with a microchannel injection (59%), and 7 of the 12 patients in whom the Carlino technique failed were still successfully treated using the STAR technique [9]. The Carlino technique subsequently evolved, injecting smaller volume of contrast (0.5 cc or less) to make the procedure safer without compromising efficacy [10]. However, the technique is infrequently utilized in most catheterization laboratories performing CTO percutaneous coronary intervention (PCI).

We report two CTO PCI cases that would have failed had the Carlino technique not been utilized.

CASE 1

A 70-year-old man with hypertension, hyperlipidemia, ischemic cardiomyopathy (left ventricular ejection fraction of 25%), and atrial fibrillation presented with Canadian Cardiovascular Society (CCS) class II angina despite maximal medical therapy. He had

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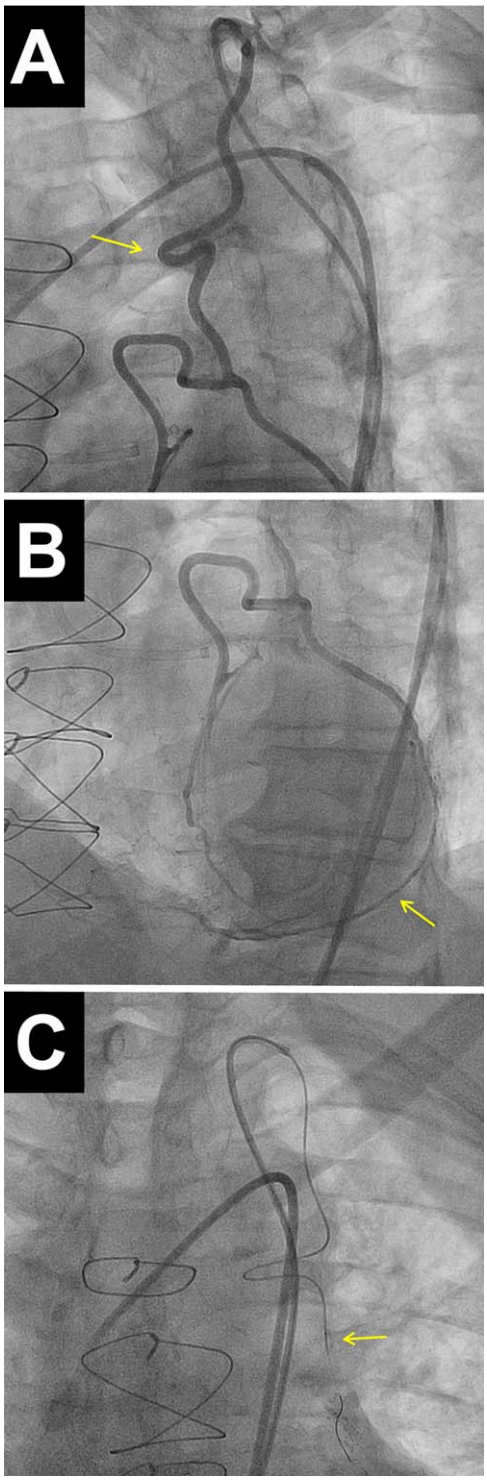

Fig. 1. Left internal mammary artery with significant mid portion tortuosity (arrow, panel A), that supplies the distal right coronary artery via epicardial collaterals (arrow, panel B) from the circumflex. After advancement of a Corsair catheter (arrow, panel C) over a Sion guidewire (Asahi Intecc) through the LIMA, antegrade flow was preserved. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

coronary artery bypass surgery (CABG) 15 years prior to presentation. The patient had undergone stenting of the proximal right coronary artery (RCA) 2 years prior to presentation. Diagnostic angiography demonstrated flush chronic total occlusion of the ostial RCA and the proximal left anterior descending artery (LAD) and circumflex. A tortuous (arrow, Fig. 1A) left internal mammary graft (LIMA) was patent, with a Y distal end anastomosed to the mid LAD and to an obtuse marginal branch (Fig. 1A), which in turn filled the distal RCA through epicardial collaterals (Fig. 1B). The patient had undergone two attempts to recanalize the RCA CTO that were unsuccessful (both retrograde attempts via septal collaterals) and was referred for a third attempt due to refractory symptoms.

Bilateral femoral arterial access was obtained with 45 cm long, 8 Fr sheaths. The RCA was ostially occluded and could not be engaged with a guide catheter. The LIMA graft was engaged with a 6 Fr IM guide catheter through which a Sion wire and a Corsair microcatheter (Asahi Intecc, Nagoya, Japan) were advanced (Fig. 1C). The epicardial collateral was easily crossed with the Sion guidewire, followed by the Corsair microcatheter that was advanced to the CTO distal cap (Fig. 2A). Due to severe LIMA tortuosity several wires could not be advanced to the tip of the microcatheter, including a Pilot 200 (Abbott Vascular, Santa Clara, CA), Confianza Pro 12, Fielder XT and FC, and Miracle 12 (Asahi Intecc). The only guidewires that could reach the tip of the microcatheter were the Gaia guidewires. In spite of using multiple ($n = 9$) Gaia guidewires the CTO could not be crossed. Because of difficulty advancing equipment through the Corsair catheter (a phenomenon commonly described as "Corsair fatigue") it was exchanged for a Finecross microcatheter (Terumo, Warren, New Jersey), that is also more flexible, hence less likely to cause pseudolesions when advanced through the LIMA. Using a 3-cc syringe we forcefully injected approximately 0.5 cc of contrast into the lesion (Fig. 2B) achieving 1–2 mm additional advancement. Further attempts to advance a Gaia guidewire failed. Repeat injection of contrast through the microcatheter achieved entry into the aorta (Fig. 2C). An RG3 (Asahi Intecc) guidewire was advanced into the aorta (Fig. 3A), where it was snared and externalized. After implantation of three drug-eluting stents postdilated at 20 atm and with an Ostial Flash balloon (Access Closure, Santa Clara, CA), an excellent angiographic result was achieved (Fig. 3B). The patient remained stable throughout the procedure and flow through the LIMA remained brisk after equipment removal. Contrast utilization was 320 mL, fluoroscopy time was 73.2 min, and air kerma radiation dose was 3.9 Gray. The patient experienced complete angina relief.

CASE 2

A 50-year-old man with a prior history of coronary artery disease presented with severe angina in spite of maximal medical therapy. He had undergone stenting of the mid LAD and the ramus intermedius four months prior to presentation. Coronary angiogram demonstrated a circumflex CTO (Fig. 4A and B) with patent LAD and ramus stents.

Femoral arterial access was obtained with a 45-cm long, 8 Fr sheath. The circumflex was engaged with an XB 3.5 guide. Unfractionated heparin was administered

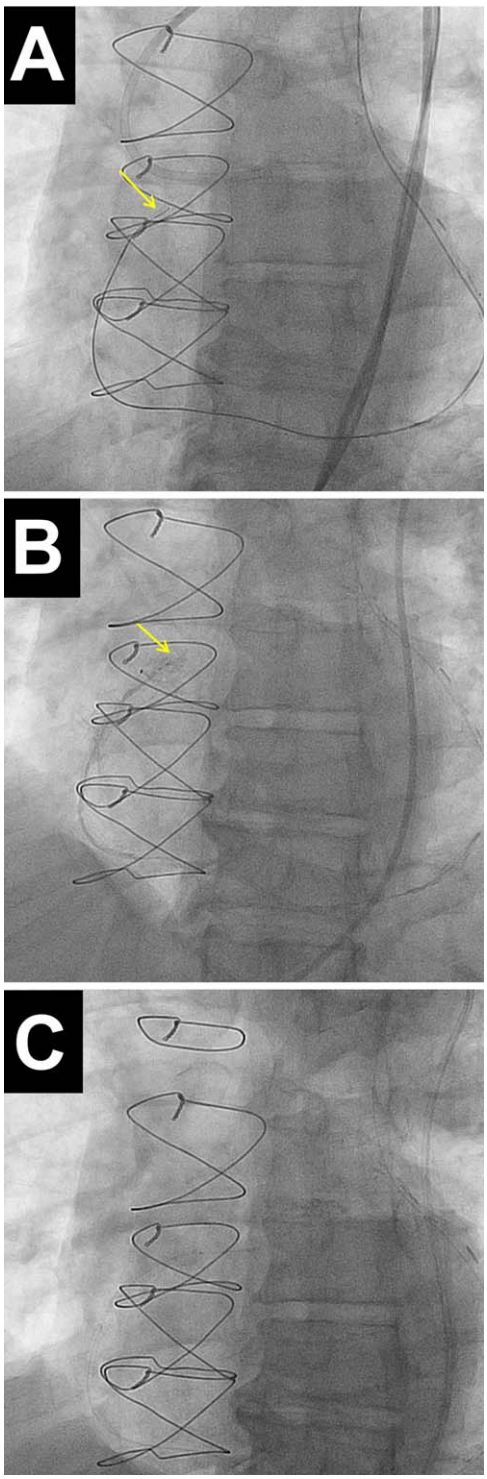

Fig. 2. The guidewire and Corsair catheter were advanced to the distal CTO cap (arrow, panel A), but retrograde wiring was extremely challenging due to LIMA tortuosity. Only Gaia guidewires (Asahi Intecc) could be advanced to the tip of the Corsair catheter but still could not penetrate the occlusion. The Corsair catheter was exchanged for a Finecross catheter and 0.5 cc of contrast was injected advancing slightly more into the occlusion (arrow, panel B). Several additional Gaia 2nd guidewires (Asahi Intecc) could not be advanced through the lesion. Intralesion contrast injection was repeated achieving contrast jet entry into the aorta (arrow, panel C). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

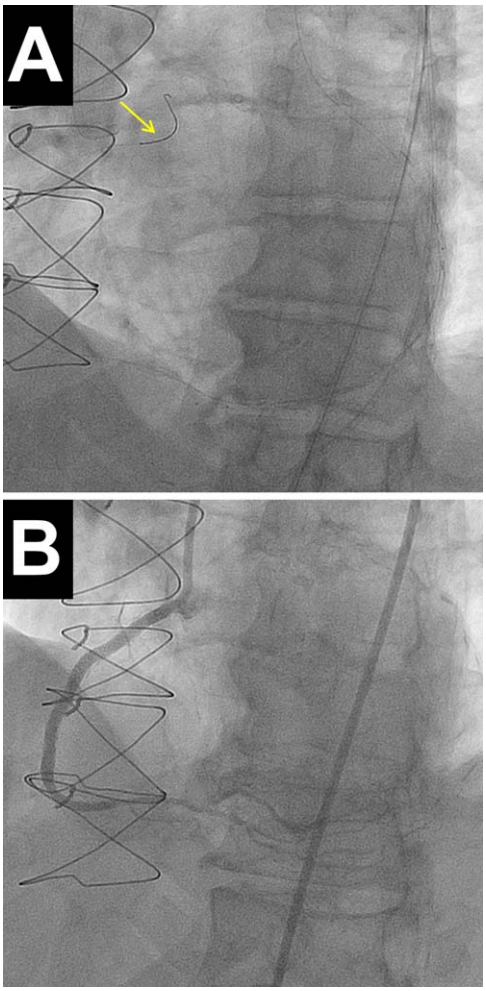

Fig. 3. An RG3 guidewire (Asahi Intecc) was advanced into the aorta (arrow, panel A), snared and externalized, enabling stenting of the right coronary artery CTO with an excellent final result (panel B). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

for anticoagulation. Several attempts were made for antegrade wire crossing through a Venture catheter (Vascular Solutions), a Corsair (Asahi Intecc), and a Finecross microcatheter. Several guidewires were tried, but all of them prolapsed into the LAD when forceful advancement attempts were made. The patient did not have interventional collaterals that could enable retrograde crossing. Given the impasse, ~0.5 cc of contrast were administered through the microcatheter embedded into the occlusion. The contrast caused hydraulic dissection into the distal circumflex (Fig. 4C). A Fielder XT guidewire then easily advanced into the distal true lumen, as confirmed by orthogonal angiographic projections (Fig. 5A and B). The circumflex was stented with two drug-eluting stents restoring antegrade flow (Fig. 5C). The patient received 320 mL of contrast, fluoroscopy time was 34 min and air kerma radiation dose was 3.6 Gray. He had an uneventful recovery with complete resolution of angina.

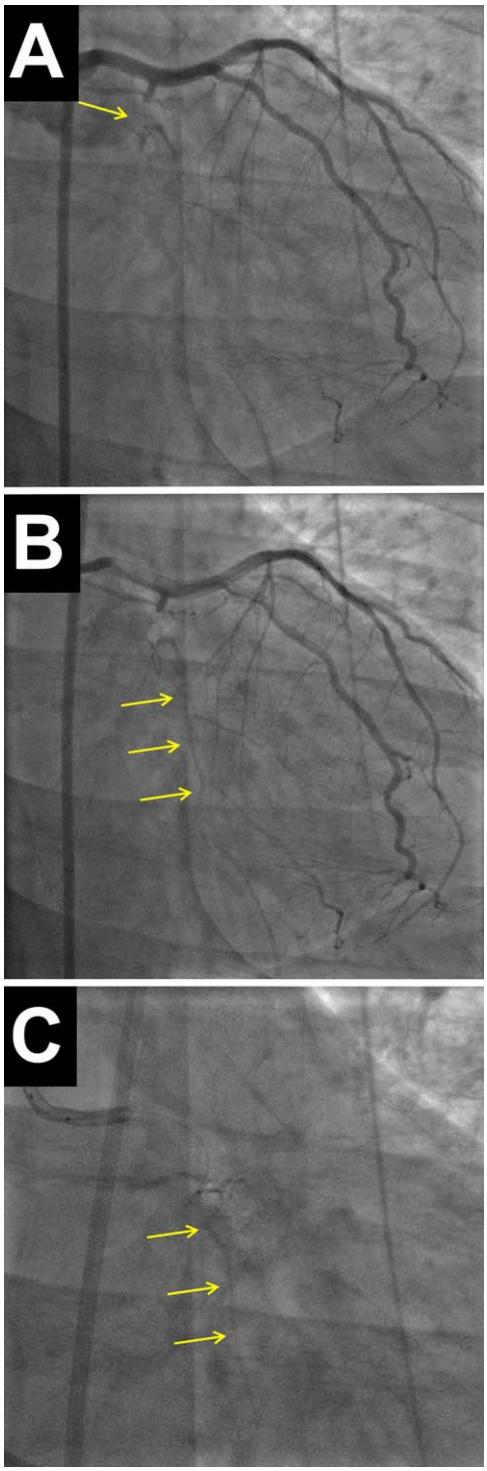

Fig. 4. Coronary angiography demonstrating a proximal circumflex chronic total occlusion (arrow, panel A), with the distal vessel filling late by ipsilateral collaterals (arrows, panel B). Antegrade crossing attempts using various guidewires (Fielder XT, Gaia 2nd [Asahi Intecc], Pilot 200 [Abbott Vascular]) through a Venture catheter, a Corsair (Asahi Intecc), and a Finecross catheter (Terumo) failed to cross (the microcatheter would become disengaged during wire advancement attempts). The Finecross catheter was advanced to the proximal cap and 0.5 cc of contrast was injected under cineangiography (arrows, panel C), hydraulically dissecting into the distal true lumen. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

DISCUSSION

Our cases demonstrate how use of the Carlino technique can result in procedural success after all other crossing strategies fail. It also highlights the usefulness of the novel composite core guidewires for advancing through tortuosity.

Although CTO PCI can be challenging to perform and has traditionally been associated with low success and high complication rates [11], experienced operators and centers can achieve increasingly high success rates [12,13], even among complex patient and lesion subgroups [14–17]. A combination of various crossing strategies is often needed to achieve these results [6,12]. However, since approximately one in ten cases fails to be recanalized [1], familiarity with additional equipment and techniques is critical for continued improvement in outcomes.

In both cases several crossing strategies were utilized without success prior to use of the Carlino technique. In the first case, no antegrade options existed due to the flush occlusion of the RCA, and numerous guidewires had been advanced retrogradely failing to penetrate the distal cap. In the second case, no retrograde option was feasible due to lack of interventional collaterals [18]. Antegrade attempts had failed due to steep angulation and lack of appropriate support, in spite of using a Venture catheter (St Jude Medical, Minneapolis, MN) [19].

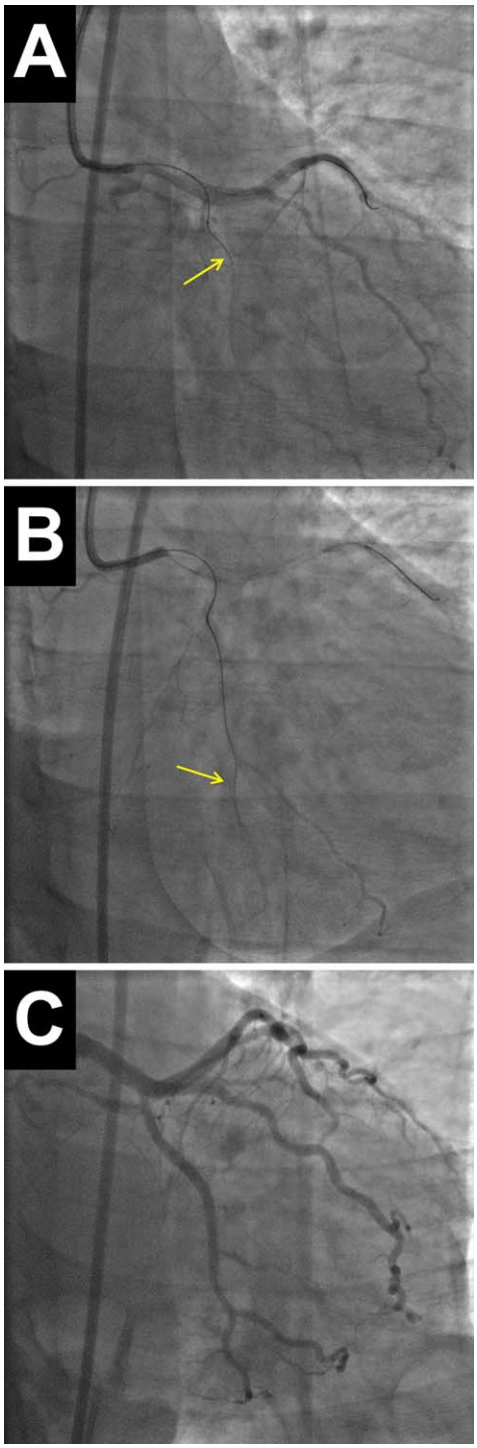

Fig. 5. A Fielder XT guidewire (Asahi Intecc) (arrow, panel A) easily advanced through the occlusion into the distal true lumen (arrow, panel B), as confirmed by orthogonal projection. An excellent result was obtained after implantation of drug-eluting stents (panel C). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

The Carlino technique is a unique form of antegrade dissection re-entry [20] that utilizes contrast to advance through the occlusion. It involves intralesional injection of a small amount of contrast (~0.5 cc) using angiographic guidance (causing limited subintimal space staining and/or crossing). It is based on the assumption that microchannels may exist throughout the occlusion that can be opened by forceful contrast injection. This is exactly what happened in both of our cases. In the original application of the technique it was successful in 20 of 32 patients, with an additional 7 patients subsequently recanalized with another technique [9]. Only one patient developed a periprocedural myocardial infarction and no major cardiac adverse events or subacute stent thrombosis was observed [9]. The contrast may not always travel down the path of the vessel, occasionally creating a "storm cloud" appearance, but with injection of small amount of contrast the risk of complications can be minimized. In both of our cases contract tracked into the distal true lumen, but even if it had tracked within the subintimal space it would have still been helpful for facilitating antegrade dissection/re-entry.

The Gaia guidewires (Asahi Intecc) have a composite core, dual coil construction [21,22] designed to enhance torquability, maneuverability, and ability to cross long tortuous occlusions, but require slower, more meticulous, and precise manipulation as compared with standard guidewires. The distal 1 mm tip is pre-shaped at a 45-degree angle. The Gaia wires are available in three types (Gaia First, Gaia Second, and Gaia Third) with increasing tip stiffness and tapered tip diameter. The Gaia wires, particularly the Second and Third, are popular because due to their ability to steer with a gentler tip, they often stay within the intimal plaque [21,22]. In the first case no other guidewire could advance through the microcatheter to the CTO distal cap due to extreme tortuosity, highlighting the usefulness of the Gaia guidewires in complex and tortuous lesions.

Use of the Carlino technique has important limitations. First, it may cause perforation, although the risk appears to be low with injection of a small volume of contrast. Second, it may be associated with high restenosis rates: in the initial reports long-term in-segment binary restenosis rate was 44.7% overall and 29.4% among patients who received drug-eluting stents [8]. However, the risk of restenosis is likely low with the use of small amount of contrast for dissection. Although data is limited, long-term patency with the use of contemporary antegrade dissection/re-entry techniques appears to be similar with other crossing strategies [23,24]. Third, contrast injection may expand the subintimal space, hindering re-entry attempts if subintimal guidewire crossing is achieved. Clearly additional short- and long-term study of this crossing strategy is needed.

In summary, the Carlino technique, which utilizes contrast injection through a microcatheter at the site of

a lesion, can enable procedural success of CTO PCI even after failure of other crossing strategies.

REFERENCES

1. Sapontis J, Christopoulos G, Grantham JA, et al. Procedural failure of chronic total occlusion percutaneous coronary intervention: Insights from a multicenter US registry. Catheter Cardiovasc Interv 2015;85:1115–1122.
2. Brilakis ES, editor Manual of Coronary Chronic Total Occlusion Interventions. A Step-By-Step Approach. Waltham, MA: Elsevier; 2013.
3. Galassi AR, Sianos G, Werner GS, et al. Retrograde recanalization of chronic total occlusions in Europe: Procedural, in-hospital, and long-term outcomes from the multicenter ERCTO registry. J Am Coll Cardiol 2015;65:2388–2400.
4. Galassi A, Grantham A, Kandzari D, et al. Percutaneous treatment of coronary chronic total occlusion. II. Technical approach. Intervent Cardiol Rev 2014;9:201–207.
5. Sianos G, Werner GS, Galassi AR, et al. Recanalisation of chronic total coronary occlusions: 2012 consensus document from the EuroCTO club. EuroIntervention 2012;8:139–145.
6. Brilakis ES, Grantham JA, Rinfret S, et al. A percutaneous treatment algorithm for crossing coronary chronic total occlusions. JACC Cardiovasc Interv 2012;5:367–379.
7. Colombo A, Mikhail GW, Michev I, et al. Treating chronic total occlusions using subintimal tracking and reentry: The STAR technique. Catheter Cardiovasc Interv 2005;64:407–411. Discussion 412.
8. Carlino M, Godino C, Latib A, Moses JW, Colombo A. Subintimal tracking and re-entry technique with contrast guidance: A safer approach. Catheter Cardiovasc Interv 2008;72:790–796.
9. Carlino M, Latib A, Godino C, Cosgrave J, Colombo A. CTO recanalization by intraocclusion injection of contrast: The microchannel technique. Catheter Cardiovasc Interv 2008;71:20–26.
10. Carlino M, Ruparelia N, Thomas G, et al. Modified contrast microinjection technique to facilitate chronic total occlusion recanalization. Catheter Cardiovasc Interv 2015 Sep 10. doi: 10.1002/ccd.26242. [Epub ahead of print]
11. Brilakis ES, Banerjee S, Karmpaliotis D, et al. Procedural outcomes of chronic total occlusion percutaneous coronary intervention: A report from the NCDR (National Cardiovascular Data Registry). JACC Cardiovasc Interv 2015;8:245–253.
12. Christopoulos G, Menon RV, Karmpaliotis D, et al. The efficacy and safety of the "hybrid" approach to coronary chronic total occlusions: Insights from a contemporary multicenter US registry and comparison with prior studies. J Invasive Cardiol 2014;26:427–432.
13. Patel VG, Brayton KM, Tamayo A, et al. Angiographic success and procedural complications in patients undergoing percutaneous coronary chronic total occlusion interventions: A weighted meta-analysis of 18,061 patients from 65 studies. JACC Cardiovasc Interv 2013;6:128–136.
14. Christopoulos G, Karmpaliotis D, Alaswad K, et al. The efficacy of "hybrid" percutaneous coronary intervention in chronic total occlusions caused by in-stent restenosis: Insights from a US multicenter registry. Catheter Cardiovasc Interv 2014;84:646–651.
15. Christopoulos G, Karmpaliotis D, Wyman MR, et al. Percutaneous intervention of circumflex chronic total occlusions is associated with worse procedural outcomes: Insights from a multicentre US registry. Can J Cardiol 2014;30:1588–1594.
16. Christopoulos G, Menon RV, Karmpaliotis D, et al. Application of the "hybrid approach" to chronic total occlusions in patients with previous coronary artery bypass graft surgery (from a Contemporary Multicenter US registry). Am J Cardiol 2014;113:1990–1994.
17. Teramoto T, Tsuchikane E, Matsuo H, et al. Initial success rate of percutaneous coronary intervention for chronic total occlusion in a native coronary artery is decreased in patients who underwent previous coronary artery bypass graft surgery. JACC Cardiovasc Interv 2014;7:39–46.
18. Christopoulos G, Wyman RM, Alaswad K, et al. Clinical utility of the Japan-chronic total occlusion score in coronary chronic total occlusion interventions: Results from a Multicenter Registry. Circ Cardiovasc Interv 2015;8:e002171.
19. Iturbe JM, Abdel-Karim AR, Raja VN, Rangan BV, Banerjee S, Brilakis ES. Use of the venture wire control catheter for the treatment of coronary artery chronic total occlusions. Catheter Cardiovasc Interv 2010;76:936–941.
20. Michael TT, Papayannis AC, Banerjee S, Brilakis ES. Subintimal dissection/reentry strategies in coronary chronic total occlusion interventions. Circ Cardiovasc Interv 2012;5:729–738.
21. Tomasello SD, Giudice P, Attisano T, Boukhris M, Galassi AR. The innovation of composite core dual coil coronary guidewire technology: A didactic coronary chronic total occlusion revascularization case report. J Saudi Heart Assoc 2014;26:222–225.
22. Galassi AR, Ganyukov V, Tomasello SD, Haes B, Leonid B. Successful antegrade revascularization by the innovation of composite core dual coil in a three-vessel total occlusive disease for cardiac arrest patient using extracorporeal membrane oxygenation. Eur Heart J 2014; 35:2009.
23. Rinfret S, Ribeiro HB, Nguyen CM, Nombela-Franco L, Urena M, Rodes-Cabau J. Dissection and re-entry techniques and longer-term outcomes following successful percutaneous coronary intervention of chronic total occlusion. Am J Cardiol 2014;114:1354–1360.
24. Mogabgab O, Patel VG, Michael TT, et al. Long-term outcomes with use of the CrossBoss and stingray coronary CTO crossing and re-entry devices. J Invasive Cardiol 2013;25:579–585.