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A Novel Maneuver to Facilitate Retrograde Wire Externalization During Retrograde Chronic Total Occlusion Percutaneous Coronary Intervention

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Background: Although the retrograde approach has improved the success rate and procedural efficiency of chronic total occlusion (CTO) percutaneous coronary intervention (PCI), it can still be challenging and time-consuming. We introduce a novel technique that aims to facilitate the critical step of retrograde wire externalization during reverse controlled antegrade and retrograde tracking and dissection (CART), which we named DRAFT (Deflate, Retract and Advance into the Fenestration Technique). Materials and Methods: DRAFT is performed by simultaneous retraction of the deflating antegrade balloon (after inflation in the subintimal space) and advancement of the retrograde looped wire in the same plane through the transient fenestrations created by reverse CART, in order to cross through the fenestrated dissection flap before its collapse. The retrograde wire is then quickly and easily advanced into the antegrade guiding catheter. Results: DRAFT was used in 11 patients (8 with right coronary artery and 3 with left anterior descending artery CTOs). Several different guidewires were used, since this technique does not need any specific wire to be performed. DRAFT was successful in all cases, after at most five attempts. CTO PCI was then completed as per standard retrograde practice. No complications occurred. Conclusions: DRAFT is a versatile approach that allows easy and quick re-entry of the retrograde wire into the true lumen during reverse CART. It can be performed with a variety of guidewires and is feasible both in the left and right coronary arteries. © 2016 Wiley Periodicals, Inc.

Key words: balloon angioplasty; percutaneous coronary intervention; complex PCI; percutaneous coronary intervention

INTRODUCTION

The retrograde approach has revolutionized the field of chronic total occlusion (CTO) percutaneous coronary intervention (PCI) by significantly increasing success rates, and is often being used as primary crossing strategy [1]. It represents an elegant solution for very challenging cases, including some that were previously considered "impossible" with antegrade-only techniques.

The retrograde approach involves two main steps: (a) delivering a guidewire and a microcatheter distal to the occlusion via a collateral vessel, and (b) crossing the CTO segment, which is usually followed by retrograde guidewire externalization [2]. This second step can occasionally be time-consuming due to poor trackability and maneuverability of the retrograde guidewire, and it might also be limited by the acute recoil of the subintimal space, when a reverse controlled antegrade and retrograde tracking and dissection (CART) technique is used.

In the present article we describe a novel approach aimed at facilitating retrograde wire re-entry into the antegrade guiding catheter, which we have named DRAFT (Deflate, Retract and Advance into the Fenestration Technique).

TECHNIQUE DESCRIPTION

DRAFT was developed to provide an easy, safe, inexpensive and reproducible strategy to facilitate the critical step of retrograde guidewire re-entry into the true lumen during reverse CART (Fig. 1). It is based

Additional Supporting Information may be found in the online version of this article.

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Conflict of interest: Nothing to report.

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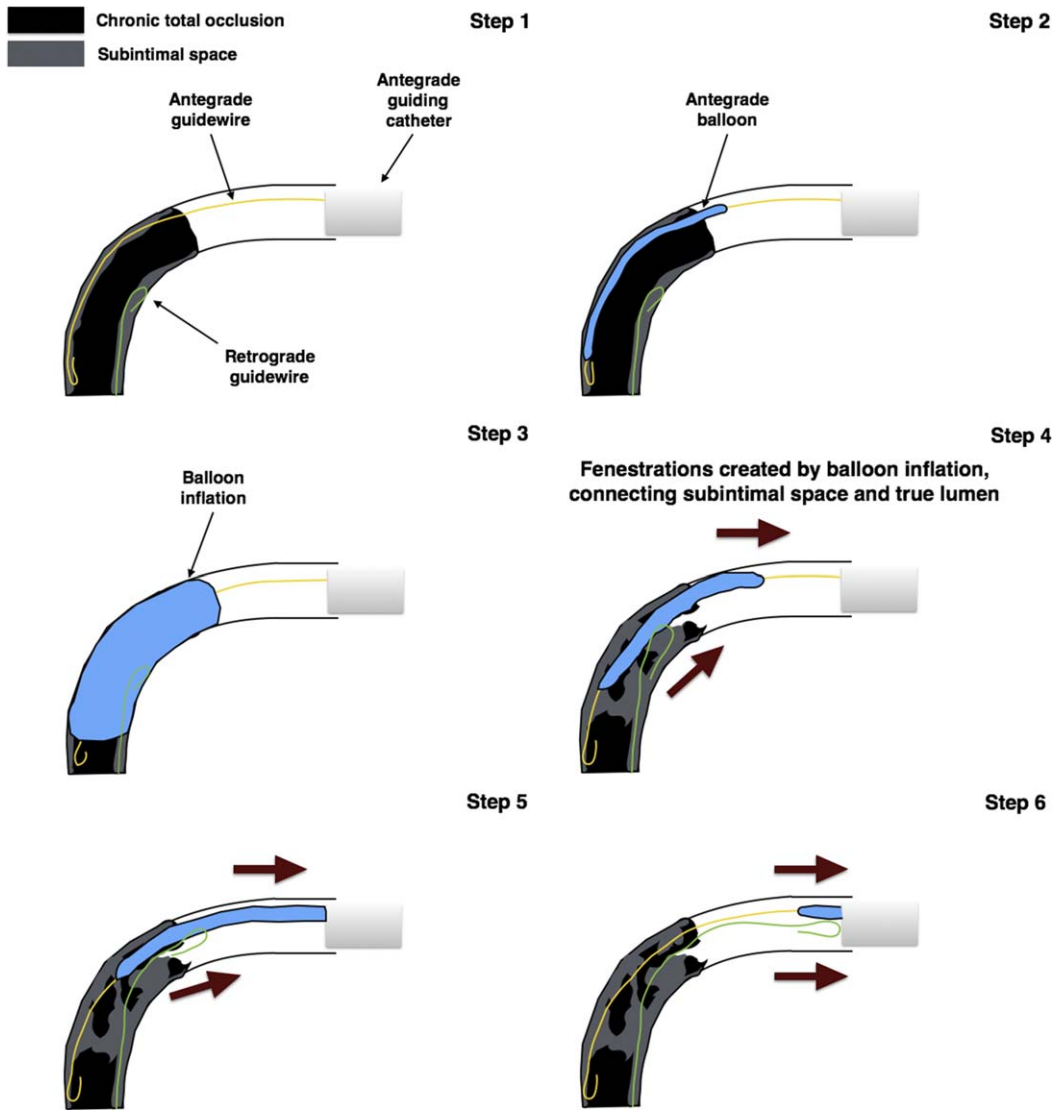

Fig. 1. Schematic representation of the Deflate, Retract and Advance into the Fenestration Technique (DRAFT). Antegrade and retrograde guidewires in the subintimal space, during reverse Controlled Antegrade and Retrograde Tracking and dissection (CART) (Step 1). A balloon is then advanced on the antegrade guidewire (Step 2). Balloon inflation (balloon-to-artery ratio ≈1) is performed (Step 3). Balloon inflation over the antegrade guidewire creates multiple fenestrations and subsequent connections between the subintimal space and the true lumen, so that, when quick advancement of the retrograde guidewire is performed before complete balloon deflation and retraction, the retrograde knuckled wire can easily penetrate the true lumen (Step 4 and 5) and enter the antegrade guiding catheter (Step 6).

on: (1) multiple inflations of an adequately sized antegrade balloon to create numerous and large fenestrations connecting the subintimal space with the true lumen; (2) pullback of the deflating balloon and simultaneous advancement of the retrograde knuckled guidewire, in order to facilitate wire re-entry into the true lumen and subsequently into the guiding catheter, taking advantage of the suctioning force while the fenestrated dissection flap is wide open, before its collapse. Additionally, the retrograde knuckled wire itself might further fenestrate some residual tissue after antegrade balloon deflation and retraction, thus successfully connecting the two tissue planes, in a sort of a "retrograde subintimal tracking and re-entry (STAR)" approach. However, unlike STAR, with DRAFT we are able to maintain control over the re-entry site.

Two operators are needed to perform the technique: one is advancing the retrograde guidewire whereas the other is deflating and withdrawing the antegrade balloon. Since DRAFT takes advantage of mechanical principles to facilitate re-entry (creation of large multiple – albeit transient – fenestrations, suctioning force

of the deflating balloon), it can be performed irrespectively of the guidewire used, and re-entry into the true lumen can be accomplished with a knuckled wire.

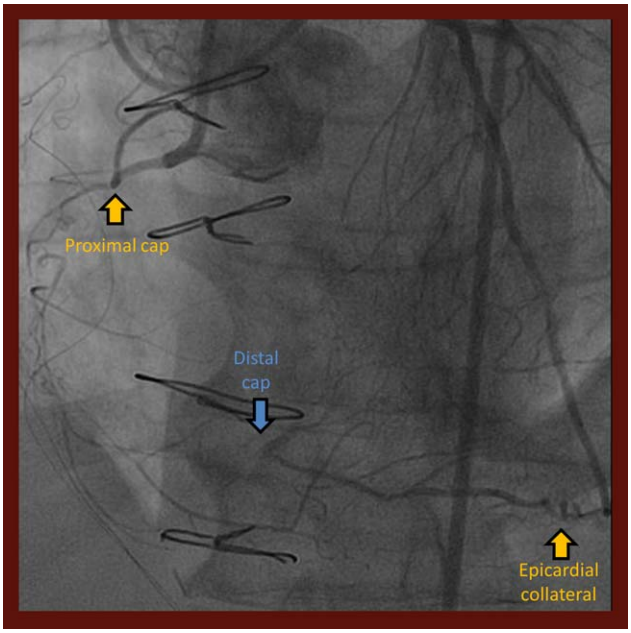

Fig. 2. Baseline coronary angiography. Long chronic total occlusion of the proximal RCA, with ambiguous proximal cap and landing zone at the bifurcation between the posterior descending artery and posterolateral branch. A large tortuous epicardial collateral from the distal left anterior descending artery filled the right posterior descending artery.

RESULTS

A case example is provided in Figs. 2–4 and Supporting Information Videos 1–2. A long, calcified CTO of the proximal right coronary artery (RCA), with ambiguous proximal cap and landing zone at the bifurcation between the posterior descending artery and posterolateral branch (Fig. 2), was approached using the retrograde approach. After "septal surfing" using a Sion guidewire (Asahi Intecc, Aichi, Japan) and a Corsair microcatheter (Asahi Intecc), retrograde and antegrade wiring of the occlusion was performed using two knuckled Pilot 200 guidewires (Abbott Vascular, Santa Clara, CA). A 3.0 × 20 mm semicompliant balloon was advanced over the antegrade guidewire in preparation for reverse CART. We subsequently did the following (Fig. 3, Supporting Information Videos 1 and 2):

1. The operators overlapped the retrograde wire and the antegrade balloon (Fig. 3A: reverse CART). Balloon inflation at 14 atm followed.
2. Simultaneous pullback of the deflating balloon and advancement of the looped guidewire was performed (Fig. 3B: a two-operator maneuver).
3. The looped wire constantly "chased" the deflating and retracting balloon, until the two devices entered the guiding catheter (Fig. 3B and C).

Using this technique, the looped retrograde guidewire was easily advanced into the antegrade guiding catheter, with the help of the suctioning force of the deflating balloon and prior to the occurrence of

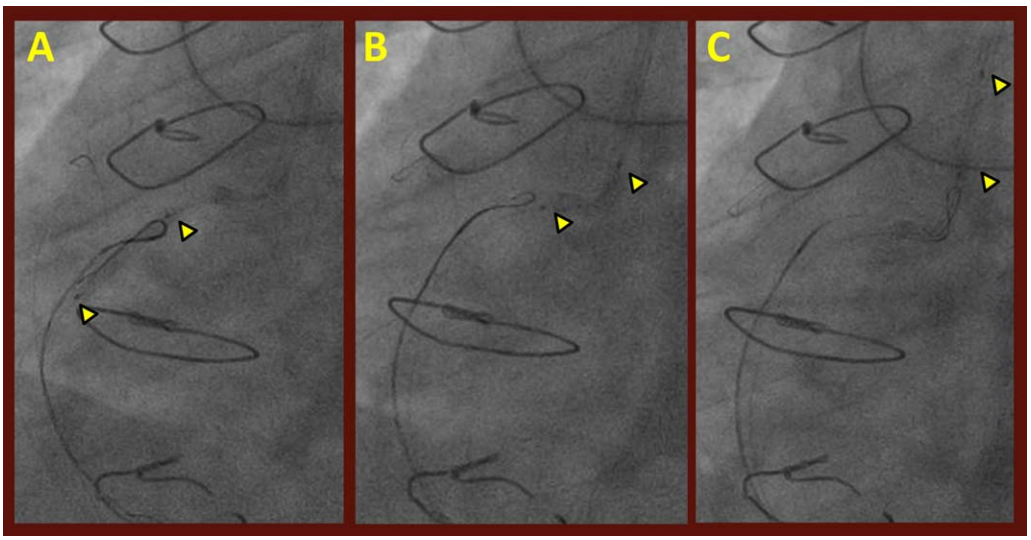

Fig. 3. Deflate, Retract and Advance into the Fenestration Technique (DRAFT). A. The loop of the distal end of the retrograde guidewire is overlapped with the antegrade balloon inflated in the subintimal space. B. Balloon deflation and retraction occurs simultaneously with retrograde guidewire advancement (the loop is "chasing" the distal end of the balloon). C. The looped retrograde wire enters the antegrade catheter. The arrowheads indicate the distal and proximal markers of the balloon.

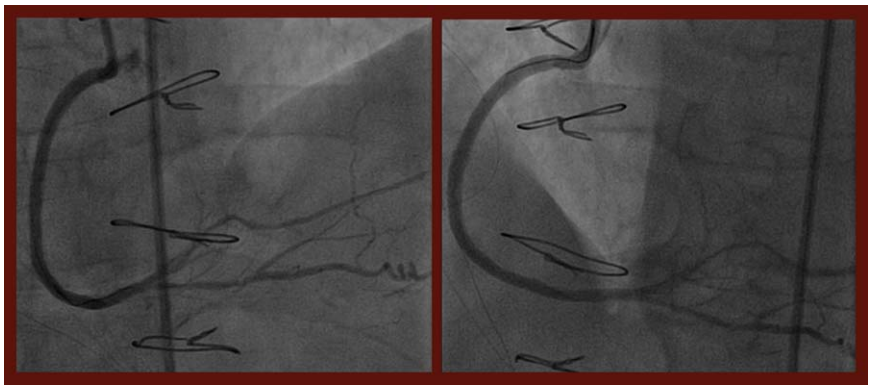

Fig. 4. Final result. Final angiogram demonstrating successful recanalization of the right coronary artery chronic total occlusion. Three drug-eluting stents were implanted.

TABLE I. Clinical and angiographic characteristics of the patients treated with the Deflate, Retract and Advance into the Fenestration Technique (DRAFT)

Patient number	Sex	Age	CTO localization	J-CTO score	Antegrade/Retrograde guidewire	Antegrade balloon (mm)	Contrast volume (ml)	Fluoroscopy time (min)	Radiation dose ($Gy \cdot cm^2$)
1	M	60	Proximal RCA	4	Pilot 200/Pilot 200	3.0 × 20	200	33	291
2	M	81	Proximal RCA	2	Confianza Pro 8/20/Fielder FC	2.5 × 20	200	60	272
3	M	77	Mid RCA	3	Pilot 200/Fielder XT-A	3.0 × 30	500	43	328
4	M	55	Proximal RCA	3	Fielder XT/Pilot 200	3.0 × 20	225	109	271
5	M	63	Mid RCA	3	Confianza Pro 9/Sion Black	2.5 × 20	300	75	271
6	F	48	Mid RCA	3	Fielder XT/Pilot 200	3.0 × 20	120	46	64
7	M	49	Proximal RCA	2	Fielder XT/Pilot 150	2.5 × 20	300	31	64
8	M	66	Mid LAD	1	Fielder FC/Sion	3.0 × 20	560	84	343
9	M	70	Mid LAD	1	Fielder XT/Fielder XT	2.5 × 20	460	99	360
10	M	68	Proximal RCA	3	Confianza Pro 8/20/Sion	2.0 × 20	400	72	289
11	M	51	Mid LAD	0	Fielder XT/Sion	3.0 × 20	400	60	284

subintimal recoil. Once the Corsair catheter was advanced into the antegrade guiding catheter, the retrograde Pilot 200 was exchanged with an RG3 guidewire (Asahi Intecc), which was then externalized through the antegrade guiding catheter. Subsequently, PCI was carried out as per standard practice and three drug-eluting stents were implanted, from the ostium to the crux, with an optimal final result (Fig. 4).

Following this case, DRAFT has been performed in 10 more cases of RCA and left anterior descending CTOs, approached using the retrograde approach (Table I). DRAFT was successful in all cases, after at most five attempts (≈10-15 seconds each). We have found that DRAFT facilitated easy and quick retrograde guidewire re-entry in the true lumen and subsequently in the antegrade guiding catheter, thus avoiding additional maneuvers (e.g., snaring).

DISCUSSION

In this article, we propose a modification of reverse CART, which we named DRAFT. This novel technique aims to facilitate the critical step of retrograde guidewire re-entry into the proximal true lumen. Two aspects differentiate DRAFT from conventional reverse CART: in DRAFT, (1) the retrograde guidewire is *simultaneously* advanced while the antegrade balloon is being deflated and withdrawn; and (2) the retrograde wire is *knuckled*.

A retrograde approach is currently widely used in complex CTO scenarios (when antegrade techniques are unlikely to succeed) [2], and dedicated CTO-PCI operators embrace this approach in up to a half of the cases [3].

The goal of the retrograde approach is the externalization of the retrograde wire to allow subsequent antegrade wiring of the occlusion [2]. However, the retrograde wire can be manipulated in a true-to-true lumen fashion only in few cases, due to its tendency to engage in the subintimal space. In this context, reverse CART is currently the most frequently used retrograde CTO crossing technique [4]. It has greatly facilitated retrograde wire re-entry in the true lumen, since it is based on the balloon-induced creation of a connection between the subintimal space and the true lumen [5].

However, this critical step of the reverse CART technique might be challenging, since the fenestrations created by balloon inflation in the subintimal space are transient and soon collapse after balloon deflation. Additionally, even if access to the true lumen is achieved, difficulties might arise while trying to advance the retrograde wire into the guiding catheter. Strategies to deal with these issues have been developed and will be briefly reviewed here. The use of antegrade intravascular ultrasound (IVUS) allows to better understand the spatial relationship between the antegrade and retrograde guidewires [6]. However, IVUS-guided re-entry does not take advantage of the favorable—but transient—large fenestrations induced by balloon inflation and maintained during balloon pullback, through which the retrograde guidewire can cross into the true lumen. Another approach is to use laser over the antegrade guidewire to enlarge the space created by the antegrade balloon and minimize tissue recoil [7]. However, laser is expensive, not universally available and carries risk of perforation.

When the retrograde wire has re-entered the true lumen, the operator's focus shifts towards advancing the guidewire into the antegrade guiding catheter. To this extent, several techniques have been described. The retrograde guidewire can be advanced into the aortic root and then captured with a snare [8]. Alternatively, the wire can be captured in the vessel architecture, once a guiding catheter extension system (e.g., Guideliner^{TM}, Vascular Solutions, Minneapolis, MN) has been advanced over the antegrade wire [9]. However, all the aforementioned techniques require dedicated skills, imply the utilization of additional devices, and increase procedural complexity and costs.

In the present article we introduce DRAFT, a novel, inexpensive and easy-to-perform technique that can greatly facilitate the critical step of retrograde wire re-entry into the proximal true lumen during reverse CART. DRAFT is based on the simultaneous retraction of the deflating antegrade balloon (after inflation in the subintimal space) and the advancement of the retrograde guidewire (with the help of the second operator). The retrograde knuckled wire should be angiographically "chasing" the distal end of the antegrade balloon prior to entry of the latter in the antegrade guiding catheter (Fig. 3, Supporting Information Videos 1 and 2). The suction force created by the deflating balloon, in combination with the forward movement of the looped retrograde wire, before the collapse of the fenestrated dissection flap, enables rapid and successful re-entry of the latter into the true lumen and subsequently into the antegrade catheter.

To maximize the success of DRAFT, careful attention should be paid to the following: first, it is mandatory to confirm the optimal co-axial alignment of the antegrade guiding catheter and the artery using two orthogonal projections before considering DRAFT, otherwise entering the antegrade guiding catheter might be very challenging or impossible, and bailout snaring of the guidewire in the ascending aorta might be needed. Guiding catheter alignment can be optimized using balloon inflation as anchoring during reverse CART. If co-axial alignment cannot be achieved, guiding catheter exchange might be considered, although this implies losing the antegrade component of the reverse CART setup, and subintimal wiring of the occlusion shall be performed again. Second, adequate predilatation of the CTO segment treated with reverse CART must be performed. This implies a balloon-to-artery ratio of approximately 1, to maximize the size of the fenestrations created with reverse CART. In addition, performing multiple balloon dilatations might hamper the collapse of the fenestrated dissection flap and is therefore encouraged during reverse CART. Third, to avoid the limitations of the movement of the retrograde wire caused by acute subintimal recoil, operators should keep close proximity of the retrograde wire and the distal end of the antegrade balloon, and advance the retrograde guidewire quickly, before the fenestrations collapse.

Even if in our experience DRAFT was successful in all 11 cases after a few tries, attempts at connecting the retrograde wire with the proximal true lumen might fail, due to either poor technique or patient-related factors. The former includes lack of synchronization between antegrade balloon deflation/retraction and retrograde wire advancement, suboptimal choice of balloon diameter (too small) for reverse CART, too large a knuckle with regards to fenestration size, suboptimal alignment of the antegrade guiding catheter, and so on. Difficult CTO anatomies might also lead to DRAFT failure, such as in case of severe calcification or tortuosity of the segment where reverse CART and DRAFT are performed, presence of a side branch within the occlusion, etc. In all these cases, advancement of the knuckled retrograde guidewire will cause further dissection without successful re-entry in the true lumen.

In our experience, long segments of an occlusion can be safely crossed retrogradely using a looped guidewire with the support of a microcatheter, always advancing within the vascular architecture (in the subintimal space). The advantage of this maneuver is that operators can cross safely and rapidly even long and tortuous segments of occlusion without the risk of perforation. Once the looped wire reaches the proximal fibrous cap of the occlusion, reverse CART is performed, and DRAFT can be used to facilitate wire re-entry into the true lumen.

Finally, it is also important to note that DRAFT can be combined with or bailed out by other techniques. For example, DRAFT can be followed by re-entry into a guiding catheter extension (Guideliner^{TM}-facilitated

reverse CART [9]), if the proximal cap is located very distally from the native coronary artery ostium. The combination of these two maneuvers could substantially increase procedural efficiency.

CONCLUSIONS

In the present report we describe the novel DRAFT, which facilitates easy and quick retrograde guidewire externalization after reverse CART, during retrograde CTO PCI. This versatile technique can be performed with a variety of guidewires, both in the right and left coronary systems, and might increase the efficiency of retrograde CTO PCI, without compromising the possibility of using alternative techniques.

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