From Reverse CART to Antegrade Wire Access - a guide to externalization, tip-in, rendezvous, and snaring from the APCTO Club.

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Abstract.

We, the Asia Pacific Chronic Total Occlusion (APCTO) club, provide a review to address this gap between reverse controlled antegrade and retrograde subintimal tracking (CART) and antegrade wire access. We describe the usual method for externalization wire. We then address how to deal with failure to wire the proximal part of the Chronic Total Occlusion (CTO) vessel or the guiding catheter. After successful antegrade guiding wiring, we address the problem of failing to cross the CTO body with the retrograde microcatheter and we recommend the use of retrograde small balloon, reversion to traditional CART, retrograde knuckle wiring into the subintimal space and antegrade scratch and go and external cap crush. We also propose rendezvous type tip in and describe the way to do this to overcome the problem. In conclusion, we reviewed and made recommendations for methods to gain antegrade wire access after successful reverse CART. We have addressed each failure mode in detail covering the different options, balancing risks and success rates. Our recommendations focus upon safety first and ease of use. We hope this work will help all retrograde operators to further improve their safety, efficacy, and success rates of their retrograde procedures.

Abbreviations:
APCTO – Asia Pacific Chronic Total Occlusion Club.
CART – controlled antegrade and retrograde subintimal tracking.
CTO – Chronic Total Occlusion.
PCI – percutaneous coronary intervention.
GC – guiding catheter
MC – microcatheter.
LAD – Left Anterior Descending artery.
PDA – Posterior Descending Artery.
RCA – right coronary artery.
IVUS – intravascular ultrasound.

Introduction.

The retrograde approach for CTO has adopted two major changes since its original description more than a decade ago [1,2]. First, the introduction of the Corsair (Asahi Intecc, Aichi, Japan) microcatheter in 2009 [3] transformed the cumbersome small balloon septal channel dilatation technique into a simple single microcatheter/channel dilator method for channel crossing. This led to the inevitable dominance of reverse controlled antegrade and retrograde tracking (Rev-CART) as the go to technique for achieving CTO segment crossing. Secondly, the widespread availability of the Gaia wire series (Asahi Intecc, Nagoya, Aichii, Japan) since 2012 improved retrograde wire control markedly, leading to the subsequent development of the more efficient "Directed Rev CART" [4]. Since then, the retrograde approach has reached a plateau in its development with widespread global adoption [5,6,7,8,9,10,11], and a significant improvement of overall success in CTO percutaneous coronary intervention (PCI) [5,8,10,11,12,13]. The retrograde approach had been incorporated into the hybrid algorithm [14,15], and the group has published step-by-step guide [16,17]. Along with the landmark work of Wu et al [18], most of the procedural details

of retrograde CTO PCI have been described. However, a more update version is required in view of the recent technical and device advancement.
Our group: the Asian Pacific Chronic Total Occlusion Club (APCTO), a group of 10 highly experienced retrograde operators, have published recently an overall algorithm for CTO intervention [19], a comprehensive retrograde algorithm [20], and a state-of-the-art guide to CTO wiring [21]. However, we noticed that there has been scarcely any publication describing what to do after successful retrograde wire crossing. This particular gap between successful Rev-CART and establishment of an antegrade wire access involves a wide array of techniques that are not well describe in the literature. Although we often think that successful reverse CART guarantees successful procedure, but this is not necessarily true. These rarely used techniques are important in certain subsets of patients: those where the retrograde microcatheter cannot pass the CTO, those with tortuous proximal vessel anatomy, and rarely the ipsilateral single guiding retrograde percutaneous coronary intervention (PCI). Familiarity with these techniques and using them safely is an important part of the armory of the CTO interventionists. The aim of this present work, therefore, is to review and describe these techniques in comprehensive detail, providing useful expert instructions to retrograde operators worldwide.

1. Default wire externalization.

This is recommended in the majority of retrograde CTO cases.

1.1 Wiring into and anchoring inside the antegrade guiding.

Once the retrograde wire enters the proximal true lumen following successful Rev-CART, it should be further advanced into the antegrade guiding catheter (GC). A trapping balloon is then inflated inside the antegrade GC to anchor the retrograde wire. This provides strong wire support for the retrograde microcatheter (MC) to be pushed across the CTO body into the antegrade GC. Once the retrograde MC is securely inside the antegrade GC, we can deflate the trapping balloon and replace the retrograde wire with an externalization wire such as RG3 wire (Asahi) or Viperwire (Cardiovascular systems Inc, St Paul MN, USA).

1.2 Anchoring the MC.

Some operators prefer to push the trapping balloon forward and inflate it to anchor the retrograde MC in the antegrade GC before exchanging the guide wires. There are two advantages for this practice: 1) the balloon will anchor and stabilize the retrograde MC during exchange, and 2) the inflated balloon will prevent back bleeding during disconnection of the antegrade hemostatic valve/connector while completing wire externalization.

1.3 Passing through the antegrade hemostatic valve/connector.

The operator should push the externalization wire until the wire tip is about to emerge from the antegrade GC hub, judged and estimated by the remaining wire length, under fluoroscopic guidance. Then, the operator should put a wire introducer through the antegrade hemostatic valve/connector in parallel to the anchor balloon (figure 1a), and disconnect the connector (figure 1b). The retrograde externalization wire should then be pushed forward out of the hub of the antegrade GC (figure 1c), and the wire tip is brought into the tip of the wire introducer (figure 1d). Finally, the hemostatic valve/connector should be reconnected to the GC, with both the trapping balloon and wire introducer still in place (figure 1e). The wire introducer is then removed, and the externalization wire may be used to deliver devices antegradely (figure 1f). The above-described wire externalization should be used as default whenever possible in retrograde approach.

1.4 When to continue on externalized wire and when to switch to antegrade wire?

Once we have externalized a wire, we have a choice to either work on the externalized wire or to put a MC or dual lumen catheter over the externalized wire and place a second antegrade wire. Although the default position is to use the externalized wire as a working wire as it provides better support for tracking devices, in some cases, the option of switch to antegrade wire is preferable.
If we need to stent beyond where the retrograde channel enters the CTO vessel due to distal disease, then it is preferable to switch to antegrade wire. This usually occurs in the Left anterior descending artery (LAD) where the Posterior descending artery (PDA) septal channel often enters the mid LAD with significant disease in distal LAD that requires stenting. In this case, using a dual lumen catheter to deliver a second wire into the septal channel and then pulling back this wire to wire the true LAD is the best method. We must remove the externalized wire before stenting to avoid wire trapping. Other reasons to switch to antegrade wire include the retrograde channel entering near the distal CTO cap or the need to protect a side branch distal to the retrograde channel entry site.

However, sometimes, this default method of wire externalization fails and we now turn to addressing these problems.

2. Failure to access proximal vessel lumen with retrograde wire.

The operator may fail to manipulate retrograde wire through the proximal vessel lumen despite successful Rev CART achieving proximal vessel true lumen position of the retrograde wire. This is almost always due to migration the retrograde wire tip back into intraplaque or subintimal space in the proximal vessel. It occurs more frequently when the proximal vessel is significantly diseased and tortuous, when balloon angioplasty had been performed in the proximal vessel segment, and when a high penetration force retrograde wire is used for Rev CART.
In this scenario, we recommend the use of guide extension, as described by Mozid et al [22]. A guide extension catheter such as GuideLiner (Teleflex, Wayne, Pennsylvania, USA) or Guidezilla (Boston Scientific, Mass, USA) should be advanced into the proximal vessel to the point where the retrograde wire is in true lumen, and the retrograde wire may be manipulated easily into the guide extension. A 2.5 or 3.0 mm balloon inflation is sometimes needed to dilate the proximal vessel and facilitate guide extension catheter delivery. The use of guide extension catheter is almost always successful in these cases.

3. Failure to manipulate the retrograde wire into the antegrade GC.

3.1 Tips and tricks for wiring into antegrade GC.

There are certain tricks to increase the efficiency of wiring into the antegrade GC with the retrograde wire. We have to recognize that manipulation of the antegrade GC is far more important than manipulation of the retrograde wire. The operator should ensure that the antegrade GC is coaxial with the coronary artery. For example, in Right coronary artery (RCA)

CTO, often the antegrade GC is pointing towards the anterior wall of the right coronary ostium. Therefore, applying clockwise rotation to the GC in right anterior oblique view will enhance its coaxiality with the right coronary ostium and facilitate retrograde wring into the antegrade GC. The operator should push the retrograde wire forward and observe its trajectory, and then manipulate the antegrade GC to cover the expected area that the retrograde wire will travel to [23]. Simultaneous manipulation of retrograde wire and antegrade GC may also be very helpful. However, certain unfavorable anatomy may require the use guide extension catheter. Inserting a guide extension catheter into the proximal part of the CTO vessel makes wiring into the antegrade system much easier, since it will always be coaxial to the vessel course.

3.2 Change the retrograde wire.

If operator failed all the above methods to wire into the antegrade GC, it is usually due to the difficulty of controlling of a stiff high penetration force retrograde wire. We recommend the operator to switch the retrograde wire to a more controllable slippery soft wire, such as Sion Black (Asahi Intecc). To do this, we need to push the retrograde MC across the CTO body into the proximal true lumen of the CTO vessel. The first step is to push the retrograde guide wire as far up the aorta as possible (figure 2a), ideally passing arch into the descending aorta. The bend at the arch will provide extra support to this wire and allow us to track the MC across. If this failed, we can consider using an antegrade balloon to trap and anchor the retrograde wire inside the proximal part of the CTO vessel (figure 2b).

If this too failed, we should exchange the retrograde MC for a new low profile rotational channel dilator type MC, such as the Turnpike LP (Teleflex) or Corsair pro XS (Asahi Intecc), which will often be able to cross the CTO body (figure 2c). Once the retrograde MC has passed through the CTO body, we can exchange the retrograde high penetration force wire with a controllable soft wire to wire the antegrade GC or guide extension catheter (figure 2d) and complete the externalization (figure 2e), and stenting (figure 2f).

When all the above techniques are used properly in a stepwise fashion, the antegrade GC wiring will be successful in the majority of retrograde CTOs. However, there are still occasional cases where retrograde wire snaring, as originally described by Otsuka et al [24], is required.

3.3 Our position on retrograde wire snaring.

We regard snaring of the retrograde wire as a last resort, to be considered only after all other methods have been exhausted. We emphasize the small but inherently real risk associated with snaring, as Fang et al [25] have pointed out. These issues included: 1) the danger of failure to release the snared retrograde wire inside the antegrade GC, and 2) failure to remove the snared retrograde wire from the retrograde MC due to an excessive bend created by the snaring. Although previous authors have suggested several methods to rectify these situations, these methods are not always reliable [26]. There is also a small but unavoidable risk of stroke, with the possible plaque embolism during snare manipulation in the aorta. We, the APCTO club group, recommend hereafter a safety first method of retrograde wire snaring.

3.4 Safety first method of retrograde wire snaring.

When the operator decides to start retrograde wire snaring, the retrograde wire should already be in the descending aorta, as a consequence of prior attempt to push the retrograde MC across CTO body for wire switch to a soft controllable wire. The 3-lobed EN snare (Merit

Medical System, Utah, USA) is the easiest to use to catch the wire but we recommend using a “homemade” snare with guiding extension catheter and monorail balloon [27,28]. The advantages of homemade snare are that the size of the snare loop can be easily increased to as large as needed [29] by pushing the wire forward (figure 3a) and also when the snare has pulled the retrograde wire back into the guiding catheter (figure 3b), release of the retrograde wire can easily be done simply by deflating the balloon. Since there is no connected loop once the balloon is deflated, the retrograde wire can almost always be released. Then an anchoring balloon can be placed to anchor the retrograde wire inside the antegrade GC allowing the retrograde MC to pass (figure 3c). We should aim to snare the floppy tip of the retrograde wire in the descending aorta or the arch. Snaring in the ascending aorta closer to the coronary ostium may increase the embolic stroke risk. After catching the retrograde wire, if we are using a more robust snare such as EN snare, we should first try pushing the retrograde MC across the CTO body into the aorta while pulling on the snare as anchor. Then the snared retrograde wire is released in the descending aorta and exchange it with a new soft controllable wire to wire into the guiding GC again. This will remove the risk of locking the snare with the trapped retrograde wire inside antegrade GC.

If we cannot push the retrograde MC across the CTO body despite snare anchoring, or if we are using a homemade snare, we may try pulling the snared retrograde wire into the antegrade GC. The retrograde MC is then tracked into the GC before the snare is released, and then the retrograde wire may be exchanged to an externalization wire. The risk of failing to release a soft hydrophilic wire from a snare is considered low, but still possible. If we cannot release the 190 cm retrograde wire from snare, we should push the snare and wire back into the aorta and try release again. We can also use a balloon inside the antegrade GC to anchor the wire tip, facilitating the release of the snare. We should never, however, try to pull the whole 190 cm wire through the retrograde channel into the antegrade GC. This is because the proximal end of wire is very stiff and un-coated, and may get stuck in a tortuous retrograde channel with the MC as a unit.

The alternative is to exchange the retrograde wire to RG3 wire, and start snaring its tip at the level of contralateral common iliac artery. This reduces the risk of embolism, and snaring in a smaller vessel such as the Iliac is often easier. If we failed to release the snare on RG3, we can always pull it’s snared distal tip out from the contralateral access. With its 300cm exchange length, the proximal end will still be controlled outside of the retrograde GC. We do not, however, recommend wiring through the coronary with RG3, as its 3g tip load and poor torquability can create dissection in diseased proximal vessel easily.

4. Rendezvous techniques.

4.1 The Rendezvous technique.

Rendezvous technique refers to using the antegrade or retrograde wire to wire into or “meet” (in French “rendezvous”) the opposite MC. The early descriptions of this technique [30,31] involves wiring the antegrade wire into the retrograde MC. Tip-in is also a kind of rendezvous technique. In tip in, the retrograde wire is wired into an antegrade MC, either in the GC [32] or in the coronary artery [33]. These techniques are used less frequently nowadays, with the availability of low profile MCs and algorithmic intravascular ultrasound (IVUS) usage in Rev-CART.

The advantages of rendezvous are: 1) rapid establishment of antegrade wire track [32] without the need for externalization wire, and 2) to bail out the situation when retrograde MC fail to cross the CTO body [33].

4.2 The role of rendezvous techniques in contemporary retrograde CTO PCI.

Much of the issues requiring original rendezvous techniques [30-33] are no longer relevant, with application of IVUS-guided Rev-CART, low profile MCs and RG3 or Viper wires, and guide extension catheters. However, there are a few conditions that may still mandate rendezvous techniques in the current era of retrograde CTO PCI: 1) failure to cross the CTO body with the retrograde MC, 2) inadequate length of retrograde MC to reach the antegrade system, and 3) the need to quickly establish antegrade track. 4) Single guiding catheter ipsilateral channel retrograde CTO PCI.

4.3 Failure to cross the CTO with retrograde MC.

Despite trapping balloon anchoring the retrograde wire in the antegrade GC, we may still fail to push the retrograde MC across the CTO body. Rendezvous techniques may be helpful, but alternative solutions may also include: 1) balloon dilatation of the CTO from the retrograde direction, 2) reverting to traditional CART [20], 3) antegrade "external cap crush" by inflating a balloon in the subintimal space parallel to the CTO segment to weaken it [34], and 4) re-cross the CTO body in a different subintimal path using retrograde knuckle wiring. These alternatives are time consuming and cumbersome, therefore in the face of these cumbersome options, rendezvous technique remains a valid choice.

4.4 Failure to reach the antegrade system.

With the provision of short (85 or 90cm) GC and guide extension catheters, failure of the retrograde MC to reach the antegrade system due to length issue is rare. However, sometimes final retrograde channel used may be different and significantly longer than the pre-procedural planning and we may need rendezvous. Extensive calcification and tortuosity of the proximal vessel segment may also prevent antegrade guide extension catheter delivery and unexpected lengthy vascular route, especially in tall patients, may prohibit the use of short GC to reach the coronary ostium. Rendezvous is a solution in these scenarios.

4.5 Need to rapidly establish antegrade track.

When a dominant collateral channel is used for retrograde approach, significant ischemia and hemodynamic instability may occur. Proper antegrade preparation before collateral channel tracking and expedited Rev-CART are helpful in this case. Rendezvous technique facilitates rapid establishment of antegrade wire track which minimizes the ischemia induced by the retrograde devices occupying the collateral channel.
Donor artery complications such as thrombosis and channel perforations may also interrupt our retrograde CTO PCI. Rapid establishment of antegrade wire track may be mandatory, so that further salvage procedures such as thrombus aspiration or embolization for hemostasis can be performed.

4.6 Ipsilateral channel collateral retrograde CTO PCI with single guiding catheter.

Although we usually recommend ping-pong guiding catheter technique when dealing with ipsilateral collateral retrograde CTO PCI, there are instances where we might end up doing a retrograde through single GC. If access is impossible, or if we began with single GC for antegrade CTO PCI but decided to try a difficult retrograde channel with low success rate, we might forego a second femoral puncture on anticoagulation for a brief try of the channel through the single GC. Sometimes, we face an easy retrograde with ipsilateral collateral and we might attempt it through single GC. In all these cases, rendezvous is essential as we cannot trap the retrograde wire with balloon anchoring in the GC and we often cannot push the retrograde MC through the CTO lesion. This remains a valid reason for rendezvous.

5. Tips and tricks for rendezvous techniques.

5.1 Position of rendezvous.

The easiest position to achieve rendezvous is at the level of the secondary bend of the antegrade GC. The tips of the MC and wire will both lean against the outer curvature of the catheter, therefore, it is will be easy to advance the wire into the MC at this level (figure 4a).

5.2 Rapid switching to antegrade.

After tip-in, the retrograde wire should be advanced as far as possible into the antegrade MC. A torque device is then locked firmly on the remaining end of the wire against the retrograde MC hub (figure 4b) to prevent loss of wire control. The antegrade MC now can be pushed, meeting the retrograde MC tip, continuously across the CTO segment [32].

5.3 When MC cannot cross the CTO body after rendezvous.

If the indication for rendezvous is the inability to pass the retrograde MC through the CTO body, then we need to maximize the antegrade MC's penetrative power to cross the CTO. In these cases we should start with the maximal back up and most powerful MC. When we suspect that the MC cannot cross the CTO body, we should change to a strong back-up support antegrade GC, engage a guide extension catheter, or use anchor balloon in a side branch. Special penetrative MC, such as Turnpike Gold (Teleflex) or Turnpike spiral (Teleflex) may also help. Applying continuous negative suction to the antegrade penetrative MC (figure 4c) may pull the retrograde wire inside indirectly, and increase the penetrative force of the antegrade MC.

5.4 RotaWire exchange technique.

If all the above described in 5.3 were tried and the antegrade MC still failed to cross, and the reminding distance between the antegrade and retrograde MCs is short, we can attempt advancing an antegrade rotablator wire into retrograde MC. The retrograde wire is withdrawn to the tip of the antegrade MC, then a RotaWire (Boston Scientific) is placed into the antegrade MC until its tip is in contact with the retrograde wire tip. The retrograde wire is then pulled back a short distance gradually, with the antegrade RotaWire advanced to follow closely (figure 4d). This will allow the RotaWire to tract the void of the removed retrograde wire, and achieve wire exchange. Once the RotaWire is across the CTO body and entered into distal vessel (figure 4e), subsequent rotation atherectomy can be carried out to complete the CTO intervention (figure 4f).

5.5 Comparison of methods to overcome tough CTO segment when MC passage is difficult.

There are several options to overcome this problem when retrograde wire crossed the CTO but the MC cannot cross. Continuing aggressive pushing on the retrograde MC can lead to rupture of the retrograde channel or retrograde MC tip deformation, both results in the loss of retrograde access. Exchanging the retrograde MC for a small balloon to dilate the lesion is also associated with risks of channel injury. Giving up the original wire position and performing retrograde knuckle wiring across CTO segment via subintimal space, or conversion to traditional CART [20], are both time consuming and does not guarantee success. External cap crush carries the risk of proximal vessel injury, hematoma extension, and perforation. Therefore, well-executed tip-in type rendezvous followed by dedicated penetrative antegrade MC is probably the most reasonable option [33]. Antegrade RotaWire change is also relatively simple and with low risk.

6. Conclusions.

Technical success of CTO PCI is usually very high after successful Rev-CART. However, operator may still be unable to establish antegrade wire access, resulting in final failure. This gap is not well covered in the previous literature.
We, the APCTO club, have provided a review and recommendations for methods to achieve antegrade wire access after successful Rev-CART. We have addressed every failure mode in detail, covering different options and their risks. Our recommendations focus upon safety first, and then ease of use. We hope this work will help all retrograde operators to further improve their procedures.

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Figures.

Figure 1. Passing the externalisation wire through the antegrade Y connector. 1a. Insertion of wire introducer in parallel to the anchor balloon shaft through the antegrade Y connector. 1b. Disconnected Y connector now pulled back over the anchor balloon. 1c. Retrograde wire pushed out of antegrade guiding hub. 1d. Putting the externalisation wire into the wire introducer. 1e. Y connector brought near to guiding hub for reconnection. 1f. Removal of wire introduced to allow passage of devices.

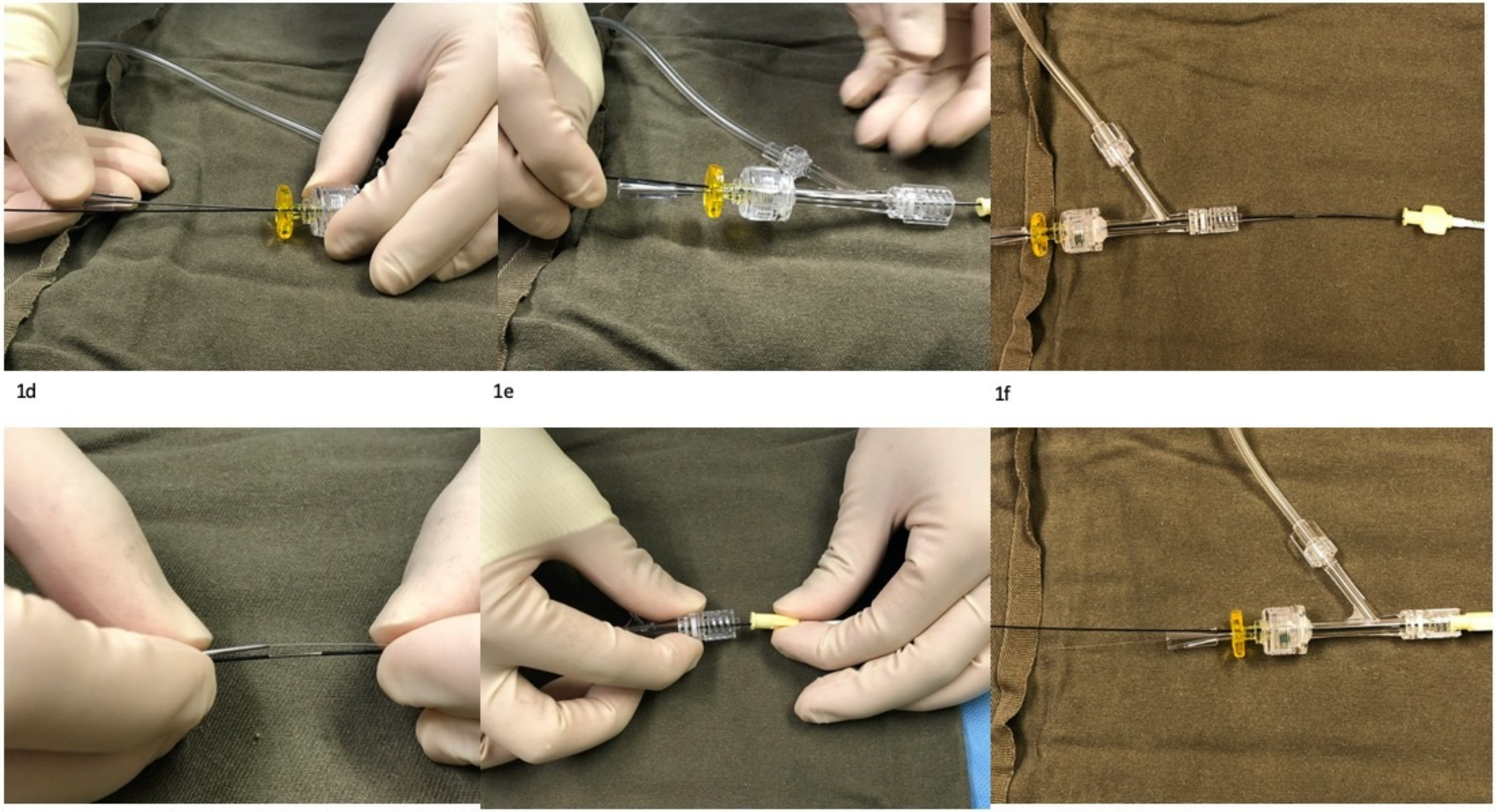
Figure 2. Initial steps to deal with failing to wire the antegrade guiding catheter. 2a. Pushing the retrograde wire far into aorta. 2b Using proximal vessel anchor balloon. 2c. Switching for new low profile rotational retrograde MC. 2d. Switching to soft wire to wire guiding. 2e. Successful externalization. 2f. Good final results.

Figure 3. Homemade snare. 3a. Homemade snare pushed to large size. 3b. Snared retrograde wire. 3c. Anchored retrograde wire, MC passed.

Figure 4. Rendezvous and tip in. 4a. Best bending position of the antegrade guide to do tip in. 4b. Locking torque device on retrograde side of wire after tip in. 4c. Applying negative pressure to improve wire tracking. 4d. Antegrade rota wire tracking retrograde microcatheter tip in technique. 4e. Successful antegrade rota wire passage to distal true lumen. 4f. 1.25 mm burr to CTO lesion.

1a. 1b 1c.

1d 1e 1f



2a. 2b. 2c. 2d. 2e. 2f.

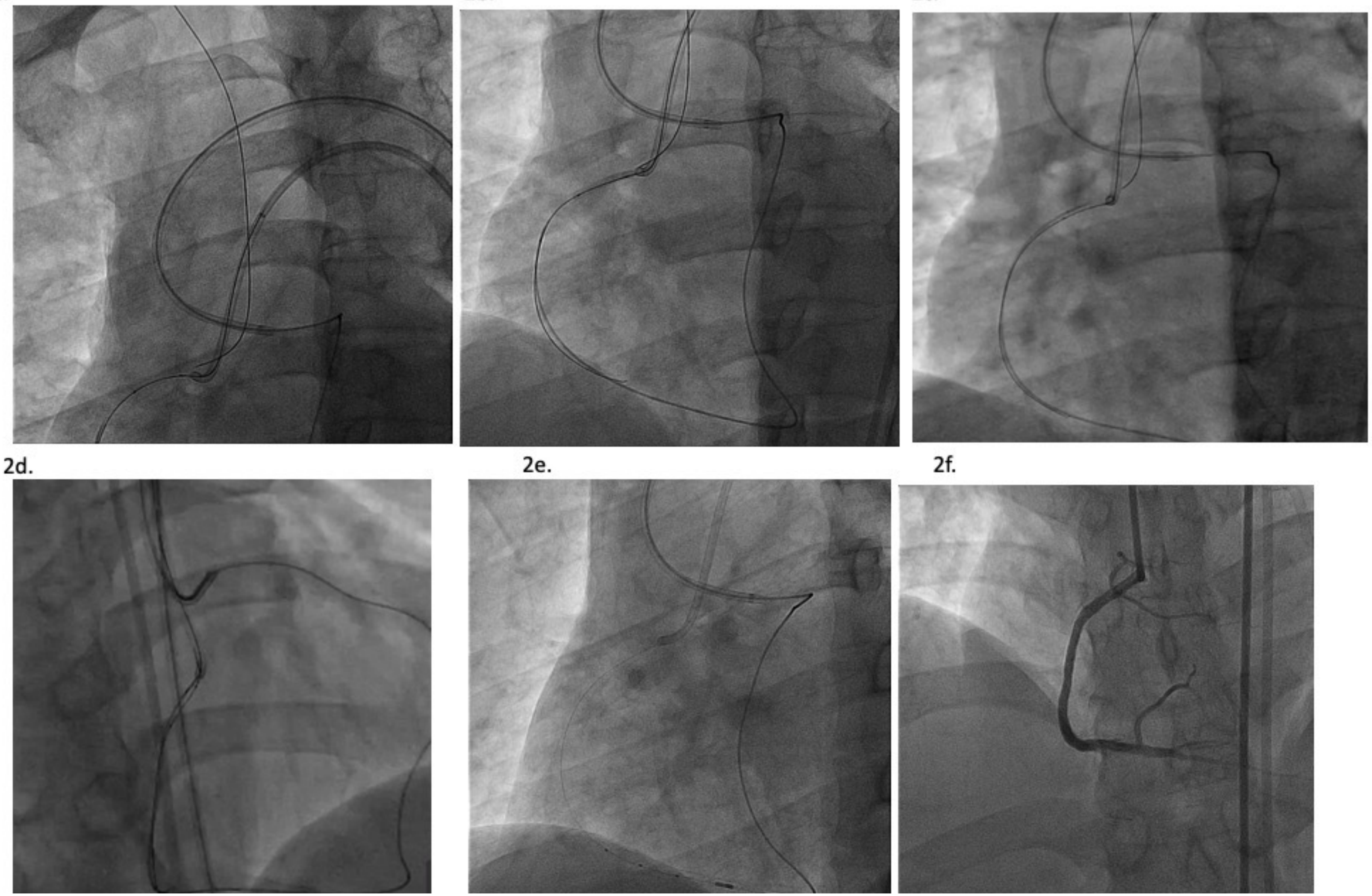
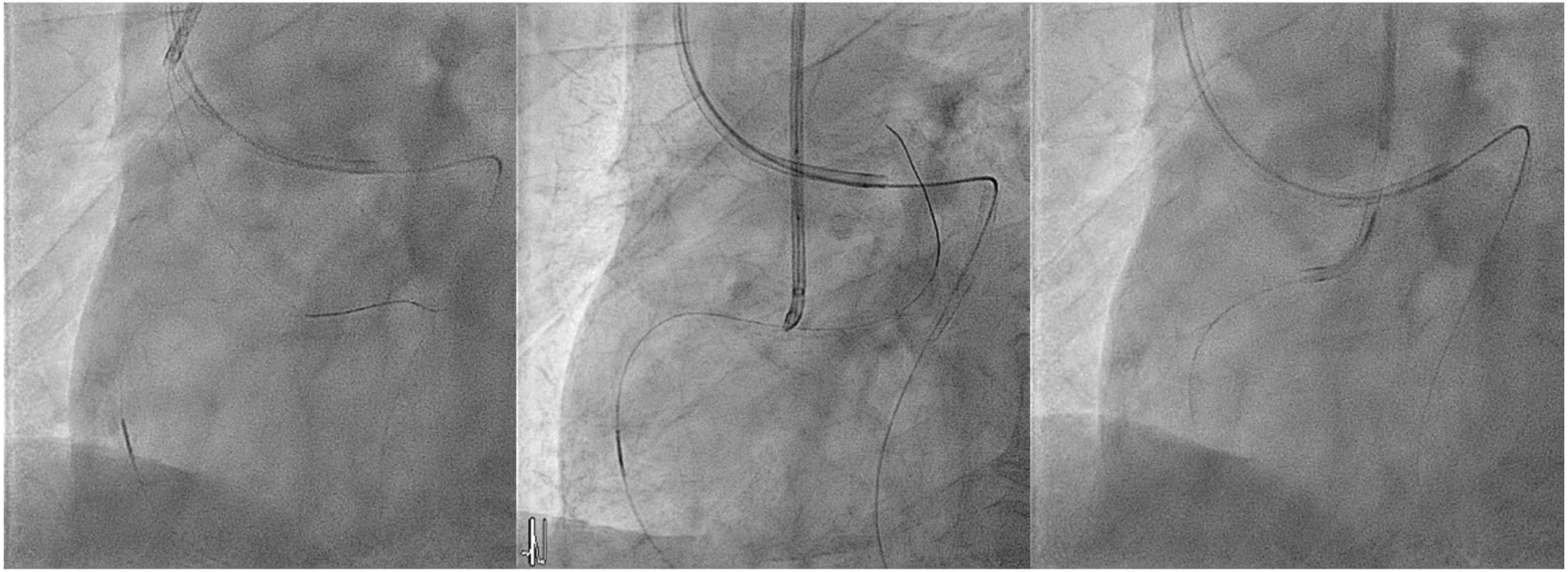


Fig 3a. Fig 3b. Fig 3c.



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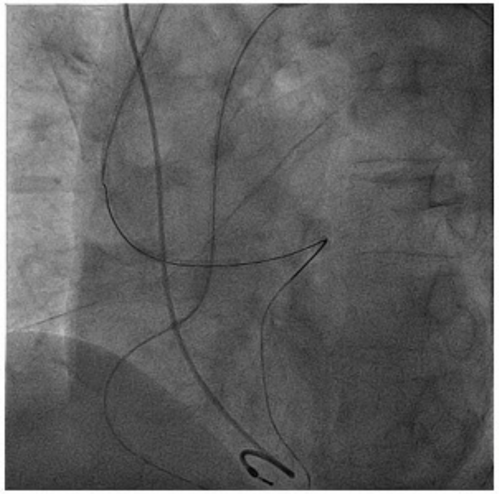

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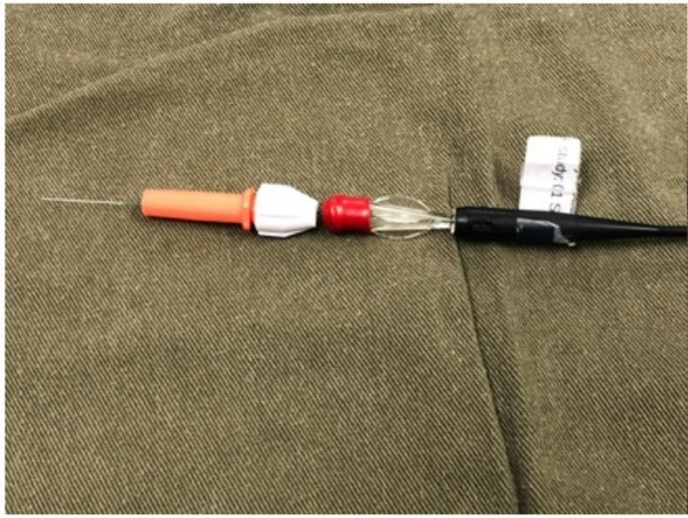

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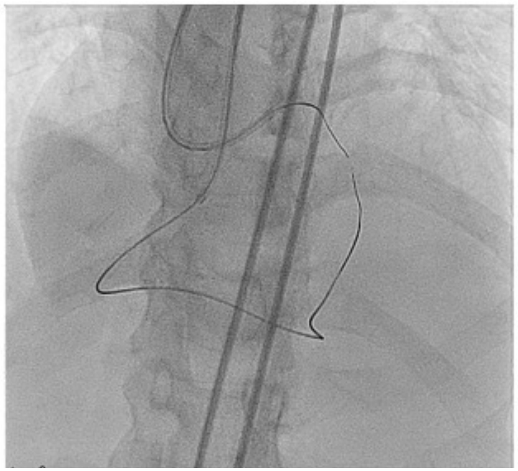

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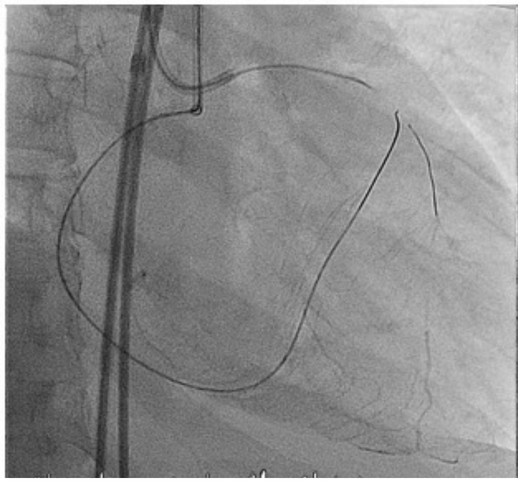

4f.