Original Article

Effectiveness and safety of a novel modified homemade snare in retrograde percutaneous coronary intervention for chronic total occlusion lesions: a retrospective cohort study

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Background: The use of a commercial snare for retrograde chronic total occlusion (CTO) percutaneous coronary intervention (PCI) is time-consuming and expensive. This study aimed to evaluate the benefits and complications of a novel modified homemade snare (MHS) for retrograde CTO-PCI.

Methods: This retrospective cohort study included patients with CTO who underwent retrograde PCI with guidewire snaring between January 2017 and June 2022 at Beijing Anzhen Hospital. The patients were divided into the MHS and gooseneck snare (GS) groups according to the devices used for externalization. Clinical, procedural, and angiographic data were collected.

Results: Ninety patients (46 with MHS and 44 with GS) were included. There was no significant difference in the location of the CTO vessel between the MHS and GS groups, and the target CTO vessel was mainly located in the right coronary artery (RCA) in both groups (73.9% and 68.2% respectively). There were no significant differences in the J-CTO (Multicenter CTO Registry in Japan) and PROGRESS-CTO (Prospective Global Registry for the Study of Chronic Total Occlusion Intervention) scores between the two groups. More patients in the MHS group had lesions with ambiguous proximal caps compared with the GS group (54.3% *vs.* 31.8%, P=0.04). Retrograde wire crossing technique was used more in the GS group (54.5% *vs.* 41.3%, P=0.04), while reverse-controlled antegrade and retrograde subintimal tracking (CART) technique was used more in the MHS group (58.7% *vs.* 45.5%, P=0.037). The mean guidewire capture time was shorter in the MHS group than in the GS group (2.7±0.6 *vs.* 3.4±0.7 min, P<0.001). One case of delayed pericardial tamponade was observed in the MHS group. No other complications occurred.

Conclusions: MHS appears to facilitate externalization in retrograde PCI for complex CTO lesions.

Keywords: Chronic total occlusion (CTO); modified homemade snare (MHS); percutaneous coronary intervention (PCI); retrograde approach

Submitted Apr 12, 2024. Accepted for publication May 15, 2024. Published online May 29, 2024.
doi: 10.21037/jtd-24-610
View this article at: https://dx.doi.org/10.21037/jtd-24-610

Introduction

In 2015, coronary artery disease (CAD) caused 8.9 million deaths and accounted for 164 million disability-adjusted life years in China (1). CAD is caused by atherosclerosis, which is found at a clinically significant level in 22–43% of individuals (2). Chronic total occlusion (CTO) lesions account for 15–20% of coronary atherosclerotic lesions (3,4). The prevalence of CTO is 30–50% in patients with CAD (5,6), with a higher prevalence in patients with prior coronary artery bypass graft (CABG) (7) and a prevalence of 10–15% in patients with acute myocardial infarction (8). Percutaneous coronary intervention (PCI) for CTO lesions is associated with satisfactory clinical outcomes, but PCI still poses some risks of poor outcomes for inexperienced cardiologists (8-10).

With the development of CTO-PCI techniques, such as the parallel wire technique (11), antegrade dissection and re-entry (12), controlled antegrade and retrograde subintimal tracking (CART), reverse-CART technique (13), and capturing the retrograde guidewire (advanced into a side branch at the distal cap) with a micro snare (14), the success rate of CTO-PCI has dramatically improved (10,15). Although an antegrade attempt is always preferred over the retrograde approach as the initial strategy, the retrograde approach, which has more important steps and challenges, remains crucial for achieving a high success rate, especially in complex CTO lesions (16,17).

Highlight box

Key findings

- The novel modified homemade snare (MHS) improved the efficiency of retrograde chronic total occlusion (CTO) percutaneous coronary intervention (PCI) in terms of shorter capture time and more accessible use by the operator compared with the gooseneck snare.

What is known and what is new?

- In cases where the antegrade guide catheter lacks coaxiality, externalization can be challenging, but the snare-assisted microcatheter crossing technique offers an effective solution, albeit with the drawbacks of being time-consuming and expensive due to the use of commercial snares.
- The MHS appears to facilitate externalization in retrograde PCI for complex CTO lesions.

What is the implication, and what should change now?

- The MHS might be worthy of promotion in clinical practice owing to its efficiency, safety, inexpensiveness, and easy availability.

One of the critical steps is externalization, which is the manipulation of the retrograde guidewire and microcatheter across the occlusion lesion into an antegrade guide catheter (GC) or guide extension catheter (GEC). Externalization can be very difficult in cases where the antegrade GC lacks coaxiality. An effective solution is applying the snare-assisted microcatheter crossing, which is to control the retrograde guidewire through the CTO lesion into the sinus of Valsalva, and then catch the guidewire with a snare from an antegrade GC (18). Generally, the use of a commercial snare is time-consuming and expensive (19).

The authors would like to introduce a novel modified homemade snare (MHS) that addresses these issues. Indeed, the consumables can be easily obtained at the intervention center, while the commercial snares are hard to get. The MHS is produced to be easy to use with good repeatability. In addition, the MHS has a catch ring of adjustable size, leading to a high success rate of catching the guidewire. This study aimed to evaluate the benefits and complications of this novel MHS in retrograde PCI for CTO lesions. The results could provide evidence of a novel, effective, easy-to-use, and inexpensive method to catch the guidewire during a retrograde procedure for CTO lesions. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-610/rc).

Methods

Study design and patients

This retrospective cohort study included patients who underwent retrograde PCI with guidewire snaring between January 2017 and June 2022 at the Cardiology Department of Beijing Anzhen Hospital. In this hospital, about 15,000 PCIs are performed yearly, and about 10% are for CTO lesions. The study was approved by the ethics committee of Beijing Anzhen Hospital (approval number: 2023001X). The requirement for individual informed consent was waived because of the retrospective nature of the study. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

The inclusion criteria were: (I) diagnosis of CTO, defined as total occlusion with an estimated duration of occlusion ≥3 months (7,8,10); and (II) retrograde PCI using either the MHS or a commercial snare for externalization. The exclusion criteria were: (I) acute myocardial infarction with emergency PCI within 24 h after admission; (II) received

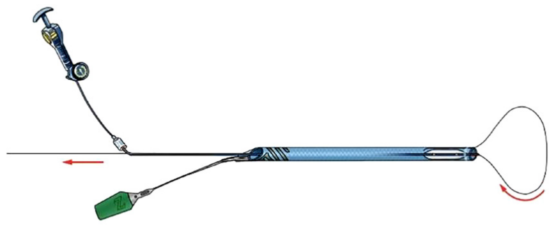

Figure 1 Structure diagram of the modified homemade snare.

other operations besides PCI (e.g., valve replacement or CABG); or (III) critical surgery-related data missing.

Materials and procedure

As per routine procedures at the authors' center, all patients received clopidogrel (300 mg) or ticagrelor (180 mg) and aspirin (300 mg) before PCI. All patients received heparin at the time of the procedure to achieve an activated clotting time of 250–350 s.

The Gooseneck snare (GS; Starway Medical Technology, Shanghai, China) is a single-ring snare with a 125-cm shelf and is used to retrieve intravascular iatrogenic foreign bodies. The maximum diameter of the ring is 15 mm when it is released.

The 6Fr-Guidezilla GEC (Boston Scientific, Natick, MA, USA) with a 25-cm soft, flexible tube attached to a 120-cm shelf has a 1.45-mm inner diameter and a 1.68-mm outer diameter. It is a rapid exchange catheter designed to be used in complex cases that need extra backup support.

In this study, the novel MHS consists of a Guidezilla GEC, a conventional Samurai 0.014" guidewire (Boston Scientific, Natick, MA, USA), and an Emerge PCI balloon (Boston Scientific, Natick, MA, USA). A conventional 0.014" guidewire is inserted into the wire lumen of an ordinary PCI balloon with a diameter of 2 mm. The guidewire and balloon are inserted into a 6Fr-Guidezilla GEC. The ends of the balloon and the Guidezilla GEC are aligned together. The guidewire tip is folded back into the Guidezilla GEC about 20–30 mm in length, which will be trapped by inflating the balloon with 12–16 atmospheres. The advancement and retracement of the guidewire shaft make a size-adjustable snare loop (*Figure 1*). By pulling back the guidewire to tighten up the loop, the MHS can be inserted into a GC through a Y-connector.

Procedure of snaring retrograde guidewire with MHS

During the procedure of retrograde PCI, when the retrograde guidewire was successfully advanced through the collateral branch to the distal end of the CTO lesion, manipulating the retrograde guidewire to enter the antegrade GC or GEC was necessary for the subsequent externalization. In the case of failure to control the retrograde guidewire directly into the antegrade catheter, manipulating it to enter the aorta where an antegrade snare could catch it solved this problem. The detailed steps of catching the retrograde guidewire were as follows: (I) antegrade GC was put into the ascending aorta to stretch out the MHS and release the loop in the aorta, which attempt was then made to advance the retrograde guidewire into the snare loop (*Figure 2A*); (II) the retrograde guidewire was caught by tightening up the loop, and the retrograde microcatheter was pushed through the CTO lesion into the aorta following the captured guidewire (*Figure 2B*); (III) the snare loop was slightly released to send the microcatheter through it, then the retrograde guidewire was changed into the RG3 guidewire (*Figure 2C*); (IV) the RG3 guidewire was then caught by the MHS and pulled out of the antegrade GC (*Figure 2D*). The broken tip of the RG3 guidewire was cut off with scissors, concluding the externalization process. A case is shown in *Figure 3*.

Data collection

The clinical data, including age, sex, body mass index (BMI), smoking, heart and renal function, comorbidities, medication, and PCI and CABG history, were retrospectively collected.

Outcomes

Procedural and angiographic details were collected. Technical success was defined as externalization assisted with catching guidewire by snare and successful recanalization of the target CTO artery with thrombolysis in myocardial infarction flow grade 3. The Japanese-CTO (J-CTO) (20) and Prospective Global Registry for the Study of Chronic Total Occlusion Intervention (PROGRESS-CTO) scores (21) were applied to evaluate the difficulty of crossing the CTO lesions. The J-CTO score consists of

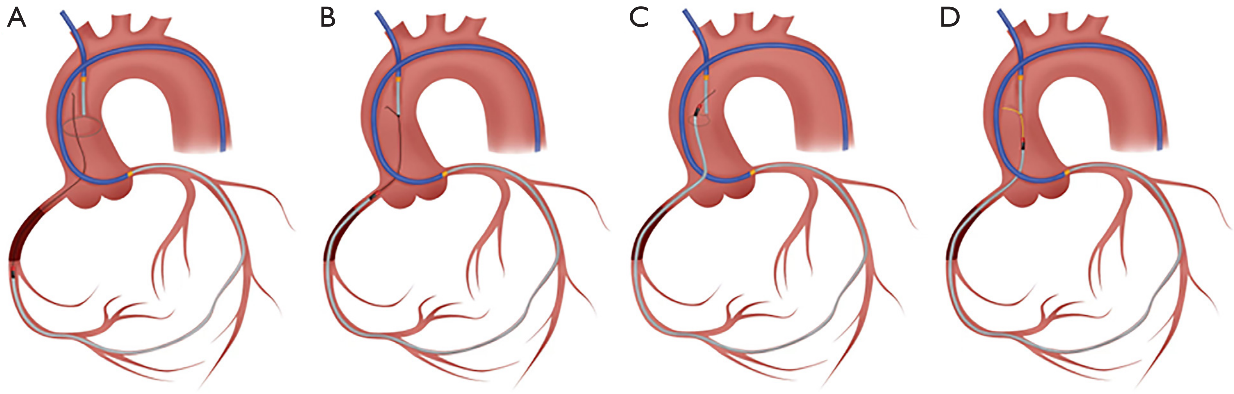

Figure 2 Schematic diagram of novel modified homemade snare catching retrograde guidewire. (A) A retrograde guidewire was advanced into the loop; (B) tightening up the loop, a retrograde microcatheter was able to be sent into the aorta; (C) a microcatheter went through the released loop; (D) an RG3 guidewire was snared and would be pulled out of the antegrade GC. GC, guide catheter.

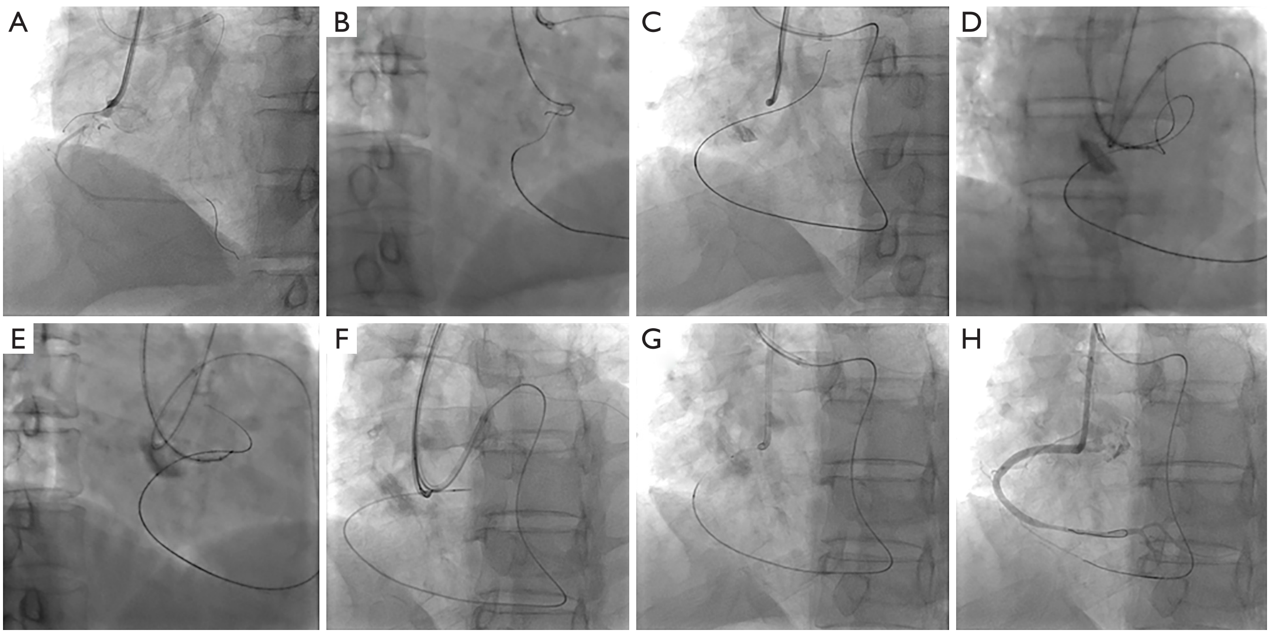

Figure 3 RCA CTO in a 51-year-old male patient. (A) RCA ostium CTO with severe tortuosity; (B) failure of reverse-CART; (C) retrograde guidewire advanced into the aorta; (D) a retrograde guidewire entering into the MHS loop; (E) a retrograde guidewire was snared by MHS; (F) a retrograde microcatheter crossing the CTO lesion and entering into the loop; (G) a retrograde wire was changed into RG3 to complete subsequent operations; (H) a good final angiographic result was obtained. RCA, right coronary artery; CTO, chronic total occlusion; CART, controlled antegrade and retrograde subintimal tracking; MHS, modified homemade snare.

five parts, including proximal cap ambiguity, calcification, tortuosity, occlusion length, and previously failed lesion (easy: 0 points; intermediate: 1 point; difficult: 2 points; very difficult: ≥3 points) (20). The PROGRESS-CTO score consists of four parts: proximal cap ambiguity, tortuosity, no interventional collaterals, and left circumflex artery CTO (21). A higher score indicates more complex lesions and more difficult operations. An ambiguous proximal cap was defined as a situation where there are multiple branches, often collaterals, a flush occlusion, and uncertainty as to the initial vessel course (22). Moderate tortuosity was defined as a segment containing either two bends >70° or one bend

>90°. Severe tortuosity was defined as two or more pre-occlusive bends >90° or at least one bend >120° (23). The visual rating distinguishes absent, mild, moderate, or severe calcification of the entire coronary arterial circulation. Mild calcification was defined as isolated flecks of calcification within a segment. Severe calcification was defined as continuous calcification within a segment, and moderate calcification was defined as a calcification degree between mild and severe calcification. The collaterals were defined according to the Werner classification (24). Guidewire capture time was defined from the retrograde guidewire was captured to the RG3 was captured.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation (SD) and analyzed using the independent sample *t*-test. Categorical data were expressed as n (%) and analyzed using Pearson's χ^2 test or Fisher exact test, as appropriate. Two-sided P values <0.05 were considered statistically significant. All statistical analyses were performed using SPSS 26.0 (IBM, Armonk, NY, USA).

Results

Characteristics of the patients

Ninety patients who met the eligibility criteria were included in this study (46 in the MHS group and 44 in the GS group). There were no significant differences in baseline characteristics between the two groups, except for the mean BMI (26.8±1.9 *vs.* 26.0±6.6 kg/m^2, P=0.03) and the proportion of smokers (43.5% *vs.* 22.7%, P=0.046) which were higher in the HMS group compared with the GS group (*Table 1*).

Characteristics of the procedure and lesions

The characteristics of the CTO lesions and procedures are presented in *Table 2*. The CTO lesions were mainly located in the right coronary artery (RCA) in both groups (73.9% in the MHS group and 68.2% in the GS group). There were no significant differences in J-CTO and PROGRESS-CTO scores between the two groups. More patients had lesions with ambiguous proximal caps in the MHS group compared with the GS group (54.3% *vs.* 31.8%, P=0.04). Regarding the CTO-PCI technique, retrograde wire crossing (54.5% *vs.* 41.3%) was used more in the GS group than in the MHS group, while the reverse-CART (58.7% *vs.* 45.5%) was used more in the MHS group than in the GS group (P=0.04). The guidewire capture time was significantly shorter in the MHS group than in the GS group (2.7±0.6 *vs.* 3.4±0.7 min, P<0.001). Snare-assisted microcatheter crossing was performed in 12 (26.1%) cases in the MHS group and 8 (18.2%) in the GS group.

Complications

One (2.2%) case of delayed pericardial tamponade was observed in the MHS group. This complication was relieved after undergoing emergency surgery to evacuate the pericardial hematoma. No other complications occurred in the two groups.

Discussion

This study aimed to evaluate the benefits and complications of a novel MHS for retrograde CTO-PCIs. The results suggest that the MHS appears to facilitate externalization in retrograde PCI for complex CTO lesions. With the advantages of efficiency, safety, inexpensiveness, and easy availability, MHS might be worthy of promotion in clinical practice.

The retrograde approach remains crucial for a high success rate, especially in complex CTO lesions (25). The retrograde approach should be adopted promptly when an antegrade attempt fails. Externalization is a crucial step in retrograde PCI for CTO lesions. It is a complex process in which the crossing retrograde guidewire and microcatheter must be guided into an antegrade GC or GEC, and is a process that can be difficult to execute in many patients. Nevertheless, it can be achieved by controlling the retrograde guidewire into the sinus of Valsalva and catching it with a snare from an antegrade catheter (18). The authors consider that there are mainly three situations that require the use of the retrograde guidewire capture technique: (I) CTO lesions at the ostium that result in the inability to manipulate the antegrade GC in place with good coaxiality, and the antegrade guidewire cannot enter the vascular structure; (II) other conditions that result in poor coaxiality, such as malformation and angulation of the coronary ostium; (III) when adopting the active greeting technique, the distance between the antegrade and retrograde guidewires is too long because of severe tortuosity and calcification of the CTO lesions. Still, using a commercial snare is time-consuming and expensive (19).

Table 1 Characteristics of the patients

Variables	Homemade snare (n=46)	Gooseneck snare (n=44)	P
Age (years)	57.7±9.1	56.3±8.7	0.46
Male	40 (87.0)	37 (84.1)	0.77
Body mass index (kg/m^2)	26.8±1.9	26.0±6.6	0.03
Smoking	20 (43.5)	10 (22.7)	0.046
Diabetes mellitus	23 (45.7)	23 (52.3)	0.67
Hypertension	25 (54.3)	24 (54.5)	>0.99
Hyperlipidemia	28 (60.9)	29 (65.9)	0.67
Stoke	13 (28.3)	8 (18.2)	0.32
Peripheral arterial disease	5 (10.9)	2 (4.6)	0.44
Prior myocardial infarction	9 (19.6)	4 (9.1)	0.23
Prior PCI	6 (13.0)	4 (9.1)	0.74
Prior CABG	1 (2.2)	2 (4.5)	0.61
Admission diagnosis			0.65
Stable angina	33 (71.7)	29 (65.9)	
Unstable angina	13 (28.3)	15 (34.1)	
Left ventricular ejection fraction (%)	54.5±6.8	55.1±7.0	0.65
Estimated glomerular filtration rate (mL/min)	86.4±14.2	88.1±12.2	0.53
ACEI/ARB	24 (52.2)	27 (61.4)	0.40
Statin	45 (97.8)	44 (100.0)	>0.99
Acetylsalicylic acid	46 (100.0)	44 (100.0)	>0.99
P2Y12 receptor antagonist			0.57
Clopidogrel	32 (69.6)	28 (63.6)	
Ticagrelor	14 (30.4)	16 (36.4)	

Data are expressed as mean ± SD or n (%). PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; SD, standard deviation.

Yokoi *et al.* (26) reported a homemade snare consisting of a wire, a balloon, and a GC. Their method requires pulling the retrograde guidewire deep into the GC, and then the retrograde microcatheter can be sent to enter the GC for changing the RG3 wire. Still, the retrograde guidewire may sometimes be folded up, and the broken retrograde guidewire probably cannot be re-straightened and pulled out from the retrograde microcatheter. In contrast, there is no need to pull the retrograde guidewire into the GC using the novel MHS described in the present study. When the retrograde guidewire is snared and fixed at the top of the MHS, enough supporting force can be provided to push the retrograde microcatheter into the aorta. Thus, the captured guidewire would not be broken, and it can be pulled back easily into the retrograde microcatheter. After that, the RG3 wire can be sent into the loop for externalization. In addition, the Guidezilla GEC used to make the MHS is relatively softer than a GC. Thereby, the MHS is safe and convenient to stretch out of the GC to adjust the snaring position without being limited by the shape of the GC.

There are some tips for the MHS. (I) Except for the RG3 wire, other captured wires should be avoided from being pulled into the GC since it would be challenging to re-straighten the wire again and pull it out from the retrograde microcatheter. (II) As the MHS is a single-loop trap, it is impossible to judge whether

Table 2 CTO lesion and procedure characteristics

Variables	Homemade snare (n=46)	Gooseneck snare (n=44)	P
J-CTO score	2.1±1.0	2.0±0.9	0.44
PROGRESS-CTO score	1.1±0.9	0.9±0.7	0.29
Target CTO vessel			0.74
RCA	34 (73.9)	30 (68.2)	
LAD	11 (23.9)	12 (27.3)	
LCX	1 (2.2)	2 (4.5)	
Ambiguous proximal	25 (54.3)	14 (31.8)	0.04
Lesion length ≥20 mm	31 (67.4)	27 (61.4)	0.66
Moderate or severe tortuosity	7	8	0.78
Moderate or severe calcification	8	10	0.60
Collateral channel			0.54
Septal	41 (89.1)	37 (84.1)	
Epicardial	5 (10.9)	6 (13.6)	
Graft	0 (0.0)	1 (2.3)	
Previously failed lesion	20 (43.5)	12 (27.3)	0.13
Multivessel disease	35 (76.1)	29 (65.9)	0.36
Technology of CTO			0.04
RWC	19 (41.3)	24 (54.5)	
Reverse-CART	27 (58.7)	20 (45.5)	
Snare-assisted microcatheter crossing	12 (26.1)	8 (18.2)	0.45
Guidewire captured time (min)	2.7±0.6	3.4±0.7	<0.001

Data are expressed as mean ± SD or n (%). J-CTO, Japanese chronic total occlusion score; PROGRESS-CTO, Prospective Global Registry for the Study of Chronic Total Occlusion Intervention; CTO, chronic total occlusion; RCA, right coronary artery; LAD, left anterior descending artery; LCX, left circumflex artery; RWC, retrograde wire crossing; CART, controlled antegrade and retrograde subintimal tracking; SD, standard deviation.

the retrograde guidewire is drilled through the loop in the two-dimensional image. Expanding the loop and adjusting the loop to be perpendicular to the flow direction may improve the capture efficiency. (III) For vessels with essential branches in the proximal segment of the CTO lesions, the retrograde guidewire's entry into the true lumen in the distal branch must be verified by intravascular ultrasound before the operators can proceed further. Otherwise, the loss of essential branches may cause serious consequences.

In the present study, the two snaring techniques were successful in all included patients. The mean J-CTO score was 2.1±1.0 in the MHS group and 2.0±0.9 in the GS group, suggesting that the CTO lesions treated in this study had a certain complexity. The CTO lesions were mainly located in the RCA in both groups. The guidewire capture time was significantly shorter in the MHS group than in the GS group. A recent study found that a shorter procedure time of CTO appears to be associated with better PCI outcomes (27,28). Compared with the 15-mm diameter of the GS loop, the MHS loop diameter has better adjustability and can be expanded to its maximum to be the same as the aorta by advancing the guidewire shaft, which will greatly improve the efficiency of catching the retrograde wire. Moreover, commercially available snares have several drawbacks, such as additional cost, inappropriate indication, risk of vessel injury, and difficult operation. Even though the GS snare was initially designed and approved for the removal of intravascular foreign bodies (27), and has been reported successful in PCI for CTO lesions (19), the MHS consists of common PCI materials found in every catheter center and therefore would be easier to access.

One case of delayed pericardial tamponade was observed in the MHS group. The patient had an ostium CTO of the RCA with an ambiguous proximal cap, nearly 40 mm of occlusion, and severe tortuosity. When the initial antegrade strategy failed, the retrograde approach was promptly taken, and the retrograde guidewire was controlled to pass the collaterals into the CTO lesion. With the induction of the retrograde guidewire, it still failed to advance antegrade wire into the vessel structure for quite a while. Finally, the active greeting technique had to be abandoned, and snaring retrograde guidewire had to be adopted to complete the CTO-PCI. Pericardial tamponade occurred 2 h after PCI, and it was confirmed as loculated pericardial effusion by bedside echocardiography. The patient was discharged 2 weeks later after undergoing an emergency surgery to evacuate the pericardial hematoma. This CTO lesion was too complex for the antegrade approach, and excessive antegrade attempts led to the formation and enlargement of the hematoma. This could potentially be avoided by switching to the snaring retrograde guidewire technique earlier. No other complications occurred in the two groups.

This study has the following limitations. This study was a single-center, small-sample, retrospective observational study. The timing of switching to snaring retrograde guidewire depended on the operator's decision, and the exact reason was not available for each case. In addition, no long-term follow-up data were available. A multicenter prospective study with a larger sample size is needed to verify the findings of this study.

Conclusions

The MHS improved the efficiency of retrograde CTO-PCI in terms of shorter capture time and more accessible use by the operator compared with the GS. Therefore, the MHS might be worthy of promotion in clinical practice owing to its efficiency, safety, inexpensiveness, and easy availability.

Acknowledgments

The authors sincerely thank the patients and doctors who participated in the study.

Funding: This study was funded by the Cultivation Fund of Beijing Municipal Administration of Hospitals (No. PZ2021008 to L.Z.).

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-610/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-610/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-610/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-610/coif). L.Z. reports funding support from the Cultivation Fund of Beijing Municipal Administration of Hospitals (No. PZ2021008). The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics committee of Beijing Anzhen Hospital (approval number: 2023001X). Individual consent for this retrospective analysis was waived.

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Cite this article as: Zhang T, Zhang Y, Feng T, Zhao L. Effectiveness and safety of a novel modified homemade snare in retrograde percutaneous coronary intervention for chronic total occlusion lesions: a retrospective cohort study. J Thorac Dis 2024;16(5):3272-3281. doi: 10.21037/jtd-24-610