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Please cite this article THE RETROGRADE TECHNIQUE FOR RECANALIZATION OF CHRONICALLY OCCLUDED CORONARY ARTERIES: CASE SERIES REPORT

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UDC:  

DOI: https://doi.org/10.2298/VSP200606124J

When the final article is assigned to volumes/issues of the Journal, the Article in Press version will be removed and the final version appear in the associated published volumes/issues of the Journal. The date the article was made available online first will be carried over.
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Short title: PCI CTO – retrograde case series report
Stefan Juricic, Milorad Tesic, Milan Dobric - drafting of the article, performed PCI, contributed to discussions on the results.
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Branko Beleslin, Goran Stankovic - contributed to discussions on the results and final approval of the article submitted.
Sinisa Stojkovic – idea and conception of the article, performed PCI, contributed to discussions on the results and final approval of the article submitted.
ABSTRACT

Background. Chronic total occlusion (CTO) of coronary artery still represents one of the most challenging lesion subset in field of interventional cardiology. Considering the complexity and increased risk posed by the retrograde approach, it is most often performed after a failed antegrade approach.

Methods. We present a series of cases dedicated to the retrograde approach as a special technique for the treatment of chronic total coronary artery occlusion. All cases have some special characteristics that are today part of a dedicated portfolio in every cath lab.

Results. In our series of cases all of three percutaneous coronary interventions (PCI) with retrograde approach finished with successful recanalization of CTO with different strategy and supported with rotational atherectomy (RA) or intravascular ultrasound (IVUS).

Conclusion. In cases where there is the presence of interventional collaterals, as well as when the anterograde approach is very difficult, the retrograde approach can increase the success rate of procedures. The retrograde approach requires a long learning curve as well as very skilled and experienced operators who are able to perform the procedure independently.

Key words: chronic total occlusion, retrograde approach, percutaneous coronary interventions

ABSTRAKT

Uvod. Hronične totalne okluzije (CTO) koronarnih arterija i dalje predstavljaju jedne od najizazovnijih lezija na polju interventne kardiologije. S obzirom na složenost i povećani rizik koji nosi sa sobom retrogradni pristup najčešće se izvodi nakon neuspešlog anterogradnog pristupa.

Metode. Predstavljamo seriju slučajeva posvećenih retrogradnom pristupu kao specijalnoj tehnici lečenja hroničnih totalnih okluzija koronarnih arterija. Svi slučajevi imaju neke posebne karakteristike koje su danas deo svakodnevog portofolija u svakoj Sali za kateterizaciju srca.

Rezultati. U našoj seriji slučajeva sve tri perkutane koronarne intervencije retrogradnim pristupom završene su uspešnom rekanalizacijom CTO različitom strategijom uz podršku rotablera ili intravaskularnog ultrazvuka.

Zaključak. U slučaju kada postoje interventne kolaterale, kao i kada je antegradni pristup veoma težak, retrogradni pristup može povećati uspešnost procedure. Retrogradni pristup
zahteva dugu krivu učenja kao i veoma iskusne operatore koji su sposobni da izvode samostalno ovakve procedure.

**Ključne reči:** hronična totalna okluzija, retrogradni pristup, perkutana koronarna interventcija

**INTRODUCTION**

For many years, percutaneous treatment of chronic total occlusions (CTO) of the coronary arteries has been a clinical and technical challenge for interventional cardiologists. Successful recanalization rates are increasing primarily due to the constant development of techniques and technological advancements for percutaneous coronary interventions (PCI) along with the growing experience of operators (1,2). Many retrospective and prospective registries show better survival, improved left ventricular function, reduced risk of malignant arrhythmias as well as CABG in procedural success groups (3,4). Recent randomized clinical studies suggest a better quality of life in patients with successful recanalization of an occluded blood vessel compared to patients on optimal drug therapy (OMT) (5-8). Among the various techniques for PCI CTO, the retrograde approach with different strategy types is considered the most complex. The retrograde approach should be considered in occlusions with “interventional” collaterals (i.e., collaterals deemed to be negotiable by the operator depending on his/her experience), diseased landing zone, bifurcation at distal cap, and/or proximal cap ambiguity (9,10).

Therefore, the aim of this case series is to present a complex retrograde technique as the first strategy choice according to the indication in every single case, combined with contemporary armamentarium of available devices (guiding catheter extension, rotablator od intravascular imaging) to achieve a succesfull and optimal result. All cases were performed at the Cardiology department of the Clinical Center of Serbia.

**Case 1.**

A 69 year old male had a posterior myocardial infarction in April 2019 as the first manifestation of coronary heart disease. He generally complains of typical anginal symptoms with minimal physical exertion. SEHO test wasn’t done. Echocardiographic examination showed a left ventricle of normal dimensions with hipokinetic inferolateral wall and preserved systolic function, EF 50%. Apart from hypertension and a positive family history of CVD, he had no other risk factors.
#1 During index hospitalization, primary PCI have been attempted, in which a single-vessel coronary disease, a calcified subocclusive lesion about 20 mm long in the proximal segment of the dominant Cx artery, intermediate stenosis in the medial segment of the LAD and minor RCA were observed. Furthermore, through the right radial approach a catheter guide EBU 3.5 / 6F was placed in the LM shaft. After a challenging placement of the Sion blue (Asahi Intec Co., Japan) coronary wire in the distal segment of the Circumflex (Cx) artery, a 2.5x20 mm semi-compliant balloon was placed at the lesion site after being supported by a GuideZilla 6F extension catheter (Boston Scientific, Marlborough, MA). Due to the inadequate expansion of the semi-compliant balloon, an attempt was made to place the non-compliant (NC) balloon, without any success (figure 1).

#2 In May of the same year, PCI of the same lesion was attempted by the femoral approach 6F. The same catheter guide and coronary wire were placed, after which a 3x20 NC balloon predilatation was performed. A larger dissection was formed and the stent could not be placed due to the deviating angle and the existing extensive calcifications (figure 2). It is proposed to present the patients to the Heart Team, which met in June at the CCS. The council made the decision to do the first FFR for the lesion on the LAD and if the lesion is functionally significant, the patient will be offered surgical revascularization of the myocardium. Otherwise, it is suggested to try PCI Cx again using a rotablator.

#3 In the same month, the EBU 3.5 / 7F guide catheter was placed by right radial access and the flow reserve was measured at 0.84. With the support of the Corsair microcatheter (Asahi Intec Co., Japan), Gaia 2 (Asahi Intec Co., Japan) has currently not undergone occlusion in the proximal Cx segment with developed ipsilateral collaterals (CC 1-2). Further intervention was abandoned (figure 3).

#4 A month later, in July 2020, a femoral approach with an EBU 3.5 / 7F guide catheter was set up for a fourth PCI attempt at the same center. After the placement of the temporary PM, the coronary arteries of BMW (Abbott Vascular) as well as Fielder XT (Asahi Intec Co., Japan) did not undergo occlusion and further intervention was abandoned (figure 4).

It was concluded that the fifth attempt would be in a dedicated center.

#5 In December 2019, the intervention began with a left femoral approach, 7F. The right femoral artery was not palpable, as was the right radial artery. Due to the pronounced
calcifications of the left radial and ulnar arteries, placement of the introducer was impossible (figure 5).

After the placement of EBU 3.5 / 7F, with the support of the Corsair coronary microcatheter Fielder XT, Gaia 3 and Confianza pro (Asahi Intec Co., Japan) did not undergo occlusion. After evaluation of interventional isplateral collaterals, a retrograde approach was attempted (figure 6). The Sion black (Asahi Intec Co., Japan) wire supported by a Corsair microcatheter passed through the septal collaterals into the Cx and without resistance through the distal occlusion cap all the way to the Left main. Corsair remained ‘stuck’ in the collateral being intervened. Since the Sion black wire could not be placed in the catheter guide after several attempts, a rendezvous in the proximal segment of the Cx artery was attempted with a Finecross microcatheter being placed anterogradely unsuccessfully. Finecross (Terumo Interventional Systems, Tokyo, Japan) then replaced the Corsair as a retrograde catheter and placed it over the lesion into a catheter guide (figure 7). Then a “rendezvous technique“ (11) retrograde coronary BMW wire was placed with the support of a retrograde Finecross microcatheter into an antegrade Corsair microcatheter (figure 8,9).

After placing the Rota wire in the distal segment of the Cx artery, a rotational atherectomy with burr 1.75 mm was performed, followed by NC balloon predilatation 3x15 mm and placement of drug eluting stents (3x30 and 3x25 mm) in the distal and proximal segment of the Cx artery with proximal optimisation with NC balloon 3.5x15 mm, without significant residual stenosis (figure 10).

**Case 2.**

A 65 year old female, complains of typical anginal symptoms with moderate physical exertion. A positive stress echo test showed hypokinesia inferolaterally. Echocardiographic examination showed a left ventricle of normal dimensions with preserved systolic function, EF 65%. Furthermore, this is a long-term cardiac patient, with a previous myocardial infarction in 2016. So far three unsuccessful attempts were made to recanalize the right coronary artery (RCA).

The fourth attempt to recanalize the CTO RCA started with a bifemoral approach. Angiographically, single-vessel coronary heart disease has been previously verified, with occlusion more than 5 cm long from the RCA ostium. The posterolateral branch did not show from retrograde collaterals and the impression was gained that it was occluded from
its ostial segment (figure 11). The Corsair microcatheter was placed practically to the distal occlusion cap via LCA intervention collaterals, after which Sion black was replaced with Gaia 3 coronary wire. Subsequently, a reverse CART technique was performed with the help of the Guidezilla extension catheter (figure 12). Gaia 3 retrograde wire was placed in an anterograde extension catheter. Following, externalization was performed with RG3 (Asahi Intec Co., Japan) and 3 drug-eluting stents were placed after appropriate predilation. Due to the lack of adequate flow in the distal segment of the artery, intravascular ultrasound (IVUS) optimization was performed, followed by additional angioplasty. TIMI 3 coronary flow was obtained (figure 13).

**Case 3.**

A 64 year old female, complains of typical anginal discomfort with greater physical exertion. A SEHO test was performed which showed hypokinesia in inferolateral and the test was evaluated as positive. Echocardiographic examination showed a ventricle of normal dimensions with preserved systolic function, EF 60%. It treats hypertension and hyperlipidemia as a risk factor for CVD. Two years ago, PCI Cx was performed with the implantation of a single stent with drug release. Diagnostic coronary angiography revealed single-vessel coronary disease, with no stump occlusion at the site of a previously implanted stent in the Cx artery, about 15 mm long. The intervention began with a femoral approach, 6F. Corsair was placed retrogradely, overcoming collaterals and Gaia 2 wire, which underwent occlusion with the support of microcatheters and was placed in prox Cx (figure 14). The Fielder XT antegrade wire was then placed, which, with a slight return of the Corsair microcatheter, was placed in the distal segment Cx in parallel with the BMW retrograde wire (which replaced the Gaia 2 wire after the microcatheter underwent occlusion). After adequate predilatation, two drug-releasing stents were implanted, after which TIMI 3 flow was obtained in the distal segment of the Cx artery, without significant residual stenosis (figure 15).

**DISCUSSION**

We presented the series of three cases of recanalization of chronically occluded arteries using the retrograde approach, supported by rotational atherectomy (RA), IVUS as well as various techniques within the retrograde approach. The first case is a clear demonstration of a technically very complex case which requires highly flexible and experienced operator. The most aggressive wires such as Gaia third or
Confianza pro 12 (Asahi Intec Co., Japan) could not cross very complex and calcified lesion. The operator quickly switched to retrograde ipsilateral technique with soft polymeric wire (Sion black, Asahi Intec Co., Japan) which crossed occlusion within few seconds, allowing further calcified lesion modification using RA. The application of RA is considered safe after unsuccessful results for predilatation of calcified lesions in CTO and are considered equally successful in nonCTO procedures. This approach made possible to finish the procedure with optimal result and minimal risk, after four previous unsuccessful attempts.

The second case demonstrated the usage of the guiding catheter extension to facilitate “reverse CART technique“ which nowadays become a standard approach. Certainly, the most ideal option of the retrograde approach is the "true-to-true lumen" technique, which is possible when there are short uncalcified occlusions. In most cases, successful retrograde recanalizations end in reverse controlled antegrade and retrograde subintimal "tracking" (reverse CART technique). Certainly, this technique is the most used. A balloon positioned on the antegrade wire creates a subintimal space for the retrograde wire to advance and make a connection between the antegrade and retrograde space. It usually starts with a smaller balloon (2mm) and in case of failure, larger balloons are used. For retrograde wire, a very controllable wire is most often used, which also has the power to make this connection (for example Gaia wire family). Furthermore, this case showed that after successful recanalization and stent implantation, lack of flow should be assessed by the IVUS. IVUS demonstrated significant mid stent compression and very diseased distal vessel. These findings allowed further stent deployment optimization and distal balloon dilatation with excellent TIMI 3 flow. Randomized studies have shown that IVUS improves the outcome of PCI CTO in terms of MACE and stent thrombosis (12), most likely due to better optimization of the implanted stent. In the arena of retrograde approach, IVUS can be also helpful in two cases: passage of a retrograde wire and reverse CART technique. When passing a retrograde wire, IVUS can be useful in bifurcation “blunt stump“ occlusions as well as ostial occlusions, especially the LAD and Cx arteries, to avoid dissection of the main trunk of the left coronary artery and closure of the second branch(13).

In-stent CTOs represent about 12% of all PCI CTOs and these procedures are more complex than in unstented blood vessels (14). In the third case proximal cap of the
occlusion was ambiguous with a small brunch originating at that exact level. The occlusion was positioned at least 10 mm proximally to the proximal edge of the previously implanted stent. In such a cases antegrade approach is possible with IVUS guided antegrade puncture (with IVUS probe in the side brunch if possible) or by the analyses of the index procedure and possibly available CT angiography. In this case, the operator correctly started with retrograde approach using septal interventional collateral which allowed very easy crossing of the occlusion body with standard Gaia second wire (Asahi Intec Co., Japan) due to the fact that distal cap is usually softer than proximal one and that proximal vessel was a relatively big target.

We would like to underline that the first retrograde procedure was performed in 2009 by prof. George Sianos from Greece as a guest operator in Belgrade, and during the same year prof. Sinisa Stojkovic did the first retrograde recanalization of right coronary artery in Clinical center of Serbia. Since than until present time we have estimated that roughly 300 procedures performed with retrograde approach in Serbia (15).

In conclusion, the retrograde approach should not be used as the first choice technique and is usually reserved for situations after an unsuccessful attempt to recanalize using the antegrade approach. In certain cases, as shown in our series of cases, the retrograde technique can be used as the first choice especially in cases where “interventional“ collaterals are observed and when anterograde recanalization seems challenging due to the complex coronary anatomy of the occluded coronary vessel (16).

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Figure 1.

Figure 2.
Figure 3.

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Figure 7.

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