



## Bifurcation lesions in the context of a PCI CTO – insight from a Belgrade single-center CTO registry

### Bifurkacije u kontekstu PKI HTO – uvid u registar HTO jednog centra u Beogradu

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#### Abstract

**Background/Aim.** Chronic total occlusions (CTOs) of the coronary artery are still one of the most complex procedures in the treatment of coronary arteries. If there is a bifurcation lesion within the CTO, it is certainly one of the biggest challenges for interventional cardiologists. **Methods.** We present a retrospective analysis of patients from our center who underwent percutaneous coronary intervention (PCI) with a bifurcation lesion within the CTO and a side branch with a diameter of 2 mm or more from January 2017 to December 2020. **Results.** Out of the total 216 patients in the four-year period, 38 (18%) had a bifurcation lesion within the CTO. The most common bifurcation lesions (50%) were on the left anterior descending artery, and the least frequent (21%) on the circumflex coronary artery. CTO recanalization was successful in 35 (92%) patients. The one-stent technique was used in 27 (77%) patients, while the two-stent technique was used in 8 (23%) patients. **Conclusion.** Bifurcation lesions in the context of PCI CTOs are a relatively common finding in coronary angiography and represent a special challenge for CTO operators. The provisional technique (one-stent technique) is the most common strategy for the treatment of bifurcation lesions in patients with CTO.

#### Key words:

coronary angiography; coronary occlusion; percutaneous coronary interventions; stents.

#### Apstrakt

**Uvod/Cilj.** Hronične totalne okluzije (HTO) koronarnih arterija su i dalje među najsloženijim procedurama u lečenju koronarnih arterija. Ukoliko postoji bifurkaciona lezija u sklopu HTO, to je jedan od najvećih izazova za interventivne kardiologe. **Metode.** Prikazujemo retrospektivnu analizu bolesnika lečenih u našem centru, kojima je rađena perkutana koronarna intervencija (PKI) sa bifurkacionom lezijom unutar HTO i bočnom granom dijametra 2 mm ili više, od januara 2017. do decembra 2020. godine. **Rezultati.** Od ukupno 216 bolesnika lečenih u četvorogodišnjem periodu, 38 (18%) ih je imalo bifurkacionu leziju u sklopu HTO. Najčešće bifurkacione lezije (50%) bile su na prednjoj descendentnoj koronarnoj arteriji, a najređe (21%) na cirkumfleksnoj koronarnoj arteriji. Uspešna rekanalizacija HTO ostvarena je kod 35 (92%) bolesnika. Tehnika jednim stentom korišćena je kod 27 (77%) bolesnika, dok je tehnika sa dva stenta korišćena kod 8 (23%) bolesnika. **Zaključak.** Bifurkacione lezije u kontekstu PKI HTO su relativno čest nalaz na koronarnografiji i predstavljaju poseban izazov za HTO operatore. *Provisional* tehnika (tehnika jednim stentom) najčešća je strategija lečenja bifurkacionih lezija i kod bolesnika sa HTO.

#### Ključne reči:

angiografija koronarnih arterija; koronarna okluzija; perkutana koronarna intervencija; stentovi.

#### Introduction

In the field of interventional cardiology, percutaneous interventions (PCI) of chronic total occlusions (CTOs) of the coronary artery are still the biggest challenge, with a still lower percentage of successful interventions compared to

non-CTO lesions<sup>1,2</sup>. Despite the complexity and certain risk that these interventions carry, there is great interest in PCI CTOs due to evidence that successful recanalization improves patient symptoms and prognosis as well as cardiac function<sup>3-10</sup>. Approximately 20% of all lesions treated with PCI are bifurcation lesions<sup>11</sup>. Bifurcation lesion, as part of a

CTO, represents an additional challenge in a rather complex intervention. These lesions are challenging because they occur at the point where two arteries branch off. There is always a need to preserve the access and maintain the Thrombolysis in Myocardial Infarction (TIMI) 3 flow through the side branch. This prerequisite can make it quite difficult to treat the occlusion and bifurcation simultaneously. Furthermore, the anatomy of the bifurcation can be complex, and the lesion itself may be long and heavily calcified, which can make it challenging to navigate a guide wire or other interventional devices through the occlusion. Overall, bifurcation lesions within CTOs require advanced technical skills, experience, and specialized equipment for effective treatment. In the available literature, there is a paucity of studies on bifurcation lesions within CTO regarding incidence, clinical, angiographic, and procedural data<sup>12-15</sup>.

In this article, we present the clinical, angiographic, and procedural characteristics of patients with CTOs and bifurcation performed in our center over a four-year period.

### Methods

From January 2017 to December 2020, in the Catheterization Laboratory of the University Clinical Center of Serbia, CTO recanalization was attempted by experienced CTO operators in 216 patients. The study was approved by the Ethical Committee of the University Clinical Center of Serbia (No. 30/4, from December 17, 2015).

CTO was defined as a coronary obstruction with TIMI flow grade 0 with an estimated duration of more than three months<sup>15</sup>. Bifurcation lesions were defined by the presence of a side branch (SB) within the CTO body or 5 mm of the proximal or distal cap of the CTO lesion, with a reference SB diameter of 2 mm or more. A successful procedure was defined when residual stenosis of less than 30% and TIMI 3

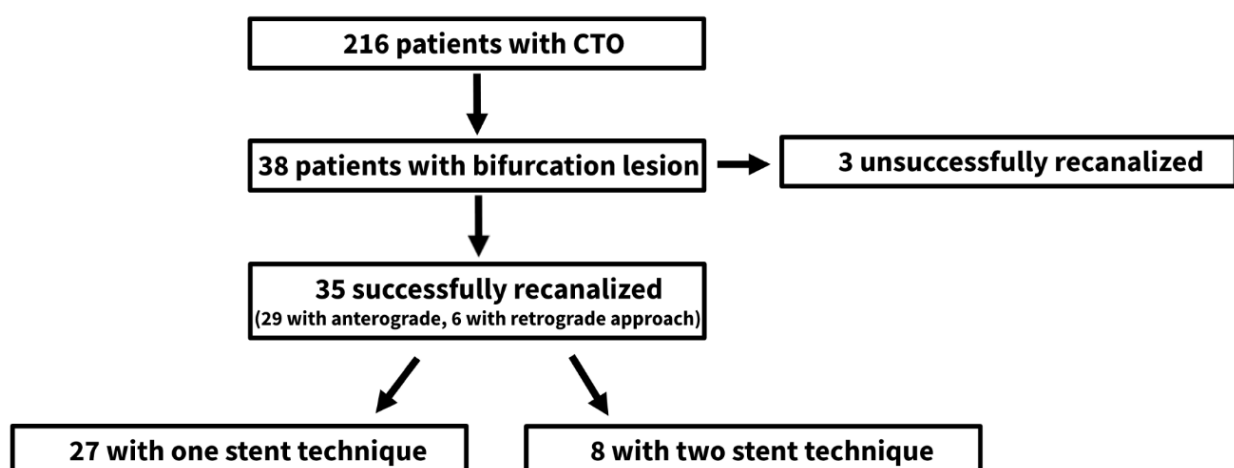
flow in both branches was achieved. Procedure time was measured from the engagement of the ostium with the guiding catheter to its removal. Procedure time, fluoroscopy time, and the amount of contrast were recorded by the X-ray technician at the end of the procedure.

All patients had a clinical indication for PCI CTO: stable angina with evidence of myocardial ischemia and/or myocardial viability in the akinetic zone of the occluded artery with a reference vessel size equal to or larger than 2.5 mm by visual estimation. Likewise, all patients were pretreated with dual antiplatelet therapy. The Japan-CTO (J-CTO) score is the most widely used score, and its introduction has created a scoring system that predicts not only successful wire passage and procedural efficiency but also technical success and even complications. It is the sum of the following five binary parameters: blunt proximal cap, calcification, bending  $> 45^\circ$ , length of occluded segment  $> 20$  mm, and previously failed PCI attempt. Each of these independent variables was assigned a value of 1 when present. The operator made the decision whether the recanalization was done with an antegrade or retrograde approach, as well as whether the bifurcation technique with one or two stents was used as part of the preparation for the intervention.

### Results

From January 2017 to December 2020, out of the total of 216 patients with CTO in the registry, 38 (18%) of them (mean age  $59.32 \pm 9.9$  years, men 76%) had a bifurcation lesion within the CTO (Figure 1).

Bifurcation lesions were most often seen in the left anterior descending (LAD) artery (50%), then in the right coronary artery (RCA), and least frequently in the circumflex (Cx) artery (21%). Patients and their angiographic characteristics are shown in Table 1.



**Fig. 1 – Chart flow of the patients.**  
CTO – chronic total occlusion.

**Table 1****Patients with bifurcation lesion within the CTO (n = 38)  
and angiographic characteristics of those patients**

Variable	Value
Age (years)	59.32 ± 9.9
Body mass index	27.2 ± 3.1
Baseline creatinine (mmol/L)	82.2 ± 15.9
Male	29 (76)
Female	9 (24)
Family history of CAD	19 (50)
Hypertension	31 (82)
Hypercholesterolemia	30 (79)
Diabetes mellitus	7 (18)
Ex-smoker	9 (24)
Current smoker	9 (24)
Previous stroke	0 (0)
Previous myocardial infarction	16 (42)
In-stent CTO	5 (13)
Angina	
CCS I	3 (8)
CCS II	28 (73)
CCS III	6 (16)
CCS IV	1 (3)
Reversible ischemia demonstrated	20 (53)
Presence of viability*	36 (95)
CTO artery	
LAD	19 (50)
Cx	8 (21)
RCA	11 (29)
Visual reference vessel diameter	2.99 ± 0.4
Visual length of occlusion	19.74 ± 8.5
Calcification	
none	4 (11)
mild	22 (58)
moderate	10 (26)
severe	2 (5)
Proximal cap tapered	27 (71)
Moderate/severe tortuosity	1 (3)
"Interventional" collateral present	23 (61)
J-CTO score	1.40 ± 1.17

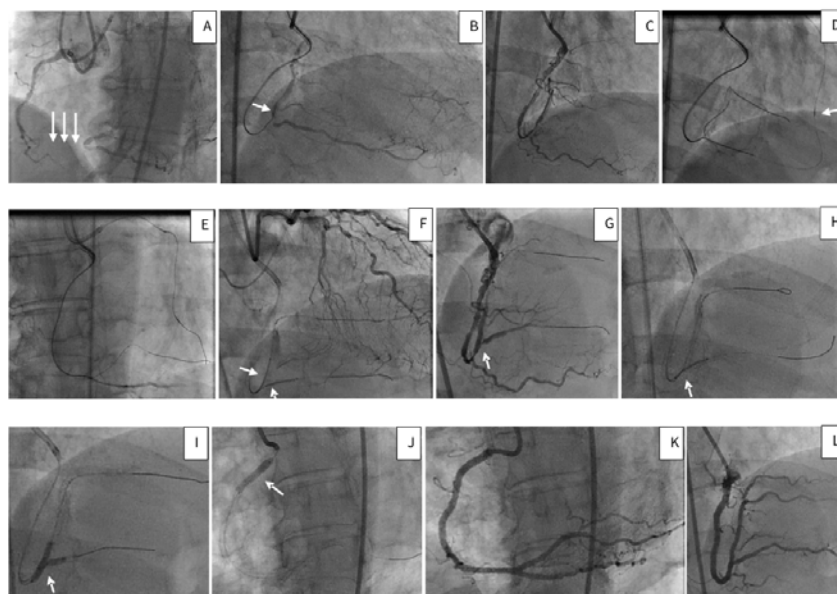
Data are expressed as mean ± standard deviation or as numbers (percentages).

CAD – coronary artery disease; CTO – chronic total occlusion; CCS – Canadian Cardiovascular Society; LAD – left anterior descending; Cx – circumflex; RCA – right coronary artery; J-CTO – Japan CTO.

\*Presence of viability: left ventricle (LV) normokinesis or segmental LV hypokinesis or documented viability in CTO territory.

CTO with bifurcation lesion was successfully recanalized in 35 (92%) patients. Out of the total number of recanalized CTOs, successful recanalization by the antegrade approach was done in 29 (83%) patients, and by the retrograde approach in 6 (17%) patients. Specific CTO wires were used for all procedures, of which Fielder XT (n = 7; 20%), Gaia 1st (n = 5; 14%), Gaia 2nd (n = 12; 35%), Gaia 3rd (n = 6; 17%), Ultimate 3 (n = 3; 8%), or Conquest PRO (n = 2; 6%) were the wire which finally successfully crossed, with the support of microcatheters such as Corsair Pro (n = 13; 37%), Finecross (n = 17;

49%), Caravel (n = 3; 8%), or dual lumen microcatheter Sasuke (n = 2; 6%). In all successful recanalizations, new-generation drug-eluting stents were implanted. In addition to the standard one-stent technique (provisional technique), we often have to apply one of the techniques with two stents due to significant SB disease. The one-stent technique was used in 27 (77%) patients, while the two-stent technique was used in 8 (23%) patients. The two-stent technique is illustrated in Figure 2. The radial approach was used in 16 (42%) patients. Table 2 summarizes the procedural characteristics.



**Fig. 2 – Application of the two-stent technique in a right coronary artery (RCA) chronic total occlusion (CTO) intervention with bifurcation lesion. A) Coronary angiography demonstrating a CTO of the distal RCA (arrow); B) A Gaia second™ guidewire (Asahi Intecc) was advanced into distal right posterolateral artery (arrow); C) Unsuccessful anterograde crossing attempt to the right posterior descending artery (PDA), after predilatation of the distal RCA, occlusion of the right PDA occurred; D) The intervention continued with a retrograde approach, the Sion Black® guidewire (Asahi Intecc) passed the septal collaterals in the right PDA but neither the Corsair® Pro (Asahi Intecc) nor the Caravel® (Asahi Intecc) (arrow) could pass into the PDA; E) A Sion Black® guidewire was advanced from the crux to the PDA subintimally, but the geometry of the bifurcation was changed so that finally the Gaia Third™ guidewire (Asahi Intecc) with the support of Corsair passed antegrade into the right PDA into the right lumen; F) and G) The idea was to create a miniCrush (or modified T) bifurcation technique of the distal RCA; two stents (RCA-PL and ostium PD) were positioned (arrow), but it turned out that the ostium was not covered; H) Bail out was seen in the conversion to the culotte technique, with prior stenting of the distal right posterolateral artery and proximal optimisation technique of the distal RCA; I) Final kissing (arrow); J) Stenting of the proximal RCA was performed (arrow); K) and L) Final angiographic result showing successful recanalization of the RCA. PL – posterolateral (branch); PD – posterior descending.**

Table 2

Procedural characteristics	
Variable	Value
Radial approach	16 (42)
Contralateral injection	19 (50)
First guiding catheter 6fr	7 (18)
First guiding catheter 7fr	31 (82)
Microcatheter	35 (92)
Successful recanalization	35 (92)
anterograde recanalization	29 (83)
single wire	21 (60)
step up step down	8 (23)
retrograde recanalization	6 (17)
one-stent technique	27 (77)
two-stent technique	8 (23)
Total number of wires	2.6 ± 1.8
Total number of balloons	2.3 ± 0.8
Number of drug-eluting stent	1.9 ± 0.9
Total length of drug-eluting stent (mm)	50.7 ± 26.8
Maximal balloon diameter for postdilation (mm)	3.0 ± 0.6
Time of procedure (minutes)	84.4 ± 52.7
Fluoroscopy time (minutes)	33.4 ± 23.2
Contrast (mL)	297.3 ± 135.6
Patient dose (mGy)	1501.4 ± 138.3

**Total number of patients = 38. Data are expressed as mean ± standard deviation or as numbers (percentages).**

## Discussion

In our study group, we analyzed the incidence of bifurcation lesions in CTO, as well as the clinical and angiographic data of patients from our center over a four-year period.

Several studies have evaluated the incidence of bifurcation lesions in the context of CTO lesions. In a series of 922 CTOs, Galassi et al.<sup>13</sup> had an incidence of 26.5% with a bifurcation lesion, while in a single-center prospective CTO registry, Chen et al.<sup>16</sup> and Ojeda et al.<sup>12</sup> had a higher incidence of bifurcation lesions (47% and 33%), which mostly depended on the adopted definition of bifurcations in CTOs. In their multicenter registry, with more than 900 CTO patients included, Ojeda et al.<sup>14</sup> demonstrated that 26% of them had a bifurcation lesion within the CTOs. In these few available CTO registries, we register higher rates of the presence of bifurcation lesions compared to the presence of the same lesions in PCI in the general population<sup>11</sup>. That can be explained by the fact that patients with CTO also have more aggressive atherosclerosis.

The registry of Ojeda et al.<sup>14</sup> showed, like our study, that the most frequent bifurcation within the CTOs was on the LAD.

In our group of patients, the majority of bifurcation lesions were treated with the one-stent technique. In the study by Ojeda et al.<sup>12</sup>, about 93% of patients with a bifurcation lesion were treated with the one-stent technique. Chen et al.<sup>16</sup> had a slightly lower percentage (75%) of the one-stent technique in proximal bifurcation lesions, and our results are similar to theirs.

Our results are also in agreement with the results by Galassi et al.<sup>13</sup> as well as Ojeda et al.<sup>14</sup> that had procedural success at 87.3% and 85%, respectively, while in another study by Ojeda et al.<sup>12</sup>, a slightly lower procedural success was observed.

When we talk about the complexity of the interventions themselves, as we said, the presence of a bifurcation lesion in the CTOs makes the operator's job even more difficult. Therefore, a J-CTO score of 1 or more is expected, which means a longer intervention time, fluoroscopy as well as radiation exposure. As shown in previous research conducted by Ojeda et al.<sup>14</sup>, patients treated with a simple approach had average values of J-CTO score (1.8), fluoroscopy time (47.1 min), and contrast volume (about 326 mL), and our results are very similar to that data. The same data from the PROGRESS-CTO register<sup>17</sup>, depending on the bifurcation site, speak in favor of a slightly longer intervention time (110–120 min) and radiation dose (2–2,500 mGy). Such data can be justified by more complex occlusions because the J-CTO score is somewhat higher (2.5–2.9).

## Conclusion

Bifurcation lesions in the context of PCI CTOs are a relatively common finding in coronary angiography and represent a special challenge for CTO operators. The provisional technique (one-stent technique) is the most common strategy for the treatment of bifurcation lesions in patients with CTOs. With the advancement of technology as well as increasing experience in the field of CTOs, there is a high percentage of success in such complex PCI.

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Received on January 16, 2023  
Revised on February 17, 2023  
Accepted on February 20, 2023  
Online First March 2023