VIA MEDICA

EXPERTS' VIEWPOINT

Cardiology Journal
2023, Vol. 30, No. 1, 6–11
DOI: 10.5603/CJ.a2022.0115

ISSN 1897–5593
eISSN 1898–018X

Anatomical classification of chronic total occlusions in coronary bifurcations

Juan Luis Gutiérrez-Chico[1, 2], Carlos Cortés[3], Niels Ramsing Holm[4], Evald Høj Christiansen[4], Maciej Lesiak[5], Bernward Lauer[6], Sylvia Otto[6], Francesco Lavarra[7], Viktor Sasi[8], Yiannis S. Chatzizisis[9], Sudhir Rathore[10], Kambis Mashayekhi[11, 12]

[1]Bundeswehrzentralkrankenhaus, Koblenz, Germany
[2]Cardio-Care Heart Center, Marbella, Spain
[3]Miguel Servet University Hospital, Zaragoza, Spain
[4]Department of Cardiology, Aarhus University Hospital, Aarhus, Denmark
[5]1st Department of Cardiology, Poznan University of Medical Sciences, Poznan, Poland
[6]Klinik für Innere Medizin I, Universitätsklinikum Jena, Germany
[7]Jilin Heart Hospital, Changchun, China
[8]Department of Internal Medicine, University of Szeged, Hungary
[9]University of Nebraska Medical Center, Omaha, Nebraska, United States
[10]Frimley Health NHS Foundation Trust, Camberley, Surrey, United Kingdom
[11]Division of Cardiology and Angiology II, University Heart Center Freiburg – Bad Krozingen, Germany
[12]MedClin Heart Center Lahr, Department for Internal Medicine and Cardiology, Lahr, Germany

Abstract

Percutaneous coronary intervention (PCI) of chronic total occlusions (CTO) in coronary bifurcation lesions (CBL) is undergoing substantial technical progress and standardization, paralleling the evolution of dedicated devices, tools, and techniques. A standard consensus to classify CTO-CBL might be instrumental to homogenize data collection and description of procedures for scientific and educational purposes.

The Medina-CTO classification replicates the classical three digits in Medina classification for bifurcations, representing the proximal main vessel, distal main vessel, and side branch, respectively. Each digit can take a value of 1 if it concerns atherosclerosis and is anatomically stenosed, or 0 if it is not. In addition, the occluded segment(s) of the bifurcation are noted by a subscript, which describes key interventional features of the cap: t (tapered), b (blunt), or a (ambiguous). This approach results in 56 basic categories that can be grouped by means of different elements, depending on the specific needs of each study.

Medina-CTO classification, consisting of adding a subscript describing the basic cap characteristics to the totally occluded segment(s) of the standard Medina triplet, might be a useful methodological tool to standardize percutaneous intervention of bifurcational CTO lesions, with interesting scientific and educational applications. (Cardiol J 2023; 30, 1: 6–11)

Key words: percutaneous coronary intervention, coronary heart disease, chronic total occlusion, bifurcation lesion

Address for correspondence: OFA Prof. Juan Luis Gutiérrez-Chico, MD, PhD, FESC, FACC, Head of Interventional Cardiology, Bundeswehrzentralkrankenhaus, Rübenacherstraße 170, 56072 – Koblenz, Germany, tel: +49 (0) 26128121610, +34 615 319370, e-mail: JuanGutierrezChico@bundeswehr.org; Juanluis.gutierrezchico@ictra.es

Received: 28.05.2022 Accepted: 19.10.2022 Early publication date: 7.12.2022

Introduction

Percutaneous coronary intervention (PCI) of chronic total occlusions (CTO) has recently undergone substantial technical progress and standardization, improving safety and procedural success rates [1]. Nonetheless, some specific anatomic scenarios, like coronary bifurcations lesions (CBL), still pose an additional challenge for CTO-PCI [2, 3]. Several groups of experts are currently undertaking a remarkable academic effort to standardize the procedures and to generate scientific evidence on this complex topic, which combines all the methodological nuisances of both frontiers in coronary interventions: CBL and CTO. This endeavor would certainly benefit from a standard consensus to classify CTO-CBL in order to homogenize the collection of data and the description of procedures for scientific and educational purposes.

The European Bifurcation Club (EBC) adopted the Medina classification [4] for bifurcation lesions in 2008 [5], which became a cornerstone in most studies and workshops about bifurcations worldwide. Although this pragmatic classification has proven to be methodologically convenient and successful to sort out and to characterize conventional CBL, it entails substantial limitations for CTO-CBL, thus losing meaning and utility in this specific anatomic subset. A modified Medina classification is hereby proposed to properly categorize CTO-CBL in a meaningful and pragmatic way for scientific and didactic purposes. This Medina-CTO classification stems from the consensus between selected experts from the EBC and EuroCTO club.

Methods

Explanation of the Medina-CTO classification

Bifurcation is defined according to the consensus of the EBC and the Academic Research Consortium as a significant division of a major epicardial coronary artery, with a relevant side branch (SB) [5–7]. A relevant SB is operationally defined as a vessel that the operator wants to preserve. Likewise, the operator can appoint the arteries as main vessel (MV) or SB according to anatomical or functional criteria [5, 6]. The Medina classification consists of three digits, which represent the atherosclerotic involvement of the proximal main vessel (PMV), distal main vessel (DMV), and the SB, in this sequence [4]. Each number can dichotomously take two possible values: 0 if not involved, or 1 if involved [4]. A CTO at a CBL is considered whenever a totally occluded vessel, for ≥ 3 months, is located within 5 mm of the carina of the bifurcation [8]. The Medina-CTO classification adds a subscript to the digit/s representing the segment/s that is/ /are totally occluded. These subscripts describe the CTO cap from an interventional perspective and can take the following values:

— t — tapered;
— b — blunt;
— a — ambiguous.

The cap is defined as the portion of the atherosclerotic plaque where the occlusion begins, considered either in an antegrade or retrograde direction [8]. A tapered cap is defined as a clearly locatable cap in angiography, with the presence of any funnel, dimple, or channel indicating the direction of the true lumen [8]. A blunt cap is defined as a clearly locatable cap without presence of any funnel, dimple, or channel [8]. An ambiguous cap is defined as a cap perfectly levelled at the carina, so it is not possible to identify its exact location in angiography [8].

Directionality for the cap description

The subscripts will always describe the cap in an antegrade direction (proximal cap), except in the case of occlusion of the 3 segments of the bifurcation (trisegmentary occlusion); in this case, the subscript corresponding to the PMV will describe the cap in an antegrade direction (proximal cap), while the subscripts of the other segments will describe the cap in a retrograde direction (distal caps).

Additional nomenclature for scientific studies

For scientific studies, the classification might modify the notation to facilitate the grouping of lesions according to the investigational goals:

— Digits can be substituted by X, meaning that lesions coded as 0 or 1 in that specific segment can be grouped together in the category;
— Subscripts can be substituted by x, meaning that all types of cap, coded as t, b, or a, can be grouped together in the category.

Number of basic categories

Basic categories are those in which each segment is fully described, while the rest can be considered grouping categories. According to this definition, each digit of the Medina triplet can take 5 possible values in basic categories, namely 0, 1, 1_t, 1_b, and 1_a. This might mathematically result in a total number of categories corresponding to variations with repetition of 5 elements grouped by 3 (VR_5^3):

$$VR_5^3 = 5^3 = 125$$

Figure 1. Medina-chronic total occlusion classification, basic categories, monosegmentary lesions (only 1 segment of the bifurcation occluded).

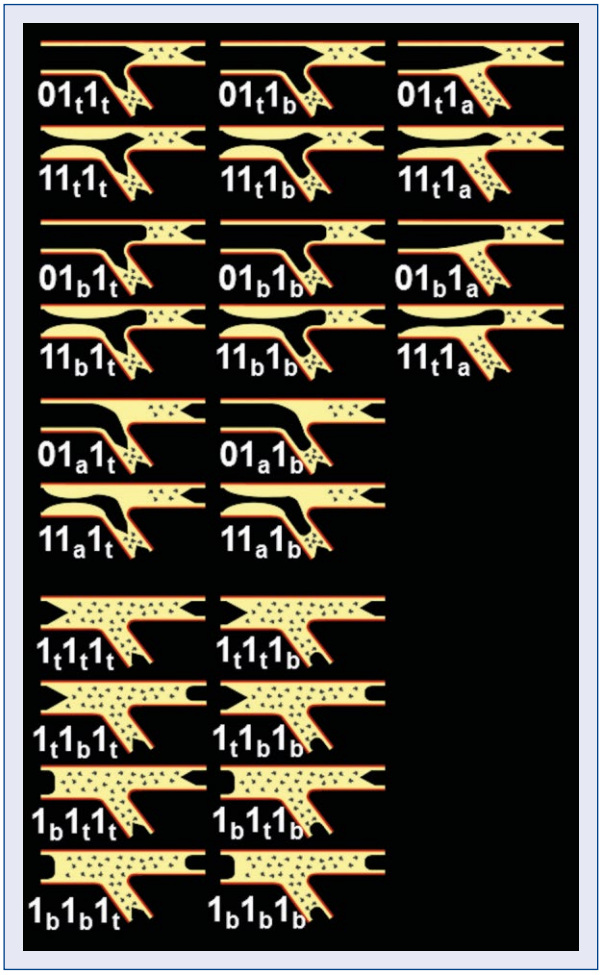

Figure 2. Medina-chronic total occlusion classification, basic categories, bisegmentary (2 segments of the bifurcation occluded), and trisegmentary lesions (all 3 segments of the bifurcation occluded).

To minimize the number of basic categories, some pragmatic and empiric rules were defined:

1. Categories containing no CTO, corresponding to the original Medina classification, or without atherosclerosis (000) are disregarded for the current Medina-CTO classification;
2. No ambiguous cap can be reported at the proximal MV (first digit);
3. If 2 segments are totally occluded and the PMV is one of them, this is by definition a CTO involving the 3 segments of the bifurcation, and it must be reported as such.
4. Occlusion of 2 segments is only possible if these segments are the DMV and the SB. In this circumstance, an ambiguous cap can be only reported in 1 segment;
5. If the 3 segments of the bifurcation are occluded, then no ambiguous cap can be reported in any segment.

Following these rules, the total number of basic categories of the classification is 56, distributed as 32 monosegmentary lesions, 16 bisegmentary lesions, and 8 trisegmentary lesions (Figs. 1, 2). Some examples of CTO-CBL classified according to Medina-CTO are presented in Figure 3.

Double, triple, and multiple CTO bifurcation lesions

High-volume CTO operators are often confronted with CTO extending between 2 or more bifurcations (Fig. 4). In such cases, the correct way of classifying the lesion would be to describe the bifurcations from proximal to distal, linked by central dashes (Fig. 3). The Medina-CTO description includes sufficient detailed information to infer whether each bifurcation is proximal, central, or distal to the CTO.

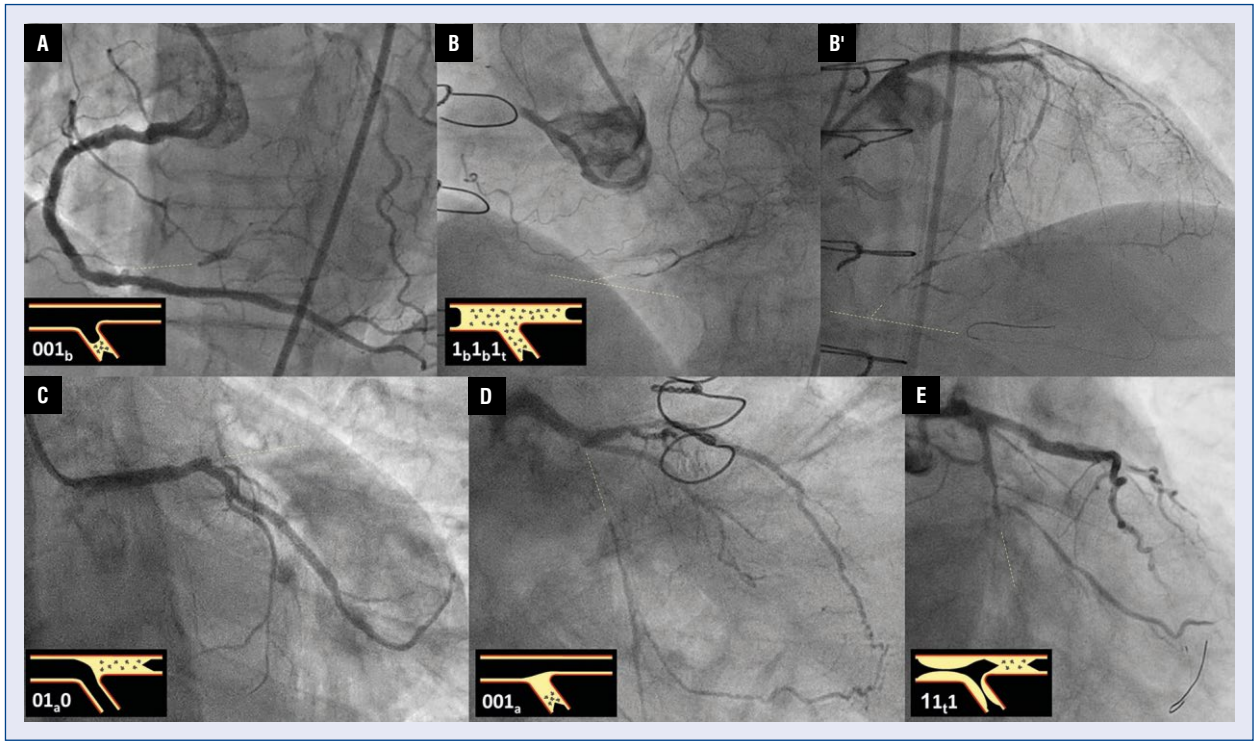

Figure 3. Examples of chronic total occlusion (CTO) bifurcations classified after Medina-CTO. **A.** CTO of the posterolateral stem, with a blunt stump (001_b); **B, B'.** CTO of the proximal right coronary artery, extending beyond the crux cordis, with blunt stump antegradely, blunt stump in the posterior descending artery retrogradely, and tapered stump retrogradely in the posterolateral ($1_b1_b1_t$); **C.** CTO of the proximal left anterior descending with ambiguous cap (01_a0); **D.** CTO of the proximal left circumflex with ambiguous cap (001_a); **E.** CTO of the distal left circumflex with tapered stump and atherosclerotic disease in all segments (11_t1).

In multiple CTO bifurcations, the digit corresponding to the occluded segment of the first bifurcation CTO must be the same as the first digit of the next bifurcation of the sequence, because the occluded segment of the first bifurcation becomes the PMV of the subsequent one in the series. The only exception happens if the proximal bifurcation contains an ambiguous cap (i.e. $X1_aX$ or $XX1_a$); because the categories 1_aXX do not exist, the cap of the distal CTO-CBL should be described as 1_bXX if needed (i.e. $X1_aX$–1_bXX or $XX1_a$–1_bXX; Fig. 4C, D).

Discussion

Interest in CBL in the setting of CTO is progressively growing among interventional cardiologists, paralleling the evolution of dedicated devices, tools, and techniques. Previous studies have classified CTO-CBL into three categories: bifurcation at the proximal part of the CTO, in the middle part of the CTO, or at the distal part of the CTO [9, 10]. This approach, dubbed trichotomous classification, has been instrumental in initiating some systematization in this challenging field. Its appealing simplicity confers the trichotomous classification an advantage for a wide acceptance; however, it might disregard a lot of crucial details that are important in planning the initial strategy or to select lesions for specific studies, thus appearing as insufficient to accommodate current specialization and diversification of interventionism in this specific topic.

The Medina-CTO classification is intended to overcome these limitations and further refine the standardization of PCI in CTO bifurcations. It is compatible with the trichotomous classification (proximal-middle-distal) of previous studies [9, 10], while adding information about the atherosclerotic involvement of the different bifurcation segments, plus some relevant features to decide the initial strategy. In this way, a detailed pragmatic description can be provided, while keeping a discrete limited number of categories, which is important for data analysis.

The classification also enables an escalating thoroughness of the description, adjusting to the specific requirements of the study, by means of the

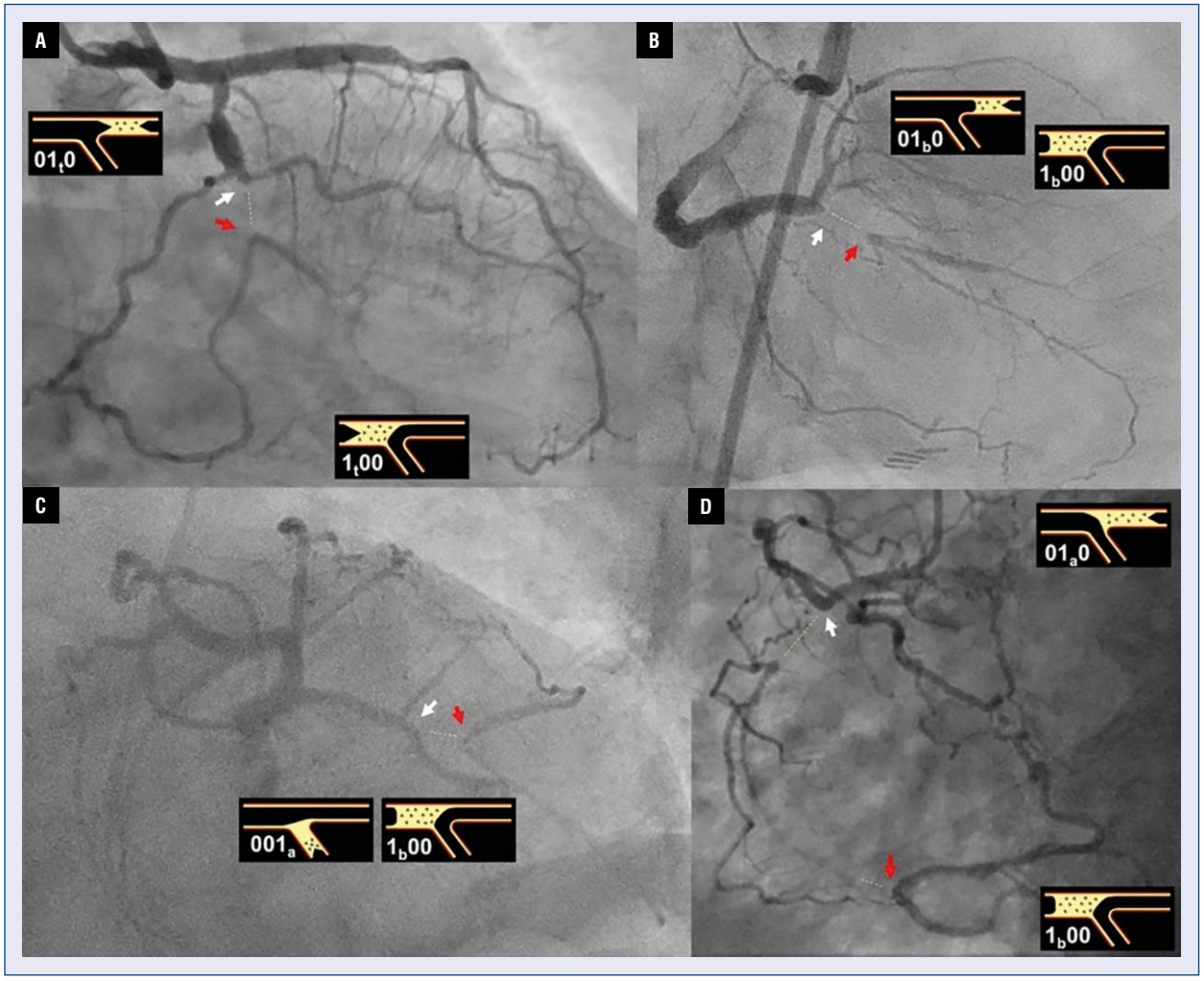

Figure 4. Examples of double chronic total occlusion (CTO) bifurcation lesions. The CTO (yellow dotted line) extends from a bifurcation at the proximal cap (white arrow) to another bifurcation at the distal cap (red arrow). In these cases, the lesion should be labelled as double CTO-coronary bifurcation lesion (CBL), describing the proximal CBL, followed by the distal CBL linked with a central dash: **A.** (01_t0–1_t00); **B.** (01_b0–1_b00). Notice that the digit corresponding to the occluded segment of the proximal bifuraction should be the same as the first digit of the distal bifurcation because the occluded segment of the former becomes the proximal main vessel of the latter (**A**, **B**). The only exception occurs in the presence of an ambiguous cap in the proximal bifurcation (**C**, **D**): in this case, the first digit of the second bifurcation will be labelled as 1_b because the categories 1_aXX do not exist: **C.** (001_a–1_b00); **D.** (01_a0–1_b00).

grouping elements, namely the X digit (i.e., meaning that the segment can indistinctively take the value 0 or 1) and the subscript x (i.e., meaning that the subscript can indistinctively take the values t, b, or a). These elements allow us to group different types of lesions according to different criteria in a highly versatile way. From a statistical point of view, these elements are easy to implement into a structured database and subsequently ease the analysis of large registries and studies. For instance, a study about a double-lumen catheter that is useful for multisegmentary CTO lesions with proximal blunt stump will specifically recruit $1_b1_x1_x$ lesions if the investigators consider that the retrograde cap in distal segments plays no role. However, if the investigators describe a hybrid ante-retrograde technique requiring tapered cap in all segments, then the study should recruit $1_t1_t1_t$ lesions. Likewise, a device considered useful for lesions with blunt proximal cap, irrespective of the involvement of other segments, should recruit 1_bXX, $1_b1_x1_x$, $X1_bX$, $X1_b1_x$, $XX1_b$, and $X1_x1_b$ lesions.

Limitations of the study

As compared with the classical Medina classification for bifurcation lesions [4], the number of categories in the Medina-CTO classification is substantially higher (8 vs. 56, respectively). Future prevalence studies might eventually help to improve and simplify this initial proposal. In that case, the versatility of Medina-CTO with its grouping elements will grant a gentle transition between future updates.

Calcification is also acknowledged as a relevant prognostic feature, exerting a powerful influence on the choice of the material and the specific interventional technique. The authors have extensively debated the convenience of adding calcium as an additional feature of this Medina-CTO, and finally decided not to incorporate it into this classification, in order to keep a reasonable number of categories. However, it can be used as an optional descriptor for clinical or interventional purposes which, combined with the anatomical Medina-CTO depiction, might help to estimate the likelihood of success or the prognosis.

Both Medina [4] and Medina-CTO classifications rely on the vague concept of atherosclerotic "involvement" of the different segments of the bifurcation. This approach entails a considerable component of subjectivity and hence variability in the assessment. Some studies have even highlighted the discrepancy between angiography and other intravascular imaging modalities in typifying bifurcations, thus proposing concepts like the "optical Medina" classification [11]. These drawbacks are common to other consolidated systems, which have however proven to be instrumental for scientific and didactic purposes in non-CTO bifurcations [5, 6].

Conclusions

The Medina-CTO classification, consisting of adding a subscript describing the basic characteristics of the cap to the totally occluded segment/s in the standard Medina triplet might be a useful methodological tool to standardize percutaneous intervention of bifurcational CTO lesions, with interesting scientific and educational applications.

Conflict of interest: None declared

References

1. Konstantinidis NV, Werner GS, Deftereos S, et al. Euro CTO Club. Temporal trends in chronic total occlusion interventions in Europe. Circ Cardiovasc Interv. 2018; 11(10): e006229, doi: 10.1161/CIRCINTERVENTIONS.117.006229, indexed in Pubmed: 30354635.
2. Galassi AR, Boukhris M, Tomasello SD, et al. Incidence, treatment, and in-hospital outcome of bifurcation lesions in patients undergoing percutaneous coronary interventions for chronic total occlusions. Coron Artery Dis. 2015; 26(2): 142–149, doi: 10.1097/MCA.0000000000000194, indexed in Pubmed: 25405930.
3. Gutiérrez-Chico JL, Cortés C, Ayoub M, et al. Subintimal shift as mechanism for side-branch occlusion in percutaneous treatment of chronic total occlusions with bifurcation lesions. Cardiol J. 2023; 30(1): 24–35, doi: 10.5603/CJ.a2021.0079, indexed in Pubmed: 34231874.
4. Medina A, Lezo JS, Pan M. A new classification of coronary bifurcation lesions. Rev Esp Cardiol. 2006; 59(2): 183, doi: 10.1016/s1885-5857(06)60130-8.
5. Louvard Y, Thomas M, Dzavik V, et al. Classification of coronary artery bifurcation lesions and treatments: time for a consensus! Catheter Cardiovasc Interv. 2008; 71(2): 175–183, doi: 10.1002/ccd.21314, indexed in Pubmed: 17985377.
6. Lassen JF, Holm NR, Banning A, et al. Percutaneous coronary intervention for coronary bifurcation disease: 11th consensus document from the European Bifurcation Club. EuroIntervention. 2016; 12(1): 38–46, doi: 10.4244/EIJV12I1A7, indexed in Pubmed: 27173860.
7. Lunardi M, Louvard Y, Lefèvre T, et al. Definitions and standardized endpoints for treatment of coronary bifurcations. EuroIntervention. 2022; EIJ-E-22-00018, doi: 10.4244/EIJ-E-22-00018, indexed in Pubmed: 35583108.
8. Ybarra LF, Rinfret S, Brilakis ES, et al. Definitions and clinical trial design principles for coronary artery chronic total occlusion therapies: CTO-ARC consensus recommendations. Circulation. 2021; 143(5): 479–500, doi: 10.1161/CIRCULATIONAHA.120.046754, indexed in Pubmed: 33523728.
9. Chen Sl, Ye F, Zhang Jj, et al. Clinical outcomes after recanalization of a chronic total occluded vessel with bifurcation lesions: results from single-center, prospective, chronic total occlusion registry study. Chin Med J (Engl). 2012; 125(6): 1035–1040, indexed in Pubmed: 22613527.
10. Baystrukov VI, Kretov EI, Boukhris M, et al. A randomized trial of bifurcation stenting technique in chronic total occlusions percutaneous coronary intervention. Coron Artery Dis. 2018; 29(1): 30–38, doi: 10.1097/MCA.0000000000000551, indexed in Pubmed: 29220345.
11. Jaguszewski MJ, Cortés C, Gutiérrez-Chico JL. Implantation of magnesium-bioresorbable scaffolds in a bifurcation under optical coherence tomography guidance. Eur Heart J. 2017; 38(25): 2017–2018, doi: 10.1093/eurheartj/ehw539, indexed in Pubmed: 27941012.