INVESTIGATION OF THE SIDE BRANCH ACCESS WITH SIMPLE VESSEL MODEL DURING BIFURCATION STENTING

D. Károly [1] , E. Bognár [2] P. J. Szabó [3]

Summary: *Endovascular stents such as coronary stents can be used for the treatment of atherosclerosis. If the narrowing involves a main vessel and a side branch as well, physicians have to use bifurcation stenting technique. Bifurcation lesions constitute nearly 15 % of all percutaneous coronary interventions (PCI), so the investigation of bifurcation stenting methods is very important. This article introduces a simple method to measure side branch access and related functional stent properties in the case of stent-balloon technique. With this method we can tell if bifurcation stenting is possible or not, and if so the size of the available access.*

Keywords: *coronary stent, bifurcation stenting, vessel model, side branch access*

1 Introduction

In the European Union most of the deaths are due to cardiovascular diseases. During the disease a plaque formation evolves in the inner wall of the blood vessel. The formed stenosis blocks the free flow of blood, which can cause long-term myocardial infarction. Endovascular stents such as coronary stents can be used for the treatment of these diseases. The stent is a biocompatible tubular mesh, which is inserted into the narrowed vessel segment to compress the plaque and support the vessel.

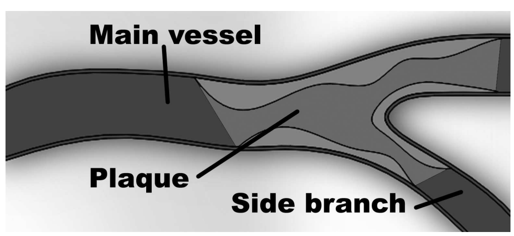

Figure 1: Bifurcation lesion with narrowing in the main vessel and the side branch as well

Coronary bifurcation lesions represent an area of ongoing challenge in interventional cardiology. A bifurcation is a division of a main vessel into two branches (Fig. 1). The accepted definition of a coronary bifurcation lesion is a coronary artery narrowing occurring adjacent to, and/or involving the origin of a significant side branch. This lesions constitute 12-15 % of all percutaneous coronary interventions (PCI). Bifurcation

[1]Dóra Károly, Budapest University of Technology and Economics, Faculty of Mechanical Engineering, Department of Materials Science and Engineering, Bertalan Lajos u. 7, 1111, Budapest, Hungary, email: kdora@eik.bme.hu

[2]Dr. Eszter Bognár, Budapest University of Technology and Economics, Faculty of Mechanical Engineering, Department of Materials Science and Engineering, Bertalan Lajos u. 7, 1111, Budapest, Hungary. MTABME Research Group for Composite Science and Technology, Megyetem rkp. 3, 1111, Budapest, Hungary, email: eszter@eik.bme.hu

[3]Dr. Péter János Szabó, Budapest University of Technology and Economics, Faculty of Mechanical Engineering, Department of Materials Science and Engineering, Bertalan Lajos u. 7, 1111, Budapest, Hungary, email: szpj@eik.bme.hu

stenting associated with increased risk of procedure-related complications, higher resource utilization, longer hospital treatment, and higher rates of restenosis, so investigating it is very important [1, 2].

Several types of dedicated stents have been designed: stents with large struts, bevelled stents for optimal ostium coverage in the side branch, bifurcated stents, and also several stent delivery systems providing permanent access to the side branch. These stents will not be used in routine practice unless they can prove as efficient as the already validated tubular stents in terms of angiographic success rate (e.g. in positioning, procedure duration, x ray exposure). The concept of these stents can be a problem in itself given the inherent multiplicity of stent diameters and lengths [3].

There are many coronary artery bifurcation lesion classifications published in the literature, but we used a simple division which distinguishes the bifurcation stenting based on the methods (and do not list separately the methods, which have a different order in stent insertion, but the final result is the same). In this division bifurcation stenting can be divided into 6 groups: one-stent technique (OST), stent-balloon technique (SBT), kissing technique (KT), T stent technique (TST), crush stent technique (CRT), and culotte stent technique (CUT) [4]. In this work we deal with the stent-balloon technique. During this method the physician implants a stent so that the side branch ostium is approximately in the middle of the stent. After that a balloon catheter is placed and dilated into the branch vessel through one of the cells of the stent in the main vessel.

The functional properties of stents are major technical parameters in the aspect of the deployment, the dilation and the long-term efficacy of the stent. These properties model the in vivo environment. Side branch access is a functional property which gives information for bifurcation stenting. After measuring and comparing the numerical value of this, physicians can choose the appropriate stent for patients more easily with these results.

2 Materials and methods

Seven stents were investigated. The stents have the same diameter but different stent pattern, length and material. Table 1 contains basic information of the investigated stents. The stents were dilated with nominal pressure and the inner cell for the side branch access was also dilated with nominal pressure. The investigations were performed by stereo microscope and scanning electron microscope. The areas were determined with evaluating the digital images by image analysis software.

Table 1: The investigated stents

Stent	Diameter (mm)	Length (mm)	Material	Nominal pressure (bar)
(A)	3	30	CoCr	9
(B)	3	24	PtCr	11
(C)	3	24	CoCr	8
(D)	3	20	CoCr	9
(E)	3	20	PtCr	11
(F)	3	19	CoCr	8
(G)	3	16	CoCr	9

The examination method of side branch access, developed by us, is a destructive test, because the stents undergo permanent deformation, so further examinations are limited. Dilations were made in a silicone vessel model. The model is a simple tube with a vent on it. The steps of the side branch measurement are shown in Figure 2. First every stent was dilated with its own balloon (in the original way). The second step was getting through the balloon catheter (with the same diameter as the stent) one of the stent cells and the vent on the vessel model. Then the balloon was dilated, and removed. After that the stent was removed from the vessel model. The whole process was monitored by stereo microscope.

After the dilation the stents were investigated with scanning electron microscope. The stents were tipped to a suitable position so the surface stretched by the bordering struts of the cell lies on the horizontal plane.

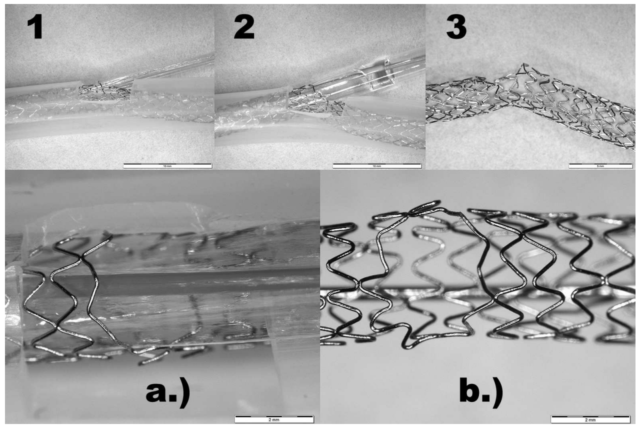

Figure 2: The steps (1-2-3) of the investigation method are shown by (A) stent. The stent placed into the silicone modell, the balloon was led through one of the stents cells and was dilated. a.) (A) stent in the silicone modell after dilation b.) (A) stent removed from the modell

Figure 3. a.) shows that the dilated cell has not yet reached the maximum circumference. Figure 3. b.) shows the maximum achievable diameter circle within the cell. It is important when the physician first dilates the cell with a balloon catheter and after that a stent has to placed in the side branch, so a stent system has to go through the dilated cell without damage.

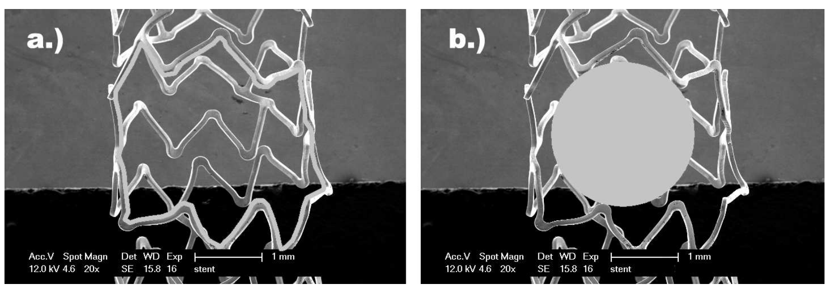

Figure 3: a.) Dilated cell in (B) stent, b.) maximum achievable diameter circle in (B) stents cell

3 Results

With this method we can tell if bifurcation stenting is possible or not, and if so the size of the available access. Table 2 contains the measurement results. Side branch access depends on the stent pattern very much. For example if one of (F) stent's cells is dilated, it can never reach as high cell diameter or area as one of (A) stent cells. In Figure 4 we can see that in every case the cells can be dilated further. None of the stent struts were broken. So all of these stent are suitable for bifurcation stenting.

4 Conclusions

The results show that this method is appropriate for the modelling of bifurcation stenting with one-stent technique. The great advantage of this method that it can be easily reproduced and does not need complicated equipment. So the measurements can be easily performed in the remote parts of the world and the results can be compared. The disadvantage is that the other bifurcation techniques (e.g. kissing technique) can not be examined with it. Another problem is that this method do not model the angle of the side branch (the angle between the main vessel and the side branch). Because of this further investigations are well-founded, but the collected experience and results of this study provide a basis for further research. The section of medical

Table 2: The results of the side branch access measurement

Stent	Circumference of cell (mm)	Area of cell (mm^2)	Diameter of circle (mm)	Area of circle (mm^2)
(A)	13.18	7.29	2.34	4.30
(B)	12.71	6.39	2.10	3.46
(C)	10.30	5.44	2.14	3.59
(D)	12.19	6.91	2.16	3.66
(E)	13.45	7.35	2.13	3.56
(F)	10.37	4.93	1.75	2.40
(G)	14.78	6.82	2.52	4.99

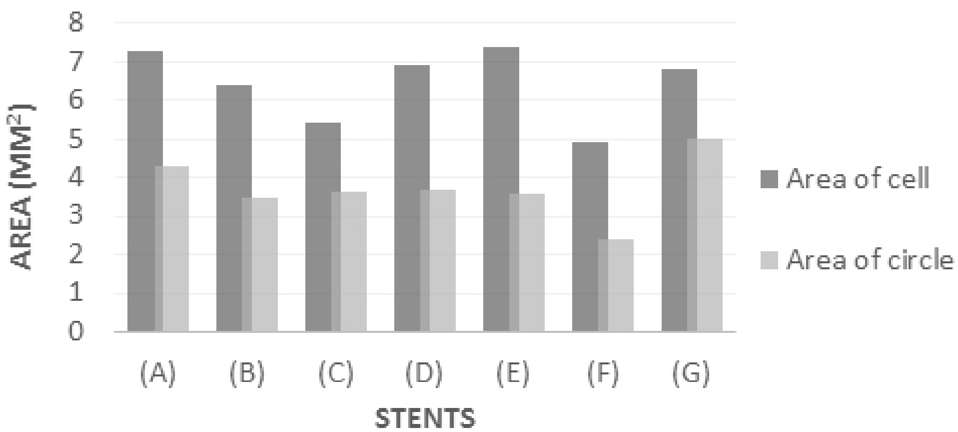

Figure 4: Diagram of side branch access areas

area, connected with stents, develop very fast. New geometries, materials and methods appear, so there is plenty to investigate in this field.

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