Case report

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OPTIMIZATION OF PERCUTANEOUS CORONARY INTERVENTION WITH OPTICAL COHERENCE TOMOGRAPHY

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Optical coherence tomography (OCT) is a method which provides precise insight into the morphology of the coronary arteries. The application of OCT can evaluate atherosclerotic plaques, stoutness of fibrous cap, and also gives precise illustration of the stent position in the coronary artery.

A 72 year old woman was received with acute myocardial infarction with ST segment elevation in anterolateral leads and immediately was sent to catheterization lab for PCI. During the procedure, we found occluded left circumflex artery and after predilatation two stents were implanted. Flow rate of stents was very slow and signs of stent thrombosis were registered. The flow rate was not restored after post-dilatation and thrombus aspiration. Due to rapid worsening of condition of the patient, the surgery was ceased, and we continued therapy with GP inhibitors, anticoagulant and antithrombotic therapy. After 7 days, coronary angiography was repeated and OCT system was used. We found substantial apposition of stents with some struts at up to 0.5 mm distance from the coronary artery wall. Post-dilatation was done with the larger balloon sized according to the arterial diameter, and subsequently the thrombosis disappeared and struts were close to the coronary artery wall. The patient was discharged from hospital with dual antiplatelet therapy in a good condition.

OCT is a new diagnostic method which provides exceptionally easy and precise identification of unexpanded stents in coronary arteries, which present main mechanical cause for stent thrombosis after PCI.

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Key words: *optical coherence tomography, percutaneous coronary intervention, stent apposition, coronary thrombosis*

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Introduction

First ever percutaneous coronary intervention (PCI) was performed by Andreas Ghruncig in 1977 and since than a new era of nonsurgical therapy for coronary artery disease started. Development of materials technology and techniques for PCIs led to safe coronary diagnostics and therapy even in centers without support of cardiosurgery which resulted in expansion and opening of huge number of cath labs through the world. As coronary angiography became the gold standard for visualization of coronary arteries, new additional diagnostic procedures were developed in order to make better assessment of severity and importance of lesions: flow measurement through the coronary artery (flow fractional reserve - FFR), intravascular ultrasound (IVUS) and few years ago, development of optical coherence tomography. Both IVUS and OCT provide visual assessment of inner side of coronary arteries which overcomes limitations of coronary angiography. These limitations often understate or overstate coronary artery stenosis.

Optical coherence tomography is a diagnostic method in interventional cardiology which provides almost histological resolution in observation and analysis of coronary arteries by the use of light (near infrared spectrum). In this way, even a small details in coronary pathology as atherosclerotic plaque specificity, analysis of stent position and periprocedural blood vessel injuries can be seen. OCT is much more sensitive than intravascular ultrasound, which was inviolable method for analysis of changes in coronary arteries until now (1, 2).

OCT measures intensity of reflected light waves and converts these optical echoes to high resolution two dimensional images, analogue to ultrasound. As the speed of light is much faster than the speed of sound, latency of reflected light wave cannot be direct so interference is used. That means that light signal is divided into two parts: referent

signal, which has a known instance, and causal signal, which comes from the tissue. The reflected signal from the tissue is compared to the light signal that comes through known distance.

High resolution image of blood vessel is made based on comparison of these two signals (signal interference). The use of light instead the use of ultrasounds has consequences. Image resolution is ten times higher compared to IVUS, but because of that there is less and limited penetration into tissue. It is necessary that the blood vessel is free of blood for a short period of time and filled with contrast because the erythrocytes could cause multiple scattering and deformation of the light signal.

OCT can be used in multiple indications (3, 4, 5):

- to check and determine characteristics of atherosclerotic plaque with the possibility to identify a high risk of plaque rupture;
- evaluation of vulnerable plaque;
- thrombus detection;
- evaluation of stent after PCI;
- assessment of acute effects in coronary artery stenting;
- follow up in covering and endothelialization of struts;
- stent apposition identification;
- follow up and assessment of restenosis;
- periprocedural lesion assessment.

If the distance from endoluminal surface of stent is bigger than the sum of strut and polymer thickness, that is called malapposition or stent struts apposition. Existence of stent apposition is significant because those struts are a site of early and late stent thrombosis and their coverage is poor and happens later or it can even fail. Stent apposition is possible when the artery size is underestimated or when the implanted stent is smaller than the diameter of the blood vessel. In acute coronary syndrome, especially in ST segment myocardial infarction (STEMI) there is often the presence of a thrombus that is adherent to the vessel wall. This can give wrong impression of the size of the coronary vessel. No matter the reason for stent apposition, if apposition is not corrected, stent thrombosis is almost certain when anticoagulation therapy is stopped despite double antiaggregation therapy. Angiography cannot detect stent apposition, so IVUS and OCT are the only known certain methods by which stent apposition can be identified for now.

There is a description of the first OCT in Serbia in further text.

Case presentation

A female patient, 72 years old was admitted to the Cardiology Clinic as an emergency with acute inferolateral myocardial infarction with ST elevation. She had only arterial hypertension as a risk factor (well regulated, for 5 years). As pain occurred for more than 3 hours from the symptom onset, and patient was admitted to the primary PCI (pPCI) capable center, decision to perform coronary angiography was made in order to determine further therapy. She was treated by STEMI protocol directed to pPCI (ASA 300 mg, clopidogrel 300 mg, unfractionated heparin 5000 IU). At the moment of coronary angiography, her blood pressure was 95/65 mm Hg and heart rate 40/min so temporary pace maker was first placed.

Left coronary artery angiography revealed occluded proximal part of the circumflex artery (TIMI flow 0) and left anterior descending artery had no changes (Figure 1).

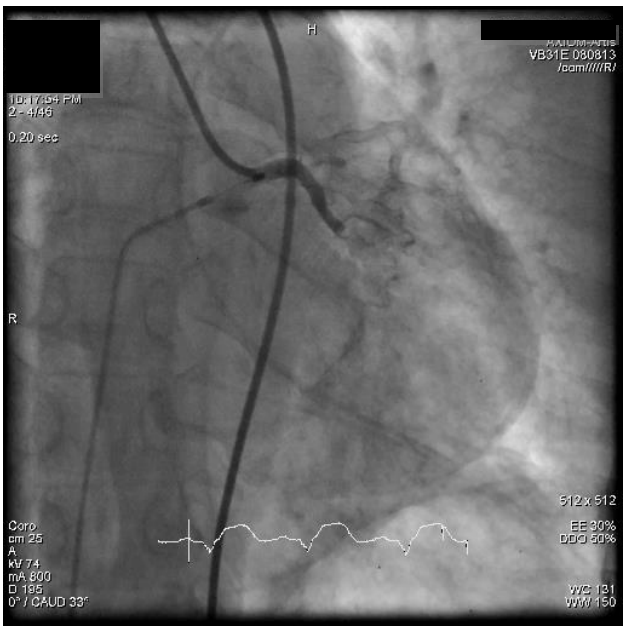

Figure 1. The occluded circumflex artery at the beginning of the procedure (TIMI 0 flow)

PCI was immediately started and angiography of right coronary artery was not done due to worsening of the patient's condition. Coronary wire was easily passed through thrombus (Runthough Hypercoat, Terumo, Japan) and predilatation by using balloon Powerline 2.0x15 mm (Biosensors, Singapore) was done. The artery was opened and the distal part of the artery was visualized (TIMI 2 flow). The surgeon decided to implant stents in the artery: Tsunami Gold 2.5x18 mm (Terumo, Japan) distally, insufflated at 16 atmospheres. The proximal part of this stent was overlapped with ML Vision 2.75x23 mm stent (Abbott, USA) insufflated at 16 atmospheres.

Despite implanted stents, the flow through the circumflex artery was not good and stent thrombosis developed (TIMI 1 flow). Post-dilatation with balloon Sprinter NC 2.5x15 mm was done (Medtronic, USA) in all segments of both stents, but the flow was not improved (Figure 2). Unsuccessful thromboaspiration was performed by the use of Diver (Invatec; USA) aspiration catheter. PCI was stopped due to rapid worsening of the patient's arterial blood pressure (50/35 mmHg), signs of hypoperfusion and threatening cardiogenic shock. Intraaortic balloon pump was placed as a hemodynamic support, tirofiban was started and she was transferred to ICU.

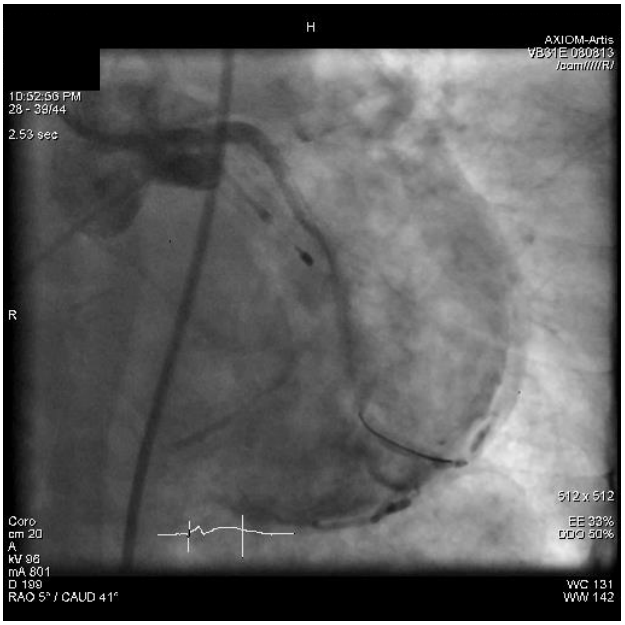

Figure 2. The circumflex artery after PCI (TIMI 1 flow)

In the next 24 hours patient became stable and blood pressure and heart rate were within reference range. Temporary pacemaker and intraaortic balloon pump were turned off. When tirofiban therapy ended, low molecular weight heparin was started (enoxaparin, 50 mg every 12 hours subcutaneously) with double antiaggregation therapy, statin and symptomatic treatment. She was treated for five days and then she was sent again to the cath lab for right coronary artery angiography and to estimate stent position with the use of optical coherence tomography (OCT). Multiplate test revealed good inhibition of thrombocyte aggregation and effectiveness of anticoagulant therapy.

The right coronary artery had no morphologic changes. Angiography of the left coronary artery revealed patent circumflex artery (TIMI3 flow) but with opacifications within the artery at the level of implanted stents which rose suspicion of thrombus not big enough to compromise flow through the artery. We decided to use OCT (LightLab Imaging, USA) in order to evaluate the presence of stent apposition and eventual need for another PCI.

Coronary wire Balance MiddleWeight (Abbott Vascular, USA) was introduced in the artery but the placement of OCT catheter over it was unsuccessful. We concluded that the wire passed beneath the struts so the tip of the wire was reshaped and then the wire was successfully placed in the artery. First OCT capture was done at the length of 56 mm which covered part of the circumflex artery distally to the placed stent all the way to its ostium.

Struts of both stents were seen very well and stent apposition was seen immediately from 6th millimeter of the distal stent all the way to the ostium of the artery, meaning that struts do not lay over the artery wall but there is a space for at least double of strut thickness.

At some places, distance of stent struts from the artery wall was greater than half a millimeter.

The most apposed struts had huge thrombotic masses around them and in a stented part of the artery thrombotic masses were also present, displaced by guidewire (Figures 3 and 4).

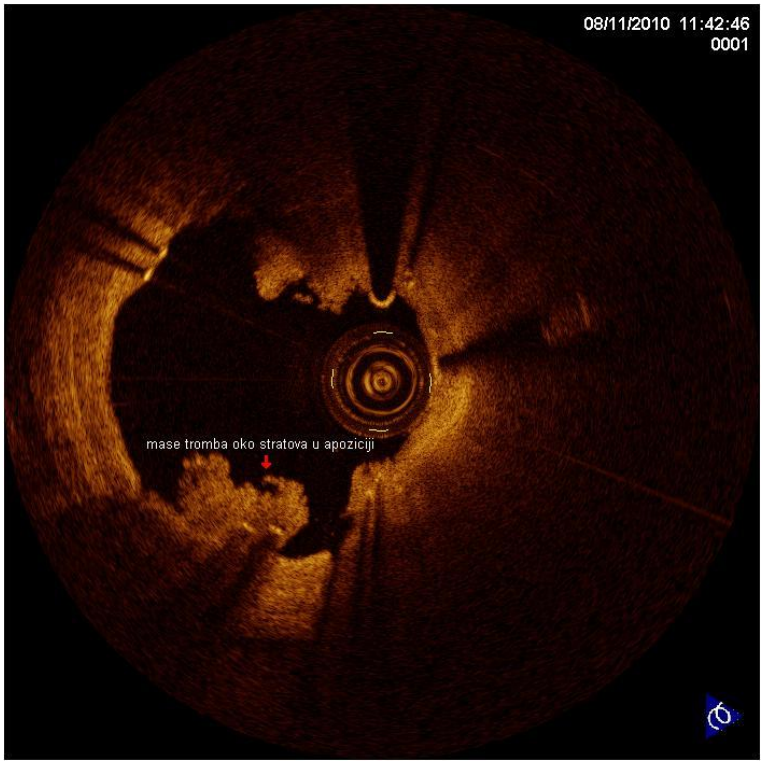

Figure 3. OCT image shows thrombotic masses around the struts in apposition

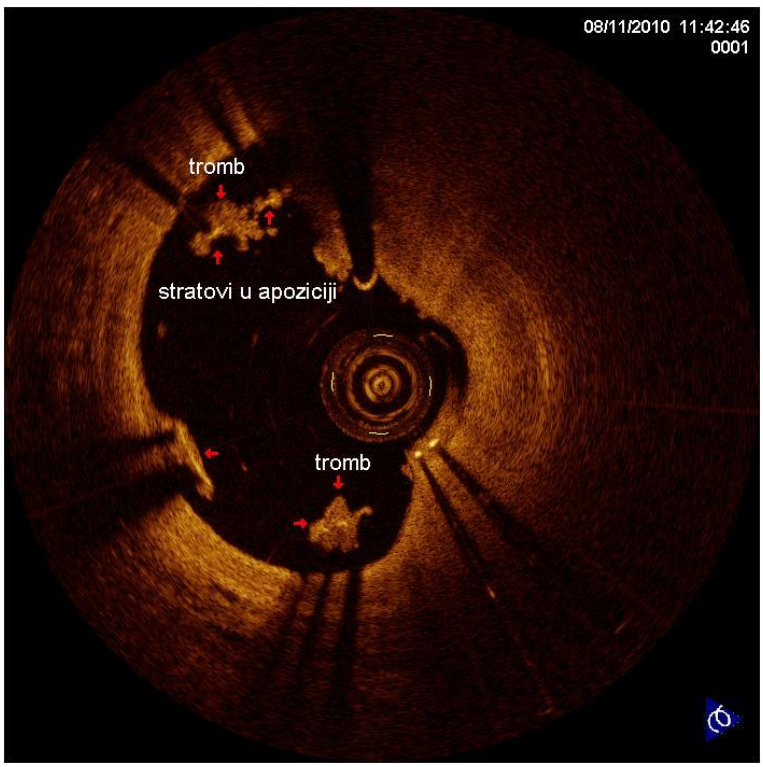

Figure 4. OCT image with few struts in apposition

We decided to postdilate implanted stents. Noncompliant balloon Sprinter NC 3.5x15 mm (Medtronic, USA) was placed over the coronary wire and insufflated at 14 atmospheres through the length of both stents. No thrombotic masses after post-dilatation could be seen on angiography and TIMI 3 flow was present (Figure 5). The artery was examined by OCT once again. All the struts were adherent to endothelium with very little thrombosis over the arterial wall which did not affect the blood flow. There were no more struts that were in apposition (Figure 6). After this, PCI was done without another stent implantation. Enoxaparin was continued for another 24 hours and the patient was discharged two day after in good general condition and symptoms free. Six month after the procedure, the patient is symptoms free.

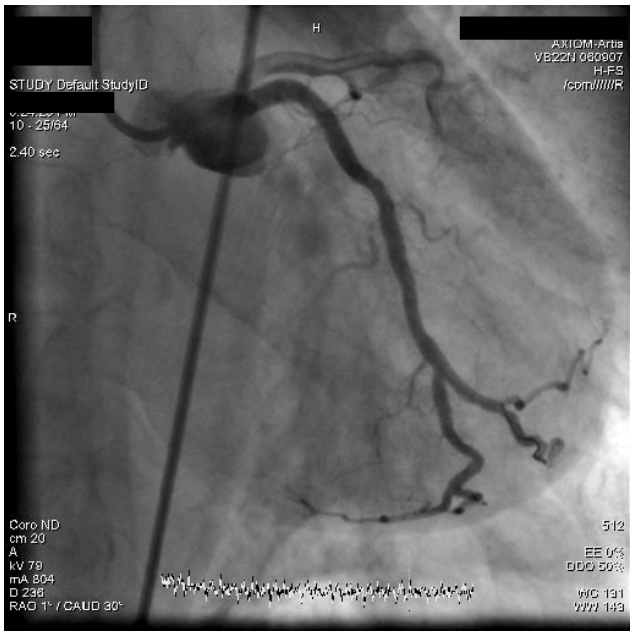

Figure 5. The circumflex artery after optimization of PCI and using of OCT (TIMI 3 flow)

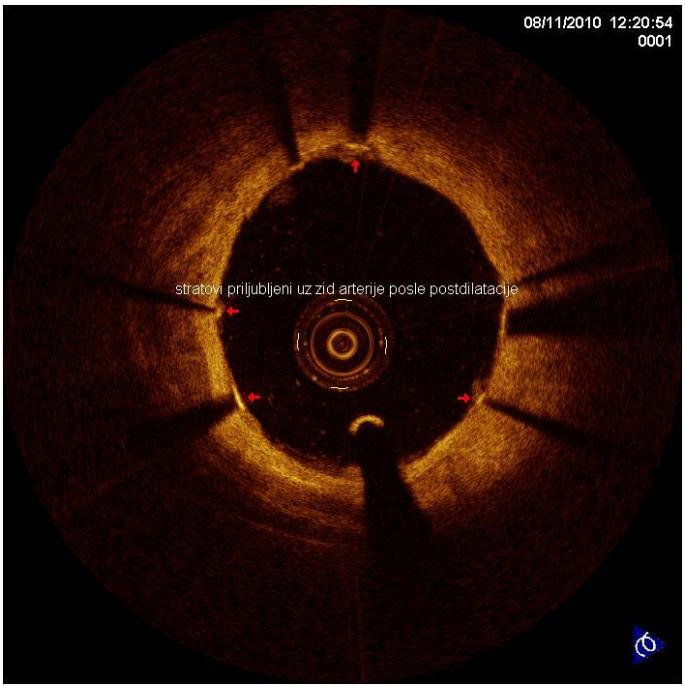

Figure 6. OCT image at the end of the procedure: struts adhering to the wall of the coronary artery after post-dilatation

Discussion and conclusion

In the last couple of interventional cardiology congresses, optical coherence tomography has become optimal or at least suboptimal diagnostic method for assessment of coronary morphology. OCT enables enormous possibilities for inspection of inner structures and around coronary arteries up to 10 microns. Compared to IVUS which was a golden standard until now, OCT has many advantages but it also has limitations. The use of OCT system provides us to see fine morphological details in arteries, it is much faster and has more flexibility. On the other hand IVUS is better for inspection of bigger arteries and the presence of blood in the blood vessels does not affect examination. Table 1 shows comparison of physical characteristics of OCT and IVUS (6).

Table 1. View of the parallel characteristics of OCT and IVUS

	OCT	**IVUS**
Frames per second	100	30
Pullback speed	20 mm/sec	0.5 or 1 mm/sec
Lines per frame	500	100
Axial resolution	12 um	225 um
Scan diameter	7-10 mm	12-15 mm

Stent thrombosis is present as long as there is PCI and it has always been Damocles' Sword above the head of the patient as well as the interventional cardiologist. Stent thrombosis refers to the presence of thrombotic formation in already implanted stent in the coronary artery. Drug coated stents, PCI in acute myocardial infarction and bifurcation lesions are thought to be risk factors for stent thrombosis and as for main mechanical predictor stands stent malapposition or overestimating of the coronary artery and the use of smaller stent (7, 8). Until now, IVUS was used as the gold standard for estimating stent apposition and newer imaging methods have been described in order to make identification of stent apposition easier (9). For the last couple of years, OCT has been described in the literature as a very successful method in detection of stent apposition mainly because of its possibility of detail visualization to size up to the one hundredth part of a millimeter. Compared to other OCT systems in which a complete closure of the artery was needed, the new LightLab C7 XR Imaging system requires only the presence of contrast in the blood vessels during one time application. The simplicity in use of OCT system and high quality of acquired information enables easy and simple identification of even small details as it is the distance of free struts of the stent from the coronary artery wall. All authors agree that this is the main mechanical reason for stent thrombosis. Once identified, stent malaposition can be easily solved by using post-dilatation with noncompliant balloons of adequate size and OCT(or IVUS) can determine the size of the balloon, that is, in which size the stent should be expanded (10). After the procedure is completed like this one, anticoagulation therapy can be stopped and double antiaggregation therapy can be continued. The number of all the complications (death, lesion revascularization or vessel revascularization, stent thrombosis) was significantly smaller in all major studies in which PCI optimization was guided and performed by IVUS compared to those in which IVUS was not used. There are not many major studies where OCT was performed, but individual studies reveal that OCT guided PCI enables significantly greater survival of patients and less complications after PCI (11, 12, 13).

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OPTIMIZACIJA PERKUTANE KORONARNE INTERVENCIJE UZ POMOĆ OPTIČKE KOHERENTNE TOMOGRAFIJE

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Optička koherentna tomografija (OCT) je metoda koja omogućava precizno sagledavanje koronarne morfologije. Upotrebom OCT može se procenjivati aterosklerotski plak, proceniti debljina fibrozne kape, a može se dobiti i precizna slika pozicije stenta u koronarnoj arteriji.

Žena stara 72 godine primljena je sa slikom akutnog infarkta sa elevacijom ST segmenta lateralne lokalizacije i odmah je upućena na primarnu perkutanu koronarnu intervenciju (PCI). Tokom procedure, pronađena je okludirana cirkumfleksna arterija, koja se otvara predilatacijom, nakon čega se postavljaju 2 stenta. Protok kroz stentove veoma je slab i registruju se znaci tromboze unutar stentova. Protok se ne popravlja ni posle postdilatacije i aspiracije tromba. Zbog naglog pogoršanja stanja bolesnika, prekida se procedura, a nastavlja se terapija tirofibanom, uz antikoagulantnu, antiagregacionu i drugu simptomatsku terapiju. Posle 7 dana, ponavlja se angiografija i upotrebljava se OCT sistem. Nađena je značajna apozicija stenta, gde su pojedini stratovi stenta i do 0,54 mm odmaknuti od zidova koronarne arterije. Urađena je postdilatacija većim balonom prema izmerenom dijametru arterije, nakon čega tromboza nestaje, a stratovi se pri ponovljenom OCT snimku nalaze uz zid koronarne arterije. Bolesnik se otpušta sa dvojnom antiagregacionom terapijom nakon par dana u dobrom opštem stanju.

OCT je relativno nova dijagnostička metoda, koja omogućava izuzetno lako i precizno identifikovanje nedovoljno ekspandiranih stentova u koronarnoj arteriji, što predstavlja glavni mehanički razlog tromboze posle PCI.

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Ključne reči: *optička koherentna tomografija, perkutana koronarna intervencija, apozicija stenta, koronarna tromboza*