Observation of the Suspected Sharp Structure Caused a Pinhole Balloon Rupture Using Optical Coherence Tomography and Coronary Angioscopy

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Both optical coherence tomography (OCT) and coronary angioscopy (CAS) are excellent modalities to observe intracoronary structures. Although most coronary artery structures are identifiable by both modalities, some difficulty to assess structures may be present. We report a case of a 76-year-old male who presented with effort angina. Coronary angiography revealed a severe stenotic lesion in the distal right coronary artery (RCA), and hence, percutaneous coronary intervention (PCI) to the lesion was performed. We additionally performed post-dilatation with a noncompliant balloon after stenting, resulting in the balloon rupturing at only 4 atm. When observing the balloon, a pinhole rupture was confirmed. OCT revealed a high signal intensity sharp structure protruding into the lumen, considered to be the cause of the balloon rupture. CAS revealed that the protruding structure was a white–white yellow color. The stent could be expanded using a new noncompliant balloon without any balloon rupture. Postprocedural OCT and CAS showed that the protruding sharp structure disappeared and a part of the structure was pressed onto the lumen. Combining the OCT and CAS findings, we considered the structure might be a micro-calcified nodule or a cholesterol crystal. We hereby report and assess the sharp structure based on the OCT and CAS findings.

Key words: balloon rupture, micro-calcified nodule, cholesterol crystal, optical coherence tomography, coronary angioscopy

Introduction

Optical coherence tomography (OCT) is a high-resolution imaging modality that offers a detailed observation of intracoronary structures. OCT can also characterize intravascular changes and abnormal structures associated with the stent implantation, such as thrombi, dissections, and even some protruding tissues.¹ Recent studies have shown that OCT is useful for the morphological assessment of the coronary plaque comparisons with the pathological tissue.² The morphological evaluation of the OCT image has gained consensus for most intravascular structures, but some structures, like cholesterol crystals and microphages, are currently under discussion.³ Coronary angioscopy (CAS) permits the direct visualization of intracoronary structures and allows evaluating them from a combination of three colors such as red, white, and yellow. We described a rare case of balloon rupture due to a sharp structure protruding into the lumen after the stent placement. The sharp structure was hard to identify even with observation using OCT and CAS. We hereby report the assessment of the unique structure based on the OCT and CAS findings.

Case Presentation

A 76-year-old male with hypertension, dyslipidemia, and diabetes mellitus was admitted to our hospital because of exercise-induced chest pain. The patient was treated with a drug-eluting stent (DES) in the proximal left anterior descending coronary artery 5 years prior and continued with dual antiplatelet therapy (aspirin 100 mg and clopidogrel 75 mg). The electrocardiogram (ECG) exhibited slight ST-segment depression in leads V5 and V6. The echocardiogram demonstrated an ejection fraction of 65% and normal wall motion. Coronary angiography revealed stenosis lesions in the middle and distal portions of the RCA (Fig. 1A). We
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performed PCI of the lesion in the middle potion and implanted a 3.5 × 23 mm DES (Xience Alpine™, Abbott Vascular, Santa Clara, CA, USA). Subsequently, we performed PCI of the distal lesion. The preprocedural OCT (C7 Dragonfly™, Abbott Vascular) of the lesion revealed lipid plaques and layered fibrous plaques on the lumen, high signal regions on the boundary of the lipid and fibrous plaques, intimal vasculatures, and a linear structure with a high signal intensity and sharp border (Fig. 2A). After the OCT examination, the lesion was dilated with a 442.5 × 15 mm Scoring balloon (Scoreflex®, OrbusNeich medical, Hong Kong) at the nominal pressure, and a 3.0 × 16 mm DES (Synergy™, Boston scientific Co., Marlborough, MA, USA) was deployed at the nominal pressure. We performed the post-stent dilatation with a 3.5 × 15 mm noncompliant balloon (NC TREK®, Abbott Vascular), but the balloon ruptured at only 4 atm (Fig. 1B). When observing the balloon, a pinhole rupture was confirmed. We assessed OCT images of the implanted stent to investigate the cause of the pinhole balloon rupture. OCT revealed stent malapposition and a sharp high signal intensity structure protruding into the lumen (Fig. 2B). It was considered that the protruding structure was identical to a linear high signal intensity structure in the plaque observed in the preprocedural OCT and it might have raised up into the stent lumen. Furthermore, in the OCT three-dimensional mode, the structure was not considered to be the stent strut because the continuity of the structure observed different from stent struts (Fig. 2D). We also observed the protruding structure by CAS (Smart-i™ type S11, SURGE Tec Co., Tokyo, Japan). The structure was confirmed to be a white–white yellow-shaped structure between the stent struts (Figs. 3A and 3B and Movie 1; The movie is available online). To observe the position of interest where the structure was located, we intentionally bent the guidewire and controlled the direction of the head of the angioscopy catheter (Fig. 3C). To prevent the balloon rupture, a post-dilation

Fig. 1 Coronary angiography. Coronary angiography revealed stenotic lesions in the middle and distal portions of the RCA (A arrows). In the post-dilatation with a 3.5 mm noncompliant balloon, the balloon ruptured at only 4 atm (B). We performed post-dilatation with a slow and careful balloon inflation using a new 3.0 × 10 mm noncompliant balloon (C). The final coronary angiography showed a good coronary blood flow (D). RCA: right coronary artery.
Fig. 2  OCT findings. Three OCT images were obtained from similar positions in the lumen. In the baseline OCT image, a liner structure with a high signal intensity and sharp border was detected in the plaque (A arrow). In the OCT image after the balloon rupture, a sharp structure with a high signal intensity protruding into the lumen was observed (B arrow). The OCT image after the post-dilatation showed the protruding sharp structure had disappeared and that a part of the structure had become pressed onto the lumen (C arrows). Three-dimensional mode of the OCT indicated that the sharp structure was not a stent strut (D arrow). OCT: optical coherence tomography.

Fig. 3 and Movie  CAS findings. The protruding structure was confirmed to be a white–white yellow structure between the stent struts (A and B arrows). We intentionally bent the guidewire and controlled the direction of the head of the angioscopy catheter to observe the structure (C arrow). Movie 1: Coronary angioscopy. Focus on the shape (The movie is available online). CAS: coronary angioscopy.
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procedure was performed using a new noncompliant 3.5 × 10 mm balloon (SAPPHIRE II NC®, OrbusNeich Medical, Hong Kong), slowly and carefully inflating the balloon and slowly pulling the balloon to push down the structure. The stent could be expanded and we succeeded in performing the post-dilatation of the implanted stent without a balloon rupture (Fig. 1C). Postprocedural OCT showed that the protruding sharp structure had disappeared and a part of the structure had become pressed onto the lumen wall (Fig. 2C).

In the CAS findings, the sharp structure had disappeared. The patient did not have chest pain associated with procedures, but ECG showed ST-segment depression in leads V5 and V6. The final coronary angiography revealed a good coronary blood flow without slow-flow phenomenon. (Fig. 1D).

ECG change improved the next morning and there was no leakage of myocardial enzymes.

Discussion

We report a case of balloon rupture caused by a sharp structure protruding into the stent lumen. Balloon ruptures are one of the infrequent complications occurring during PCI procedures. It has been reported that balloon ruptures are caused by the over inflation of balloon, dilation for the severe calcification lesion, and treatment of in-stent restenosis. Balloon ruptures sometimes lead to more severe complications such as coronary perforation, dissection, and balloon entrapment.4–6) Balloon ruptures may also be caused due to higher balloon pressures during post-dilatation within the stent, but they rarely occur with normal pressures because of sharp calcium spicules protruding into the lumen.6) In our case, the pinhole balloon rupture occurred with a low balloon pressure during a simple post-stent dilation procedure. Protruding stent struts, asymmetric expansion of stent struts, large calcified lesions occupying the inside of the lumen or severe calcified plaques under stent struts could not be confirmed in the OCT examinations. Instead, a sharp small structure protruding into the lumen was observed. We considered that the sharp structure was involved in the balloon rupture and that the structure was sufficiently hard and sharp enough to puncture a hole in the balloon. From the temporal changes of OCT images, the sharp structure was observed to have separated from the plaque and raised up into the lumen during the stent implantation.

Assessment of the structure from the OCT images, the sharp structure with a high intensity signal causing the balloon rupture was identified as a linear structure with a sharp border and a middle to high reflection signal at the borderline between the lipid plaque and fibrous plaque in OCT before PCI procedure. We considered that it was a micro-calcified nodule or a cholesterol crystal. Fibrocalcified plaques have a circumferential signal-poor heterogeneous region with well-delineated borders on OCT and a typical calcification on OCT are evaluated by well-delineated, signal-poor masses with a sharp border structure, but there are some variations.3) On the other hand, cholesterol crystals are defined by OCT as thin, linear regions with a high intensity, usually associated with a fibrous cap or necrotic core within the plaque.3 A recent OCT study by Nishimura et al.7) demonstrated that cholesterol crystals were frequently observed in the lesion of plaque rupture, thin-cap fibroatheroma, plaque with macrophage accumulation, and intimal vascularule. In the present case, we observed a high signal region associated with the presumably accumulated macrophages and intimal vascularule in the lesion that was identified to have a sharp structure in the preprocedural OCT. We considered that the sharp structure might have been a cholesterol crystal, but the possibility of it being a calcified object such as a micro-calcified nodule also remained in the OCT findings.

In the assessment of the structure from the CAS images, a protruding structure with white and white yellow color was observed between stent struts. The presence of superficial calcification is usually observed as a yellow area with a clearly partitioned boundary by CAS, but a calcified object protruding into the vessel lumen or bare calcification, such as a calcified nodule, is identified as a white to white yellow structure in the CAS findings.8,9) On the other hand, there are few reports regarding the observation of cholesterol crystals protruding into the lumen in CAS. Cholesterol crystals produced in vitro have a white-yellow color,10) and are highly likely to be observed as a similar color tone in the CAS observations. The structure observed in the present case might have been either a micro-calcified nodule or a cholesterol crystal.

The sharp structure which existed in the plaque protruded into the lumen due to the stent implantation and it caused an unexpected balloon rupture. It was impossible to confirm whether the structure was a micro-calcified nodule or a cholesterol crystal because a pathological assessment could not be performed. According to previous some reports,5,6) it is reasonable to resolve that the sharp structure was a micro-calcified nodule. However, based on the OCT and CAS findings, especially the evaluation of OCT images before and after stent implantation, the structure could also be a cholesterol crystal. No one knows whether a cholesterol crystal has enough hardness to puncture a pinhole in a balloon, but the structure with the possibility of the cholesterol crystal caused the balloon rupture. As well as micro-calcified nodules, cholesterol crystals may have the potential to rupture balloons depending on their hardness, sharpness, and the angle of the object. When confirming the sharp structure with high intensity and clear border in the plaque, it is necessary to pay attention to unexpected complications due to changes of structure condition during the PCI procedure.

Disclosure Statement

The authors have no conflict of interest to disclose.

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