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OCT-Corner: It's all about the flow

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It's all about the flow

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Thrombus formation is a physiological response to vascular damage based on a complex interaction between platelets, coagulation factors, immune cells, and the vessel wall. The dynamics of intracoronary thrombus formation are related to various factors including atherosclerotic plaque rupture or erosion, reduced shear forces and stasis (e. g stent underexpansion and/or malapposition), and the native or medically modified coagulation status of the patient [1].

Coronary angiography is the gold standard for diagnosis of coronary artery disease including acute coronary syndrome. Occlusive and non-occlusive thrombi usually show as filling defects. However, calcifications, dissections, and less often honeycomb structures like septal divisions of the lumen may mimick thrombi in the angiogram [2].

OCT imaging plays a crucial role in the characterization of atherosclerotic plaques, the identification of complications such as plaque rupture and thrombus formation, the planning of PCI providing sizing and length of lesions, and the post PCI assessment of stent apposition and expansion [3].

By using OCT imaging, interventional cardiologists can obtain high-resolution images that can help identify the presence of thrombus that could go unnoticed by conventional angiography.

Near infrared light (approx. 1300 nm) used in OCT is attenuated by red blood cells (RBCs) and even more fibrin meshes. Subsequently, it is fundamental to flush out the blood from the vessel segment during pullback to enhance resolution of structures in the arterial wall [4].

The following image sequences show how blood appears on OCT when it is flowing (incomplete flushing of the coronary) and compare this to the red and white thrombus. Differentiation between blood artifacts and different kinds of thrombi is crucial for image interpretation and leads to appropriate diagnosis and management planning (Fig. 1).

The differential diagnosis is the red thrombus – a blood clot mainly comprising RBCs and fibrin – which shows similar OCT characteristics, a rich signal with high attenuation beneath it [5].

However, some studies have suggested that the attenuation of signal and lack of backscattering is more related to the percentage of fibrin in the composition of the clot rather than the content of RBCs. Attenuation depends also on the wavelength of the near-infrared light used in OCT-aquisition [6–7].

Abbott's latest OCT-software version OCT Ultreon 2.0 offers frame-by-frame co-registration of angiography and simultaneously acquired OCT images which is a feature that can greatly help differentiate between flowing blood and stationary red thrombus sitting on the vessel wall (Fig. 2).

White thrombus, on the other hand, appears in OCT as signal-rich, inside the lumen, generally with irregular surface and most importantly, it allows backscattering – which is translated into a low attenuation of signal beneath [5].

Figure 3 displays an intrastent-white-thrombus protruding through the stent struts.

White and red thrombus can also build up in insufficiently flushed guiding catheter and guide extensions or on the guidewire as shown in Figure 4.

OCT provides rich data of coronary structures and intracoronary thrombus with high resolution, and features like attenuation and backscattering enable identification of different subtypes.

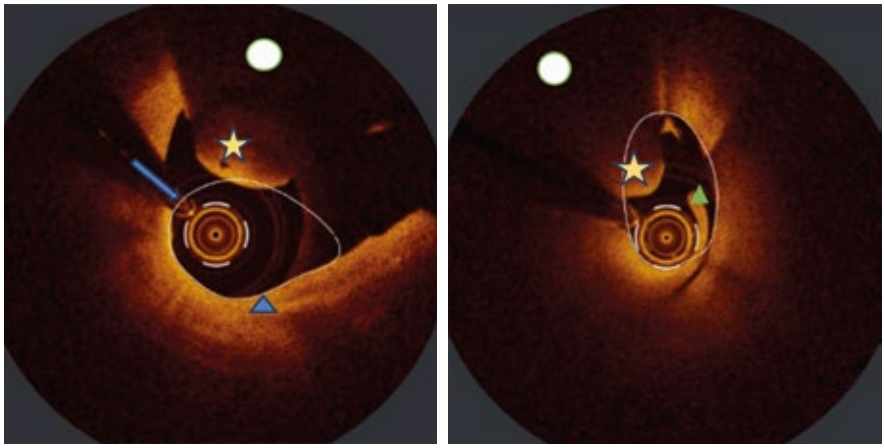

Figure 1. Left: The imaging displays a reduction of the lumen due to an intra luminal protrusion of a high signal formation (yellow star) with high attenuation beneath it (white circle), intima (high signal) is intact and thin (blue triangles), the arrow indicates the coronary wire. **Right:** The high attenuation of signal beneath a protruding formation with a smooth surface, its proximal localization and intraluminal swirling contouring the wire (green triangle) in the following sequence of images, are all arguments suggesting an artifact related to the blood flowing into the coronary artery when flushing stopped before the pullback was ended.

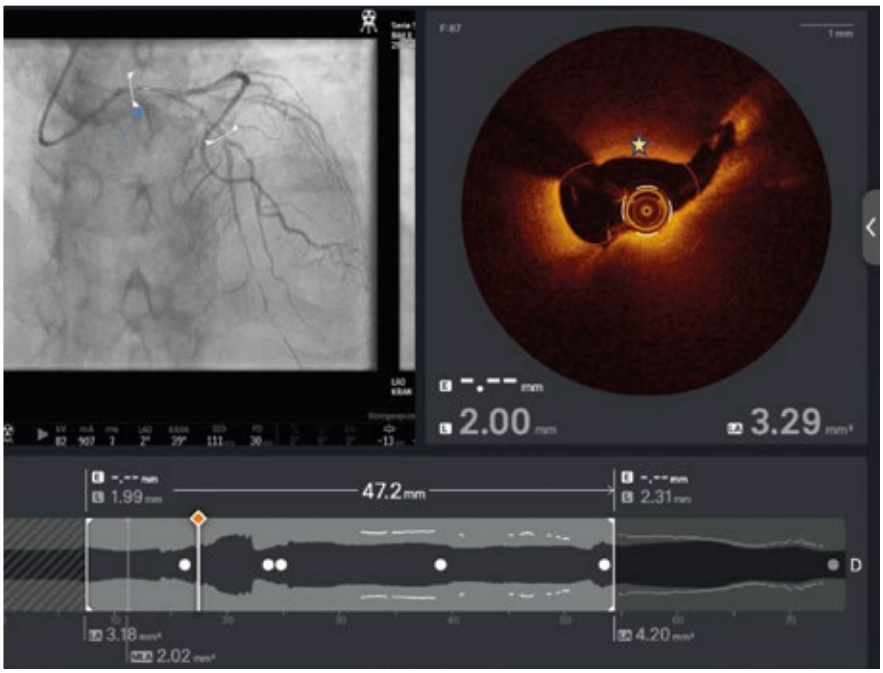

Figure 2. A PrePCI OCT run using Ultreon 2.0 Software by Abbott with co-registration feature: The blue arrow on the angiogram indicates the white marker showing the position of corresponding OCT image if 15 fps are filmed and displays that the contrast has been flushed out by the upcoming blood. (In this series, only 7.5 fps were filmed, so the exact positions of the corresponding OCT pictures had to be extrapolated.
Fps: frames per second.

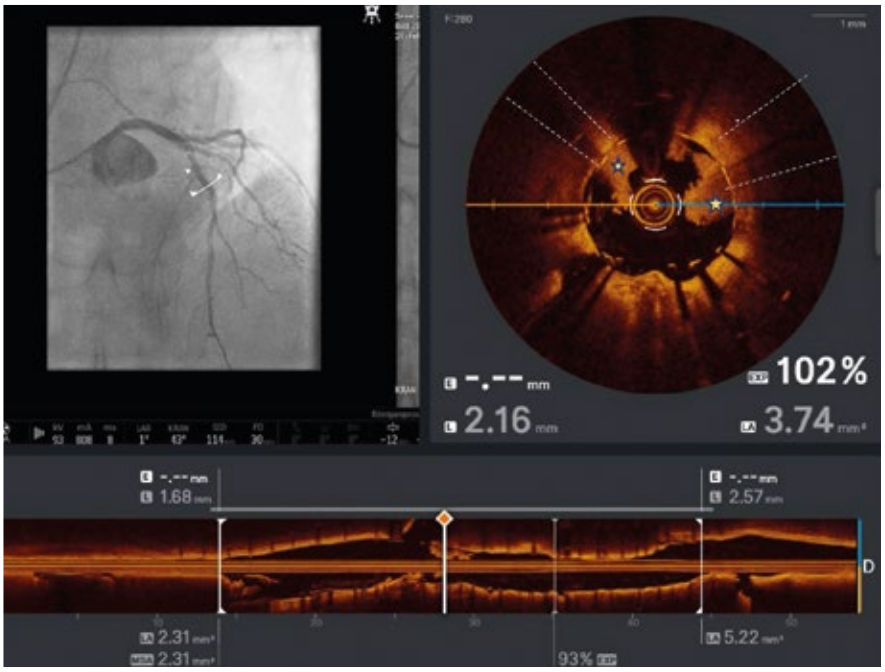

Figure 3. Co-Registration of angiography and OCT: A Post PCI OCT run displays stent underexpansion and malapposition with intrastent thrombosis: The yellow star indicates the white thrombus – the dashed white lines demarcate the backscattering beneath (low attenuation).

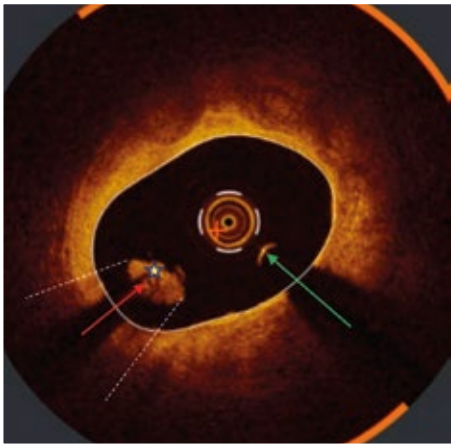

Figure 4. Two guide wires characterized by blocking incident OCT light, casting black shadows on the vessel wall, one is clean (green arrow), the other is surrounded by the a white thrombus (white dotted lines) with low attenuation beneath in a a shape of butterfly. OCT was in the therapeutic range. Different wire surfaces, insufficient wiping, and different indwelling times may explain why one wire stayed completely clean while the other is covered with fresh thrombus.

The development of high-speed scanning interfaces and continued advances in software development make it a valuable tool in the cath-lab for diagnosing coronary disease, guide lesion preparation and judge quality of interventional treatment. Recently, the OCTOBER trial tested an algorithm of systematic use of OCT that resulted in reduction of postinterventional patient MACE especially in complex anatomies and bifurcation [8]. The latest metaanalysis of both OCT- and IVUS-guided PCI trials showed a mortality benefit compared to angio-guided PCI, with OCT being slightly superior to IVUS [9].

VIDEO

Video 1: Co-registration of OCT run in the LAD using Ultreon 2.0 software and Dragonfly Optis catheter. The video commences with the proximal segment of the left anterior descending artery (LAD) displaying simultaneous coronary angiogram on left and OCT imaging on right. Notably, the filling of the proximal LAD with contrast appears suboptimal in the angiogram, concomitant with the OCT images which vividly depict blood entering the vessel lumen. As the video progresses distally, the OCT frames exhibit significant artifact clearance from blood and better resolution of the vessel wall segments, concurrent with adequate contrast filling in the angiogram. This is a nice example how artificial intelligence (AI) can prepare imaging data for quick and easy review by the interventional cardiologist: In reality, blood is cleared from the lumen by antegrade dye injection and the OCT-lens is moved from distal to proximal, so in this case it reached the LM when blood already followed the contrast-bolus. AI used the coregistered images and presents the video in antegrade mode for more intuitive interpretation. Keep in mind, though, how the pictures were created, to better understand the creation of artifacts. In this case, less experienced cardiologists may misinterprete blood for thrombus if they only look at still frame OCT pictures. Coregistration of angio and OCT clearly shows the movement of blood. *"It is all about the flow !"*

Conflict of Interest

None.

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