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New insight into the aortic microcirculation in coronary disease — intraoperative laser Doppler flow measurement and vasa vasorum imaging

Authors: Andrzej Łoś, Iga Walczak, Michał Bieńkowski, Barbara Kutryb-Zając, Marcin Hellmann

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New insight into the aortic microcirculation in coronary disease — intraoperative laser Doppler flow measurement and vasa vasorum imaging

Short Title: Aortic microcirculation and vasa vasorum imaging

Andrzej Łoś[1], Iga Walczak[2], Michał Bieńkowski[3], Barbara Kutryb-Zając[2], Marcin Hellmann[4]

[1]Department of Cardiac and Vascular Surgery, Medical University of Gdańsk, Gdańsk, Poland

[2]Department of Biochemistry, Medical University of Gdańsk, Gdańsk, Poland

[3]Department of Pathomorphology, Medical University of Gdańsk, Gdańsk, Poland

[4]Department of Cardiac Diagnostics, Medical University of Gdańsk, Gdańsk, Poland

Correspondence to:

Prof. Marcin Hellmann, MD, PhD

Department of Cardiac Diagnostics, Medical University of Gdańsk,

ul. Smoluchowskiego 17, 80-214 Gdańsk, Poland,

phone: +48583493380,

email: marcin.hellmann@gumed.edu.pl

Surgical coronary artery bypass grafting (CABG) is the standard procedure in coronary revascularization. Compared to on-pump CABG, the off-pump CABG (OPCABG), or beating heart surgery without cardiopulmonary bypass, provides a less invasive technique as it does not require the ascending aorta or right atrium cannulation. This approach is favourable in high-risk patients with extensive atherosclerotic plaques in the aorta, which could be mechanically disrupted during cannulation or cross-clamping leading to the subsequent embolization [1]. However, OPCABG is not devoid of complication risks. In particular, it is associated with an elevated risk of aortic dissection due to not infrequently required the potentially necessary lateral aortic clamping and the pulsatile pattern of arterial pressure [2].

Although the predisposing factors for perioperative aortic dissection remain ill-defined, recent studies suggest that the function of vasa vasorum (VV) may play a role. It has been demonstrated that disturbances in VV flow led to an acute decrease in the distensibility of the ascending aorta. Similarly, structural changes in the aortic wall have been found to be a direct consequence of decreased VV density [3]. Thus, we suggest a routine intraoperative evaluation of the ascending aorta VV perfusion in order to indicate the appropriate surgical technique and predict possible complications.

Our recent study showed that Laser Doppler Flowmetry (LDF) can effectively monitor changes in myocardial perfusion during CABG [4]. LDF uses a fiber-optic probe to emit 780 nm laser light, which shifts in wavelength when upon meeting moving blood cells. Single point LDF measures blood flow in a small volume (around 1 mm^3) detecting quick microvascular perfusion changes and presents the readings in arbitrary perfusion units (APU).

A 67-year-old woman with diabetes and coronary artery disease was referred for CABG surgery due to the two-vessel disease. During beating heart CABG, we provided the measurements of microvascular perfusion of the ascending aorta adventitia assessed continuously by LDF (Periflux System 5000, Perimed, Järfälla, Sweden) (Fig. 1A–B). In addition, we collected the biopsy material (0.5 cm^2) of the ascending aorta. The material was formalin-fixed, paraffin-embedded and used for the imaging of aortic microvessels. Cross-sections (3 μm) were stained with hematoxylin and eosin to reveal aortic layers and VV (Fig. 1C). Then, sections were processed for endothelial cell immunolabeling [5]. The results exposed a considerable density of adventitial VV and individual microvessels in the media. In addition, a positive staining for endothelial nitric oxide (NO) synthase in microvascular endothelium underlined the significant role of adventitial aortic tissue as a source of NO that plays a critical role in vascular homeostasis.

To the best of our knowledge, the presented case is the first to perform noninvasive real-time microcirculation monitoring in ascending aorta during the surgery on the beating heart in patients with coronary disease supplemented by evaluation of the VV distribution and functional role in NO production. In future, we expect to find a strong correlation between the hyperperfusion of the aortic wall and the severity of atherosclerotic plaques in histochemical findings in a larger group of patients.

Article information

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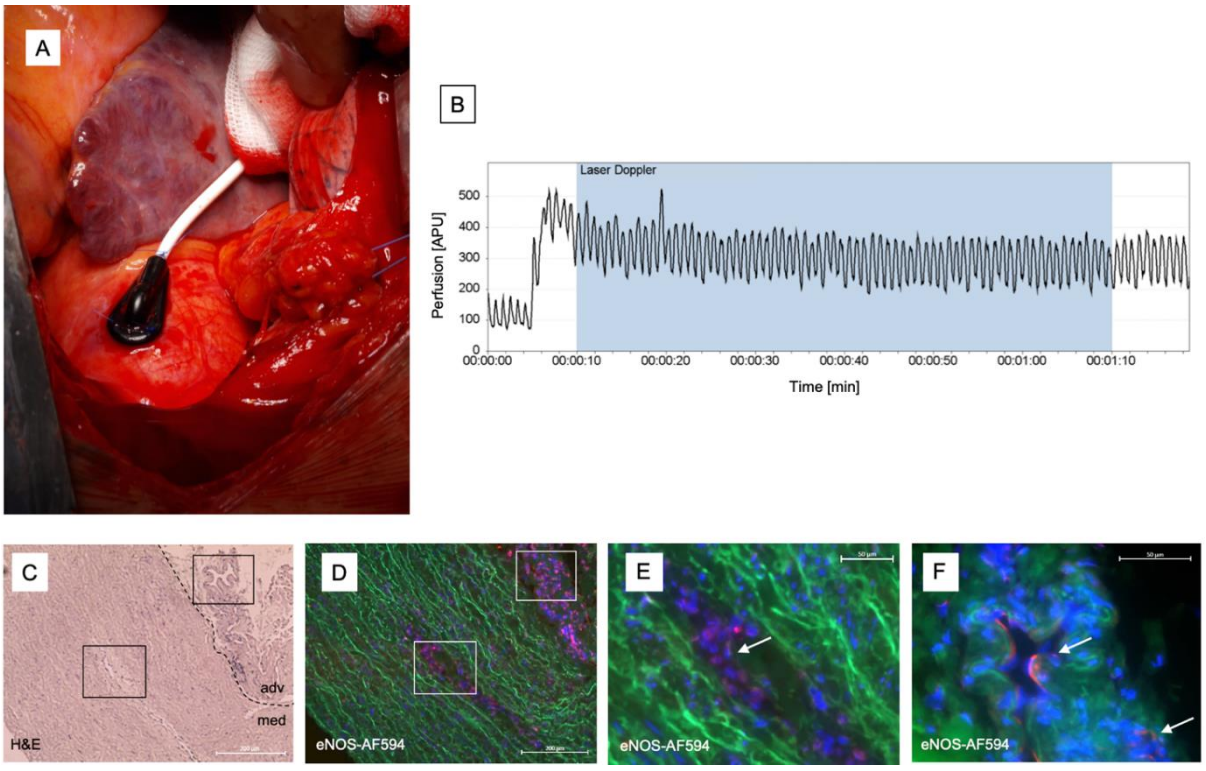

Figure 1. A. Intraoperative image of the laser Doppler probe stitched to the ascending aorta; **B.** Representative image of Laser Doppler Flowmetry recording in arbitrary perfusion units (APU) **C.** Ascending aorta stained with hematoxylin and eosin (H&E). The border between the adventitia (adv) and the media (med) is denoted by a dashed line. **D–F.** Immunofluorescence

(IF) staining of the endothelium in the vessel vasa vasorum. Endothelial cells are labelled by staining against endothelial nitric oxide synthase (eNOS-AF594, red). Cell nuclei are counterstained with DAPI (blue). Elastin fibers autofluorescence (green). Squares indicate zoom areas. White arrows point to vasa vasorum.