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High wall shear stress predicts plaque rupture of the aortic arch: computational fluid dynamics model and non-obstructive general angioscopy study

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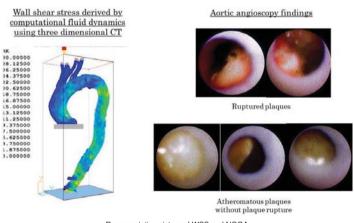*Nihon University School of Medicine, Tokyo, Japan*

Background: Wall shear stress (WSS) has been considered as a major determinant of aortic atherosclerosis. Recently, non-obstructive general angioscopy (NOGA) was developed to be able to visualize a variety of its atherosclerotic pathology, including in vivo ruptured plaque (RP) in the aorta. We, therefore, investigated the relationship between NOGA derived RP in the aortic arch and the stereographic distribution of WSS by using computational fluid dynamics modeling (CFD) on three-dimensional CT angiography (3D-CT).

Methods: We investigated 30 consecutive patients who underwent 3D-CT before and NOGA during coronary angiography. WSS in the aortic arch was measured with an application of CFD based on finite element method by using uniform inlet and outlet flow conditions. Aortic RP was detected by NOGA.

Results: The maximum and mean values of WSS were 67.2±29.2 Pa and 2.4±0.6 Pa. A total of 18 RPs was detected by NOGA. The patients with a distinct RP showed a significantly higher maximum WSS in the whole aortic arch, and the greater and lesser curvature of the aortic arch than those without it (73.3±29.0 Pa vs 50.4±15.2 Pa, p=0.035, 95.0±27.5 Pa vs 42.8±25.2 Pa, p=0.003, 70.8±29.3 Pa vs 46.1±11.9 Pa, p=0.013, respectively), whereas there was no significant difference in the mean WSS between those with and without it. In a multivariate analysis, the maximum value of WSS was an independent predictor of RP in the aortic arch (odds ratio 1.05, 95% confidence interval 1.01–1.13, p=0.019).

Conclusions: Aortic RP detected by NOGA was strongly associated with the higher maximum WSS in the aortic arch derived by CFD using 3D-CT. Maximum WSS may explain the underlying mechanism of not only aortic atherosclerosis, but also aortic RP.

Representative picture of WSS and NOGA