Analysis of the Influence of Blood Flow on the Prediction of Non-Invasive Fractional Flow Reserve from CTCA and Reduced Order CFD

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Background and Aims: We developed a method to compute non-invasive FFR_B by combining computed tomography coronary angiography (CTCA) and reduced-order computational fluid dynamics (CFD). Physiologic principles of baseline and hyperemia boundary conditions were necessary for patient-specific CFD simulations. One of the principles used in FFR_B calculation was that baseline coronary flow was proportional to left ventricular (LV) mass (M) as 140.22+0.418*M (ml/min) [1]. Because the error of LV mass measurement from CTCA images was approximately 10-20% [2], we aimed to investigate the influence of the variation and errors of LV mass in FFR_B.

Methods: All subjects (10 males, 4 females; aged 58±7 years old) underwent CTCA scans and invasive FFR measurement. From CTCA images, 3D coronary artery tree models were reconstructed and LV mass was measured for subsequent CFD simulations. Simulations with varying LV mass as 70%, 80%, 90%, 100% 110%, 120% and 130% of the measured LV mass, respectively, were repeated for every patient-specific case. The correlation between FFR_B and invasive FFR was performed by using Pearson's analysis. The differences among groups with different LV mass were analyzed by one-way analysis of variance (ANOVA) analysis.

Results: For the 16 coronary lesions studied, the correlation between FFR_B (calculated with measured LV mass) and invasive FFR was excellent (r=0.93, $p<0.001$) and the difference between FFR and FFR_B was non-significant (-0.016±0.037). FFR_B decreased with increasing LV mass. There was no significant difference for FFR_B and (FFR- FFR_B) among the groups having LV mass variations less than 30% ($p>0.05$ from ANOVA test).

Conclusion: The results have shown that the variation of LV mass has an effect on the predicted value of FFR_B, however, they tend to be non-significant for the investigated variation range of LV mass (70%-130%), in comparison with invasive FFR measurements.

References:

1. Journal of Applied Physiology 2005; 98(3):1076–1082.
2. European Heart Journal - Cardiovas Imaging 2017; 18 (1): 95–102.