Combined Study for Estimation of Coronary Flow based on Flow Distribution in the Coronary Tree

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Diagnostic angiography procedures assess the severity of the patient's coronary arteries atherosclerosis (stenosis). The severity is assessed by either examining the visual information, or using hemodynamically based parameters. X-ray angiographic procedures are considered the ‘‘gold standard’’ for non-invasive determining anatomical information, such as lumen boundary. However, procedures for estimation of blood flow related functional stenosis severity require invasive measurements (e.g. FFR). Non-invasive flow estimation techniques (such as bolus tracking) are not accurate. Accurate, reliable and minimally or noninvasive measurement of blood flow are in need.

The primary goal of this study is to suggest the bolus tracking noninvasive approach combined with angiography and a semi-empirical lumped model of flow distribution in the coronary tree as a method that allows on-site estimation of stenosis severity. We performed a large set of numerical simulations and experiments involving bolus tracking, and measurements of flow and pressure gradient maps in a model of coronary tree. We used a lumped model based on the measured hydraulic resistances and succeeded to estimate stenosis severity in all the models. The results of the numerical and experimental analyses helped to cross-validate both the methods and construct a lumped model that is sufficiently accurate in its prediction of the flow distribution and pressure gradients in the coronary tree. Further extension of this approach has a potential to become a useful non-invasive diagnostic procedure.