Effect of Arterial Wall Compliance on the Pressure Drop across Coronary Artery Stenoses

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ABSTRACT

Hemodynamic endpoints such as flow and pressure drop are often measured during angioplasty procedures to determine the functional severity of a coronary artery stenosis. There is a lack of knowledge regarding the influence of compliance of the arterial wall-stenosis on the flow-pressure drop relationship across the lesion. This study evaluates the influence in flow and pressure drop caused by variation in arterial-stenosis compliance for a wide range of stenosis severities.

The flow and pressure drop were evaluated for three different severities of stenosis and tested for limiting scenarios of compliant models. The Mooney-Rivlin model defined the non-linear material properties of the arterial wall and the plaque regions. The non-Newtonian Carreau model was used to model the blood flow viscosity. The fluid (blood)-structure (arterial wall) interaction equations were solved numerically using the finite element method.

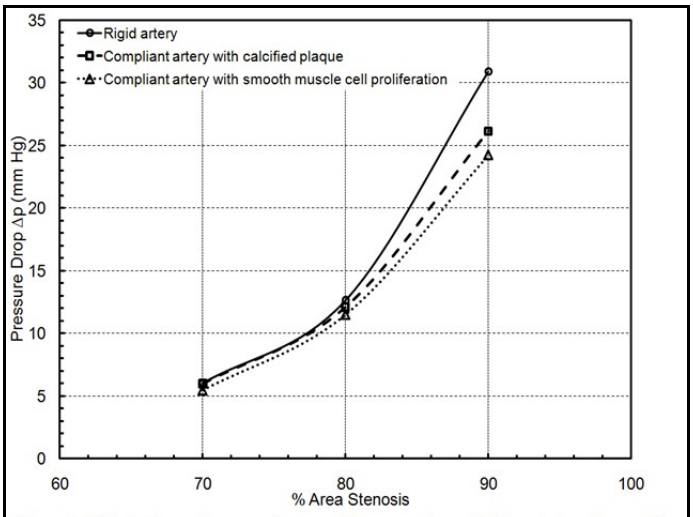

Figure 1: Effect of compliance on the overall pressure drop at different stenosis severities

Irrespective of the stenosis severity, the compliant models produced a higher pressure drop than the rigid artery due to the compliance of the plaque region (Fig. 1). A wide variation in the pressure drop was observed between different compliant models for significant (90% area occlusion) stenosis with 30.9, 26.1 and 24.2 mmHg for the rigid artery, compliant artery with calcified plaque and compliant artery with smooth muscle cell proliferation, respectively. When compared with the rigid artery for significant stenosis the pressure drop decreased by 15.5% and 21.6% for the calcified plaque and for the smooth muscle cell proliferation case, respectively. These significant variations in pressure drop for the higher stenosis may lead to misinterpretation and misdiagnosis of the stenosis severity.