Impact of Stent Mis-sizing and Mis-positioning on Fluid Wall Shear and Intramural Stress

Henry Y. Chen\textsuperscript{a}, Bon-Kwon Koo\textsuperscript{b}, Deepak L. Bhatt\textsuperscript{c}, and Ghassan S. Kassab\textsuperscript{a}

\textsuperscript{a}California Medical Innovations Institute, San Diego, CA

\textsuperscript{b}Division of Cardiology, Seoul National University Hospital, Seoul, South Korea.

\textsuperscript{c}VA Boston Healthcare System, Brigham and Women’s Hospital, and Harvard Medical School, Boston, MA

Introduction: Stent deployments with geographical miss (GM) are associated with increased risk of target-vessel revascularization and peri-procedural myocardial infarction. The aim of the current study was to investigate the underlying biomechanical mechanisms for adverse events with GM. The hypothesis is that stent deployment with GM (longitudinal, LGM, i.e. stent not centered on the lesion, or radial, RGM, i.e. stent oversizing) results in unfavorable fluid wall shear stress (WSS), WSS gradient (WSSG), oscillatory shear index (OSI) and intramural circumferential wall stress (CWS).

Materials and Methods: 3-D computational models of stents and plaque were created in a Computer Assisted Design package. The models were then solved in validated finite element and computational fluid dynamic packages. The dynamic process of large deformation stent deployment was modeled to expand the stent to the desired vessel size.

Results: It was found that stent deployed with GM resulted in a 45% increase of vessel circumferential wall stress (CWS) as compared with stent that was centered and fully covered the lesion. An oversized stent resulted in higher CWS than correct sized stent. The linkages between the struts had much higher stress than the main struts; i.e., 180 MPa vs. 80 MPa. Additionally, LGM and RGM reduced endothelial WSS, and increased WSSG and OSI.

Translational Impact: The simulations suggest that both LGM and RGM adversely reduce WSS, and increase WSSG, OSI and CWS. These findings highlight the potential mechanical mechanism of the higher adverse events and underscore the importance of stent positioning and sizing for improved clinical outcome. A potential benefit of these simulations is for design optimization of stents. For example, the finding that the links between struts are the most vulnerable to fracture suggests that it is a design feature that requires further optimization.

Disclosure Statement: None.