
MRI-Based Computational Modeling for Carotid Plaque Rupture and Stroke

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Dalin Tang
Worcester Polytechnic Institute

Stroke is the third leading cause of death in the United States which is often caused by atherosclerotic carotid plaque rupture. The objective of this project is to integrate computational modeling, Magnetic Resonance Imaging (MRI) technology, ultrasound(US)/Doppler technology, mechanical testing, and pathological analysis to perform quantitative mechanical analysis to atherosclerotic carotid plaques, to quantify critical blood flow and plaque stress/strain conditions under which plaque rupture is likely to occur, and to seek the potential that quantitative mechanical analysis can be integrated into state-of-the-art imaging technologies for better screening and diagnostic applications. The specific aims are: (1) develop and integrate 3D MRI, US technologies and computational methods to quantify plaque structure and vessel material properties; (2) develop 3D multi-component computational models with blood-vessel interactions based on in vitro, ex vivo and in vivo measurements; (3) perform complete mechanical analysis for atherosclerotic plaques; (4) quantify and validate correlations between critical stress/strain conditions and plaque vulnerability and identify critical stress/strain indicators which could be used by doctors to make clinical and diagnostic decisions. This study will establish the base for future software development and technology integration which will lead to better interpretation of the information already contained in MRI and ultrasound images and more accurate assessment of plaque vulnerability, and potential early prediction of possible stroke. Our preliminary results indicate that the popular "maximal stress hypothesis" may be misleading and should be replaced by a modified "local maximal stress hypothesis", i.e., plaque rupture may be related to local maximal stress conditions found at critical sites where rupture is likely to occur (Fig. 1). Results from 18 cases using the new hypothesis showed 89% agreement rate with histopathological classifications.

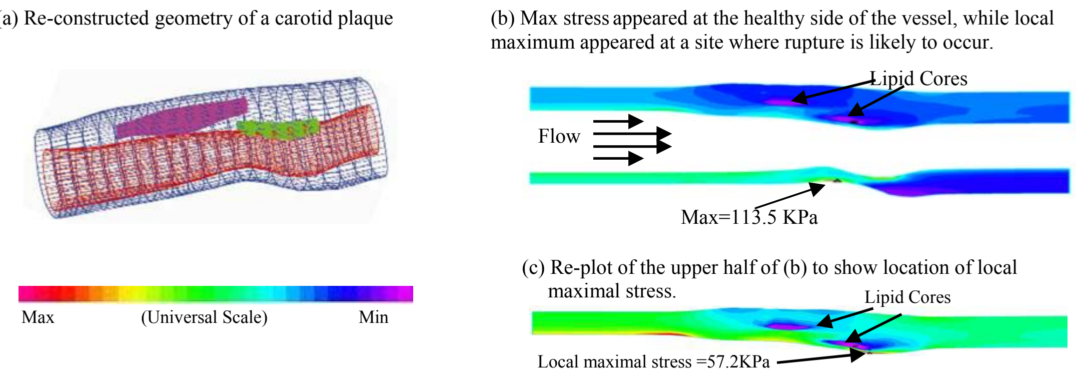

Fig. 1. Plaque rupture may be related to local maximal stress conditions. Results shown in (b)-(c) are maximal principal stress distributions in a carotid plaque using a 3D multi-component model with fluid-structure interactions.

PI Website

http://users.wpi.edu/~dtang/

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Other Items:

Patent(s):

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