Abstract 13

Primary Author: Perry Fisher, MSIV

Hospital Affiliation: Albany Medical College, Astoria, NY

Co-Author: Hamed Nasrabadi 1; Marios S. Pattichis 1; Andrew N. Nicolaides 2; Maura Griffin 2; Gregory C. Makris 2; Efthyvoulos Kyriacou 3; Constantinos S. Pattichis 4

Co-Affiliations: 1 Dept. of Electrical and Computer Engineering, The University of New Mexico, Albuquerque, NM USA; 2 Vascular Screening and Diagnostic Centre, London, U.K.; 3 Dep. of Computer Science and Eng.; 4 Frederick University, Limassol, Cyprus.

Title: Measurement of Motion of Carotid Bifurcation Plaques

Background:
Cardio vascular disease is the leading cause of death in the US. The majority of ischemic cardiovascular events are due to atherosclerotic plaque. For asymptomatic atherosclerotic cases, the decision to remove the plaque depends on the identification of high risk plaques. This is because in patients greater than 70% stenosis reduces the 5 year stroke rate from 2% to 1% as reported in the ACAS and ACST. However, at best, only 70% of the strokes occurred in this high risk group during follow-up. The remaining strokes occurred in the low risk group. It has been suggested that plaques may rupture not only as a result of inherent instability, but also due to excessive mechanical forces during the cardiac cycle. In this study, we introduce a new image analysis methodology for quantifying discordant plaque motion, which is the phenomenon of different parts of a plaque moving in different directions during the cardiac cycle. In contrast, concordant plaque motion is the phenomenon of all parts of the plaque moving in the same direction during the cardiac cycle. Discordant motion is associated with higher strain, as opposed to concordant motion that is associated with lower strain values. Our aim is to classify and quantify the motions that can help clinicians differentiate between plaques that are likely to rupture because of high internal strains from plaques with low strains.

Methods:
Video loops of B-mode ultrasound images of 35 carotid bifurcation plaques were obtained (4 symptomatic and 31 asymptomatic) from patients with carotid bifurcation atherosclerosis. Institutional Ethics Committee approval was obtained. The video loops were anonymised and studied blind; i.e. without knowledge of presence or absence of symptoms. 13 plaques were visually classified as showing discordant movement and 22 as showing concordant movement. A plaque was classified as concordant if it had all of its components simultaneously move in the same direction throughout the cardiac cycle. On the other hand, a plaque was classified as discordant if it had components move in different directions, at certain parts of the cardiac cycle, especially in peak systole. Motion estimation is based on Farneback’s method. Over
each pixel, the approach fits two local polynomials between two reference video frames. Thus, motion is computed between any two video frames. Statistical analysis of the estimated motion vectors is performed over the region of the plaque. The discrimination between concordant and discordant motions is based on estimating the motion velocity spread over each video frame, over the entire video. The magnitudes of pixel motion velocities are diagrammed in vectors by the motion analysis software. These vectors are aligned in circular orientation, making fan-like structures. The widths of these "fans" were used in order to assess concordance and discordance of motion.

Results:
To differentiate between concordant and discordant motions, we collected ultrasound videos from 35 patients. These videos were visually classified into concordant plaques (n=22) and discordant (n=13) plaques. The motion analysis software was optimized and used in order to test for its ability to discern concordance vs discordance. An orientation histogram produced by the motion analysis software displayed either concordant motion, shows a narrow fan (or wedge) width, or discordant motion, shows a wide fan (or wedge) width. We compared the scatterplots for all cases. From the boxplots, we discerned the optimal setting for the software to provide the best separation between stable and unstable plaques. The software was then utilized for the previously identified plaques, and was able to separate concordant ones from discordant ones. The same trials were run under the control of different operators of the software, with 100% sensitivity and 100% specificity in detecting discordance and concordance. Thus, we have a new tool to differentiate between concordant and discordant plaques.

Conclusion:
Video loops of B-mode ultrasound images of 35 carotid bifurcation plaques were obtained (4 symptomatic and 31 asymptomatic) from patients with carotid bifurcation atherosclerosis. Video loops were classified visually as showing concordant (n=22) or discordant motion (n=13). Concordant plaques were characterized by uniform orientation of motion throughout the cardiac cycle. Discordant plaques exhibited significant spread in motion orientation at different parts of the cardiac cycle, especially at systole. We developed a real-time motion analysis system that applies Farneback's method to estimate velocities between consecutive video frames. For our purposes, we allow a 100msec time interval between the video frames used in the analysis. This approach allows us to analyze significant motions associated with a larger time interval. Over each video frame, we measure the spread of the motion orientation around the dominant orientation. For each video, we look at the spreads of the motion orientations for different motion magnitudes. Using these motion-spread measurements, we can quantify discordant movement. We are currently testing our approach on larger datasets in a multicenter study.