Early Prediction of CVD Using Retinal Vessel Features

June 2011

Honggang Yu, Ph.D. / Research Scientist
505-508-1994 / hyu@visionquest-bio.com

VisionQuest Biomedical

Early Prediction of CVD Using Retinal Vessel Features

SIGNIFICANCE

Cardiovascular disease (CVD) is the leading cause of death in the U.S., according to the Centers for Disease Control (CDC). In 2007, more than one in four deaths in the U.S. was attributable to heart disease. This means that a person in the U.S. has a heart-disease-related event every 34 seconds and a death each minute. It is estimated that 1 in 3 Americans (80 million) suffer from CVD. By 2030, 40.5% of the US population is projected to have some form of CVD, according to the American Heart Association. Between 2010 and 2030, real total direct medical costs of CVD are projected to triple, from $273 billion to $818 billion. Real indirect costs (due to lost productivity) for all CVD are estimated to increase from $172 billion in 2010 to $276 billion in 2030, an increase of 61%. Effective prevention strategies for CVD are important and needed if we are to limit the growing burden of CVD.

It has been shown that the retinal vasculature reflects the health of the microvasculature of the brain, heart, and other organs, thus providing a non-invasive means for evaluating the status of the cardiovascular system. Our goal is to use digital retinal imaging and automated retinal vascular network analysis techniques for screening early sign of CVD in retina.

OUR PRODUCT

The computer-aided screening of systemic CVD, which is based on automatic segmentation of retinal vasculature and quantitative analysis of the global branching network pattern and local vessel structure features, consists of seven processing steps (Figure 1).

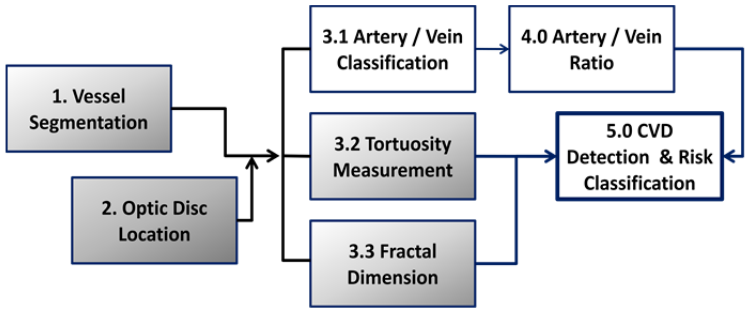

Figure 1 – CVD detection and classification

The optic disc (OD) is located using template matching and vessel branch detection inside OD candidates[1]. Vessel segmentation is implemented on the green channel image using local entropy thresholding on the multi scale Hessian enhanced vessel map[2]. Vasculature analysis includes arterio-venous ratio (AVR), tortuosity index (TI), and fractal dimension. The region of interest (ROI) for vessel analysis is shown in Figure 2. AVR is automatically calculated using the Parr-Hubbard method within an annulus surrounding the OD of radius 1 to 1.5 disc diameters. TI is determined by the ratio of arc length to chord length and integrated curvature magnitude normalized by the number of vessel segments and vessel length. Fractal dimension is calculated using the box-counting method on the skeletonized vessel network.

RESULTS

The associations between the above three retinal vasculature features and systemic CVD are revealed using retrospective data obtained from the Retinal Institute of South Texas (RIST). Small AVR values, which indicates generalized retinal arteriolar narrowing, and high tortuosity were consistently associated with hypertension, coronary artery disease, stroke and congestive heart failure. It indicates that AVR and tortuosity can be used as prominent features in CVD classification. Fractal dimension can be considered as subordinate feature besides other topography features in CVD classification. Preliminary results have been presented in Yu 2011.

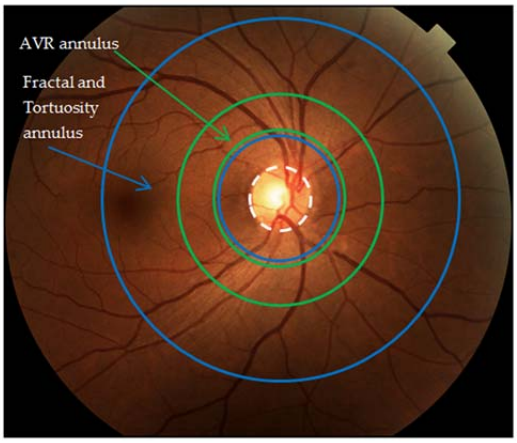

Fig. 2. ROIs of vessel feature analysis

THE FUTURE

Our automated vasculature analysis system will integrate previously studied features, AVR, fractal dimension, and tortuosity with other vessel abnormality, such as AV nicking, copper wiring (vessel reflex and color), vessel length to diameter ratio (LDR), bifurcation angle, and junctional exponent, all of which have been previously associated with cardiovascular diseases. Our group has developed partial least squares (PLS) classifiers for the detection of diabetic retinopathy (DR) achieving excellent results[3]. We will use PLS classifier for CVD screening.

The system will be integrated into other eye disease screening programs, such as screening for diabetic retinopathy, glaucoma, and age-related macular degeneration. The system will be deployed at the primary care physician stage for CVD screening using retinal imaging and has the potential to give patients an opportunity to make diet or life style changes and reduce the huge cost burden of CVD. The system will be an invaluable tool for CVD prevention and health maintenance.

Contact: Simon Barriga, Ph.D. / Chief Research Scientist

Corporate Headquarters: VisionQuest Biomedical LLC 2501 Yale Blvd. SE Suite 301 Albuquerque, NM 87106

Phone: 505-508-1994 / Fax: 505-508-5308 / Web: http://visionquest-bio.com / E-mail: sbarriga@visionquest-bio.com

[1] Yu H, Barriga S, Agurto C, et al., "Fast localization of optic disc and fovea in retinal images for eye disease screening", SPIE Medical Imaging, 2011.

[2] Yu H, Agurto C, Barriga S, Bauman W, Soliz P and Zamora G, "computer-aided screening of cardiovascular disease based on retinal imaging: results using retinal vasculature features", ARVO, 2011.

[3] Agurto C, S Barriga, V Murray, S Nemeth, M Pattichis, W Bauman, G Zamora, and P Soliz, "Automatic algorithm for detection of diabetic retinopathy pathologies", accepted IOVS journal, May 2011.