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Method and system for vascular elastography

Reference: VAL-360-CHUM

Keywords: Endovascular ultrasound elastography (EVE), elastic properties of vessel walls, atherosclerosis

Background

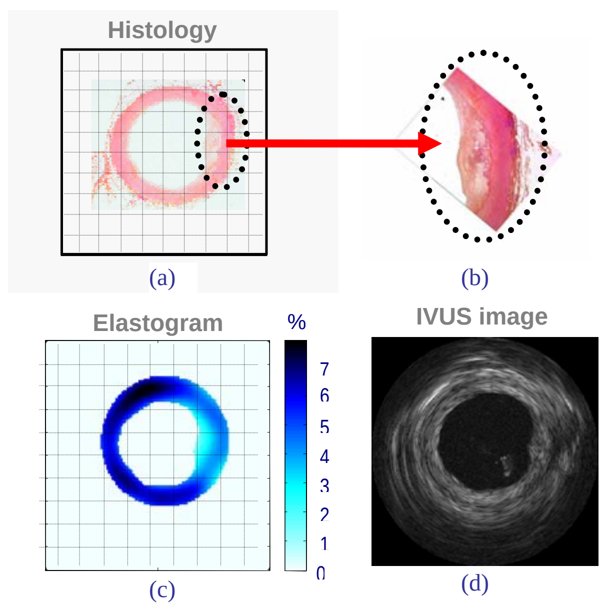
Atherosclerosis is a disease of the intima layer of arteries characterized by a focal accumulation of lipids, complex carbohydrates, blood cells, fibrous tissues and calcified deposits, which form a plaque that thickens and hardens the arterial wall. The diagnosis of this disease relies primarily on plaque morphology and vessel stenosis degree. This information can be assessed with radiological techniques such as x-ray angiography, computed tomography angiography and magnetic resonance angiography. Intravascular ultrasound imaging (IVUS) is also used since high-resolution cross-sectional images of arteries are generated. However, IVUS only enables a rough qualitative characterization of the plaque components in terms of being fatty, fibrous, or calcified, and does not produce quantitative information on the mechanical behavior of the artery. To obtain the quantitative elastic properties of vessel walls, elastographic processing methods must be applied to radio-frequency (RF) IVUS images.

Technology

An endovascular ultrasound elastography (EVE) model-based approach that allows the computation of the biomechanical properties of the vascular tissue is proposed. It consists of a nonlinear minimization algorithm that was adapted to speckle motion estimation based on the hypothesis that the ultrasound speckle can be seen as a material property. This method is known as the Lagrangian Speckle Model Estimator (LSME). To gain in computation time, the LSME was adapted using an analytical formulation of the Jacobian matrix, which is required to solve the minimization problem. This adaptation was achieved from the derivation of optical flow equations, since the speckle material property can be assumed. A strength of the LSME is to provide the full two-dimensional (2-D) strain tensor. The mechanical properties of the plaque can thus be assessed in terms of radial strain, tangential strain, radial shear or tangential shear components.

Results

The figure below shows an example of a radial strain elastogram. The histological section in (a) shows a very thin atherosclerotic plaque at three o'clock and (b) shows this section in closer detail; the elastogram and corresponding IVUS image are shown in (c) and (d) respectively. The colorbar in (c) gives the strain in percent; in this elastogram, dark signifies soft tissue structures, whereas bright corresponds to hard structures. Unlike the IVUS image, the elastogram illustrates that the plaque area is harder than the normal vessel wall.



Applications

- Calculation of the vessel wall elastic properties.
- 2D-strain tensor computation with the Lagrangian Speckle Model Estimator.
- Characterization of atherosclerotic plaque vulnerability (plaque rupture sites).
- Characterization of the vessel wall mechanics in arterial aneurysms.
- Assistance for clinicians in disease diagnosis and therapy planning.

Competitive Advantages

The LSME is more reliable than one-dimensional (1D) motion estimators that are more sensitive to pre- and post-motion signal decoherence. With the LSME, the mechanical properties of the vessel wall can be more accurately evaluated. Furthermore, while all other existing methods only evaluate the radial strain component, this method provides the 4 strain components of the 2D-tensor, giving unique assessment with shear elastograms.

Patent Status

PCT application (PCT/CA2005/000162)

Business Opportunity

Univalor is seeking an exclusive licensing agreement or contracts with a commercial partner.

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