**2017 高莲—基于解析速度仿真动脉瘤超声多普勒血流信号**

**不足目的:** 许多研究致力于建立计算机腹主动脉瘤超声多普勒血流信号仿真模型。这些研究多半借助计算流体动力学(C FD )方法来数值合成腹主动脉瘤血流信号，这些模型理论上可 以合成不同结构动脉瘤超声多普勒血流信号，但若其结构特性(大小、形状等)发生变化，已确定的 CFD 数值合成过程不再适用；模型建立、网格划分及数值仿真等过程需从新进行，耗时耗力，无法灵活仿真动脉瘤形成、发展不同时期超声多普勒血流信号。

**方法**：建立了一种基于解析速度分布的动脉瘤超声多普勒血流信号仿真模型。 模型首先通过解析求解血流动量及质量守恒线性化 N avier-Stokes 方程，得到  
不同病变程 度动脉瘤 血管 内血流速度 剖面 ；此后，使用总体分布的非参数估计获得病变血管内血流功率谱密度；最后，通过累加余弦信号仿真超声多普  
勒血流信号。

**展望**：人体动脉瘤几何形状较复杂多变，未来应建立几何形状较为复杂的动脉瘤超声多普勒血流信号仿真模型 ，进一步完善动脉瘤超声多普勒血流信号仿真方法。

**观点：**

**2016 Lian Gao--Compound Doppler ultrasound signal simulation for pulsatile carotid arteries with a stenosis**

**Purpose:** The simulated Doppler blood flow signals are widely used to assess the performance of the clutter filters（杂波滤波器） for removing wall components while reserving（保留） low-velocity signals scattered from physiological blood flow approaching the inner vessel-wall injured by a stenosed lesion（狭窄的损伤）. By simultaneously taking into account the natural attributes of the Doppler equipment, blood flow as well as vessel wall of pulsatile carotid arteries（动脉硬化） with a stenosis（狭窄）, a computer simulation method is presented to produce the compound Doppler ultrasound blood flow signals.

**Methods:** The in-phase（同相） and quadrature（正交） (I/Q) axial as well as radial blood flow signals（径向血流信号） are simulated by superposing（重叠） a series of cosine functions regulated by the spectrograms（频谱图） estimated from the axial and radial velocity profiles firstly obtained through the solution of the incompressible（不可压缩的）Navier–Stokes equations, respectively. Meanwhile, the I/Q Doppler signals echoed from pulsatile near (anterior) and far (posterior) walls are reproduced based on their radial movements（径向移动） during a cardiac cycle（心动周期）. Ultimately, those confirmed quadrature signals（正交信号） are summed to generate the compound Doppler signals including the contribution from both blood flow and stenosed vessel-wall.

**Results:** The compound Doppler ultrasound signals echoed from both axial and radial blood flows as well as vessel walls with obstruction grades of 0% (normal arteries), 10% and 25% are simulated respectively. The real signals from the left carotid artery with an approximately 10% stenosis degree are also collected for further assessing the believability of simulated versions. The simulated and clinical tests demonstrate that the proposed computer simulation method can produce compound Doppler signals with confirmed qualitative and quantitative characteristics resembled with the clinical versions, which could be used as an theoretical data source for evaluating the performance of the signal separation between pulsatile blood flows and vessel walls with mild stenosed-lesions.