The low frequency signal of vasomotion is induced by the variation of heart period

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Introduction

Vasomotion is a rhythmic and spontaneous change in microvascular diameter which can mirror physiological conditions of other part in human body, and its frequency is about 0.001 ~ 0.2 Hz. Rhythmical contraction in vascular smooth muscles form the basis of vasomotion, and it is primarily driven by the oscillatory release of calcium flux. On the other hand, calcium releasing can be activated by either applying an acoustic shear wave on endothelial cells and muscle cells or stretching on smooth muscle cells [1,2]. However, the mechanisms contributing to the vasomotion are still not well known. Traditionally the heart beating is considered as regular rhythm with constant heart period. In fact, the heart rate is a nonstationary signal; its variation may contain indicators of current disease, or warnings about impending cardiac diseases [3]. As shown in Fig. 1(a), the measured heart period by Laser Doppler flowmetry is changing with time, which indicates that the heart period varies from beat to beat. As the blood circulation system is predominantly governed by heart beating, it is possible that vasomotion is related to heartbeat. Thus, we speculate that the low frequency of vasomotion is induced by the variation of heart period. Hence in this research, we conduct numerical studies to understand the interaction between vasomotion and the variation of heat period.

Methods

The three-connected-tubes vessel model (model A) shown in Fig .1(b) contains five tubes simplified from palmar arteries. Another simple model with a single straight tube (model B) is also studied as comparison. In numerical simulation, the inlet velocity is based on real measured profile and variation of heart period. As comparison, the inlet velocity with 1Hz sinusoidal signal is also studied.

Results

The mean wavelet results are computed as the time averaged power spectrum from wavelet analyses and demonstrated in Fig.1 (c) and Fig.1 (d). With 1Hz sinusoidal signal input, model A can only produce 1Hz frequency; with varied heart period input, we capture lower frequencies at ~0.1Hz which is similar to vasomotion. As comparison, for model B with varied heart period input, we only get the results of ~1Hz and 0.2Hz that is related to input frequencies. Therefore, we could conclude that the variation of heart period and interconnected micro vasculature induce the low frequency blood flow oscillation, and this low frequency flow oscillation stimulates the release of calcium flux which may result in vasomotion.

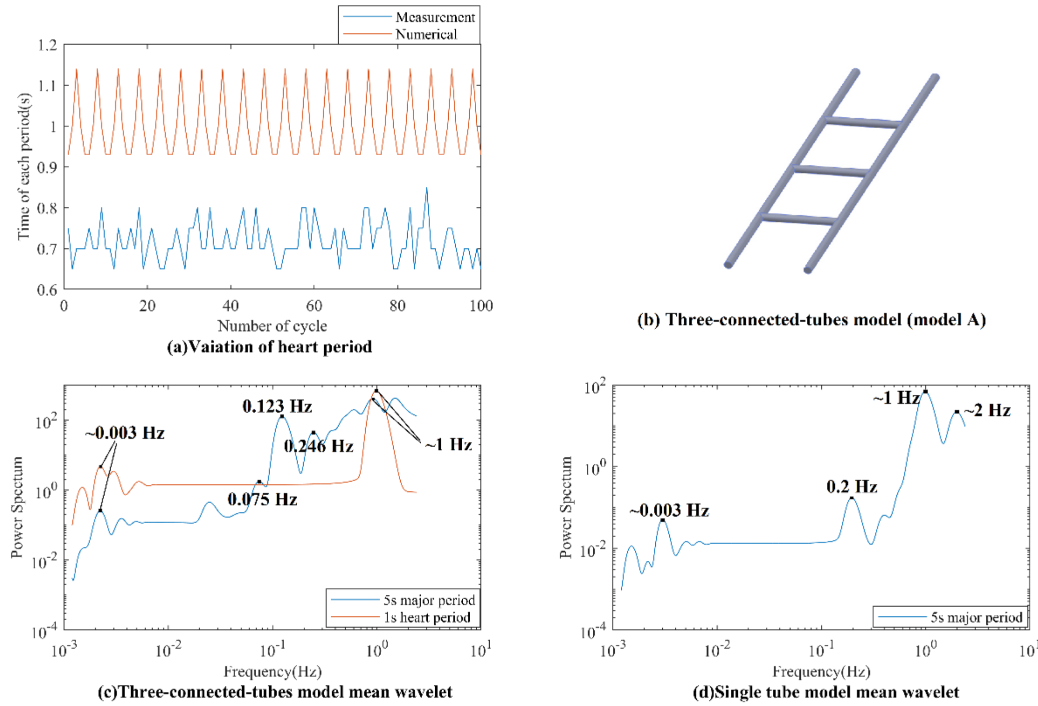

Fig. 1 Numerical model and results

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References

[1] Davis, M.J., et.al. (1992). *Am. J. Physiol*.263(4), H1292-H1299.

[2] Li, G., et.al. (2011). *Pflugers Archiv*. *462*(4), 587.

[3] Acharya, U.R., et.al. (2006). *Med. Biol. Eng. Comput*. *44*(12), 1031-1051.