PRESSURE WAVE PROPAGATION IN THE ARTERIAL SYSTEM OF THE UPPER EXTREMITY AND PULSE WAVE DIAGNOSTICS

Natalya N. Kizilova

Department of Theoretical mechanics, Kharkov National University, Ukraine

INTRODUCTION

Pulse diagnosis method of the traditional oriental medicine gives an accurate and sensible tool for the early diagnosis of the whole body state, its regulatory systems and inner organ diseases, treatment prescribing, disease correction and prevention (Hammer, 2001). Palpating the pulse of the radial arteries at the wrists and at other sites of the body is based on the consecutive compressions of the arteries and some pulse parameters estimation. A novel pulse diagnosis method that is based on the concept of the so-called resonant frequencies of the vascular beds of inner organs is proposed recently. Any changes in the parameters of intraorgan microcirculation cause noticeable alterations of the amplitudes of resonant harmonics of vasculatures with and without anastomoses (Kizilova, 2003). Reasonable biomechanical interpretation of the pulse diagnosis methods, more particularly the inner organ state diagnosis is absent at the moment.

MODEL AND EQUATIONS

The arterial system of the upper extremity is modeled as a system of viscoelastic tubes filled with viscous incompressible fluid and the special topology is taken into account (fig.1). An axisymmetric wave motion of the fluid is considered. The governing equations of the fluid motion in each tube in one-dimensional form have been taken to be the following (Pedley, 1980):

$$\frac{\partial S_i}{\partial t} + \frac{\partial}{\partial x}(S_i U_i) = 0 \qquad (1)$$

$$\frac{\partial U_i}{\partial t} + U_i\left(\frac{\partial U_i}{\partial x} + \frac{8pn}{S_i}\right) + \frac{1}{r}\frac{\partial P_i}{\partial x} = 0 \qquad (2)$$

$$P_i - P_{i_e} = F(S_i) \qquad (3)$$

where x is the longitudinal coordinate measured along each tube from its inlet, i is the number of the tube, $S_i(t,x)$ is the cross-sectional area, $U_i(t,x)$ is the longitudinal velocity, $P_i(t,x)$ and P_{i_e} are inner and outer pressures. Pressure and volumetric rate continuity conditions are considered at each bifurcation of the tubes.

The solution of the linearized system (1)-(3) which describes the propagation of small perturbations in forward and backward directions is considered. The nonlinear system for pressure amplitudes and reflection coefficients in each tube is solved by numerical methods. Computer simulation of the pressure picture in the segment AB at different outer pressure distributions $P_e(x)$ is carried out.

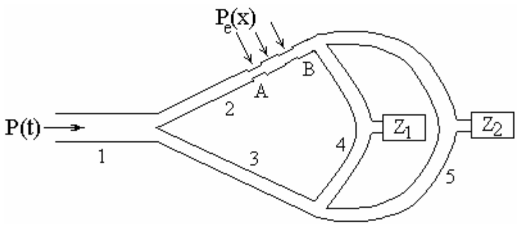

Figure 1: Arteries of the upper extremity and the outer pressure distribution on the radial artery at the wrist including the brachial (1), radial (2), ulnar (3) arteries, deep (4) and superficial (5) arcs terminated in Windkesses with impedances $Z_{1,2}$.

RESULTS

Separate harmonics of the input pressure $P(t)$ can be amplified due to the variation of $P_e(x)$, the length and position of the segment AB. The additional wave propagation through the arcs leads to increasing the amplitudes of the main and dicrotic peaks of the pulse wave registered along AB. When $P(t)$ contains the information on the normal/pathological state of the inner organs due to the imposition of the waves reflected by the vascular beds of different organs, the separation of the resonance harmonics of the organs can be reached by the special non-uniform compression of the radial artery along AB.

REFERENCES

Hammer L., Chinese Pulse Diagnosis: A Contemporary Approach, 2001.

Kizilova N.N., J.Chinese Institite of Engineers 26:869-880, 2003.

Pedley T., The fluid mechanics of large blood vessels, 1980.

Wang Y.Y. *et al*, Circulation Research, 69:246-249, 1991.