Biomedical & Translational Science

Short Communication

Strain Energy in Active Elastic Arteries

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According to the classic Windkessel model, arterial system is assumed to be an elastic chamber that only acts as a channel and buffer for blood circulation, and heart is the only power source. The Studies have shown that the heart of a healthy person at rest pumps 5 - 6 L/min of blood, and the amount of blood needed is 7.6 - 9.1×10^3 Kg per day, however, cardiac output power at rest is only about 0.9 to 1.9 W. It's impossible for the heart pump blood through the entire body by such low power. We believe that there are other sources of energy in the body for blood circulation, including that from the active elastic arterial system.

According to the circumferential stress-strain relationship, the area of triangle that enclosed by the dashed line in Figure 1A is the strain energy density increment (SEDI). The SEDI (Δu) between the systolic and diastolic periods can be approximated as:

$$\Delta u=\varphi^{2}(\alpha_s p_s-\alpha_d p_d)2/8E \qquad (1)$$

Where

φ is defined as the expansion constraint coefficient,

P_s and P_d represent systolic blood pressure (SBP), diastolic blood pressure (DBP),

E is stiffness (circumferential elastic modulus) of the aorta,

In which

$$\alpha_s = D_s / h_s - 2,\ \ \alpha_s = D_s / h_s - 2, \qquad (2)$$

Where

D_s, D_d, h_s and h_d are the outer diameters and wall thicknesses of the aorta in systole and diastole, respectively.

From the formula (1), it can be seen that the SEDI is positively correlated with the squared value of pulse pressure, and negatively correlated with the circumferential elastic modulus. Fig. 1B is the relationship between SEDI and DBP/SBP in artery. It can be seen that the SEDI for the proximal artery is higher than that for the distal artery, and the ascending aorta stores the most strain energy. It is due to the different elasticity of different parts of artery. The SEDI achieves the maximum at the appropriate SBP/DBP, not when the SBP/DBP is too high or too low.

Our understanding of blood circulation is that the heart provides the initial kinetic energy, then, the potential energy (i.e. strain energy) of arterial vessels drives blood flow, and the dissipated energy is the work done by blood on shear force of vascular wall. This formula can be used to evaluate arterial blood transfusion capacity by using biochemical parameters obtained from routine physical examinations, and contributes to the prevention, diagnosis and treatment of cardiovascular disease.

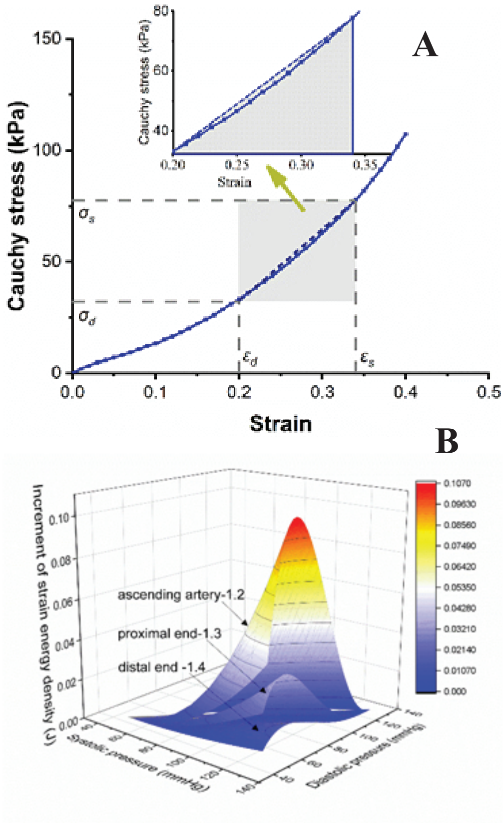

Figure.1 *Circumferential stress-strain relationship (A) and strain energy density increment of aorta (B)*

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