Biomedical & Translational Science

Short Communication

The Blood Demand of Organs and Tissues is Highly Correlated with Blood Pressure

Jifeng Dai[1], Heming Cheng[2*]

[1]*Faculty of Mechanics and Civil Engineering, Kunming University of Science and Technology, Kunming, China.*
[2]*Department of Mechanics, Kunming University of Science and Technology, Kunming, China.*

Correspondence
Heming Cheng
Department of Mechanics, Kunming University of Science and Technology, Kunming, China
E-mail: chengheming@kust.edu.cn

- Received Date: 07 Mar 2023
- Accepted Date: 14 Mar 2023
- Publication Date: 21 Mar 2023

Hypertension is a main risk factor for many cardiovascular and cerebrovascular diseases such as stroke and myocardial infarction, threatening the health of millions of people globally every year. The current research on hypertension is insufficient. For instance, in terms of research methods, most studies were carried out by the collection of clinical data for meta-analysis or epidemiological studies, and in clinical practices, the treatment of hypertension is mainly through antihypertensive drugs for the regulation and control of blood pressure. However, from the perspective of clinical diagnosis and treatment effects, drug compliance of patients is poor and side effects of antihypertensive drugs also bring many impacts on the patient's life quality, such as diuretic drugs can cause elevated blood uric acid and low potassium, and so on. To sum up, the current treatment of hypertension failed to pay attention to the blood demand and blood pressure of hypertension patients. In fact, the blood demand of target organs and tissues is highly correlated with hypertension.

Currently, the heart has been considered the sole engine for promoting blood flow. In fact, the in vivo pre-stretched aorta also plays a significant role in driving blood flow due to its elastic strain energy. Based on this situation, we proposed a new multi-parameter fluid-structure coupling model, which combines aortic structural parameters and functional parameters measured by clinical practices to quantitatively calculate the contribution of the aorta to promote blood flow [1]. The blood flow can be expressed as:

:

$$Q = Q_0 + \Delta Q = (1+\varphi\frac{Dp}{Eh})Af\sqrt{\frac{\varphi h}{D\gamma(1+\beta)}(\alpha_s p_s - \alpha_d p_d} \quad (1)$$

where, A_f is the initial blood flow area of the aorta $\alpha_s = D_s/h_s$ and $\alpha_d = D_d/h_d$, E is the circumferential elastic modulus of the aortic artery, D_s and Dd are the outer diameter of the aorta and h_s, h_d are the wall thickness in the cardiac systolic and diastolic period, respectively. γ means per-unit volume weight of blood.

The average flow volume $\bar{Q}$ per minute through the cross section of the vessel can be calculated by the equation as follows:

$$\bar{Q} = n\left(1+\varphi\frac{Dp}{Eh}\right)A_f\sqrt{\frac{\varphi h}{D\lambda(1+\beta)}(\alpha_s p_s - \alpha_d p_d} \quad (2)$$

where n is the pulse frequency. This model expresses the coupling effect of multiple physiological variables on blood supply. It should be noted that the calculation of blood flow volume is an approximate analytical solution to the average velocity, rather than a numerical solution. This new fluid-structure coupling model can be used to analyze the changes in blood flow caused by abnormal blood pressure, as well as aortic structural parameters and physiological parameters in patients with hypertension.

Hypertension is usually classified as isolated diastolic hypertension (IDH), isolated systolic hypertension (ISH), and combined hypertension (SDH) according to different characteristics of elevated blood pressure. The incidence, characteristics and affected population of the subtypes of hypertension are also different. For young people, especially those under 50 years old, the diagnosis of hypertension is mainly IDH. Also, epidemiological studies have shown that IDH is a risk factor for cardiovascular disease in young people but not in the elderly. For young people with good arterial elasticity (the value of elastic modulus E is small), the ability of the aorta to transmit blood is strong. Unhealthy diet, obesity, staying up late and high pressure will increase the body's blood demand and cause an increase in peripheral vascular resistance, also, diastolic blood pressure (DBP) is easily affected to increase under the influence of increased peripheral resistance. According to the expression of mean blood pressure, MBP=(2DBP+SBP)/3, the effect of DBP on average blood pressure is greater than that of systolic blood pressure (SBP). Therefore, with formula (2), through comparing of the relationship between blood supply and blood pressure, it is not difficult to find out that IDH is commonly found in young people. However, for the elderly, ISH and SDH

Citation: Dai J, Cheng H. The Blood Demand of Organs and Tissues is Highly Correlated with Blood Pressure . Biomed Transl Sci. 2023;3(1):1-2.

are more common. As the effect of ageing and other factors, arterial elastic decreases gradually, thus impairing the ability of the aorta to promote blood flow. According to formula (2), it can be seen that in order to guarantee sufficient blood for target organs and tissues, blood pressure has to be raised, either the SBP alone or both the DBP and the SBP simultaneously. Therefore, for the elderly with hypertension, ISH and SDH are more common. Besides, some scholars also regard IDH as the early stage of hypertension, and it has been reported that long-term IDH can also develop into ISH or SDH. This phenomenon can be explained by the fact that under the influence of long-term IDH, the roughness of the inner wall of arteries and thickness of the artery wall would increase gradually, which leads to decreased arterial elasticity (increased value of elastic modulus E). According to formula (2), when other physiological parameters remain unchanged, the increased vascular elastic modulus will lead to a significant decrease in blood supply Q. In order to ensure the blood demand for target organs and tissues, SBP or both the DBP and SBP would rise inevitably, and thus IDH will develop into ISH or SDH gradually.

Although the pathogenesis of hypertension is complex, many factors are involved such as endocrine regulation, hormone regulation, body fluid regulation and others. Blood supply, as the core factor that connects blood pressure, alters as well as the blood demand for target organs and tissues, should not be ignored. By using the new fluid-structure coupling model which combines physiological and structural parameters, personalized parameters of patients can be used to quantitatively calculate the body's blood supply of hypertension patients. Thus, this new model can be used to explain the pathogenesis and transformation mechanism of hypertension. Therefore, it can be concluded that the blood demand of organs and tissues is highly correlated with hypertension. Therefore, this study is hopeful to serve as new knowledge for clinical diagnosis and treatment of hypertension.

References

1. Cheng H, Li G, Dai J, et al. A fluid-structure interaction model accounting arterial vessels as a key part of the blood-flow engine for the analysis of cardiovascular diseases. Front Bioeng Biotechnol. 2022;10:981187.