Numerical Reproduction of Hemodynamic Change Induced by Acupuncture to ST-36

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Abstract : Acupuncture therapy is one of the treatments in traditional Chinese medicine. Recently, some reports have shown the effectiveness of acupuncture. However, its full acceptance has been hindered by the lack of understanding on mechanism of the therapy. Acupuncture applied to Zusanli (ST-36) enhances blood flow volume in superior mesenteric artery (SMA), yielding peripheral vascular resistance – regulated blood flow of SMA dominated by the parasympathetic system and inhibition of sympathetic system. In this study, a lumped-parameter approximation model of blood flow in the systemic arteries was developed. This model was extremely simple, consisting of the aorta, carotid arteries, arteries of the four limbs and SMA, and their peripheral vascular resistances. Here, the individual artery was simplified to a tapered tube and the resistances were modelled by a linear resistance. We numerically investigated contribution of the peripheral vascular resistance of SMA to the systemic blood distribution using this model. In addition to the upstream end of the model, which correlates with the left ventricle, two types of boundary condition were applied; mean left ventricular pressure which correlates with blood pressure (BP) and mean cardiac output which corresponds to cardiac index (CI). We examined it to reproduce the experimentally obtained hemodynamic change, in terms of the ratio of the aforementioned hemodynamic parameters from their initial values before the acupuncture, by regulating the peripheral vascular resistances and the upstream boundary condition. First, only the peripheral vascular resistance of SMA was changed to show contribution of the resistance to the change in blood flow volume in SMA, expecting reproduction of the experimentally obtained change. It was found, however, this was not enough to reproduce the experimental result. Then, we also changed the resistances of the other arteries together with the value given at upstream boundary. Here, the resistances of the other arteries were changed simultaneously in the same amount. Consequently, we successfully reproduced the hemodynamic change to find that regulation of the upstream boundary condition to the value experimentally obtained after the stimulation is necessary for the reproduction, though statistically significant changes in BP and CI were not observed in the experiment. It is generally known that sympathetic and parasympathetic tones take part in regulation of whole the systemic circulation including the cardiac function. The present result indicates that stimulation to ST-36 could induce vasodilation of peripheral circulation of SMA and vasoconstriction of that of other arteries. In addition, it implies that experimentally obtained small changes in BP and CI induced by the acupuncture may be involved in the therapeutic response.

Keywords : acupuncture, hemodynamics, lumped-parameter approximation, modeling, systemic vascular resistance

Conference Title : ICBEBS 2015 : International Conference on Biological Engineering and Bionatural Sciences

Conference Location : Dubai, United Arab Emirates

Conference Dates : September 13-15, 2015