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EDITORIAL

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Did you know developing quantitative pulse diagnosis with realistic haemodynamic theory can pave a way for future personalized health care

1 | INTRODUCTION

Helping everyone prevent or detect disease early is an important goal of health care. To achieve this goal, we need low-cost, non-invasive and easy-to-implement diagnostics; the measured parameters must be sensitive to reflect small changes in a person's physiological condition, and the results can be quantified.

The arterial pulse was known as a vital sign to the ancient Chinese, Greeks, Romans and Indians, who employed its diagnostic value for thousands of years.[1] Traditional Chinese medicine described the pulse feeling in term of conditions of different meridians.[2] Galen advocated palpating the pulse at the wrist and has described at length the variations of the pulse in different situations.[3]

In order to build a quantitative approach to this personalized health care, Wang (1944-2017) and his team dedicated to the modernization of traditional pulse diagnosis and have reported many conclusive results.[4]

2 | SCIENTIFIC RATIONALE FOR ARTERIAL PULSE DIAGNOSIS

Since Euler, most haemodynamic studies consider the cardiovascular system as a flow system and described the distributed oscillatory motion of the arterial system as a transient travelling wave associated with the axial motion of the blood induced by the instantaneous heartbeat. The blood flow wave and the pressure wave, or their ratio, were always considered simultaneously. The correlation between the coupled physiological condition of the whole cardiovascular system with the pulsatile motion of the peripheral arterial wall, or the radial arterial pressure pulse that is palpated since ancient time, cannot be explained by this historical flow system model.

However, we took the cardiovascular system as a compound irrigation device[5] and decomposed it into subsystems with specific ranks and different mechanisms.[6] In most region of the arterial system, as proposed by Galen, the primary power carrier is the elastic arterial wall, not the blood; and the coupled distributed arterial oscillatory motion was governed directly by a low dissipative radial momentum equation with the longitudinal tension as the major force to pass over the power provided by the repeated heartbeat and the feedback from subsystems. Through arterial resonance to enhance its power transformation efficiency, the cardiovascular system can quickly reach a steady state and the coupled physiological condition of the whole cardiovascular system can be analysed by the eigenwave modes of the whole arterial system and reflected in the distributed steady arterial pulse at any site.[5,6]

3 | THE BENEFIT OF PALPATING THE PERIPHERAL ARTERIAL PRESSURE PULSE

Why is it important that the arterial pressure pulse at the peripheral sites can reveal the coupled physiological condition of the whole cardiovascular system?

It solves the controversy of many researchers as to whether the incident pressure wave from the left ventricle can be analysed from patterns of peripheral arterial pressure pulse. It justifies that the systolic and diastolic blood pressure at the brachial artery may provide useful information about the cardiovascular system, it also offers a scientific basis for pulse diagnosis employed since ancient times. Measuring arterial pulses at the peripheral site rather than at the central site is beneficial, because it is non-invasive and low cost.

Flow pulse measurements are not easy to perform and different flow patterns were regularly seen. However, anatomy of arterial systems reveals that the major function of the heart is not to emit waves associated with the axial blood motion, flow pulses actually play a minor role in the cardiovascular system and do not need to be considered together with pressure pulses at the first step. Therefore, palpating the peripheral pressure pulse alone makes the pulse diagnosis easy to perform with high precision.

4 | NECESSITY AND ADVANTAGES OF ANALYSING THE MEASURED PULSE BY FOURIER HARMONIC SERIES

An ongoing debate exists between two different paradigms: wave analysis in the frequency and time domains.[7] As the cardiovascular system reaches the steady oscillatory state,

the arterial pulse becomes a periodic function. Translation of a periodic pulse into a numerical Fourier series is an exact way of defining the pulsation, hence analysing the harmonic spectrum of the measured arterial pulse enables us to get the most precise information. As Parker pointed out,[1] this has been clearly stated in the introduction of the second edition of McDonald's book: "The main developments since 1950 have been in terms of treating the whole arterial system as being in a steady-state oscillation produced by the regularly repeated beat of the heart. This describes the pressure pulse as a collection of sinusoidal waves of frequencies determined by the harmonic, or Fourier, series."

The cardiovascular system, being a highly efficient operating system, has the ability to respond to the feedback from all parts of the system, and the adjustments of its power spectrum can quickly reach any site of the arterial system.

Furthermore, due to the specific natural frequencies and the specific connecting aortic sites of different organs, we have shown that the conditions of organs or cardiovascular diseases are correlated with specific frequency components of the pulse spectrum.[4] Thus, harmonic spectrum analysis has a further advantage of indirectly providing information about the conditions of different organs.

5 | APPLICATION OF THE PULSE DIAGNOSIS

The harmonic analysis of arterial pulses has been used by researchers to study the frequency characteristics of organs; to explore the meridian theory in traditional Chinese medicine; to find the effect of herbs, coffee, acupunctures,[4] fasting[8] and exercise.[9] It has also been used to link the harmonic spectrum with some cardiovascular risk factors in clinical monitoring.[4,10]

Quantitative analysis of the arterial pulse applied to personal daily activities can verify their effectiveness for individuals seeking to live a healthy life. Two thousand years ago, Greek Physician Galen has stressed the importance of feeling the pulse in health and described at length the variations of the pulse due to age, sex, season, exercise, sleep, pregnancy, bathing, food and wine.[3] We suggest that incorporating scientific methodologies into traditional pulse diagnosis may be applied to study the effects of any daily activity for each individual. This technique has a high potential to be used as a non-invasive method for health-preserving and quality-of-life-preserving decision supports. It may also help to explore principles for the reaction of the cardiovascular system to redistribute its power or blood as facing different situations in life. Hence, we conclude that developing quantitative pulse diagnosis with realistic haemodynamic theory can pave a way for future personalized health care.

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CONFLICT OF INTEREST

There is no conflict of interest to declare

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