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Perspective Questions of Mechanopulsography

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Abstract

Among the methods based on the diagnosis of the pulse, the most informative method is sphymography, where the sensors measure mechanical fluctuations of the arterial wall. This allows non-invasive methods to obtain undistorted high-resolution pulse waves and to perform a mathematical analysis of their contours (high resolution sphygmography [1,2]). It should be noted that the key to the development of this direction is the creation of a perfect pulse wave sensor, in which the positioning problem is partially or completely overcome. To date, all attempts by researchers in this direction have not led to the emergence of a solution that could be considered practically useful. Some progress has been made in the Institute of Experimental Physics of the Russian Academy of Sciences, where more than 25 years work is under way on mechanopulseography using fiber-optic probe transducers.

Keywords: Sphygmography; Mechanopulseography; Sphigmocor

Introduction

Figure 1 shows the sensor modules of the axial and radial type, created in the IMASh RAS on the basis of fiber-optic collector probes, which can be recommended for pulse wave recording. Modules can be solved in both wired and wireless, more convenient for the doctor. Based on this development, a method for determining the velocity of propagation of the central pulse wave (SRVV) near the aorta was proposed, based on a two-channel pulse wave with a radial and carotid artery. The calculation procedure is based on the assumption that the SWR in the region of the central pulse differs from the peripheral PSVB. Pulse wave (PW) recordings, synchronously recorded by two sensors on one of the volunteers, are shown in Figure 2.

The result of the application of this development was its validation with the help of Australian equipment firm "Sphigmocor", occupying a leading place in applanation tonometry. The validation was carried out by the specialists of RK NPK Roszdrav and gave positive results [3]. It should be noted that in comparison with the Australian analog, the equipment of IMASh RAS has the following advantages: individual recording of the propagation velocity of PV, wireless connection of the sensor to the computer. Another close analogue is the equipment of the Singapore company "HelthStats", executed in a miniature version in the form of a wristwatch. It claims to determine the arterial pressure in the shoulder (without the cuff) and the definition of CASP. This development is significantly inferior to the IMASh RAS equipment because of the low sensitivity of the sensors. In addition, it should be noted that the manufacturers mentioned above did not affect the sensor positioning problem, therefore their products are far from perfect. Having the technology of fabricating a fiber optic PT sensor that meets the requirements of high spatial and temporal resolution, the researchers of the IMASh Biomechanics Division of the Russian Academy of Sciences have outlined the development of mechanopulseography, not only with the development of the above-mentioned measuring modules, but also with the solution of the positioning problem due to multipoint sensors [4,5]. Prospects for the development of this direction can be divided into hardware, software and functional (expansion of functions).

The first point concerns the development of more miniature and more versatile measuring modules using 3-D type technology and multi-point sensors. The second position implies the improvement of algorithms in terms of increasing the accuracy of calculations, taking into account the individual characteristics of this organism and applying a mathematical apparatus with elements of artificial intelligence. Functional technology can develop in the following areas: 1) non-invasive determination of blood pressure in a man-free manner; 2) determination of the parameters of the central pulse: CASP, indices of augmentation, speed of distribution of PV in the shoulder and aorta; 3) non-invasive measurement of blood sugar concentration; 4) biometrics-solving problems of identity identification, information protection, neural network technologies; 5) the study of the nature of meridional diagnostics and therapy, the study of the appointment of heart rate variability in terms of management of local blood flow, the development of treatment methods by modulating the heart rate and targeted delivery of blood and drugs.

Let's briefly dwell on each of these directions. Non-invasive determination of blood pressure (BP) - One of the most common to date examinations of the cardiovascular system of patients, both in medical practice and in the domestic sphere for self-monitoring. For this purpose, traditionally used cuff tonometers with vascular transmission. Possessing varying degrees of accuracy, the cuffed blood pressure gauges, however, have become firmly established in the practice of controlling blood pressure in both doctors (Korotkov's tonometer) and in patients who want to know their blood pressure (mainly automatic tonometers-oscillometers). A fundamentally new step in this area is the use of no-mange methods, one of which is Arterial tonometry. In this technique, the analysis of the pulsed wave (PW) contour is used to determine blood pressure, followed by a recalculation into blood pressure. Numerous attempts have been made in the literature to create an instrument capable of providing diagnostic information on the state of the cardiovascular system and other body systems in terms of the pulse wave parameters [1-3]. To study the pulse was once aimed and ancient Tibetan pulsodiagnosis, accompanied by palpation examination. It was used not only by well-known doctors

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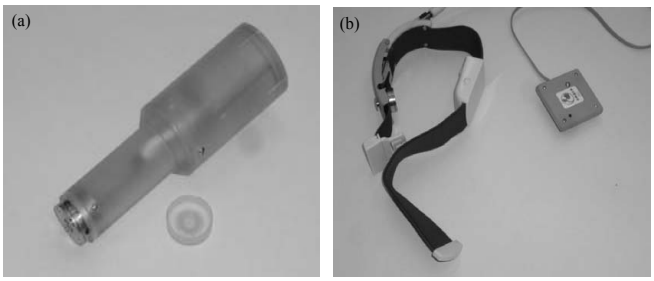

Figure 1: Wireless modules for recording PV: an axial module for fixing by hand; B-radial module for fixing under the harness.

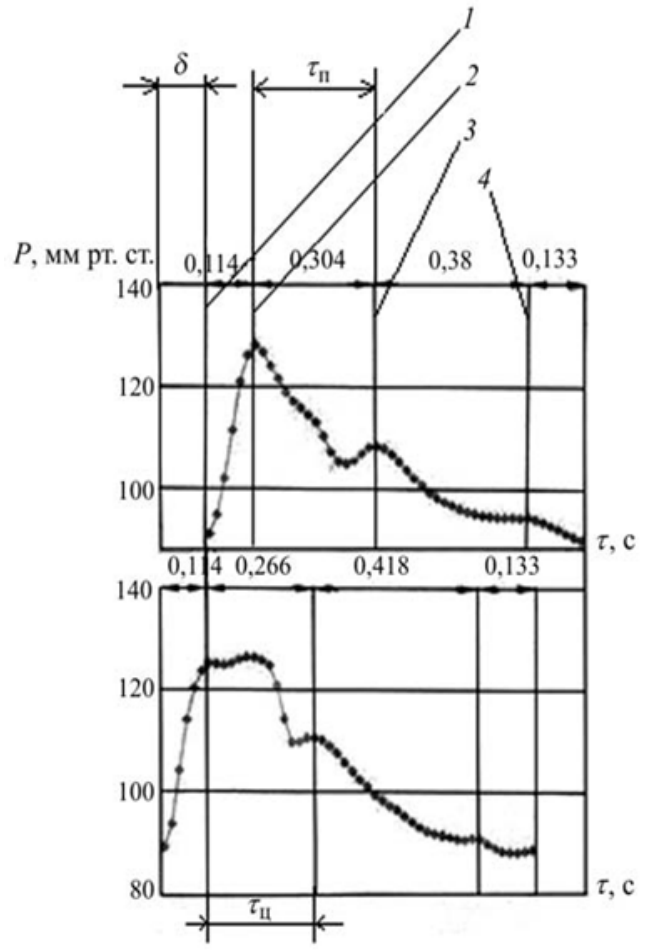

Figure 2: Pulse waves synchronously shot from the radial (top and bottom (s) of arteries with the marking of the duration of events: 1-beginning of the PV, 2-reaching the maximum pressure, 3-first response of the posterior stingray, and 4-second response of the posterior stingray.

of antiquity. Tactile examination of the pulse is also used in European modern medicine. However, only modern instruments equipped with sensors and processor services can provide an objective result in the study of the pulse wave.

It should be noted that the ability to observe a non-invasive pulse wave gives the doctor (cardiologist or therapist) valuable information for a quick diagnosis, without resorting to a lengthy examination in various rooms. In addition, it allows you to come close to solving the problem of creating a non-manometer tonometer (arterial tonometer), suitable for measuring and monitoring blood pressure (BP), i.e., In exchange for bulky Korotkov's automaton monitors, carried in a shoulder bag or fastened to the belt, patients will be able to use a miniature modern device that resembles a wristwatch.

At the moment, a mobile medical device has been created in the IMASh of the Russian Academy of Sciences, which makes it possible to determine the peripheral resistance of blood vessels, blood pressure, CASP, heart rate and stress index according to the parameters of IV. The problems of positioning the sensor and maintaining the medical accuracy of the blood pressure measurement are successfully solved. It should be noted that the search for CASP and central parameters has been successfully validated by the equipment of the Australian firm "Sphigmocor" [3]. Thus, the second position of the list of directions mentioned above has been achieved.

Receiving a non-invasively high-quality pulse wave by changing the new sensors (high resolution sphygmography) gives grounds for expanding the functions of a mechanopulsograph, namely, for Determination of sugar content without puncture. Solving this problem will save a huge number of people from daily anguish, so large funds are allocated all over the world for search works. So, the sources say that Apple has been engaged in this initiative for at least five years and the development has been allocated up to a billion dollars. However, all attempts to create such a device have suffered a fiasco [6].

The IMASh of the Russian Academy of Sciences outlines ways to solve this problem on the basis of a combined mechanopulsograph using the already verified algorithms for determining blood pressure and the dependence of the peripheral resistance of blood vessels on the sugar level, determined experimentally, in the cycle of measuring the sugar level. The experiments are in an active phase and need the support of investors.

The next direction in the development of high resolution sphygmograms is biometrics. The use of signals received from the human body to identify an individual has long attracted the attention of researchers. Quite recently an article appeared in the open press, which describes the successful use of the ECG signal to solve the problem of identity identification. However, it is well known that obtaining a qualitative ECG signal is associated with certain difficulties due to its small size and special requirements for the application of electrodes. In this sense, the signal from the mechanocouple sorcerer is much more comfortable for the design of mobile devices (for example, the positioning of the MF sensor in a wristwatch type device). In addition, the PV signal is significantly richer for analysis, hence it is more convenient to process. In the department of biomechanics of IMASh RAS, work was begun on the formation of a database for subsequent calculations using artificial neural networks in connection with the identification of a person in the mechanopulsegram. At the moment, the private task of recognizing the image of the pulse wave in nine basic parameters characterizing the biological age and the functional state of the cardiovascular system has been solved.

In conclusion, we note that with the help of mechanopulsography, a preliminary survey of a group of volunteers for the analysis of heart rate variability (HRV) was conducted in connection with the development of a hypothesis about targeted delivery of blood (or local increase in blood flow). It was suggested that the cardiac rhythm modulation (in particular, "respiratory arrhythmia") observed on integrogystograms is nothing more than a natural solution to optimize blood flow in connection with the minimal energy expenditure during cardiac muscle work [5].

If the idea of the nature of the HRV is correct, then the secret of the meridional connections on which all reflexotherapy and, in general, oriental medicine is based, is opened. Particularly understandable is the relationship between the impact on bioactive points for acupuncture or pressurization, as well as other ways of influencing them with a beneficial therapeutic effect, which is most likely due to an increase in local blood flow. It remains only on statistically reliable samples to prove the validity of the above assumptions. At the same time, there is a serious prospect of improving the therapeutic effect in connection with the possibility of increasing the targeted delivery of blood and blood products. It is natural to assume that a certain role in this can be played by the improvement of technologies capable of providing the required modulation of the heart rhythm. This includes various controlled massagers (including electromassagers), as well as devices such as pacemakers, capable of imposing not only the basic heart rate (HR), but also its modulation.

In conclusion, it should be noted that the promise of mechanopulseography is, as can be seen from the above-mentioned directions, not only in the development of applanation tonometry, but also in the formation of new medical care systems using modern information technologies, including the Internet and cellular telephony. See you at the online clinic.

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