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Methodological property for study of resistive arteries resistance as diagnostic method in arterial hypertension

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Abstract

The article draws on resistive vessels (vessels of resistance), which include precapillary (small arteries, arterioles, precapillary sphincters) and postcapillary (venules and small veins) vessels. The article discusses a new non-invasive method for studying resistive arteries. The article considers their diagnostic role in arterial hypertension.

KEY WORDS: hypertension; resistive artery; resistant index

Introduction

In the section of the new recommendations of the European Societies of Cardiology and Arterial Hypertension (2018 ESC/ESH Guidelines for the management of arterial hypertension) [1] on instrumental methods for the treatment of arterial hypertension – "Bevice-Based-Treatment" (DBT) it is recommended to measure systolic central aortic pressure for accurate differentiation of false-positive hypertension, for the diagnosis of isolated systolic arterial hypertension in young people. In this cohort, increased pulse pressure amplification is observed, as a result of which systolic blood pressure, measured by manometers, often does not correspond to central aortic pressure. Central aortic pressure measurements will make it possible to avoid diagnostic inaccuracies, reduce the use of hypertensive drugs, which will positively affect the occupational health of the younger generation.

It should be noted that today there are already available and relatively inexpensive diagnostic techniques that allow measuring central aortic pressure based on the analysis of pulse waves in a peripheral artery (in our case, in resistive arteries) when they are transformed into aortic pulse waves using a special mathematical function transfer (general transfer function) proposed by O'Rourke (2011) [2,3,4,5].

In the circulatory system, resistive arteries play a particularly important role, which they perform, both under normal and pathological conditions. Being a kind of "faucets" located on the border of the central and peripheral circulation, they are involved in the regulation of the most important physiological parameters of the circulatory system [6]. The constancy of the level of total arterial pressure, on which the normal blood supply of any organs and tissues depends, is largely due to the peripheral resistance of the circulatory system and depends on the "tone" of the resistive arteries [7].

On the other hand, microcirculation in any organs and tissues, in turn, is determined by the functional state of the corresponding resistive arteries, which determine the resistance in their lumen [8,9]. In addition, the development of various pathological and compensatory processes in the system of regional blood circulation and microcirculation is associated with resistive arteries. In view of all this, it is the resistive arteries of the circulatory system that should be the subject of diagnostic studies, as well as therapeutic effects in various types of pathologies.

Material and methods

The work is devoted to the description of the original non-invasive method for assessing the functional state of resistive arteries, developed in the laboratory of rheology and diagnostic and analytical services of Ivane Beritashvili Center of Experimental Biomedicine, as well as some results of studies, concretely we have presented one clinical case of isolated arterial hypertension in a young person.

The principle of the technique used in the work for assessing the functional state of resistive arteries is based on the study of postischemic (reactive) hyperemia resulting from a standard stop of local blood flow lasting one minute. Since, at an unchanged level of total arterial and venous pressure, the value of the blood flow measured in the radial artery depends precisely on the functional state of the corresponding resistive arteries formed during its branching, one can judge their functional state by the blood flow velocity recorded in them.

For a correct assessment of the functional state of the resistive arteries, the technique used must meet the following requirements: a) the data obtained must be direct (not indirect) and as accurate as possible; b) they must be quantitative; c) possible measurement errors and artifacts should be kept to a minimum; d) the technique should be easily used on an outpatient basis and does not require special and lengthy training of the relevant medical personnel.

At the same time, under conditions of a constant level of total arterial pressure, the blood flow velocity measured in the radial artery reflects the functional state of precisely the resistive arteries of the human hand. In view of this, the dynamics of changes in the velocity of blood flow in the radial artery after its standard stop during the development of postischemic hyperemia can be used to judge the functional state of branching of the resistive arteries in the human hand [9].

The measurement of blood flow velocity in the radial artery of the subjects was carried out in this study using an ultrasound device, whose operation is based on the Doppler effect. As is known, the essence of this effect consists in a specific change in the frequency of ultrasound oscillations depending on the speed of the source of sound oscillations. By directing an ultrasonic signal to the radial artery at an angle of 45° and registering the reflection of this signal from the erythrocytes of the flowing blood, it is possible to determine the linear velocity of blood flow in the corresponding resistive arteries formed during branching by the frequency shift of the incident and reflected signals.

In this work, we used an ultrasonic device with a frequency of 4 MG “Dop 8/4” (Germany) with a built-in recorder.

To register normal (background) blood flow in the radial artery, the sensor is installed in the wrist area, in the place where the pulsation of this artery is maximum audible.

Then we increased the pressure in the sphygmomanometer cuff applied to the brachial artery and stopped the blood flow in the hand for 1 minute. After that, we quickly reduced the pressure in the cuff to zero. During the test, we recorded the blood flow and its stop using the Doppler blood flow apparatus. Carrying out such functional tests is easily feasible in hospitals, on an outpatient basis, and does not create discomfort for patients.

To determine the functional state of resistive arteries, we introduced the concept of “resistance index”. The resistance index is the ratio of two areas. The first area is the space between the blood flow curve under normal (background) conditions and the zero line. The second area is the space between the curve of increased blood flow during hyperemia and the zero line, for a time interval t. The time interval t is equal to the period of return of the value of postischemic blood flow to its original value.

The second area reflects the amount of blood flowing through the radial artery. The curve is the sum of discrete values of blood flow velocity ($S=\sum V_i$).

The values of these two areas – before ischemia and after it – differ from one another, because in the postischemic period there is an increase in the intensity of blood flow.

Recovery time of increased blood flow to its original value reflects the functional state of the resistive arteries of the hand.

The resistance index is mathematically calculated using the following relationship:

$$\frac{S_1}{S_2} = \frac{\sum V_{1i}}{\sum V_{2i}}$$

S_1 is the area between the blood flow curve under normal (background) conditions and the zero line;

S_2 – the area between the blood flow curve in the postischemic period and the zero line;

V_{1i} – background blood flow velocity in the studied artery at point i, which takes discrete values over time t_1;

V_{2i} – blood flow velocity in the studied artery during postischemic hyperemia at point i, who takes discrete values over time t_2.

These mathematical calculations were performed using a special software package for the TAS-plus texture analysis system from Leitz (Germany).

In a young person, a functional test was performed using a new non-invasive method for studying blood flow. This test, as described above, compares post-schema flow with normal flow in the radial and brachial arteries.

This test shows the resistance of the resistive arteries in a young person. It was normal. In addition, the young man underwent a complete test for rheological status: in a venous blood sample, the deformability of erythrocytes, the ability to aggregate, plasma viscosity, blood viscosity, and deformability of leukocytes were examined. All listed parameters corresponded to normal values. Thus, the young man was determined to have a rare clinical case of false systolic hypertension. Determining the functional state of the resistive arteries is very important. This approach will eliminate many inaccuracies and diagnostic errors. False systolic hypertension is one of the most important problems of modern biomedicine and practical cardiology.

Increased heart rate is common in young people. Amplification (in cardiology) is an increase in blood pressure compared to the central pressure in the aorta (relative to the location of the counting point).

Results

In young people, the pressure measured in the brachial artery by the traditional method may be high, while the pressure in the central aorta may be normal. This is a very important fact.

Conclusion

We came to the conclusion that it is necessary to pay special attention to the resistance of resistive arteries in the list of diagnostic tools for arterial hypertension. This approach eliminates many inaccuracies and diagnostic errors. This is one of the most important problems of modern biomedicine and practical cardiology [10, 11].

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