CHANGES IN VISCOELASTIC PROPERTIES OF ARTERIES IN HEALTHY PERSONS BETWEEN 20 AND 40 YEARS OF AGE

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In healthy men and women aged 18-22 years (group 1) and 35-45 years (group 2) the velocity of spread of the pulse wave (V) remained constant. With an increase in age, V increases in large blood vessels of elastic type (V_e in group 1, 6.45 ± 0.12 m/sec and in group 2, 7.71 ± 0.16 m/sec), while in the distal arteries of the limbs, vessels of true muscular type, on the contrary, it falls (V_m for digital arteries 9.63 ± 0.36 and 7.49 ± 0.22 m/sec respectively). Along the course of the limb arteries it can be seen that V in the proximal segments is greater in group 2, and in the distal segments in group 1.

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Pathological investigations [1] have shown that atherosclerotic changes in the arteries begin to develop in the second or third decades of life. It has also been shown [6, 7] that hardening of the vascular wall in atherosclerosis gives rise to a distinct increase in velocity of spread of the pulse wave (VSPW). The VSPW is regarded as a reliable index of the viscoelastic properties of the arteries.

In most clinical physiological investigations the VSPW is determined in two main segments: from the arch of the aorta to the radial artery and from the arch of the aorta to the femoral artery at the point where it emerges from beneath Poupart's ligament. It is claimed [9] that the first index, denoted by V_m, reflects mainly the properties of arteries of muscular type, while the second (V_e) reflects those of arteries of elastic type. The overwhelming majority of workers who have investigated this problem from the age aspect have reported a steady increase in V_m and V_e with age [2, 9, 12-14]; this process has been even followed in childhood and adolescence [8, 11]. However, a decrease in the value of V_m with age has also been reported [13].

We have attempted in our laboratory to study the age dynamics of the VSPW in various segments of the arterial system in healthy human subjects.

EXPERIMENTAL METHOD

A comparative study was carried out on subjects of two age groups: 18-22 years (group 1) and 35-45 years (group 2). Each group consisted of 100 subjects (50 men and 50 women). The usual indices (V_m and V_e) and values of VSPW were investigated in various segments of the arteries along the course of the vessels in the limbs and head, altogether in 12 segments of the arterial system [10]. Sphygmograms were recorded at points indicated in Fig. 1 by means of piezoelectric detectors on a 3-channel "Multivector-Visocard" electrocardiograph with a recording speed of 100 mm/sec. The point of origin for measurement when estimating delay in sphygmograms of the various arteries was the beginning of the steep rise in the pulse curve. The delay time was calculated from mean data in three successive cycles. The distances between the selected points of the blood vessels were measured and the value of VSPW calculated by the usual method. Altogether about 2500 sphygmograms of 200 subjects were analyzed. Since no consistent sex differences were found in the value of VSPW in either age group, the material is analyzed purely from the age aspect.

EXPERIMENTAL RESULTS

The index V_e rose significantly from 20 to 40 years (6.45 ± 0.12 and 7.71 ± 0.16 m/sec respectively), clearly reflecting an increase in rigidity of the arterial wall at an age before clinical manifestation of

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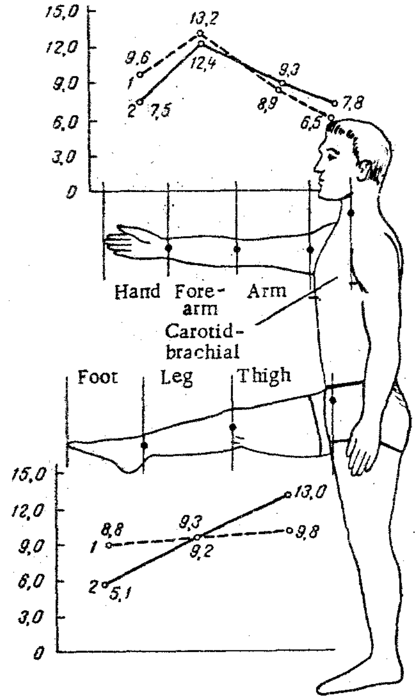

Fig. 1. Age differences in velocity of pulse wave in different segments of limb arteries (mean data) in persons aged 18-22 (1) and 35-45 (2) years. Dots denote points where sphygmograms recorded.

atherosclerosis had appeared. Meanwhile, the value of V_m remained practically unchanged, being 8.35 m/sec in persons aged 18-22 years and 8.78 m/sec in those aged 35-45 years.

Analysis of mean values of the VSPW in individual segments of the limb arteries revealed well-marked but opposite age dynamics in VSPW in vessels of elastic and muscular types. Together with a considerable increase in VSPW in the proximal segments, consisting of vessels with well-marked elastic properties, a significant decrease in this index was found in distal segments, i.e., in arteries of truly muscular type. The curves of mean values of VSPW for the two age groups have their specific points of intersection (Fig. 1). Whereas the mean value of VSPW in the segment from the carotid to the brachial artery, consisting of vessels of mainly elastic type, rose with age from 6.55 to 7.8 m/sec ($P < 0.001$), in the brachial artery, containing more muscle cells, this difference disappeared, and in the forearm the opposite tendency was observed, the value of VSPW decreasing with age from 13.18 to 12.37 m/sec. This dynamics was seen still more clearly in the most distal segment, the digital arteries (decrease in VSPW from 9.37 to 7.49 m/sec; $P < 0.001$). Similar relationships were found in the vessels of the lower limbs: in the thigh the pulse wave velocity increased with age from 9.84 to 12.98 m/sec ($P < 0.001$), while in the leg these differences disappeared, and in the foot higher values of the VSPW were found in the younger age group (8.85 and 5.13 m/sec; $P < 0.001$). Data in the literature also indicate a decrease in VSPW in the digital vessels with age [4].

The results obtained can presumably be explained by assuming that the viscoelastic properties of the arterial wall are determined, on the one hand, by structural considerations and on the other hand, by the state of its tone, and with increasing age these two factors change in different directions. Along with changes in the structure of the vessels causing rigidity of the vessel wall (development of atherosclerosis, etc.), the arterial tone falls and this has the opposite effect. By the use of another method of investigation (sphygmooscillography) a decrease in tone of the arterial wall was observed [5]. The viscoelastic properties of the main arteries of elastic type are mainly dependent on structural factors, so that with age the rigidity of these vessels increases, whereas the properties of arteries of muscular type are principally determined by the state of their tone, so that with increasing age the rigidity of these vessels decreases.

It can be concluded from these results that the VSPW in the segment from the carotid to the radial artery cannot, strictly speaking, be called the velocity of spread of the pulse wave along the vessels of muscular type, because part of this segment consists of elastic vessels (from the carotid artery as far as the arm), part of mixed vessels (brachial artery), and only the distal segment consists of muscular vessels proper (arteries of the forearm and hand). On the whole, this segment behaves largely as blood vessels of elastic type, because changes in proximal segments conceal the age dynamics of the distal muscular arteries which is opposite in direction. It is only in individual cases, for example during investigation of long-standing athletes, in whom atherosclerotic changes are less marked, that the distal segments of the arteries may assume the dominant influence. This explains the results obtained by some investigators who found that V_m decreases with age.

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