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EFFECT OF DISTRIBUTION OF FREQUENCY OF STIMULI IN THE VOLLEY ON WORKING HYPEREMIA OF THE GASTROCNEMIUS MUSCLE IN CATS

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UDC 612.741.61

The effect of the distribution of frequency of stimuli in the volley on indices of postcontraction hypermia of the gastrocnemius muscle was studied in acute experiments on cats. The introduction of a high initial frequency into the rhythmic volleys was shown to increase the indices of postcontraction hyperemia: the peak blood flow and the supplementary blood volume.

KEY WORDS: gastrocnemius muscle of cats; muscular contraction; postcontraction hyperemia.

The study of postcontraction hyperemia (PCH) in muscles of the human forearm during static and rhythmic exercises has shown that the character of the relationship between the indices of PCH (peak blood flow and supplementary blood volume) and the strength of contraction is the same in both types of exercises [1, 2]. However, after rhythmic contractions with a force of 40-50% of the maximal voluntary effort the values of the peak blood flow and supplementary blood volume were significantly higher than these indices of PCH after static contractions of the same strength. This difference has tentatively been explained [2] by the appearance of a high-frequency burst of discharges of motoneurons at the beginning of each contraction in a rhythmic series [3, 4, 8, 9].

To test this hypothesis the effect of a short high-frequency burst at the beginning of volleys inducing contraction of the gastrocnemius muscle was studied in experiments on cats. It was expected that such a burst would lead (provided that the total number of impulses in each volley remained the same) to an increase in the peak blood flow and the supplementary blood volume.

EXPERIMENTAL METHOD

The hindlimb of anesthetized cats (0.03 g/kg chloralose and 0.5 g/kg urethane) was fixed [6] and the gastrocnemius muscle was mobilized. To record the outflow of blood from the gastrocnemius muscle the popliteal vein (all branches of which except those supplying the gastrocnemius muscle were ligated) was connected to the main trunk probe of an RKÉ-1 electromagnetic flowmeter [7], from which the blood passed through a photo-

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(Presented by Academician of the Academy of Medical Sciences of the USSR A. M. Chernukh.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 82, No. 10, pp. 1170-1172, October, 1976. Original article submitted February 13, 1976.

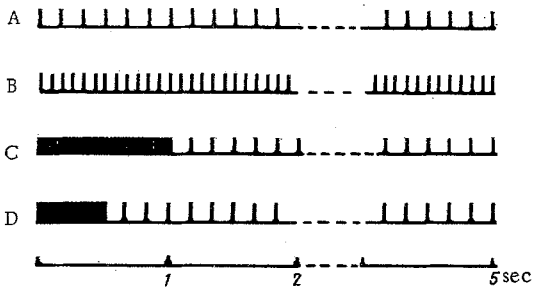

Fig. 1

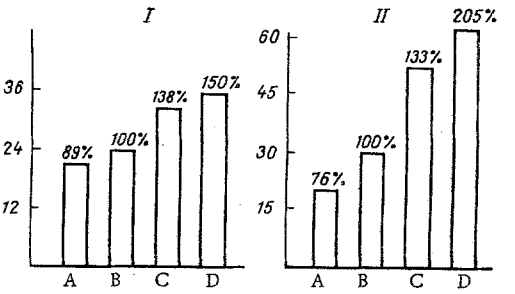

Fig. 2

Fig. 1. Diagram showing distribution of frequencies of stimuli in rhythmic volleys. Explanation in text.

Fig. 2. Dependence of characteristics of postcontraction hyperemia – peak blood flow (in ml/min/100 g; I) and supplementary blood volume (in ml/100 g; II) on presence of high-frequency bursts at beginning of volleys. A-D) Cycles with different grouping of stimuli in time.

electric drop counter [4] and was returned to the body through the femoral vein. Signals from the RKÉ-1 instrument (transmission band 0.3 Hz) were recorded on a KSP-4 electromagnetic potentiometer, and the deep blood flow was measured from these recordings. The number of drops of blood was recorded with a digital writer every 10 sec, and the supplementary blood volume was calculated by summation from the number of drops. The reason why the supplementary blood volley was determined from the number of drops was that the time drift of the RKÉ-1 instrument during restoration of the blood flow after contraction of the gastrocnemius muscle (15-25 min) could distort determination of the supplementary blood volume, whereas it could be measured reliably by counting the drops of blood. The pressure in the carotid artery was recorded on the KSP-4 automatic potentiometer. The peripheral end of the divided sciatic nerve (all branches of which except those supplying the gastrocnemius muscle were divided) was stimulated by volleys of pulses (duration 0.2 msec, amplitude 0.4-0.8 V). The ÉSU-1 stimulator was used. In all experiments three cycles of rhythmic contractions were carried out (the muscle contracted against a constant force of 0.5 kg). Each cycle consisted of four periods of contractions, 5 sec in duration, separated by pauses also of 5 sec. During contraction cycles B, C, and D the number of stimuli in each volley remained the same (60), but the grouping of the stimuli in the volley differed (Fig. 1). In cycle B the stimuli followed at uniform frequency of 12 sec^{-1}; in cycle C the frequency was 36 sec^{-1} for 1 sec and then 6 sec^{-1} for the next 4 sec; in cycle D the frequency for the first 0.5 sec was 66 sec^{-1}, then 6 sec^{-1} for the next 4.5 sec. Since for most of the time in cycles C and D the frequency of the stimuli was 6 sec^{-1}, the individual experiments started with an A cycle during which the frequency of the stimuli in each volley of rhythmic stimulation was 6 sec^{-1} (and the corresponding number of pulses was 30).

EXPERIMENTAL RESULTS

Increasing the frequency from 6 to 12 sec^{-1}, i.e., doubling the number of pulses (from 30 to 60) received by the muscle during each volley, led to an increase in the peak blood flow (Fig. 2, I) by 11% and in the supplementary blood volume (Fig. 2, II) by 24% (in both cases the values of the PCH at a frequency of 12 sec^{-1} were taken as 100%. Introduction of burst of high-frequency stimuli (36 and 66 sec^{-1}) at the beginning of the volleys increased the peak blood flow (Fig. 2, I) by 38 and 50% respectively, and the supplementary blood flow (Fig. 2, II) by 73 and 105% respectively. The results given in Fig. 2 were typical of seven of the eight experiments. No effect was found in one experiment. In two animals, despite maintenance of a stable arterial blood pressure, a progressive decrease in PCH developed during repetitive stimulation.

The introduction of a high initial frequency into rhythmic volleys thus leads to an increase in the indices of PCH, although the total number of stimuli in the volley remains constant. Regrouping of stimuli in the volley (i.e., the presence of a high initial starting frequency) imitates the processes during rhythmic contractions of human muscles only roughly; however, it reflects the characteristic distinguishing feature of natural volleys – a higher frequency of motoneuronal discharges at the beginning of a movement [3, 4, 8, 9]. Nevertheless, the experiments revealed an effect of the starting frequency in a rhythmic series, namely, an increase in the indices of PCH. Consequently, the significant increase in the indices of PCH during rhythmic exercises in man [1, 2] could be determined by the development of high-frequency initial discharges of motoneurons during each contraction.

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ROLE OF INTERMEDIATE PRODUCTS OF PROTHROMBIN PROTEOLYSIS BY THROMBIN IN STIMULATION OF THE ANTICLOTTING SYSTEM

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UDC 612.115.3:612.111

Two components were isolated from the products of proteolysis of prothrombin by immobilized thrombin: intermediate product 1 (P1) which, under suitable conditions, can be transformed into thrombin, and product 2 (P2), which does not have this property. After intravenous injection of P1 into rats the total clotting time and the plasma recalcification time were lengthened. The total fibrinolytic activity (TFA) and the level of fibrinogen degradation products were raised, the fibrinogen concentration was lowered, and the degree of nonenzymic fibrinolysis and its contribution to TFA rose sharply. Mobilization of the anticoagulant and fibrinolytic potential of the body was due to the response of the second anticlotting system. Intravenous injection of P2 or prothrombin into rats did not stimulate this system.

KEY WORDS: prothrombin; intermediate products 1 and 2; second anticlotting system.

The principal agent stimulating the function of the second anticlotting system (SAS) is thrombin [3]. Thrombin preparations, which differ in their degree of purification but possess equal clotting activity by their direct action on chemoreceptor zones or after intravenous injection, evoke a response from the body which may vary in degree [1, 2]. The strongest effect is observed after injection of unpurified, crude thrombin preparations. In this connection the question arises of the role of intermediate products of prothrombin activation in stimulating the function of SAS. Products of proteolysis of prothrombin by immobilized thrombin were obtained in a previous investigation [5]: intermediate product 1 (P1) and product 2 (P2). Intermediate product 1 (mol. wt. 50,000) was slowly converted into thrombin in vitro under the influence of active factor X or trypsin, but the rate of thrombin generation increased when a relative excess of factor Y, thromboplastin, and Ca ions was added. Before P1 can exhibit clotting activity it had to shed a fragment with molecular weight of 13,000 and one additional peptide bond (Arg–Ile) in the molecule had to be ruptured. Unlike the P1 fragment, P2 is not a thrombin precursor [5, 9].

In this investigation the role of these products of prothrombin proteolysis in activation of the SAS was studied.

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(Presented by Academician of the Academy of Medical Sciences of the USSR S. E. Severin.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 82, No. 10, pp. 1172-1174, October, 1976. Original article submitted January 14, 1975.