ACTION OF BURN SERUM ON ELECTRICAL AND CONTRACTILE ACTIVITY OF THE HOMOIOTHERMIC MYOCARDIUM

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In experiments on isolated rabbit papillary muscles the action of burn serum (BS) obtained 1 h after thermal injury to rabbits was studied. During stimulation varying in frequency between 0.1 and 2 Hz isometric contractions and action potentials (AP) of myocardial cells were recorded. BS (diluted 1:1 in Tyrode solution) inhibited the contractile activity of the papillary muscles, increased the duration of AP, and reduced the duration of the contractile response. Inotropic effects on the rhythm of contractions remained unchanged: An increase in the frequency of stimulation to 2 Hz led to an increase in the amplitude of contractions. Inhibition of the contractile response increased progressively with an increase in the duration of perfusion of the preparations with BS. Addition of 6.4 mM Ca^{++} to the solution of BS caused only a temporary increase in contractions, and rinsing the preparations with Tyrode solution did not result in complete recovery of the original contractions. It is concluded that humoral factors play an important role in the disturbance of the contractile properties of heart muscle during burn shock.

KEY WORDS: myocardium; electrical and contractile activity.

It was shown previously that burn shock is accompanied by disturbances of inotropic effects on the rhythm of contraction in the myocardial cells [2]. In preparations isolated from the heart of burned animals the amplitude of contractions progressively diminished during an increase in the frequency of stimulation over the range from 0.1 to 2 Hz, whereas in the control (preparations from the hearts of unburned animals) an increase in the frequency of stimulation within this range led to an increase in the amplitude of contractions. The degree of disturbance of myocardial contractile activity increased with an increase in the duration of burn shock from 10 to 180 min [1]. Normal inotropic effects on the rhythm of contractions were not easily restored, only after prolonged (3-4 h) perfusion of the preparations with Tyrode solution. It was interesting to discover whether the changes in myocardial contractile activity in burn shock were the result of the action of a humoral factor on the heart muscle. Several investigators have found that the blood serum from burned animals has an inhibitory effect on the myocardium [4, 7]. Blood serum from burned patients has been shown to reduce the contractile response of rat papillary muscles [6].

The object of this investigation was to study the action of blood serum from rabbits in a state of burn shock for 1 h on the papillary muscle of healthy rabbits. Its aim was to discover the contribution of blood factors to changes in myocardial contractile activity observed in this stage of burn shock.

EXPERIMENTAL METHODS

Papillary muscles from the right ventricle of the rabbit heart were used as the test objects. The preparation (diameter 0.5-1 mm, length 3-5 mm) was placed in a working chamber through which Tyrode solution saturated with carbogen (95% O_2+5% CO_2) at 35-36°C flowed. During the 30 min before the investigation began the papillary muscle was stimulated by above-threshold pulses 5-10 msec in duration and with a frequency of 1 Hz. Intracellular action potentials were derived by floating glass microelectrodes (resistance 10-30 MΩ). The near-isometric contractions of the preparations were recorded with a type 6MKh1S mechanotron. The following solutions were used: I) Tyrode, composition (in mM): NaCl 136.9, KCl 2.68, $NaHCO_3$ 11.9, $Na_2HPO_4 \cdot 2H_2O$ 0.42, $CaCl_2 \cdot 2H_2O$ 1.8, glucose 5.6; II) control serum (CS); III) burn serum (BS). The serum was obtained from the blood of healthy and burned animals. A burn affecting 30-35% of the body surface was inflicted by

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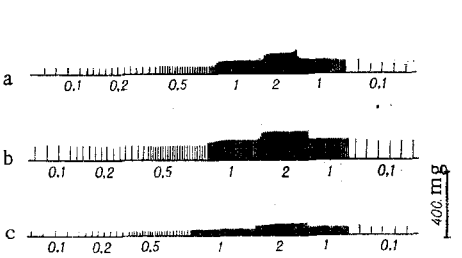

Fig. 1

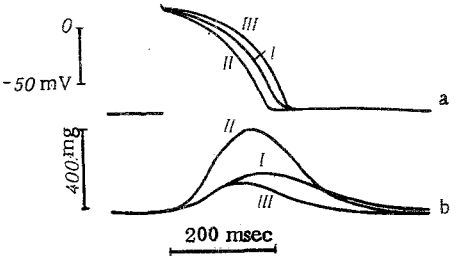

Fig. 2

Fig. 1. Changes in isometric contractions of rabbit papillary muscle during repetitive stimulation: a) in Tyrode solution; b) in Tyrode solution containing control serum; c) in Tyrode solution containing burn serum. Both sera diluted 1:1 with Tyrode solution. Frequency of stimulation changed in the order 0.1-0.2-0.5-1-2-1-0.1 Hz.

Fig. 2. Effect of control and burn sera on action potential (a) and isometric contraction (b) of rabbit papillary muscle. I) In Tyrode solution; II) in CS solution; III) in BS solution. Sera diluted 1:1 with Tyrode solution. Frequency of stimulation 1 Hz.

TABLE 1. Changes in Strength of Isometric Contractions (in %) on Stimulation of Preparations at Frequency Varying between 0.1 and 2 Hz

Treatment	Frequency, Hz				
	0,1	0,2	0,5	1	2
Tyrode solution	100	95,2±2,0	104,3±2,2	120,0±6,8	148,4±10,0
CS	130±11	127±12	142±15	178±18	242±18
BS	57±9	51±7	44±9	69±12	81±21

Legend. Strength of contractions during stimulation at 1 Hz in Tyrode solution (n=12) taken as 100%. Recording of contractions in CS and BS began 30 min after addition of the solutions.

the method described by Len'kova [3]. The blood was centrifuged at 6000g for 20 min and frozen. CS and BS were diluted with Tyrode solution 1:1 for the experiments.

EXPERIMENTAL RESULTS

In all experiments during stimulation of the papillary muscles in Tyrode solution the strength of isometric contractions (at the steady state level) was a biphasic function of the frequency of stimulation (between 0.1 and 2 Hz). As Fig. 1a shows, during the change from a frequency of stimulation of 0.1 to 0.2 Hz the amplitude of contractions fell very slightly, whereas an increase in frequency from 0.2 to 2 Hz was accompanied by an increase in amplitude of the contractions. Typical changes in the contractile response during the change from high to lower frequencies in the order 2-1-0.1 Hz are also shown in Fig. 1a. These inotropic effects on the rhythm of contraction are characteristic of the normal homoiothermic myocardium [8]. The parameters of the contractile response were: time taken to reach the maximum of contractions and the relaxation time (T_{con} and T_{rel}) in the case of stimulation of the preparations in Tyrode solution with a frequency of 1 Hz were 159.0 ± 7.1 and 178 ± 10.5 msec respectively. As the parameter characterizing the action potential (AP), its duration at levels of 20, 50, and 80% of the total amplitude of AP, measured from the resting potential, was chosen. The duration of AP in Tyrode solution (Fig. 2a) at 80, 50, and 20% levels was 88.6 ± 4.0, 155.4 ± 6.8, and 189.0 ± 5.8 msec respectively (n=6).

Perfusion of the preparations with Tyrode solution containing CS led in most experiments to an increase in the amplitude of contractions (Fig. 1b). The degree of increase in the strength of contractions was directly dependent on the frequency of stimulation: The maximal increase in the contractile response corresponded to a frequency of 2 Hz (Table 1). The action of CS was accompanied by a decrease in T_{con} by 7.4 ± 3.4 msec ($P < 0.05$; n=11), but the changes in T_{rel} were not significant (the statistical significance of the results was estimated by the method of comparison of pairs). CS caused shortening of AP. A typical AP during stimulation of the preparation with a frequency of 1 Hz is shown in Fig. 2a. The maximal shortening of AP compared with its initial value in Tyrode solution took place at the 50% level and amounted to 13.8 ± 3.3 msec. The effect

of CS was stable, and prolonged (for 60 min or more) perfusion caused no significant change in the contractile response.

The burn serum caused a decrease in the amplitude of contractions (Fig. 1c). Despite this fact, inotropic effects on the rhythm of contractions remained unchanged: An increase in the frequency of stimulation to 2 Hz was accompanied by an increase in the amplitude of contractions. Perfusion of the preparations with BS caused gradual inhibition of the contractile response, and 60 min after the time of application of BS the amplitude of contractions was only 10-20% of the initial value. Besides a decrease in amplitude, the duration of the contractile response also was changed: T_{con} and T_{rel} were reduced by 21.3 ± 3.4 and 33 ± 13 msec ($P < 0.05$; $n = 11$). Unlike CS, BS caused an increase in the duration of AP. One typical AP to stimulation of the papillary muscles with a frequency of 1 Hz is shown in Fig. 2a. Maximal lengthening of AP was observed near its plateau, at levels of 80 and 50%, and amounted to 30.0 ± 10.8 and 32 ± 11 msec compared with the initial AP in CS.

The addition of 6.4 mM Ca^{++} to the solution containing BS caused a temporary increase in the amplitude of contractions at all frequencies of stimulation. However, subsequent perfusion of the preparations led to gradual depression of contractile activity. On the change from BS to Tyrode solution the amplitude of contractions was not fully restored.

The experiments thus showed that burn serum obtained 1 h after thermal trauma to the animal inhibits contractile activity of the isolated papillary muscles and leads to an increase in the duration of AP. The fact that the action of BS on the myocardium led to a very marked decrease in the amplitude of contractions suggests that humoral factors play an essential role in the pathogenesis of burn shock. The increase in the duration of AP, the biphasic character of the frequency–strength curve, and the shortening of the duration of the contractile response under the influence of BS can evidently be attributed to the increased blood catecholamine level in burns [5].

LITERATURE CITED

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