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INTRAVASCULAR PRESSURE AND SPONTANEOUS CONTRACTION OF THE LYMPHATICS

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Relations between spontaneous contractile activity and the level of the intravascular pressure were studied in isolated segments of lymphatics. Spontaneous contractions arise when the pressure is of the order of 0.5-1.5 cm water. With an increase in pressure up to 5 cm water the frequency and amplitude of the contractions increase, but when the pressure is 10 cm water they decrease. The indices of the spontaneous rhythm of the lymphatics change not only with absolute values of the intravascular pressure, but also with the rate of their change.

KEY WORDS: *lymphatics; spontaneous contractions; intravascular pressure.*

The lymphatics of warm-blooded animals possess spontaneous rhythmic activity [1-6] which plays an important role in the movement of lymph. A special place among the factors which change the character of the spontaneous contractile activity of the lymphatics is the initial length of the smooth-muscle cells of their wall. Spontaneous contractions of isolated segments of the vessels do not arise in the absence of initial stretching [1-3, 6], and *in vivo* the frequency of pulsation of the lymphatics is connected with the volume of lymph flowing along them [4].

The object of this investigation was to study relations between spontaneous contractile activity and the level of the intravascular pressure in the lymphatics.

EXPERIMENTAL METHOD

Spontaneous contractions of the afferent lymphatics of the mammary glands of goats and sheep aged 2-5 years were recorded. Segments of the vessel measuring 1.5-2 mm in diameter and 8-10 mm in length, corresponding to 1/2-2/3 of a lymphangion [1-3, 6] were isolated. A cannula 1-1.5 mm in diameter, filled with Krebs' solution, was introduced into one end of the lymphatic and the other end tied and connected to a mechanoelectrical transducer of the 6MKh1B type. The preparation was kept in a chamber containing running oxygenated Krebs' solution at 37°C and pH 7.3. The cannula was connected through a three-way tube to a microsyringe with graduated step (by means of which the intravascular pressure changed) and a water manometer to record the pressure. Spontaneous contractile activity was

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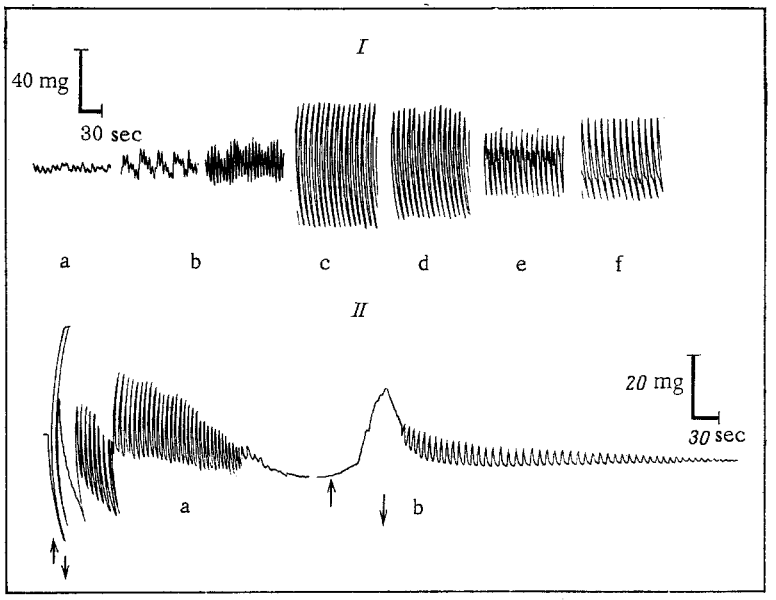

Fig. 1. Effect of intravascular pressure (I) and rate of its increase (II) on spontaneous contractions of a lymphatic. I: a-f) Pressure 0.5, 1.5, 3, 5, 8, and 10 cm water, respectively; II: a) rate of rise of pressure 4 mm/sec, b) 0.5 mm/sec.

recorded by means of a multichannel high-speed N-327 automatic writer and the temperature was recorded simultaneously. Altogether 275 measurements were made in 35 experiments.

EXPERIMENTAL RESULTS

Wide variability of the amplitude and frequency of the spontaneous contractions of the efferent lymphatics of the mammary gland was observed; the amplitude varied from 3 to 290 mg (41.3 ± 8.7 mg) and the frequency from 2 to 20 (8.4 ± 0.7) contractions per minute depending on the intravascular pressure (Fig. 1).

When the intravascular pressure was below 0.5 mm water as a rule no spontaneous rhythmic contractions were present. Usually the critical level for the onset of spontaneous contractions was a pressure of the order of 0.5-1.5 cm water. With an increase in pressure of 1 cm water the amplitude of the contractions arose by 70% and their frequency by 30% relative to the previous level. At relatively low levels of intravascular pressure (of the order of 1.5 cm water) the increase in the frequency of spontaneous contractions went parallel with the increase in their amplitude (Fig. 2). However, when the level of the intravascular pressure reached about 3 cm water a turning point was reached: The frequency of the spontaneous contractions decreased whereas their amplitude continued to increase. When the pressure was 8-10 cm water the frequency of the contractions reached a maximum while their amplitude continued to decline. A further increase in pressure led to a gradual decrease in both indices of spontaneous activity. With an increase in the intravascular pressure, the increase in amplitude of the contractions took place faster and it reached its maximum faster (in the region of 5 cm water).

The effect of the rate of increase in the intravascular pressure on the time of appearance and characteristics of the spontaneous contractions was investigated in special experiments. It was found that a slow rise in intravascular pressure (0.5 mm/sec) led to the appearance of spontaneous contractions 1.5-2 min after the beginning of the experiment (Fig. 1, II). A rapid increase in pressure (4 mm/sec) caused the appearance of spontaneous contractions after 10-15 sec. The indices of the spontaneous rhythm of the lymphatics thus varied as a function not only of the absolute values of the intravascular pressure, but also of their rate of change.

In previous experiments on the lymphatics of rats the writers showed [2, 3] that the smooth-muscle cells of certain intervalvular segments form a functional syncytium and possess frequency-inotropic relationships of the negative ladder type, i.e., the amplitude

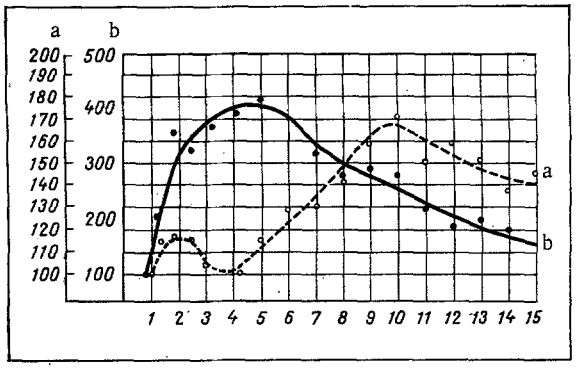

Fig. 2. Frequency (a) and amplitude (b) of spontaneous contractions as functions of the level of intravascular pressure, Abscissa, intravascular pressure (in cm water); ordinate, increase in frequency and amplitude of contractions (in %).

of contractions, whether spontaneous or evoked by electrical stimulation, increases with an increase in the interval between contractions and decreases with a decrease in the interval. When the pressure is between 5 and 8 cm water, stretching presumably activates the pacemaker cells of the intervalvular segments and creates optimal conditions for the conduction of excitation over the smooth-muscle functional syncytium. The frequency-inotropic relationship of the negative ladder type is evidently an important mechanism of self-regulation of the pumping activity of the lymphatics. It has in fact been shown in the case of the mesenteric lymph nodes of sheep [4] that lymph is effectively propelled by infrequent contractions of the walls of the lymphatics, the amplitude of which increases when the intravascular pressure reaches certain values. It can tentatively be suggested that unfavorable conditions for the activity of the lymphangion (the single intervalvular segment) as a functional unit are created in the zone of low and high values of intravascular pressure. A low intravascular pressure is insufficient to ensure equal stretching of all the smooth-muscle cells and, consequently, to create the conditions for effective conduction of excitation. A high pressure perhaps overstretches the smooth-muscle cells and this may also disturb synchronization of the spread of excitation to all cells of the lymphangion.

Potential pacemakers in the lymphangion, as these experiments have shown, can be activated both by a gradual and by a rapid rise of pressure. A sudden rise of pressure induces stronger activation of the smooth-muscle cells with a short latent period, further confirmation of the role of the rate of stretching of the walls of the lymphatics as an adequate stimulus for the onset and maintenance of their spontaneous activity [6].

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