Effects of Metabolic Inhibitors on the Electrical and Mechanical Activity of the Vascular Smooth Muscle of the Rabbit

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(Received August 3, 1968)

This study was carried out to investigate the effect of metabolic inhibitors on the electrical and mechanical activity of the vascular smooth muscle of rabbit. A sucrose-gap method and a mechano-electronic transducer were used to record the electrical activity and tension simultaneously. Isolated spiral strips of the common carotid artery and longitudinal strips of the anterior mesenteric vein from rabbit were used, 3-4 cm length and 1-1.5 mm width, mounted in the gap apparatus.

The normal Krebs's solution used in the experiments contained (mM): NaCl 120.7; KCl 5.9; $CaCl_2$ 1.2; $MgCl_2$ 1.2; $NaHCO_3$ 15.5; NaH_2PO_4 1.2; glucose 11.5 and was aerated with O_2. Solutions, at 37°C, flowed through the active side of the apparatus, continuously at the rate of 8-10 ml/min. The inhibitor of oxidative metabolism, 2:4-dinitrophenol (DNP) and the inhibitor of glycolysis, mono-iodoacetic acid (MIAA) were used.

Usually there was no spontaneous activity of the carotid artery in normal solution. After administration of DNP 10^{-4}M, the change of membrane potential was variable but the tension was decreased immediately as shown in Fig. 1.

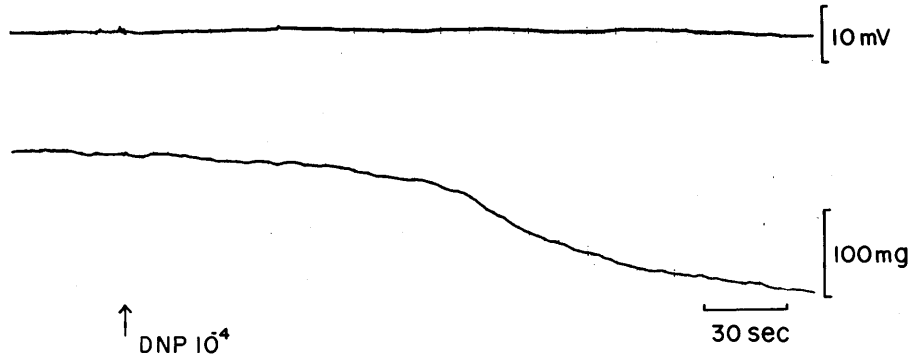

Fig. 1. Effect of DNP 10^{-4}M on the electrical (upper) and mechanical (lower) activity of the common carotid artery of the rabbit.

Tension was reduced simply by DNP 10^{-4}M to 10^{-6}M in many cases, but sometimes it was increased initially and then decreased gradually, i. e., the effect of DNP was biphasic in a few cases. The reduction in tension may be

proportional with the concentration of DNP.

The rabbit anterior mesenteric vein was spontaneously active in normal solution, as reported previously.[1)2)] By DNP 10^{-4}M, the membrane potential was changed but the changes were variable. Fig. 2 shows resulting a case of the hyperpolarization and the abolition of spontaneous action potential in DNP 10^{-4}M, while the tension was decreased. The change in spontaneous action potentials in DNP 10^{-4}M was shown in Fig. 3. The tension was decreased gradually in DNP 10^{-5}M but the effect on tension was biphasic in a few cases.

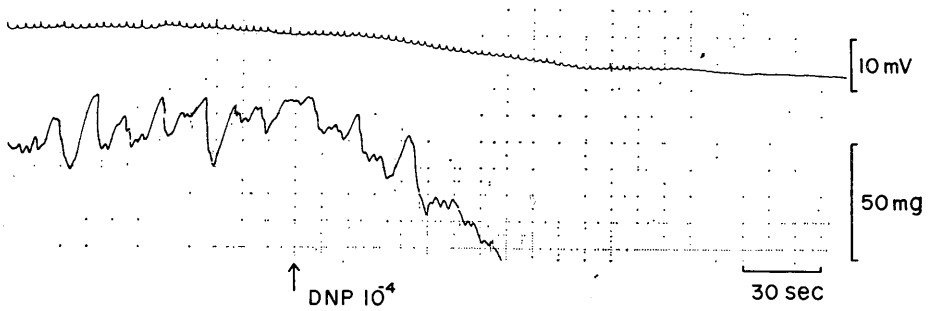

Fig. 2. Effect of DNP 10^{-4}M on the electrical (upper) and mechanical (lower) activity of the anterior mesenteric vein of the rabbit.

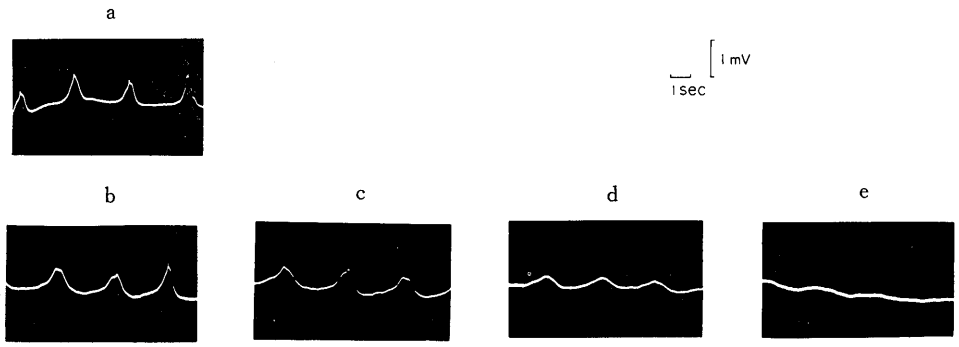

Fig. 3. Effect of DNP 10^{-4}M on the spontaneous action potential of the anterior mesenteric vein of the rabbit.
a; normal solution b-e; DNP 10^{-4}M solution (after 30, 60, 120 and 160 sec respectively).

After administration of MIAA 10^{-3}M in the carotid artery, the membrane potential was decreased slightly while the tension was decreased in some preparations. But the changes in membrane potential were veriable. In high concentration of MIAA 10^{-2}M, the initial increase in tension was observed in all preparations, however, the tension decreased gradually during exposure period. In mesenteric vein, the solution of MIAA 10^{-3}M produced the small depolarization immediately, but effects on spike discharge were different from preparation to preparation, i. e., the spontaneous action potential disappeared after 2 min, or

was maintained for 10 min of exposure. The tension was decreased with spike abolition in the former. In the latter, burst type action potential well corresponded with rhythmic contractions had been observed in normal solution. It is considered that the action potential have conducted through wide region in this preparation. When MIAA 10^{-3}M was applied, small depolarization, shortening of duration of burst, and increase in frequency of train were observed. In accordance with these changes the amplitude of rhythmic contractions decreased and its frequency increased, but asynchronous contractions were seen later. These changes were shown in Fig. 4 A.

Fig. 4 B shows the later effect on this preparation. Spontaneous discharges were observed through 10 min exposure but burst type action potention had been converted to single or double spikes and the rhythmic contractions became more irregular and smaller than that in initial, indicating there occurred conduction disturbances.

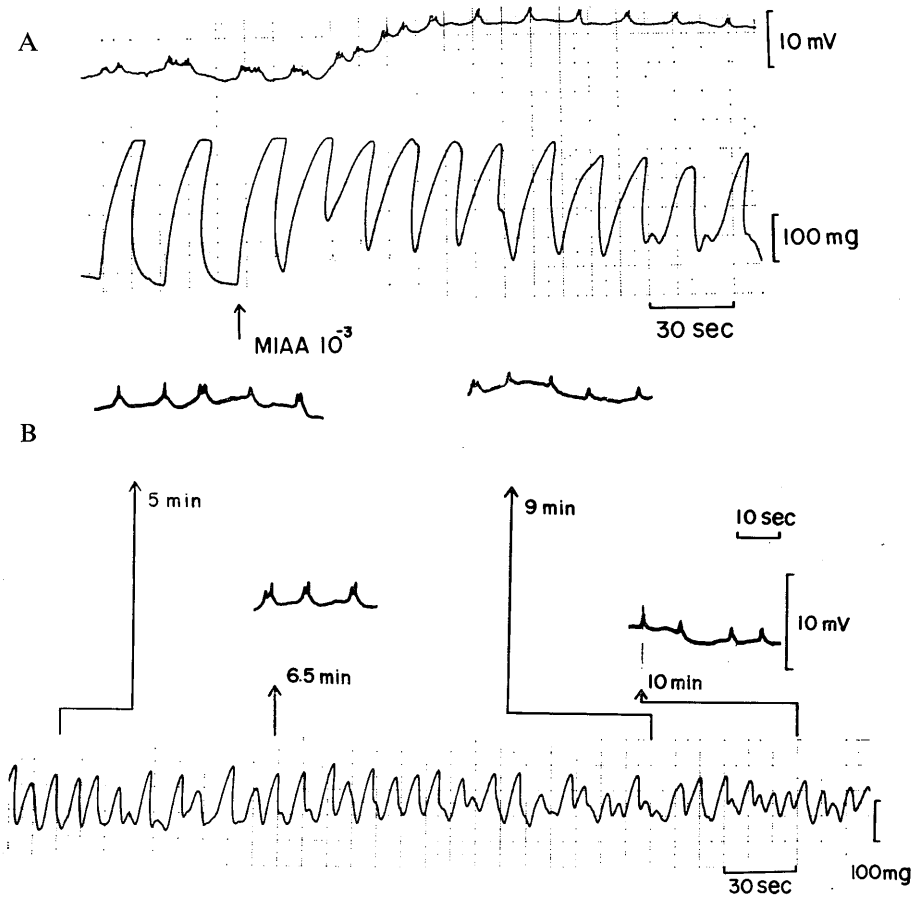

Fig. 4. Effect of MIAA 10^{-3}M on the electrical (upper) and mechanical (lower) activity of the anterior mesenteric vein of the rabbit.
A; initial phase, B; second phase.

Bülbring et al[3] reported the effect of metabolic inhibitors on the electrical and mechanical activity of the taenia coli of the guinea-pig. In taenia coli the action of DNP on spike activity was biphasic, initial effect was to increase spontaneous spike activity and during the second phase of its action DNP depressed spontaneous spike activity, however, during the initial phase of membrane excitation by DNP there was a fall in tension. Thus during the first phase of its action abolished the normal relation in excitation-contraction coupling.

In our results, as described above, the electrical activity of membrane in mesenteric vein was influenced by DNP and MIAA. This result suggests that the effect of these inhibitors could be related with a structure of cell membrane.

In mesenteric vein, however, the effect of DNP on excitation-contraction coupling was not consisted with the results obtained from taenia coli smooth muscle. In some preparations of mesenteric vein, DNP caused no dissociation between electrical activity and tension, therefore the inhibition in tension in initial stage by DNP can be explained from the change of electrical activity of membrane, but when muscle is soaked during long period it is not clear whether it can be explained or not without the consideration about energy loss.

In carotid artery, the tension was decreased independently with the changes of membrane potential by these inhibitors. This mechanism was not clear.

REFERENCES

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