INDIRECT STIMULATION OF UNSTRIATED MUSCLE

A Preliminary Communication

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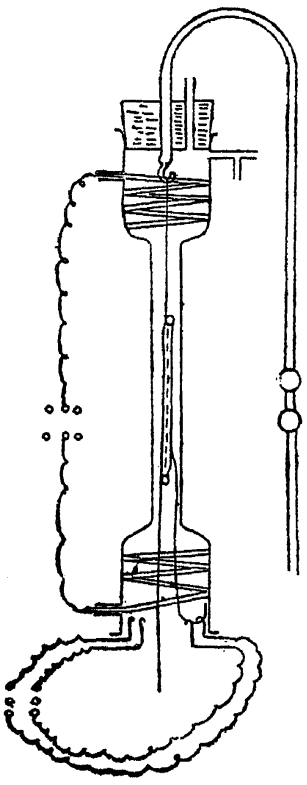
Received June 17, 1943

PLAIN muscle appears to be excited by two agencies difference in concentration of ions within and without the fibres and surface action. When ions are added from without, the increase in concentration takes place outside the cells; when it is stimulated electrically or by increase in ismotic pressure, increase in concentration takes place inside the cells. In this paper a preliminary study of the mechanism of surface action and that of nervous stimulation is presented. For literature see review by McSwiney (1931).

Methods

Strips of dog stomach were isolated. The attached vagus nerve was isolated from the lower end of the œsophagus; the peri-arterial sympathetic may also be attached. The muscle was placed in a chamber, so that it could be stimulated (*a*) chemically, (*b*) electrically with alternating or direct current, (*c*) or through the nerves. In these experiments we have stimulated only the vagus by induction shocks for 15 sec. (Fig. 1).



Results

The muscle nerve preparation thus made was immersed in mammalian saline described previously (Singh, 1940). The responses obtained by stimulation of the vagus every 10 min. were quite regular and the muscle was responsive for several hours (10 A.M. to 8 P.M.), the tension obtained being as high as 30–40 g. Only result obtained was contraction, which showed staircase and fatigue effects.

Relation to tone.—The response obtained by stimulation of the vagus was a twitch, the rate of rise and fall of which was somewhat less than that of the twitch produced by alternating current; relaxation may be prolonged like the direct current contraction in *Mytilus* muscle. The vagus twitch was antagonistic to

tone. If the muscle exhibited much tone it was inexcitable to vagus. Just after the vagus twitch, tone was partially neutralised, showing, that, as with other forms of stimulation, the excitation by the vagus contained an inhibitory component. This does not necessarily mean that the vagus contains inhibitory fibres, because it is given by all forms of stimulation, such as by alternating current, potassium and acetylcholine.

The above inhibition of tone is enhanced by increase of temperature, even though the respone may diminish; so that it is probably due to the liberation of calcium.

Tone in the vagus-stomach preparation is thus myogenic. The inhibitory component in the vagus excitation is necessary, for the efficient performance of the contraction, as inhibition of tone during the vagus contraction will be attended with diminution of viscosity. The dual action of the vagus is thus explained and the nerve is motor.

A stimulus appears to consist of two components, one excitatory and the other inhibitory. The excitatory component may be antagonised by (*a*) antagonistic excitation, such as increase of tone; (*b*) diminution of excitability; (*c*) adaptation; (*d*) drugs, or it may be made ineffective by the use of stimulus of sub-laminal strength. Under such conditions inhibition will be produced; thus a relaxed muscle will contract, and a contracted muscle relax. This inhibitory component appears to be an integral part of the excitation process, so that a muscle may be excited to contract or relax. If this active process requires more oxygen than that producing contraction, then oxygen consumption will be increased, when the muscle relaxes, otherwise it will decrease.

Effect of temperature.—In 3 experiments the optimum temperature was found to be 30° C.; as a matter of fact, at 37° C., the muscle may become inexcitable to vagus. At 37° C., though the response becomes smaller, it is, however, more brisk than at 30° C. The optimum temperature for acetylcholine is also 30° C. In previous experiments (Singh, 1940), and by Winton, the optimum temperature for alternating current was found to be 24° C., but in the present experiments, it was 30° C., so mammalian tissues are also likely to vary in their properties.

Effect of calcium.—Calcium is necessary for vagus stimulation, as with striated muscle nerve preparation of the frog. In 3 experiments, the optimum was found to be 0·05–0·10 M $CaCl_2$, more than that required for alternating current and same as that required for acetylcholine (0·05 M $CaCl_2$). With optimum concentration of calcium the responses may be very powerful.

Effect of potassium.—The optimum concentration of potassium is the same as that for alternating current (about 0·06 M KCl; 3 experiments). The muscle becomes inexcitable in excess of potassium.

Effect of hydrogen ions.—The optimum pH was found to be about 7·4–7·8 (3 experiments), somewhat greater hydrogen-ion concentration being necessary than that for alternating current. For acetylchloine the same pH was necessary.

Discussion

The stimulation produced by the vagus as well as acetylcholine does not belong to the potassium group; their properties resemble more those produced by alternating current. However, it has not been possible to say whether it forms a group distinct from that produced by alternating current.

Summary

(1) The excitation produced by vagus stimulation has an inhibitory component.

(2) Tonus is antagonistic to vagus stimulation.

(3) The optimum temperature for vagus stimulation is 30° C.

(4) The optimum concentration of calcium is about 0·05–0·07 M CaCl, potassium about 0·06 M KCl and hydrogen ions, pH 7·8–7·4.

(5) The stimulation produced by vagus and acetylcholine does not belong to the potassium group. It resembles more that produced by alternating current.

REFERENCES

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