

The Function of the Sympathetic Nerve Supplying the Intestine and the Action of Adrenaline.

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Ehrmann¹⁾ and Courtade et Guyon²⁾ stated that the splanchnic nerve contains, besides the inhibitory nerve fibres, the augmentatory nerve fibres which control the tonus and the movements of the intestines. But Bayliss and Starling³⁾ insisted that in the splanchnic nerve, there exist the inhibitory nerve fibres only and the report of the former stating the presence in it of the augmentatory nerve fibres must have been based on the failures of their experiments. Since then, the existence of the augmentatory nerve fibres in the splanchnic nerve has generally been denied.

When the splanchnic nerve is stimulated by electricity, tonus of the intestine decreases and its movement comes to a standstill, while the tonus of the ileo-colic sphincter increases (Elliott⁴⁾). Therefore, it is now admitted that in the splanchnic nerve, there must be the inhibitory nerve fibres for the intestine and the augmentatory nerve fibres for the ileo-colic sphincter. The observation of the histological relations between the small intestine and the ileo-colic muscle shows that there is no fundamental difference between the two. The ileo-colic sphincter may be regarded as a part, in which the circular muscle of the small intestine is specially developed. Hence we can hardly imagine that there is an essential difference in the function of the nerves supplying these two parts. May not the report of Courtade et Guyon that in the splanchnic nerve, there is augmentatory nerve fibres, in addition to the inhibitory nerve fibres and that the longitudinal muscle is supplied by the inhibitory and

the circular muscle by the augmentatory nerve fibres be true? If it is so, it is quite intelligible that in stimulating the splanchnic nerve, the inhibitory result follows in the intestine where the longitudinal muscle is developed to a comparatively high degree, and an augmentatory phenomenon arises in that part where the circular muscle is more developed. To decide this question it is desirable to separate the circular and the longitudinal muscles of small intestine and to examine on these separately, for if the two muscles are supplied by the nerve fibres functionally different, they may react simultaneously to the stimulation of the nerve and make the result ambiguous. While it is easy to isolate the longitudinal and the circular muscles, it is impossible to isolate the nerve fibres supplying

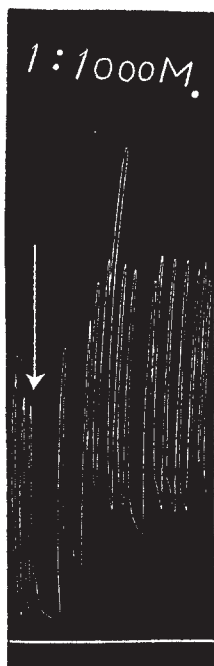
Fig. 1.



them. We can, therefore, not employ the electric stimulations for this purpose. But adrenaline stimulates the sympathetic nerve endings (myo-neural junction) electively. A small quantity of this substance applied to the intestine just as when the splanchnic nerve is stimulated by electricity, brings about the relaxation and a standstill of the movement of the small intestine and increases the tonus of the ileo-colic sphincter (Elliott⁴, Dale⁵, Kuroda⁶). For this reason, our purpose will be attained, if we substitute adrenaline for the electric stimulation. So I have examined the action of adrenaline upon every unstriated muscle to decide the function of the sympathetic nerve supplying it.

A segment 3 cms. long of the small intestine of a cat was taken. When the serous membrane was removed from it, a layer of the longitudinal muscle appeared. From this a piece of the longitudinal muscle about 2 mms. wide was stripped off with a sharply pointed pin. After removal of the longitudinal muscle the circular muscle about 2 mms. wide was stripped off in the same way. Those strips were suspended in the Ringer's bath and their movements were recorded by means of a lever. Each strip prepared in this manner was not very active, but still showed the rhythmic movement usually. When 1 in 100 000 to 1 in 100 000 000 adrenaline was added to the both the circular muscle increases its tonus, as is to be seen in Fig. 1 and its movement sometimes augmented. This

Fig. 2.



reaction is just like that of the ileo-colic muscle to adrenaline. The same phenomenon was seen in the circular muscle even when a large quantity of atropine was previously applied to it. Thus the circular muscle and the ileo-colic muscle show the same reaction to adrenaline. Therefore we infer that the nerves supplying them must be the same and it is beyond doubt that in the sympathetic nerve supplying the intestine there exists besides the inhibitory the augmentatory nerve fibres.

Ehrmann¹⁾ stated that the stimulation of the splanchnic nerve caused the augmentatory effect in the longitudinal muscle and the inhibitory effect in the circular muscle of the small intestine. But the result of my experiments rather agrees with the report of Courtade et Guyon³⁾ which states that stimulation of the splanchnic nerve produces the inhibitory effect in the longitudinal and the augmentatory effect in the circular muscle.

The longitudinal muscle was more sensitive to adrenaline than the circular muscle. It reacted even in a concentration of 1 in 1 000 000 000 of adrenaline, and the reaction was somewhat different according to the concentration of the substance. In a concentration of 1 in 1 000 000 000 the movements were augmented and tonus sometimes increased (Fig. 2). This phenomenon agrees with the result of the experiment made by Hoskins⁷⁾ who used the specimen which contained fully the layers of two kinds of muscles. In a concentration of more than 1 in 100 000 000, like the experiments of Magnus⁸⁾ and of many others, the movement of muscle was so inhibited as to be relaxed and finally stopped (Fig. 3). The above mentioned adrenaline reaction of the longitudinal muscle of the small intestine is also observed even when a large quantity of atropine had been applied to it previously. We have reasons to believe that adrenaline does not stimulate the vagus endings and Auerbach's plexus. Considering that it has no action whatever upon other striated muscle (Y. Kuno⁹⁾),

Fig. 3.



we believe it does not also act upon the unstriated muscle. Accordingly the phenomenon caused by a small quantity of adrenaline must be regarded as the result of its action upon the sympathetic nerve ending. If the nerve which supplies the longitudinal muscle were the inhibitory nerve only, we must conclude that the drug paralyses at first (in a small quantity), and then excites (in a large quantity). But then it is contradictory to the general law of the action of drugs. Therefore in order to explain this phenomenon, we must suppose that in the sympathetic nerve supplying the longitudinal muscle, there are two kinds of nerve fibres, the augmentatory and inhibitory whose sensitiveness to adrenaline is different and which will be excited or inhibited according to the quantity of the drugs applied to them.

To sum up, it is probable that in the sympathetic nerve supplying the intestine, there exist besides the inhibitory nerve fibres whose existence was already demonstrated, the augmentatory nerve fibres, and that the circular muscle is supplied by the latter, and the longitudinal muscle is supplied by both of these nerve fibres. The reports of Courtade et Guyon were not after all based on failures of their experiments. Adrenaline stimulates these nerve endings (neuromuscular junction), and whether it excites or inhibits depends upon its quantity.

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