On the explanation of Stannius's experiment and on the action of strychnia on the heart / by T. Lauder Brunton and Theodore Cash.

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AND OF

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BY

T. LAUDER BRUNTON,

AND

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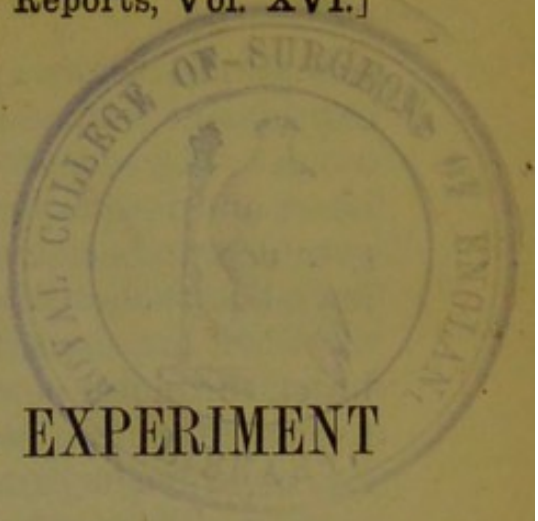

ON THE EXPLANATION OF STANNIUS'S EXPERIMENT AND ON THE ACTION OF STRYCHNIA ON THE HEART.

BY

T. LAUDER BRUNTON, M.D., F.R.S.,

AND

THEODORE CASH, M.D.

The remarkable experiment to which Stannius has given his name consists in applying a ligature around the venous sinus of the frog's heart, just at the point where it joins the auricles. The consequence of this is, that the auricles and ventricles at once cease to beat, and remain in a state of quiescence, lasting for a time varying from a few minutes to half an hour or more, while the venous sinus still continues to pulsate uninterruptedly. A similar result is produced when, instead of applying a ligature round the sinus, the sinus itself is separated from the auricles by an incision. If, however, instead of suddenly removing the whole of the venous sinus from the remainder of the heart, it is gradually removed, the instant stoppage of the auricle and ventricle does not take place. If the ventricle be now separated from the auricle, while the two are remaining in a state of complete quiescence, the ventricle again commences to pulsate, while the auricle remains perfectly still. Two explanations of these phenomena have been given. The one is that the section or ligature of the heart at the junction of the venous sinus and the auricles excites the inhibitory apparatus in the auricles to such an extent as to prevent both them and the ventricle from moving. This explanation, however, seems to be disproved by the fact that the same result is obtained after the heart has been previously poisoned by atropia, which completely paralyses its inhibitory apparatus, and

it would therefore appear that the still-stand of the heart in this experiment cannot be due to excitement of the inhibitory apparatus. The second explanation is, that the motor ganglia of the heart are unequally distributed in the ventricle and auricle, the greater number being in the venous sinus and ventricle, and the fewest in the auricle.

When the sinus, then, is separated from the remainder of the heart, the motor power in the auricles and ventricle is insufficient to make them pulsate, although the ventricular ganglia are sufficient, when separated from the auricle, to set the ventricle in motion. This explanation is opposed to the fact that if the venous sinus be gradually, instead of suddenly, separated from the auricle, they will still continue to pulsate. Notwithstanding this objection, however, it seems to us that this explanation, although very probably it does not represent the whole truth, is to a considerable extent true, and the cessation of the auricular and ventricular movements, after the removal of the venous sinus, is really due, in a great measure at least, to want of motor power. It occurred to us that if this were so, we ought to be able, by stimulation of the motor ganglia, to reinduce the cardiac pulsations after they had ceased from ligature of the venous sinus. It is well known that if a single galvanic shock be applied to the ventricle when in this state of diastolic quiescence, the ventricle will contract once at each application of the stimulus, but the single pulsation is not succeeded by a succession of rhythmical beats. As warmth has a very powerful effect in increasing the cardiac activity, it seemed probable that the application of warmth to the heart, when in the condition of still-stand thus described, might so far stimulate its motor ganglia as to allow it to resume its rhythmical pulsations. We therefore induced complete still-stand in the frog's heart by applying the ligature in the usual way. On then warming the heart, either by directing upon it a current of air heated by passing it through a hot glass tube, or by bringing into its neighbourhood a heated copper wire, we found that the rhythmical pulsations again commenced, and continued for two or three minutes after the time that warmth was applied.

The cessation of the movements of the heart, after the removal of the venous sinus, seemed to us analogous to the cessation of respiratory movement and of vaso-motor tone after the influence of the medulla oblongata has been removed by division of the spinal cord at the occiput. It has been found by Prokop Rokitansky that the movements do not cease completely, after division of the cord, when the animal has been previously poisoned by strychnia, and that both vaso-motor reflex and respiratory movements can be reinduced in such animals by strychnia adminis-

tered after the cord has been divided. It occurred to us that possibly a similar phenomenon might be observed in the heart. We, therefore, administered strychnia to a frog, and as soon as the spasm occurred, the animal was killed and a ligature placed around the heart. No cessation of movement, however, was observed. When a frog was first killed, however, and still-stand of the heart was induced by application of a ligature, a solution of strychnia placed on the outside of the heart did not reinduce rhythmical pulsations, but when the solution was injected by a fine pipette into the interior of the ventricle, rhythmical pulsations again commenced. This rhythm, however, was independent of that which the venous sinus still continued to pursue. After maintaining this for some minutes, it again stopped, and the auricle was seen to contract after the ventricle. The aorta was now cut, and the ventricle again contracted, but the auricles remained quiescent. On stimulating the ventricle, it now went on beating regularly.

From these experiments it would appear that the still-stand induced by ligature of the venous sinus has a deficiency of motor power in the auricle and ventricle, and that when we increase the excitability of the ganglia in these parts by warmth or by strychnia, the pulsations recommence. The following seems to us the best explanation of the phenomena observed. The motor ganglia of the heart, we think, are in all probability called into action by reflex stimulation. This reflex stimulation may originate in impressions conveyed to them by afferent nerves from the internal or external surface of the heart, or by impressions conveyed to them by the afferent nerves from the other cavities of the heart. We think, also, that although they respond to the stimuli conveyed reflexly from the internal or external surfaces of that part of the heart in which they are contained—as shown, for example, in contraction of the ventricle on stimulation by a needle or an electrical current—they are nevertheless most readily thrown into rhythmical action by the impressions conveyed to them from the other cavities. In a normal condition of the heart, the venous sinus is the first cavity to contract; next comes the auricle, and next the ventricle; and a stimulus of contraction probably proceeds from one to the other along a channel furnished by the nervous filaments which connect them. When the channel is suddenly interrupted, as by ligature or division of the venous sinus, the motor stimuli proceeding from the venous sinus to the auricle and ventricle can no longer pass to them, and the reflex impulses proceeding to their ganglia from the external and internal surfaces of these cavities are insufficient to call them into action. The auricles and ventricles, therefore, remain in a state of

quiescence for a longer or shorter period; this quiescence, however, is not completely permanent. After a while the ganglia seem to become adapted to the new conditions. Their sensibility, too, increases, and the stimuli proceeding to them from the surface of the heart are sufficient to call them into action. When the venous sinus is gradually removed from the auricles and ventricle, instead of being suddenly detached, time is afforded for this adaptation to take place before the removal has been completely effected, and thus the rhythm is not disturbed, as it is when the division is suddenly made or the ligature suddenly applied. In these respects the cardiac nervous system is analogous to the vaso-motor and respiratory systems. The ordinary channels through which the vaso-motor and respiratory centres and spinal cord are called into action are the fibres which proceed to them from the medulla oblongata. If these channels are suddenly interrupted by section of the spinal cord at the occiput, those parts of the vaso-motor and respiratory centres contained in the spinal cord cease to act. The same is the case when a large portion, but not the whole, of the respiratory centre in the medulla is destroyed, as by division of one-half of the medulla. When a large portion of this respiratory centre is thus destroyed, the animal at once ceases to breathe, and remains in this condition for many hours. If left to itself, death would of course take place; but if artificial respiration be maintained for a long time, by and by faint respiratory movements occur, which very soon cease if the animal be left to itself. But Schiff has found that if artificial respiration be still kept up, these movements become stronger and stronger, until at length spontaneous respiration is sufficiently re-established to save life.

In Rokitansky's experiment, the ordinary channels for the passage of stimuli from the medulla oblongata to the respiratory and vaso-motor centres in the cord were at once destroyed; but the application of strychnia before or after the section had so greatly increased the activity of the centres in the spinal cord that they were able to take up their functions at once, instead of after a lapse of time, as in Schiff's experiment. It seems to us, then, that the function performed by the venous sinus in regard to the rhythmical movements of the frog's heart is to a certain extent analogous to the functions of the medulla oblongata in regard to respiration and vascular tension, and that the action of heat and of strychnia upon the systems is very similar indeed. The very marked action as a cardiac stimulant which strychnia is shown by the experiment to possess, is one the practical importance of which it is hardly necessary to point out. We would merely remark, that in cases of general debility and lack of tone, especially when

occurring in consequence of overwork, there is, perhaps, no tonic in the pharmacopœia to be compared to strychnia; and widely known though its utility may be, it is not nearly so commonly employed as it deserves, especially at this season of the year, when both medical men and their patients are suffering from the consequences of prolonged overwork and mental strain. Small doses of strychnia or nux vomica restore both mental and physical power, and give a sense of well-being in a manner in which, so far as our experience goes, nothing else will.