The action of chloroform upon the heart and blood vessels / by E.A. Schäfer and H.J. Scharlieb.

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The action of chloroform upon the mammalian heart. We have lately again investigated the action of chloroform, both inhaled into the lungs and injected into the blood vessels in solution in normal saline, upon the heart in the dog. We have nothing to add to what is already known regarding its immediate effect upon the heart and circulation. As has been abundantly shown by the researches of Gaskell and Shore, McWilliam, L. Hill, Embley, and many other observers, the drug has a markedly depressant effect upon the action of the heart, eventually bringing this to a complete standstill. This effect is entirely independent of its action upon the respiratory centre. What we wish especially to insist upon is the specific nature of the action of the drug upon cardiac muscle in mammals.

After the heart has been brought to a standstill as the result of inhaling a mixture of chloroform and air containing a large proportion of chloroform vapour—and this condition of standstill may occur almost instantly, but is more common after the lapse of a minute or more—the condition of the cardiac muscle is such that no kind of stimulation applied to it, directly or indirectly, will elicit any response; the heart being in a condition of diastole with the cavities more or less filled with blood and remaining permanently in this condition. This state of the heart is that which has been termed by some authors "paralytic dilatation." It appears to us, however, that it is more than a condition of mere paralysis, for a paralysed muscle will still respond to direct stimulation. Mere paralysis would be such a condition as is associated with cessation of rhythm, the heart being still irritable to extraneous stimuli. But the condition of which we are speaking is one in which the irritability of the heart has disappeared, the cardiac tissue being in a permanently refractory state, associated not with systole, as in the ordinary refractory phase, but with diastole. It might almost be described as a condition of death of the tissue—precedent of course to rigor—but it is not actual death, for in many, if not in all cases, as the heart begins after some lapse of time (the circulation through its

vessels having of course long ceased) to pass into the state of death, the transition may be marked by slight flickering or more or less localized contractions, which are quite inefficient to drive the blood out of the cavities but which indicate that the tissue is not killed by the drug. It appears to us that this condition of the cardiac tissue, which is produced by the action of strong chloroform vapour and which renders the employment of that drug so especially dangerous in inexperienced hands, is rather to be regarded as one of excitatory inhibition than as a paralytic state. The absolutely refractory nature of the condition points strongly to this—resembling as it does the condition into which cardiac tissue is brought during excitation of its inhibitory nerves. That it is not however brought about by an action upon the cardio-inhibitory centre nor upon the endings of the vagus fibres within the heart is shown by the fact that it will eventually occur after section of both vagi and even after doses of atropine sufficient to paralyse all vagus action. That it is really nevertheless due to an excitation of the terminal inhibitory mechanism—whatever this may be, whether nervous or inherent in the cardiac muscle tissue itself—is indicated by the fact that although the heart is brought into this absolutely inexcitable condition by chloroform, no other kind of muscle in the body is similarly affected—both the skeletal and the visceral muscles responding as usual to stimuli applied to them. And since the main physiological distinction between cardiac muscular tissue and ordinary muscle is the possession by the former of an inhibitory mechanism which is altogether absent in skeletal muscles and which if present in visceral muscles is far less readily affected by external agencies such as drugs than cardiac muscle, the conclusion appears natural that it is this inhibitory mechanism which is brought into play by the action of chloroform.

The action of chloroform upon the blood vessels. With regard to the action of chloroform upon the blood vessels, it appears to be the almost universally received opinion of physiologists who have devoted attention to the action of this drug that it produces dilatation of the arterioles (although both Gaskell and Shore, and Martin and Embley got a primary constriction, which they ascribed to the excitation of the vasomotor centre in the medulla oblongata by the drug). We have not however been able to find out upon what direct evidence this opinion is based. No doubt the administration of chloroform is attended by a marked fall of blood-pressure, but we have failed to get any evidence in our experiments upon dogs that this fall of blood-pressure is not wholly due to the depressing action that it exerts upon the heart: and our perfusion

experiments upon the frog—animals being employed (*a*) in which the central nervous system was entirely destroyed, and (*b*) others in which the central nervous system with the exception of the cerebral hemispheres had been left intact—conclusively show that this drug so far from producing dilatation causes extremely marked contraction of the arterioles. In these experiments the perfusion has been performed with normal saline (Locke's) which has been mixed in varying proportions with saline solution saturated with chloroform. Whether the amounts of chloroform-saline added were relatively small (*e.g.* one part chloroform-saline to ten parts normal saline), or even if the chloroform-saline were used undiluted (containing probably one part of chloroform to 200 of saline), the results have been similar. Provided that the perfusion of the chloroform-saline has not lasted for too long a time, in which case a large amount of œdema is produced, the arterioles again pass into a condition of comparative dilatation on resubstituting normal saline for the saline containing chloroform, and this result can be alternated several times. It is therefore certain that, in the frog at least, the action of chloroform is to produce contraction, and not dilatation, of arterioles.

PAPERS REFERRED TO.

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