A PRELIMINARY INQUIRY INTO THE TONICITY OF THE MUSCLE FIBRES OF THE HEART.

By JAMES MACKENZIE, M.D.,
Burnley.

THIS paper is intended to direct attention to the explanation of a common cause of heart failure. Even in the present day heart failure, and particularly dilatation of the heart, is looked upon too much from a mechanical standpoint. The question of tonicity is one that still needs a great amount of study from physiological, pharmacological, and clinical aspects, and here I touch only on a few points that I have already worked out.

What is the Cause of Dilatation of the Heart?

In considering the causes of dilatation of the chambers of the heart one cannot fail to be struck with the inadequacy of the explanation usually given for this condition. The prevalent idea seems to be that it is due to an increased pressure within the chambers forcing the walls outwards. But if it be asked, Whence comes this distending force? the inadequacy of such an explanation is at once apparent. During systole the increased pressure within the chamber is produced by the contraction of the wall of the chamber itself, and one can scarcely assume that in the process of contraction dilatation is produced. One can conceive that dilatation of an auricle might be produced by the forcible regurgitation of blood from a powerful ventricle, but such a thing can only happen when there is a lesion of the auriculo-ventricular valves. Regurgitation apart from valvular lesion can only occur after the muscle fibres surrounding the auriculo-ventricular orifices have become relaxed—that is to say, dilatation of the auricles from such a cause would be produced after dilatation of the ventricle.

That neither the difficulty opposed to a chamber during its emptying nor the distending force during its diastole is the cause of dilatation, becomes evident when the conditions observed in certain hearts are carefully studied. Thus hearts whose walls are thinned, and whose muscle fibres are degenerated may continue to work against an abnormally high arterial pressure, and never show any signs of dilatation. In fact, the wall of the left ventricle may be so thinned that it will actually burst in its efforts to overcome the aortic pressure, and the walls will show no signs of dilatation. Dr. Arthur Keith, who has especially looked into this matter of ruptured hearts, informs me that such hearts may show no sign of increase in the size of their cavities. In a patient under my care the heart was so enfeebled that he could scarcely walk fifty yards without an attack of angina pectoris coming on, but no enlargement of the heart could be detected. He died suddenly from rupture of the heart, and I found that part of the heart wall was so thinned as to be made up of little beside the endocardium and pericardium, while, notwithstanding this enfeeblement of the heart wall, there was no sign of dilatation of the cavity.

Dilatation of the left ventricle may occur even when the diastolic force filling the ventricle is greatly diminished, as in cases of pure mitral stenosis. Here the quantity of blood reaching the ventricle, and the force with which it enters the ventricle is so greatly diminished that we must look for some other cause to account for the dilatation of the left ventricle that is found in advanced cases of mitral stenosis.

A Vital Factor and not a Mechanical Cause of Dilatation.

From such considerations as I have detailed we are forced to conclude that dilatation is not due to a mechanical distension of the chambers of the heart. In considering what may be the cause, we turn naturally to the consideration of the functions of the muscle fibres. As the permanent lengthening of skeletal muscles is due to lack of tone, and as the lengthening of the muscle fibres of the heart is the immediate cause of the dilatation, and therefore comparable to the lengthened skeletal muscle, the cause of dilatation will in all likelihood be found to be due to depression in the function of tonicity.

The Function of Tonicity.

Gaskell has shown that the heart muscle fibres possess equally with the skeletal muscles this function of tonicity. He was able to produce experimentally both depression and

increase of this function by appropriate drugs and by the stimulation of certain nerves. Thus by such drugs as sodium hydrate, digitalis, antiarrine he was able gradually to prevent the relaxation after each beat till at length it was scarcely possible to recognize the separate beats. On the other hand, by the administration of such drugs as lactic acid and muscarin, the relaxation of the fibre gradually increased, while the contraction gradually diminished till finally the heart stood still in diastolic relaxation.

The Symptoms of Depression of Tonicity.

It might seem at first sight that the main result of the affections of this function would be dilatation of the chambers of the heart. There can be little doubt, when dilatation does occur, that here we have depression of tonicity; but in stating that dilatation is an evidence of depression of tonicity we only state but a part of the truth, for the enlargement of the heart which we associate with dilatation depends on the affection only of certain portions of the musculature of the heart. There are other symptoms which also point directly to failure of tonicity, such as "functional" murmurs and regurgitation of blood from the heart into the veins. These symptoms have hitherto been looked upon as a consequence of simple dilatation of the chambers of the heart, but this explanation is far from being sufficient. Thus we may have considerable dilatation of the heart without a murmur, and with no regurgitant waves in the veins, even though the veins of the neck are full and turgid. Again, we may have very little dilatation with marked systolic murmurs at apex and base, and with great regurgitant wave in the veins. The explanation of these apparent anomalies in the symptoms has hitherto baffled me, but I think an explanation is to be found when the functions of the muscle fibres are considered along with the remarkable description of the structure of the heart given by Dr. Arthur Keith. This observer has drawn attention to the fact that the musculature of the heart is built up of bundles of fibres, having as distinct places of origin and insertion as skeletal muscles, and that each bundle has its function as peculiar to itself as a skeletal muscle. But the heart-muscle fibres are distinct from skeletal muscle in this respect, that according to their special duties certain portions have individual functions more developed than other portions, some having such functions as rhythmicity, conjunctivity, or contractility more developed, while it is fairly certain that some have the function of tonicity more developed than others. It is manifest, for instance, that the muscle bundles that constitute the rings of the auriculo-ventricular orifices have a different function to perform from the muscle bundles constituting the auricular appendages or apex of the ventricle. In the latter cases contractility is the special requirement of the fibres, while in the former case there is but little need for contractility, but a firm contraction—that is, tonicity—is essential for the integrity of the valvular apparatus.

The Cause of Functional Murmurs.

This view of the subject cannot be better expressed or more convincingly illustrated than in the following quotation from Keith:

Dr. G. A. Gibson proved years ago that the pulmonary valves of the human heart received their competency from the musculature of the infundibulum. The fibres of the bulbus arteriosus in lower vertebrates are not truly discharging, but regulating, fibres that maintain their tonicity when the true fibres of the ventricle have passed into a state of diastole. As far as one can tell with the naked eye, this seems to be also the case in the mammalian heart. They probably play a part in the much-discussed question of functional systolic bruit at the pulmonary orifice. When the right heart is distended the circular fibres round the base of the pulmonary artery form a functional stricture at the commencement of ventricular systole between the infundibulum and greatly-dilated artery, and are a factor which must be considered in explaining the production of pulmonary systolic bruits.

Seeing that the integrity of the valvular apparatus depends on the tonicity of the muscle fibres forming the auriculo-ventricular rings, the causation of the functional murmurs at the mitral and tricuspid orifices may be explained as due to a depression of tonicity affecting these muscle fibres. Any one who carefully studies the condition of the heart associated with these murmurs cannot but be impressed with the fact that they are frequently met with in cases that show little or no enlargement of the heart. As, on the other hand, one meets with cases of considerable dilatation without these murmurs, one seems justified in assuming that the tonicity of the muscle fibres forming the auriculo-ventricular ring may

be differently affected from that of the muscle fibres forming the wall of the ventricles.

The Cause of Regurgitation back into the Veins.

A similar explanation seems to be the cause of the regurgitation from the heart into the veins. Hitherto, in explaining the cause of the venous pulse, I have followed the usual description of the manner in which the blood is prevented from being forced back into the veins during auricular systole. But the view of Keith is so rational and based upon such convincing evidence that I have no hesitation in accepting it. He says:

How are the caval orifices closed during auricular systole? The current teaching is that they are closed by the contraction of muscular fibres which surround the termination of the great veins. The largest vein of all, the inferior vena cava, has no circular fibres surrounding its termination, those round the superior vena cava are weak and do not seem strong enough to act as a common sphincter. The coronary sinus, on the other hand, is covered by circular and longitudinal layers of muscle, and is provided with competent valves as well. Thus, the explanation usually given of the manner in which the venous orifices are closed breaks down under anatomical examination, and the true explanation is still to seek.

He then enters into a minute study of the evolution of the structures that prevent regurgitation in primitive hearts, and finally shows that the caval orifices are closed during auricular systole by the contraction of bands of muscle fibres in the auricular wall specially adapted for this purpose. Just as I have been struck by the want of relationship between the size of the heart and the presence of regurgitant murmurs, so in the past I have been greatly puzzled by the seeming anomaly of an absence of the venous pulse in some cases of extreme engorgement of the right heart. On the other hand, I have seen large forcible waves of blood sent back into the veins during auricular systole with no perceptible increase in the size of the right heart. It might, therefore, seem that in the former case the muscle bands that close the caval orifices acted efficiently, while in the latter case the tonicity of these bands had become so depressed that they failed to close the orifices efficiently, and thus permitted regurgitant waves during the contraction of the auricle.

The Cause of Depression of Tonicity.

The most striking instances of depression of this function occur with "failure of compensation in cases of valvular disease, the dilatation being the main evidence. In such cases exhaustion of the muscle no doubt plays the principal part. There are other cases, however, where some other factors seem to be at work. From the study of the experiments of Gaskell and others we can infer that certain drugs have a selective affinity for certain functions, and my clinical experience seems to suggest that similar results may be met with in the human heart. When in this part of Lancashire the beer was contaminated with arsenic some few years ago, cases of heart failure of a peculiar type amongst beer drinkers were fairly common. These cases have been described by Dr. Graham Steell in a paper on Muscle Failure of the Heart. Since the arsenical contamination of the beer has been prevented these cases are not nearly so common, though Dr. Steell informs me he still occasionally meets with them. Some of these I studied minutely, and there was one striking feature which Steell does not mention—namely, great regurgitation of blood back into the veins. Thus, in a publican, a heavy beer drinker, the veins in the neck exhibited large pulsations during two attacks of muscle failure of the heart, the pulsation disappearing on recovery. After the arsenic had been removed from the beer he continued his evil courses, and had two attacks of great prostration with a rapid, feeble heart, but there was no pulsation in the veins of the neck. In the last of these attacks he developed delirium tremens and died from exhaustion. Here I suggest that the peculiar combination of alcohol and arsenic had poisoned more particularly the function of tonicity, which was evidenced by the large venous pulse in his first and second attacks of heart failure.

In certain constitutional states I find a tendency to this depression of tonicity, and it seems possible that a poisoning of this function occurs. In anaemic conditions one finds a puzzling variety of heart changes. In some extreme cases one can detect no abnormal symptom, in others, systolic bruits in the heart and pulsation in the veins are very marked. Thus, in a case of what seemed to me severe pernicious anaemia, there was very slight enlargement of the heart, but distinct systolic murmurs at the apex and base of the heart,

with large pulsations in the veins of the neck of which Fig. 1

Fig. 1.—Simultaneous tracings of the carotid and jugular pulses showing the large waves thrown back by the heart into the jugular vein. The *a-c* interval (space A) is nearly one-fifth of a second. (The time marked in this and the other tracings equals one-fifth of a second.)

is a tracing. This patient's anaemia gradually disappeared, with a complete disappearance of the jugular pulse and of the murmurs. In a somewhat similar but less severe case the venous pulse was also well marked (Fig. 2), and on recovery

Fig. 2.—Simultaneous tracings of jugular and radial pulses. The *a-c* interval (space A) equals two-fifths of a second. (Mrs. W., October 5th, 1904.)

there was left a trace of the venous pulse. I give these tracings in order to point out a peculiarity in Fig. 2 that I have occasionally met with in anaemia—namely, a depression of the function of conductivity.

I have already shown in the BRITISH MEDICAL JOURNAL that one can estimate the condition of the function of conductivity by measuring the time the stimulus takes to pass the fibres between the auricle and the ventricle. This is done by measuring the time from the beginning of the auricular systole (which causes the wave *a* in the tracings of the jugular pulse) to the beginning of the carotid pulse (wave *c*). The normal *a-c* interval is usually about one-fifth of a second as shown in Figs. 1 and 4. In Fig. 2 it is nearly double this time, that is to say, the conductivity in the patient's heart from which Fig. 2 was taken was so depressed that the stimulus took nearly twice as long to cross the *a-v* fibres.

Fig. 3.—Simultaneous tracings of the jugular and radial pulses. The *a-c* interval (space A) is greater than one-fifth of a second. (Miss W., January 14th, 1905.)

Fig. 4.—Simultaneous tracings of the jugular and radial pulses. The *a-c* interval (space A) equals one-fifth of a second. (Miss W., May 14th, 1905.)

With recovery from the anaemia the conductivity was gradually restored, as is shown by the *a-c* interval in Fig. 3 being smaller than in Fig. 2. While in Fig. 4, taken when the anaemia had disappeared, the *a-c* interval is of normal duration. In this latter case we have evidence, therefore, not only of a depression of tonicity, but also of a depression of conductivity, during a profound anaemic condition, with simultaneous restoration of both functions on the disappearance of the anaemia. Here, again, I suggest that in such cases as those from which Fig. 2 was obtained there is a poison that

selects not only the function of tonicity but also that of conductivity of certain fibres.

Digitalis and the Function of Tonicity.

In my observations on the effect of digitalis on the human heart, I pointed out that when a function such as conductivity or contractility was depressed, digitalis had a tendency to increase this depression. Notwithstanding this I found that while the digitalis depressed these functions a patient's condition may be distinctly improved, and it seems at first sight very anomalous that benefit should be derived from a drug which manifestly injures certain functions of the muscle fibres. But the drug digitalis affects more functions than one, and from such experiments as those of Gaskell already mentioned, we learn that digitalis primarily affects the function of tonicity. In cases of heart failure where there is dilatation of the chambers, the contraction of the heart takes place at a disadvantage, for presumably efficiency of contraction will depend on a certain normal distension of the chambers, and an over-distension or dilatation will interfere with the efficiency of contraction. In such cases the digitalis by restoring the tonicity will reduce the cavity to a size more fitted for the effective accomplishment of its contraction. Herein, probably, lies part of the explanation of why it is that the heart's condition is improved with a depression of certain functions manifestly due to the digitalis.

INEBRIETY AS A PHYSICAL DISEASE.*

By H. W. MANN, M.B. EDIN.,

Resident Medical Officer, Larkfield, Nairn, N.B.

I VENTURE to ask your attention to this question of alcoholism, as it concerns us of the medical profession, and more particularly with regard to its treatment by the hypodermic method by injections of atropine. Perhaps next to tubercle there is no question more pressing or more discussed at the present time than this question of inebriety and the inebriate; and certainly there is no one on which the charlatan and the advertiser, lay and political, have thriven more abundantly. To this may in some measure be attributed the fact that medical men as a rule look sceptically and askance on the "cures" and specifics so lavishly offered in the daily press and monthly magazine.

Happily of late years medical men of note have given this matter scientific study and attention, and by regarding inebriety as a physical disease, in many cases capable of cure, they have rescued it from the advertising quack, who too often exploited the inebriate to his own purposes. The late Dr. Norman Kerr was the pioneer in this, and his work has been carried on by such men as Sir Victor Horsley, Professor Sims Woodhead, Mr. McAdam Eccles, Sir James Crichton-Browne, Dr. Clouston, to mention but a few of the more prominent.

In psychological medicine the great forward step in our times has been recognition of the insanities "as a physical disease with mental manifestations," as a condition cerebral in its essence rather than psychic, and on this recognition the modern treatment of this disease is based. Inebriety is one of the phases or varieties of the insane diathesis, and is akin to the *folie circulaire* or alternating insanity. It has its term of excitement, its depression, and its apparent equilibrium.

Inebriety has its etiology, its pathology, and its treatment. It is essentially an irresistible, uncontrollable, and periodic desire for alcohol. It is not thirst, and while the "crave" is present the appetite knows no satiety. In his book on *Mental Diseases*, Clouston places it under "States of Defective Inhibition," and while conscious of its gravity as a social evil, clearly regards it as a neurosis of defective inhibition, as a lack of that control which is the highest function of the cortical centres.

Briefly considered, the following have a place in the causation of this condition: traumatism, concussion, shock, injuries to the head. Epilepsy is frequently associated with inebriety, and, like it, is a periodic nerve storm. Perhaps no association is more commonly observed than tubercle or the tuberculous habit, and it is remarkable in how large a number of cases a family history of tubercle is found to occur.

Among what may be termed "moral" causes there are the numberless social influences, adversity, prosperity, education imperfect and education to excess, ambition, worry, and all

those undefinable states comprehended in the word "Society." Though in such it is sometimes difficult to discriminate between cause and effect. Lastly, heredity has a prominent place in the etiology of alcoholism, and in this case undoubtedly the children do suffer for the sins of their parents.

The pathology of inebriety has received much attention of late years, and if any one fact in pathology is established, it is this—that alcohol, even in physiological quantities, is a direct nerve poison, affecting the cortical layers in the cerebrum, the cerebellum, and the peripheral nerve endings. In a recent lecture Sir Victor Horsley has pointed out how even by the ingestion of small quantities of alcohol the brain functions are affected, how the reaction time is lengthened, both simple and complex, as estimated by Kraepelin's method. And he has demonstrated that in continued absorption the nerve cell degenerates, the granules become obscured, the nucleus and nucleolus gradually disappear, and the active protoplasm is replaced by pigmentation, until finally the cell is inert and functionless. In the peripheral nerve endings the same toxic process goes on, and so in the confirmed alcoholic there are the pains of neuritis, affecting his peripheral nerves, while the tremulous hands and ataxic shuffling gait indicate cerebellar mischief, and the confused misty intellect corresponds to and is co-extensive with the destruction of the cortical layers in the grey matter of the cerebrum.

Ford Robertson, in his work on *Cerebral Pathology*, describes this destructive process graphically when he compares each successive bout of the dipsomaniac as resembling a hurricane of wind sweeping through a forest, which when it has passed shows to the casual onlooker no change, though the trained eye can see the broken stems, the torn branches, and the disarranged undergrowth. But, unlike the forest, to the alcoholic there is no new growth; no proliferated cells replace those lost.

With such a pathology of destruction it may well seem futile to talk of treatment, but with the 600 million of nerve cells which has been calculated to be the average endowment of the average brain there may be always the possibility of calling up from this vasty deep of subconscious cerebration some reserve and reinforcement of those altered and destroyed.

And so the treatment of inebriety, always granted the abolition of alcohol, amounts to a re-education. It must be borne in mind clearly that no treatment will help an inebriate unless he is willing to help himself. He cannot be cured against his will. If one can but control or abolish the insane impulse for alcohol, then the case resolves itself into a dependence on time and the ordinary processes of assimilation and metabolism. What is destroyed cannot be replaced, but what remains may be utilized.

Various drugs have been used for the purpose mentioned—notably the bichloride of gold. An antiethylic serum was put forward some years ago, but with what success I know not. The treatment by hypodermic injection of atropine combined with strychnine has in my hands proved of great value in relieving the intensity of the appetite, and when thoroughly pushed it does confer an indifference to alcohol. I may be mistaken, but I think it is to Dr. McBride of Norwood that the profession owes the first clear record of this method of treatment.¹ The following notes of cases will illustrate this:

A. R., admitted July 24th, a case of chronic alcoholism with degenerative nerve and tissue changes, ataxic gait, tremulous twitchy fingers, patellar reflex absent on both sides, plantar greatly increased, has had neuritis very badly, great mental confusion of time, place, and person; appetite for alcohol intense and continuous. He was given a calomel purge, and put upon atropine gr. $\frac{1}{15}$, with strychnine gr. $\frac{1}{15}$, given at 9 a.m., 3 p.m., and 9 p.m., with a cinchona mixture sandwiched midway between each dose of atropine. July 28th. Slept well, mental condition improved, quiet, calm, and clear; alcohol crave diminished. July 31st. Much better, complexion clearer, cheerful and pleasant, weight 9 st. $2\frac{1}{2}$ lb. August 7th. Atropine increased to gr. $\frac{1}{10}$. August 23rd. Atropine gr. $\frac{1}{10}$; atropine stopped. October 2nd. Continues well, no relapse, no desire for alcohol, weight 9 st. 13 lb., is on parole.

Another case: August 29th. A.M., drinking for weeks, mainly solitary drinking; for a time he would square up, and then have a deeper and deeper debauch. Confesses his weakness, laments it, and promises reform. Put upon atropine and strychnine with cinchona, as in the other case. September 11th. Continues to improve, appetite for alcohol largely gone, is allowed to cycle out and go to and fro practically uncontrolled; has had no relapse. October 3rd. Improvement maintained and

* Read at the meeting of the Northern Counties Branch of the British Medical Association at Dingwall.