NEW METHODS OF STUDYING AFFECTIONS OF THE HEART.

By JAMES MACKENZIE, M.D.,
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I.—AFFECTIONS OF THE FUNCTION OF CONDUCTIVITY.

I propose to endeavour to apply some of the results of recent experimental and clinical discoveries to the explanation of certain phenomena observed in the clinical examination of the human heart. Although, in the main, these papers are explanatory and indicate how certain signs may be recognised, and have accumulated evidence to show how these signs profoundly modify our conception of many afections of the heart, and how the views here set forth may have a very practical bearing on the treatment of a great variety of cases of heart disease.

1. THE FUNCTIONS OF THE HEART MUSCLE FIBRES.

Gaskell describes the functions of the muscular fibres of the heart as rhythmicity, excitability, contractility, conductivity, and toxicity—that is to say, the muscular fibres of the heart possess the power of rhythmically creating a stimulus, of being able to receive a stimulus, of responding to the stimulus by contracting, of conveying the stimulus from muscle fibre to muscle fibre, and of maintaining a certain ill-defined condition called "tone." By virtue of these inherent functions the heart is able to beat and to keep up the circulation of the blood independent of any nervous assistance. In the ordinary sense of the term the heart possesses no motor nerves, the vagus and sympathetic nerves having only a moderately influence upon these varied functions of the heart muscle fibres.

2. ARRHYTHMIAS DUE TO AFFECTIONS OF THESE FUNCTIONS.

While the nature of these functions has been abundantly demonstrated experimentally, little has been so far to apply the "myogenic" doctrine to the study of heart affections in a clinician's view in the absence of any facts showing how modifications of these functions exhibit themselves in the movements of the heart, or in modifying the blood flow in arteries and veins. Engelmann, in a minute and detailed inquiry into the nature of these functions, demonstrated, among other things, that the first four of these functions may each be affected independently of the others. Wenckebach, who had made himself familiar with the most minute details of Engelmann's experiments, conceived the idea that where one of these functions was depressed an arrhythmia peculiar to that function would be manifested. He was able to detect such arrhythmias in the experiments of Engelmann and Hoffman, and afterwards was able to recognize similar types of arrhythmia in certain forms of irregularity in the human heart. His method consisted mainly in taking sphygmographic tracings of the radial pulse and minutely analysing the variations in rhythm. As Engelmann's results were obtained from the dying heart of the frog, it seemed rather a far cry to compare these with those of a fairly healthy human heart. On these grounds objections were plentifully raised against Wenckebach's views, and as his observations depended on inference only, his position seemed somewhat untenable, particularly as arrhythmias bearing a superficial resemblance to some of his special types could be referred with certainty to other conditions. As I had pursued the study of heart irregularities by a different and more conclusive method whereby I could frequently demonstrate the parts played by both auricles and ventricles, I was able to demonstrate the correctness of Wenckebach's interpretations in many of the most striking arrhythmias.

3. NATURE AND FUNCTIONS OF THE MUSCLE FIBRES CONNECTING AURICLES AND VENTRICLE.

While the functions that have been cited are inherent in all muscle fibres, some of these functions are more highly developed in certain portions of the heart muscle than in other portions. The muscle fibres at the mouth of the great veins and joining portion of the right auricle (remains of the sinus venosus) possess the greatest power of automatically creating the stimulus for contraction, and because of this wave of contraction normally starts here, and passes in a peculiar manner over the rest of the heart, with varying speed, quickest over the tissue which has become modified so as to approach more nearly in its properties to ordinary striated muscle—namely, the reticulated bulged portion of the auricle and ventricle—more slowly over those parts which retain a more embryonic character—namely, the auriculo-ventricular muscular ring and the bulbus arteriosus.

Gaskell further points out that the muscular tissue joining the auricle and ventricle (canalis auricularis) shows a less-developed type of muscle fibre, being less striated, a condition which has been verified in the mammalian heart by Kent, His, jun., and others. This muscle tissue is distinct in its functions from the more striated muscle fibres in that the wave of conductivity passes more slowly over its fibres, and it possesses a greater power of automatically creating a stimulus for contraction. In the human subject these peculiarities can be recognized, and their recognition explains satisfactorily a great number of obscure actions of the heart some of which have hitherto escaped attention, while others have been completely misunderstood. In this paper I shall deal only with the evidence of the first of these peculiarities—that is, the nature of the conducting power, whereby the stimulus is conveyed from auricle to ventricle, leaving for a subsequent communication the description of the results of over-excitability of these fibres.

4. METHOD OF ESTIMATING THE CONDITION OF THE CONDUCTIVITY.

This function is recognized by the time that elapses between the auricular systole and the ventricular. The method of studying the movements of the heart by taking simultaneous tracings of the radial and jugular pulses affords an exceedingly simple and readily demonstrable method for observing the conductivity in man. To obtain a tracing of the jugular pulse a shallow, open cup is placed over the lower end of the relaxed jugular, as in Fig. 1, and the jugular vessels are connected to the aorta by means of a tube with a tambour, which is fitted on a Dudgeon or von Jacquet sphygmograph in such a manner that the lever of the tambour can be made to write on the same paper as the jugular. At the same time the sphygmograph lever inscribes the movements of the radial pulse. It is frequently impossible to get tracings of the jugular pulse without some movement due to the carotid. With the radial pulse as a standard one can with certainty assign the part of the tracing due to the carotid and the jugular. That part of the tracing which has been verified as the movement produced by the carotid is marked C. In this paper I shall deal only with the evidence of the first of these peculiarities—that is, the nature of the conducting power, whereby the stimulus is conveyed from auricle to ventricle, leaving for a subsequent communication the description of the results of over-excitability of these fibres.

Fig. 1. The space X represents the time of the ventricular systole. The wave a is due to the right auricle, and the wave c to the carotid impact. The space x represents the a-c interval. The time marked in all these tracings equals one-fifth of a second.

Fig. 2. The upper tracing is from the neck and shows a small wave (c) from the jugular vein, and due to the right auricle, preceding the large carotid wave.

For the special purposes of studying affections of conductivity this interference by the carotid is a fortunate circumstance, inasmuch as it provides a readily recognizable point.
in the cardiac cycle from which to gauge the interval between the auricular and ventricular systoles.

5. The Intersystolic Period (a-c interval).

This interval is occupied by three events—namely (1) the systole of the auricle; (2) the transmission of the stimulus from auricle to ventricle; (3) a minute portion of time taken up by the interval during which the ventricular pressure is rising before opening the semilunar valves (asthmiform or presphygmic interval). As 1 and 3 are practically constant, they may for the purpose of this inquiry be ignored, any variation in the length of the a-c interval being due to variation of the rate of stimulus conduction.

In normal hearts I have found that the a-c interval is fairly constant, lasting usually one-fifth of a second (Fig. 1). Sometimes it appears a little shorter. The rapidity with which the tracing paper moves does not separate the events widely enough to enable us to measure the changes with sufficient minuteness. Still the differences can be appreciated readily by the eye.

6. Depression of Conductivity without Arrhythmia.

While the a-c interval may be considered normal when it does not exceed one-fifth of a second, as in Fig. 1, considerable increase of this interval may take place with no manifestation in the rhythm of the heart. The recognition of this depression of conductivity can only be afforded when we have evidence of the contraction of the auricles.

In Fig. 3 there is a tracing of the auricular and the carotid waves taken at the same time as the auricular tracing shows a perfectly regular rhythm, while the neck tracing shows a great increase in the a-c interval equal to two-fifths of a second (space A). The heart may continue to beat perfectly regularly for years with the conductivity affected to this extent. Thus Fig. 3 was taken from the same patient as Fig. 3 in 1893, and the jugular tracing shows a like increase of the a-c interval to two-fifths of a second. Except for a short period in 1893 (Figs. 6 and 9) this patient’s pulse was quite regular up to 1904.

7. Influence of Rest upon Conductivity.

With each contraction all the functions of the muscle fibres are at the time being abolished. During diastole these functions are gradually restored. Normally their recovery is simultaneous, so that when the rhythmical stimulus arises at the auricle or great veins it passes over the whole heart, and the muscular fibres respond at a uniform time. When one of these functions is depressed, its recovery does not take place as speedily as the others, therefore the relationship of the action of these functions is not uniform, and an interference with the regular sequence of events results. Certain variations in the rate of conduction can frequently be detected, not only when conductivity is depressed, but also when it is presumably normal, such variations apparently depending on the time required for recovery after the previous exhaustion.

One has little difficulty in illustrating this in a variety of ways in certain forms of heart irregularity. In a patient aged 24, and pregnant with her first child, auricular fibrillation, I noted an increase in the a-c interval for some years. During labour it frequently happens that the pulse becomes irregular, the irregularity often being of a respiratory type. The radial tracing Fig. 3 shows such an irregularity.

The tracing of the carotid and jugular shows a rise and a fall due to the movements of respiration—the rise in the tracing corresponding with expiration, and the fall during inspiration. It will be noted that there is a distinct shortening of the radial pulse period at the beginning of inspiration. It will be seen that the a-c interval during the short pulse period (space A,) is nearly double the duration of the a-c interval during the long pulse period (space A.).

As the rate of conduction is continually depressed, but when the heart beats at a slower rate the conductivity has time to recover, so that the stimulus is conveyed from auricle to ventricle at about the normal rate (A,, A,,). Here the arrhythmia is not originally due to the depressed conductivity, but evidently starts at the auricle, for the auricular wave, a, appears at irregular intervals. The modifying effect on the ventricular rhythm of the variable condition of the conductivity can be illustrated in a variety of ways. If we examine minutely the incidents where an occasional premature or extra systole occurs, sometimes very curious variations in conductivity can be detected.

When a stimulus arises prematurely in the auricle, the conductivity has not been completely restored, therefore the stimulus takes a longer time in passing to the ventricle, and as a consequence there is an increase of the a-c interval.

The patient from whom Fig. 6 was taken always showed a slight but distinct depression of the conductivity, as can be observed by the slight and varying length of the a-c interval (spaces A,, A,). The radial pulse shows two premature beats (x x) with corresponding premature beats (c c) in the jugular tracing. These premature beats are due to extra systoles of auricular origin, for it will be observed that in the jugular tracing the waves c’ occur too soon. The interval between a’ and c’ is greater than the average a-c interval (A,) and is very markedly greater than the a-c interval (A,) following the premature contraction.

as speedily as the others, therefore the relationship of the action of these functions is not uniform, and an interference with the regular sequence of events results. Certain variations in the rate of conduction can frequently be detected, not only when conductivity is depressed, but also when it is presumably normal, such variations apparently depending on the time required for recovery after the previous exhaustion.
8. Arrhythmia due to Depression of Conductivity.

Slight arrhythmia may be due to variations of conductivity. Thus the short space o in the radial (Fig. 6) is seen to be due to an increase of the preceding a-c interval (space A), that is, to a delay in the venous systole. Arrhythmia of a more marked character arises when the conductivity is so greatly depressed that the stimulus occasionally or frequently fails to cross the auriculo-ventricular junction. How this occurs is well seen in Fig. 7.

![Diagram](image)

Fig. 7.—Shows a gradual shortening of the a-c interval till a radial and carotid pulse beat drop out after the auricular wave c. The following a-c intervals is shortened.

There is a constant delay in the conduction of the stimulus here, the a-c interval being unduly prolonged. Before the intermission there is a slight but gradual increase of the a-c interval. After the auricular wave c there is no carotid wave (o) nor pulse beat in the radial. The reason for this is manifestly that the auricular systole a' occurred so soon after the previous ventricular systole (as evidenced by the carotid wave c immediately before a') that there was not sufficient time for the recovery of the function of stimulus conduction in the auricle and ventricle and a beat dropped out. By this means a longer rest was procured for these fibres, and when the next stimulus comes down from the auricle the rest has so restored the function of conductivity that the a-c interval following the previous interval is the average. In Fig. 8 there is a dropping out of ventricular beats at regular intervals.

Fig. 8 was taken in 1898 from the patient from whom Figs. 3 and 4 were taken. For many years tracings from this patient showed constant slight depression of the conductivity. For some reason in 1898 this conductivity became further depressed so that at regular intervals a ventricular beat dropped out (Fig. 8). The true nature of this arrhythmia is shown in the jugular tracing (Fig. 9), where the auricle is shown to contract regularly (wave a), while the ventricle fails to respond to every third auricular systole. To demonstrate this more clearly I reconstruct Fig. 9 in the form of a diagram (Fig. 10), after the manner of Wenckebach, modifying it so as to show the actual site of delay at the fibres joining auricle and ventricle. The down strokes in the upper division represent the auricular systoles (A). The down strokes in the lower division represent the ventricular systoles (V), and correspond with the radial and carotid pulses in Figs. 8 and 9. The thick, slanting lines represent the conduction at the fibres joining auricle and ventricle (A-V). It will be seen that a ventricular beat drops out regularly after every third auricular systole.

This form of arrhythmia has been described by Wenckebach and its cause inferred from the manner in which the radial pulse varied. His proof rested upon similar variations in the movement of the frog's heart described by Engelmann, and it affords me much pleasure to be able to verify the interpretation of this shrewd observer.

9. Bradycardia due to Depression of Conductivity.

Gaskell states that on applying a screw clamp around the auriculo-ventricular groove of a frog's heart, "according to the tightness of the clamp the ventricle can be made to beat synchronously with the auricles, to respond to every second contraction of the auricle, to respond to every third, fourth, or other contraction, or to remain quiescent." All these varying results can be demonstrated to occur in the human heart.

In Fig. 11 there is one short pulse period and the a-c interval here is much longer than the a-c period after the longer periods, the lengthening being an evidence that the conducting power of the fibres at the auriculo-ventricular groove have had time to recover as effectually as after the longer pulse periods. In Fig. 12 there are three auricular contractions to one ventricular, except during the last arterial pulse period, when there are but two auricular waves, and after the second of these the a-c interval is longer than the other a-c intervals in this tracing.

In an excellent tracing published recently by Gibson there are four auricular beats to one ventricular. This blocking may be so extreme that the auricle may beat ten or twelve times and the ventricle stand still. When this occurs anemia of the brain induces syncopal and epileptiform seizures (Adams-Stokes syndrome). I have seen a few such cases, but unfortunately I was not able to take tracings during the attacks, but the classical case so remarkably well recorded by Webster demonstrates these points most conclusively.

10. Independent Ventricular Rhythm due to Heart Block.

In the tracings I have given so far it could be shown that when the ventricle does contract it is in response to a stimulus from the auricle. When a ligature is applied in the auriculo-ventricular groove of the frog's heart, so that the stimulus can no longer be conducted from auricle to ventricle, after a time the ventricle will beat with a rhythm different from, and independent of, that of the auricle (heart block).
The systole and auricular relationship in the human subject is independent of time as the ventricular systole is a constantly varying one, sometimes at a distance, then gradually approaching till they are synchronous. Whatever relationship the a has to e no variation takes place in the rate. The same thing is shown in Fig. 14, where the apex beat is recorded at the same time as the radial. Here there is a small wave, a, due to the systole of the left auricle, and the same maintenance of the independent rhythms is manifest here. One can infer with certainty that the auricle contracted at the same time as the ventricular systole during the first four or five of the ventricular apex beats, but that the evidence of this simultaneous contraction is obscured by the large ventricular wave, for we can see in Fig. 13 how the wave, a, occurred at the same time as the carotid pulse. I have taken a large number of tracings from this patient at various times and under various circumstances, and I have invariably found the independence of rhythm between the auricle and ventricle.

Another peculiar feature present in this case was the remarkable manner in which this patient's pulse seemed shut off from the effects of external stimuli. The pulse-rate was almost invariably 20 to 12 beats per minute whether she was working or lying in bed. Even when undergoing a surgical operation, observations before, during, and after the administration of chloroform showed the same uniform pulse-rate. Professor Wenckebach informs me that in a similar case a glass of port wine considerably quickened the rate of the auricular contractions, while the ventricular rate was unaffected. To demonstrate the evidence of all four of the functions of the heart muscle fibres I will describe in some further papers the effects of digitalis on the human heart, as this drug has a remarkable effect on the individual functions.

REFERENCES.

CONJUNCTIVAL BACTERIOLOGY.

SOME PRACTICAL ASPECTS OF CONJUNCTIVAL BACTERIOLOGY.

BY FREELAND FERGUS, M.D., F.R.S.E., Surgeon to the Glasgow Eye Infirmary.

I desire to say something as to the necessity and utility of daily bacteriological work in the modern eye clinic. The science of pathology and the science of therapeutics are sisters. The problem to be solved is the treatment of disease. The object of pathology is to explain the origin of disease, and the ideal object of rational therapeutics is to apply the teachings of pathology to its cure or to its alleviation. In all its departments medicine is in many respects more of an art than a science, and probably to a large extent must remain so; but, unquestionably, recent pathological advances have done a great deal to illumine the work of the practitioner, and to bring his efforts more into line with the biological sciences.

Thanks to the pathologists, we now have clearer ideas as to the nature of the many forms of inflammation of the conjunctiva, which in days gone by were all classed together as catarrhal ophthalmia, and were for the most part put down to exposure to cold, or to other indefinite causes. Some considerable number of years ago it came under my notice that a number of persons, who all lived in the same tenement in High Street, Glasgow, were suffering from acute catarrhal conjunctivitis.

I investigated the matter at the time, and found that no fewer than forty persons were thus affected in this one tenement. It seemed to me, then, that we here had to deal with something which was epidemic, and to some extent analogous to one of the specific fevers. Some time later I read a very interesting paper by Dr. Weeks, which seemed to afford a complete explanation of such occurrences. In that paper he described his bacillus and the contagious catarrh to which it gives rise.

Many changes have taken place since then, and thanks to the labours of several distinguished pathologists we now know a considerable amount about the bacteriology of the conjuncti...
CASE XXX (Reported by Mr. Connell, F.R.C.S., Surgeon, Sheffield Royal Infirmary).

Married woman, supposed to have intestinal obstruction following recent abortion. Mr. Connell, called in consultation, found marked blue line, constipation, anemia, etc. The woman admitted having taken "-fly" in 1803.

NEW METHODS OF STUDYING AFFECTIONS OF THE HEART.

By JAMES MACKENZIE, M.D.,
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II.—THE ACTION OF DIGITALIS ON THE HUMAN HEART.

Considering the number of years during which digitalis has been employed in the treatment of affections of the heart, and considering the great number of experiments that have been performed on animals to determine the action of digitalis, it might be assumed that the nature of the action of the drug is fairly well known. But if one examines the results of these observations, clinical as well as experimental, no clear conception of the manner in which this drug acts can be obtained. The study of its effect upon my own patients has engaged my attention for many years, and I have added a large number of observations which show its effect on the movements of the heart. The correct interpretation of these observations baffled me for a long time, but at last two events happened which threw a flood of light upon this subject. The first of these events was the observation that in a large class of patients, for whom digitalis is frequently prescribed, the rhythm of the heart does not proceed from the auricle to the ventricle, but originates in the ventricle, which is thus the primary focus of the conduction of the pulse (a, Fig. I). We know this to be true, through the work of Wilkens, who showed that in many cases until other functions of the heart are affected, and until severe gastric disturbances have resulted, without the slightest sign of conductivity being delayed. But when conductivity is depressed—that is to say, when the a-e interval is more than one-fifth of a second—then digitalis may depress this function with fatal results. Patients who have prolonged depression of conductivity for years, and during that time the rhythm of the heart may be invariably regular. Such patients are, however, exceedingly susceptible to the influence of digitalis, and any large quantity of the drug produces an arrhythmia, due to the dropping out of ventricular systoles. The auricle will continue to contract with perfect regularity, but the stimulus occasionally fails to cross the fibres that connect auricle and ventricle.

A.—ACTION OF DIGITALIS WITH THE NORMAL RHYTHM OF THE HEART.

1. Effect of Digitalis on Stimulus Conduction (Dromotropic Effect).

In a paper recently published in this JOURNAL I described how the stimulus for contraction was conveyed from muscle fibre to muscle fibre. The stimulus arises at the mouths of the great veins, passes over the auricle, and reaches the ventricle by the fibres joining auricle and ventricle. By observing the time that elapses between the systole of the auricle and the systole of the ventricle we can gauge the rate of conduction along these fibres. This is shown in tracings of the jugular and carotid pulses, when in the jugular a (Fig. I), due to the auricle being present, and c is immediately followed by a wave, c, due to the carotid. The time between a and c represents the time that the stimulus takes to cross the fibres between auricle and ventricle. The conductivity is normal when the a-c interval does not exceed one-fifth of a second. When this function is normal, it is doubtful if digitalis can effect it. At all events, I have pushed it in many cases until other functions of the heart were affected, and until severe gastric disturbances have resulted, without the slightest sign of conductivity being delayed. But when conductivity is depressed—that is to say, when the a-c interval is more than one-fifth of a second—then digitalis may depress this function with fatal results. Patients who have prolonged depression of conductivity for years, and during that time the rhythm of the heart may be invariably regular. Such patients are, however, exceedingly susceptible to the influence of digitalis, and any large quantity of the drug produces an arrhythmia, due to the dropping out of ventricular systoles. The auricle will continue to contract with perfect regularity, but the stimulus occasionally fails to cross the fibres that connect auricle and ventricle.

CASE I.

Female, aged 42. She was under my care in 1900, and I had prescribed digitalis, and phenomena similar to what I am about to describe supervened. She had rheumatic fever in 1900. She married early in 1903.

![Fig. 1—Simultaneous tracings of the jugular and carotid pulses with the radial, showing that the a-e interval (Space marking here) is twice the normal period (Space marking twice of one-fifth), indicating a delay in the stimulus passing from auricle to ventricle. Dyas (2) marking here and in the other figures represents one-fifth seconds.](image-url)
There was a well-marked systolic murmur at the apex (in 1900 I had noted a presystolic murmur). There was marked pulsation in the veins of the neck, a tracing of which shows an abnormal wide a-c interval (Space A, Fig. 1). Being in a fair condition of health, I advised her to the avoidance of any means whereby the heart's work might be increased. On November 4th she consulted me for extreme weakness and shortness of breath. I prescribed her tincture of digitalis (B.P.), 15 minutes, three times a day. On November 5th, when she had taken 3 drachms of the tincture, she complained of shortness of breath and general distress—not pain, but a feeling of oppression over the front of the chest. The heart's action varied in a curious manner. For a few minutes the pulse would be perfectly regular, beating at the rate of 90 beats per minute, then it would suddenly become irregular and slow for a few minutes, then again resume the more rapid and regular rhythm. The digitalis was at once stopped, but the irregular action of the heart persisted until the 11th of November. From that date I kept the patient under constant supervision until a month after her confinement in February, 1904. I took tracings of her jugular and radial pulses at every visit and a very large number while she was in labour and under chloroform; I have seen her at intervals during the past year, and I have never found a single instance of the dropping out of the ventricular beat, or any resemblance to the irregularity which occurred from November 5th to November 11th. (On November 10th she fell for two hours into a curious mental condition, her memory for recent events being quite gone, talking in a slow hesitating manner, scarcely understanding what was said to her. The attack suddenly passed off, and never returned.)

I took a large number of long tracings during the days when the pulse was irregular, and the analysis of the short examples given in Figs. 2 and 3 applies equally to the whole of the tracings obtained.

Fig. 1 shows the widened a-c interval, which is even yet (January, 1905) a constant phenomenon in tracings from this patient. Figs. 2 and 3 are instances of the different forms of the interval which occurred after the administration of the digitalis. It will be noticed that the auricular wave, a, is perfectly regular in its appearance, whereas the radial pulse and the carotid (wave c) is markedly irregular.

Further, it will be seen that the relationship of the radial and carotid to the auricular wave is a curiously varying one, approaching near to the auricular wave after a long pause, and receding from it after the next beat.

It will also be seen that after the auricular wave a' no radial or carotid beat follows—that is, a ventricular systole drops out, and the arrhythmia is really due to the occasional dropping off of ventricular systoles. The nature of the arrhythmia will be more apparent if a diagram is constructed to show the auricular and ventricular systoles and the passage of the stimulus along the fibres uniting auricle and ventricle. In Fig. 4 the dots at the a-c interval represents the auricular waves (a) of Fig. 2, occurring at exactly the same intervals. In the lower division, v., the downstrokes represent the carotid pulse beats (or radial pulse beat), and occur at exactly the same intervals as the carotid waves (c) in Fig. 2.

The narrow division (A-V f) in the middle represents the fibres joining auricle and ventricle, and corresponds to the a-c interval in Fig. 2. The thick line passing through the A-V fibres slants at different degrees, and this varying slant represents the varying rate which the stimulus takes to pass through the fibres from auricle to ventricle. Before the first ventricular intermission this slant is the greatest, after a ventricular intermission the slant is always the least. The increase in the slant indicates an exhaustion in the power of conduction, and this exhaustion becomes ultimately so great that, after a systole of the auricle, the stimulus fails to reach the ventricle, and so a ventricular systole drops out. This failure of the stimulus to affect the A-V fibres permits them to have a long rest, so that when the next physiological stimulus comes the auricle contracts, as is seen in the diagram (Fig. 4), and the stimulus is conveyed to the ventricle with greater rapidity, as is shown by the shortened a-c interval in the tracing (Fig. 2) and by the diminished slant of the thick line in the diagram (Fig. 4).
patients with no venous pulse the effect of digitalis in depressing conductivity can be recognized by the finger or by a tracing of the radial. I think I can assert with confidence that in any given case, when the auricles are active, when in response to the administration of digitalis, the pulse becomes irregular, with long pauses, these pauses are due to the propping out of ventricular systoles, because the stimulus has failed to pass from auricle to ventricle. To my mind, the only other cause which could occasion these long pauses is the occurrence of extra-systoles, but on listening over the heart the sounds of the heart are absent when a ventricular systole drops out; whereas, with extra-systoles, the characteristic short, rapid sounds can be heard, due to the premature contraction of the ventricles.

I quote the following case to show how the nature of the arrhythmia can be proved with fair probability without the presence of a venous pulse to guide us:

Female, aged 73. She has suffered from attacks of palpitation, for which I have attended her at intervals for many years. She consulted me in April, 1904, for great shortness of breath and violent throbbing in the neck and upper part of the chest. The pulse was usually from 80 to 100 beats per minute, full and forcible. There was marked pulsation in the carotid, but no venous pulse. There was a faint pulse at the 5th interspace, and the heart's dulness extended to the left in. beyond the nipple. There was a rough systolic murmur at the apex, also well heard at the base. I was doubtful whether there was a slight aortic systolic murmur. There were no murmur during my previous attendances on this patient. Notwithstanding rest and appropriate treatment she did not improve, and in June she visited Neuchâtel, and there underwent a six weeks' course of treatment—bed and exercise—followed by a visit to Switzerland. She returned to Burnley distinctly worse, very much thinner, less able to undertake exertion because of the palpitation and breathlessness, and the pulse rate under 100 beats per minute. I tried her with various remedies, including digitalis; but in a few days this drug produced such gastric derangement that I had to stop it. She steadily got worse, and, as there was sleeplessness and much muscular tremor I prescribed ammonium bromide. In a few days she had an extensive attack of erythema nodosum on both legs. She recovered from this in a fortnight, being kept in bed and gently massaged. I resolved again to try the effect of digitalis. She began with three granules of digitalis a day on September 12th. No effect was observed till September 24th, when her heart began to intermit very frequently, sometimes she said she could feel her heart beating every second. When I examined her on September 29th the pulse-rate varied in its rhythm, periods of perfect regularity varying with periods of irregularity as in Figs. 7 and 8.

Fig. 7.—Tracing of the radial pulse, showing irregularity due to digitalis. The nature of this irregularity is shown in Fig. 9. The minute elevation preceding the tall at is due to the systole of the left auricle.

Fig. 8.—Shows the same as Fig. 7. The nature of this irregularity is shown in Fig. 10.

During the intermissions no pulse could be detected in the heart. The digitalis was stopped, and the arrhythmia daily got less until the 4th of October when it had entirely disappeared. Since that date the pulse has never shown a single irregularity, the heart has become much quieter, the rate gradually falling as low as 72 beats per minute. The heart’s dulness is now within the nipple line, the murmurs are still present, but the patient’s general health has wonderfully improved. Although the improvement dates from the period of arrhythmia, the patient has a horror of the digitalis.

While the absence of a venous pulse deploys us of the absolute proof of the nature of the arrhythmia we can infer that depression of conductivity was the cause from the similarity of the irregularity to that shown in Figs. 2 and 3. The nature of this arrhythmia becomes all the more evident if we construct diagrams on the basis of the two tracings Figs. 7 and 8.

The Milroy Lectures ON INDUSTRIAL ANTHRAX.
Delivered before the Royal College of Physicians of London.
BY T. M. LEGGE, M.D.OXON.,
H.M. Medical Inspector of Factories.

LECTURE II.
[ABSTRACT.]

TREATMENT OF EXTERNAL ANTHRAX.
The treatment of anthrax until recently has either been merely expectant or consisted in cauterization or other allied treatment of the local pustule. But the use of a serum derived from an immunized animal is coming more and more into use, especially in Italy and South America. Since in external anthrax spontaneous cures are frequent, a consideration of the case mortality will not suffice to establish the relative value of the three methods of treatment mentioned. Other points must be considered, such as (1) the relative amount of scarring or of deformity left; (2) the applicability of the form of treatment to the different types assumed by the disease and the stage which it may have reached; and (3) the length of time which elapses from the beginning of the treatment to resumption of employment. The third point is of material moment in connexion with an industrial disease.

Müller 1 has described 13 consecutive cases treated successfully in Jena by rest, fixation, and elevation of the part affected, stimulating diet, and the local application of great ointment. Ramstedt, 2 from the same clinic, has added more recently other 7 consecutive cases (one very severe), in which nothing but the same expectant treatment was pursued. And, similarly, Fr. Schnitzler 3 of Bonn has cited a case of extremely severe malignant pustule of the cheek, with extensive oedema of the eyelid, neck, and chest, which was cured after a plastic operation on the eyelid without other operative treatment. Müller considers that adoption of expectant treatment may be defended on the ground that any operation may facilitate the distribution of the bacilli throughout the system.

Surgical interference usually takes the form of free excision, dissecting out the pustule from the healthy tissues beneath, swabbing the wound out with pure carbolic, and allowing the wound to granulate up from the bottom. Subcutaneous injections of 5 per cent. carbolic acid around the malignant

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1. Müller 2.
2. Ramstedt.
3. Fr. Schnitzler.
which his bowels receive during the period of convalescence. When the erect attitude again is assumed the patient soon becomes affected with the troubles from which he suffered before his appendicectomy was removed. This condition of the large bowel is the main objection to this operation. It is seen in the patient experiences after these unsuccessful appendicectomies excepting such conditions as are due to an incorrect diagnosis in the first instance. It is exactly what one would expect from a knowledge of the causation of the present state of affairs.

That the operation of removal of the appendix not infrequently fails to relieve patients of their painful symptoms is well known to all of us, and no amount of statistics pointing to a contrary conclusion to this effect can change it. It is possible at the time of the operation to gauge fairly accurately the amount of success that will follow upon the removal of the appendix, and, if necessary, upon the division of such bands as might cause the obstruction of a portion of the ascending colon, or hitching up and obstructing the hepatic flexure.

I think that the failure to permanently relieve patients of their symptoms in a number of so-called cases of appendicectomy is due to its removal in an incorrect diagnosis of the condition. It is seen in the patient histories and the results of the subsequent operation performed upon the surgeon most materially by recounting their experiences of the subsequent history of these cases after operation.

In certain cases the patient refers all the pain to the epigastrium or complains of a full feeling and the defecation sometimes comprised under the term indigestion may be present in an aggravated form, and these I do not think it necessary to describe in detail. In such cases of advanced constipation in which the small intines have become affected to such an extent that it is pinned down at intervals severe pain is complained of, and certain loops become so palpable during attacks and the pain so severe as to suggest obstruction.

The symptoms due to the absorption of toxins all tend to produce a sense of listless and even cross hostility in the patient. The patient wakes up with a feeling of weakness and rises unrefreshed from his sleep. There is an utter lack of tone and an inability to perform the ordinary routine duties. Consequently upon this weakness the respiratory function is carried out in an unsatisfactory manner, and attitudes of rest are habitually assumed, any active exercise being quite impossible, and the patient acquires resting deformities which I have described elsewhere. The consequent diminution in the respiratory capacity becomes an added factor in the progressive loss of energy, and diminishes the resisting power of the individual. The diminution of the power of resistance, which is brought about by the presence of the toxins and their consequent conditioned action, causes sepsis, the teeth becoming curious and the gums inflamed from the invasion of organisms. This naturally adds to the depression of the vitality of the patient. The skin of the patient becomes dry, thin, and atrophic, such as the axilla and groin, the secretions acquire a nasty offensive smell. This smell is also perceptible in advanced cases, when the abdomen is opened and the viscera are exposed. The colour of the skin is altered; it becomes a dirty brown colour. This pigmentation is exaggerated in certain parts, as, for instance, about the lower eyelids, at the inner angles of the eyelids, in the temporal region, in the neck, in the axillae, near the apple, under the umbilicus, round the anus and around the generative organs. In some cases isolated well-defined pigmented areas exist on the body.

In infancy the nidus afforded by the irritated lymphatic glands in the mesentery and by the presence of fluid in the peritoneal cavity serve as excellent media for the development of tubercle. The loss of resisting power brought about by the presence of toxins renders the child liable first to the entry of organisms in the tubercle, and secondly to the entry of tubercle into areas whose vitality is still further depereated by traumatism. Later in life tubercle, gum, gastric ulcer, rheumatoid arthritis, and many other similar diseases appear among the class of patients with what might almost be called selective action.

Perhaps one of the most conspicuous consequences is the loss of fat that the patients undergo after a certain period of time. How long they are able to hold out against the influence of the plagues without losing fat varies greatly in different subjects. Once, however, that it commences, this loss of fat increases with marked activity, and it affords the best indication one can have that the patient is going repeatedly downhill. I particularly call your attention to the importance of this symptom, as I believe it is one that should lead us to take very definite measures.

Associated with this symptom of loss of fat there are the symptoms arising from the dropping of such organs as are largely dependent upon the presence of fat for their retention in their normal position; I refer particularly to the kidney and the heart. Then there is the special degenerating influence upon the sexual apparatus which is particularly marked in women.

There is often also a considerable amount of mental depression, and this often is not noticed by the patient, in whom the presence or absence of a small quantity of toxin makes the difference between a manageable and an unmanageable patient.

The question of treatment I do not propose to deal with any form other than operative, since I assume that everything short of operative interference has been tried. When it becomes apparent that something must be done beyond drug and other such treatment, the question resolves itself into whether an attempt should not be made to liberate the constiction by the division of bands or adhesions, or whether it would not be better to establish direct continuity between the lower end of the ileum and the termination of the descending colon and the flexure of the colon, in which case the only considerable alleviation of symptoms may frequently be obtained by the division of bands and adhesions, nevertheless, in women, as a rule, it is better to proceed at once to the division of the sigmoid, or even of the rectum, which in these cases is dilated, afford a more suitable site for implantation I establish continuity with that part of the intestinal tract. The operation is extremely simple and its result are excellent, providing that the case has not been too far advanced, and that there has been no considerable dilatation of the stomach that has taken place. I cannot urge too strongly the importance of operative interference being carried out at an early period since the benefits to be gained vary inversely with the length of time during which the constipation has existed and with the mechanical changes resulting from such constipation.

Many have objected to the operation on the ground that the patient will be affected by an acute toxic disease. Such is certainly not the case. In a large proportion of the cases the patient has still for some considerable time to take drugs, or by preference use glycerine enemata, which latter are advisable in that they obviate any possible back-flow of faeces through the large bowel and their accumulation in the cæcum. In a small proportion of careless feeders a certain number of fluid motions may follow upon an inordinately large vegetable meal such as not uncommonly occurs in the diet of the poor. This is the objection that I have to make to the operation, but, on the other hand, the duration of the colonic obstruction is one of the most vital importance.

References.
1 The Causation and Treatment of Hydrocele and Hernia in Young Infants.

NEW METHODS OF STUDYING AFFECTIONS OF THE HEART.

By JAMES MACKENZIE, M.D.,
Barnsley.

III.—THE ACTION OF DIGITALIS ON THE HUMAN HEART.—(Continued).

The Effect on Stimula and Deceleration (Chronotropic Effect) and Excitability (Bathromorphic Effect).

At the end of systole all the functions of the heart are for the time being abolished. The starting of the contraction is due to the power possessed by the muscle fibres of the heart to contract within themselves material capable of stimulating the fibres to contract. Though all the fibres of the heart possess the power, those fibres at the mouth of the great veins possess this power in a greater degree, and hence the stimulus to contraction normally proceeds from this part over the whole heart. In addition, these fibres possess the power of creating
the stimulus matter in a remarkably regular manner, with the result that the heart normally beats with great regularity—in striking contrast to what happens when other parts of the heart take on the infection of the rhythm. The power to receive the stimulus—that is, excitability—is a distinct and definite function of the heart-muscle fibre. As this function may vary, the rate of the heart may depend on the sensitivity of the heart to stimulation. The stimulus matter continues to be created until sufficient is formed to overcome the excitability of the muscle fibres.

When the heart's action becomes slower under the influence of digitalis, it is due to the slower formation of stimulus material (chronotropic effect) or to diminished excitability of the heart muscle (bathmotropic effect)? I know of no means by which we can distinguish whether the slowing is due to one effect or the other.

The fact that digitalis slows the heart is so well known that I need not dwell at any length on this part of the subject. I quote the following case, however, to demonstrate that the digitalis in materially affecting either the chronotropic and bathmotropic functions, does not affect the bathmotropic (conductivity). In this respect this case is typical of most cases when the pulse becomes slow and regular under the influence of digitalis.

CASE 1.

Male, aged 34, schoolmaster, has been rather short of breath for two years. During December, 1903, he was troubled with violent beating of his heart and shortness of breath. He rested a week and felt better. In the beginning of March, 1903, he again became very short of breath and his legs began to swell. I examined him on March 15th, and found him propped up in bed. He complained of shortness of breath and pain over the region of the liver. The respiration was short and shallow, thirty per minute. Both legs were greatly swollen and the abdomen was distended, but no fluid could be detected. The skin and muscles over the upper part of the right side of the abdomen were very tender to pressure. The liver was enlarged, extending 3 in. below the ribs. There was marked pulsation of the veins of the neck and the auricular type (see Fig. 1). The pulse was small, soft and rapid. 93 beats per minute. There was a diffuse ill-defined cardiac impulse, the heart's dullness extended transversely from 2 to 3 in. to the right of the sternum across to 3 in. outside the left nipple line. There was a slight systolic murmur at all the areas. The urine was scanty and free from albumen. It was a steady man, but a heavy smoker. (He has subsequently suffered from an attack of rheumatism.) The patient was restricted to a milk diet and prescribed a pill containing pulv. digitalis, pulv. scill., pil. hydrarg., ext. hyoscyam.; of each one grain, one to be taken three times a day. Gradual improvement took place. After March 21st the urine became more abundant, the liver dullness diminished, and the tenderness of the covering tissues became less marked, though the pulse rate at times continued as rapid as ever. By April 1st the liver was normal in size, all tenderness of the superficial tissues had gone, the heart's dullness had diminished by 2 in. and only a slight systolic murmur was heard at the mitral orifice, and the urine was abundant and all dropsy had disappeared. The pulse rate had fallen to 65, and the venous pulse was not so large (Fig. 1). By April 20th the patient had quite recovered, and the venous pulse had almost disappeared (Fig. 3).

Fig. 1.—Simultaneous tracing of the radial and jugular pulses during failure of compensation. Note the slight increased a-c interval (space A).

Fig. 2.—Shows the effect of digitalis in slowing the pulse, and the longer rest permits the restoration of conductivity (compare space B in Fig. 1).

The points to which I wish to draw attention are the marked slowing of the pulse and the information shown by the venous pulse in these tracings. It might be said that the slowing was due to other agencies employed besides the digitalis, but the same results as are here shown have happened with the prescription of the tincture of digitalis and digitalin, so that one can reasonably attribute the slowing of the digitalis. This slowing is shown to be unaccompanied with any depressing effect on the conductivity. Rather we can say that the conductivity has been increased, inasmuch as in Fig. 1, is greater than the same interval in Figs. 2 and 3. The increase in the length of the a-c interval in Fig. 1 is due to the exhaustion consequent on the long-continued rapid action of the heart, and the shortening of the period in Figs. 2 and 3 is due to the beneficial result of the rest obtained by the slowing of the heart—a result to be expected from what was shown in the two previous papers of this series. We can say then that the digitalis then depressed the function of excitability and stimulated production, it did not depress the function of conductivity.

Fig. 3.—With continued improvement the jugular pulse has almost disappeared, the tracing showing a small wave (a) due to the auricle before the carotid pulse (c).

Effect on Contractility (Inotropic Effect).

The function of contractility is the most essential and the most notable function of the heart muscle. The more vigorous this function the more forcible will be the contraction of the heart. Certain circumstances materially affect this function, none more beneficially than rest. Within certain limits, the longer the pause the more vigorous will be the contraction, and the contraction will also last longer. It is a matter of everyday experience that a heart beating at a certain rate which is normal to the individual results in the circulation being efficiently carried on. An excessive slowing is no more conducive to an efficient circulation than an excessive quickening. The rate most compatible seems to be that which permits the heart muscle just enough time to recover its full power of contraction. As this function, like all the other functions of the heart, is abolished during systole, its recovery is gradual. If stimulated to contract too soon after systole the contraction is weaker and if time were given it to recover fully. We have already seen how short a time is sufficient to make a great difference in the rate of conductivity, and we shall see how short a time is sufficient to make a great difference in the vigour of contractility.

The good effect of digitalis on contractility may be due simply to the fact that in slowing the rate (chronotropic or bathmotropic effect) it gives time for the function of contractility to be restored; but that digitalis under certain circumstances may affect the function of contractility directly can be demonstrated in a most striking and convincing manner. It is again to Wenckebach and his groups of allorhythmia, where every second beat rhythmically varies, Wenckebach distinguished one where a small beat regularly followed a large heart, while the rate of the heart was perfectly regular. He, most appropriately, desires to limit the name pulseu alternans to this form of allorhythmia (see Figs. 5 and 8). Hitherto the name has been applied very loosely to whatever we note that we cannot regard as regular systoles. Wenckebach's explanation of the cause of pulseu alternans is as follows: When contractility is depressed, if time be allowed for a full and strong contraction, the longer duration of contraction encroaches upon the period of rest, but this time the next stimulus arrives the contractility has not sufficiently recovered, and a smaller and shorter contraction results. As this contraction is shorter in duration, the period
of rest is thereby lengthened before the next stimulus arrives, so that the contraction will be stronger and longer; being longer it will again encroach upon the period of rest, and so the process of alternation goes on. For the interesting and convincing manner in which Wenckebach demonstrates the real nature of this arrhythmia I would refer the reader to his book.

Case II.

Female, aged 24, enjoyed good health till 1900, when she began to be short of breath. Towards the end of 1901 the difficulty in breathing increased and her legs began to swell. I saw her first in November, 1903, and she was then very weak and had to be propped up in bed, her legs and abdomen being swollen and urine scanty. The pulse was small and weak, and there was a large pulsation in the veins of the neck. The heart's dullness extended 2 in. to the right of the sternum and 1 in. to the left of the nipple line. The sounds were clear and free from murmur. I prescribed the pill of digitalis, castor, and squill, and it speedily increased the flow of urine, diminished the dropsy, and slowed the pulse, though the jugular pulse continued large (Fig. 4).

Unfortunately she was seized with severe salivation and ulceration of the gums, and the pills had to be stopped. She became worse after the pills were stopped, and though I tried digitalis and tincture of digitals, no effect was produced. She again tried the pills, but soon began to salivate and had to stop them. After trying other remedies unsuccessfully she hit upon the plan of taking the pills with her food. She suffered no more from the salivation and benefited greatly by the pills. By February, 1903, she had made a fair recovery. I did not see her again till the beginning of November, 1903, when she was again suffering from shortness of breath, persistent cough, and unable to lie down. There was no dropsy. She had been occasionally taking the digitals, castor, and squill pills, and I advised her to take them regularly, three daily. They seemed to relieve her, and on November 14th the pulse tracing showed a rhythmical variation of the kind described as the pulsus alternans (Fig. 5).

Fig. 4.—Jugular and radial pulses after partial recovery from an attack of failure of compensation in November, 1903. The jugular pulse is of the auricular type. Compare space $h$ (period of ventricular systole) with space $h$ in Fig. 7.

The point to which I wish to direct attention in this case is the occurrence of the pulse-beats in Fig. 5 at perfectly regular intervals, showing that the arrhythmia is entirely due to variations in the size and duration of the ventricular systole. Fig. 6 gives the jugular pulse at the same time, and shows that here there is no effect on the conductivity, the $a-c$ interval corresponding to that in Fig. 4. It also shows that the alternating action of the heart has no appreciable effect on the auricular systole, as the waves $a$ are apparently of the same size. The space $s$ in all these tracings represents the time of ventricular systole during which the semilunar valves are open, and it will be noted that in the jugular pulse in Figs. 4 and 6 this period is occupied mainly by a great fall, while in Fig. 7 it is occupied by a great rise. Furthermore, there is no sign of a wave due to the auricle in Fig. 7, implying that here the ventricle has taken on the inception of the rhythm. Note that, with the inception of the rhythm by the ventricle, the rhythm of the pulse is continuously irregular. It might be suggested that in this case the alternating action was due to one of the other drugs accompanying the digitalis, but the fact that the same result followed the administration of the tincture in Case III and of digitalis in a case I shall record later, and agrees closely with experimental production of the pulsus alternans in Fig. 12, points fairly conclusively to digitalis being the potent agent in producing the pulsus alternans in this case.

Case III.

Female, aged 44, has suffered since 12 years of age from several attacks of rheumatic fever. She was first seen on November 15th, 1903, complaining of shortness of breath and dyspnea on the slightest effort. The pulse was small, quick, and regular, 100 per minute. There was great distension of and pulsation in the jugular veins. The apex beat was

Fig. 7.—Simultaneous tracings of the radial and jugular pulses taken on November 9th, 1904. The jugular pulse is now of the ventricular type, and the rise in the jugular during the ventricular systole (space $s$) is in marked contrast to the fall during this period in Figs. 4 and 6. There is no wave due to the auricle; the inception of the rhythm is here taken up by the ventricle, and in consequence the rhythm is continuously irregular.

This arrhythmia had disappeared by the 14th, and I have never found it to recur. The patient gradually recovered from this attack, and I did not see her again until November, 1904. She was then very ill, her legs and abdomen being enormously swollen, and her left pleural cavity contained a large quantity of fluid. Her pulse was now continuously irregular, and the venous pulse had completely changed its character from one of the auricular type (Figs. 4 and 6) to one of the ventricular type (Fig. 7).

Digitalis in its various forms and strophanthus was pushed, but without result, and the patient died on December 17th, 1904. At the postmortem examination there was found slight stenosis of the mitral orifice.
large and forcible in the fifth interspace 1/2 in. outside the nipple line. The heart sounds extended 2 in. beyond the middle line. There was a loud, long systolic murmur—heard at all the areas, loudest at the mitral. She was prescribed a mixture containing tincture of digitalis and tincture of iron, 1/2 mins of each, three times a day. On November 31st her pulse was observed to be irregular, and a tracing showed a good example of the pulsus alternans (Figs. 8 and 9).

Fig. 11.—Shows the persistence of the alternating action in the radial pulse with marked slowing of the rate, and with no apparent effect on the auricle or on conductivity.

From this date the patient steadily improved. On November 3rd the tracing, Fig. 10, was taken. By November 5th she felt very well, the pulse became regular, and the auricular pulse much stouter. The slight alternating rhythm remained observable in the radial pulse (Fig. 11). By the 14th all the signs of the jugular pulse and of the pulsus alternans had disappeared. By the 21st the patient felt much better. Since that date she has had several slight relapses, and though the digitalis has been pushed I never got a marked alternating rhythm as in these tracings, though after long use of the drug the majority of the postures previously had been relieved. In the jugular tracing of Figs. 9 and 11 there is, again, no sign of conductivity being affected, and it should be noted that, so far as one can judge, the arrhythmia did not appear to affect the auricle. Fig. 10 is of interest. The first part of the tracing shows a slight alternating action with the pulse beats occurring at regular intervals till the beats marked 1-4 occur at slightly more rapid rate, and these beats correspond in size to the smaller beats in the first part of the tracing. This diminution in size is manifestly due to the fact that conductivity has not had time to recover. After the fourth small beat there is a pause longer than usual, followed by the largest beat in the tracing. This large beat is manifestly due to the fact that the conductivity has had more time for recovery by reason of the long pause after the preceding small beat. The exhaustion after the large wave results in a small wave followed by a larger, and here is apparently the beginning of a period of alternating pulse beats (unfortunately the tracing was stopped here). Hoffmann and Wenckebach have particularly referred to this manner of starting the alternation.

I am inclined to think that there may be found a means of estimating the condition of the function of conductivity by noting what effect a change in the period of rest has upon the size and character of the succeeding pulse beat. In a future paper I shall demonstrate this method with more fulness.

This depression of conductivity is not common in cases where the auricle is active. From among a large number of observations I have only found three or four instances, and I might have had some doubt in attributing the effect to digitalis were it not that in cases of ventricular rhythm the effect is much more pronounced, and I hope to demonstrate how a depressed condition of conductivity in cases with ventricular rhythm can be connected with a similar depression in cases with the auricular or normal rhythm. Furthermore, the following experimental observations demonstrate the justness of the interpretation given above.

Since I wrote this description of the effects of digitalis in conductivity, Professor H. E. Hering has sent me the results of some experimental work done in his laboratory at Prague. In one paper Pletnew describes the effect of electric stimulation on the hearts of rabbits under the influence of medicinal doses of digitalis. The drug was carefully pushed, and in two instances, of which he gives tracings, the digitalis produced an alternating effect on the contraction of the heart. It will be seen in Fig. 12 that the arrhythmia is a good example of the alternating action of the ventricle and is in perfect agreement with the results I have just described in the human heart. These tracings also confirm the most striking manner Wenckebach's description of the nature of the pulsus alternans. By careful measurement of the events in Fig. 12 it will be seen that the starting of the v, is perfectly regular, but that systole of the lesser beat is distinctly shorter in duration, so that the period of rest after the short beat is distinctly faster than the large beat. Wenckebach has further pointed out that a beat may drop out from exhaustion of the function of conductivity, and the missed beat at X Fig. 12, is due to this cause. The size of the wave and shows the exhaustion is increasing. There is no beat following the auricular systole a'. It might be said that the missing of a beat was due to the depression of conductivity, so that the stimulus failed to reach the ventricle from the auricle, but I have already shown that digitalis conductivity so as to produce a ventricular intermission, that the time between a, and v, gradually lengthens, and that the v, succeeding the pause at a shorter interval after the a, By careful measurement it will be noted that conductivity is not in the least affected at any period here, the interval between a, and v, being a constant one. The total cause is the one which has been in the auricle, and confirms the explanation I gave for the large beat in Fig. 10. These tracings also confirm the facts shown in my tracings that it is only the degree of leucopения in cachexial fever and kala-azar, and suggested that it might prove to be of diagnostic value. Further experience has convinced me that this is the case, and I propose to set forth the evidence in favour of this view in the future. As it is connected with the function of the system, it is one of the most important to determine the matter of the greatest practical importance if even a large proportion of cases of this disease can be correctly inferred from a simple examination of the finger blood, instead of the much more serious operation of spleen puncture; for although the latter method can, with proper precautions, be safely resorted to, it is not possible to determine in the majority of cases, yet not infrequently the coagulability of the blood is so reduced in cachexial fever as to render it highly inadvisable to puncture the spleen. This is the case mainly in very cachectic subjects, and from various forms of haemorrhage, petechial or otherwise, in some of whom I have found the coagulability of the blood to be considerably reduced, and in such cases I estimate the coagulability of the first drop of blood obtained, and only puncture the spleen if the blood clots within five minutes or less. A fine hypodermic needle should be used.

The Diagnostic and Prognostic Value of the Leucopenia of Cachexial Fever and Kala-Azar, and Its Treatment by Quinine and Bone Marrow.

By Leonard Rogers, M.D., M.I.C.P., I.M.S., Acting Professor of Pathology, Medical College, Calcutta.

In a paper read before the Oxford meeting of the British Medical Association I drew special attention to the marked degree of leucopения in cachexial fever and kala-azar, and suggested that it might prove to be of diagnostic value. Further experience has convinced me that this is the case, and I propose to set forth the evidence in favour of this view in the future. As it is connected with the function of the system, it is one of the most important to determine the matter of the greatest practical importance if even a large proportion of cases of this disease can be correctly inferred from a simple examination of the finger blood, instead of the much more serious operation of spleen puncture; for although the latter method can, with proper precautions, be safely resorted to, it is not possible to determine in the majority of cases, yet not infrequently the coagulability of the blood is so reduced in cachexial fever as to render it highly inadvisable to puncture the spleen. This is the case mainly in very cachectic subjects, and from various forms of haemorrhage, petechial or otherwise, in some of whom I have found the coagulability of the blood to be considerably reduced, and in such cases I estimate the coagulability of the first drop of blood obtained, and only puncture the spleen if the blood clots within five minutes or less. A fine hypodermic needle should be used.
I am indebted to Mr. Mayo Robson for the suggestion which I found in his book—as to the injection of saline solution—and I cannot help thinking that it was the washing out of the clogged ducts that cured this patient.

REMOVAL OF GALL BLADDER IN A WOMAN
AGED 75.

BY AUGUSTUS W. ADDINSELL, M.R.C.P.,
Physician, London Temperance Hospital.

The following case may be worth recording on account of the age of the patient, the severity of the symptoms, and the completeness of the recovery.

Mrs. M., aged 74, a widow, had suffered from frequent attacks of pain in the right hypogastric region, accompanied by jaundice. There had been progressive exhaustion and emaciation for eighteen months. I saw her first in consultation with Dr. Muzio Williams in March, 1902. The history was that eighteen months previously she had been suddenly seized with pain in the right hypogastric region, vomiting was severe, and the following day all the usual symptoms of jaundice manifested themselves. The stools were pale, the urine was plate-coloured; the skin yellow, and the temperature high. This condition lasted for three days, the jaundice never completely disappearing; when in about a month another attack came on. These attacks recurred with increasing frequency, until, at the time I saw her, she was completely bedridden, rarely out of pain, deeply jaundiced, had lost more than 2 st. in weight, and had all the appearance of a woman suffering from malignant disease of the liver. There was a large, soft mass reaching from below the right costal margin to the level of the anterior superior iliac spine; percussion over the right chest gave a clear note down to the last rib. There was complete enterophasis. The lower border of the liver was easily felt below the umbilicus, and in the right iliac fossa a small movable mass was made out.

Dr. Turney had previously seen the patient and advised, in the interest of the continuance of the symptoms, that an operation should be attempted. Dr. Muzio Williams agreed with me that, as the patient was markedly losing ground, the operation was at once decided upon.

I made an incision as for appendicitis, as that corresponded with the lower edge of the liver and was over the mass which I took to be the gall bladder. That organ was found constricted, and an incision was made, greatly thickened; the walls were more than 3 in. thick, and it was filled with a large mass of inspissated bile which readily broke down; there were in addition several large gall stones. After removing the mass and the stones, 6 oz. of normal saline solution were injected into the cystic duct; these were followed by another 3 oz. As none returned, it evidently passed through the via duodenales into the duodenum.

I removed the gall bladder and succeeded in getting the neck of the cystic duct into the lower angle of the peritoneal wound. The peritoneum was then closed and the fascia muscles sown round the orifice of the duct, but the skin was not attached to the stump. The dressing was changed daily for a week, and 3 oz. of normal saline solution injected into it during the day. After that the injecions were discontinued. There was a gradually diminishing quantity of bile discharged, and in a month the wound was healed.

From the next day the following decision was taken in all the symptoms set in; the urine became normal in colour; bile passed freely into the intestine, as evidenced by the stools; and gradually the jaundice disappeared, the pain entirely ceased.

I have just seen the patient, two years after operation; she has put up more than two stone in weight. She takes daily walks of the exercise of four miles. She has had no pain or return of any of the symptoms, and is quite well, and stronger than she has been for years past. The eminently satisfactory result of operation on this case of severe cholangitis is encouraging.

NEW METHODS OF STUDYING AFFECTIONS OF THE HEART.

BY JAMES MACKENZIE, M.D.,
Burley.

IV.—ACTION OF DIGITALIS ON THE HUMAN HEART IN CASES WHERE THE INCEPTION OF THE RHYTHM OF THE HEART IS DUE TO THE VENTRICILE.

I have already endeavoured in two papers in this Journal to demonstrate the fact that the rhythm of the heart may originate with the ventricle. Continued observation has afforded me still stronger proof in favour of this observation. The study of the effect of digitalis on my patients has brought out very striking differences between these cases and those where the rhythm starts at the auricle. No single idea of the general action of these drugs can ever be obtained unless this change in the heart’s action is appreciated. The means whereby one can recognize and demonstrate whether the rhythm of the heart is auricular or ventricular in origin is by far the most significant. When a poli is present in the jugular if the auricle is active it will undoubtedly always produce a wave with its systole, but if the ventricle is active, then no wave will be seen, except the one usually occupied by the auricular systole, but the jugular pulse will be found to be synchronous with the ventricular systole. This change of the jugular pulse from one auricular type to one of the ventricular type is illustrated by examples in my previous papers in this Journal and in my book, and very convincing illustrations will be found in the second case recorded in this paper, and in the paper which Deutsch read at the last German Medical Congress at Leipzig.

Apart from the scientific interest which this view would evoke, the matter is one of the highest practical importance, as a large number of the cases of heart failure which we are called upon to treat present not only this feature, but the inception of the rhythm by the ventricle is the direct and immediate cause of the heart’s failure. I have been engaged for some time on a minute inquiry into this subject, and the results obtained so far justify me in stating that they will not only profoundly modify our conception of many forms of heart failure, but will give to a more direct and definite aim in our attempts at treatment.

In my first paper in the ventricular rhythm, I showed that this condition might arise in different ways, which occurred in advanced disease of the mitral valves. In this complaint, towards the end of life, the pulse frequently becomes irregular—the well-known “mitral pulse.” This is almost invariably the sign that the ventricle has taken on the inception of the rhythm of the heart. If there has previously been present an auricular systolic murmur of the crescendo type it disappears, though a low-toned diastolic murmur may continue; and if there has been a jugular pulse present, it will now be found to be of the ventricular type. If the heart’s action is rapid, it may be quite regular with the ventricular rhythm (see Figs. 5 and 6).

There seems to be reasonable ground for assuming that an anatomical basis will be found to account for some varieties of ventricular rhythm. In those cases where the venourse rhythm is a standing disease of the mitral valves and great dilatation, I hold that the auricle, like an over-distended bladder, became paralysed, temporarily or permanently. Certain signs, however, now lead me to doubt the correctness of this view in all cases, as it would seem that the auricle might contract during the ventricular systole. I mention this, that the term “auricular paralysis” may be understood to apply to those cases of long-standing mitral disease where the rhythm is ventricular in origin, and where no evidence of an auricular contraction occurs. Dr. A. K. has, in recent Hunterian lectures, dwelt upon the nature and functions of certain bands of muscle fibres in the heart. In these lectures he analyses the anatomical condition of a number of hearts. He sent me a specimen which he brings out to illustrate the relationship between certain anatomical conditions and the symptoms during life. Thus, in describing the heart from the first case cited below, he found extreme atrophy of the musculature of the auricle with great elongation and atrophy of the auricular canal, there being also marked stenosis of the mitral and tricuspid orifices (see his Fig. 9). In another heart with mitral and tricuspid atresia which I
had under observation for three years, and whose pulse never showed any irregularity, and in whom the auricle was active until her death. Keith found great hypertrophy of the musculature of the auricle, and neither stretching nor atrophy of the auricular canal.

To illustrate the effect of digitalis in cases of ventricular rhythm I shall deal first with those cases that result from advanced mitral disease, as a peculiar and distinctive reaction is produced that I have not found in other forms of ventricular rhythm nor in cases when the auricle is active. The reaction about to be described does not occur in all cases, but may show it in a remarkable degree, and it is astonishing how readily susceptible these hearts are to the influence of digitalis.

**CASE I.**

Female, aged 51, seen first on March 23rd, 1902. There is a history of weakness and shortness of breath, extending back for many years. She lies propped up in bed, her legs and abdomen being greatly swollen. The urine is scanty, the respirations are short and shallow. There is marked pulsation in the veins of the neck of the ventricular type (Fig. 1).

The pulse is small and very irregular. There is a great enlargement of the heart, the apex being felt in the sixth interspace, a. beyond. The heart’s dullness extends z. to the right of the middle line. There is a systolic murmur heard at the apex, and also heard all over the back of the chest. A systolic murmur of somewhat different character is heard over the front of the heart and at mid-sternum. A diastolic murmur occupying sometimes the whole of the diastolic period is heard in a small area at the apex. It is of a low, quietly blowing character, fading away towards the end—not sounding in the characteristic crescendo murmur of the auricular systolic murmur. She was prescribed the pill containing digitalis, squill, and calomel three times a day. The pulse began to get slower in ten days’ time, and on April 15th it had taken on the rhythm shown in Fig. 2.

**CASE II.**

Female, aged 16. Seen first on March 24th, 1903. Had had rheumatic fever, and for some years has suffered from breathlessness and palpitation on exertion. This has increased lately, and there is slight oedema of the legs. There is marked pulsation of the veins of the neck of the auricular type (Fig. 4). The pulse is small, regular, 62 per minute. There is great heart-sound with the left chest and with the right side of the greatly enlarged heart. The apex beat is large and diffuse, and felt in the sixth interspace and in the anterior axillary line. There is a loud, harsh, systolic murmur heard over the whole back and the back, loudest at the apex. With rest and digitalis she rapidly improved. She broke down again, and a note on January 5th, 1904, states that the abdomen is greatly swollen, the heart is presented, and the oedema of the legs, oedematozous, and the urine scant. The radial pulse is small, soft, and rapid, 126 per minute, while the jugular pulse is of the ventricular type. Under digitalis granules were again improved, but in February the granaules were stopped, and she speedily broke down again. On
March 10th, 1904, the condition was similar to that described on January 9th, the radial and jugular pulse tracings being shown in Fig. 5.

She was prescribed digitalin granules, one per day. They speedily took effect, and on March 16th the pulse had become slow and irregular (Fig. 6). The urine had greatly increased in quantity, the abdomen and liver had diminished in size, and all signs of dropsy had gone. The digitalin was continued till March 28th, one granule being taken every second day, and she continued in fair health, the pulse still slow and irregular, as shown by Fig. 7, which was taken on March 26th.

The digitalin was stopped on March 28th. Four days after stopping it the pulse had increased to 85 per minute, though she felt still fairly well. On April 5th—that is, eight days after stopping the digitalin—the rate of the heart had increased to 120 beats per minute, the pulse had become small and weak and the jugular distention had increased.

Eight days after stopping the digitalin failure of compensation again set in, the pulse here being 120 per minute, and the jugular pulse being still of the ventricular type. (April 5th, 1904.)

(Fig. 8.) The other signs of heart failure were beginning to show themselves. She was again put on digitalin, one granule per day. On April 9th the pulse was still 120 per minute. On April 16th it was 130, on April 14th it had again become slow and irregular. (Fig. 9.)

The digitalin was again stopped, but as the pulse began to increase in rate on March 17th, one granule per day was prescribed. The patient continued in fair health, but as the pulse did not slow down satisfactorily, on May 1st I doubled the dose. I did not take any further tracings till May 14th, continuing myself with watching for the slowing of the pulse. Finding it did not yield as before to the increased doses of digitalin, I took tracings on this day, and found a perfectly regular radial pulse, while the jugular pulse had completely changed its character, being now of the auricular type—that is, the auricle has again resumed its activity, and the heart is completely in its normal sequence. Occasionally, for a short period, it would show a slight alternating rhythm, as in Fig. 10.

With continued use of digitalin the auricles resume the inception of the rhythm of the heart, as shown by the fact that here the jugular pulse is of the auricular type. (May 15th, 1904.)

The digitalin was stopped, and the patient continued in fair health for some months. Up till now (February, 1905) the jugular pulse has continued to be quite regular except during a short period shortly to be described. On December 16th, 1904, she was again beginning to get oedema of the legs, and the abdomen began to swell, and she was very breathless. The pulse was small, soft, and rapid, 110 per minute, and the jugular pulse was still of the auricular type. She was prescribed 0.8 gr. of the digitalin per day. No improvement had taken place by December 27th, when she was ordered to take two granules per day. By January 2nd, 1905, the rate had fallen to 80, as a rule quite regular, but occasionally an extra-systole of ventricular origin would occur (Fig. 11). Sometimes for a short period these ventricular extra-systoles would appear after every second beat (Fig. 12). The digitalin was stopped, and the arrhythmia disappeared. She still continues in fair health, with a perfectly regular pulse.
OBLITERATIVE ARTERITIS.

I need not dwell on the convincing character of this series of tracings from this patient. The demonstration of the normal rhythm in Fig. 4 and of the ventricular rhythm in Fig. 5 and the return to the normal rhythm in Fig. 10 is surely sufficient to give pause to the most sceptical critic. That some profound change had taken place in the rhythm of the heart is beyond doubt, but if any interpretation is wrong there are sufficient striking facts recorded in the tracings to afford material for a close investigation into this matter. The space x in all these tracings represents that portion of the auricular systole when the auricular wave is open, and in the jugular tracings it will be seen that when the auricle is active a wave, a, precedes the space x, and a fall occurs during that period. When the rhythm is ventricular the auricle wave precedes x, and the space itself is always filled by a large wave.

The effect of digitalis when the rhythm is ventricular is manifestly the same nature as that in Figs. 2 and 3; that is, it is mainly, if not entirely, an effect on the contractility. This case shows a remarkable sensitiveness to digitalis when the rhythm is ventricular, and I have often been able to slow and quicken the pulse rate in this manner in similar cases. Even when the auricle was restored to activity—as in Fig. 10—we seem to get an echo of the effect on contractility, for the slight arrhythmia shows also an alternating large and small beat. This is not a pure puleus alternans, for we saw in the previous paper the rate was perfectly regular, whereas here—in Fig. 10—the pulse periods vary in length, a short period and a long period alternating. It will be seen that there was a due to variation in the auricular rhythm, whereas in the case of the true puleus alternans the variation was entirely due to difference in the size of the ventricular beats.

When arteritis was admitted in December no further reaction followed like that in previous attacks of heart failure. When a definite reaction did occur (Figs. 11 and 12) it was of a totally different nature—namely, the occasional occurrence of ventricular extrasystoles independent of the stimulation from the auricle—that is to say, ventricular extrasystoles. In my experience this is an unusual effect of digitalis, and in the next paper I will suggest a probable explanation along the lines of relationship of digitalis to fibres joining auricle and ventricle.

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OBLITERATIVE ARTERITIS,
LEADING TO GANGRENE OF EXTREMITIES IN OTHERWISE APPARENTLY HEALTHY MEN IN THE PRIME OF LIFE.
BY E. MICHELS, M.D., F.R.C.P., Surgeon to the German Hospital, London.
AND F. PARKES WEBER, M.D., F.R.C.P., Physician to the German Hospital, London.

In a paper read at the annual meeting of the British Medical Association, in July, 1903, we described two cases of obliterative arteritis in young men, leading to gangrene of the extremities. Of these cases the second was a complicated one, but the first was a typical case, affecting three limbs, in an otherwise apparently healthy man aged 37 years, there being absolutely no evidence of syphilis, alcoholism, renal disease, satiunism, ergotism, or premature senility. Our present case is remarkably similar in its main features, though only the two lower limbs have been affected.

Case.

The patient, A. H., a cigarette maker, aged 39 years, a Jew from Roumania, was admitted into the German Hospital on August 3rd, 1904.

He enjoyed good health, but at twenty-three years of age commenced to suffer from pain in the right lower extremity. The pain was in the foot and the muscles of the calf of the leg. It used to come on when he had walked for six or seven minutes and was accompanied by circulatory weakness, so that when the pain came on he had to stand still, but after two or three minutes it used to get better, and he was able to go on for six to seven minutes and then stop again, and so on. Evidently this was a kind of "intermittent claudication" of the extremity. He says the foot was quite red at that time, as it is not rarely in cases in which the blood supply is obstructed, owing to changes in the arteries of the affected limb. At Riga, in 1889, after more than a year of these sufferings, the right lower extremity was amputated below the knee joint. The wound healed rather slowly—that is to say, in about five months, and he then remained well till 1903. About June of that year he began to suffer from severe pains in the toes and the calf of the left lower extremity, and he had a kind of "intermittent claudication" in that extremity, similar to that which he previously had had in the other. It was this trouble which brought him as a patient to the German Hospital. There is not much more to be said in regard to the past history of the case. The patient has been moderate in alcohol, and there is not any history of venereal disease. He says, however, that he has been accustomed to smoke at least ten cigarettes a day, and has also taken a good deal of strong tea. His father died at over seventy years of age, and his mother is still living, aged about sixty-six years.

Fig. 1.—Transverse section of part of the popliteal artery (X 20), showing its channel obliterated by connective tissue (a). In this are many newly-formed blood vessels (b), and in some parts groups of brown pigment granules, some of which are represented diagrammatically in black (c). d=the middle coat. There are some small areas of calcification (x) just outside the elastic lamina, which is not very distinctly seen in the section illustrated.

Condition after Admission (August, 1904).—The patient was a medium-sized, active man, without signs of disease in the heart, lungs or abdominal organs. The urine showed nothing abnormal. There were no signs of any disease of the nervous system. The arteries and nutrition of the upper extremities seemed to be natural. Arterial pulsation could be felt in both inguinal regions, but pulsation was hardly, if at all, perceptible in the left popliteal artery (the right leg had been amputated in 1889, as already stated). Examination of the blood (October 6th, 1904) showed the haemoglobin value to be about 100 per cent. of the normal standard; the number of red cells in the cubic millimetre was 5,120,000, and nothing remarkable was noticed in regard to the white corpuscles. Ophthalmoscopic examination (October, 1904) showed nothing abnormal.

On account of gangrene, Dr. Michels first of all removed the left big toe on August 5th, 1904. The wound did not heal properly, and in tolerable pain in the foot continued, so that on October 7th, 1904, Dr. Michels, at the patient's repeated request, other treatment having been found useless, amputated the left lower extremity below the knee. At the operation there was hardly any bleeding from the cut vessels, and on examination it was found that the lumen of the popliteal artery was completely obliterated at the site of amputation.

The progress of the case was quite uneventful. The patient was free from pain after the operation and the wound healed well. In December the stump appeared a good one, although at one part he said it was tender to pressure. His general
empyema for two reasons—(1) If anything were to go wrong with the pump, water would pass into the cavity; (2) if there were much discharge the pump would become dirty and rust. A large bottle was at least connected between the pump and the chest, and this was partially filled with carbolic lotion; by placing the bottle on a higher level than the pump, it was found that even when the water was flowing out good, slow respiratory movements did not lead to sufficient alteration in pressure to draw the water into it. A negative pressure of 80 mm. Hg was used in adult cases, and this was accomplished by having a fall of nearly 2 metres.

Since the apparatus described above, although possessing the advantage of costing less than ten shillings, nevertheless labourors from the disadvantage of requiring a slight amount of attention, it was thought worth while to devise one that would work without any attention at all. A small exhaust pump of about 16 cm. capacity was run by a small electric motor; with this arrangement it is necessary to place a valve in the system to prevent too great a negative pressure being developed. The arrangement which was adopted consisted in connecting the pump with a large wide-mouthed bottle, through the cork of which three tubes passed. One of these was connected with the pump, one with the chest, and the third was open above, but inside the bottle passed into a cylinder containing mercury.

The depth of the mercury was over 15 cm., the tube could be drawn up so that the distance of the end from the surface of the mercury could be adjusted as ease. It is necessary for the cylinder to be about a centimetre in diameter, because air bubbling through mercury agitates it so greatly that if a small cylinder be used the mercury would be thrown out of it; hence should be tied over the top of the cylinder. The negative pressure developed depends upon the depth of the opening of the tube below the surface of the mercury and efficiently prevents a dangerous exhaust being established.

The treatment is painless; usually the pulse is slightly accelerated, but that may be due to the excitement of having the apparatus by the bedside.

The Advantages.

The advantages which may be claimed for this treatment are two: the negative pressure tends to expand the lung without necessarily causing empyema of the other lung, which may be expected from the use of James’s bottles.

The negative pressure produces a hyperaemia of the tissues of the pleural cavity, which probably increases their local resistance.

The comparative opsonic values of exudates from the pleurae under normal and under reduced pressures are being estimated.

This is only a preliminary account, but the results obtained so far seem to me to justify publication.

IRON ACETATE IN THE TREATMENT OF PNEUMONIA.

By HERBERT J. ROBSON, M.R.C.S., L.R.C.P.,
Leeds.

For the last seven years all cases of pneumonia—whether bronchopneumonia or lobar pneumonia—met with in my practice have been treated by iron acetate, and in severe cases by alternate doses of iron acetate and strychnine, and with surprisingly good results. The statistics I intend publishing later when I get more time at my disposal.

A furled tongue or complications such as bronchitis and pleurisy or whooping-cough seem to make no difference to the success of the treatment, but the condition of the patient the better the value of the treatment demonstrated.

The prescriptions used are:

- Liquid ferri phosph. mrx., liquer ammon. acetat. 3i., aq. chlorof. ad 3 sas (adult dose). Take every 4 hours in water when given alone; take every 6 hours alternately with the strychnine mist, when this latter is needed. (It is administered every 4 hours until the patient is well over the crisis; then it is given every 6 hours, and later every 12 hours alternately with the strychnine.)
- Strychnine mrx., aq. chlorof. ad 3 sas; & mist. Take every 6 hours in water alternately with the ferric mist, and as above stated (in severe cases only).

But the patient's health must be considered. Alcohol is seldom given until towards or after the crisis, and often it is not required at all, and then only as the pulse or condition of the patient directs.

Oxygen is seldom required; and, in my opinion, its value is very much overestimated. But when it is given it is administered “warm,” being either gently blown into the patient’s mouth and nose at a temperature of 56° or 58° F., at which temperature there is no cold draught or feeling of cold, or inhaled directly at a temperature of 65° F. from the oxygen warmer made for me by Messrs. Reynolds and Bramson; though always the temperature of the oxygen is regulated by the warmer.

Quinine is never given, as in my opinion it does positive harm in this disease.

Digitalis seems seldom needed if the treatment by iron acetate is adopted early.

Antipneumitics of the coal-tar series are carefully avoided, as in this disease I believe them to be dangerous.

Tellip sponging or the cold pack is resorted to for lowering a high temperature; though under the above treatment it seems to be seldom required. The temperature of the bedroom is kept at 63° F., and free ventilation is encouraged.

For pleuritic pain an occasional mustard leaf and a flannel binder carefully applied round the chest are resorted to. If these fail to relieve the pain, a small dose of morphine is given. Systematic poulticing is condemned.

For tasmnia, which is seldom met with, trional is given, 15 gr., repeated in six or eight hours if needed.

Remarks.

The treatment by this alternate administration of the iron acetate and the latter is called for seems to be particularly useful under the following conditions:

1. Cases of severe bronchopneumonia occurring in infants or children and in catarhial and lobar pneumonia occurring in debilitated persons.

2. Where one has not got two properly-trained nurses for night and day respectively, as by the regular administration of the strychnine through the night as well as through the day, the heart's action is kept up, and the danger of heart failure at the crisis is very much lessened.

3. In that infectious, creeping, and spreading form of pneumonia following influenza.

4. The crisis is hastened and favourably modified, the virulence of the disease is lessened, and the complication of empyema seldom occurs.

5. When bronchitis is present, seldom seems need to order depressing drugs like ipecacuanha, as the iron acetate seems to act as a good expectorant.

NEW METHODS OF STUDYING AFFECTIONS OF THE HEART.

By JAMES MACKENZIE, M.D.,
Bursley.

V.—THE INCEPTION OF THE RHYTHM OF THE HEART BY THE VENTRICILE.

In this series of papers I have been seen to demonstrate the method of investigating the movements of the heart. For this purpose I have used for illustration cases where digitalis has modified the functions of the heart muscle, as thereby we can the more readily appreciate the nature of the changes, and more definitely determine the manner of their production. There are, however, many forms of heart failure in which digitalis has little or no effect, and truth to tell, where no remedy seems capable of checking the onward progress of the heart failure. But even from the fact that these hearts do not sensibly react to digitalis, certain limited deductions may be drawn. Of such facts the heart failure there is one to which I have been giving special attention for many years, and the treatment of which has been unsatisfactory. This form includes many of the cases of heart failure, the last stages of the organ, and a continued irregularity in its action, often without any antecedent history of valvar affection, and in whom post-mortem examination reveals no structural changes in the heart. Much has been written about such cases, and numerous terms of supposed diagnostic significance have been applied to them, such as chronic myocarditis, fatty degeneration, dilated heart, paroxysmal tachycardia, chronic cordis, chronic bronchitis with irregular heart, and so forth. A careful study of such cases—and particularly of those, now somewhat numerous, whom I have seen start on their downward career—convinces me that the whole train of
symptoms is due to the inefficient action of the heart, induced by the ineffectiveness of the rhythm of the heart by the ventricle. The ventricular rhythm starts variously in some cases, gradually, by the occurrence in increasing frequency of ventricular extra-systoles, in some cases suddenly in consequence of unenforced exertion, while in others the heart quietly drops into this condition without apparent cause. In all cases the heart's work is performed less efficiently, and usually there is at once a great limitation of the field of cardiac response—thus the patient's condition settles with their wonted ease and comfort, shortness of breath, palpitation or pain being easily induced.

In certain cases, within a few hours of the inception of the ventricular rhythm, especially when the heart's action is rapid, marked changes take place in the circulatory system. The lips become darker in hue, and the face dusky. The area of the heart's dullness in the chest, the respirations become short and hurried, marked pulsation in the neck occurs, due to waves of blood being thrown back into the jugular veins. Then speedily follow oedema of the lungs and legs, enlargement of the liver, and all the typical signs of grievous heart failure. Other cases may not show such symptoms so rapidly; some, indeed, show but a slight limitation of the field of cardiac response, and may for years live a quiet life with continued irregularity in the heart's action, but liable to temporary attacks of heart failure.

When by some good fortune the heart reverts to its normal rhythm, the improvement in the patient's condition is at once remarkable, and the rapidity with which all the signs of heart failure disappear is even more striking than the rapidity with which they came on. In this—the restoration to the normal rhythm—we have the objective evidence towards which all our efforts at treatment ought to be directed. Inasmuch as probably nearly one-third of the cases of serious heart failure we are called upon to treat owe their entire cause to the inception of the rhythm by the ventricle, it will be realized that such an inquiry as this is not of mere academic importance, but is a prime necessity if we desire to treat our patients intelligently.

The Cause of the Ventricle Rhythm is Due to Overexcitability of the Fibres Joining Auricle and Ventricle.

In order that the aim for diagnostic and therapeutic purposes might be precise and definite, I have for many years been collecting evidence which might throw light upon the subject. The facts that I have gathered, point to the conclusion that the cause of the ventricles contracting before the auricles ("ventricular rhythm") is due to an over-excitability of the muscular fibres joining the auricle and ventricle. I am aware, the reader will say, that this gives a faint idea of what is a simple contraction, still I shall adduce sufficient presumptive proof in favour of this suggestion, and in doing so try to indicate the line on which further investigation into this difficult problem may profitably be pursued.

Experimental Evidence.

Although I have worked out the solution of this question from the study of the action of the human heart, I find many striking corroborative and suggestive facts given by experimental physiologists, more especially in the researches of Gaskell. This observer specially insists on the fact that the muscular fibres joining auricle and ventricle in cold-blooded animals are extremely sensitive to stimulation. Touch the auriculo-ventricular ring with the slightest stimulation, immediately a series of rhythmical contractions occur. It is most striking to see, after removal of the septum, how every portion of auricular and ventricular tissue can be explored up to the very edge of the ring without obtaining what is called a simple contraction, while immediately the needle touches the muscular ring a series of rapid contractions results. He points out that in applying a ligature or section in the auriculo-ventricular groove a series of contractions immediately result from the stimulation of these fibres. Stimulation of the vagus sufficiently strong to stop the auricular movements may be followed by a starting of the heart's movements which are due to the ventricle taking on the rhythm—the rhythm arising at these a-v fibres.

From such results as these one can safely deduce that there and a-v points in the heart where there is an excessive tendency for the rhythm of the heart to start—at the sinus venosus (in man at the mouths of the great veins and adjacent portions of the auricle) and at the canalicus auricularis (in man in the muscle fibres joining auricle and ventricle).

Normally the rhythm starts at the former place, but when any undue excitation affects the latter, or even when the former fails to transmit a stimulus to the ventricle, the rhythm of the heart may start at these a-v fibres.


By the following train of reasoning I now suggest that the starting point of what I have hitherto called the "ventricular rhythm" is at the fibres joining the auricle and ventricle. In setting forth this argument I would specially call attention to the utility of this method of observation by pointing out the fund of information to be obtained from the study of such a simple tracing as Fig. 2.

At the Nottingham meeting of the British Medical Association in 1892 I demonstrated the fact that in certain common forms of irregular heart, when the pulse seemed to miss a beat the irregularity was due to the contraction of the ventricle prior to and independent of the auricle (Fig. 1). The early occurring ventricular contraction—which I then called the ventricular extra-systole—may cause so small a radial beat as to be imperceptible to the finger although shown in a sphygmograph, as in Fig. 1. I published the proofs for this statement in the Journal of Pathology in 1894.

![Fig. 1. Simultaneous tracings of the auricular and radial pulses.](image1)

![Fig. 2. Simultaneous tracings of the radial and jugular pulses, showing the occurrence of a ventricular extra-systole at x. In the radial tracing: c corresponds in time with x, and is due to the a-v cord. The auricular contractions at its regular rhythm, the wave of c occurring at the normal time, and after the ventricular systole which produced c.](image2)
the radial tracing. It will be observed that this small wave occurs too early, and is followed by a pause longer than the pauses after the other pulse beats. In the jugular tracing the wave $c'$ is due to the carotid, inasmuch as its appearance corresponds exactly with that of the small wave $a'$ seen in the radial. The wave $a'$ is due to the auricle, for the interval between it and the preceding auricular wave, $a$, exactly corresponds to the intervals separating all the other auricular waves. This retention of the rhythmicity of the auricle is one of the most striking features in this form of irregular heart, and the interpretation here given has been abundantly confirmed by other observers, and by experiments on animals. This tracing demonstrates, therefore, that, as in Fig. 1, the ventricle has contracted before the auricle. Engelmann has stated that the stimulus coming down from the auricle ($a'$) finds the ventricle refractory after its premature contraction ($c'$), so that it fails to respond to the stimulus from $a'$, but remains quiescent until the next physiological stimulus arrives from the auricle. This explanation may need modification, for here it is not that the ventricle is too exhausted, but, as this tracing demonstrates, it is because the conductivity of the $a'$ fibres is so exhausted that the stimulus from the auricle ($a'$) is not conveyed to the ventricle. This is brought out in the diagram (Fig. 3) representing the events in Fig. 2.

To prove this statement consider the duration of the $a-c$ interval. All these intervals up to the extra-systole show a slight increase over the normal interval. Thus space $a$ in Fig. 2 equals $a'$ of a second, while $a'$ equals about half that time. The salient point to be elucidated here is why is $a'$ so much shorter than $a$? It may be noted that the $a'$ fibres had responded to the stimulus from $a'$ there would not have been a longer rest for these fibres, and the space $a'$ would have had the same length as the other $a$-intervals. If, however, these fibres were stimulated in the production of the extra-systole ($c'$ and $x$), then they would be refractory to the stimulus from the auricle ($a'$), and would remain quiescent till the physiological stimulus arrived from the next auricular systole. In this manner they would have had a longer rest; their conductivity would be more completely restored, the stimulus would be conveyed across to the ventricle at a greater rate, and a shortening of the $a-c$ interval would result, which shortening we find in $a'$. The next question is, Did the stimulation of these fibres precede or follow the ventricular extra-systole? I am of opinion that they preceded, and therefore caused, the ventricular extra-systole, because, first, the shortening of $a'$ implies that the stimulation of the $a'$ fibres must have taken place at a time considerably in advance of $a'$; and secondly, if these fibres had been stimulated by a backward wave from the ventricle, the stimulus would have passed back to the auricle and interfered with the auricular rhythm. We see, however, that the auricular rhythm is undisturbed. But it might be asked, if the stimulus arose in the $a'$ fibres, why did it not pass backwards to the auricle as well as forwards to the ventricle? In many cases it does so, as one can tell from the disturbed auricular rhythm. In other cases, as here, a minimal stimulus that will provoke a forward contraction is not strong enough to start one in the backward direction. This argument, if not conclusive, is at all events suggestive, and indicates the lines which further investigation should pursue.

### The Results of Continuous Excitability of the $a'-v$ Fibres

Suppose, now, that instead of an occasional extra stimulus, producing an occasional extra-systole, there was a continuous excitability producing a series of ventricular contractions, just as though they were produced experimentally by a very rapid or irregular (paroxysmal) tachycardia of ventricular origin), or a less rapid action of the heart, but with a continuous irregular rhythm. When this occurs a remarkable change takes place in the jugular pulse—a change from a pulse of the auricular type to one of the ventricular; that is, that whereas during the regular rhythm the auricular pulse produced the principal wave in the jugular vein, there is during the abnormal rhythm no wave at this period of the cardiac cycle, one large wave synchronous with the auricular systole. As a further proof I have found in a number of cases that patients with extra-systoles may show the irregular action at very varying intervals, occurring after a short or a long interval, of one, two or three hours. I have also had extra-systoles occurring together, and again have found a long-continued series of these, lasting sometimes for hours, sometimes for days and weeks, and in a number of cases persisting continuously until the heart became so exhausted that the patients succumbed. The proof that this rhythm was started by the ventricle I have given in my book on the pulse, and with greater detail in a paper published in the British Medical Journal of March 7th, 1904.

### The Treatment of Cases of Ventricle Rhythm due to

#### Over-Excitability of the $a'-v$ Fibres

As I have remarked, the objective should be the restoration of the heart to the normal rhythm, and this can only be done by diminishing the excitability of the $a'-v$ fibres. I have tried a variety of methods—rest in bed, massage, Schottmovements, and all manner of drugs, and pushed the drugs as far as I dared, and have quite failed to achieve the object I had in view. I have seen many cases revert to the normal rhythm, and I have failed. When this failed, I have been led to the method of treatment employed, but continued observation showed that it was due to other causes. This experience is well illustrated in the case of paroxysmal tachycardia of ventricular origin (there is another rarer form of paroxysmal tachycardia where the rhythm is auricular in origin). The fewer cases a doctor sees of this nature, and the more he is of his power to subdue the attack. I have now recorded a large number of cases, some of whom have had ten to twenty attacks, and I can say with confidence that when the heart has reverted to its normal rhythm it may have a slight effect, it fails to restore the normal rhythm.

In the paper in this series on the effect of digitalis on the conductivity of the $a'-v$ fibres I showed how this drug readily and speedily affected this function in predisposed cases. Apart from such cases, I find that these fibres are the most resistant of all the muscle fibres of the heart to the influence of this drug, and when they are excitable the drug has but a slight effect upon the excitability, as far as one dare. In many of my cases it has been absolutely without effect, and the following instance illustrates that. It may have a slight effect, it fails to return the normal rhythm.

In my paper on ventricular rhythm in the British Medical Journal of March 7th, 1904, I cited the case of a woman aged 57 years, of age, who had had single ventricular extrasystoles, and these became more frequent, ultimately culminating in attacks of paroxysmal tachycardia, which lasted at times for hours, days, and weeks, and how these attacks would subside independently of any method of treatment. Since the last note published of that patient in November, 1903, she has had a number of other attacks, one of which began while I was taking tracings of her pulse, and the jugular pulse at once changed from one of the auricular type to one of the ventricular. On October 1st, 1904, she was taken with an attack, which has continued up to the present (March, 1905), and since then the heart has been in an extremely feeble state, with dusky countenance, persistent cough, enlarged liver, and swollen legs, the heart enlarged, invariably rapid, and irregular (Figs. 4 and 5).
By November 1st, 1904, her condition had become so bad, and as rest, treatment, and careful nursing had failed to afford any relief, I determined carefully to push the digitalis, which, in the form of tincture, she began to take on November 5th. No effect was produced till November 8th, when she began to suffer from severe epigastric pain. This pain gradually descended lower in the central areas of the abdomen (due to hypogastric), and when over the pubes terminated with an abundant fluid evacuation. She had several attacks like this on November 9th and 10th. The effect on the heart was to cause an appreciable slowing (Fig. 7), the rhythm, however, remaining ventricular.

The digitalis had an effect on the heart muscle, but the musculature of the digestive tract was evidently more susceptible than the heart muscle, and the disturbing effect on the stomach and bowels probably prevented sufficient of the drug being taken to affect materially the heart muscle. Although digitalis may fail to restore the normal rhythm, it may have a beneficent effect on certain cases of ventricular rhythm. Thus a woman, aged 77, who has been under my care for two years, invariably attacks of heart failure when she cease to take the digitalis, I have tried strychnine and other drugs, but with no good result. The last attack was on February 6th, 1905, with dropsy, enlarged liver, blue face, great pulsation in the veins of the neck, and early urine. The pulse was small, rapid, and very irregular (Fig. 6). She was prescribed tincture of digitalis 10 minims three times a day. She began to improve at once, and by November 17th the dropsy had nearly all disappeared; she breathed easier and passed more urine. The pulse became slower and more regular, but the ventricular rhythm persisted, and the jugular pulse remained very large (Fig. 7). A year ago, after a course of digitalis, the jugular pulse would disappear, though the rhythm of the heart remained slightly irregular and ventricular in origin.

**THE PRODUCTION OF VENTRICULAR EXTRA-SYSTOLES BY DIGITALIS.**

In the last paper of this series I gave a tracing showing extra-systoles occurring after digitalis. In another recent case I observed a similar occurrence. A female, aged 22, complained of being weak, of having attacks of palpitation, of having fainted; she had a presystolic murmur. On February 10th, 1905, she was prescribed tincture of digitalis. In a few days she felt distinctly better. On the 17th, after taking 1/2 of the tincture, she complained of distressing "bumping" of her heart. The pulse felt regularly intermittent, and a tracing showed the regular occurrence of ventricular extra-systoles after every second normal beat (Fig. 8). The digitalis was stopped, and the next day all trace of extra-systoles had disappeared. She began again on the 20th to take 10 minims twice daily, and on the 23rd the "bumping" of her heart began again, and a tracing showed the same arrhythmia as Fig. 7. The drug was stopped; there has been no recurrence of the irregularity, and the patient's condition is distinctly improved.

As digitalis when pushed has a depressing influence on all the functions of the heart, it seems at first sight strange that it should manifest a tendency to produce extra-systoles, which implies a certain degree of irritability. I can only account for it by the fact that while it has depressed the functional activity of all the other fibres of the heart, as shown by the slowing, it has failed to affect the a-ß fibres, which retain their previous irritability, and "fire off" an extra-systole from time to time. But why it should do this so regularly I do not understand. If this surmise is right, it forms an additional argument in favour of the a-ß fibres being the source of the extra-systoles.

**MEDICAL CERTIFICATES FOR MARRIAGE.**—It is said that the Armenian Church in the Caucasus has decided that no priest shall be allowed to perform the marriage ceremony unless the contracting parties can produce a medical warrant of physical soundness.

**REQUESTS TO MEDICAL CHARITIES.**—Under the will of the late Mr. Henry Allen of Rolney, Sussex, which has now been proved, St. Mark's Hospital for Fistula receives a sum of £1,000, the London Fever Hospital half that amount, and St. Mary's Hospital, Paddington, and the Brompton Cancer Hospital £100 each, while £150 goes to the Dorking Cottage Hospital. After the payment of certain other legacies it is expected that there will be a residue of £10,000, which sum is left in trust for such charitable institutions as the trustees may themselves select, the desire being expressed that some portion may be allotted to charities connected with Great Missenden, Buckinghamshire.