An Address

ON

THE SIGNIFICANCE OF CARDIAC MURMURS.

READ AT THE ANNUAL MEETING OF THE KENT BRANCH,
HELD AT TONBRIDGE, JUNE, 1918.

BY

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GENTLEMEN,—Four years ago you elected me to the presidency of your Branch. I expected to hold the position for one year, and I read an address on irregular action of the heart. Since then has come the Great War, and, as a minor consequence, I still hold the post to which you elected me, another being that during this period no general meetings have been held within the area of the Branch. The President of the Association has recently issued an appeal for the revival of clinical and scientific work in the Branches and Divisions, and I have thought that a paper on a sister subject which recent work has for the moment placed in a somewhat confused position might be of interest and of use.

Since the war cardiac murmurs have become rather generally suspect. Not very long ago any murmur, with the solitary exception of the pulmonary systolic, was regarded as a sign of serious trouble, either temporary or permanent, and the insurance offices still look askance at murmurs of all kinds. But a reaction has arrived, and there are, among those who have followed superficially the trend of recent research, men who are inclined to go to the other extreme and say generally that a murmur does not matter. The truth lies between these two extremes. Some murmurs do not matter, others do, and, in forming an estimate of their import, we should in the first place endeavour to differentiate between the varieties, and, in the second place, realize that in any case a murmur is only one sign, and must be read in conjunction with other signs and symptoms of cardiac efficiency or the reverse.

Here I may enunciate an aphorism, the result of recent work, which is already very widely held, and which I venture to predict will become universally accepted. It may be stated thus: "On no solitary sign shall any heart be condemned." There are those among the elders who may say that they have always held this view. But such are either very few or they deceive themselves, for there is no shadow of doubt that upon the presence of a systolic murmur, and especially a well-marked systolic mitral murmur, and in the absence of any other sign or symptom pointing to cardiac inefficiency, countless individuals have been refused or heavily weighted when applying for life assurance; have been cut off from participating in healthy sports and exercises; have gone through life under a sense of incapacity and often in the apprehension of a special liability to sudden death, and have perhaps suffered the apprehension of the condemned cell when an operation became imperative, because some doctor had told them, on this or equally slender grounds, that they must never take an anaesthetic.

Very early in my career I was confronted with a case which caused me to revise my outlook on murmurs. The patient was a young lady who exhibited the most remarkable murmur I have ever listened to. It was very loud—systolic—and heard equally all over the heart. It was also heard all over both lungs, in the carotids, in the abdominal aorta, and with diminishing intensity in both femoral arteries. The murmur had been discovered a few years previously by a general practitioner, and the advice of a specialist had been sought, with the result that the patient, at about 20 years of age, was told she must live on one floor, and must not walk uphill. Before that she had run about and danced. I was a young man, but I had had a fair experience of cardiac disease, as resident physician in a large hospital, and I began with caution to test the efficiency of this patient's heart. I made her swing her arms about, go up and down half a dozen stairs, and then more; and I found that, as her exercises increased, the pulse improved rather than the reverse, that no dyspnoea nor pain was caused, and that no cyanosis, oedema, nor albuminuria developed. I took her to see the late Sir William Broadbent, and stated my reasons for

believing that the heart was practically sound, though I could not account for the murmur. He acquiesced, and suggested an ingenious explanation of the murmur—a minute congenital patency of the ductus arteriosus, leaving a negligible communication between the aorta and the pulmonary artery. Anyway the result was that the lady was restored to a life of useful activity, and that she lived for about twenty-five years more without any signs of cardiac failure, and died of pneumonia a few years ago.

This case made a profound impression on my mind. I argued that if so remarkable a murmur might exist in a heart which, for the practical purposes of life, was healthy, there were probably many murmurs which might be ignored; and I gradually came to the conclusion that a heart which could play football or go up Monte Rosa could not have anything very serious the matter with it. The argument I found applied equally to irregularities of the pulse; though, until the work of Mackenzie and Lewis enabled us to differentiate between the varieties of arrhythmia and to understand their varying significance, I had not the confidence I now possess regarding irregularity of action.

Functional and Physiological Murmurs.

In the case already cited, the murmur, whatever may have been the actual cause, was undoubtedly organic in origin. It illustrates a type which is extremely rare. To-day I have examined a case of a very different kind, but having this point in common: a systolic murmur which may not only with safety, but with great advantage to the patient, be ignored.

A young lady, working as a V.A.D. nurse, got tired, thin and easily fatigued, but showed no symptom referable to the heart. I saw her in bed, and found the first sound in the mitral area inaudible, and replaced by a blowing murmur which was conducted to the axilla. On sitting up in bed the same phenomena were observed; but, on standing up, the murmur completely disappeared, and the sounds became normal. On lying down again, the first sound disappeared and the murmur returned.

To what was this murmur due? We do not know. We may conjecture; but people never die from such conditions, and if they die and an autopsy is performed, the heart is found to be quite normal. "Functional" would be the term most commonly applied; but "functional" implies some derangement of function, and in these cases, where a systolic murmur is present in one position and not in another—a common type—there is, as a rule, no derangement of function, and Mackenzie prefers to call these murmurs "physiological." Under this heading, too, come the numerous systolic murmurs which are present one day and gone the next; and also many systolic murmurs which are constant and do not vary with position. It is not uncommon to find a very definite murmur which at the apex accompanies but does not replace the first sound, while at the base it is still more emphasized, and may render the first sound in both aortic and pulmonary areas inaudible.

Another murmur, rarer, is that which follows a normal first sound but stops abruptly with the second. Similar murmurs may be caused by valvular lesions; but if there is no history of rheumatic fever, and the heart responds normally to effort, the chances are that the murmur is not organic in its origin. But, even if it were, the valvular lesion which produces a systolic murmur and yet leaves a heart with good response to effort, and capable of riding a bicycle uphill, or other strenuous exercise, is probably trifling, and in such a heart the musculature is pretty certain to be healthy. Again, many of these murmurs are observed in children and adolescents, and in such there is a ready means of satisfying oneself that the heart is really sound. Sinus arrhythmia is common in the young, and can generally be readily induced. Make the patient take long, slow breaths pausing at the end of inspiration and of expiration. During inspiration the pace of the heart-beat will become accelerated, while during the later part of expiration, and during the pause before inspiration, the beats become very obviously slower and perhaps irregular. If this sign is present, the heart may very safely be pronounced sound. The following case is very similar to the last cited:

Some five or six years ago I saw a boy, aged 12, for some trifling ailment, and found he had a well-marked mitral murmur in bed, but that when he stood up it completely

disappeared. I took the view that the thing was of no importance and let him play football and cricket, and no harm resulted. Recently, for the purposes of this paper, I went to see him. He is 17½, well grown, and is working at wireless telegraphy. I examined the heart and found precisely the same condition present. Sinus arrhythmia was easily evoked, and this confirms the opinion I formed before I was aware of the significance of this condition.

Among the cautious commentators on this modern disregard of systolic murmurs in the young are those who hold that this optimism is not justified. They have noted and watched cases which later on develop serious heart disease. Of course these patients are not more immune than are those with obviously healthy hearts, any more than adolescents with postural albuminuria are immune from the possibility of nephritis at a later period. But my own experience is that heart disease and kidney disease do not result from these conditions; and, while I cannot recall a case which supports the contrary contention, I can cite many cases which I have had the opportunity of following for years, and which point to the conclusion that there is no danger in allowing patients presenting these anomalies to undertake any forms of exercise they may be inclined to and can perform without producing distress which is either severe or enduring. The general health, and with it the heart's efficiency, suffers if such patients are restricted. If there is anything the matter which matters, it will soon reveal itself; and we shall do infinitely more good than harm by reassuring all such patients as to the soundness of their hearts and encouraging them to do what they incline and feel equal to and by discouraging them from dwelling upon their health.

The next case presents somewhat different features:

This is a boy I have watched for many years. His father had died suddenly from heart failure, and the element of heredity—an element which in these conditions is, in my opinion, quite negligible—had been impressed upon the mother, and had also, in conjunction with certain physiological peculiarities, caused various doctors and “specialists” to regard the child's heart as one requiring the utmost care and many restrictions. When I first knew him as a child of 7 or 8 he was a miserable specimen, and pining under the continual solicitous observation of his mother and a devoted nursery governess. I shortly sent him to a mixed day school for little children and he did well. Later he went as a day boy, and ultimately as a boarder, to a boys' preparatory school. I let him ride a bicycle and play the usual school games, and sanctioned his being entered for a public school, in spite of the fact that a systolic murmur was occasionally present, that the heart could be seen beating over a wide area, and that, though the impulse could not be felt lower than the fifth space, it was readily detectable opposite the nipple in the anterior axillary line—a condition which, with perhaps a sixth space apex beat, is not necessarily pathological. This child has gradually grown into a fine healthy specimen of boyhood. I had arrived at my conclusions somewhat cautiously, and had gradually trained the heart and general physique from a state of weakness to a normal state of strength. Sinus arrhythmia is now easily evoked, as was doubtless the case when first I saw him, though it was not noted at that time because I was then unaware of its significance, and did not—as I now do—look for it in any youthful case I am asked to examine. Two years ago, when he was 12½ years old, he went with his mother to Cornwall for the summer holidays. There he developed a cough, and his mother took him to a doctor, who, after carefully examining him, pronounced his lungs healthy, but said, “I suppose you know about his heart?” The mother had all her old fears revived, but told him that her own doctor at home had watched the boy carefully for years and pronounced his heart sound; had permitted games and bicycling, and sanctioned a public school. The Cornwall doctor said that, were he his own child, he would on no account permit any of these things. He prohibited all exercise for the time, but wisely advised the mother, when occasion offered, to seek Sir James Mackenzie's opinion. On her return home she came to me in a terrible state of agitation, and we shortly all went together to see Sir James, who, I am glad to say, confirmed my opinion in all respects. The boy has now been for two or three terms at a public school, and he comes to see me during each vacation. He is a bright, happy boy, healthy in mind and body, and joins in the studies and sports of the school without restriction, no more attention being paid to his health than to that of the other boys.

I could multiply these cases and cite similar ones in adults where a general test of cardiac response to effort will usually lead to a right conclusion, though we seldom, after 20 years of age, have the help that is given if long slow breaths produce their physiological and characteristic effect upon the pace of the heart-beat.

Of the cases hitherto recorded, the first was an example of negligible congenital defect and the rest were physio-

logical anomalies. The following is a case of quite a different kind:

A young lady, aged about 20, had a sharp attack of influenza. It left her enfeebled and with a mitral systolic murmur. On getting about she panted a good deal on going up gentle inclines. But I let her walk in the garden and roads near by in preference to keeping her in bed. A little later on she and her sister went to Switzerland, and I was not surprised to hear that she was taking walks and enjoying them. But I was surprised, when they returned home, to find that they had become Alpine climbers and had been up the Jungfrau and the Schreckhorn. I found the heart normal and the murmur had disappeared. This occurred twelve years ago and the patient has kept well ever since.

The case is an example of what Mackenzie calls the poisoned heart—the heart affected by toxæmia, a thing that may happen during any systemic infection. Such patients get well much sooner under good hygienic conditions than if they are kept for long in bed, as they often are. The difficulty lies in excluding organic disease, which may occur under similar conditions, but which far more commonly develops during an attack of rheumatic fever than in other acute febrile infections. A rough murmur is more likely to be organic, while a soft one is more probably due to a slight dilatation which, provided the myocardium is intrinsically sound, is set right pretty quickly if the patient gets about and gradually increases exercise as it is comfortably tolerated. The condition corresponds to the temporary weakening of the skeletal muscles from similar causes. I can well remember in my own case, when convalescing from measles, that on first going out I was obliged to sit down after walking a couple of hundred yards. Within a week I could do a five-mile walk, taking the hills as they came. This rapid recovery of muscular tone would have been delayed had I remained longer in bed, and the same is true of the heart muscle, poisoned but not damaged during fever.

Systolic Murmurs Resulting from Endocarditis.

These are more serious because they are apt to be permanent, to become associated with other murmurs which are not systolic, to be accompanied by vegetations, and because both in pericarditis and endocarditis the myocardium is very likely to be invaded, and the heart muscle damaged, perhaps permanently. It is not always possible at first to say whether a murmur is due to dilatation or to endocarditis, and a poisoned heart may give rise to signs of muscle weakness similar to those of early inflammatory invasions. But severe cases are generally obvious and the slighter can usually be diagnosed as time goes on. Organic disease may be assumed as the rule when cardiac signs and symptoms develop in the course of rheumatic fever. And when organic disease is obvious, or suspected on adequate grounds, caution during convalescence is clearly indicated. Later on diastolic murmurs may develop, or the missed beats of partial heart-block may be noted in the cases which go badly. On the other hand, if recovery of myocardial tone takes place, gradual but cautiously graduated exercise may be permitted in spite of any murmurs which may remain. The muscle will not regain its maximum potential of health and energy unless it is given the chance, and in the later stages of convalescence, whatever be the damage remaining, exercise that is easily borne, and which increases the patient's sense of well-being, may be safely permitted.

Auricular Fibrillation.

The effect upon the pulse will naturally be watched, and any undue acceleration will inculcate caution; while, if exertion habitually produces a noticeable irregularity, we are probably confronted with auricular fibrillation. This must be distinguished from irregularity which becomes emphasized as the heart slows down after exercise, and which may be due to one of three causes: (1) Sinus irregularity, which we look for in the young and which is of excellent augury; (2) extra-systoles, easily detected, and, apart from other signs and symptoms, fairly negligible; and (3) (much more rarely) the minor phases of heart-block—a condition which should never be out of our minds when dealing with hearts damaged during the course of acute fevers, and especially acute rheumatism. Missed pulse beats are generally due to extra-systoles, and the cardiac sounds which accompany them are usually characteristic. Missed pulse beats synchronizing with

missed heart-beats suggest heart-block, though they may be due to extra-systoles too faint to be audible.

The most important point to recognize regarding systolic murmurs developed during febrile attacks is that the condition of the heart muscle is the all-important factor. In one of the most obviously and permanently damaged hearts that I have seen, following acute rheumatism, there never was any murmur at all, but there were (and still are, fifteen years later) obvious signs of cardiac embarrassment on any attempt at really active exercise. Had this lad shown a systolic murmur his symptoms might have been attributed to a valvular lesion, whereas the inefficiency exists without it, and is due to myocardial disease.

Such cases are, of course, not uncommon. I have recently seen an elderly lady whose early history I have been unable to unravel. She has general cyanosis, clubbed fingers, breathlessness on exertion, and oedema of both legs, and she has often been "doctored for her heart." But the pulse when I saw her was regular and not very fast, the heart not obviously enlarged, and the sounds quite normal. The exact diagnosis admits of more than one hypothesis, but that there are degenerative changes in the cardiac muscle is obvious, and the addition of a systolic murmur would not materially affect the prognosis, which is certainly grave.

It would be easy to quote many cases of such cardiac enfeeblement in which a systolic murmur was the only audible sign, but in these cases there is always evidence of weakened muscle and often of auricular fibrillation. In this condition—and it is one in which the outlook is always menacing—a systolic murmur is very often the only audible anomaly, and I think there can be no doubt that it is this association, in conjunction with the accompanying gamut of serious signs and symptoms resulting from inaction of the auricles, which has given rise to the long-standing impression that this is the natural ending to mitral incompetence, and has invested the mitral systolic murmur with its halo of sinister augury. The signs and symptoms have been attributed to "back pressure," and we all know the classic chain of events which is supposed to be gradually and surely forged. But the familiar clinical syndrome is often found without any murmur at all, and is in reality due to the impairment of the cardiac mechanism as a whole consequent on disease of the muscular wall and on the failure of the auricles to contract; and, if there is any "back pressure" at all, it is a minor factor, and proceeds, apart from extreme narrowing of the mitral orifice, equally and simultaneously from both sides of the heart. In many such cases there was once a double murmur, and mitral stenosis was the really important valve lesion; but as with the onset of fibrillation the presystolic murmur necessarily disappears, the serious results have been wont to be attributed to the regurgitation of which evidence still remains.

In all cases of obvious cardiac embarrassment a general survey must be made, and one point which can generally be settled at once is whether auricular fibrillation is present or not. The point is so important, and is as yet so commonly misunderstood, that a short review of its most obvious signs may not be out of place, seeing that it is often associated with a systolic murmur. The pulse, which may be moderate or fast, presents an "absolute irregularity"—generally recognizable by the finger, or by the heart sounds, and always by the sphygmograph—in which no two consecutive beats are quite the same in time or volume, and the irregularity is increased by effort. This is sufficient to establish the presence of the rhythm, but corroborative evidence is often found by noting that the pulsation in the jugulars is simple and not undulating, and that it corresponds exactly with the ventricular contractions, to which it is directly due.

So much for systolic murmurs accompanying serious heart disease. The murmur does not indicate the real trouble, which may be associated with fibrillation, or with heart-block, or be due to degenerative changes without abnormal rhythm. But the common association need in no way bias our judgement as to the unimportance of systolic murmurs in the very numerous cases in which they are heard in hearts which show no evidence of inefficiency or other signs of structural impairment; and in all such cases a systolic murmur may be safely and wisely disregarded.

Murmurs which are not Systolic.

Here we are confronted with a difference between the physiological and clinical terminology. Clinically the systolic phase commences with the beginning of the first sound and ends with the beginning of the second. It coincides with the systole of the ventricles, and murmurs occurring during this period are always called systolic. But while the physiological systole commences with the contraction of the auricles, the murmurs caused by the auricular systole are clinically termed "pre-systolic."

As all the murmurs occurring during the diastole of the ventricles have a graver significance than that which attaches to systolic murmurs proper, it is convenient to group them under a common heading; and, provided we keep the above considerations in view, we may welcome Mackenzie's suggestion that they be grouped under the generic designation "diastolic."

The Three Chief Varieties of Diastolic Murmurs.

1. *The aortic diastolic murmur*, easily detected, replacing the second sound, generally accompanied by Corrigan's pulse, and due to aortic regurgitation.
2. *A murmur occurring early in the pause*, due to aspiration of blood from the auricle to the ventricle, found as a late sign of mitral stenosis and occurring alone in many cases of auricular fibrillation, with stenosis.
3. *The crescendo presystolic murmur* characteristic of mitral stenosis, running up to the first sound, or alternatively to a systolic murmur (double mitral), due to the systole of the auricle in conjunction with a narrowed outlet, and naturally disappearing when the systolic action of the auricle ceases with the onset of fibrillation.

It will be noted that, while systolic murmurs are often due to negligible or transient causes, the diastolic murmurs all indicate serious and hampering disease. Of this I shall have more to say, but may here state that, while aortic incompetence gives rise at once to a diastolic murmur and always implies the necessity of restricting effort to well within the limits of tolerance, the case of mitral stenosis is somewhat different; this condition comes on gradually after an attack of endocarditis, and it may be months or years before evidence arises on which to base a diagnosis. It at first results in only a very slight narrowing, and, while the process may become arrested at any stage, it may proceed till the orifice is represented by little more than a slit. But if a presystolic murmur is heard, a guarded prognosis must be given, and it may be stated generally that patients showing any one of the diastolic murmurs should be discouraged from running risks, and should always be protected from the strain of occupations which imply the necessity of strenuous effort.

Prognosis.

In the early part of my paper I cited several cases from the point of view of prognosis—cases which, in my judgement, were of good augury. I have also referred to cases, only too familiar to us all, of far more serious portent. I will now speak of two more patients, illustrating many of the points I have already alluded to, and taking up their history in retrospect, for both are elderly ladies, spare of body, and active in temperament, and both about 70 years of age. They are neighbours, and each of them is known to have had a systolic mitral murmur for thirty or forty years, and it may be more. Their condition is, however, very different.

The first has never had any cardiac symptoms at all. I examined her the other day, and found a rough systolic murmur heard all over the heart, quite replacing the first sound. The mitral area appears to be the point of maximum intensity, and the murmur is audible in the axilla and all over both lungs at the back. The apex is in the sixth space. Barring an occasional extra-systole there is no irregularity. She can mount stairs and walk up hills, and is exceptionally active for her age. How or when the murmur started no one knows. It may be a congenital affair, or it may have originated in endocarditis. But though no doubt there is an organic lesion (mitral incompetence) the murmur is obviously sound and the effect of the regurgitation is negligible so far as the calls of ordinary life are concerned. She is a good example to quote in favour of Graham Steele's dictum, recently unearthed by Mackenzie, that no one dies from mitral regurgitation, though at her age, with the degenerative period of life well advanced, the future can hardly be regarded with equanimity.

Her neighbour's condition is far otherwise. Her heart trouble began during an attack of rheumatic fever. She has had many attacks of heart failure, and at her best is easily made breathless and has to pause on an ordinary flight of stairs. But by taking small doses of digitalis two or three times a

week and keeping within her limits, she gets along fairly well. She has a softish blowing systolic mitral murmur; her heart beat is diffuse, the left ventricle slightly enlarged, and her pulse, which is always slightly irregular, becomes markedly so after very moderate exertion. What is the condition of her heart? Clearly, like the other case, there is mitral regurgitation; but that is not the main thing. Her heart muscle was doubtless invaded when the trouble first developed, and now her auricles are not acting at all. They are in a state of permanent diastolic dilatation, and their musculature is in a constant state of ineffectual fibrillary contraction (auricular fibrillation). I suspect that she, at one time, had in addition a presystolic murmur, that there is narrowing as well as incompetence of the mitral valve, and that the case is really one of mitral stenosis, accompanied by myocardial invasion and secondary degeneration.

These two cases form a very instructive contrast, and suggest certain reflections on the effect of valvular lesions in general.

Why should it be that systolic murmurs are often negligible, and diastolic murmurs not so? I cannot say that I have seen any convincing explanation, though I have been convinced as to the facts. And yet it seems to me that a consideration of the lesions which give rise to the murmurs, and of the effects which are likely to result on the cardiac mechanism and on the heart's nutrition, do afford an explanation. I do not now speak of the grave cases in which a systolic murmur has been known to exist for years, which terminate in progressive heart failure, and in which a widely dilated mitral orifice is found *post mortem*. As in the case of the clinical association of fibrillation with a systolic murmur, so it is with these. We have got so accustomed to the assumption that the whole of the disorganized *post-mortem* findings are the end results of mitral regurgitation, that it is not easy to reshuffle the conditions in our minds, and realize that the main factor lies in disease or degeneration of the heart wall, and that mitral incompetence on a large scale is a result, and only in the later stages a contributory factor to the eventual catastrophe.

Nor need I dwell, at the other end of the series, on the physiological and functional murmurs—always, by the way, systolic—which are so common, especially in the young. They are often associated with febrile and debilitated conditions, and these of course need care and treatment; but, where found in conjunction with a good cardiac response to effort, they are negligible, and the only difficulty lies in distinguishing them from murmurs due to organic causes. Fortunately this difficulty, which is sometimes a very real one, is of comparatively little importance if it can be shown that organic systolic murmurs, existing alone, and unaccompanied by other evidence of cardiac disease, depend on lesions which are in themselves not serious.

On the right side a tricuspid systolic murmur is known to be often physiological, and that the regurgitation is generally inconsiderable is clearly shown by the small size of the ventricular wave in the jugular tracing. It is probable that a similar state of things is common also at the mitral valve, while even a more considerable back-wave is not very serious in an otherwise healthy heart. In the cycle of events the left auricle contracts, and throws its blood into the ventricle, and then immediately dilates and begins to fill again from the large veins, which are not only full of blood ready to pour into it, but must also be actively aspirated by the intrathoracic pressure being lower than the atmospheric. When the ventricle contracts the blood will be driven in the direction of least resistance—into the open aorta—and any that regurgitates through the mitral valve is met by the contents of the auricle already rapidly filling. Unless the mitral dilatation is considerable, very little will get through, and even if it is considerable, the counteracting forces are far from negligible. The period, too, during which regurgitation is possible is limited to the duration of the ventricular systole, and there is no interference with the blood supply to the heart itself through the coronary arteries. This is, perhaps, the main point, for—as has been shown by Starling¹ and others—the reserve power of the heart is enormous, and depends essentially on an unrestricted blood supply to the myocardium. Certain it is, as we have seen, that such cases may go on for years without any interference with the ordinary calls of life.

The small importance attaching to aortic systolic murmurs is perhaps even easier to explain. Some of them are probably functional, as at the pulmonary orifice;

but, granted that a murmur is due to narrowing, it need have but little adverse effect. Stenosis is due to the adhesion of the margins of the cusps, and though a slight narrowing (extreme stenosis is very rare) may give rise to a loud murmur, it offers no serious barrier to the passage of the blood through the valve, and is easily compensated by a slight hypertrophy. If the process of adhesion continues, the margins of the cusps get shortened, and an aperture is left on closing, through which regurgitation takes place. So that, if there is much stenosis, we will also get incompetence, and we may be pretty sure that if there is no diastolic murmur the narrowing does not amount to very much; and further, unless there is incompetence, the circulation in the coronaries will not be interfered with.

I now turn to the diastolic murmurs, and hope to show that the lesions giving rise to them (mitral stenosis and aortic incompetence) produce effects which hamper the mechanical action of the heart, and also that interference with the circulation in the coronaries is, in both cases, a probable result. This latter factor is a most important one, for it must lead immediately to cardiac inefficiency and eventually to fatty or other degenerative changes. It is clear that any marked narrowing of the mitral opening must throw an extra strain on the auricle, which will hypertrophy to meet it; but if the narrowing proceeds and gets extreme, the auricular musculature at last gives way and fibrillation supervenes. But before this event, and apart from any inflammatory invasion of the myocardium, the nutrition of the heart wall is likely to have been impaired from inefficient blood supply. In stenosis that is more than very slight, the ventricle may fail to get adequately filled, the effect of which is seen in a general feebleness of the whole body, and, as the coronaries participate in the general failure of the circulation, the degenerative changes in the myocardium, which are the precursors of fibrillation, result.

In aortic regurgitation, the hampering effect on the machine is too evident to need dwelling upon. It is not, like mitral regurgitation, a process limited to the short period of the ventricular systole, but one which begins as soon as the systole terminates, and continues throughout the ventricular diastole, during the whole of which period the back-flow from the aorta into the ventricle, resulting from the systemic blood pressure in the aorta, is aided by the aspirating effect of the dilating ventricle. And further, as the force which normally fills the coronaries is derived from the high pressure in the aorta at the end of systole, and from the consequent back-kick which closes the aortic valves, it is obvious that in regurgitation there will be interference with this important function, and degenerative changes in the cardiac muscle are an almost certain consequence.

Having now reviewed the nature and significance of the commoner endocardial murmurs with which we are daily confronted, I come back to where I started, to remind you that our final judgement must always be based on a general consideration of each case as a whole, and in this estimate the presence or absence of definite signs of cardiac embarrassment, and a careful examination of the heart's response to effort, should always be given their due weight, and often a preponderating weight, in the formation of an opinion of the organ's capacity to meet the ordinary—and the extraordinary—strains of life.

The views I have expressed are those to which my own experience and reasoning have led me, and on which I have acted with increasing confidence for nearly thirty years. But I owe a debt of gratitude to Sir James Mackenzie both for personal encouragement and for his illuminating writings, which have both strengthened and clarified my opinions. Similar conclusions have been drawn by other workers, and it is satisfactory to find that the Medical Research Committee's "Report on soldiers returned as cases of D.A.H. or V.D.H."² after a very careful investigation, arrives at the view that systolic murmurs existing alone, and "without other disqualifying signs and symptoms," should be ignored. This has now come to be the modern teaching, and it has come to stay, though as yet many of the authorities have not accepted it, and the profession in general has hardly been able to divest itself of preconceived ideas. On the other hand, the subject is "in the air," and, as I stated early in my paper, the conclusion has been drawn by some that murmurs of all kinds may be discounted, and that consequently there is not much use in

spending time and trouble over them. Such is far from being the case, and the suggestion of the Medical Research Committee, that the issue, in estimating efficiency, is confused if the presence of a systolic murmur is noticed at all, does not appear to me to be a sound one. Every murmur is well worthy of attention, and those which can be classified as negligible should be noted as such. A knowledge of the nature and significance of the different types will lead to a reasoned conclusion as to how much weight should be attached to each. Diastolic murmurs have always a serious significance, and systolic murmurs are often associated with grave disease. But many systolic murmurs are negligible, and the general recognition of this truth will free a considerable section of the community from a needlessly restricted life, and from a cloud of unnecessary and haunting apprehension.

REFERENCES.

¹ The Linacre Lecture, 1915 (BRITISH MEDICAL JOURNAL, January 26th, 1916, p. 122). ² 1917, pp. 8 and 32.

TRANSFUSION WITH PRESERVED RED BLOOD CELLS.

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THERE is a definite need in front area medical work of a method for giving transfusions rapidly. At casualty clearing stations during the busy time of an attack, it is obviously impossible to perform transfusions by the usual methods in nearly all the cases in which transfusion is indicated. The difficulty of procuring sufficient blood under rush conditions, the time consumed in carrying out the transfusions, and the need of every available medical officer in the operating theatre, all tend to reduce the number of transfusions which can be given. The use of preserved human blood cells for transfusion suggested itself as a possible solution of certain of these difficulties. A quantity of blood sufficient for a number of transfusions could be stored up beforehand and used as needed. The technique of transfusing such blood is simple and could be handled by one medical officer.

History of the Subject.

The experimental basis for this work was laid by Bous and Turner¹ working at the Rockefeller Institute for Medical Research. They found that blood taken into a solution of dextrose and sodium citrate and kept in the cold could be preserved for several weeks. Not only did the red blood cells thus treated remain intact, but they retained their viability for a long period. The preserving fluid used consisted of 5.4 per cent. dextrose combined with 3.8 per cent. sodium citrate; both of these solutions are isotonic with blood plasma. The optimum proportions of blood and dextrose citrate solution were found to be as follows: Three parts of blood, two parts of citrate, and five parts of dextrose solution. This mixture was placed in the ice chest and the red cells allowed to sediment. The supernatant fluid showed no signs of haemolysis even after the red cell layer had been stirred up repeatedly. Furthermore, after washing these cells in Locke's solution, there was no evidence of loss of integrity. It was found that the rabbit's blood preserved in this way could be kept intact for three to four weeks, and sheep's blood for as long a period as eight weeks. Human red blood cells showed no apparent deterioration at the end of four weeks. They determined the viability of preserved blood cells by means of transfusion of these cells in bulk. Rabbits were used for this purpose. A normal rabbit was bled a large quantity, up to half its blood volume, causing a marked drop in the haemoglobin percentage and red cell count. Immediately afterwards the rabbit was transfused with an amount of preserved rabbit's blood cells equal to the amount lost in bleeding. The haemoglobin returned promptly to its previous level. The animal showed no ill effects from the procedure, and the haemoglobin and red cell count remained normal. This demonstrated that the transfused preserved blood cells were behaving as normal red corpuscles. By this means it was found that rabbit's blood could be kept living for two weeks. Many similar experiments were carried out with the same result. Parallel tests were made with blood cells kept for longer periods. Rabbits were bled a large quantity as before and immediately transfused with preserved blood cells kept three weeks or more, but which still showed no signs of haemolysis. There was a prompt return of the haemoglobin to normal after the transfusion. This condition, however, was only temporary. The red cell count and haemoglobin soon began to fall, and by the end of the second day the transfused cells had practically disappeared from the circulation, leaving the rabbits markedly anaemic. The animals seemed normal

otherwise—that is, there was no apparent harmful effect from the transfusion of intact preserved blood cells kept beyond the period of their viability. On the other hand, the transfusion of preserved blood cells that were beginning to show haemolysis had an extremely harmful effect, and the recipients died often within twenty-four hours. At the necropsy evidence of marked haemolysis was found.

An opportunity to test the usefulness of this method of transfusion with preserved human red blood cells was afforded me by the medical authorities of the Third Army, B.E.F., at whose casualty clearing stations the work was carried out.

METHODS.

1. PREPARATION OF THE PRESERVING SOLUTIONS.

The solutions of dextrose and sodium citrate are made up on the basis of 500 c.cm. of blood, as this is the usual amount taken from a donor. This requires in round numbers 350 c.cm. "isocitrate" (isotonic sodium citrate solution) and 850 c.cm. "isodextrose." These two solutions must be made up and must be autoclaved separately. Freshly distilled water should be used for all solutions.

For the preparation of "isodextrose" powdered dextrose is preferable, but since this substance is no longer obtainable in any quantity liquid glucose is used instead, and thus far has proved satisfactory; 2 grams of the liquid glucose is equivalent to 1.6 grams powdered dextrose. Thus, to make up 850 c.cm. of a 5.4 per cent. solution, 46 grams of powdered dextrose or 57.5 grams of liquid glucose is needed. On account of the difficulty in weighing out and dissolving liquid glucose, it is convenient to make up a large quantity of a 20 per cent. solution. This can be used as a stock from which the "isodextrose" may be prepared. Enough stock for six lots of "isodextrose" is made by dissolving 360 grams of liquid glucose in sufficient distilled water to bring the total volume of the solution to 1,800 c.cm. It is then filtered through coarse filter paper. If the solution is to be kept it should be sterilized. For making "isodextrose" 287 c.cm. of this concentrated solution is diluted with distilled water to 850 c.cm. in a clean two-litre bottle (Winchester). The bottle is stoppered with a cotton-wool plug, which is covered with gauze and tied on. The solution is sterilized in the autoclave for one half-hour at a temperature of 105° C. (equals 3 lb. steam pressure). This temperature should be reached slowly, as bottles of this size are liable to break if the change of temperature is rapid. For this purpose a one-burner Primus lamp is suitable. Care should be taken that the temperature does not exceed 105° C., as glucose may decompose if heated above this point.

There are no difficulties in preparing the 3.8 per cent. sodium citrate solution, but it is convenient to make up a 20 per cent. stock solution. A quantity sufficient for six lots of "isocitrate" is prepared by dissolving 90 grams sodium citrate in distilled water to a volume of 450 c.cm. and filtering. If this concentrated solution is to be kept it should be sterilized. For making "isocitrate," 66.5 c.cm. of the 20 per cent. solution is diluted to 350 c.cm. with distilled water. These 350 c.cm. amounts are sterilized in small bottles of the size used for transfusing the blood (described later). The same precaution is taken to cover the mouth of the bottle as in the case of the glucose solution; 105°–110° C. in the autoclave for one half-hour is sufficient.

2. PROCURING THE BLOOD.

(a) Donors.

Persons belonging to blood group IV² only are used. This saves the necessity of doing agglutination tests before transfusion, since blood cells of this group are not haemolyzed or agglutinated by the blood of any individual. The writer has not had the slightest difficulty in getting volunteers for donors. The importance of transfusion is explained to them beforehand and they are told that it is now possible to keep blood for some time and have it immediately available when needed. The donors are chosen from among patients with trivial wounds or those who have recovered from slight wounds. Persons giving a history of malaria, trench fever, or syphilis are excluded.

(b) Apparatus.

The apparatus for bleeding and the method of measuring are shown in Fig. 1.

The Winchester bottle containing the sterile isodextrose serves as the bleeding bottle. Before mixing the solutions