

The normal heart-sound is either completely lost in, or still remains audible along with the murmur, systolic or diastolic, which accompanies it. This sound, when associated with a systolic murmur, is either synchronous with it or immediately antecedent to it; it is sometimes louder, sometimes feebler, than the murmur, and is always of shorter duration. If such a sound, accompanying, for instance, a systolic murmur at the apex, presents any decided difference in intensity and timbre from the systolic sound of the right ventricle, it is obviously not to be regarded as propagated from the latter, but as being produced independently at the mitral valve. The diagnostic significance of a sound of this kind, coinciding with a systolic mitral murmur, is that a portion of the valve in question is still functionally perfect, capable of entering into vibration and of complete closure.

As at the apex (mitral valve) so over every other part of the heart, a systolic murmur may be attended by a systolic heart-sound, and the latter, when not traceable to transmission from some other valve, points to the conclusion formulated above,—that the corresponding valve or arterial wall is still to some extent anatomically intact and susceptible of vibration.

A diastolic sound often mingles with diastolic murmurs, but generally only at their outset; this applies almost exclusively to the murmur heard in aortic insufficiency, when the presence of the sound, as in the other cases just mentioned, shows the partial integrity of the valve concerned.

The louder and rougher the systolic murmur the greater the difficulty in hearing the systolic sound which possibly accompanies it, as the sound is masked and altered by the murmur. This may be obviated, however, by withdrawing the ear a little way from the stethoscope, when it will be found that the murmur is thereby rendered weaker, while the sound, on the contrary, becomes clearer and stronger (Rapp and Gendrin). Friedreich advises, for the attainment of the same end, that the larger end of the stethoscope be displaced somewhat from its usual situation over the ear, in such a way that it covers only a portion of the external auditory meatus, causing all sounds passing through the instrument to be conducted through the bones of the head. I have had many opportunities of convincing myself of the great utility of both of these methods in enabling one to distinguish clearly the sounds of the heart.

A systolic sound associated with a systolic murmur, heard at the apex of the heart and of a moderate degree of loudness, distinctly different

in *timbre* from the systolic sound proceeding from the right ventricle, and therefore evidently not a sound transmitted from the right side of the heart, must necessarily be regarded as originating at some part of the mitral valve still untouched by degenerative change. The only exception to this general rule is seen in those very rare cases in which, as has been proved by post mortem examination, a sound is heard while the valve from which it seems to arise is totally disorganised; it is these cases only which are entitled to be considered instances of *muscular heart-sound*. I have, moreover, met with a not insignificant number of cases of systolic murmur in which no trace of systolic sound could be detected, even by the aid of the various methods of auscultation just described.

Systolic murmurs are *not invariably* dependent on structural change within the heart (the exceptions are given on p. 286); *diastolic* murmurs, on the contrary, never occur save as the *result of anatomical lesion*.

The changes which give rise to *systolic* murmur are, on the left side of the heart, *insufficiency of the mitral valve, contraction of the aortic orifice, atheromatous degeneration and aneurism of the ascending aorta*; on the right side of the heart they are due to *tricuspid insufficiency and narrowing of the mouth of the pulmonary artery*.

Nevertheless systolic murmurs, really emanating from the auriculo-ventricular valves or the arterial orifices, may exist without insufficiency or stenosis of these parts, merely from the presence of a somewhat abundant pathological deposit on their endocardial surfaces; in such circumstances all the consecutive changes in the heart, observed to follow insufficiency and stenosis, are wanting. Thus, when the mitral valve is roughened by deposit, *without being thereby rendered incompetent*, there is no hypertrophy of the right ventricle, and when the aortic orifice is similarly affected, *without stenosis*, there is no hypertrophy of the left ventricle, &c. A deposit on the inner surface of the ventricular walls also may, if it project far into the cavity, cause a systolic murmur.

The anatomical alterations which give rise to *diastolic* murmurs are *contraction of the auriculo-ventricular orifices and incompetence of the arterial valves*. It is the *mitral orifice* which is most frequently the seat of stenosis, and the *aortic valves* that are most often incompetent; the same anomalies on the right side of the heart are, on the contrary, extremely rare.

These anatomical structural modifications, which consist usually of the deposition of lymph and the formation of excrescences on the valves and arterial orifices, atrophy or shrinking of these parts, adhesion of the valvular segments to each other or to the endocardial lining of the heart, &c., are always the sequelæ of a previous attack of acute or chronic endocarditis.

INORGANIC (ACCIDENTAL, ANÆMIC) MURMURS.

Whilst, as already remarked, *diastolic* murmurs appear *only* in connection with some actual mechanical disturbance of circulation, it is one of the commonest experiences to find a *systolic* murmur in a heart in which there is no valvular disease or other anatomical lesion, that is, under normal conditions so far as the organs of circulation are concerned. Such a murmur, in contradistinction to those which result from organic affection, is termed an *inorganic* murmur.

Inorganic murmurs are distinguished from those of organic origin by the following characters :

1. By their softness, febleness, and short duration ; they are of a gently blowing quality or softly aspirated, never harsh, sawing, or rasping, &c.
2. By their rhythm ; they are, as already noted, *never diastolic*,* but invariably systolic and generally attended by a more or less marked systolic heart-sound.
3. They occur most frequently at the pulmonary orifice, next most often at the mitral orifice, but very seldom at the aortic or tricuspid valve. The systolic murmur is most usually limited to the pulmonary orifice, sometimes it is heard over both it and the mitral valve, occasionally over the latter alone, and very rarely over *both* auriculo-ventricular valves and both arterial orifices.
4. *They are very commonly*, in chlorotic subjects, *combined with murmurs in the veins of the neck*.
5. They are not permanent, but become feeble as the general health improves, and ultimately disappear altogether.

Systolic, inorganic murmurs are noticed not unfrequently in *severe acute diseases*, such as pneumonia, typhus, puerperal fever, scarlatina, small-pox, in the later stages of relapsing fever, &c. ; but it is particularly in *anæmic* conditions that they are heard, whether this impoverishment of the blood be due to direct loss

* Several authors state that in some extremely rare cases they have observed an inorganic murmur *diastolic* in rhythm ; I have never yet seen such a case.

by hæmorrhage (as in women who have been recently confined) or to chronic disease leading to changes in the constitution of the blood, (especially *chlorosis*, pernicious anæmia, leukæmia), to marasmus (as in carcinoma of the various organs and in malarial cachexia), or occasionally to pregnancy.

Inorganic murmurs at the mitral orifice are caused by the unequal tension of the segments of the valve, and at the pulmonary orifice by the unequal tension of the sides of the artery.

This abnormal vibration (or tension) of the valves and arterial walls is chiefly the result of slight fatty metamorphosis of the muscular substance of the heart, more especially of the *papillary muscles*, which takes place whenever anæmia becomes profound.*

When the papillary muscles, as the consequence of fatty degeneration of their constituent fibres, contract unequally and with less energy than in health, the tension of the auriculo-ventricular valve with which they are connected is likewise diminished and non-uniform ; in this way, as in cases of dilatation of the heart, a temporary *relative insufficiency* of these valves, particularly of the mitral, may be produced.

The recognition of an inorganic murmur is, as a rule, comparatively easy, its character and seat, the general morbid condition in which it seems to have its origin, and the existence of anæmic murmurs in the veins of the neck, being usually sufficient to establish its identity. The inorganic nature of a murmur, however, is most conclusively demonstrated by proving the absence of consecutive organic changes in the heart.

As an inorganic murmur (in chlorosis, for instance) may be loudest at the apex of the heart, and as the heart's action is commonly also increased in vigour, the first impression communicated to the examiner may be that he has to deal with mitral insufficiency, but this hypothesis is at once disposed of by the *absence* of hypertrophy of the right heart and of any intensification of the second pulmonary sound. It is, nevertheless, quite conceivable that in certain cases in which chlorosis is present murmurs may be generated by a *relative* insufficiency of the mitral valve.

* In animals fatty degeneration of the heart may be experimentally produced by repeated and copious venesection (Perl).

PROPAGATION AND POINT OF ORIGIN OF CARDIAC MURMURS.

When it has been ascertained simply that a murmur, systolic, diastolic, or both, is heard over the heart, the only diagnostic inference that can be drawn is the general one that there exists some obstacle to the circulation of the blood within or near the heart; but the particular valve or arterial orifice at which it arises can be determined only by finding that it is loudest at a certain spot corresponding to the anatomical situation of that valve or orifice, by fixing, in other words, its point of *maximum intensity*. Wherever the murmur presents greatest intensity, there is the centre from which it emanates; the further the ear is removed from this spot the feebler becomes the murmur. In general murmurs are propagated to, and reach their maximum intensity at, certain points according to the same laws that are found to hold good in the case of the heart-sounds; they are transmitted most distinctly, therefore, towards those parts at which the heart is not covered by lung and in the direction taken by the blood-current. Thus, murmurs arising at the *mitral valve* are loudest at the apex of the heart or immediately above it, *tricuspid murmurs* are loudest over the lower part of the sternum, *pulmonary murmurs* in the second left intercostal space close to the sternum, and *aortic murmurs* in the second right intercostal space at the edge of the sternum and over the whole length of the body of that bone.

1. MITRAL MURMURS.

Systolic murmurs originating at the mitral valve, whether that structure be functionally competent or not, are almost always of maximum intensity at the apex of the heart, while at that point beneath which the valve really lies they are but faintly audible, as the heart is there sheltered behind a layer of pulmonary tissue. Even in those cases in which the base of the heart is not so covered over by lung, whether this be due to retraction of the anterior border of the lung from hypertrophy and dilatation of the right heart or to the presence of pulmonary condensation complicating the cardiac lesion (a very rare circumstance), the murmur is still loudest at the apex, the cases being very exceptional in which it is of *greatest intensity* over its point of origin, that is, in the *second left intercostal space*. The results

of post mortem examination warrant us in attributing the last-mentioned phenomenon, when it does occur, to *hypertrophy of the left auricular appendix*, as this part of the auricle, when much enlarged, comes into immediate contact with the anterior wall of the chest (Naunyn); thus, as in every case of mitral insufficiency the systolic regurgitant current of blood, rushing from the left ventricle, enters not only the corresponding auricle but penetrates also to its appendix, (the cavities of both parts being continuous), the further the latter passes round the pulmonary artery and the nearer its apex comes to the anterior chest-wall, the more favourable are the conditions presented for the propagation of the mitral murmur through the left auricle into the appendix and thence to the thoracic parietes.

Naunyn based his opinion that the abnormal intensity of this murmur in the second left intercostal space is really caused by hypertrophy of the left auricular appendix on a simple experiment: he found that if at the spot at which the murmur was loudest during life a slender needle be thrust perpendicularly into the chest it pierces the appendix exactly at the part at which it turns round the pulmonary artery and comes forward towards the anterior surface of the heart.

The *diastolic* murmur arising from stenosis of the mitral orifice is always loudest at the apex of the heart and in the region immediately adjoining it towards the right; it is transmitted, therefore, in the direction of the blood-stream, as it is produced by the commotion of the latter in passing from the left auricle into the ventricle.

But this murmur, apart from the circumstance that it presents its greatest intensity at the apex, is marked by one very distinctive feature by which it may be known from the other diastolic murmurs heard over the heart, particularly from those emanating from the aortic valves: it is not of precisely the same quality throughout the whole period of its duration, but is generally divided into *two*, sometimes even *three portions*, which are not indeed separated from each other by any very appreciable pause but which differ very strikingly in character and in the rapidly increasing loudness of the murmur from its commencement to its end. Thus, while the murmur is at first feeble and soft, it speedily becomes louder and towards the end of the diastole is usually rough, rasping, or grating in quality.—Frequently, also, in cases of mitral contraction no murmur what-

ever is audible over the apex of the heart at the beginning of the diastole, this being developed only at the end of the diastole, immediately before the systole; it is accordingly in such circumstances named a *presystolic* murmur.

That the murmur is so often absent at the *commencement*, and is developed towards the end, of the diastole, that is, in the presystole, is probably to be explained in the following way: when the heart is at rest in the diastole the pressure on the blood flowing from the left auricle into the ventricle is very low, and if the valvular orifice be not excessively contracted and its walls not very rough the blood-stream encounters no resistance in its passage through it, and therefore no murmur is set up; but when, just before the contraction of the ventricle, in the presystole, the auricle contracts, the onward current into the ventricle is suddenly quickened, the pressure at the narrowed auriculo-ventricular opening is considerably increased, the blood is thrown into commotion and a murmur is of necessity produced.

In like manner the presystolic murmur may be intensified, and a true diastolic murmur, coming shortly before it, may be called into existence, by exciting the heart to more forcible contraction. In such cases, therefore, there is generated a murmur which occupies the *whole* of the diastole, but which, as it is added to and rendered louder in each presystole, is composed of two distinctly recognisable parts.

As stenosis of the mitral orifice is almost invariably complicated by insufficiency of the mitral valve, the diastolic-presystolic murmur generally passes at once into the systolic murmur resulting from that insufficiency; the latter is often accompanied by a short dull systolic heart-sound when the valve at any part still preserves enough of its normal structure to enable it to enter into vibration.

Sometimes in stenosis of the left auriculo-ventricular orifice the diastolic or presystolic murmur disappears entirely when the heart is acting quietly, and is replaced by a *double diastolic sound*, which is immediately converted into a diastolic murmur when the force of the heart's contraction is increased (compare p. 278).—The diastolic valvular sound also, proceeding from the arterial orifices and propagated downwards towards the apex of the heart, is commonly heard along with the diastolic or presystolic murmur.

The long duration of the diastole, which in cases of mitral stenosis is owing to the slow filling of the ventricle, explains the *long duration*

of the *diastolic murmur* as compared with the *shortness* of the systolic sound or, when the stenosis is complicated by insufficiency, of the systolic murmur.

2. AORTIC MURMURS.

Murmurs originating at the *aortic orifice*, at the *aortic valves*, and beyond them in the *ascending aorta* are, like the normal arterial sounds, conducted with greatest intensity in the direction taken by the blood-stream, and are therefore frequently very loud and distinct in the *second right* intercostal space at the sternal insertion of the third right costal cartilage; *they have the same intensity*, however, *over a large part of the sternum*, and are indeed often *louder over that bone* than at the point just mentioned. It is essential, therefore, in investigating any case of aortic disease, that the *whole* of the sternum should be carefully auscultated, as the murmur presents its greatest intensity sometimes at one spot, sometimes at another, on the surface of the bone.

The *systolic* aortic murmur is caused by contraction of the aortic orifice, by rough excrescences which retard the current of blood through it, by atheromatous disease in the initial portion of the vessel, and by aortic aneurisms. The *diastolic* aortic murmur arises from the regurgitation of blood from the aorta into the left ventricle when the semilunar valves which guard the aortic orifice prove incompetent; it is distinguished from the systolic aortic murmur by its longer duration, and from the diastolic mitral murmur (which, however, it resembles in point of duration) in being of more uniform character; it is not, like the mitral murmur, divided into several detached and dissimilar portions, but preserves its rushing or blowing quality in full intensity often throughout the whole of the diastole. This peculiarity alone, apart from the situation in which it is best heard, is sufficient to identify it as aortic in origin.—Systolic and diastolic murmurs may co-exist, and are then generally separated from each other by a well-defined pause, though occasionally the one runs directly into the other without any such interval.

3. TRICUSPID MURMURS.

These are commonly loudest over the lower part of the sternum. As they are exceedingly rare, however, the diastolic