so prevent them from rubbing on each other. On the other hand, friction-sounds often persist for weeks after the subsidence of the pericarditis, but they diminish gradually in intensity as the fibrinous deposit melts and becomes more fluid, till they disappear altogether when the surfaces regain nearly their normal smoothness or when the two portions of the membrane are glued together by adhesions.

Pericardial friction-murmurs are not dependent solely on pericarditis; they are sometimes due to tuberculosis or cancer, ecchymoses or callous thickening, of the pericardium, muscular tumours of the heart, and similar affections. It is stated also that abnormal dryness of the pericardium, in the stage of asphyxia in cholera, occasions pericardial murmurs; for my part I have never observed murmurs of this nature, though I have frequently searched for them in patients in the condition described.

Murmurs are also sometimes caused by the presence of roughness of the *outer* surface of the pericardium, when this part of the membrane rubs against the adjoining portion of the lungs or the thoracic parietes; these are termed *extrapericardial* or pneumo-pericardial murmurs, and are identical in character with the intrapericardial murmurs.—Finally, the pericardium may be perfectly smooth but may move to and fro on the roughened pleura (in cases of Pleurisy). Murmurs (pleuro-pericardial) so produced are usually enfeebled or even abolished by simply holding the breath; very rarely they persist notwithstanding that respiration is suspended. The formation of a diagnosis between intra- and extrapericardial murmurs is possible only on taking into full consideration all the other signs furnished by physical examination, though even then it cannot always be made with perfect certainty.

AUSCULTATION OF THE ARTERIES AND VEINS.

Arterial Sounds.

As in the initial portion of the aorta, so in the great vessels springing from it, certain sounds are heard accompanying each contraction of the heart, developed partly in these arteries themselves, but for the most part conducted thither from the aorta. The only arteries which it is customary to auscultate for the purpose of investigating these sounds, are the carotid and subclavian; in certain cases, however, to be mentioned further on, vessels of much smaller calibre, such as the brachial or femoral, are examined with the same end in view. The point at which the carotid may best be auscultated is in the fossa inter-sterno-cleidomastoidea, that best adapted for the study of the subclavian sounds being in the supra- or infraclavicular fossa, towards the acromial end of the collar-bone.

If the stethoscope be placed lightly on the carotid artery, when the circulatory apparatus is in its normal state, there are heard *two* perfectly pure *sounds* accompanying each cardiac systole, separated from each other by a short pause; the first of these coincides with the expansion, the second with the contraction of the artery. The expansion of the carotid artery is synchronous with the systole of the heart, its contraction is simultaneous with the cardiac diastole.

To prevent misunderstanding I think it is better to avoid the use of the terms "systole" and "diastole" in describing the periods in which sounds and murmurs are heard in the arteries, as those words have become so intimately associated with the nomenclature of the phases of the heart's action that they at once and involuntarily recall the latter to mind; all risk of confusion in this matter may be obviated by employing the terms "contraction" and "expansion" with reference to the arteries.—It is only in large arteries, those situated close to the heart, that arterial expansion, *i.e.*, the arterial pulse, corresponds exactly with the heart's systole; in the more remote vessels the interval between the cardiac pulsation and the arterial throb may be so prolonged that the latter comes to coincide almost with the diastole of the heart or occurs

even several hundredths of a second later. The average length of the interval between the first and the second sounds of the heart is stated by Landois to be 0·31 seconds, that of the period which elapses between the first heart-sound and the radial pulse 0·22 seconds, between the same sound and the pulsation of the arteries of the foot 0·35 seconds.

The first sound in the carotid artery must be regarded as consisting partly of the transmitted first aortic sound; to some extent, also, it is generated independently in the vessel itself, by the stretching of its walls. Various facts may be adduced in support of the view that it is in some measure of local origin: it is often quite as loud as the first sound over the aorta; it sometimes continues audible even when this sound is wanting or is superseded by a systolic murmur; in other large arteries, and also in some of smaller size at a great distance from the heart, sounds may be heard when from any cause the arterial walls are more fully expanded than usual by the blood-wave.

The second carotid sound is not developed in the artery, the conditions necessary to its production being wanting locally; it is simply *the transmitted second aortic* sound. This view is based on the facts that when the second aortic sound is replaced by a diastolic murmur the second carotid sound also disappears, there being then either no sound whatever in the carotid during the diastole of the heart or in its stead a propagated diastolic aortic murmur.

A. Weil found, as the result of a series of observations on 600 individuals, in which special attention was directed to the acoustic phenomena noticed in the arteries, that in the healthy subject there were two sounds in the carotid in four-fifths of the cases, and that in the remainder if a sound were absent it was invariably the first; the second was constant. My own experience enables me fully to corroborate these statements.—The rhythm of the carotid sounds is iambic, as in the pulmonary artery and the aorta; the first sound is somewhat feebler and duller, the second stronger and clearer. Weil holds that the first carotid sound is exclusively of cardiac origin, that it is conducted from the heart; I, on the contrary, believe that it in part also arises independently in the vessel, and for this among other reasons, that in a number of cases I have detected it when at the aortic orifice there was a systolic murmur unaccompanied by any trace of a systolic sound.

In the *subclavian artery* also, in normal conditions, two sounds are associated with each contraction of the heart; these

have the same rhythm as the carotid sounds, are due to the same causes, and in similar pathological circumstances undergo the same modifications. If either of the subclavian sounds is abolished it is generally the first.

Like the carotid and subclavian arteries the *aorta*, in the whole length of its course through the thorax and abdomen, presents a systolic sound which depends directly on the contraction of the heart. When the heart's action is vigorous the sound of the descending aorta is appreciable with considerable distinctness close to the vertebral column (provided especially the respiratory murmur be eliminated by suspending respiration); the sound of the abdominal aorta may readily be observed in emaciated persons, whose abdominal walls are soft and flaccid, by pressing deeply with the stethoscope. There is no second sound in this portion of the vessel the second aortic sound not being carried to parts so remote from its point of origin. In the other peripheral superficial arteries, the femoral, brachial, and radial, no sounds are as a rule discoverable in health; in the first-mentioned of these, however, in the femoral, a very feeble sound is occasionally audible, during its period of expansion.

In diseased conditions all peripheral arteries, even those of small calibre, may yield a sound at the instant in which their walls are put on the stretch by the advancing blood-wave.

One of two conditions seems to be necessary to the production of this sign: the artery is either more *forcibly* distended by the blood-wave than normally, or (and this is a still more important factor) is brought more *quickly* than usual into a state of complete tension. These conditions are found combined in cases of insufficiency of the aortic valves; the arteries are rendered abnormally tense by the force exerted by the hypertrophied left ventricle, and this increase of tension is developed with great rapidity, as the artery is possessed of but a low degree of tension when it is in the act of contraction, it being emptied of blood in two directions at once, centripetally and centrifugally. The arterial sounds are therefore louder and more exquisitely defined in aortic insufficiency than in any of the other disorders still to be mentioned. In aggravated cases of this valvular lesion a short and well-marked sound is obtained on applying the stethoscope lightly over the axillary, brachial, radial, femoral, or popliteal artery, sometimes even over smaller vessels, such

as the palmar arch, as they are expanded by each successive systolic blood-wave; it disappears, however, or becomes weaker in the later stages of this affection, when the contractile power of the left ventricle begins to fail and the tension of the arteries, and the blood-pressure within them, are consequently diminished. In those instances, moreover, in which the cardiac disease consists simply of hypertrophy of the left ventricle without any valvular defect in the aorta, a sound is heard in the larger arteries (the femoral, for example), though this sound is not by any means constant in its occurrence, and even when present is feeble; so long as the aortic valves preserve their normal structure the arteries show no unusual diminution of tension during the period of contraction, the increase in their tension is therefore not so great, nor does it take place so rapidly, as in other cases in which the valves of the aorta are incompetent.

Further, a soft, faint sound is occasionally detected over the femoral artery during the period of systolic expansion, in febrile diseases, and in anæmia and chlorosis (Weil), but only when the tension of the vessel in contraction is in some way lessened, so that the difference between the tension of contraction and that of expansion is greater than in health.

It has been stated above that sounds in the large arteries near the heart are to be considered as purely physiological phenomena, and that sounds in vessels at a distance from the heart and in all the smaller arteries have a decidedly pathological signification. There is another variety of arterial sound, however, *produced artificially, by compression*, which is different in nature from both of those just described, occupying a middle position between them. If an artery of somewhat large calibre be pressed upon with the finger or the edge of the trumpet-shaped extremity of the stethoscope, so as to close it *completely* or almost completely, its expansion at the point of compression is accompanied by a sound, as the walls of the vessel, above the obstruction, are by this proceeding more forcibly stretched and rendered tense, with each cardiac pulsation,—exactly the conditions which are held to be requisite to the physiological production of the first (systolic) sound in the great vessels, the aorta and pulmonary artery. If, on the other hand, the pressure made on the vessel be not sufficient to completely arrest the flow of blood through it a murmur

is heard instead of a sound, as the blood-stream is thrown into the necessary whirling or eddy-like commotion at the narrowed part of the artery.

In all cases in which a sound, of pathological or artificial origin, presents itself in arteries remote from the heart, this sound is, with very rare exceptions, *single* and is associated with the *expansion* of the vessel. O. Wolff asserts that over arteries of medium size, such as the radial or ulnar, (in very emaciated subjects of middle age, and by being careful to exercise only a certain moderate amount of pressure with the stethoscope), *three* sounds may be recognised in each cardiac cycle, following very quickly on each other and corresponding with the phenomena of *tricrotism* as demonstrated by the sphygmograph; the first of these he explains as due to the expansion of the arteries, and the two others, occurring during the period of contraction, as caused by the arterial recoil-waves. My own observations are not confirmatory of Wolff's statements, though I have repeatedly examined, with this special object in view, patients whose condition was such as to be highly favourable to the practice of arterial auscultation.—In certain cases of very marked insufficiency of the aortic valves, not merely one sound, connected with the expansion of the vessel, is audible over the femoral artery, but also a second sound, dependent on arterial contraction; the *sound* here, therefore, is *double*. Traube accounts for this second sound by the supposition that during the period of contraction the artery subsides suddenly from the state of extreme tension into which it was thrown in expansion, to a condition in which its tension is very low (as the result of the rapid draining-away of the blood in two opposite directions simultaneously, towards the heart and peripherally into the capillaries), and that in so doing it emits a sound strictly analogous to that yielded by any other tense membrane, such as a violin-string, when it is *suddenly* relaxed. There are cases, however, in which the second sound appears only some time after the relaxation of the arterial walls is completed; to these, accordingly, Traube's explanation is not applicable.—Bamberger's theory on this subject is that the second sound is caused by the returning blood-wave; when the volume and force of the latter are above the average, and the tension of the artery in this way increased, the result is a sound, but if the wave be small and the arterial tension low a murmur is produced (see p. 307). This doctrine furnishes a ready explanation, as Bamberger points out, of the fact that the double sound is observed almost exclusively in the femoral artery, as this vessel, on account of the directness and great length of its course, is better adapted for the reception and propagation of the centripetal regurgitant wave than even large arteries which after a short course break up into numerous branches. It seems, moreover, that the occurrence of a double arterial sound is not limited to cases of aortic insufficiency; Weil reports having met with this sign in two cases of stenosis of the mitral orifice.

Arterial Murmurs.

Murmurs may arise from *local* causes in the large arteries (the carotid and subclavian), or *may be transmitted to these vessels from the heart,* or *may be developed artificially in all superficial arteries by simple pressure.* Murmurs of *local origin* and artificial murmurs are *invariably synchronous* with the arterial pulse, *i.e.*, with the expansion of the artery; *transmitted* murmurs, on the other hand, may be audible both *in the period of expansion and in that of contraction of the artery.*

1. Murmurs in the carotid and subclavian are to be set down as of *local* development, when over the heart no trace of their existence can be made out. Such murmurs, always exactly coincident in time with the pulse, not unfrequently occur even while the structure of the arteries is still perfectly normal. *One* condition, however, is essential to their existence,—increased action of the heart; when by this means the artery is widely dilated, and when this expansion is effected suddenly, a murmur is excited by the oscillation of the blood-wave as it enters the widened part of the vessel. It is nevertheless conceivable that these are not merely "fluid-murmurs" but that they may also be owing to unequal tension of the *arterial walls;* thus, as it is undoubted that the expansion of the arterial walls by the pulse-wave (in the large arteries) occasions a sound, it appears not improbable that in certain circumstances, particularly when the action of the heart is accelerated and strengthened, that is, when the arteries are more quickly and more forcibly dilated, a murmur may be generated instead of a sound. As a matter of fact it is frequently observed that pure and unmistakeable sounds are transformed into indubitable murmurs when the action of the heart is increased in vigour. These local carotid and subclavian murmurs are also always attended by a more or less distinct and loud sound. And further, whilst the really arterial murmurs, so long as the circulatory apparatus continues unaltered in structure, occur only periodically,—when the heart is stimulated to more energetic contraction,—they often persist for a comparatively lengthened period when the left ventricle is the seat of a considerable degree of hypertrophy, especially the hypertrophy which is consecutive to aortic insufficiency; here are presented circumstances most favourable for the formation of arterial murmurs,—dilatation of the arteries and extreme and rapid tension of their walls.

In the branches of the carotid also, local arterial murmurs, synchronous with the heart's systole, are heard when these vessels undergo such morbid changes as cause them to become tortuous and dilated, and when the widened portions of the arteries are continuous with others the lumen of which is normal and which are therefore narrower. In small vessels which suddenly widen at certain parts of their course, and equally in large vessels which at points are abruptly reduced in calibre, an oscillation of the particles of blood ensues, a vortiginous motion is communicated to the blood-stream, and a murmur is produced. The arterial murmurs heard in the enlarged thyroid gland (and also in the carotid and subclavian) in exophthalmic goître, are of this nature; they are to be distinguished from the venous murmurs also observed in this kind of tumour (see p. 313) by being audible only with each systole of the heart, while those emanating from the veins are continuous.

Murmurs set up locally in the subclavian and carotid arteries, coincident with the cardiac systole, are also sometimes due to pathological changes (sclerosis) of the arterial walls, particularly when these are complicated by hypertrophy of the left ventricle of the heart, or, above all, by aneurism. The cause of the murmur in these cases as in the others, is the whirling commotion imparted to the blood-current at the diseased part.

To the group of murmurs under consideration, those developed in the carotid or its ramifications, falls to be added the *encephalic murmur*, discovered by Fisher in 1833. It occurs in nearly one-half of all mammals (Steffen); it consists of a soft blowing murmur, which keeps time accurately with the heart's systole, and is heard most frequently over the great fontanelle and in its immediate vicinity (sometimes also at the small fontanelle) from the fourth month to the second year of life, or, in certain affections in which the fontanelles remain open, even as late as the sixth year. It probably arises in the manifold windings and turnings of the arteries at the base of the cranium, and is conducted thence through the brain mass to the surface. With the cerebral murmur is often combined a cardiac-systolic carotid murmur (Jurasz). Brain-murmur is destitute of any diagnostic importance; it is present in children both in health and disease.

2. Murmurs in the carotid and subclavian arteries are also very frequently of more central origin, being *propagated* into

these vessels from the orifice and initial portion of the aorta; murmurs from other parts of the heart never reach the vessels named, or if in exceptional cases they do they are of very feeble intensity. When such arterial murmurs coincide with the *diastole* of the heart the inference is unavoidable that they proceed from the aortic orifice, as in the carotid and subclavian arteries the generation of a murmur of cardiac-diastolic rhythm is impossible, the necessary physical conditions being there wanting. This explanation finds ample confirmation in the results of auscultation of the aortic orifice; the diastolic murmur caused by insufficiency of the aortic valves is observed to be loudest in this situation. But should the diastolic murmur be soft and faint in character at its starting-point it may not be recognisable even in the large arteries, in which case, of course, nothing whatever is heard in the carotid artery during the cardiac diastole.—Those carotid and subclavian murmurs also which are synchronous with the cardiac *systole* are very frequently of central origin, being directly propagated from the aortic orifice (when it is the seat of marked narrowing or is partially obstructed by very rough growths, in cases of atheromatous degeneration and of aneurism of the aorta), and this transmission of aortic systolic murmur takes place with much greater regularity than is the case with diastolic murmurs, the former being carried along with the blood-stream towards the periphery, the latter (which are caused by the regurgitation of a quantity of blood from the aorta into the left ventricle) tending rather to pass backwards towards the heart.

3. By exercising moderate pressure with the stethoscope *artificial* murmurs may be produced in the arteries,—the carotid, subclavian, femoral, and (rarely) the brachial. They give to the ear the impression of a short blowing murmur synchronous with the pulse, often of great intensity in the larger arteries, such as the carotid and subclavian. In auscultating the apices of the lungs pressure-murmurs of this kind are often heard; on relieving the pressure they disappear at once. Very slight pressure is enough to elicit them, especially when the velocity of the blood-current is increased as the result of excitement of the heart's action. The femoral artery also, on account of its proximity to the surface, is equally favourably placed with the carotid and subclavian for the development of pressure-murmur.

As already explained, artificial murmurs owe their existence to disturbance of the blood-stream (oscillation of the particles of the circulating fluid), inasmuch as the blood-wave passes from a relatively wide channel into one which, at the point of compression, is relatively narrow.

A *double murmur*, one division of which is associated with the expansion of the artery and the other with its contraction, may, but only in persons suffering from positive disease, be generated by pressing upon and nearly closing the arteries. This double murmur is observed most often in the *femoral* artery, much more seldom in the axillary, brachial, or popliteal. It was first noticed by Alvarenga da Costa, in insufficiency of the aortic valves, and has been declared by Duroziez to be absolutely pathognomonic of that valvular lesion. It is true that the double arterial murmur is a very common and characteristic sign of aortic insufficiency, occurring, in my experience, in at least one-third of the cases, but it does not appear exclusively in connection with this affection, being occasionally met with in various other morbid conditions,—a fact which Duroziez himself has pointed out; thus, Friedreich detected it in chronic endarteritis of the aorta and of the large arterial trunks, in aneurism of the aorta, in hypertrophy of the left ventricle from contraction of the kidneys, in typhoid fever, &c. The first murmur, that which is coincident with the pulse in the femoral, is, as above stated, caused by compression of the blood-wave as it travels towards the *periphery*, the second by compression of the backward wave which, in aortic insufficiency, returns towards the *heart*.

Venous Murmurs.

Venous murmurs occur almost exclusively in the *internal jugular vein;* when very loud, also, but only then, they may be audible in the intrathoracic venous trunks with which the jugulars communicate (the innominate veins and the superior cava), and now and then in the femoral veins. They are observed not unfrequently in perfectly healthy persons, but in them attain only a moderate degree of intensity; they are loudest in *anæmic* patients, especially in *chlorotic females*.

On auscultating low down in the hollow between the two sternal portions of the sterno-mastoid muscles, where the lower end of the internal jugular vein, a saccular dilatation known as the *bulbus*, is situated, a persistent continuous murmur is heard in anæmic subjects. This is sometimes of a soft, blowing or humming character, at other times it is loud and hissing or roaring in quality, not unlike the noise made by the wind in the chimney