added; these râles, however, may be so loud as to completely cover the proper expiratory sound.

The Bronchial (Laryngeal, Tracheal) Respiratory Murmur.

In auscultating the larynx there is heard, both in inspiration and in expiration, a loud, rough murmur, which may best be compared with the sound of the aspirate "h," or with the puffing sound produced by blowing through a tube, such as that of the stethoscope. The pronunciation of the German word "hauchend" reproduces fairly the peculiar characters of the laryngeal respiratory sound; when the latter is soft the quality of the "h" predominates, when rough, that of the guttural "ch." The laryngeal sound is also sometimes described as *tubular*, from its complete identity with the hollow, blowing sound caused by the rushing of air through a tube. It is loudest at the rima glottidis, this being the narrowest part of the tube through which the aerial current passes. From the larynx it is propagated downwards into the trachea and both bronchi, but with gradually decreasing intensity; in the trachea, however, it is quite as loud as in the larynx, and is of almost equal strength in inspiration and in expiration. Opposite the bifurcation of the trachea, (between the shoulder-blades and near the fourth dorsal vertebra), the laryngeal respiratory murmur is already considerably feebler and softer, and is clearly audible only in expiration; it is more distinctly appreciable on the right side than on the left, the right bronchus being wider than the left and lying nearer to the surface of the thorax. From the point at which the trachea divides the tracheal murmur is carried onwards into the bronchi, so that it may sometimes be heard over the whole interscapular, and occasionally even in the supraspinous, regions.

Lippe examined 203 healthy individuals, to determine the limits of the area of bronchial respiration. He found that it was invariably bounded superiorly by the seventh cervical vertebra, that it extended downwards from that point and to both sides of the chest, in only four cases being limited to the right side. Inferiorly its boundary varied, being usually marked by the second, fourth, or sixth cervical vertebra, and but rarely reaching further downwards.

Outside of the region described bronchial respiration is not heard in the normal thorax, although, as may be inferred from

certain pathological phenomena, the laryngeal sound is conveyed even to bronchi of medium calibre, its tubular quality being obviously modified or suppressed by the low conducting power of the spongy lung-tissue.

In *pathological* conditions bronchial respiration may become audible at any part of the thorax, and during both inspiration and expiration; it is usually louder during expiration, rarely louder during inspiration.

The pathological bronchial respiratory murmur is, in well-marked cases, very similar in character to the laryngeal sound, that is, it has almost the same pitch and timbre, so far as it can be said to possess these properties of a true musical tone; but in the majority of cases it resembles more nearly the bruit heard at the bifurcation of the trachea, which is softer and weaker than the laryngeal sound, and which, therefore, has a better claim to the attention and study of beginners, to whom the correct appreciation of the qualities of bronchial breathing always presents considerable difficulty, as the type of bronchial respiration.—It frequently happens that the bronchial character of the sound is not so pronounced as usual, and in such circumstances it is easily mistaken for harsh and prolonged expiration; no sure guide can be given for the accurate discrimination of these phenomena, except the already-mentioned aspirate quality of "h" or the guttural quality of "ch" in the bronchial sound. Practice and experience can alone confer the power of forming a certain diagnosis when the sounds are badly defined, or when the bruit is of the indeterminate class, on the border-land between bronchial and vesicular respiration. These indistinct respiratory murmurs are designated as "somewhat bronchial", "obscurely bronchial", or "approximately bronchial" sounds.

In bronchial respiration of pathological origin two qualities are distinguishable,—it may be *harsh* or *soft*, *high-pitched* or *low-pitched*. It becomes rough when the tracheal or bronchial mucous membrane is swollen, and the lumen of the bronchi in that way diminished. Similarly the bronchial murmur may take on an excessively harsh character, audible even at some distance from the patient, when the upper part of the wind-pipe is compressed by glandular tumours or reduced in calibre from other causes,—croup in children, diphtheritis of the larynx and trachea, &c. It is particularly in these cases that the tracheal

bruit is conducted to any great distance downwards into the bronchi, when in the whole of the upper part of the thorax the vesicular murmur may be accompanied by the sound generated in the trachea.—The circumstances which give rise to variation in the pitch are less clearly understood; these differences, however, have no diagnostic importance, as in the same patient there are often rapid alternations of high-pitched with low-pitched bronchial breathing without any change in the other physical signs of the disease.—The *intensity* of bronchial respiration is also very variable; the sound is sometimes almost as loud as at the level of the larynx or trachea, at other times it is very feeble, as if it proceeded from some distant part. These differences are due, apart from the energy with which respiration is carried on, more particularly to the nature of the morbid process in which the bronchial breathing has its origin, and to certain other factors still to be discussed.

The Conditions which give rise to Bronchial Respiration.

Bronchial respiration occurs in cases of *pulmonary cavity* and of *condensation of the lung-tissue*, under the following conditions:—

1. In *pulmonary caverns*, when these are situated superficially, surrounded by rigid and dense walls, and at least so large as to involve one of the larger bronchi, the air of which freely communicates with that of the cavity on the one hand and with that of the trachea on the other. In the absence of any of these conditions bronchial respiration ceases, or loses its distinctive character: thus, if the excavation be deep-seated, covered over by normal air-containing lung-substance, the bronchial quality of the respiration in the cavity is lost in the vesicular sound coming from the expansible tissue; even if the vomica be near the surface, but invested by healthy lung, the waves of sound of bronchial quality from the former are scattered and broken up by the adjoining lung-substance, which is of feeble conducting power. Further, if the cavern be too small to be in free communication with a bronchus of moderately large calibre, the sonorous undulations are propagated from the larynx so feebly as to be inaudible. And finally, should the bronchus leading to the cavity be occluded by mucus the production of the bronchial sound is obviously rendered impossible, as the respiratory current cannot

penetrate beyond the obstruction; but as soon as free intercommunication is re-established by coughing and expectoration, the bronchial bruit reappears. Its intensity, in cases of pulmonary excavation, depends, other things being equal, on the size of the cavity, on the diameter of the bronchus opening into it, and on the energy of the act of respiration.

2. Bronchial respiration is observed in partial or complete *condensation* of the lungs, whether the result of compression or infiltration of the air-cells.

The highest degree of infiltration takes place in pneumonic hepatization; here, therefore, bronchial respiration is louder than in cases of less complete consolidation from other causes. That the hepatized portion of lung may present a sound of bronchial quality it must fulfil the same physical conditions that have been already described as necessary in the case of pulmonary cavities. The larger the part hepatized, and the greater, therefore, the number of bronchi ramifying in it, the louder the bronchial sound. As pneumonia attacks most frequently the lower lobes bronchial respiration is most common in the posterior lower regions of the chest; and when the whole of the lower lobe is affected the bruit is audible from the base of the lung up to the middle of the shoulder-blade.—The bronchial respiratory murmur in pneumonia disappears at the beginning of the stage of resolution, when the air again gains access to the alveoli.

In cases of condensation of the lungs from other causes, such as caseous degeneration, chronic interstitial pneumonia with consecutive dilatation of the bronchi, &c., the parts so affected frequently have isolated patches of healthy tissue scattered in their interior; bronchial respiration in these circumstances is much less intense than in the hepatization of pneumonia. More often bronchial respiration is obscured by the presence of râles originating in the air-passages; after coughing, however, especially if it result in free expectoration, the bronchial character of the respiratory sound comes out more distinctly. But if the portions of spongy texture, enclosed within the indurated tissue in the above instances, be relatively of large size the respiratory murmur may be almost perfectly vesicular. In all varieties of condensation of the lungs, from whatever cause arising, the same conditions are necessary to the production of

bronchial respiration as in pneumonic hepatization, which simply serves as the type of the most complete solidification.

Bronchial respiration may also be observed in all those conditions in which *the lung is rendered void of air by compression.* The most marked degree of pulmonary collapse takes place from pleuritic exudation, that from pneumothorax being scarcely less complete; more partial collapse is caused by copious pericardial effusion, large aneurisms of the aorta, excessive hypertrophy of the heart, morbid growths within the pleural sac, and tumours of the abdominal organs, which push the diaphragm upwards. Nevertheless, bronchial respiration occurs in but a small proportion of the cases of pleuritic effusion, and only when the fluid is moderately abundant, that is, when the air-cells and finer air-tubes, not the larger bronchi, are pressed upon; *small* effusions occasion no bronchial respiratory murmur, as they do not usually exercise sufficient pressure to drive all the air from the lungs, but produce only retraction of these organs, reducing somewhat the quantity of air they contain. The weight of a great mass of fluid in the pleura, on the other hand, tends to obliterate also the larger bronchi, and so to hinder the free transmission of the waves of sound from the larynx downwards into the lungs. Further, on the front of the chest, in cases of pleuritic exudation, bronchial respiration is never heard, as the fluid comes between the lung and the anterior wall of the thorax, and to a great extent absorbs or suppresses the respiratory murmur. But posteriorly, where the shrunken and dense lung is in close contact with the chest-wall, the bronchial sound transmitted from the trachea is heard in considerable intensity.—It is a much rarer event to find the lung compressed to such a degree as to favour the production of bronchial respiration, from the presence of air in the pleural cavity than from pleuritic effusion; in such cases there is generally no respiratory murmur, or only one of indeterminate character, which is sometimes accompanied by a metallic echo (see "amphoric respiratory murmur," p. 139).

The other morbid changes above enumerated, giving rise to compression of the lungs, very seldom induce a state of complete collapse in the parts concerned, so that the respiratory sound does not commonly, from these causes, assume the unmistakeably bronchial quality.

Physical Cause of Pathological Bronchial Respiration.

The bronchial respiratory murmur heard in disease is nothing more than the laryngeal sound, carried with scarcely diminished intensity through consolidated lung-tissue. This was the explanation adopted by Lænnec, though in certain details his views must be held as erroneous. His theory is to the following effect:—in normal conditions the bronchial sound is so blended with the vesicular sound as to be inaudible as an independent phenomenon; but if the pulmonary tissue become consolidated, and the vesicular respiratory murmur in that way abolished, the bronchial bruit is heard, not merely in its original intensity, but more strongly, as the *dense, airless lung-substance is a better conductor of sound.*

This explanation is inaccurate in only one point. The occurrence of bronchial respiration is not dependent merely on the disappearance of the vesicular murmur, for if that were the case respiration should be distinctly bronchial in severe pulmonary emphysema, in which every trace of the vesicular sound is lost. But the second part of Lænnec's proposition—that consolidated lung-tissue is a good conductor of sound, and that thereby the bronchial bruit is rendered audible,—must be accepted as well-founded, notwithstanding the objections urged against it by Skoda (see p. 136).

It is a matter of daily observation that the cardiac and vascular sounds are conveyed to the thoracic parietes in a much more intense form through indurated than through expansible lung; when condensation takes place in the left apex the sounds from the pulmonary artery, when in the right those from the subclavian, are heard with great distinctness. Similarly, marked increase in the size of the liver, or the presence of morbid growths in its immediate neighbourhood, magnifies the sound of the abdominal aorta. The reason that dense pulmonary tissue forms a better conductor of sound than that which is normal and expansible, is that the structure of the former is homogeneous, whilst that of the latter is not, the air contained in the alveoli alternating with the bands of tissue constituting the parenchyma of the organ; and when a sound is made to traverse media differing in consistence it is weakened and finally suppressed.

These observations show that it is necessary to modify Lænnec's theory, and somewhat in the following manner. In health bronchial respiration is heard only at the larynx and over the trachea and its bifurcation, which lies close to the chest-wall; but from the point at which the bronchi enter the lung bronchial respiration disappears, as, though sounds of bronchial quality are undoubtedly transmitted to the larger, perhaps also to the medium-sized air-tubes, they never reach the surface, being arrested in their course by the pulmonary tissue, which, being non-homogeneous, is a bad conductor. But should the lung become consolidated, and thereby acquire the property of conducting sound clearly, the bronchial murmur is conveyed with undiminished intensity to the thoracic parietes, provided that the portion of lung affected is of sufficient size to include a large bronchus, in which tracheal respiration is audible.

Skoda has sought to overthrow Lænnec's teaching, which ascribes bronchial respiration to the superior conducting-power of a condensed lung. His objections are based on a long series of experiments, the general tenour of which led him to the opposite conclusion,—that as a conductor of sound expansible, air-containing lung-substance far excels consolidated tissue. One of the simplest of these experiments may be here mentioned: two lungs, one normal, the other hepatized, are removed from the thorax and examined by applying a stethoscope to its surface; into this instrument one experimenter speaks, while another auscultates the voice through another stethoscope. As the result of this comparative investigation it was found that the sound was heard over a somewhat more extensive area in the healthy than in the hepatized lung.

Choynowski obtained very different results. In his experiments he eliminated one likely source of error,—the varying intensity of the human voice, and substituted for it the constant sound given by an ordinary watch; this was, further, held as far as possible from the auscultating ear and surrounded by substances of low conducting power, to exclude the possibility of the transmission of the ticking sound through the air. The result was that the sound was carried with *greater intensity* through *hepatized* than through normal lung.—Bondet and Chauveau, also, having introduced a cannula into the trachea of a horse suffering from pneumonia, and whispered into the instrument, heard the voice clearly over the hepatized lung, but not over the healthy lung.

Skoda asserts further that to the production of a bronchial respiratory murmur as loud as that which is usually audible over hepatized tissue a strong current of air is necessary; such a current, however, can scarcely exist in the hepatized lung, as it neither expands in inspiration nor contracts in expiration, its volume remaining unchanged throughout the whole of the act of respiration. In opposition to this Choynowski justly observes that the air in the bronchi *is* in motion, even when the alveoli are completely infiltrated; its density varies in respiration, becoming less in inspiration and greater in expiration, provided that it is in free communication with the column of air in the

trachea. But when the air contained in two communicating cavities is subjected to unequal pressure, a current is at once set up from the chamber in which the density is greatest to that in which it is least; and this takes place in the lung during each new inspiration. The probability of the existence of such a current is also rendered more evident by the fact that in a completely consolidated lung very minute râles are frequently heard, which obviously can originate only in the finest ramifications of the bronchi.

Skoda combats Lænnec's views on the further ground that in hepatized tissue bronchial respiration is instantaneously abolished when the bronchus is closed by a plug of mucus, and returns equally quickly when the obstructing body is expelled and free communication re-established. If condensed tissue, argues Skoda, were a better conductor of sound than normal lung, it should make no difference whether the bronchi of the portion of lung concerned be pervious or impervious. —But conduction has nothing to do with this phenomenon, as the disappearance of the respiratory murmur on occlusion of the bronchus is caused simply by the inability of the waves of sound to penetrate the hepatized tissue on account of the opposition offered by the obstruction.

In the same way may be refuted Skoda's objection, that if dense bodies are really the best conductors of sound the respiratory murmur and voice should be louder, not weaker, in cases of pleuritic exudation. It is the fact that very frequently bronchial respiration is heard in the interscapular space, close to the vertebral column, where the compressed and airless lung is closely applied to the thoracic wall; but on the front of the chest no respiratory sound is perceptible, as the lung is separated from it by the mass of fluid exudation; the sonorous vibrations, therefore, in their passage through non-homogeneous media, lung and fluid, are so considerably enfeebled as to be no longer audible on reaching the surface or the auscultating ear.

Skoda has endeavoured to define bronchial respiration as a *phenomenon of consonance*.

The basis of this consonance-theory, which will be described in detail on another page (see "Bronchophony"), is that bronchial respiration is generated or magnified in caverns and in the bronchi of condensed lung substance by the air in these cavities and bronchi vibrating in consonance with that of the trachea; the condition necessary for this consonance is provided in the circumstance that the air is pent up in confined spaces, whose *solid* walls (the indurated parenchyma surrounding the bronchi) reflect the sonorous undulations.

This theory is capable of but a very limited application, having a bearing only on those cases in which the bronchial respiration is of metallic character, or is accompanied by an amphoric echo (in caverns of large dimensions) or by râles of metallic timbre. But here *it is not the bronchial respiration, but the metallic* (*amphoric*) *quality* which is added to it and to the râles, that constitutes the *consonance-phenomenon*. —Skoda bases his theory almost exclusively on the ground that in it may be found the explanation of his observation that bronchial respiration

is sometimes *louder* over the thorax than over the trachea. Such cases have never yet come under my observation; at best they must be exceedingly rare.

The Metamorphosing Respiratory Murmur.

(Das Metamorphosirende Athmungsgeräusch.)

This is a special modification of bronchial respiration. It has, according to Seitz, who was the first to describe it, the following characters: it occurs only in *inspiration;* at the outset it is distinguished by an unusual harshness, which is quite different from that of harsh vesicular breathing, and which may be imitated by placing the tongue against the palate, as in pronouncing the letter g (hard), and making a forcible inspiration; the sound so obtained is that which is so often observed in *stenosis* of the bronchi, as in the diffuse bronchial catarrh associated with emphysema of old standing. This harshness lasts only about one-third of the inspiratory period, when it suddenly ceases, and gives place, during the rest of the inspiration, to bronchial breathing accompanied by a metallic echo, or to ordinary râles.

Seitz has met with this variety of respiration only in cases of cavity in the lungs (most often in the upper lobes), and has accordingly classed it as a cavernous phenomenon.—The harsh sound with which metamorphosing respiration begins manifestly has for its physical cause the fact that the air, in entering the cavern, passes through an opening which in relation to the size of the cavity may be regarded as narrow, and which is often further diminished in diameter by mucous secretions; it is lost at the instant in which powerful inspiration effects the dilatation of the orifice, and in its place we have either bronchial respiration or râles caused by disturbance of the fluid lying in the cavity.

The metamorphosing respiratory murmur is usually heard only when respiration is vigorously carried on, seldom when it is tranquil and easy; its peculiar characters, also, are not always so pronounced as above described. It cannot even be considered a constant symptom of pulmonary cavity; it comes and goes, and varies to some extent, like the bronchial respiratory sound, ordinary râles, &c. But when it has once been clearly made out in any individual case, repeated and prolonged examination rarely fails to reveal its presence on subsequent occasions.

The fully-developed form of this murmur, as defined by Seitz, is rare; much more frequently there is, in excavation of the upper lobes, a respiratory murmur which resembles it thus far,—that it begins with a short, harsh, hissing sound, followed by râles and indeterminate respiration. If the simple fact that the inspiratory act consists of two sounds be held as sufficient warrant for designating it as a metamorphosing respiratory murmur, the relative frequency of the occurrence of this phenomenon is greatly increased.

To the category of bronchial respiratory sounds belongs

The Amphoric Respiratory Murmur.

(The respiratory sound with a metallic tone or echo.)

By this name is understood a bronchial, rarely an indeterminate, respiratory murmur, accompanied by a tone of metallic quality or to which is added a metallic echo. It owes the appellation *amphoric* to the perfect analogy it presents to the sound produced by blowing into a pitcher or bottle.—This murmur occurs sometimes in inspiration alone, sometimes in expiration, at other times in both, but is almost always loudest and most distinct when accompanying expiration. Its fundamental character, as already mentioned, is generally that of the bronchial sound, the physical conditions which give to it its amphoric quality being precisely those which are most favourable to the development of bronchial respiration. It is only in very exceptional cases (see p. 141) that the *indeterminate* respiratory murmur is found attended by the amphoric echo.

The amphoric respiratory sound arises, as the production of an analogous sound by blowing into a pitcher teaches, only *in large pulmonary cavities* and in cases of accumulation of air in the pleural sac (*pneumothorax*). Its occurrence is subject to the following conditions:—

1. The *excavation* in the lung must be at least of the size of the closed fist, enclosed by walls of uniform density and thickness throughout, in free communication with one of the larger bronchi, and situated close to the surface of the lung. The first condition is a necessary one, as it is only in cavities of some considerable magnitude, possessing walls of uniform density, that the sonorous waves generated by the respiratory current of air can be reflected with that degree of regularity which is required for the formation of a really musical tone. Since, however, the amphoric quality is frequently wanting, even in cases in which the foregoing conditions are present, the explanation of the causation of the amphoric echo is incomplete without the addition of another factor, namely, *consonance*. The air-space of the cavern forms a resonance-chamber, in which the breath-sounds are intensified and, through the regular reflection of the waves of sound, so modified as to acquire a tone of distinctly musical quality.

The second condition,—free communication between the vomica and the bronchus leading to it, requires little argument in its support, as it is obvious that if the bronchus be blocked up the respiratory sound must disappear or become confused and indistinct; it returns, however, after repeated and forcible coughing, particularly when this is accompanied by expectoration.—The third condition,—the proximity of the cavity to the surface of the lung, is rarely absent when the vomicæ are of large size.

The clearness of the amphoric respiratory murmur is in no way influenced by the presence of a certain amount of fluid, as well as air, in the cavity. This may be shown by blowing, first into an empty pitcher, and then into one nearly full of water. It is essential only that the vomica do not contain so much fluid that the volume of the latter greatly exceeds that of the air-contents, as in such circumstances the respiratory murmur is usually completely hidden by abundant moist râles, and, more particularly, the existence of *consonance*, on which, to a great extent, depends the amphoric character of the breath-sounds, is rendered impossible.

As the great majority of pulmonary vomicæ occur in the *upper* lobes, so it is chiefly at the corresponding parts of the thorax that amphoric respiration is heard; it is loudest *anteriorly*, owing to the greater facilities offered by the front wall of the chest for the conduction of sound. In cases in which the cavities were very large I have observed it also on the *posterior surface* of the chest.

The metallic echo is always clear and acute, and its musical character often so marked that its pitch is accurately and easily determinable. Frequently several tones, the harmonic over-tones of the fundamental tone, are recognisable in it, and the impression then conveyed to the ear is precisely that given by the sweeping of the wind over the strings of an Æolian harp.—The amphoric echo may be the sole abnormal quality distinguishable in the respiratory sound, when there happens to be little or no fluid in the cavity, or when the patient breathes so feebly that the fluid is not agitated by the breath-current; but in the greater number of instances the amphoric respiratory murmur is accompanied by râles having a ringing metallic character (*metallic tinkling*, see p. 156).

At those parts where the respiratory murmur is amphoric the percussion-sound is also frequently modified in a similar way.

2. Amphoric respiration is also met with in *pneumothorax*, but only when the lung is still able to expand so far as to permit the entrance of a certain quantity of air. This is possible only when the pulmonary fistula, through which the air reached the pleural sac, closes again relatively quickly; this rapid closure takes place in most cases, while persistence of the fistula, that is, the establishment of free communication between the air in the pleura and that in the bronchi and trachea, is the rarer event. If the bronchial fistula be obliterated, and if the lung be not completely collapsed, but still capable of a certain amount of expansion, a breath-sound may be heard at those points (usually posteriorly) which correspond to the position of the permeable portion of lung; this respiratory murmur is most commonly of the *indeterminate* variety, more seldom bronchial, and attended by a metallic clang or echo.

Here the explanation of the occurrence of amphoric respiration is that the sonorous waves borne along by the air entering the lung,—those constituting the ordinary respiratory murmur, are transmitted through the pulmonary substance to the air confined in the pleural cavity, throwing it into simultaneous vibration.

In certain rare cases, in which dyspnœa is the most prominent symptom, amphoric respiration is sometimes developed altogether independently of the existence of cavities. It arises in the pharynx, on making a deep inspiration with the mouth widely open, and may be conducted to the surface with such intensity as to be audible over the greater part of the upper thoracic region, more especially in the interscapular area. This variety of amphoric respiration is sometimes at once abolished by closing the mouth.—Friedreich asserts that in some very aged persons an amphoric respiratory murmur may be heard between the shoulder-blades, unconnected with any dyspnœa; I have never seen such a case.

Indeterminate Respiratory Murmur.

A large number of respiratory murmurs have not the characters of either vesicular or bronchial breathing; these, on Skoda's suggestion, are named *indeterminate* respiratory sounds. Strictly speaking, however, this category includes also all those transition-murmurs which, though somewhat undefined, are more or less distinctly bronchial or vesicular; these are designated, as formerly stated, as "somewhat vesicular," "obscurely vesicular," "obscurely bronchial," &c., the term indeterminate being reserved for those in which no trace of either fundamental