

quality is appreciable. The more practised the ear in the discrimination of the less-marked shades of difference between bronchial and vesicular respiration the more limited becomes the domain of the indeterminate respiratory murmur. It is those transition-murmurs which seem to present most difficulty to learners, the *truly indeterminate* sounds being as easily recognised as the purely bronchial or purely vesicular sounds.

As the indeterminate respiratory murmur resembles no other known sound it scarcely admits of description; a knowledge of its properties, therefore, is obtainable only by personal investigation and practice. A general conception of its qualities may be arrived at by auscultating the chest of a robust man, directing him at the same time to breathe exceedingly *superficially*, when the respiratory sound heard at those parts in which the muscles are well developed (the supra- and infra-spinous regions, for instance), will be found to be no longer vesicular but of the *indeterminate* class. The cause of this lies in the fact that in shallow inspiration the aerial current enters the alveoli with so little force or energy that the respiratory sound, in its transmission through the thick covering of muscles about the shoulder, is wholly deprived of its vesicular character; but on *deep* inspiration the indeterminate murmur becomes clearly vesicular. The gradual transition from vesicular to indeterminate breathing may be demonstrated by slowly increasing or decreasing the depth of each inspiration. An equally good method of exercising the ear in the study of the transition sounds is to auscultate the respiratory murmur at a point some distance removed from the part at which it originates,—as by passing the stethoscope slowly downwards from the borders of the lung into the hepatic region; the nearer the instrument is brought to the margin of the ribs the more obscure, the more indeterminate, becomes the respiratory sound.

As a pathological phenomenon the indeterminate respiratory murmur is of very frequent occurrence; it is sometimes persistent, at other times of short duration, confined to a limited area or diffused over a considerable extent of surface.—The causes giving rise to it may be arranged in the following groups:—

1. *Insufficient expansion of the alveoli.* This may be the result of diminution of their elasticity, as is so often observed in vesicular emphysema; or of infiltration of the air-cells (with fluid or plastic exudation), or of compression or atrophy of the

lung. In all these cases the volume of air which gains access to the alveoli is so small that the vesicular murmur is not developed,—in shallow respiration at all events. The intensity of the indeterminate sound is still further lessened when it traverses a mass of fluid, such as abundant pleuritic exudation. Effusions into the pleura are the most common conditions which are found to obstruct the free transmission of the breath-sounds; compression of the lung also, by air or tumours in the pleural sac, acts in the same way.

2. *Obstruction of one of the larger, or of several of the smaller, bronchi of an infiltrated portion of lung, by the presence of superabundant mucous secretion.* In such cases, as only a very small quantity of air reaches the vesicles, the respiratory murmur is indeterminate. This occurs extremely frequently as the result of the bronchial catarrh which accompanies infiltration of the lung-tissue. If the mucus be expelled by coughing, or shifted from one part of the air-passages to another, the bronchi of the part affected again become pervious, the indeterminate quality disappears from the respiration, and breathing becomes vesicular or bronchial according as the lung substance is still capable of expansion or is completely consolidated.

3. *All respiratory murmurs become indeterminate when masked by loud accessory sounds (râles);* hence the frequency of indeterminate respiration in all cases in which the bronchi, alveoli, or pulmonary excavations are occupied by fluid secretion, the agitation of which by the breath-current gives rise to numerous râles. According to the distribution of the latter the indeterminate murmur is strictly circumscribed or widely diffused. Free expectoration also, or vigorous coughing, may so far alter or diminish the intensity of the râles that the true respiratory sound becomes again audible, this being vesicular if the lung still possess its normal spongy structure, bronchial if it be totally devoid of air. But in other cases, notwithstanding the diminution in the intensity and number of the râles, the indeterminate character of the breath-sound remains. In many instances a deep inspiration on the part of the patient causes the indeterminate respiratory murmur, on whatever condition it depends in the particular case, to become vesicular or bronchial,—vesicular, for example, in pulmonary emphysema, or bronchial in infiltration of the parenchyma; it is only in cases of very copious pleuritic

exudation that deep inspiration does not cause it to take on the vesicular character.

It is often possible to determine, and that with a considerable degree of certainty, to which of the above-named causes the indeterminate respiratory murmur owes its origin. They may all be in operation together: thus, in an infiltrated lung, the bronchi of which are also in a state of intense catarrhal inflammation, it is due to the slight amount of expansion of which the consolidated part is capable, to diminution in the quantity of air which reaches it (from tumefaction of the bronchial mucous membrane), and to the masking of the respiratory sounds by moist, catarrhal râles. In other instances, as in severe pulmonary emphysema without catarrh of the bronchi, or in cases of complete atelectasis of the lung-substance from the presence of a large pleuritic effusion, but *one* cause can be alleged for the indeterminate character of the breathing,—the insufficient expansion of the alveoli.—From these examples it may, with justice, be inferred that the indeterminate respiratory murmur possesses in general no precise diagnostic signification. Whilst the vesicular murmur or bronchial breathing at once discloses the condition of the subjacent lung, the former showing that it is still permeable, the latter that it is consolidated, indeterminate respiration *alone* gives no information of this kind, as even where it is heard the lung may or may not contain air; it is only on taking into account the other auscultatory phenomena that it may, in certain cases, be traced back with confidence to its physical cause. But occasionally, even when occurring *alone*, it may, if strictly localised, be sufficient to warrant a diagnostic conclusion. Thus, if it be audible and persistent in *one* apex, whilst in the other respiration has its ordinary vesicular character, it points decidedly to incipient condensation, to diminished expansibility from commencing disease in the part. Nevertheless, such instances (the occurrence of indeterminate respiration without accessory sounds) are rare, as the morbid process beginning in the apex usually excites also a catarrh of the finest air-tubules, giving rise to small, fine râles. Sometimes, however, an unaccompanied indefinite respiratory murmur may be observed in one apex when the disease has been arrested and to a certain extent cured, some condensation only remaining; here the catarrh has disappeared, and the râles, accordingly, are wanting.

RÂLES.

When the organs of respiration are perfectly normal the unmixed vesicular inspiratory and indeterminate expiratory murmurs are the only breath-sounds heard over the whole thorax; râles are entirely absent, as the mucous lining of the air-passages is everywhere smooth and secretes no more fluid than is just necessary to keep it moist. But as soon as this membrane becomes rough and uneven through swelling, and an augmented secretion of fluid takes place at any part of the bronchial ramifications, certain accessory sounds, named *râles*, are added to the respiratory murmur.

The manner in which these râles are produced in the larger and smaller bronchi, in their most minute subdivisions, and in the air-cells, varies very considerably. In bronchi of large calibre and in pulmonary vomicae the passage of the respiratory current of air (both in inspiration and in expiration) through the fluid products, causes the formation of numerous bubbles which burst with an explosive, crackling sound,—like those rising in soapy water or other frothing or fermenting fluids, or in liquids which are forcibly shaken.* The disturbance of the fluid secretions also, by the breath-current, (which can obviously take place only within very narrow limits), may give rise to râles *without* the throwing up of bubbles, as in a body of fluid roughly shaken; and finally similar crackling sounds sometimes originate in bronchi in which no fluid is present, from vibration of the folds of the swollen mucous membrane. But in the bronchioles and in the air-cells the force of respiration is so slight as to be insufficient for the raising of bubbles in the secretions, and the alveoli, further, scarcely afford room enough; doubtless the râles here owe their existence to the circumstance that at the instant in which the smallest air-tubes and the air-vesicles are dilated in inspiration their walls are suddenly separated from their fluid contents to permit the passage of the current of air.

* Talma has recently asserted, as the result of a number of physical researches conducted by him, that the bursting of bubbles is of itself noiseless, and that râles depend on the agitation of the fluid and the formation of a multitude of little projections on its surface; these little tongues vibrate and awake secondary vibrations in the mass of air pent up in the tubes which contain the fluid (in the case of the lung—the bronchi and cavities).

In expiration, on the other hand, when the vesicles shrink again to their former dimensions, the above-named cause is not in operation, and in fact râles are somewhat rare in this phase of respiration; but in those cases in which they are heard their occurrence may be explained on the supposition that the viscid, tenacious exudations offer considerable resistance at parts to the expiratory air-current, which, nevertheless, forces its way through them, and so breaks them up and agitates them again.

That the râles developed in the bronchioles and air-cells containing fluid secretions do not depend on the formation and bursting of bubbles, but on the rapid and violent separation of the agglutinated walls of these finer air-passages from each other, may be inferred from certain physical analogies and some physiological and pathological observations still to be mentioned; thus, a very similar sound is obtained by pulling asunder two fingers previously gummed together by their palmar surfaces, by applying the tongue to, and suddenly detaching it from, the roof of the mouth, or by inflating the collapsed lungs in the dead body (Wintrich), the walls of the alveoli being in contact after death. From the last of these examples, the sound generated in which bears a very close resemblance to a râle often heard in the living subject (the crepitant râle, to be subsequently described), an important diagnostic inference may be drawn: *that the râles originating in the air-cells and in the finest air-tubes do not necessarily depend on the presence of fluid secretions in these parts, but that they may sometimes arise from the sudden separation of the cohering walls of the alveoli, quite independently of the existence of any trace of exudation.*

Râles are classified as *moist* and *dry* according to their character, that is, according to the impression they convey to the ear. The difference results from the varying consistence of the bronchial secretions, the former variety being produced when it is *thin* and watery, the latter when it is *thick* and tenacious.

Moist râles most usually resemble the sounds caused by the breaking of bubbles in a fluid, such as the bursting of soap-bubbles in water, or of the bubbles which come to the surface of water beginning to boil; other, finer râles are more comparable to the sound elicited by rubbing the hair between the fingers, or to the crepitation of salt thrown on the hot-plate of a stove. But râles are subject to so much modification, and vary so considerably in character even in one and the same case, that to describe them fully by the common sounds, of ordinary life is scarcely practicable, these latter being too few in number and not permitting of an accurate enough definition of the acoustic phenomena observed.

It is very seldom possible to determine, from the nature of the râles, the constitution of the fluid in which they are generated, that is, to affirm with precision whether it is serous, mucous, purulent, or sanguineous; such inferences are deducible only from a general knowledge of the character of the local morbid process.—But the seat of the râles, on the other hand, whether in the largest, medium-sized, or smallest bronchi, or in pulmonary cavities, may usually be ascertained with the greatest exactness, by a consideration of the various qualities of the râle, now to be described in detail.

1. STAGE OF RESPIRATION IN WHICH THE RÂLES OCCUR.

Râles are audible sometimes in inspiration alone, more rarely in expiration alone, or during both inspiration and expiration. They usually appear at the acme of inspiration and at the beginning of expiration, when the fluid in which they originate is lodged in the finer bronchi. But if the secretion be so abundant as to occupy the larger as well as the smaller air-tubes, and if respiration be carried on with sufficient energy, the râles are heard not merely during the whole of the inspiratory period but also—though necessarily considerably enfeebled by the resistance offered to the escape of the expired air—throughout expiration; the rattling sound is then, in fact, almost *continuous*. The best example of this condition is found in diffuse bronchitis, though even here the râle is only temporarily, and not at every examination, continuous. Violent coughing, accompanied by expectoration of mucus, deprives it of its continuous character for a longer or shorter period.

Sometimes râles occur even in the *respiratory pause*. These are described as *postexpiratory râles* by Baas, their peculiarity being that they follow, or prolong, the expiratory râles, whilst the chest-walls are in a state of absolute repose.—I have not unfrequently observed this postexpiratory râle, in cases of large pulmonary vomicae containing much fluid, and am of opinion that its production may be most consistently explained on the assumption that the commotion set up in the contents of the cavity by the respiratory air-current does not at once subside, but goes on for a short time in certain small portions of the fluid. It can be shown by a simple experiment,—watching the bubbles that form on the surface of soapy water shaken up in a vessel,—that the bursting of bubbles in a fluid does not begin and end precisely with the act of agitation, but continues after the vessel is at

rest.—I have not noticed the postexpiratory râle in any other conditions than those mentioned,—large pulmonary cavities.

2. AMOUNT OF THE RÂLES.

Râles may be *abundant* or *scanty*. Their abundance depends on the quantity of fluid in the bronchi, air-cells, or cavities, on the proximity of the affected part of the lung to the surface, (by which the explosion of every individual bubble is transmitted more or less accurately to the ear), and on the violence of the agitation of the secretions by the aerial current. Numerous râles, therefore, always indicate free communication between the diseased part of the lung and the bronchi leading to it; and if this be interrupted temporarily by the impaction of mucus in the air-passages, they are either abolished or become very scanty, even though the parts be loaded with fluid secretions.—Very abundant and persistent râles are designated as *gurgling*, from their resemblance to the bursting of large bubbles in a viscid substance. These present themselves most frequently in pulmonary vomice of considerable size containing a large quantity of fluid, and occasionally also in the smaller bronchi when these are filled with catarrhal secretions.

The less the amount of fluid the scantier become the râles and the stronger the inspiratory effort necessary to produce them. Occasionally they are so scanty that only a few bubbles form or burst during each inspiration, whilst during several consecutive respiratory acts absolutely none may be heard, or they may become appreciable only after prolonged coughing. A very scanty râle often disappears completely when the patient breathes deeply and strongly for some time, as when undergoing examination by auscultation. An extremely scanty râle, consisting, for instance, of but one or two isolated bubbles, appearing only after deep and forcible inspiration, is not necessarily dependent on the presence of fluid in the air-passages or alveoli, but may be caused by the rapid and violent separation of the adhering folds of the mucous membrane lining the bronchioles, or by the distension of collapsed alveoli. Perfectly healthy persons may thus, on making a sudden and deep inspiration, present a few scanty râles at various parts of the lungs,—in the apices, the lower borders, and some other regions; these, however, are lost

at the next inspiration. In other respects they do not differ from the scanty râles which characterise the earliest stages of catarrh in the apices; a knowledge of the fact, therefore, that these sounds are sometimes produced in the above-mentioned way becomes of the greatest importance, as one is always tempted to refer the slightest trace of a râle in the summits of the lungs to commencing catarrh.

3. INTENSITY (CLEARNESS, LOUDNESS) OF THE RÂLES.

Râles show very marked differences in *intensity* in different cases, and are very variable even in one and the same individual. Their intensity is the greater the more abundant the secretions, the more energetic the act of respiration, the wider the lumen of the bronchi within which the fluid is accumulated, and the closer the affected part of the lung to the thoracic parietes.—The more abundant the fluid the more numerous the bubbles formed by each draught of air and the greater the total volume of sound produced. Râles are similarly intensified also by energetic respiration, as by this means more bubbles, and those frequently of larger size, are thrown up on the surface of the fluid. It is for this same reason, further, that râles occurring in the principal bronchi are louder than those formed in the smaller air-passages. There are certain râles, however,—such as those arising in the larynx, trachea, or bronchial trunks,—which, though they may be, and commonly are, so intense as to be audible even at some distance from the patient, (a phenomenon known as “a rattling on the chest” among the laity), yet do not necessarily indicate the presence of any very large quantity of fluid in those parts; it is but seldom, also, that râles generated in the finer ramifications of the bronchial tree, even though exceedingly numerous, are observed otherwise than by mediate or immediate auscultation, and in these exceptional cases they are feeble. Râles originating in pulmonary excavations, though extremely loud as heard through the stethoscope, are never so intense to the ear held away from the chest as those produced in the large bronchi.

Râles, finally, are invariably stronger the nearer their place of origination to the part to which the stethoscope is applied. They are all capable of transmission through the tissues to points more or less remote, the loud being carried farther than the feeble;

we are never, therefore, warranted in concluding that the spot at which the râle may be detected corresponds precisely to the part at which it takes its origin. Very loud râles,—those met with in the right lung, for example,—may be propagated, though feebly, as far downwards as the hepatic region. But the ear, with a little practice, soon learns to distinguish with sufficient readiness between râles arising immediately under the auscultated spot and those which are transmitted thither, whether from adjoining or more deeply-seated parts of the lung. Transmitted râles are always *scanty*, as only the loudest of the bubbling noises, not *all* of them, are conducted to any distance; they are also *feebler* and *duller*, in this respect showing themselves subject to the same laws as other sounds. If râles of nearly equal intensity be heard over a large extent of surface, it may be inferred that the cause producing them is in operation at all parts throughout the whole of the space indicated; if at different, opposed parts of the thorax,—on the right and left sides, for instance, they belong to both lungs, as the conduction of râles from one lung to another is rare, taking place only when they are exceedingly loud and abundant in the region in which they are set up.

Galvagni has stated that râles developed in the *deeper* parts of the lungs are best heard *through the mouth*, in the cavity of which they are considerably intensified by consonance, and that they lose in intensity in transmission through the spongy lung substance (which is of very low conducting power) and the thoracic parietes.

I have been led, as the result of a long series of original investigations, to modify this view considerably. It is perfectly true that certain râles, those in the apex, for instance, appear surprisingly loud and clear if the trumpet-shaped extremity of the stethoscope be placed in, or even close to, the open mouth of the patient; in this way dull, indistinct râles acquire a clear resonant character, while those which are already of this nature become exquisitely metallic. Râles, therefore, are intensified by consonance in the *buccal cavity*, as the same sound is heard much more feebly over the larynx than at the apex of the lung. But I have never been able to convince myself that râles arising in the deeper and lower portions of the lungs, sounding faint and scanty on the surface of the chest, are louder and more numerous when auscultated in the mouth, though I have observed that dull, non-resonant râles originating even in the lower lobes, may be audible in the mouth, and assume there a ringing character.—These methods of auscultation obviously do not enable us to decide whether a râle comes from the right or left lung, from the upper or lower lobe, &c.

4. SIZE OF THE RÂLES.

Different râles convey very different impressions to the ear with respect to *the size of the bursting bubbles*.

The size of the bubbles is determined by the quantity of fluid present and the strength of the current of air passing through it, above all by the lumen of the bronchi in which the râles are developed.

Râles are divided, according to the apparent size of the bubbles, into *fine bubbling* and *coarse bubbling râles*, those of intermediate magnitude, or which present a combination of the two preceding varieties, being designated as *medium-sized bubbling râles*.

The *fine bubbling râles* are generated for the most part in the smaller and smallest subdivisions of the bronchi, the *coarse bubbling râles* in the larger bronchi; but even in the largest and widest parts of the air-passages very fine moist râles may arise. If the fine and coarse bubbling be combined,—a condition readily detected by the ear,—they are termed *unequal or irregular bubbling râles*; if, on the other hand, the bubbles seem to the ear to be equal in size, they are named *uniform bubbling râles*.

Among the *fine bubbling râles* there is one variety which demands special attention. It originates in the extremities of the bronchioles and in the air-cells,—air-spaces of the very smallest capacity; the bubbling of which it consists is therefore exceedingly minute; as the alveoli, also, are all equal in diameter the individual explosions are of uniform size. Such a râle is spoken of as a *fine, uniform bubbling râle*; it is known also as the *moist crepitating râle* of Lænnec, from its resemblance to the sound produced by rubbing the hair of the head, especially in front of the ear, between the fingers. It is usually only at the acme of inspiration, seldom at the beginning of expiration, that it is heard.

When crepitation is distinctly appreciable we have proof that the air-vesicles still admit air, and the proper diagnostic inference with regard to the state of the pulmonary parenchyma is simply that the alveoli contain both air and fluid. This condition occurs in the most pronounced form in the first and third stages of pneumonia, so that uniform crepitation may be considered as almost pathognomonic of the disease in these stages.

Crepitation in which the bubbles are uniform must be sharply distinguished from that in which they are *irregular* in size. The latter is specially characterised by the fact that in it not only fine and regular bubbles, but also some others of much larger size, are heard. Diagnostically this distinction is of some importance, as the genuine uniform crepitation of Lænnec is developed in lung-substance which is still permeable to air, the irregular form very frequently in consolidated tissue, that is, not in the air-cells, but in the finest bronchi or their terminations.

Pneumonic crepitation lasts, provided there is no obstruction of any of the larger bronchi leading to the infiltrated part,—a condition which would weaken or abolish the râle,—till the alveoli are so completely filled with fluid that the air is entirely excluded; it returns as soon as the fibrinous exudation begins to be absorbed and the air once more gains admission to the vesicles.—Crepitation is also usually unaffected by coughing, as the contents of the alveoli cannot in this way be dislodged.

In pulmonary œdema, also, a serous exudation,—not fibrinous, as in pneumonia,—is poured into the air-cells, so that here too are furnished the conditions necessary to the existence of the crepitant râle,—the intimate intermingling of air and fluid; but in this instance the râle is not so well defined as in the fore-mentioned stages of pneumonia, as the bronchi also are filled with fluid, and the *irregular bubbling râles* produced in them being added to the crepitation proceeding from the alveoli, the general impression given to the ear is no longer that of the *uniform* crepitant râle as in pneumonia.—In the catarrhal affection of the most minute bronchi which usually attends the various diseases of the lung-substance, a few *non-uniform*, but nevertheless very fine, crepitations may be heard here and there over the chest, and these may be of merely temporary duration or persistent.

Crepitation is also occasionally audible for a short time in collapsed conditions of the lung, in those, for instance, in which the organ has been for a long period subjected to pressure by pleuritic effusion, or in the retracted pulmonary parenchyma situated above the level of a pleuritic exudation; here it may possibly be the result of a catarrh of the extremities of the finest air-tubes,—a condition often associated with pleuritic exudation,—though it frequently arises, altogether apart from the presence of fluid in the bronchioles, solely from the tearing asunder of the collapsed and adherent alveolar walls (compare p. 146).

There is a very deceptive kind of *artificial crepitation* which must be guarded against in auscultating the thorax. In those in whom the

skin on the front of the chest is plentifully covered by hair each inspiration is accompanied by a sound the exact counterpart of the crepitant râle, produced by the rubbing of the little crisp hairs on the end of the stethoscope. This noise is often so loud as to interfere seriously with the perception of the true respiratory sounds. It is a source of error, however, which may be completely eliminated by simply wetting the hairs with water, when they apply themselves flatly and closely to the surface of the chest.

The *medium-sized bubbling râles*, by which is meant, as already noticed, the transition-form between fine and coarse râles or the sound which results from the mixing of these, is set up in bronchi which differ considerably with respect to calibre, but not in the very finest or in the very largest; in the smaller air-passages the fine bubbles greatly outnumber the large ones, in the larger bronchi the reverse is the case. In pulmonary excavations, also, in which there is a very abundant fluid secretion, the râles are usually composed of bubbles of medium size.—These râles may be still further subdivided into two classes, according as the bubbles are *over* or *under* the *average* size,—a degree of refinement which, as it depends almost entirely on subjective appreciation, is of no practical value.

Coarse bubbling râles occur chiefly in the principal bronchi and in the trachea, and are usually loudest and most prolonged in expiration; to this category belongs the death-rattle in the air-passages of the dying. The ability to distinguish between medium-sized and coarse bubbling râles,—a point of no great diagnostic importance, is easily acquired by the ear, with a little practice, while the difference between fine and coarse râles is so obvious as to strike every one at once.

The medium-sized and coarse râles, which are always louder than the fine râles, are found not only in simple primary catarrh of the bronchi, but also in the secondary bronchial catarrh which accompanies the parenchymal diseases of the lungs, and in pulmonary cavities. These râles, therefore, can have but one diagnostic signification,—that fluid is present in some of the larger air-passages; but without a consideration of the character next to be discussed, (resonance or non-resonance of the râles), and of the properties of the respiratory sound, such phenomena alone are not sufficient to indicate whether the tissue of the lung is still freely permeable to air or is consolidated.

Skoda has for this reason applied to the whole group of râles just