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AUSCULTATION

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When one suggests the displacement of an established opinion, he should offer a logical substitute. In previous publications (1, 2, 3, 4) the writer made a new appraisal of auscultation based on clinical experience and facts in physics and physiology which have been discovered since Laennec's time. He now wishes to add further evidence to show that the respiratory murmur is composed of sound vibrations which originate in all component parts of the respiratory mechanism, and to point out how this fact may be used advantageously in the physical examination of the lungs.

For more than a century auscultation has been accepted as the chief measure on which dependence can be placed in the physical diagnosis of diseases of the lungs and pleura; and yet, as taught, it is not satisfactory. This is a prime reason why physical diagnosis in chest diseases has been disappointing and why its place has been yielded so willingly to the roentgenogram. On the other hand, could physical examination be satisfactory, the personal element in it should make it an invaluable procedure.

No matter if we are obliged to change our opinion as to the cause of the normal and abnormal respiratory murmurs, this can in no way take away the value of auscultation; or remove from Auenbrugger (5) and Laennec (6) the honor of having founded physical examination of the chest.

Laennec said: "The sound of respiration presents different characters, according as it takes place in the pulmonary tissue, the larynx, the trachea, or the large bronchial trunks." He described vesicular respiration thus: "a gentle but extremely distinct murmur, which indicates the penetration of air into the pulmonary tissue, and its expulsion." It may be heard best "where the lungs are nearest the surface of the body, namely, the anterior-superior, lateral and posterior-inferior parts."

He designated: "as bronchial respiration, the sound produced by inspiration and expiration, in the larynx, trachea, and large bronchial trunks situated at the roots of the lung .... After the roots of the lungs, the summits are the parts of these organs where the bronchial respiration is manifested in the most characteristic manner." He practically ignored expiration, but his associates described the length of inspiration to expiration as 10:2.

Beau (7) in 1834 suggested that the respiratory murmur is caused by air passing through the glottis, the sound being transmitted and modified by the bronchi and air cells, as suggested by Laennec.

Textbooks for the past century have almost universally accepted the explanations of the respiratory murmur as given by Laennec and Beau, some being more favorable to Laennec's explanation; others to that of Beau.

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Skoda (8) accepts the cause of the vesicular and bronchial murmur as given by Laennec.

Musser (9), in discussing the bronchial murmur, states: "The sound is caused by the passage of the air through the nares into the wider pharynx when the mouth is closed, and through the trachea and large bronchial tubes;" and states:

"The vesicular murmur is produced partly in the finest bronchial tubes and air cells by their expansion and contraction, and partly in the upper air passages, the latter sound being modified on account of the intervention of the air-vesicles between the ear and the larger bronchi."

Guttmann (10) discusses the theory of Beau that the respiratory murmur is due to the sound made by the air passing through the larynx, the bronchi, and air cells, and says that this theory must give way to Laennec's idea that the sound is produced by the air passing through and dilating the bronchi and then the air cells.

Da Costa (11) believes that the pulmonary tissue is the principal factor. In discussing the theories of the respiratory murmur arising in the larynx and being transmitted down through the bronchi and air cells, and the theory of Sahli that the local movements of the pulmonary parenchyma account for certain elements in the murmur, he states: "Together these two hypotheses serve as a better explanation than the original theory of Laennec that the sound was due to the friction of the air current in the bronchi and infundibula."

Powell and Hartley (12) state: "Laennec was of the opinion that the sounds originated in the affected lung, but it is now admitted that they are in reality generated in the larynx, and thence conducted down the passages into the chest, and so to the observer's ear."

Elmer and Rose (13) are dissatisfied with both Laennec's and Beau's suggestion for the cause of the respiratory murmur and state that the "vesicular murmur is merely bronchial breathing softened in its transmission from the larynx along the aerial column contained in the trachea and bronchi, mingled with the soft crepitation of innumerable pulmonary alveoli during their inflation and subsequent collapse."

It will be seen that none of these authors divorces his idea from the air column and the structures of the upper air passages and the bronchial and pulmonary tissues. All describe the inspiratory murmur as being longer than the expiratory.

These descriptions are not satisfactory, nor are they in accordance with present knowledge. They must be studied further to make them most useful. The physician who practices at the bedside should develop his ability to see, hear, and feel the signs of disease which the patient presents. It is necessary for him to make himself as independent as possible of roentgenographic examination because it is not always available. Any knowledge that will make physical diagnosis more useful is to be desired. The following discussion of auscultation and the respiratory murmur is offered with this in mind.

During the writer's more than fifty years of examining chests, he has made certain observations which are contrary to these teachings and which he believes will make auscultation more useful.

It is evident to anyone who will examine carefully that, normally, inspiration is not longer than expiration—10:2, 5:3, 3:1, et cetera, as taught; but actually shorter.

The weakness of the respiratory murmur in case of abdominal breathing indicates that the air column passing through the larynx and bronchi and expanding the air cells cannot be the origin of the respiratory sounds, for the air enters the

air passages the same as it does in the usual type of breathing, yet the murmur is weak. We also have a respiratory murmur when the larynx is by-passed by the bronchoscope.

Moreover, it is not rational to accept without questioning that the murmur heard near the hilum and in the interscapular region is produced, even chiefly, by the air as it passes the glottis, enters and dilates the bronchi, impinging on their surfaces, and that in the main portion of the lung, by air entering and dilating air cells.

Relation of respiratory murmur to respiratory mechanism: What may we offer as a substitute for these long held opinions? After noting that inspiration is not longer than expiration, the writer was next impressed with the fact that there is a muscular element in the murmur (14). By placing the stethoscope over a contracting biceps, a sound was heard which possessed some of the qualities of the respiratory murmur. It was noted during normal breathing that a fairly good but weak murmur could be heard over the abdominal muscles. A murmur was also noted over the chest wall where the lungs were collapsed by pneumothorax and the lung tissue was separated widely from the chest wall by an air cushion. Such murmurs are usually weak if the pressure is marked, but sometimes, when the parietal pleura is thickened, they may not be far from normal in their intensity, indicating that different factors enter into their production. The thickness of the pleura alters the murmur, sometimes increasing and sometimes decreasing it. More recently a weak respiratory murmur was heard over the chest wall where the lung had been removed by pneumonectomy. Surely the entry of air could not be responsible for this sound because the pulmonary elements with the air current had been removed from the side.

To what can the sounds be attributed in pneumothorax and pneumonectomy, where a little air may enter in the one case, and none in the other? On careful analysis the answer seems evident. The respiratory murmur begins with the inspiratory movement and ends with the adjustment of the pulmonary tissues at the end of the expiratory movement. Is it not reasonable then to attribute the murmur to the respiratory mechanism, every part that causes and transmits sound vibrations; the muscles, the bony cage, the pleura when inflamed or thickened, the mediastinum especially when pathological, the bronchi, the pulmonary tissue, the air passages, and the column of air?

It seems rational to look upon the air column and air spaces as incidental rather than the chief factors in the production of the respiratory murmur. The force of the tidal air as it enters the lungs is nullified by the residual air already present, and the air after entering the large bronchi diffuses into the small bronchi and alveoli when the thorax is enlarged and is expressed during the contraction of the thorax.

That part of the respiratory mechanism which is responsible for the *bronchial murmur* is normally limited to the superior portion of the chest and is most distinct posteriorly. Here the sound vibrations are produced by the air current, the larger bronchi, a comparatively small amount of pulmonary tissue, a heavy musculature, and the least elastic portion of the bony cage.

On the other hand, that part of the respiratory mechanism which is largely

responsible for the *vesicular murmur* is dominant in the anterolateral and lower portions of the lungs. Here the murmur is composed of vibrations which originate in structures largely air-containing (the finer bronchi and air cells) plus a limited musculature and an elastic bony cage.

In auscultation of the normal lung and pleura, we are listening to the complex sound caused by vibrations in the respiratory mechanism in action; and in pathological conditions, we hear that modification of the normal sounds which the particular pathological process causes in the action of the respiratory mechanism. No other explanation seems adequate to account for the variations in the respiratory murmur which are met in diseases of the lungs and pleura. Infiltration decreases the proportion of air-containing elements, which produce sound vibration, and disturbs the action of the respiratory mechanism.

Moreover, in the sounds heard on auscultation it is evident that there are two distinct factors which must be taken into consideration: sound production and sound transmission. Sometimes one is predominant, and again, the other. The respiratory murmur heard at any given point consists of a composite sound originating in that portion of the respiratory mechanism which is transmitted to the ear at the point of observation.

Infiltrations in the lung alter respiratory movement and, according to their nature, size, density and location, change the sounds. They act in two ways:

First, acute inflammatory processes such as active tuberculosis cause spasm of apical muscles, particularly the sternocleidomastoid, scaleni, levator anguli scapulae and acromial portion of the trapezius above, and the crus and central tendon of the diaphragm below, and modify respiration by reflexly lessening the movement of the hemithorax in which the pathological process is located (15, 16, 17).

Second, all infiltrations, whether inflammatory or noninflammatory, interfere with full respiratory movement by their presence, the amount of interference varying with the extent and character of the infiltration. They also modify sound transmission.

It readily can be seen that the effect of both the reflex and the infiltration *per se* is to slow and lessen both the inspiratory and expiratory movement. This alters the sound vibrations. It prolongs both phases of the respiratory murmur and in many instances produces a higher-pitched note. If the infiltration results in much fibrosis, then the murmur may show the above disturbances to a high degree and be transmitted with increased force. This we see in the increased voice transmission caused by extensive scar tissue in tuberculosis, particularly when situated near the apex; or in a cavity with smooth walls surrounded by dense scar tissue—the *pectoriloquy* of Laennec.

The respiratory murmur may have different qualities according to the individual chest, the part of the chest in which the infiltration is located, and the particular characteristics of the infiltration. All of these factors will influence respiratory movement differently. One rarely finds a markedly harsh murmur or marked voice transmission when the infiltration is small, scattered, or situated deep in the lung, surrounded on all sides by functioning pulmonary tissue, no matter what the characteristics of the pathologic process. If the infiltration is small, the

respiratory mechanism may be influenced so little that the presence of the pathology may be wholly overlooked on auscultation.

Emphysema, such as we find in chronic bronchitis, bronchiectasis, asthma, or the compensatory emphysema found in chronic, far advanced tuberculosis, changes the respiratory movement and the accompanying murmur according to the following pattern which varies according to the degree of emphysema present: The lungs at rest are dilated; the intercostal spaces are distended; the bony cage is fixed and rigid; and the diaphragm is depressed and incapable of full movement. Every factor which enters into normal respiratory movement is limited in its activity, hence the respiratory murmur is weak.

In pneumothorax, the auscultatory sounds consist partly of the weak contraction of the chest muscles and those made by the feeble movements of the bony cage, plus whatever pulmonary tissue there is to engage in the respiratory movement. In pneumonectomy the stretching of the tissues which occupy the former lung space in response to respiratory effort may produce detectable sound vibrations.

In a chronically contracted lung the pulmonary, the muscular, and the bony cage elements of the respiratory murmur may or may not be largely removed and the sounds vary accordingly. But if there is marked fibrosis or a cavity in the midst of dense scar and the air freely enters, the vocal sounds may be strongly transmitted. This is *bronchophony* and *pectoriloquy*, in which transmission greatly overshadows sound production.

Diseases of the pleura may also alter the respiratory movement and change the respiratory murmur. Acute pleuritis causes local spasm of the intercostal muscles and reduces the movement of that segment of the bony cage over the part of the pleura which is inflamed, causing a decrease in the intensity of the murmur. It also may cause a friction rub when the inflamed surfaces move on each other. Should an effusion occur, the nature of the sounds will depend on the amount of fluid present. Much fluid distends the intercostal spaces, reduces the movement of the muscles and bony cage, separates the pulmonary tissue from the parietal pleura, and lessens the respiratory sounds.

Rales and the respiratory mechanism: Rales may be heard in pathological conditions of both the lungs and pleura. They are called *crepitant, subcrepitant, gurgling,* and *musical.* Roughly speaking, the first three varieties are considered to be caused by mucus in the bronchi, air cells, and cavities, while the musical rale is an obstructive rale caused by partial blocking of a bronchus. But there are pleural rales which cannot be distinguished from nonmusical rales of pulmonary origin.

The writer knows of no sure way to differentiate the fine and moderately coarse rales originating in the lung from those originating in the pleura. Both may be heard on deep inspiration and on expiration followed by cough and a quick inspiration; and both may now and then be heard on both inspiration and expiration.

The best evidence for differentiating these rales depends on the pulmonary and pleural reflexes; and this is not wholly satisfactory.

If atrophy of the subcutaneous tissue is present and does not extend below

the second rib anteriorly and the spine of the scapula posteriorly, rales heard are most likely of pulmonary origin, because this is the area of the pulmonary trophic reflex.

If atrophy is found anywhere between the second rib anteriorly and the spine of the scapula posteriorly above, and the lower margin of the ribs, this shows that the pleura has been inflamed and as a result the intercostal (18) and subcutaneous tissues (3) are degenerated and rales heard over these areas are likely to be of pleural origin. The fact that sometimes rales are not heard does not mean that no pathology is present.

When the trophic reflex extends from the apex down below the second rib anteriorly and the spine of the scapula posteriorly, rales are uncertain as to origin, for this indicates that both pulmonary and pleural tissues have been involved.

After inflammation of the pleura has subsided, or an effusion has become absorbed, the overlying intercostal and subcutaneous tissues may be permanently degenerated and alteration of the respiratory movement and murmur may persist. Degeneration of the subcutaneous and intercostal tissues with alteration of the murmur frequently follows the thickening of the parietal pleura caused by the irritation of the air in case of pneumothorax treatment. In some of these cases, rales are found and occasionally pain is present. Detectable atrophy is nearly always present if the pneumothorax has been maintained for more than a few months.

Rales arising in both the pulmonary tissues and the pleura may be persistent, and pleural rales may be permanent. I have heard these rales on re-examining patients nearly fifty years after I first noticed them.

It is not at all uncommon for the movement of the chest wall, hence the respiratory murmur, to be perceptibly lessened if the previous pleural involvement was extensive.

Pain may recur years after the acute phase of the pleurisy has passed, especially under conditions of low energy, tiring, emotional stress, worry and disappointment, menstruation, and changes in weather.

Constructive suggestions: This discussion of auscultation is not wholly destructive. There is a constructive side. It attempts to show what the respiratory murmur is not, and also what it is. This discussion takes away much of the independent value heretofore ascribed to auscultation and shows that all methods of physical examination of the lungs and pleura are interdependent. It raises auscultation from its dependence on the erroneous belief that the respiratory murmur is caused by the rush of air into the bronchi and air cells, and gives as its basis vibrations arising in the respiratory mechanism.

With this new conception the so-called *vesicular murmur* is heard in the anterosuperior, lateral, and lower portion of the lung, where the pulmonary tissues are dominant in the production of sound vibrations; and the so-called *bronchial murmur*, in the hilar area and the posterosuperior portion, where the nonpulmonary tissues are dominant, as has long been taught. Infiltrations, no matter where located, reduce the dominance of the vibrations from the pulmonary tissues and make the sounds take on what Laennec called a *bronchial* quality.

The terms *bronchial* and *vesicular* may be retained but they should be assigned to the entire respiratory mechanism and carry the new meaning of dominance in non-air-containing tissues in the production and transmission of the *bronchial murmur*, and dominance in the air-containing tissues in the *vesicular murmur*.

By carefully inspecting and palpating chests, the examiner may determine with fair definiteness how the respiratory mechanism is disturbed. He should pay due regard to the reflex spasms and degenerations caused by pathological changes in both lungs and pleura, and also note the effect on both the form and movement of the chest caused by infiltration and other pathological changes. Prominent among these are emphysema, rigid thorax, and marked contraction, which are often evident to the eye and more fully determined by palpation and percussion. If he will make these initial observations he will have some idea of what the respiratory murmur may be before putting a stethoscope on the chest. However, he must not expect to find the same sounds caused by the same pathology in all chests. We have been taught to expect to find far greater changes in the murmur than are present, especially where infiltrations are small or widely scattered. It is surprising to find how often they are so slight as to be almost unrecognizable.

The examiner must make more of physical examination of the chest than the use of auscultation and percussion. It must mean a complete and careful study of the patient's respiratory mechanism. Seeing and feeling are of equal importance to hearing. Disturbed physiology, as shown in the reflexes and in interference with the respiratory mechanism, which may be determined by inspection and palpation, take on added importance and must be utilized in order to obtain a full picture of any disease affecting either the lungs or pleura. Physical examination must be rewritten with due emphasis on the utilization of all data obtained on sight, touch, and hearing, rather than limiting it to what is heard through the stethoscope and determined by the use of the percussing finger.

SUMMARY

The respiratory murmur cannot be due to the air rushing through the larynx and impinging on the bronchial walls and dilating the air cells, because the lungs always contain residual air which stops the force of the incoming current and causes the air to enter the finer bronchi and air cells by diffusion.

The respiratory murmur consists of a mixture of sound vibrations originating in all components of the respiratory mechanism.

The sound vibrations which cause the *vesicular murmur* originate in the respiratory mechanism in the anterior, lateral, and lower portions of the chest where the air cells predominate, the musculature is light, and the bony cage elastic.

That part of the respiratory mechanism which normally causes the *bronchial murmur* is found in the superior portion of the chest and is most distinct posteriorly. Here the sound vibrations are produced by the air current, the larger bronchi, a comparatively small amount of pulmonary tissue and air cells, a heavy musculature, and the least elastic portion of the bony cage.

The importance of the trophic reflexes in the differentiation of pulmonary and pleural rales is discussed.

One should begin examination by inspection and palpation. By these measures he determines the shape, deformities, and movements of the chest, and whether or not any reflexes or any departures from the normal are present. With this information he may proceed to percussion and auscultation more intelligently and with greater confidence and understanding.

SUMARIO

La Auscultación. Nuevo Concepto del Soplo Respiratorio y de su Puesto en el Diagnóstico

El soplo respiratorio no puede deberse al rápido paso del aire por la laringe, chocando después contra las paredes bronquiales y dilatando las células aéreas, porque los pulmones contienen siempre aire residual que atenúa la fuerza de la corriente de entrada y hace que el aire penetre por difusión en los bronquios más delicados y en las células aéreas.

El soplo respiratorio consta de una mezcla de vibraciones sonoras procedentes de todas las partes componentes del mecanismo de la respiración.

Las vibraciones que ocasionan el *soplo vesicular* tienen su origen en el mecanismo respiratorio de las porciones anterior, lateral e inferior del tórax en las que predominan las células aéreas, la musculatura es liviana y la caja ósea elástica.

La porción del mecanismo respiratorio que ocasiona normalmente el *soplo bronquial* radica en la porción superior del tórax, hallándose más en evidencia en la región posterior, y produciendo allí las vibraciones sonoras, la corriente de aire, los bronquios mayores, una proporción, comparativamente pequeña, de tejido pulmonar, una musculatura pesada y la porción menos elástica de la caja ósea.

Discútese la importancia que revisten los reflejos tróficos en la diferenciación de los estertores pulmonares y pleurales.

El examen debe comenzar con la inspección y la palpación, que permiten determinar la conformación, deformidades y movimientos del tórax y si existen reflejos o desviaciones de lo normal. Con esta información, puede pasarse entonces a la percusión y la auscultación en forma más inteligente y con mayor confianza y comprensión.

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