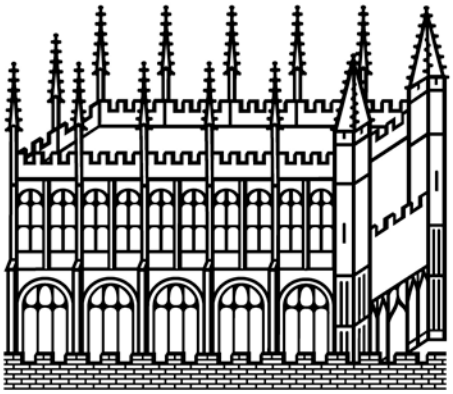

ON

CERTAIN MOVEMENTS

OF THE

THROAT AND CHEST

IN

RESPIRATORY ACTS.

BY

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PROFESSIONAL attention has been recently called to the movements of the larynx by the demonstrations of Dr. Czermack, in the use of his effective modification of Avery's speculum; and an interest is now being felt in the subject beyond that which it has hitherto commanded. It is with a view of further extending this inquiry that I venture to publish the details of an investigation into the movements of the parts of the throat above the larynx which are consentaneous with chest movements in the performance of respiratory acts, which were prosecuted some time ago, and then laid aside from the pressure of other engagements, and from a desire—since proved to be futile—to obtain photographs of the parts *in situ*. I cannot think that the subject has been as yet studied with the minuteness which it deserves, whether we regard its importance in

relation to the mechanism of respiration in health, or the influence of affections of the throat, locally or in their reaction upon respiration, which occurs in disease; neither do I think that we can now make that full practical application of the observed facts which will be possible in a few years to come.

I purpose, in the following communication, to describe the motions of the throat, observed in myself and others, in two sets of respiratory acts—those which do not and those which do involve the closure of the larynx, and to add some observations upon a voluntary respiratory act, showing that the configuration of the chest may be so changed that nearly the full quantity of air may be admitted and emitted, with variation in the perpendicular diameter only.

1.—THE THROAT.

Movements which do not involve Closure of the Larynx.

ORDINARY AND FORCED RESPIRATION.

In *ordinary breathing* through the mouth, if we commence from a state of rest of the parts about the throat, the tongue sinks, and especially at its root, and the *velum palati* rises. A continuance of the act scarcely excites further movement in the velum, or varies the figure of the fauces; but the tendency thereto is a little greater with expiration than with inspiration. A state of true repose is not permitted so long as the act is continued through the mouth, notwithstanding the intervals between the inspirations; but the velum and tongue have the same posture in the interval as during the act. When the state of repose occurs, the tongue rises and the velum falls; and hence the contrary acts must occur when inspiration is again effected through the mouth; but the state of repose is neither common nor necessary during expiration, and must be carefully distinguished from that of expiration.

In ordinary breathing through the nose, from the closest inquiry which I could make, I believe the parts to be then in a state of rest, so far as that the velum is depressed, and the root of the tongue raised.

In *forced respiration* through the mouth the effects are much more pronounced. In both expiration and inspiration the posterior isthmus is elongated from above downward, by the ascent of the velum, and greatly contracted laterally, and particularly at the key

of the arch, by the drawing inwards of the roots of the posterior arches; and it is in the latter position that the greatest muscular effort seems to occur. In the raising of the velum the chief action appears to be at the root of the uvula; and that point, indeed, is manifestly the centre of all the movements connected with the fauces. It is very peculiar in direction during expiration. During inspiration the uvula is carried backwards and upwards, even so far as to be horizontal, and it is greatly tightened; whilst during expiration it is directed forwards, and is loose; but the velum is still tightened at the point of connexion with the uvula. It is, however, needful to observe that the tightening of the velum ceases at or near to the end of expiration, whilst at the same moment the fauces expand, and the velum falls downwards and forwards, and so far resembles a state of repose; but the latter state does not, in fact, occur during the act of expiration. A momentary rest occurs ordinarily after the inspiration, and before the expiration begins—and again after the expiration, before the inspiration is renewed; so that there is a frequent alternation of constriction and dilatation; but the state of repose is not due to either the expiration or the inspiration.

Hence it is proved, that not only is there violent muscular action in the throat during the forced efforts of respiration, but that there is a consent between them and the other inspiratory movements of the thorax; and particularly that during their continuance there is no opposing action on the part of the diaphragm and abdominal muscles.

I then inquired as to the channels by which we breathe in ordinary respiration, and found it a much more difficult inquiry than experience would have led me to expect. In this investigation I made use of the spirometer and mirror.

We do not ordinarily breathe by both the mouth and nose at the same time; but when the mouth is open the air enters chiefly, if not entirely, by that aperture. If a tube be held in the mouth it is just possible to breathe through it as well as through the nose at the same time, and without producing any nasal sound; but it would then be most unusual to breathe through the nose by persons of ordinary manners. It is, however, possible to hold a tube in the mouth, and yet breathe as entirely by the nostrils, as it is to breathe entirely through the tube; and the latter may be continued after having been once effected without any fear of air entering by the nose so long as the attention is given to it. In blowing through

the mouth with moderate force it would be impossible to expire also by the nose; and it is but barely possible to inspire forcibly through both nose and mouth at once.

It is quite possible to breathe either by the nose or mouth separately at will, or with the two alternately as well as with both at the same time. The alternate action is requisite in using certain spirometers and inhalers, and demands a little practice. In inspiration by the mouth and expiration by the nose, the tongue is first lowered, and the velum raised; and then those conditions are reversed; and in this latter action the anterior arch is closed by the back of the tongue. The communication from the pharynx to the mouth can be shut off whether the mouth be open or closed; but if it be open, an effort is required to raise the back of the tongue, and thus to meet the velum.

As it respects the closing of the nostrils from the pharynx, I remark that there is power to do so, as is proved by the following facts:—When the mouth is open we can expire even forcibly, and yet no air pass by the nose. When the mouth is shut we can distend the cheeks with air, and yet no air pass out by the nose. To open the nose it is then needful to make an effort, or to arrest the previous effort, and this is followed by a crack and a rush of air through the nose. There is also some change in the position of the velum when the posterior nares are thus opened to the pharynx.

The mode by which this is effected cannot be seen during the act; but I believe it to be by the movement of the velum, as in forced respiration by the mouth. Hence, anything preventing the action of the velum, or any want of integrity of it, or deficient elevation of the back of the tongue would render the isolation of either of the two orifices impossible. I have endeavoured to draw the tongue downwards, and backwards, and in various other ways, to ascertain if the falling backwards of the tongue in anesthesia could close up the fauces, and thus prevent respiration; but without being able to prove or disprove it, I believe it cannot entirely do so.

SINGING.

In singing the posture of the throat and tongue is much the same as in all forced respiratory efforts, but it differs with the pitch and and register of the voice. In singing there are three registers of the voice, viz.:—1st, the chest tones; 2nd, the medium tones; and 3rd, the head tones.

In singing in the chest register—viz., up to *la* or *si*—the position of the throat is as in ordinary talking, the fauces being contracted, the velum raised and arched, the uvula pendant and thick, and the tongue depressed with recession of the posterior arch and thickening of its root. No posturing of the throat is necessary; and neither the pitch nor the quality is influenced by any motion of the uvula. In the medium register—as from *si* to *fa*—the same posture is found, except that the uvula now begins to be drawn up at its root, and the velum also rises with it.

It is in the head tones that posturing of the throat occurs; and in them it is considerable and forcible. All the parts in the fauces become tightened to the last degree; and so narrow are the fauces at the uvula that that little body seems to fill up the chink. The uvula exhibits remarkable changes in form and posture. At the very highest tones— viz., *sol*, octave above the line—it is so contracted as to be reduced to a narrow point. It is also drawn backwards and upwards from points in its length, descending from its root towards its free end, progressively, as the pitch rises, so that at the very highest notes it is perfectly horizontal. It is remarkable, that with all this tension the other parts of the fauces may be quite motionless, unless an inspiration should be made, and then they posture as in forcible inspiration.

In all the registers alike, the employment of a mirror shows that the breath passes out through the mouth alone, when the tone is clear and pure; but it passes partly by the nose when a nasal sound occurs. The sound, however, is not so limited; but in the chest tones is chiefly through the nose, in the head tones through the mouth, and in the medium through both. In the head tones the sound is cut off from the nose by the ascent of the velum, and the closure of the nares by a very low vibrating membrane. It is also worthy of remark, that closure of the nares anteriorly does not necessarily affect the quality of the tone in any register; and this expedient is a good test to the singer himself of the degree of purity of the tone. But in reference to the chest tones which pass through the nose naturally, it is difficult to avoid injury to them if the nose be closed anteriorly; and it is needful to raise the velum. The pitch of the note is produced in the larynx.

TALKING.

The posture of the throat in talking is that of ordinary respiration. In the open posture—as in saying "Ah!"—the velum is carried

further upwards and backwards, and then falls in the opposite direction when the talking has ceased; but it never falls so low as to lie upon the back of the tongue. Speaking in the three registers requires the same posturing of the throat as in singing in those registers. The nose vibrates, during talking in the chest and medium registers, but not with the head tones; and this is the same in singing in those registers. The sound may pass through the nose, and yet the current of the breath pass by the mouth, showing that it is due to vibrations of air in the nares, and not necessarily to the current of air passing through the larynx; but the vibrations are set in motion by that current.

The quantity of air emitted during talking or singing is small at each moment; for, although it is continuous it is but little, if any, greater per minute than occurs with the intermittent efforts of ordinary respiration. When singing in the *bravura* style there is an increased expiration of only 40 cubic inches per minute.

YAWNING.

In yawning, the posture of the throat is the same as in the most forced respiration, with two exceptions, viz., that in the expiration the velum is raised higher than in inspiration, even above the level of the bony palate, and the tongue exhibits a remarkable ridge at its middle part. The order of the actions is as follows:—

1. There is a very deep, the utmost complemental, inspiration, preceded by a peculiar sensation at the precordium, and inducing, or attended by, the wide opening of the jaws. 2. The breath is held—not by closure of the larynx, I believe—but by the muscular efforts of the diaphragm or abdominal muscles; and the jaws are widened to their utmost degree. 3. Then follows a long expiration, during which the mouth naturally remains open; but by great effort it may be closed, and then the air enters the Eustachian tube, and the gaping is less complete. During the inspiration and the holding of the breath the larynx descends greatly with the lower jaw

SNORING.

This act may occur with the air passing through the nose alone, through the mouth alone, or through both at the same time. When through the nose alone it is very difficult, and then there is some noise produced by movement of the nasal cartilages which cannot be often repeated, and by a dull rolling noise about the velum and posterior nares. This can scarcely be ordinary snoring. The act

is the most easy and natural when the mouth is open, and the breath passes through the mouth alone. There is then a rattling of the velum against the back of the tongue, except when the tongue is held down at its root by voluntary effort. When the air passes through both orifices the snoring is not so easy; but it, doubtless, does so ordinarily, and perhaps with the deepest snore. The mouth is less open than in the former condition; but I believe the rattle to be still due to the tongue and velum If the mouth be kept widely open the rattle does not occur; or if it do occur it is very indistinct and uncertain, because the back of the tongue is held at too great a distance from the velum.

Those acts which involve a Closure of the Larynx.

It is possible and easy so to fix the throat that no air can pass outwardly either through the nose or mouth, and yet the communication by the mouth shall be free by the ascent of the velum and uvula, as it is in singing or talking in the chest register. This is not dependent upon any position of the jaws or cheeks, for the former may be moved at will, and the latter be distended and collapsed repeatedly, and yet no air shall have left the lungs. This is also observed in the act of coughing, and in various efforts, as the carrying of weights, in defecation, and other expulsatory acts. When the obstacle is overcome, there is a crack and a rush of air. During its continuance the precordium is tense, and the diaphragm fixed, and the larynx is also drawn up considerably, but yet to a less extent than occurs with swallowing.

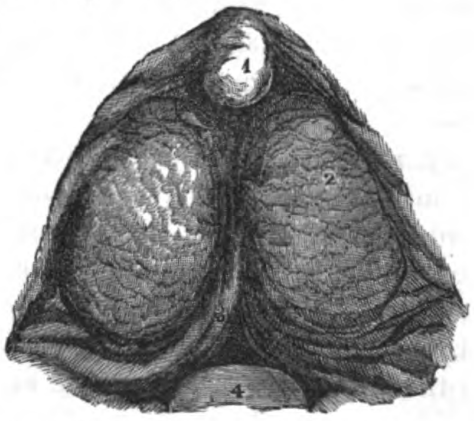
The point of interest is to determine where the obstruction is placed. It must be, judging from the sensation, either in the larynx or about the diaphragm; and, on carefully inquiring into it, I believe that it is not from any arrest of expiratory action in the abdominal and other expiratory muscles, but in the larynx, for the following reasons:—

1. The expiratory muscles appear to be acting forcibly, both from the sensation internally, and from that communicated to the hand externally, and from the change in the figure of the abdomen.

2. When the obstruction is overcome, there is a sensation in the larynx besides that of the sudden passage of a volume of air. This is also confirmed by distending the cheeks, first with the communication open, and then without it. When the air passes through the lips there is a difference in the sensation in the throat in the two experiments; and in only one does it indicate that an obstacle has been overcome.

But, admitting that it is in the larynx, does it follow that it is necessarily at the glottis? The sensation, when the obstacle is overcome, seems to be higher up and nearer to the epiglottis; and in addition, there is the ascent of the larynx; both of which circumstances point to the superior aperture of the larynx as the seat of obstruction, and indicate that it may be due to the elevation of the larynx underneath the epiglottis. Proof of this is difficult to a self-experimenter; but it could be obtained by means of a tube of half an inch in diameter being passed down to, and, if possible, into the larynx, and noticing at what point the obstacle is removed. It is however easy enough, when the throat of another person is examined.

Let a person be selected in whom, by practice or absence of hyperesthesia, it is possible to expose the free edge of the epiglottis with ease; and place him before a window, in good sunlight, at a height convenient to the stature of the observer. Let the mouth, and particularly the lips, be completely expanded, so as to render the opening of the mouth of an egg-shaped form, but with the short axis somewhat longer; and direct the patient to inspire by the mouth, so as to lift up the velum, and to continue to respire at his ease during the inquiry. Place the broad spatula carefully upon the tongue, as far back as it can be borne, and by the aid of the long handle, steadily and firmly depress it, and at the same time draw the root of the tongue somewhat forward. Having previously instructed him to hold his breath, and make a strong expulsatory effort at the same time, direct him to do so now that the epiglottis and the surrounding parts are exposed to view; and if he have understood what is required, and have done it, the following changes will be observed during the act:—



Drawing, showing the position of the parts of the Fauces and Pharynx in the first part of coughing and other expulsatory acts.

1. The larynx is carried upwards to the extent of perhaps half an inch. 2. The free edge of the epiglottis becomes somewhat curved, and is carried backwards towards the posterior wall of the pharynx. 3. The whole circumference of the pharynx becomes contracted and corrugated, so as to reduce the circular aperture below; but the lateral walls particularly project, and diminish the area in that direction, and the posterior wall of the pharynx is brought forward. 4. With these acts the posterior aspect of the epiglottis is brought into approximation to the posterior wall of the pharynx, and the lateral edges are near to the lateral bulging of the pharyngeal muscles. When the expulsatory act ceases, all the parts return to their former state, and the cavity instantaneously enlarges; and the contraction and enlargement may be repeated alternately, at pleasure, for several times, in a suitable subject.

Hence, in this act it will be readily seen that the apertures of both the larynx and œsophagus are temporarily closed; and it may be affirmed that such is the condition in all expulsatory acts at the period preceding the emission of air.

Such, moreover, is supported by two well known facts. In cases of destruction of the free edge of the epiglottis such acts as coughing can be only imperfectly performed, for the compression of the chest space is never perfect; and the crack which accompanies the emission of air in ordinary coughing does not occur, or it is exceedingly feeble. Hence, in such cases, the free edge of the epiglottis could not be fully applied to the pharynx, and the full benefit of the expulsatory act of coughing, and perhaps of other expulsatory acts, is not obtained. Again, when, after the application of the strong solution of nitrate of silver to the lower part of the pharynx, there is apnea, the strangulation passes away very frequently with the eructation of wind from the œsophagus at the same instant, which implies that both the larynx and the œsophagus were closed together and reopened together.

Hence I cannot doubt for a moment that *a* seat of the occlusion, in expulsatory acts, is at the bottom of the pharynx, and that the muscles of the pharynx act the part of constrictors, and the free edge of the epiglottis that of a valve; but it does not follow that there is not a consentaneous act of a similar import proceeding in the larynx. Dr. Czermack has informed me that, in the act in question, the vocal chords are drawn together, the arytenoid cartilages approximate closely, and the epiglottis is carried backwards, and closely applied to the anterior aspect of the cartilages, and thus closes the

chink which otherwise exists between them. But it is evident that in the extreme effort the interior action of the larynx can be no longer observed, since the apposition of the epiglottis to the posterior wall of the pharynx cuts off the admission of light.

COUGHING.

The position of the throat and tongue in coughing is the same as in forced respiration; but the posterior arch is thinner than occurs with singing. The peculiarity of the act is that it alternately discharges and renews this position. The following is the sequence of the phenomena attending the act:—

1. The posture, in the throat, of forced respiration is induced.
2. There is closure of the larynx, most probably at its upper termination, with ascent of that organ, fixing of the diaphragm, and the exertion of great expiratory force; and, as the exit of air is prevented, the air contained in the lungs must be compressed and dislocated. The fauces also, during this part of the act, become more compressed laterally.
3. Cessation of the obstruction, followed instantly by violent spasmodic expulsion of air through the mouth only, relaxation at the precordia, and sudden descent of the larynx.

It is not needful that there should be an inspiration before every cough; and when there is not, the air which is discharged must be the reserve air; and hence the volume of the lungs and the distension of the air-cells will be less than in a state of rest, as occurs in such spasmodic acts as those of hooping-cough.

2.—CONDITIONS ATTENDING A CERTAIN VOLUNTARY CHEST MOVEMENT.

I find that with the larynx closed, and without any air entering the lungs, I can, by the violent action of the thoracic muscles, expand the thorax antero-posteriorly and laterally to the utmost degree, or nearly so, to which it can be expanded in those directions with the admission of air; and that when it is so expanded I can admit the same quantity of tidal and complemental air, or nearly so, which could have been admitted in the fullest inspiration without this postural effort. I cannot determine the perpendicular measurement, but I presume that it is lessened. The whole thorax is elevated 1 inch, and there is a decrease of $\frac{3}{4}$ of an inch in the distance from the navel to the upper extremity of the sternum. The figure of the chest with the postural effort, without air, is the same

as with ordinary deep inspirations, but there is a greater tucking inwards at the precordium. During the effort the whole body appears to be on the strain, and particularly the muscles of the neck posteriorly and laterally, of the jaw, and of the ribs; and those of the loins are stiff and sore after the exertion. The arms feel as if they were fixed; but it is not so necessarily, for they may be moved about at will. When the posture has been effected, and it is desired to admit the air, there is a peculiar and loud clack in the throat; but this does not take place on the instant, with the will, and seems to imply that the voluntary closure of the throat in preventing inspiration, cannot, on the instant, be removed. The tongue has no essential part in the fixing of the throat referred to, to prevent inspiration, for it may be at rest or extended, and yet it never affects the closing or the opening of the larynx.

The following are the admeasurements before and after the admission of air, the quantity inspired at each ordinary inspiration being 35 cubic inches, and the movement across the seventh rib being an increase of $\frac{1}{8}$ inch.

1. *With the postural effort commencing at the normal point of expiration:—*

Across the seventh rib there is an increase in the circumference to the utmost degree of expansion, without air, of 12-10ths of an inch, and a further increase of 2-10ths of an inch on the admission of air to the utmost degree. Across the nipple the increase without air is 7-10ths of an inch, with a further increase with air of 6-10ths of an inch, and across the second intercostal space the first-mentioned increase is 9-10ths of an inch, and no more with air admitted.

In reference to the abdomen there is, just below the ribs, a decrease of 6-10ths of an inch, without air, and then an increase of $2\frac{9}{10}$ inches with air admitted. Across the navel the decrease without air is 1 inch, and then the increase with air is 2 inches.

2. *With the postural effort commencing from the point of deepest expiration:—*

Across the seventh rib the increase without air is $2\frac{3}{10}$ inches, and another 1 inch with the admission of air. Across the nipple the former is 7-10ths of an inch, and the latter 4-10ths of an inch, whilst across the second space the former is 9-10ths of an inch, and the latter 1-10th of an inch.

In the abdomen, just below the ribs, there is a decrease of 3-10ths of an inch without air, and then an increase of $3\frac{3}{10}$ inches with

admitted air, and across the navel a decrease of 8-10ths of an inch without air, and an increase of 2 inches with air.

The quantity of air admitted without increasing the size of the thorax beyond that of the fixed posture under discussion is 180 cub. inches, and that to the utmost capacity of the chest is 210 cub. in., the starting point being that of ordinary expiration. When, however, the effort is made from the point of most complete expiration, the quantity of air admitted is 230 cub. inches, without increasing the size, and 260 cub. inches when expanded to the utmost degree.

The admeasurement and quantities vary somewhat with the fatigue, for it is impossible to maintain for a long time, or to repeat often, the exertion without fatigue. It is also imperative to have the movements most perfectly under the control of the will.

Thus in the postural efforts a very great increase in the admeasurement of the chest is effected, without the admission of air, and a slight further increase on the admission of air; whilst the circumference of the abdomen is lessened without the admission of air, and greatly increased afterwards on its admission. But as much as 80 cub. inches of air may be admitted into the lungs before the circumference of any part of the abdomen enlarges. When the starting point is that of complete expiration the chest admeasurements are increased, whilst those of the abdomen are decreased, before air is admitted, and a proportionate increase in the size of the abdomen results after air has been admitted. The direction of the enlargement of the chest by the inspired air is downwards.

It is thus evident that complete inspiration may be effected by expansion of the lungs in one direction only, but with regard to expiration that is either impossible or very difficult under the same circumstances. Whilst inspiration may be thus as quickly and as surely effected as under ordinary conditions, the expirations must be made very slowly, and unless a much longer period is allowed for its performance than under ordinary circumstances, the whole of the complemental and tidal, and part of the reserve air, is not emitted, and, as a consequence, less air is admitted during the following inspiration. Hence I think it is proved that inspiration may be completely effected by the diaphragm alone, and that the attendant expansion of the thorax is not essential, provided it be expanded at the period of inspiration, but that expiration cannot be effectually performed by the abdominal muscles alone, so long as the thorax remains expanded; and hence that the respiration would be seriously

impeded, if from any cause the thorax remained expanded beyond the normal degree.

I do not know if the capacity of the chest is varied in either direction by this postural effort, since it is impossible to determine on myself the perpendicular depth of the chest. There is no doubt, I believe, that the capacity of the chest may be enlarged to a certain extent, without the admission of air, by the expansion of the contained air; and the conditions under which the air is placed during this effort, are very favourable to its expansion.

There must be a dislocation of the air within the lungs, so as to permit of the change of figure of the lungs; and hence the air-cells in parts of the lungs must be at the same moment in two opposite conditions, viz., those at the base containing as little air as possible, whilst those centrally, laterally, and superiorly situate must be distended either to their utmost extent, or to utmost capacity of the chest at those points. Hence it is proved that an empty condition, or nearly so, of the air cells, is not necessarily due to the pressure of the thoracic walls, as a whole, and that, in fact, partial collapse on a large scale may occur; and, in like manner, that distension of a great part of the air cells may occur without the entrance of air from without, and simply by dislocation of that within the lungs.

It is also clear that whilst the air cells of the greater part of the thorax are so distended that they cannot permit the entrance of any further quantity of air, those at the base are capable of receiving 260 cub. inches—or, in fact, the whole quantity which the lungs can inspire from the point of most complete expiration; and hence that the abolition of a large part of the air cells at the apex could not prevent the introduction into the lung of the full volume of air required, provided that the cells at the base could be first sufficiently emptied, and that the requisite amount of muscular power and space in the abdomen could be obtained.

It may also be inferred, that if it be possible to keep the air cells of so large a part of the lungs permanently distended beyond the natural degree, there would be a more limited interchange of gases; and it would be of interest to determine the effect which this would have upon the chemical changes and the circulation of blood in the lungs. Hence, in states of disease in which the mobility of the chest is lessened it is a desideratum to determine whether that results from the retention of an unusual quantity of air, or simply from an absolutely lessened capacity to contain air.

Such are the results of this inquiry on the two subjects indicated; and whilst I must leave the practical application of them to the physician, in his investigations of chest and throat disease, and to the physiologist in studying the mechanism of respiration, I would conclude by directing attention to the great diversity which exists on these two subjects in the two most widely-spread classes of chest disease—bronchitis and phthisis.

In old bronchitis we find the cavity of the fauces large, the mucous membrane more or less suffused and thickened, and the movements of the throat materially lessened; whilst in phthisis there is commonly a narrowed state of the fauces, attenuation of the lining membrane, and particularly of the arches of the palate, with almost obliteration of the anterior arch, and with perfect and free movement of the throat.

In old bronchitis the chest is fixed at its upper and lateral parts, and the abdomen tucked in, *as in the position of the chest which has been discussed*, rendering the expiration of air extremely difficult, and diminishing greatly the interchange of air. This fixedness of the thoracic walls often extends even to the lowest ribs, leaving the respiration to be performed almost entirely in the direction of the perpendicular axis of the chest. In phthisis there is no fixing of the chest by violent muscular effort; and the cause of the respiration being carried on chiefly at the base is due simply to the closure of the lungs at their upper part.

Hence it is impossible not to notice how completely the cause of the dyspnea differs in the two conditions, how greatly is the respiratory act lessened in bronchitis, and how much the diminution is due to an abnormal action of the inspiratory chest muscles, whereby the collapse of the chest is prevented during expiration, and the expiration greatly impeded—a condition evidently greatly connected with cerebro-spinal action, and to be treated on that indication much more than has hitherto been practised.