On the movements of respiration in disease, and on the use of a chest-measurer / by Francis Sibson ; communicated by Dr. Hodgkin.

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ON THE

MOVEMENTS OF RESPIRATION IN DISEASE,

AND ON

THE USE OF A CHEST-MEASURER.

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Communicated by Dr. HODGKIN.

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The incomparable Laennec says, "L'inspection du thorax pendant la respiration est très peu utile." Well did Dr. Forbes remark, in translating this passage, that Laennec underrated the inspection of the motions of the chest as a means of diagnosis.

Notwithstanding this opinion of Laennec, almost all the principal subsequent authors on the diseases of the chest, such as, among others, Andral, Collin, Dr. Forbes, Dr. C. J. B. Williams, Sir James Clark, Dr. Stokes, M. Voilliez, M. Fournet, Dr. Watson, and Dr. Walshe, have successively investigated the respiratory movements in chest disease. There has been indeed, of late years, a growing sense of the importance of observing the motions of respiration in forming a diagnosis.

Impressed with the importance of the inquiry, and desirous of ascertaining the true value of the phenomena in diagnosis, I have for some years investigated the movements of respiration in health and disease. Many of my observations on this subject were published in 1844 in the Transactions of the Provincial Medical and Surgical Association, in a paper on "The Changes in the Situation of the Internal Organs;" and in

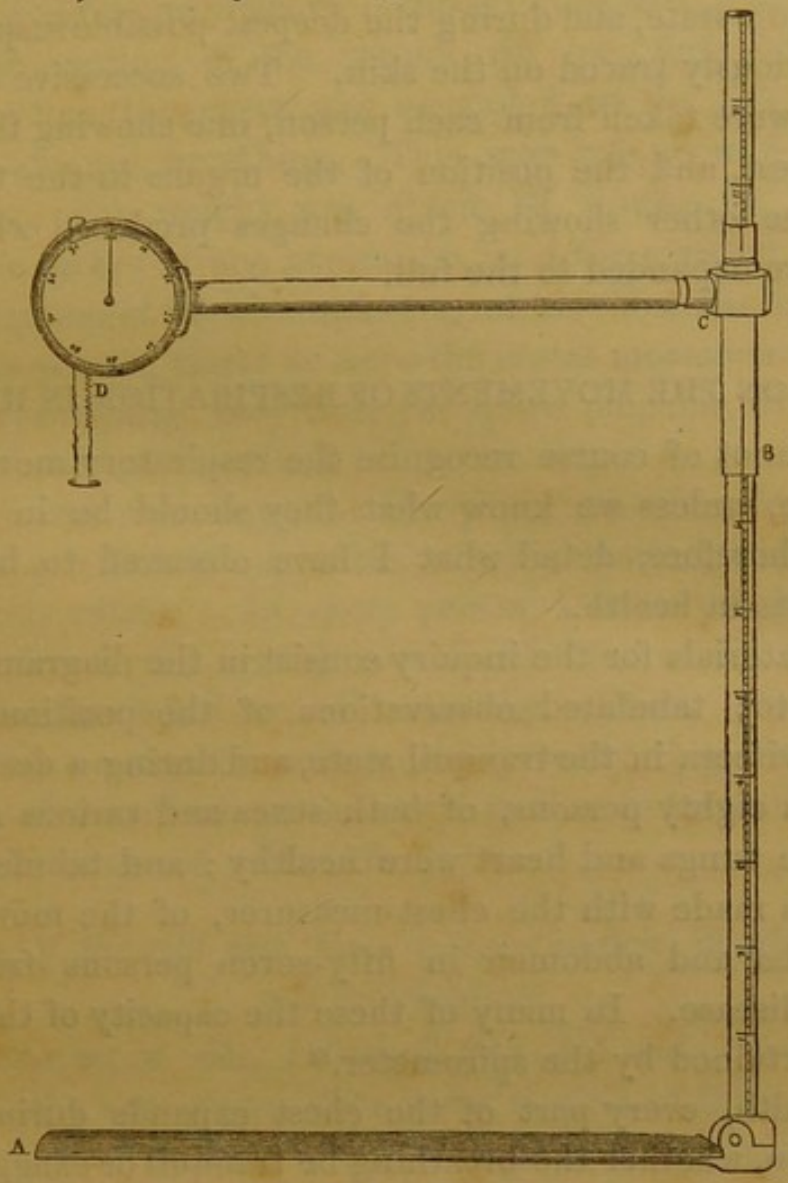
1846, in the Philosophical Transactions, in a paper "On the Mechanism of Respiration," which treated of the anatomy and movements of the breathing apparatus in man and other animals supplied with lungs.

In pursuing the researches comprised in those papers, I found the want of an instrument for accurately and minutely measuring the movements of respiration. About two years ago, I succeeded, with the assistance of a patient in the Nottingham Hospital, and finally of Mr. Simmonds, in completing such an instrument. It is a *Chest-Measurer*, measuring the diameter of the chest, and indicating by the motion of the index on a dial any movement of respiration to the hundredth of an inch. It is in fact a micrometer of motion. It can be readily applied to any part of the body, and by successive applications of it over the chest and abdomen, all the movements of respiration can be ascertained with minute accuracy. The character as well as the extent of motion may be read off from the dial. It indicates the rythm of respiration, showing whether the expiration be equal to, longer, or shorter than, the inspiration.

The chest-measurer shows the exact amount of chest movement, both during tranquil breathing and the deepest possible inspiration and expiration. It thus tells indirectly the extreme breathing-capacity of the chest, which is rendered perfectly by the "spirometer" with which Dr. Hutchinson has made so many valuable observations. In this respect it is indeed a "pocket spirometer."

To assist in the inquiry into the movements of respiration, I have made diagrams from the dead—in health and in disease—of the position of the ribs and internal organs, both before and after the complete inflation of the lungs. I traced the outlines of the organs with chalk on a piece of black lace, stretched on a frame, and placed over the body. I transferred these outlines to paper, and reduced them by a pentagraph. The tracing-frame and the pentagraph were the suggestion of my friend Dr. Hodgkin. Engravings from these diagrams were published, in the papers referred to above, in

the Provincial Medical and Surgical, and the Philosophical, Transactions, and very recently in the Medical Gazette.



THE CHEST-MEASURER.

A. Brass plate, covered with silk, on which the patient lies (see the figure at p. 364).

B. Upright rod, divided into inches and tenths, to indicate, by the slide at B, the diameter of the chest.

C. B. Slide, moving on the vertical rod B, and carrying the horizontal rod and dial C. D.

C. D. Horizontal rod, dial and rack (D). This rod can be drawn out like a telescope from C—an outer rod sliding on an inner; and as the outer rod can be rotated on the inner, the inclination of the rack and dial can be varied at will, by the finger and thumb. This combination of slides forms a universal joint (see fig. at p. 364).

D. Rack and dial. The rack, when raised by the moving walls of the chest, moves, by means of a pinion, the index on the dial. One revolution of the index indicates an inch of motion in the chest; each division indicates the 100th of an inch.

The Chest-measurer packs into a pocket case.

Mr. Kaim, of this town, has taken for me the daguerreotypes which accompany this paper. The outlines of the organs in the tranquil state, and during the deepest possible inspiration, were previously traced on the skin. Two successive daguerreotypes were taken from each person, one showing the form of the chest, and the position of the organs in the tranquil state; the other showing the changes produced when the lungs were expanded to the full.

PART I.—ON THE MOVEMENTS OF RESPIRATION IN HEALTH.

We cannot of course recognise the respiratory movements in disease, unless we know what they should be in health. I shall, therefore, detail what I have observed to be those movements in health.

The materials for the inquiry consist in the diagrams above referred to; tabulated observations of the position of the thoracic viscera in the tranquil state, and during a deep inspiration, in eighty persons, of both sexes and various ages, in whom the lungs and heart were healthy; and tabulated observations made with the chest-measurer, of the movements of the ribs and abdomen in fifty-seven persons free from organic disease. In many of these the capacity of the lungs was ascertained by the spirometer.*

In health, every part of the chest expands during each inspiration, whether the breathing be tranquil or exaggerated.

The costal motion in tranquil breathing is, in the robust man, exceedingly small. In a man whose chest was the finest in development I have seen, and who stands third among English runners (Westall, Case 12 in Table I.), the

* See the annexed Table I. In all the persons included in this table, the internal organs were, after careful examination, considered to be healthy. The majority of them were surgical and medical patients in the Nottingham General Hospital. I had two reasons for preferring such persons to those in perfect health; firstly, they were completely at my command; and, secondly, they were more nearly allied, in general health, to those cases of chest-disease with which they were to be compared, but from which they differed in this—that their internal organs were healthy.

motion of the second rib, taken in the sitting posture, was, in tranquil breathing, ·03 to ·05 of an inch, while during the deepest possible inspiration it moved forwards 2·25 inches. Here the motion of the second rib was forty-five times greater when the chest was expanded to the full than it was in tranquil breathing. This man was about 5 ft. 9 in. in height; his weight was about 12 stone; he expelled 290 cubic inches at one expiration, and the greatest inspiratory expansion of the circumference of his chest was 5½ inches.

In this person, slight as were the costal movements during tranquil breathing, they were yet quite palpable over every part of the chest examined.

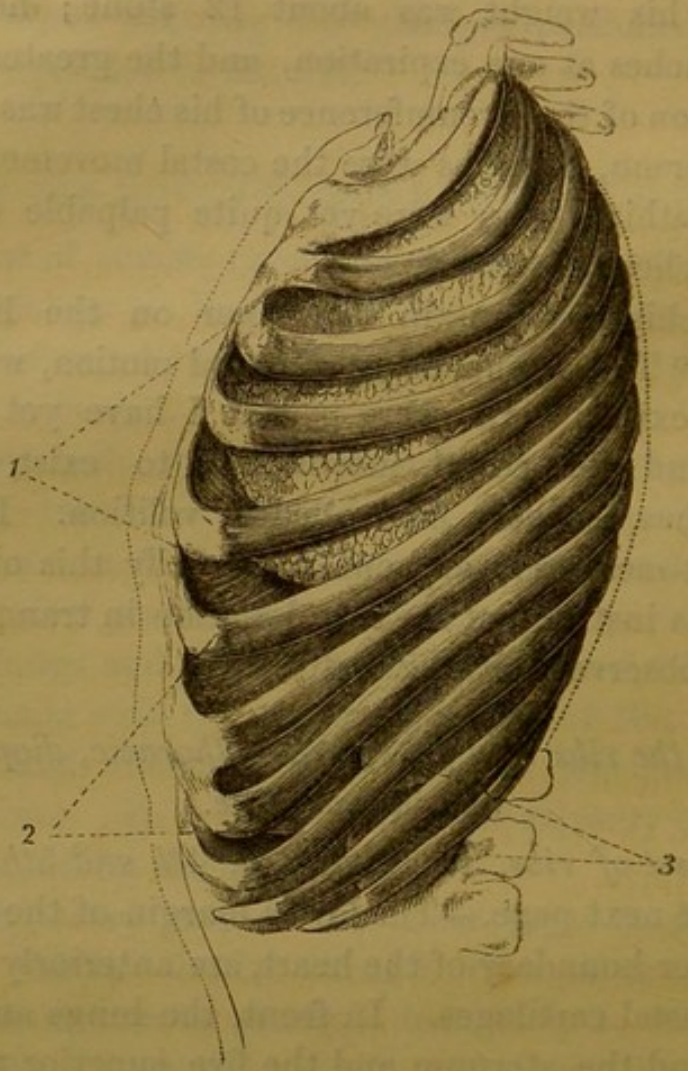
Dr. Hutchinson says, in his paper on the Respiratory Functions, "This is supposing a costal motion, which I believe rarely exists." In every person I have yet examined I have found the costal movements to exist, whenever respiration has not been controlled by volition. By the aid of the chest-measurer, any one may verify this observation. Without this instrument the costal motion in tranquil breathing can be observed with difficulty.

Division of the ribs into three sets,—thoracic, diaphragmatic, and intermediate.

Thoracic set of ribs, 1st, 2nd, 3rd, 4th and 5th.—See the figure at the next page.—The lower margin of the right lung, and the lower boundary of the heart, are anteriorly just above the sixth costal cartilages. In front, the lungs and heart lie wholly behind the sternum and the five superior ribs, which I have termed, in the paper on the Mechanism of Respiration, The Thoracic Set of Ribs, and which form in front the true thorax. The motion of the thoracic set of ribs expands the superior and middle lobes. To the side, the lower margins of the lungs, as they spread outwards, pass successively within the sixth, seventh, eighth, ninth, tenth and eleventh ribs.

Diaphragmatic set of ribs, 9th, 10th, 11th, and 12th.—The ninth, tenth, eleventh and twelfth ribs protect the

lower and back part of the lungs, and, in great part, the liver, stomach and spleen. They give origin to the diaphragm, and when the diaphragm acts they move outwards and backwards to expand the lower and back part of the lung, and they form the *diaphragmatic set* of ribs.



1. The Thoracic set of ribs.
2. The Intermediate set of ribs.
3. The Diaphragmatic set of ribs. The left lung, the heart, stomach, spleen, and left kidney, are seen through the intercostal spaces.

The dotted lines indicate the outlines of the chest when the lungs are fully inflated (as they are during a deep inspiration).

Intermediate set of ribs, 6th, 7th and 8th.—The sixth, seventh and eighth ribs are both diaphragmatic and thoracic in their position and action; they form the *intermediate set*, and

expand the upper portion of the lower lobe, and, on the descent of it, the lower portion of the upper lobe.

The division of the ribs into the three sets of thoracic, diaphragmatic, and intermediate, which I proposed on anatomical grounds, I find of practical value in the diagnosis of disease, as I shall have to state more fully hereafter. The important practical point to bear in mind with regard to the respiratory movement of the different sets of ribs is, the portion of lung that each set expands.

During a deep inspiration, the anterior portions of the ribs move forwards and upwards, and through the intervention of their cartilages carry forwards and upwards the sternum; while the posterior portions of the ribs move backwards, and push backwards the dorsal column.

The dorsal vertebræ form an arch, and as the ribs of the intermediate set, the sixth, seventh and eighth, are longer than those of the thoracic set, they thrust backwards the middle of the dorsal arch further than those of the thoracic set push backwards the upper part of the arch; the dorsal arch is consequently deepened, and, therefore, shortened.

The shortening of the dorsal arch, and consequent lowering of the head, during each involuntary inspiration, is very manifest to the eye in persons, especially in females, lying on the side, suffering from dyspnœa.*

* Dr. Hutchinson says (Med.-Chir. Transactions, vol. xxix. p. 191), "The head is protruded and lowered in the deep expiration," "raised and thrown back in the deep inspiration." I am satisfied that this is accurate as applied to those he observed, who were examined when erect, and who were desired to expire and inspire deeply; as they were erect the straightening and lengthening of the lumbar curve counteracted the deepening and shortening of the dorsal curve. Besides this, their breathing was voluntary. They elevated the head with one set of muscles, while they expanded the chest with another. One thing is certain, that in the erect posture, although healthy men usually raise the head when they take a deep voluntary inspiration; yet women in tight stays, whose breathing is markedly costal, and persons affected with emphysema, lower their heads when they inspire involuntarily to the extent of ·01 to ·02 in. When I take a deep inspiration, I can either elevate the head ·50 in. or lower it ·40 in., or keep it perfectly still, so much

Each of the four or five superior ribs (the thoracic set) ascends during inspiration more than the rib above it; they consequently then move nearer to each other; while the diaphragmatic and intermediate ribs move further apart. This, as I have shown in my paper on the Mechanism of Respiration, is in great part due to the articulation of the ribs with a moveable dorsal arch.*

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control has will over the movements of respiration. In the tranquil breathing of men, the shortening of the dorsal arch is imperceptible, their costal respiration being so trifling; but in females, it may usually be observed. It follows from these observations, which can be readily verified, that Dr. Hutchinson's remark, that "The body is lowered or shortened in expiration," must be qualified; as in the instances I have mentioned, the body was then markedly lengthened. During voluntary deep expiration, and during the act of coughing, the body is markedly shortened, as then the powerful abdominal muscles pull downwards and forwards the sternum and ribs, and, through them, bend forward the lumbar vertebræ.

* Dr. Hutchinson says, p. 215, "In inspiration the ribs diverge from each other, in expiration they converge towards each other." This statement, correct as regards reptiles and birds, requires to be qualified in regard to man, and the mammalia who possess, like man, a dorsal arch. It may be easily observed on a thin person by placing one finger on the third and another on the first rib, that they converge during inspiration, while, by adopting the same plan, from the seventh to the twelfth, it will be found that they diverge. The divergence of the diaphragmatic ribs is very great, and it is in part owing to their great divergence that the action of the middle parts of the tenth and eleventh external intercostals is expiratory; while it is owing to the great convergence of the upper ribs that the internal intercostals between the first and the third ribs are inspiratory, thus reversing in each instance the natural action of those muscles, the former of which is in the bird and reptile throughout inspiratory, and the latter throughout expiratory. I beg to refer on this interesting subject to the plates and description in the paper on the Mechanism of Respiration.

Postscript, August 1848.—It is interesting to notice that these views, which I hope to have an early opportunity of demonstrating, account for and reconcile the different views of the action of the intercostals, held by the great physiologists of the last century, who occupied themselves so warmly in what may be termed the battle of the intercostals.

Hamberger constructed a machine representing the sternum, the vertebræ, and two ribs, with threads interposed to imitate the external and internal intercostals and the inter-cartilaginous muscles. From this he inferred that the external intercostals are all inspiratory—the internal

While the thoracic set of ribs approach each other, their cartilages ascend and the inter-cartilaginous portions of their internal intercostal muscles act during inspiration.*

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all expiratory, and that the inter-cartilaginous muscles are inspiratory. —(Haller de Respiratione. Opuscula Anatomica, pp. 50. 92.)

Of this machine, Haller says, "Ponit nimirum CL. AUCTOR machinæ suæ costam utramque æque mobilem esse. Sed hujus modi costas DEUS nobis non dedit."

In opposition to Hamberger, Haller observed that he had overlooked, among other things, the difference of mobility in different ribs—the second rib being five times more moveable than the first, and so on; and he showed, from experiment, that during extreme inspiration the space between the first and second ribs diminished from ·85 in. to ·63 in.; and on extreme expiration it again increased from ·63 to ·89 (p. 52). He also showed that the ribs rotated on themselves, the lower edge moving outwards (p. 126). That the external intercostal and the inter-cartilaginous muscles were inspiratory, he agreed with Hamberger; but he differed altogether with regard to the internal intercostals, which he observed to be inspiratory in the superior intercostal spaces, especially in the first, in many experiments carefully conducted. He noticed that, below, the internal intercostals scarcely acted; but he laid it down as a rule that the internal and external intercostals combine to expand the chest during inspiration, thus agreeing with Mayow.

In this controversy both were right and both were wrong. Each was right in what he observed; but he did not observe the whole of the complex respiratory apparatus. Hamberger was right as to the lower ribs, for they diverge during inspiration. Haller as to the upper ribs, for they then converge. Hamberger, with Bayle, Fabricius, and Hoadley, was right in part, as to the separate functions of the outer and inner intercostals, the external being inspiratory, the internal expiratory throughout, behind and between the intermediate and adjoining ribs, at the side in man and the other mammalia, and throughout in reptiles. Haller was right in stating that the internal and external intercostals acted together in the upper intercostal spaces.

Dr. Reid, in an admirable article on respiration (Cyclopædia of Anatomy and Physiology, vol. iv. p. 333), says, the two lower ribs descend during inspiration. I observe that the lowest is stationary, the eleventh ascends, and both move backwards. From this relative motion of the two lowest ribs, whether on Dr. Reid's view or mine, the lowest external intercostal must be expiratory.

I imagine that Dr. Hutchinson's machine (which is like diagrams in Hoadley's, Bernoulli's and Monroe's works, and in my own paper) resembles Hamberger's, and that, like Hamberger, in acknowledging partial truth he has been led into partial error.

* "The cartilaginous portions" "of the second, third, fourth, and fifth

The movements that take place during a deep inspiration are these:—the scapulæ are raised; the anterior portions of the ribs, the sternum and the clavicles move forwards; the posterior portions of the ribs and the dorsal and lumbar vertebræ move backwards; the sternum and the dorsal arch become, both of them, more curved; the third, fourth and fifth costal cartilages at each side of the sternum advance more than the sternum, and the anterior prominences formed by those cartilages become fuller; the angles of the ribs move backwards more than the spine, and the deep space formed for the lung to each side of the spine increases in depth; the ribs expand laterally to a great but varying extent, the diaphragm descends, and the abdomen protrudes considerably, often more than an inch.

These movements of thoracic expansion are necessarily attended by the expansion and descent of the lungs and heart, and the compression and descent of the liver, spleen and stomach, and all the abdominal and pelvic viscera.

The lungs of course spread wherever the space is increased for them. The bulk of the upper portions of the lungs is in front, and of the lower portions behind; and, in conformity with this arrangement, the inspiratory movements of the superior ribs, or the thoracic set, is chiefly forwards and upwards, while that of the inferior or diaphragmatic set is chiefly backwards, (see the dotted lines in the figure at page 364, which indicate the thoracic expansion anteriorly and posteriorly,) the lower ribs not ascending so much as the upper, and the lowest of all having scarcely any ascending motion.

The diaphragm, in its descent during a deep inspiration, first flattens its own convexity, especially on the right side, and then descends from an inch to an inch and a half. It, consequently, lessens the concavity at the base of each lung,

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ribs" "are, during inspiration, raised and brought nearer to each other by the contraction of the sternal and inter-cartilaginous portions of the deep intercostal muscles."—The Author, on the Changes in the Situation of the Internal Organs. Provincial Medical Trans., vol. xii. p. 354.

especially the right, and draws down the whole base of each lung; in front, the right base descends from the lower end of the sternum to the lower end of the xyphoid cartilage, and both bases descend from the sixth costal cartilages to the seventh. At the side and behind, the descent is in the same proportion. The contraction of the central muscular fibres of the diaphragm draws down its central tendon from three-quarters of an inch to an inch. The heart is necessarily drawn downwards to the same extent; while the lungs spread into the space previously occupied by the heart, and cover it to an increased extent, so that the exposed portion of it is diminished. The heart is now shielded by the left lung at the fourth and fifth intercostal spaces, and its impulse is no longer felt there, but it is felt, instead, behind, below, and to the left of, the xyphoid cartilage.

While the descent of the diaphragm lengthens the thorax it compresses the abdomen. The liver, stomach, spleen, pancreas, kidneys, and all the abdominal organs, the uterus (the inspiratory descent of which has been felt by Dr. Frederick Bird), and all the pelvic viscera, are pushed downwards during a deep inspiration; at which time the perinæum protrudes more than it does in the tranquil state.

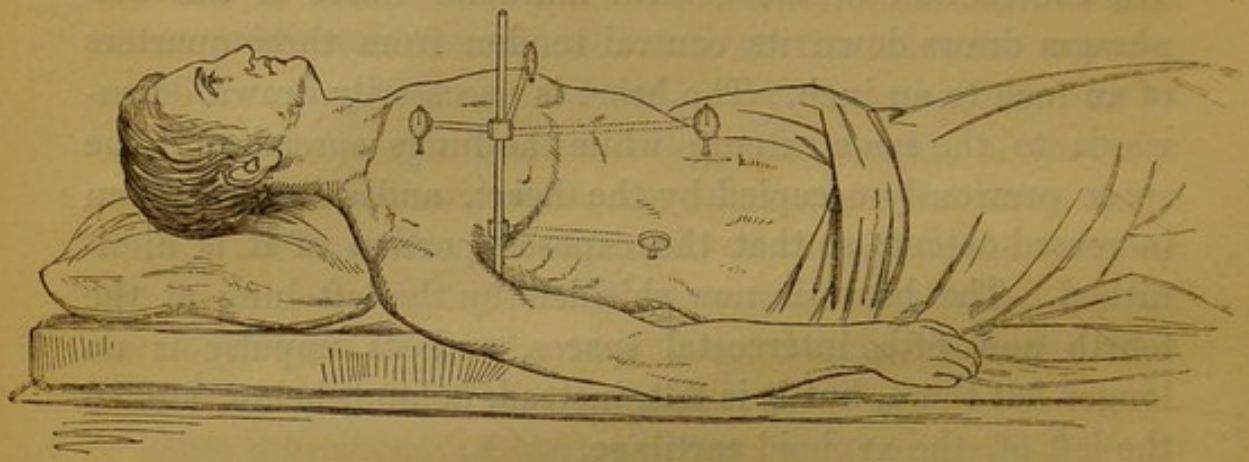
These inspiratory movements of the diaphragm have doubtless an important physiological action on the abdominal organs in thus displacing and compressing them. The blood, which accumulates during expiration in the solid viscera, is, during inspiration, drawn off, and the hollow viscera have their innate contractile force assisted.*

* Dr. Hutchinson says, op. cit., p. 187, "It appears to me a matter of doubt whether the diaphragm in the act of inspiration descends at all." This doubt has arisen from the falling in of *a part* of the abdomen during voluntary deep inspiration in the erect posture. In healthy persons when recumbent the abdomen between the xyphoid cartilage and the umbilicus moves forward, during an ordinary inspiration, ·3 in., and during a deep inspiration from ·5 in. to 1·5 in.

Any one may readily prove to himself the extensive descent of the diaphragm during a deep inspiration. Percuss over the lower margin of the right lung, ascertain its boundary, and mark it; desire the person to

On the Employment of the Chest-Measurer in Health.

The immediate indications afforded by the chest-measurer in health, must be considered during ordinary involuntary respiration, and during the deepest voluntary respiration.



CHEST-MEASURER APPLIED.

By placing the instrument in the manner here represented, the patient lying on the flat plate forming the basis of the instrument (see fig. at p. 355), the rack and dial, by a little adjustment, can be successively applied over the various parts of the chest and abdomen, without disturbing the patient.

The patient should be desired to look at the ceiling, that his attention may not be directed to the dial, by watching which his inspiratory movements are inevitably disturbed.

The instrument should be steadied by the hand holding the slide carrying the rod and dial, the finger and thumb having hold of the outer rotating tube of the horizontal rod (see fig. at p. 355).

To make a complete examination, the rack and dial may be successively applied over the different parts of the chest and abdomen, in the manner detailed in the note in the opposite page.

In almost all cases I employed the chest-measurer when the patient was lying on the back, perfectly straight, in bed. The instrument was thus perfectly steadied by the patient, lying on the horizontal flat plate that forms its basis: the

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take a deep breath, and hold it; then percuss downwards, and the hepatic dulness will be replaced by pulmonic resonance to the extent, in the adult, of an inch or an inch and a half. Notice the seat of the heart's impulse, first during ordinary breathing, and then during a deep inspiration; it will be displaced from the intercostal spaces, and will be felt behind or even below the xyphoid cartilage,—a manifest proof that the extensive descent of the central tendon of the diaphragm draws own the

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whole antero-posterior motion was conveyed to the index on the dial; and the examination was made in the manner usually most convenient, especially in hospital practice. It mattered little, however, whether the recumbent or sitting posture was adopted, so long as all the observations were made in the same manner.*

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heart. Notice the forward movement of the abdomen between the xyphoid cartilage and the umbilicus during a deep inspiration both in the recumbent and the erect posture; taking care not to be led astray by the irregular and volitionary play of the abdominal muscles that often takes place, especially when the person is erect.

No other proof of the descent of the diaphragm during a deep inspiration is needed than the inspection of Dr. Hutchinson's own accurate silhouettes, p. 186, 191. In diagram 16, p. 191, the abdominal organs from the ensiform cartilage to within a shade of the umbilicus are considerably more prominent during a deep inspiration than in the tranquil state, and they are everywhere more prominent than they are during a deep expiration.

* To observe the motion of the sternum and the thoracic set of ribs, and the expansion of the upper lobes, the middle lobe of the right lung, and the heart, I applied the instrument successively to the upper and lower end of the principal bones of the sternum, to the second rib, and to the fourth or fifth costal cartilage within and below the nipple;—to ascertain the motion of the intermediate ribs, and the expansion of the upper portion and bulk of the lower lobe and the lower portion of the upper, it was placed over the sixth rib in front and to the side, and the eighth ribs to the side;—to discover the motion of the diaphragmatic set of ribs, and the expansion of the lower portion of the lower lobe, and the displacement of the abdominal organs through diaphragmatic breathing, it was applied over the tenth ribs. Finally, it was applied to the abdomen in the centre, between the lower end of the sternum and the umbilicus, and at each side, to ascertain the motion of the diaphragm.

After taking these observations successively, and in the latter cases simultaneously on the two sides with two chest-measurers, I repeated them all, after desiring the patient during each observation to take as deep a breath as possible, and blow out as far as he could.

I then took the actual diameter of the chest from dorsum to sternum, and from side to side, at the fifth, eighth, and tenth ribs.

I also measured each side, at various places, with tape, from sternum to dorsum, observing the mobility of the ribs during the deepest possible inspiration and expiration.

Finally, the number of respirations in the minute, the extreme capacity of the chest, as tested by the spirometer, and the height and weight, were taken.

I also described the form of the chest, and its surfaces, the position of

Many and various applications of the instrument, of course by no means required in actual practice, were adopted in my inquiry, with the view of bringing the subject of the respiratory movements in health and disease to the test of accurate and general observation.

Motions observed by the Chest-Measurer during an Ordinary Inspiration.

In robust healthy males from the age of 12 to 45, the motion of the first six ribs (the thoracic and the uppermost of the intermediate set) was found to be trifling, but still in every case and everywhere some slight motion existed.

The motion of the upper end of the long bone of the sternum is usually from ·02 to ·06 in.; that of the lower end is about the same. The motion of the upper end is often greater than that of the lower; but the reverse is sometimes the case. The motion of the second ribs near their costal cartilages is a little greater than that of the corresponding portion of the sternum. The sternum is, indeed, pushed forward by those ribs through the medium of their cartilages; but a part of the force is spent in slightly bending the cartilages, and consequently the forward motion of the second ribs is necessarily greater than that of the sternum; thus, while the movement of the sternum is from ·02 to ·06 in., that of the second rib is from ·03 to ·07 in.

The advance of the sixth costal cartilages usually corresponds to that of the lower end of the sternum, being from ·02 to ·06 in.

The movement of the fourth and fifth costal cartilages is usually scarcely equal to that of the second ribs.

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certain of the viscera, and the changes induced in the seat of them, and the heart's impulse during a deep inspiration. (These notes are in my possession, and are accessible to any one interested in the subject.)

It was necessarily only the healthy *males* that underwent all this examination, and indeed only a portion of them. The tables and the cases in the Appendix will tell which were complete and which incomplete, as far as regards their examination.

The lateral expansion of the sixth rib is in almost all cases less than the forward motion of the sixth costal cartilage; but in this comparison the lateral expansion of each sixth rib is taken separately, while the whole forward movement over the sixth cartilage is observed from dorsum to sternum: the whole lateral expansion of the chest, from sixth rib to sixth rib, is equal to, or even greater than, the whole antero-posterior expansion of the chest over the sixth costal cartilage.

Owing to the presence of the heart, the motions of the left fourth, fifth and sixth cartilages, and the sixth rib, and indeed of all the left lower ribs, are less than those of the right; the difference being most usual and greatest over the fourth and fifth cartilages, and at the lateral expansion of the sixth rib.

The motions of the five superior or thoracic ribs are, with the exceptions stated, everywhere pretty nearly equal.

The lateral motions of the eighth and tenth ribs are almost invariably greater than those of the thoracic ribs and cartilages, so long as the breathing is quite tranquil, and the motion of the thoracic ribs small; the lateral expansion of the eighth and tenth ribs ranges usually from ·05 to ·1 in., while the motions of the thoracic ribs and cartilages vary from ·02 to ·05 in. It will be remarked, that if the motion of the thoracic ribs be greater than usual, say ·06 to ·1 in., the lateral motion of the eighth and tenth ribs is not increased, and then all the costal motions are nearly equal.*

There is very little difference between the exact motion of the ribs in healthy robust boys and in men, from the age of 10 upwards to 45. This rule does not, however, obtain with regard to the diaphragm; for while in man, during tranquil respiration, the advance of the centre of the abdomen between the xyphoid cartilage and the umbilicus is from ·25 to ·35 in., in boys and youths it is from ·2 to ·25 in.

The movements of the abdomen to each side is about the same in boys and men, being usually from ·08 to ·12. in.

* See Stevenson, Case 32, Table I.

It is manifest, from these observations, that in tranquil breathing diaphragmatic respiration far outweighs costal, in the proportion of about 30 to 5. It is also evident that the eighth and tenth ribs have a greater expansion than the thoracic ribs, owing to their action being auxiliary to that of the diaphragm.

Respiratory Movements during the deepest Voluntary Inspiration.

When a person takes as deep an inspiration as possible, the motion both of the ribs and diaphragm is everywhere much greater than during tranquil breathing, but the increased motion of the ribs is much greater than that of the diaphragm.

As I have stated above, the greatest observed difference between the motion of the second ribs during tranquil breathing and their motion during the deepest possible inspiration was in the runner ·05 in. and 2·25 in., or in the proportion of 1 to 45. This was, however, a man of unusual thoracic mobility and breathing-capacity, and his was in every respect an extreme case. The amount of increased motion evidently bears a ratio to the capacity of the lungs, and the mobility of the chest. Contrast the third of the following cases with the other two :—

Number in Table.	Name.	Height.	Extreme capacity of lungs.	Motion of second rib during	
				Tranquil breathing	Deepest insp.
		Ft. In.	Cubic inches.	In.	In.
17	O'Connell . . .	5 8½	170	·03 to ·07	·50
6	Nettleship . . .	5 4½	190	·02 to ·07	·50
12	Westall, the runner	5 8½	290	·05	2·25

In all these cases I felt satisfied that there was no chest-disease.

The eye, on running down the columns of the respiratory movements in ordinary and exaggerated breathing in health

(Table I.), will observe that in some cases where the breathing-capacity is small, the extreme costal motion is considerable, while in others, where the capacity is great, the extreme costal motion is comparatively but little. I do not doubt, however, that, if a sufficient number of cases were collected, it would be found that the extreme respiratory motions, as indicated by the chest-measurer, will, as a general rule, agree with the sound and important conclusions to which Dr. Hutchinson has arrived with regard to the breathing-capacity and the influence upon it of height, mobility of chest, age, weight, and other circumstances.

One thing is certain, that the extreme range of motion may vary considerably in persons whose chest and general system are perfectly sound. This is, I take it, in great part due to the inability of many persons, when recumbent, to inspire and expire deeply when directed so to do. In practice we shall find that healthy persons when recumbent may have a range of extreme respiratory motion varying from one-half or three-quarters of an inch to about an inch and a half, or even two inches.

The various ribs have nearly the same amount of motion during extreme respiration, but the lateral motion of each rib is less than its anterior motion. The extent of motion of the diaphragm is about the same as that of the ribs, since it descends about an inch; and that of the abdomen, between the lower end of the sternum and the umbilicus, is also about an inch, sometimes more and sometimes less.

The motion of the lower or diaphragmatic ribs and the eighth rib, which in tranquil breathing is greater, is in extreme respiration less than that of the thoracic ribs.

Many persons in perfect visceral health, affected with pain or injury, or some peculiarity of constitution, have an ordinary costal expansion of ·08 to ·12 or ·14 in.: in such persons the diaphragmatic motion is from ·20 to ·25 in., and the motion of the diaphragmatic ribs and the eighth ribs, instead of being greater, is often only equal to or even less than that of the thoracic ribs. (Table, Cases 28—37.)

In one man—Clay—(Table I., Case 30)—who had suffered from sciatica, the breathing, instead of being natural, was rather a succession of irregular sighs about nine in the minute; the second ribs had during inspiration a motion varying from ·1 to ·2 in., the abdominal muscles (diaphragm) advanced ·9 in. to 1 in., and the eighth and diaphragmatic ribs moved outwards from ·3 to ·4 in. In extreme inspiration the second rib advanced 1 in., and the abdomen (diaphragm) 1·60 in.

Respiratory Movements in Boyhood and Old Age.

In boys the cartilages are more flexible, and the costal mobility is greater than in adults. The extreme costal motion is in them greater in proportion to their breathing-capacity than in adults. Thus in Coupe, (Table I., Case 25,) aged 11, whose height was 4 ft. 7½ in., and breathing-capacity only 110 cubic inches, the ordinary movement of the second rib was ·06 in. and the extreme movement 1·30. Some boys, especially if they have been long in bed, have very little command over their inspiratory muscles, and in them the extreme movement may be slight. In Greenfield, (Table I., Case 27,) for instance, a boy of 10 years of age, pale, having a diseased knee, but whose chest was healthy, the ordinary motion of the second rib was ·03 in., and sometimes 0, and the extreme motion ·3 in. Such boys, besides their irregular volition, are manifestly out of practice in the complete action of their ribs.

In old age (Table I., Cases 38—44) each cartilage is ossified, forming with the rib one unbending piece. The costal motion is carried on by the lateral anterior and posterior thrust of the solidified rib and cartilage; and in old men, owing to the non-yielding of the cartilages, the advance of the sternum, both during ordinary and extreme inspiration, is often greater than that of the second rib. In this respect old age differs remarkably from boyhood, when, owing to the great flexibility of the cartilages, the costal advance is greater than the sternal.

For the same reason, namely, the completion into one un-

yielding piece of the rib and cartilage in the aged, the lower end of the sternum, owing to the sixth and seventh ribs being longer than the second, usually advances more than the upper portion; while in youth, owing to the flexibility of the cartilages, the upper portion of the sternum usually advances more than the lower end.

In the aged, the lateral motion of the sixth rib is increased, during both ordinary and deep inspiration, while that of the diaphragmatic ribs is diminished.

The ordinary diaphragmatic breathing of the aged is rather above the average, being from ·3 to ·5 in., but its extreme movement is not remarkable.

The difference both in the ordinary and extreme respiratory movement of the left diaphragmatic and intermediate sets of ribs, as compared with the right, is usually more marked in old age than in youth.

In the adult period of life the younger man has more often those varieties of costal motion characteristic of the boy, and the older man more often those of old age.

Influence of Height on the Respiratory Motions.

Height has a perceptible influence on the extreme costal motion, following the important law laid down by Dr. Hutchinson, that the breathing-capacity increases with the height.

I feel convinced of the soundness of Dr. Hodgkin's view that the increased capacity with height is in great part due to the increased length of the dorsal portion of the spinal column. The long-bodied dwarf given by Dr. Hutchinson at p. 184 does not really militate against this view, as that man is evidently a deformity.

An additional reason for the greater capacity of the tall is, I conceive, the greater length of their ribs as well as of their other bones. If so, in the narrow-chested tall man of great breathing-capacity, the ribs will be more oblique than in a short man whose chest is of equal diameter but whose capacity of breathing is smaller. In such a case, the tall man will have a

greater range of motion of his ribs, just as he has of his thighs when he raises them.

Respiratory Movements in the Healthy Female.

In the adult female, the form of the chest and abdomen, and the respiratory movements, are often undoubtedly modified by tight lacing.

The form of the chest and the respiratory movements do not differ perceptibly in girls and boys below the age of 10. Although the form of the chest remains nearly the same until the age of 12, the abdominal movement is then somewhat less, and the thoracic, somewhat greater, in girls than boys. At this age, and earlier, stays are worn; and though they do not compress the body materially, yet they restrain the free expansion of the lower ribs during brisk exercise. After the age of 14 the form of the chest and the respiratory movements differ materially in females and males. The transverse diameter of the chest from seventh rib to seventh, instead of being greater than that from fifth rib to fifth, as it is in males, is in females considerably less. This difference is greater or less, in proportion as the stays are worn more or less tight. There is a great difference in the respiratory movements, when the stays are on, and when they are off. When they are on, the thoracic movement is very much exaggerated, the second ribs then moving forward from ·06 to ·2 in., while when they are off, they only move forward from ·03 to ·1 in. On the other hand, the movements of the lower ribs and diaphragm are much more restrained when the stays are on (the abdominal movement being then ·06 to ·11 in.), than when they are off (the abdominal movement being then from ·08 to ·2 in.). During a deep inspiration the disproportion in the abdominal movement, or rather that at the so-called waist, is still greater, being about ·1 in. when the stays are on, and from ·15 to ·4 in. when they are off. The difference at the waist, when measured with the tape, is very striking, the increased measurement during an extreme inspiration being ·05 to ·3 in. when they are on, and from ·6 to 1·5 in. when they are off. I have found the

circumference at the waist from one to two inches less when the stays were worn than when they were taken off.*

These observations render it certain that the wearing of stays materially influences the respiratory movements, lessening the movement of the diaphragmatic ribs, and exaggerating

* The form of the chest in Ann Winfield, aged 6, (Table I., Case 52,) and Eliza Elsom, aged 11, (Table I., Case 49,) did not materially differ from that in boys of about the same age and size; and in M. Daft, aged 17, (Table I., Case 48,) but whose form and development was that of a girl of 14, the difference in form was inconsiderable.

In Winfield, during inspiration, the upper end of the sternum advanced	·05 in.;	the abdomen	·25 in.
In Elsom, the second rib advanced	·10	,,	·20
In Daft ,, ,,	·06	,,	·18 to ·20

Elsom and Daft both wore stays, and though the stays were loose, yet I conceive that their influence upon the chest had already commenced.

Jane Goodall, aged 33, (Table I., Case 45,) had at one time worn very tight stays; in her, while the lower part of the chest over the intermediate and diaphragmatic ribs was remarkably compressed, the seventh costal cartilages of the opposite sides below the sternum, being pressed near each other, the upper part of the chest was excessively developed. The diameter of the chest from side to side was from fifth rib to fifth rib 10·2 in., and from eighth rib to eighth rib 9·5 in. Compare this with Elsom's chest, in which these measurements were respectively 8·4 and 8·6 in., and with Daft's, in whom the influence of stays was more pronounced, and in whom the measurements were respectively 9·5 in. and 9·3 in.

In Goodall the second rib advanced, during each ordinary inspiration with stays on ·12 to ·2 in., and the abdomen ·08 in., (as well as it could be ascertained,) and the waist expanded during the deepest possible inspiration only $\frac{1}{10}$th of an inch. When she had her stays off, the second rib advanced ·06 to ·08 in., the abdomen ·12 to ·2 in., and the extreme expansion of the waist was about 1 in.

In Eliza Ball, aged 25, (Table I., Case 47,) who had always worn loose stays, the chest was not so excessively full above and contracted below, as was that of Goodall; the upper and lower diameter being respectively 11·7 in. and 11·2 in. The motion of the second rib with stays on was ·05 to ·11 in.; with the stays off ·12 to ·25 in. In Ball, though the stays were loose, they prevented the full expansion of the lower ribs during a deep inspiration; since, when they were on, the extreme expansion of the waist was $\frac{3}{10}$ths of an inch, and when they were off, an inch and a half. Here, although the stays were loose, there was an inch of compression, and the expansion, which ought to have been an inch and a half, was only $\frac{3}{10}$ths of an inch.

In Julia Green, (Table I., Case 45,) the amount of compression from stays was two inches, although the stays were not so tight as usual.

that of the thoracic. Even comparatively loose stays tend to produce this effect; since, though they may allow the ordinary movements of the diaphragm and the lower ribs, yet they do not permit their normal extreme movement, and they prevent the outward displacement of those ribs when the stomach and intestines are distended. I think it probable that in females, even if they wore no stays, the thoracic respiration would be relatively greater, and the diaphragmatic less, than in man; but this is only surmise.

The expansion of the lower ribs is much more impeded by stays than the descent of the diaphragm; indeed, I observed in one instance an increased movement over the lower part of the abdomen when the stays were on, to make up, apparently, for the diminished expansion of the lower ribs.*

Respiratory Movements in Children.

The respiratory movements in children are difficult to observe, owing to their irritability and constant motion.†

Although, in children, the inspiratory movement of the abdomen, indicating diaphragmatic respiration, is greater than that of the upper part of the thorax, yet it is not nearly so much so as it is in the adult: in children, the abdominal

* In Goodall, (Table I., Case 45,) the waist could only expand the tenth of an inch, while the lower part of the abdomen expanded seven-tenths, when her stays were on; yet, when they were off, the waist expanded an inch and a half, the abdomen only half an inch.

† In a child one day old I found the thoracic expansion to be ·03 in., and the abdominal ·03 in.; but the latter was more continuous than the former.

In J. Drake, aged 2 months, (Table I., Case 53,) a perfectly healthy child, observed when asleep, the upper portion of the sternum and the second rib moved forward during inspiration ·02 to ·04 in., while the lower end of the sternum and the sixth cartilage fell back from ·01 to ·02 in., and the lateral motion of the sixth and eighth ribs fell in ·01 in.; the abdominal advance was ·08 to ·15 in., and the diaphragmatic ribs, auxiliary to the diaphragm, moved outwards ·03 to ·04 in.

In Smith, aged 6 months, in perfect health, the upper ends of the sternum advanced during inspiration ·01 to ·03 in., the second rib ·1 to ·15 in., and the abdomen ·1 in.; while the lower end of the sternum and the sixth rib in front and at the sides fell back, during inspiration, from ·01 to ·08 in.

movement being from ·06 to ·15 in., and the thoracic, at the second ribs, from ·02 to ·12 or even ·15 in.

The respiration of children is notably different in this circumstance, that in them the lower end of the sternum and the adjoining cartilages, instead of advancing during inspiration, usually fall backwards. This is especially remarkable during rapid or sobbing inspiration.

The inspiratory falling back of the lower part of the chest is much more marked when the abdomen is large, its amount bearing a ratio to the abdominal prominence.

In children the abdominal organs are of greater bulk than the thoracic; and when, owing to the descent of the diaphragm, the latter replace the former, the walls of the chest collapse wherever the smaller thoracic replace the larger abdominal organs.

If the disproportion between the thoracic and abdominal organs be slight, and the inspiration gradual, the lower part of the chest may possibly not recede.*

When, owing to the inspiration being deep, the lungs enlarge considerably, the lower end of the sternum and the adjoining cartilages advance. When this is the case, they usually recede at the beginning of inspiration, and advance during its progress.†

If the cartilages and ribs be yielding at their junction, as in ricketty children, the sixth, seventh and eighth ribs and their

* In M. A. Scott, (Table I., Case 56,) a well-formed child, comatose, and occasionally breathing freely, who eventually died, and in whom the chest was full and the abdomen moderate in size, the lower as well as the upper end of the sternum, the sixth cartilages, the eighth and tenth ribs, all moved forwards or outwards from ·02 in. to ·05 in., the abdomen advancing ·08 to ·12 in. In this well-formed child, when the breathing was exaggerated, the sixth rib at the side fell in ·01 in. to ·02 in., although during tranquil breathing it moved somewhat outwards.

† In Susan Hotter, aged 2 years 8 months, a healthy child, with a fractured thigh, in whom the abdomen was rather large, the sixth rib, which fell in ·03 in. during tranquil breathing, moved outward ·06 in. when she breathed deeply. In her, when the larger abdominal organs were replaced by the smaller lungs, the ribs over them fell back, but when the lungs were enlarged by deep inspiration, they became larger than the abdominal organs, and then the ribs moved outwards.

cartilages bend inwards at the side, close to their point of junction, during inspiration, and in this case the lower end of the sternum is thrust forward.*

Summary of the Respiratory Movements in Health.

In the healthy, robust male, the movement of the sternum and of the thoracic and intermediate ribs, from the first to the seventh, is from ·02 to ·07 in. during an ordinary inspiration, and from ·5 or ·7 in. to 2 in. (the amount varying with the extreme breathing-capacity) during a deep inspiration. The ordinary abdominal movement (diaphragmatic) is from ·25 to ·3 in.; the extreme, ·6 to 1·6 in. The ordinary lateral expansion of the diaphragmatic or lower ribs is greater, and the extreme expansion is usually less, than the respective ordinary and extreme expansion of the thoracic or upper ribs. The expansion of the second ribs is usually alike on both sides; below, all the inspiratory movements, especially those over the heart, are usually somewhat less on the left side than on the right, both during ordinary and extreme inspiration.

In the healthy boy, owing to the greater flexibility of the costal cartilages, the extreme movement of the thoracic ribs is greater in proportion to the breathing-capacity than it is in the adult: the upper portion of the sternum advances more than the lower end during a deep inspiration; but there is little decided difference during tranquil respiration.

In the old man, owing to the consolidation of the cartilages, the motion of the sternum during inspiration is usually greater than that of the ribs (in youth it is less), and the lower end of the sternum usually advances more than the upper.

In females the thoracic expansion is exaggerated, and that of the diaphragm and the lower ribs is restrained, owing, in

* In Mary Wain, (Table I., Case 57,) an emaciated child of 2 years of age, thirsty, having a remarkably large abdomen and a small but prominent chest, the upper portion of the sternum moved forwards ·4 to ·5 in., and the lower portion ·12 to ·2 in., the sixth and eighth ribs and their cartilaginous portions on each side fell in ·02 to ·2 in., at the same time the abdomen moved forward ·15 to ·2 in., and the diaphragmatic ribs outward from ·05 to ·15 in.

great part, to the use of tight stays. The difference is much greater when the stays are on than when they are off.

When the stays are on, the thoracic movement at the second ribs is from ·06 to ·2 in.; the abdominal, from ·06 to ·11 in. When they are off, the thoracic movement is from ·03 to ·1 in.; and the abdominal from ·08 to ·2 in.

The restrained movement of the lower ribs during a deep inspiration is much greater when the stays are on than when they are off.

In infants, the thoracic expansion is considerable, being from ·02 to ·12 in.; while the abdominal is from ·06 to ·15 in. The lower end of the sternum and the adjoining ribs usually recede during inspiration, especially if the abdomen be large and the inspiration quick or sobbing.

The Rhythm of Respiration in Health.

In the perfectly tranquil respiration of the adult, inspiration and expiration are of nearly equal length. The inspiration is slow at the beginning, gradually quickens, and towards the end again becomes slow. The pause between inspiration and expiration is rather a transition than a pause; expiration, like inspiration, begins slowly, soon quickens, and towards the end of the act again becomes slow, gradually passing into the inspiratory act. In many healthy persons, the duration and character of the two acts is exactly the same, each beginning slowly, quickening in the middle, and gradually becoming again slow towards the end. A perfectly normal respiration is, in the adult, exactly pendulum-like in rhythm.

In general, the expiration begins more rapidly and ends more slowly than the inspiration.

In females and children this is almost always the case; in them the inspiration is usually rather quick; the expiration starts off quickly and becomes very slow towards the end. This is especially the case if they be excited or the breathing hurried from any cause whatever. The inspiration is quick and loud. The expiration rushes off at the beginning with an audible gush, and then becomes gradually slower.

	Duration of Inspiration beats.		Expiration beats.
In the perfectly tranquil breathing of adults the inspiration is equal to the expiration, or as	6	to	6
Frequently in adults the inspiration is to the expiration as	6	to	7
In the tranquil breathing of women and children inspiration, is to expiration as .	6	to	8 or 9
In the hurried breathing of females, as .	6	to	10 or 12
In old age the expiration becomes again prolonged, and inspiration is to expiration as	6	to	8 or 9

When the expiration is prolonged, it usually begins quickly and ends slowly; and it may be observed that, in this case, the diaphragm ceases to act before the end of the expiration, while the costal contraction continues, however slightly, to the end of the act.

In many healthy persons having prolonged expiration, the expiratory action of the diaphragm begins, perceptibly, before that of the ribs.

PART II.—CAUSES THAT DISTURB THE RESPIRATORY MOVEMENTS, THE LUNGS THEMSELVES BEING HEALTHY.

SECT. I.—*Cases in which the Motion of the Ribs of both Sides is restrained.*

In posterior curvature at the fifth and sixth dorsal vertebræ the motion of all the ribs above the curvature, and of the upper portion of the sternum, is restrained though not annihilated, while that of the ribs below it, and of the lower end of the sternum, is exaggerated; the action of the diaphragm being much increased.

If the curvature be at the last dorsal vertebra, the motion of the ribs immediately above is restrained, while that of the thoracic ribs and the abdomen (diaphragm) is exaggerated.*

* Effect of posterior curvature of the spine on the respiratory movements:—

In the two cases observed with the chest-measurer, the motion of the

Sect. II.—*Cases in which the Motions of the Ribs on one Side may be restrained.*

These are, lateral curvature of the spine; injury or disease of the ribs; of the intercostal muscles, including pleurodynia; of the mamma; or of the axilla, shoulder, or arm, and probably hemiplegia.*

A.—*Effect of lateral curvature of the spine on the respiratory movements.*—In excessive curvature with the convexity to the right, the left lung is very small, and the left ribs

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ribs superior to the curvature was much interfered with. In the boy Bulwer, (Table II., Case 58,) in whom the first five dorsal vertebræ were perfectly horizontal, and all below the sixth quite vertical, the motion of the second rib was ·05 in., and of the fourth costal cartilage ·02 in., while that of the right eighth rib was ·1 in., and the left ·12 in., and that of the right diaphragmatic rib was ·18, and the left ·07. The motion of the sixth rib, which was immediately below the curvature, and the usual motion of which is less than that of the second, was, in Bulwer, even greater than that of the second. The lower end of the sternum, which was considerably more prominent than the upper, moved forward ·15 in., while the upper part of the long bone moved forward only ·05 in. This great increase in the motion of the lower end of the sternum is due to the greatly increased range of motion of the lower ribs. The motion of the abdomen, which was greatly increased at the sides, was but little affected in front, the movement at each side being ·18 in., while that in the centre was only ·2 in. In the case of a youth, (Table II., Case 59,) obligingly shown to me by Mr. Hare, whose posterior curvature had been (as shown on a cast) very great indeed, but was then very materially lessened, the motion of the lower end of the sternum, which protruded considerably, was ·1 in., while that of the upper end of its long bone was only ·02 in. The abdominal motion was, in this case, very great anteriorly, being, in tranquil respiration ·5 in., and on deep inspiration 1·5 in.; but the lateral abdominal movement was only ·1 in. on the right side, and ·07 in. on the left.

* Effects of hemiplegia on the respiratory movements:—

I have made a cursory examination of several cases of hemiplegia, but have not met with one in which the amount of respiratory movement was palpably affected.

Dr. Todd favoured me with the examination of the case of Williams, (Table, Case 72,) at King's College Hospital, who had, in addition to hemiplegia, mitral regurgitation. In this poor woman the left second rib moved ·08 in., while the right moved ·06 in., consequently this rib was not affected by the paralysis; over the fourth and sixth ribs, and, to a less degree, over the diaphragmatic ribs, the motion was lessened, and, at

are all approximated, while the right ribs are unusually far apart. During inspiration, the whole costal and diaphragmatic expansion of the left side of the chest is restrained, while that of the right side, especially of the diaphragm and diaphragmatic ribs, is exaggerated.

If the convexity be to the left, the motion of the right side is restrained and that of the left exaggerated.*

If the curvature be inconsiderable, the costal motion may not be modified, though that of the diaphragm may, that

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the sixth rib, was reversed on the left side; but this was manifestly due, not to the paralysis, but to the heart disease.

In the child, E. Brooks, (Table II., Case 73,) who suffered from left hemiplegia, there was little or no marked difference between the motion of the two sides.

Although I have not yet met with a case of paralysis in which the respiratory movements were affected, I think it likely that such cases exist. Paralysis of the voluntary muscles is complete in chloroformization, and yet the respiratory movements remain if the inhalation be not pushed too far. It is therefore clear that even in complete hemiplegia of the voluntary muscles, there may be no hemiplegia of the respiratory muscles. Under chloroform the diaphragm continues in action after the costal respiration has ceased. I think it probable that the same state of things may obtain in some cases of hemiplegia; that there may be hemiplegia of the costal muscles while the diaphragm on the affected side remains active.

* Movements of respiration in excessive lateral curvature:—

The ribs articulating with the concavity of the curvature are approximated, as is well shown in the figure in Mr. Bishop's papers on deformities, in the Lancet, p. 63, July 1846 (while those articulating with the convexity of the curve are separated). In a girl, Jane Clifton, having extreme lateral curvature to the left side, of whom I have a diagram, the lower end of the sternum was drawn over, as well as the curvature, considerably to the left; the right lung was greatly diminished in size (it weighed 7 oz., while the left lung weighed 15 oz.), and the right belly of the diaphragm was much lessened.

In the case of a young person (Table II., Case 61) having extensive curvature to the right, (with the examination of whom Mr. Hare favoured me, and in whom the curvature, when I saw her, had been much lessened,) the motion of the right second rib was ·2 in.; left, ·1 in.: right fourth rib, ·15 in.; left, ·03 in.: sixth rib, right, ·15; left, ·08: tenth rib, right, ·15 in.; left, ·03 in.: and in the abdomen, that of the right side was ·15 in., and left ·03 in. The central motion of the abdomen was ·35; of the lower end of the sternum, ·12, and the upper end, ·15.

side of it having the greatest motion which is in the direction of the convexity.*

B.—*Effects of injuries or diseases of the ribs or parts contiguous to the ribs on the respiratory movements.*—Non-motion or diminished motion of one side of the chest may exist, and yet the lungs may be perfectly healthy. The cases given below† prove that the respiratory motion of the

* In the case of Beaton (Table II., Case 62) the lateral curvature with the convexity to the right side was slight, affecting the lower dorsal vertebræ. The gastric bulge was almost obliterated, while the hepatic bulge was greatly increased. In him the motions of the left side were generally nearly equal to those on the right side, or that of the spinal convexity. The difference in the motion in this boy's left diaphragmatic ribs was more markedly lessened, being ·03 in tranquil, and ·15 in deep respiration, while on the right side these ribs had the respective motions of ·06 and ·35.

† Respiratory movements modified by injury to, or disease of, the parts contiguous to the ribs, the lungs being healthy :—

I have a diagram, taken from a boy who, some years since, had his left arm almost dragged off by machinery; the arm was removed at the shoulder-joint; the chest was itself uninjured; the lungs perfectly healthy. The whole of the left side had shrunk in, and, so far as the eye could judge, was motionless, while the right side was capacious and moved freely. The lower margin of the right lung descended during a deep inspiration nearly an inch, while the descent of the left lung was not perceptible, and the heart descended five-eighths of an inch. In this boy, as the wound healed, the size and motion of the left side gradually increased, until at length it was equal to, or probably even greater than, that of the right side. Here, there was no injury to the ribs, and no affection of the lungs, yet the ribs adjoining the injury did not move.

In the case of a woman, aged about 40, admitted into the hospital, there was deep-seated cellular inflammation around the left scapula and shoulder-joint. She had a cough, expectorated frothy mucus, and had diminished motion, with falling in, and partial dulness on percussion over the second and third ribs below the left clavicle. The question presented itself, did this dulness on percussion and non-motion depend upon disease in that part of the lung, or on the extensive and painful disease in the contiguous structures? There were varying mucous and sonorous rhonchi in different parts of the chest, not more so at one part than another, and the presumption that the external disease was the cause of the non-motion was confirmed by the autopsy, which revealed extensive suppurative inflammation around the scapula, and general bronchitis; but there was no perceptible disease in the upper part of the left lung.

In Severn, (Table II., Case 63,) a lad in whom the left shoulder and left side of the neck and head were severely injured in a coalpit, but in whom

whole of one side of the chest, or of any of the ribs, may be restrained, prevented or reversed; by the fracture of a

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there was no perceptible injury to the lungs or even to the ribs, the left second and third ribs fell in ·06 in. during inspiration, while the right second rib moved forward ·03 to ·06 in.; the movements of the left diaphragmatic ribs and the left side of the abdomen were but little less than those of the right side. His recovery was slow. Several months after the injury, being then well, he was again examined, and it was found that the movement of both second ribs was alike. The exact injury was never ascertained in this case; but, from the complete recovery of lost motion, it is almost certain that his ribs were uninjured.

In the case of Frost, (Table II., Case 64,) extensive deep-seated cellular inflammation of the left arm; in that of Bingham, (Table II., Case 65,) fracture of the left arm; in that of Lane, (Table II., Case 66,) erysipelatous abscesses in the right axilla; and in that of Mrs. Barker, (Table II., Case 67,) an extensive scirrhous ulceration of the mamma,—caused in each instance restraint in the motion of the contiguous thoracic ribs to an extent varying in proportion to the severity of the injury or disease. In the case of Ward, (Table II., Case 68,) there was an irregularity in the second rib from the union of a fracture inflicted years before: during tranquil breathing, though not during a deep inspiration, the motion of that rib was less than that of the corresponding rib on the left side. In the case of Parker, (Table II., Case 69,) there was an abscess between the second and third costal cartilages, and there were good reasons for thinking that no disease existed in the lung itself. The various motions of the second, fourth and sixth ribs were materially less on the affected than on the sound side, while those of the diaphragmatic ribs were quite normal. Sketchley, (Table II., Case 70,) a stout fellow, a porter, suffering habitually from bronchitis, was brought lately into the hospital with emphysema diffused through the cellular tissue of the body and right arm and hand; the third left rib was broken, causing a loud jerk during each inspiration. There was no pneumothorax; noisy rhonchi were audible over the whole chest. In this man the ribs of the injured side fell in during inspiration, while those of the right side in part moved forward. This case is, of course, complicated both with disease of, and injury to, the lung; but the side on which the injury was seated could be fixed upon, without the aid of any other sign, by the reversed motion of the affected side. The injured side in this case was indeed discovered by this sign before the precise injury was made out.

In addition to the causes just illustrated, pleurodynia may restrain the local respiratory movement, as the case of John Moore (Table II., Case 71,) evidences. He complained of a violent intolerable pain between the fourth and fifth left costal cartilages on moving or taking a deep breath, or rising in bed, or making any quick motion; indeed, his involuntary cries were

rib, abscesses in the intercostal spaces, local pleurodynia, inflammation of the axilla, shoulder-joint, or arm, or fracture of the arm,—in short by any injury or affection of the ribs or of the parts contiguous to the ribs. Whenever, indeed, the motion of one or more ribs would give pain to or injure either the ribs, the intercostal muscles, or any neighbouring part, their respiratory movements may b trestrained or arrested.

Sect. III.—*Cases in which the Motion of the Ribs on one Side may be permanently exaggerated.*

This happens from the loss of an arm, and certain congenital or acquired malformations.

When an arm is cut off, the weight with which it formerly bore upon the thoracic ribs is necessarily removed, the ribs are less restrained in motion on the mutilated than on the sound side, and the movements of those ribs are consequently exaggerated.*

In some persons there is excessive development of the right third, fourth and fifth costal cartilages; the respiratory movements may then be abnormally great over the unusually developed costal cartilages.

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very loud and agonising, and were accompanied by universal violent contraction of all the expiratory muscles.

The respiratory movements during tranquil breathing were everywhere normal, except at the region of the pain, over the left fourth and fifth costal cartilages, the motion on the right side was ·04 in., and that on the affected side ·005 in., sometimes ·03 in.

In this man there were no signs either of lung or heart disease, and the pain was evidently exclusively muscular. The normal character of all the other movements, except at this isolated patch, was in itself a demonstration of the soundness of the thoracic organs.

* Effects of the permanent loss of an arm on the respiratory movements :—

The removal of an arm necessarily lightens the weight with which it bore upon the ribs. The thoracic ribs are less compressed on that than on the opposite side. In W. Glossop, (Table II., Case 75,) a boy whose left arm was removed below the deltoid some weeks before, for an injury, the motion of the right second rib was ·15 in. to ·4 in., while that of the left was ·1 in. to ·3 in. The whole of the rest of the movements were quite normal. I do not doubt that this isolated case is a perfect type of its class; it is so reasonable that the ribs should move more freely after the removal of the greater part of what was before a compressing weight.

SECT. IV.—*Cases in which the Motion of the Diaphragm, both during tranquil and deep Inspiration, is restrained.*

The motion of the diaphragm is restrained throughout by peritonitis, abdominal tumours, especially those connected with the diaphragm, and aortic aneurism. It is restrained on the right side only by greatly enlarged liver, from abscesses or hydatid cysts, and adherent liver.

A. — *Effect of peritonitis on the respiratory movements.* —In peritonitis there is always great intestinal distention. The diaphragm is raised, and the lungs and heart are in consequence compressed upwards. The descent of the diaphragm and the abdominal movements are very much restrained, especially at the centre, where they are, indeed, sometimes annihilated. The diaphragmatic or lower ribs partake of the diminished movement of the diaphragm, to the action of which they are auxiliary. The motion of the superior or thoracic ribs is very much augmented. The movement of the lower end of the sternum is scarcely altered, its tendency to diminished motion, owing to the restrained diaphragmatic movement, being a little more than balanced by the exaggerated forward movement of the thoracic ribs.

The motion of the abdomen at the side is not so much lessened as it is in front, especially, I conceive, if the peritonitis do not seriously affect the serous surfaces of the diaphragm, and the liver, spleen and stomach.*

* Effect of peritonitis on the respiratory movements :—

The diaphragm in peritonitis is nearly at rest, as during each inspiration the diaphragmatic movement would necessarily rub the inflamed surfaces upon each other, and thereby increase the affection. We consequently find that in peritonitis the diaphragmatic motion is very much restrained.

In the case of Barratt, (Table II., Case 76,) a man in the hale and prime of life, affected with extensive peritonitis following the operation for hernia, the central abdominal expansion in tranquil breathing, which ought to have been ·3 in., was ·01 to ·05 in., and the costal breathing at the second rib, which ought to have been ·02 in. to ·04 in., was ·16 in. to ·22 in. In the same way, in Kew, (Table, Case 77,) a young man with retention of urine and universal peritonitis, the abdominal movement was ·06 in.,

In *diffused* peritonitis, the restrained abdominal movement is central and diffused; when the inflammation is

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and that of the left second rib was ·3 in.; and in Hussey, (Table II., Case 78,) a female with peritonitis, the abdominal movement was ·03 in. and that of the left second rib ·4 in. In all these cases the central abdominal movement was slight, while the thoracic respiration was much exaggerated. The diminution of the abdominal and exaggeration of the thoracic breathing being in an inverse ratio to each other, as the one falls the other rises, until the actual amount of each may be exactly translated, the abdominal movement falling from ·20 in. or ·30 in. to ·03 in. or ·06 in., and the thoracic movement rising from ·03 in. or ·06 in. to ·20 in. or ·30 in.

In the case of Severn, (Table II., Case 79,) a spare young man who had chronic peritonitis with abdominal effusion, and from whom the effusion had almost but not entirely disappeared, the diminution of the central abdominal movement was proportioned to the mildness of the disease, it being ·08 in. to ·13 in., while that of the second ribs was ·1 in., and of the upper sternum ·13 in.; the proportion of diminished abdominal and increased thoracic movements being here, as in the extreme cases, strictly kept.

We may refer to Simpson's case, (Table II., Case 81,) in which the same ratio obtained, owing to an abdominal tumour, without peritonitis, the abdominal advance being here ·15 in. and the thoracic ·10 in. or ·08 in.; and to the case of Clarke, (Table II., Case 84,) with abdominal distention, in whom the abdominal advance was ·20 in. and the thoracic ·08 in. or ·09 in.; and to that of Barton, in whom, from hepatic or abdominal adhesions, the abdominal movement at the centre was ·10 in., preceded by falling in, and the costal advance was on the left side ·30 and on the right ·19 in., the left movement being further exaggerated in his case by the restrained movement of the whole right lung.

Indeed, this important law of compensation obtains in every disorder of respiration,—when the movement is restrained in one part it makes up for it, and often more than makes up for it, in another. Besides this, in peritonitis, the demands on respiration, owing to the severity of the disease, are increased, and the respirations are not only more frequent but deeper.

It will be observed that in all the cases of peritonitis given, three of which were fatal, the lateral abdominal movement was but little lessened, being—

	At the sides of the abdomen—		While at the centre it was—
	Right.	Left.	
In Barratt	·02 in.	·0 in.	From ·01 in. to ·06 in.
In Kew	·07	·08	·06
In Hussey	·07	·06	·03
In Severn	·1	·1	·08 ,, ·13
In healthy males . .	·09	·09	·25 ,, ·3
In healthy females .	—	—	·1 ,, ·2

[The figures denote the forward movement during inspiration.]

The case of Barratt, the only exception, is the best proof of the completeness of the law, that, when peritonitis is local, the motion of the con-

local, the motion of the contiguous abdominal walls is lessened.

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tiguous abdominal walls is lessened. The peritonitis in this case followed the operation for strangulated femoral hernia on the *left* side, and there was no lateral motion whatever on the left side, while on the right it was ·02 in.

While the motion of the thoracic ribs was exaggerated, that of the diaphragmatic ribs was diminished. This is in accordance with the whole auxiliary function of those ribs.

The sixth rib has a slightly increased motion. Being the superior of the intermediate set, it partakes more of the increased motion of the thoracic than of the diminished motion of the diaphragmatic ribs.

In the subjoined Table, the abdominal movement may be compared with that of the diaphragmatic ribs, and contrasted with that of the second ribs, and both may be compared with that of the sixth costal cartilages.

	Abdominal movement.			Diaphragmatic ribs.		Second ribs.		Sixth costal cartilage.	
	right.	centre.	left.	right.	left.	right.	left.	right.	left.
	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.
1. Barratt . . .	·02	·01 to ·06	·00	·06	·06	·16 to ·22	·16 to ·22	·08	·06
2. Kew	·07	·06	·08	·05	·03	·20	·30	·06	·06
3. Hussey . . .	·07	·03	·06	·02	·02	·33	·40	·07	·08
4. Severn . . .	·10	·08 to ·13	·10	·05	·05	·10	·10	...	·05
5. Average male	·09	·25 to ·30	·09	·10	·10	·03 to ·07	·03 to ·07	·03 to ·06	02 to ·05
6. Average female	...	·10 to ·20	...	...	...	·05 to ·10	·05 to ·10	·03 to ·05	·02 to ·05

[The figures denote the forward movement during inspiration.]

We see that the sixth intermediate cartilage has an intermediate amount of motion; and we also find that the advance of the lower end of the sternum bears a close ratio to that of the sixth costal cartilage. Consequently, while the motion of the upper portion of the long bone of the sternum is greatly exaggerated, that of the lower end is about the same as in the healthy state, as is well illustrated by the actual movements in the above cases.

	Upper end of sternum.	Lower end of sternum.	Sixth costal cartilage.	
			right.	left.
	inch.	inch.	inch.	inch.
Barratt.....	·10	·05	·08	·06
Kew	·15	·01	·06	·06
Hussey.....	·20	·05	·07	·08
Severn	·13	·05	..	·05
Average healthy male ..	·03 to ·06	·02 to ·06	·03 to ·06	·02 to ·05
Average healthy female	·06 to ·10	·03 to ·06	..	...

[The figures indicate the forward movement during inspiration.]

Owing to the great exaggeration of thoracic respiration, the head, in peritonitis, is visibly lowered during each inspiration.*

Rhythm of respiration in peritonitis.—In one case only, that of Barratt, was the rhythm noted, and in him inspiration was longer than expiration. The abdominal expiratory muscles are, in peritonitis, always tense; they offer, in consequence, resistance to the diaphragmatic movement, and they support the inflamed surfaces. Even during inspiration, the expiratory muscles act, resisting and retarding the inspiratory act; while, during expiration, the momentum is, as it were, already in action, and the expiration is shortened.

Shortened expiration may be regarded as one of the effects and signs of peritonitis.

B.—*Effect of abdominal tumours and aortic aneurism when contiguous to the diaphragm on the movements of respiration.*—Abdominal tumours will have a greater restraining effect on the movements of respiration the higher they are, and the more closely they are attached to the diaphragm. In Simpson, (Table II., Case 81,) a hard tumour, the size of a cricket-ball, was seated in the abdomen, between the sternum and the umbilicus; it was raised at each aortic pulsation, though it had no lateral pulsation of its own. During inspiration, the abdomen advanced ·15 in., being only half the normal movement. The motion of the diaphragmatic ribs was unusually small, being only ·05; while that of the thoracic ribs was above the average, being from ·05 to ·1 in.

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* Local peritonitis:—

Ch. Osborne had, when suffering from fever, lasting pain over the head of the colon. There were, unquestionably, ulcerations in the mucous follicles, in the first instance; and, afterwards, partial peritonitis. This is inferred from the fact of the partially restrained motion over the seat of the head of the colon. In cases of fever attended by ulceration of the inflamed mucous membranes, there is usually no restraint of abdominal motion. In Osborne's case, contrast the motion over the head of the colon, ·06 in. to ·08 in. with that over the corresponding region of the opposite side, which is ·15 in., and, at the centre, from ·10 in. to ·15. in. Here the motion was restrained fully one half.

In a case of abdominal aneurism (with the observation of which I was favoured by Dr. Burrows) pointing to the side of the left seventh costal cartilage, the contiguous abdominal movements were less than those of the corresponding parts on the right side.

C.—*Effects of greatly enlarged liver on the respiratory movements.*—If the liver be simply enlarged, it finds its way downwards and to the left, and therefore does not encroach much on, or embarrass the movements of, the diaphragm, especially in the erect posture.

If there be large adventitious deposits in the liver, as hydatid cysts, malignant tumours or abscesses, the form of the organ is changed; it then often protrudes upwards, displacing the diaphragm upwards and restraining its descent.

In such cases the descent of the right side of the diaphragm and the movements of the diaphragmatic and intermediate sets of ribs are very much restrained. The motion of the thoracic ribs of the right side, though often somewhat exaggerated, is usually much less so than that of the left thoracic ribs. The movements of the left thoracic and intermediate sets of ribs are much exaggerated. The motion of the upper end of the sternum is much greater than that of the lower end. The abdominal movement at the centre and on the left side is not materially affected.*

* I possess a diagram, taken from a young man in whose liver were several large abscesses. He had also peritonitis, and great intestinal distention. In this case, the hepatic bulge is enormous. The heart is displaced upwards, and altogether to the left of the centre of the sternum, and the upper convexity of the liver rises as high as the second intercostal space (Table II., Case 82).

In the case of a young person whose habits had been athletic, but who was, when examined, much attenuated, the hepatic bulge was very large. The liver was of great size, encroaching, upwards, on the right lung; forwards, on the costal cartilages; and, downwards, many inches below its usual site. Two rounded swellings, one of great size, evidently with fluid or semi-fluid contents, (hydatids ?) in the substance of the liver, could be felt below the costal cartilages. The right lung was much duller on percussion than the left. Its lower lobe was evidently consolidated, while the upper was resonant and respiring. The heart was

If the liver be adherent, especially if the base of the right lung be adherent also, I infer from the cases referred to below* that the action of the right side of the diaphragm is much restrained, but more so in front than behind.

The extreme inspiratory movements and the breathing-capacity are much diminished in persons suffering from greatly enlarged liver, containing adventitious deposits, and also, I conceive, in those in whom the liver is adherent.

SECT. V.—*Cases in which the action of the Diaphragm is slightly lessened during an Ordinary Inspiration; considerably restrained during a Deep Inspiration.*

These are cases of *general abdominal distention* from flatus, ascites, or extensively enlarged and adherent ovarian cysts.

In the extreme cases, the motion of the diaphragm also is restrained during an ordinary inspiration.

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somewhat displaced to the left, evidently by the enlarged liver. The left lung was everywhere resonant, and expanded freely. In this case, the enlargement of the liver was complicated with consolidation of the lower lobe of the right lung. The effect of each morbid state on the respiratory movements was traceable. The whole of the respiratory movements of the right side were restrained or reversed, while the whole of those of the left side were exaggerated. The motion of the right diaphragmatic ribs, over the liver, was particularly affected, as they fell in ·02 in. to ·03 in., while those of the left side moved outwards ·05 in. The falling in, or non-motion, of these ribs may be considered the special effect of the enlarged liver. The motion of the fourth and sixth costal cartilages was 0 in. and ·01 in. on the right side, and ·04 in. on the left side. Here the influence of the consolidated right lower lobe combined with that of the enlarged liver to restrain the movements. The expansion of both upper lobes was exaggerated; but, while the right second rib advanced ·10 in., the left advanced ·25 in., the motion of the right being restrained by the condensed lower lobe and the enlarged liver. The upper end of the sternum, in conformity with the abnormal influences, advanced more than the lower end, in the proportion of ·10 in. to ·04 in. The abdominal motion was not much lessened, being, at the centre, ·25 in.

* I believe that in Barton, (Table II., Case 83,) aged 32, and Stone, (Table II., Case 84,) aged 69, the liver was adherent to the diaphragm. In them, the lower margins of the right lung and liver did not descend perceptibly during a deep inspiration, while the lower margin of the left lung descended freely.

Abdominal distention elevates the diaphragm, presses upwards the lungs and heart, and lessens their size.

The motion of the thoracic ribs is somewhat exaggerated during ordinary breathing; that of the diaphragm, except in extreme cases, being scarcely altered.

During a deep inspiration the increased motion of the diaphragm is unusually small, while that of the thoracic ribs is considerable.

If the stomach be greatly distended, the expansion of the left side of the chest is less than that of the right.*

* Effects of abdominal distention on the respiratory movements:—

In the case of Clarke, a lad who died from diabetes, caused and kept up by masturbation, the abdomen was much distended by *flatus*; the abdominal muscles were permanently rigid; the chest was flat, while the gastric bulge, and, to a less extent, the hepatic bulge were unusually prominent; the lower costal cartilages and ribs being pushed outwards, both to the sides and in front. The thoracic viscera were pushed up by the abdominal distention; the lower boundary of the lungs and heart was high, being behind the fourth intercostal space, instead of the fifth. The motion of the left side of the chest was throughout less than that of the right, the chief abnormal difference being at the seat of the chief distention, which, as is well shown in the diagram now before me, was due to the enormously swollen stomach and colon. These encroached upwards on the left lung and the heart more than the liver encroached on the right lung; the movement of the right fourth and sixth cartilages and the sixth rib were respectively ·08, ·10 and ·09 in., while those of the left were ·05, ·05 and ·05 in.; the right and left second ribs had the same motion, ·08 in., in tranquil breathing, but on deep inspiration the difference was marked, being over the right 1·10 in. and over the left 1 in. The abdominal motion was somewhat lessened in tranquil breathing, being at the centre ·20 in.; but during a deep inspiration the increase was unusually small, being only ·50 in. In Clarke, the left lung was perfectly sound, as the autopsy manifested; and yet the anterior expansion of the left lung was considerably less than that of the right. This was due to the upward pressure of the stomach being more immediate than that of the liver, and to the comparative non-descent of the heart, which, therefore, could not be replaced by the anterior superior portion of the lung. In health the heart descends, as already stated, to a great extent, and makes way for the expanding lung.

The upper boundary of the liver, the highest part of its convexity, lay behind the third intercostal space, the liver being pushed upwards by the distended stomach and bowels.

The very small size to which the lungs are reduced by abdominal dis-

Sect VI.—*Cases in which the Respiratory Movements are unaltered during both Tranquil and Deep Inspiration.*

Such are cases where there are ovarian cysts of moderate size free from adhesions; and the impregnated state, even to the last months.

Enlarged ovarian cysts, when they are free from adhesions, and of moderate size, do not modify the respiratory movements. When they are very large, they restrain the extreme diaphragmatic movement; and when they are adherent, they restrain that movement still more. The cysts descend freely, to the extent usually of an inch, when they are free from adhesions; but only to a slight extent when they are adherent: a test is thus afforded of the presence or absence of adhesions by the non-descent or the descent of the cyst during inspiration. Dr. Frederick Bird habitually avails himself of this test.*

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tention fully explains the distress occasionally seen in peritonitis and other affections.

I have not observed any case of *ascites* with the chest-measurer; but the general effect is undoubtedly the same with that from accumulated flatus. A greater amount of distention can usually be borne from ascites than from accumulated flatus, as the accumulation in the former is slow, and the system adapts itself to it, while in the latter it is usually quick; for the same reason the diaphragm can be forced higher in extreme cases of ascites than in distention from flatus.

In Frederick Green, the subject of ascites, a diagram of whom is given at p. 398 of my paper in the Provincial Medical Transactions, the diameter of the left side is an inch less than the right. The cartilages of all the lower ribs are thrust outwards.

* Abdominal distention from ovarian dropsy:—

This state differs from ascites in that the tumour does not affect the diaphragm in the earlier stages; and at the later stages only acts intermediately on it, pushing it upwards. From the enormous size sometimes attained by the ovarian cysts, they may elevate the diaphragm to the utmost extent. In one diagram in my possession, from a case of ovarian dropsy, in which the cysts were enormous, the upper convex boundary of the liver was just below the second rib. I have not observed any cases of this class with the chest-measurer; but I possess three diagrams taken from living cases.

In the case in which the ovarian cysts were very large, the descent of the diaphragm, though much restrained, was quite appreciable, and in the

In the pregnant state, the respiration, whether tranquil or deep, is not interfered with; indeed, I conceive that, in the present mode of dressing, the breathing is carried on with less interruption in the impregnated, than in the unimpregnated, state, owing to the requisite loosening of the stays. At the same time, the increased demands on the vascular system in the pregnant state call then for increased respiratory movements.*

If the abdominal distention be very great in the impregnated state, I doubt not but that the diaphragmatic movements will be somewhat restrained.

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other two cases the descent was considerable, being in one scarcely diminished. In both these cases, the inspiratory descent of the upper boundary of the tumour was at least an inch, manifesting that there were no adhesions. Dr. Frederick Bird informs me that he judges that the ovarian cyst is free from adhesion if its inspiratory descent be considerable.

* Influence of parturition on inspiratory movements:—

This is not of course a pathological influence; but it is so closely analogous in its effect to some of the causes (ovarian dropsy) of abdominal distention, that its effect can be most readily studied in this place.

I have before me two diagrams from women, one being in the sixth the other in the ninth month of pregnancy. In both of these the diaphragmatic descent, ascertained by percussion, was very little affected; the lower border of the lungs and the liver descended on each side about an inch, and the upper boundary of the gravid uterus descended at each inspiration a full inch; indeed, the impregnated uterus has a natural inclination to fall forwards out of the way of the abdominal viscera, thus making room for them during the displacement.

I observed two pregnant women (Table II., Cases 86, 87) with the chest-measurer. In both of them the costal movements were perfectly normal, being unexaggerated; the motion of the second rib being in each only ·05 in., half the usual amount in women wearing stays. This tranquil state is, no doubt, due, in great part, to the impossibility of these persons wearing tight stays. In Sands, the abdominal expansion at the centre was only ·10 in., somewhat less than that in health with the *stays off*; but the expansion over the whole abdomen was equal, there being a motion on the right and left side of ·10 and ·08 in. As the whole abdomen was increased in size, the diaphragmatic descent diffused its effect over a more extended surface than in the unimpregnated state; consequently we may infer that in these persons the diaphragmatic descent was fully equal to that in the unimpregnated. In Mrs. Key, whose abdomen was very much distended, the descent was not so great, being ·08 in. at the centre, and ·04 ·06, or ·08 at the side.

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Sect. VII.—*Effects of Disease external to the Thorax on the Rhythm of Respiration.*

The rhythm of respiration is not materially altered by any of the causes that affect the respiratory movements, when the thoracic organs are healthy, except peritonitis, in which the expiration is shorter than the inspiration.

The want of alteration in the rhythm of respiration in these cases is one of the means by which they may be distinguished from diseases of the chest.

PART III.—ON THE EFFECT OF DISEASES OF THE RESPIRATORY ORGANS ON THE MOVEMENTS OF RESPIRATION.

Having inquired into the movements of respiration in health, and into the abnormal causes which modify those movements, the heart and lungs remaining healthy, we now inquire into the modifications of the respiratory movements, caused by diseases of the respiratory organs.

Sect. I.—*The Effect of Obstruction to Respiration in the outer Breathing Passages on the Movements of Respiration.*

The obstruction to respiration may exist in the nostrils and palate, the fauces, the larynx, or the trachea.

If the obstruction to respiration be considerable, the diaphragm is low, the lower boundaries of the lungs and heart are drawn down, and the chest is elongated, narrowed, and flattened. Owing to the falling back of the lungs to each side of the heart, a large portion of that organ is in contact with the walls of the chest, and its impulse is felt over a considerable space.

The efforts to inspire are powerful, but more or less inefficacious and struggling, in proportion to the amount of the obstruction. Inspiration and expiration are performed with a loud, harsh, hissing noise—often audible over the whole room.

The respiratory muscular efforts are powerful, but the motions are restrained.

The diaphragm, which is permanently low, descends during inspiration with great force; but the abdominal movement is seldom greater, and is often considerably less, than it is in ordinary healthy inspiration.

The walls of the chest recede during inspiration.—The motion of the chest is very peculiar. Instead of the ribs and sternum obeying the inspiratory muscular efforts, in extreme cases, where the obstruction to respiration is almost complete, the sternum and the costal walls fall backwards, the whole chest collapsing during each inspiration. At the same time, the abdomen protrudes, owing to the descent of the diaphragm; and the lower or diaphragmatic ribs, instead of falling in like the rest of the ribs, move outwards to a slightly exaggerated extent. The outward motion of those ribs is owing to their action being purely auxiliary to that of the diaphragm. It is only in extreme cases that the whole thoracic walls fall in: usually, the upper thoracic ribs (the second) advance, while the lower end of the sternum and the adjoining cartilages and ribs recede. It is manifest that the costal muscles are powerfully exerted, but their force is overpowered by a stronger force, and, yielding in the struggle, the lower end, and sometimes perhaps the whole, of the sternum and the thoracic walls fall backwards, instead of advancing, during inspiration.

See the cases detailed below, illustrating this interesting subject.*

* Effect of narrowing of the outer breathing passages on the movements of respiration:—

I have before me two diagrams, taken from William Piner, one immediately before, the other some time after, the operation for laryngotomy was performed. I extract the following from the report of his case:—"May 18, 1843.—W. Piner, aged 34.—He breathes with difficulty, and with a loud noise, on expiration; is very pale; his countenance expresses distress, anxiety and starvation. A very small quantity of air enters at each inspiration, to effect which the abdomen is much protruded, but the sternum falls backward about half an inch at the lower end, and one-eighth of an inch at the upper. This is due to the diaphragm, at its descent, dragging down the base of the lung; and as air cannot rush in

The cause of the collapse of the chest during inspiration is very apparent, and is well illustrated by an observation made

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through the narrowed larynx to fill up the chest, the pressure of the external air forces in its walls: the pulse is just perceptible, 130. The soft palate and the pillars of the fauces are matted together, hard, cartilaginous, contracted, united apparently to the vertebræ, and forming one large contracted cicatrix.

"2½ P. M.—Mr. White forced a curved trochar and canula into the larynx, between the cricoid and thyroid cartilages; the patient immediately inspired freely through the canula. The chest expands freely; the sternum no longer falls back, but rather moves forward; pulse much stronger; face red, and surface warm; heart's action perceptible; expression of anxiety gone. He soon fell asleep, when the respirations, previously 20, were 12 to 16 per minute."

In this man, *before* laryngotomy, the chest was flattened and narrowed, especially on the left side, the size of the right side of the chest being larger, owing to the presence of the liver. The lower margin of the right lung was behind the seventh cartilage, a full inch below its normal site. *After* laryngotomy, the lower margin of the right lung ascended a full inch. The chest became normally full and well developed; the chief increase being on the left side. The action of the diaphragm was no longer violent; when he took a deep inspiration it descended three-quarters of an inch.

In another case of laryngitis, (the case of Daniel Bull,) in which Mr. White performed laryngotomy, and on which observations were made with the chest-measurer, the whole sternum, and sometimes the whole thoracic walls, fell in during each inspiration. Immediately after the operation the normal inspiratory expansion returned.

At whatever part of the air-passages the obstruction may be, the general effect will be the same.

There will be the same difficulty to the entrance and exit of air through the air-passages, whether the obstruction be in the nostrils and palate, as in Robinson, from erysipelas; or in the fauces, from enlarged tonsils, as in Chester, ill with scarlatina (Table III., Case 88); or in the larynx, from inflammation, as in Scattergood; or from laceration of the trachea, as in Slater; or in the trachea, from bronchocele, as in Mann and Maltby.

We have seen that in Piner's case the lower margin of the lung was drawn down, and the chest flattened: all the rest would possess, more or less, similar characteristics.

In all of them, the chest, especially the sternum, was flattened, while the abdomen was somewhat enlarged.

In Scattergood, as well as Piner, the lower margin of the lung was an inch lower than it is usually: no doubt varying degrees of this permanent descent obtain.

by Professor Sharpey, which any one may repeat on himself. Pass a tape round the chest; close the glottis, so as to pre-

In all of them the walls of the chest fell backwards to an extent varying in proportion to the obstacle.

Respiratory movement. Ordinary inspiration, where the contrary is not mentioned.	Abdomen.			Diaphragmatic ribs.		Lower end of sternum.	Sixth costal cartilage.		Upper end of sternum.	Second ribs.	
	right	centre.	left.	right.	left.		right.	left.		right.	left.
	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.
Piner, æt. 37, great obstruction in the fauces and larynx	...	..	...	...	...	*·50	...	...	*·12	...	...
Ball — laryngitis	...	rose	...	...	...	fell	...	...	fell	...	...
J. Chester, æt. 13, enlarged tonsils—scarlatina	·18	·0	·25	·12	·15	*·14 to *·20	*·10 to *·15	...	*·06 †·20	·30	·25
J. Maltby, æt. 21, bronchocele;	·18	·30	·10	·07	·06	*·04	*·03	*·03	*·03 †·005	*·03	*·02
deep inspiration	...	...	...	...	...	*·10 †·20	...	...	...	...	*·10 †·70
J. Mann, æt. 13, bronchocele:	...	·30	·03	·10	·09	*·02 †·02	*·03	*·03	*·02 †·05	·05	*·01 †·05
deep inspiration	...	1·00	...	...	...	...	...	...	·40	·40	...
A. Scattergood, æt. 16, enlarged tonsils and laryngitis:	·12	·12	·06	·10 to ·15	·10	*·04 †·07	·10	*·01 †·06	·08 to ·15	·10	·08
deep inspiration	...	1·00	...	...	...	·50	...	...	...	1·00	·70
Robinson, æt. 25, obstructed nostrils and palate:	·05	·15	·10	·10	·09	*·06	*·01 †·05	*·02	*·02 †·04	·10	*·01 †·06
deep inspiration	...	·20	...	...	...	...	...	...	·30	...	...
Ann Slater, æt. 27, lacerated larynx, hung herself:	·02	·06	·02	...	...	*·02	·02	·02	·40	·06	·02
deep inspiration	·20	·40	·20	...	...	*·30	*·30	...	*·06	·60	·40
Sarah Meads, æt. 27, chronic laryngitis	·10	·20	·10	·11	·12	*·04	*·01 †·02	*·01 †·02	*·01 †·04	·05	·05
In healthy male	·09	·25 to ·30	·09	·10	·10	·02 to ·06	·03 to ·06	·02 to ·05	·03 to ·06	·03 to ·07	·03 to ·07
In healthy female	...	·10 to ·20	...	...	...	·03 to ·06	·02 to ·06	·02 to ·05	·06 to ·10	·05 to ·10	·05 to ·10

[The sign * prefixed, signifies a falling to that extent. Where no mark is prefixed, and also where the † is prefixed, a *rise* is indicated.]

In each of these cases the first line of figures indicates the movements during ordinary respiration; the second line when added shows the movement on deep inspiration.

vent the entrance of air during the inspiratory efforts, and then attempt to breathe with the diaphragm: the abdomen will protrude considerably, but the anterior walls of the chest will fall backwards, and the tape round the chest will show a diminution in circumference of from a half to one inch. In hiccough, the vocal chords are closed immediately after the beginning of a convulsive attempt at inspiration; the descent of the diaphragm and the protrusion of the abdomen is great, and the chest is elongated, narrowed, and flattened. In hysteric struggling, the vocal chords come together during inspiration, and the same respiratory movements take place, the abdomen protruding unusually, and the chest falling in.

If we lengthen a closed India-rubber bottle, containing air, the sides of it collapse; if we compress and shorten it, they swell out. So with the lungs; if they be lengthened when the air can neither escape from nor enter them, their sides will collapse; if they be shortened, their sides will swell out.

In the extreme cases, in which no air can enter the lung during the inspiratory efforts, the diaphragm descends with power, and drags down the yielding, spongy lung. The lung is considerably lengthened, and, as no air can get into it, it necessarily collapses at the side and in front, owing to atmospheric pressure. Under these circumstances, the walls of the chest are forced backwards.*

In all the cases the thorax was flattened, narrowed or elongated, the abdomen relatively full, and the lower boundary of the thoracic viscera unusually low.

The great inspiratory action was diaphragmatic; the motion of the sternum and of many of the ribs being reversed. It was not that the costal muscles were inactive, but the contrary: for in Chester the second ribs advanced ·30 and ·25 in.; and in Maltby they fell back on tranquil respiration, but on deep inspiration they advanced ·70 in.

* "The passage of the air into and from the lung has an important effect upon the muscular respiratory movements. When a lung, or a considerable portion of it, is prevented from expanding by disease or any other cause, the pressure of the air on the inner surface of that portion of the chest covering the unexpansible lung is not now exercised during its dilatation; in other words, this portion of the chest, in expanding, must do

The force of the muscular expansion of the chest is overpowered by the superior force of atmospheric pressure. According to the degree of diaphragmatic descent and of closure or narrowing of the air-passages, is the falling back of the thoracic walls partial or universal. The falling in of the lower end of the sternum, and of the contiguous sixth costal cartilages, is, in these cases, almost invariable, unless, as in old age, the costal cartilages be ossified, when the lower end of the sternum may be protruded by the upward and forward movement of the ribs; but in this case there is usually falling in of the sixth and eighth ribs to the side.

The second ribs almost always advance, and they, in consequence, often push forward the upper end of the sternum; but, in the extreme cases, that also falls back, as in Piner, Maltby, Mann, and Slater (Table III., Cases 89, 90, 93). The following is the order in which different parts of the chest fall in, according to the extent of the diaphragmatic descent and the obstruction in the air-passages:—

When the obstruction to the entrance of air is slight, as in Scattergood, from enlarged tonsils, (Table III., Case 91,) only the lower end of the sternum falls in.

If the obstruction be a little greater, the sixth costal cartilages, in addition, fall in.

If it be still greater, as in Slater, from laceration of the larynx or trachea, (Table III., Case 93,) the upper end of the sternum, in addition, falls in.

If still greater, as in Mann, from bronchocele, (Table III., Case 90,) the fourth costal cartilages, in addition, fall in.

If still greater, as in Maltby, from bronchocele, (Table III., Case 89,) and in Piner, from obstruction in the fauces, the second costal cartilages, in addition, fall in.

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so in opposition to the whole of the atmospheric pressure on its outer surface, amounting to 15 lbs. on the square inch. This pressure appears to be too great for the muscles of inspiration, acting upon that part of the chest, to overcome, for the ribs are there motionless, or nearly so, and, if the lung is in a state of collapse, the walls of the thorax covering it fall in."—Dr. Reid, art. Respiration, Cycl. of Anat. and Phys., August 1848, p. 337.

While, in the extreme cases, all the thoracic and the intermediate ribs may collapse during inspiration, in every case the lower or diaphragmatic ribs move outwards to the normal or to an exaggerated extent. Thus in Chester, an extreme case, the diaphragmatic ribs moved outwards from ·12 in. to ·15 in., instead of ·09 in. or ·10 in. This is a striking corroboration of the purely diaphragmatic auxiliary action of those ribs.

In a patient with consolidation of the lower lobe of the left lung, and in whom there was very slight laryngeal narrowing, the whole of the thoracic expansion was diminished, but it was nowhere reversed.

It will be observed in all the cases, that, at certain parts, the same rib that falls in at the beginning of an inspiration moves forwards towards the end of it. In such instances, the first action of the diaphragm, the descent of which is sudden, is to draw down the lung more rapidly than air can rush in to supply the displaced portion of it, and the walls over the lung necessarily collapse. The diaphragm acquires almost at once its complete descent, and the lung its complete elongation and collapse; the action, however, of the thoracic ribs, at first overpowered, continues, and the lung becomes thereby gradually expanded; the reversed motion consequently speedily ceases and gives place to the usual expanding motion.

Effect of narrowing of the air-passages on the respiratory movements during a DEEP *inspiration.*—In the cases of Scattergood, Maltby, Mann, and Slater, it may be noticed that certain ribs that fell in during an ordinary, moved outwards to a considerable extent during a deep, inspiration; the ribs in question usually but not always fell in just at the beginning of the deep inspiration.

Mrs. Slater, before she coughed, inspired quickly and deeply, and then the falling in of the lower end of the sternum was greatly increased, and the upper end of the sternum that previously advanced then fell backwards. In all cases, if the inspiration increased in rapidity, the falling in

increased in extent, although the whole inspiration was deeper; the increased rapidity of the diaphragmatic descent causing a greater lateral and anterior collapse of the lungs and chest. When the deep inspiration is performed slowly, the ribs that recede in ordinary inspiration may advance during the whole act.

Whatever cause impedes the entrance of the air through the air-passages—whether obstruction in the nostrils and palate; enlarged tonsils; narrowed fauces, obstructed larynx (as in laryngitis) or trachea (as in croup and bronchocele);—may produce restrained and reversed motion of the thoracic walls during inspiration, owing to the excessive action of the diaphragm and the diaphragmatic ribs, and the consequent elongation and collapse of the lung.

Obstruction in the right or left bronchus.—I have not met with a case in which the right or left bronchus alone was obstructed by a foreign body, or by narrowing of the bronchus, either from disease in its walls or external pressure; but it is very evident that in such a case the motion of the ribs over the affected side will be reversed, while that of the opposite ribs and of the diaphragm will be exaggerated: indeed, this sign will indicate into which bronchus a foreign body may have fallen.

Effect of obstruction of the air-passages on the EXPIRATORY *movements.*—In cases of obstruction in the air-passages, the expiratory motions are usually the exact reverse of the inspiratory; that is to say, when a rib falls back in inspiration it advances in expiration; and when it first falls in and then moves forward during inspiration, it first moves forward and then falls in during expiration.

Effect of narrowing of the air-passages on the rhythm of RESPIRATION.—In Robinson, (obstruction in the nostrils,) the duration of the inspiration was to that of the expiration as 6 to 10.

In Maltby, (thyroid body enlarged,) it was as 5 to 8.

In Scattergood, (disease of larynx,) expiration was slower than inspiration.

In these cases the expiration was slower than the inspiration; but in that of T. Chester, a boy with enlarged tonsils, the inspiration was slow and followed by a pause, after which the expiration was performed with a gush; here the inspiration and pause seem to have been longer than the expiration.

In all the cases I have seen of obstruction to respiration arising from laryngitis, the expiration has been longer than the inspiration. The greater length of the expiration is due, I conceive, to widening of the laryngeal inlet by muscular control during inspiration, while, during expiration, the vocal chords not being drawn asunder, the outlet is narrower, and the obstruction greater. It is difficult to account for the lengthening of expiration in Robinson's case, from interruption in the nostrils, and in Maltby's, from bronchocele.

In Robinson, during expiration the abdomen fell back, quickly at first and then slowly, while the thoracic ribs moved forwards, their advance being equally slow throughout. Here the diaphragm returned suddenly at the beginning of expiration, pushing the lungs into the thoracic space more quickly than the air could escape from them. The walls of the chest were forced outwards to give increased lateral space for the shortened and thickened lung; the action, in fact, of inspiration was reversed.

The falling back during expiration of the thoracic walls at the second ribs was equally slow throughout: this was noticed both in Scattergood's case and that of a patient with condensed left lower lobe, as well as in Robinson; and this equal slowness of thoracic expiration is characteristic of obstruction in the outer air-passages. The rhythm, then, in these cases is disturbed, the expiration, which is equally slow throughout, being usually longer than the inspiration, especially in laryngitis.

In the case of enlarged tonsils, the expiration was not prolonged.

Summary.—Obstruction to respiration in the outer air-passages may arise from clogged and narrowed nostrils and palate, enlarged tonsils and narrowed fauces, larynx or trachea

(pp. 393-398); obstruction to respiration in one lung, from narrowed or clogged right or left bronchus. (p. 400.)

In cases where the air-passages are materially obstructed, owing to the elongation and collapse of the lungs, the chest is flattened, narrowed and elongated, the lower margins of the lungs are unusually low; from the presence of the liver, the right side is fuller than the left, and, from the collapse of the left lung in front, the heart is in great part in contact with the walls of the chest, its impulse being extensive.

The diaphragmatic descent and abdominal protrusion are very rapid and sometimes extensive, but generally the abdominal protrusion is diminished; the lungs, admitting air with difficulty, are lengthened, and, owing to atmospheric pressure, they collapse, and the sterno-costal walls, especially at the lower end of the sternum, fall backwards. (pp. 394-399.) The thoracic walls, in some places, often recede at first and then advance during inspiration. (p. 399.)

The extent of the reversed thoracic motion is in proportion to the narrowing of the air-passages and to the extent and rapidity of the diaphragmatic descent. (p. 398.)

During a deep inspiration, many parts of the thoracic walls, that fall in at the beginning of the act or during tranquil breathing, advance considerably as the expiration is prolonged. (p. 399-400.)

The inspiration is shorter than the expiration, especially in laryngitis: the expiratory falling back of the abdomen is often quick at first and then slow, but the expiratory falling back of the thoracic ribs is always equally slow throughout. (p. 400-401.)

Sect. 2.—*Effect of Obstruction in the smaller Bronchial Tubes, Bronchitis and Vesicular Emphysema, on the Movements of Respiration.*

In the cases considered in the last section, the air found its way into the lungs with difficulty, owing to obstruction to respiration in the outer passages; the lungs and chest were consequently elongated, narrowed and flattened, and they contained little air.

In *bronchitis* and *vesicular emphysema*, the outer passages are free, but there is obstruction to respiration in the smaller bronchi; and while the air enters the cells with difficulty, there is much greater difficulty to the exit of the air from the cells. The air gradually accumulates in the air-cells, which are distended, and in emphysema very greatly dilated, the whole lungs being necessarily greatly enlarged.

The chest of course partakes of the increased size of the lungs and heart. It is rounded, broad and deep, being expanded to the utmost. The dorsal curve is unusually great, and the diaphragm is also very much lowered.

Effects of bronchitis and emphysema on the respiratory movements during ordinary respiration.—The chest and its contents are throughout amplified to an extent greater in extreme cases than they can be in health during the deepest possible inspiration.

The heart is enlarged and lowered. The enlarged lungs spread forwards and downwards in front of the heart, occupying a great portion of the space previously occupied by that organ; they in great part cover the heart and interpose themselves between it and the sternum, ribs and intercostal spaces. A small portion of the right ventricle is in contact with the thoracic walls, immediately behind and to the left of the xyphoid cartilage. The impulse is no longer perceptible over the intercostal spaces, but is felt over, below, and to the left of the xyphoid cartilage.

The diaphragm is everywhere flattened, and is a full inch lower than it is in health.

Owing to the obstruction in the smaller bronchi, and to the chest being already almost expanded to its greatest possible extent, the efforts of inspiration, though energetic and laborious, cannot inflate the lungs to anything like the healthy degree.

The lower end of the sternum and adjoining cartilages recede during inspiration.—During inspiration, the diaphragm descends with great force, drawing down and elongating the inferior portion of the lungs, while the upper part of the chest moves forwards and upwards, expanding the superior por-

tion of the lungs. While the abdomen and the upper part of the chest protrude, the lower end of the sternum and the adjoining costal cartilages collapse during inspiration. The same remarkable phenomena occur that take place in extreme narrowing of the larynx; the chest falls backwards during inspiration: but, whereas in extreme cases of laryngeal obstruction the whole chest may be flattened and narrowed during inspiration, in emphysema and bronchitis the upper part of the chest always moves forward during inspiration, and it is only the lower part of the chest that recedes.

The chest collapses in bronchitis and emphysema, for the same reason that it does so in extreme laryngeal obstruction; the lungs are enlarged above and lengthened below more rapidly than air can enter them, and, owing to atmospheric pressure, they necessarily collapse below, and the walls of the chest there fall backwards. The walls of the chest at the lower end of the sternum and the adjoining cartilages recede in bronchitis and emphysema, for the same reason that they recede (though more extensively) in extreme narrowing of the larynx. The falling back during inspiration of the lower end of the sternum, and the adjoining costal cartilages, and the protrusion of the abdomen and of the upper part of the chest, is shown in the accompanying Daguerreotype views of W. Rawson, a boy aged 13, suffering from bronchitis and emphysema. In relation to this subject, I beg to refer to the explanation given in the last section, p. 394-398.

The inspiratory efforts of the diaphragm and the upper part of the chest are very great and laborious, but the inspiratory movements of these parts are far from being augmented to a corresponding extent. The abdominal movement is often lessened, and but seldom augmented, in emphysema; and although the motion of the second ribs is often somewhat exaggerated, in some cases it is not so. In every case, the inspiratory muscular efforts are much more exaggerated than the respiratory movements of the upper part of the chest. The movement of the diaphragm, during the deepest possible inspiration, is never so great as in health, its extreme descent being in the

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worst cases only the third of an inch, and in milder cases two-thirds (as will be seen in the Table and analyses of cases given below);* while the inspiratory muscular efforts of the dia-

* Table referred to above :—

	Upper portion of sternum.	Second rib.		Abdomen.
		right.	left.	
	inch.	inch.	inch.	inch.
In W. Redmill, age 46, emphysema, bronchitis—Table III., Case 101	·05	·07	·04	·30
John Hart, 32, bronchitis, some emphysema, dyspnœa—Table III., Case 99	·02 to ·06	·02 to ·09	03 to ·12	·18
John Worth, 30, bronchitis, emphysema—Table III., Case 102	·03 to ·05	02 to ·05	·02 to ·10	·25 to ·35
C. O'Donnell, 46, bronchitis, emphysema ...	·07	·05	·05	·40
W. Galloway, 46, diseased heart, emphysema, bronchitis—Second observation.—Table III., Case 98*b*	·06	·12	·14	·20
Geo. Simpson, 50, bronchitis—Table III., Case 97	·04	·09 to ·12	·09 to ·08	·25
W. Rawson, 13, bronchitis, emphysema—Table III., 96*a* 96*b*.—See Daguerreotypes	·04 to ·10	·06 to ·11	·12	·12 to ·18
Second observation	·03 to ·10	·03 to ·12	·15	·35
W. Shaw, 30, emphysema, bronchitis—Table III., Case 108	·08	·10 to ·15	·08 to ·15	·45
J. Shaw, 45, chronic bronchitis, slightly obstructed larynx—Table III., Case 104	·12 to ·20	·10 to ·15	·10 to ·15	*5 †·23
J. Linthwaite, 50, chronic bronchitis—Table III., Case 100	·09 to ·24	·10 to ·25	·10 to ·25	·10 to ·40
J. Squire, 30, chronic bronchitis, emphysema—Table III., Case 95	·20 to ·30	·25 to ·26	·22 to ·25	·31 to ·50
Healthy male from 10 to 45 or 50	·03 to ·06	·03 to ·07	·03 to ·07	·25 to ·30

The ordinary figures, and those with † prefixed, denote a forward motion during inspiration; those with * prefixed, a backward motion.

In Linthwaite, J. Shaw, and Galloway, the upward movement of the upper end of the sternum was a little more than its forward movement.

	Linthwaite.		J. Shaw.		Galloway.
	Ordinary inspiration.	Deep inspiration.	Ordinary inspiration.	Deep inspiration.	Ordinary inspiration.
	inch.	inch.	inch.	inch.	inch.
The upper portion of the sternum advanced	09 to ·24	·40	·25	·90	·04 to ·05
,, ,, moved upwards	·09 to ·21	·55	·30	·90	·06

In many of the cases, the inspiratory muscular efforts were very powerful, the supplementary muscles being called into action. The amount

phragm are unusually energetic. (With a much slighter effort, I have seen the diaphragm descend in health from one

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of motion was far from being equal to the muscular force. The resistance to the muscular effort is unusual, and resides in the costal walls, (which have already, even at the end of expiration, the dimensions produced in health by the deepest possible inspiration, their minimum being the maximum of health,) and in the minute tissue of the whole lungs.

The abdominal protrusion was above the average in—

	Abdomen.			Diaphragmatic rib (10th.)	
	right.	centre.	left.	right.	left.
W. Shaw	inch. ·12	inch. ·45	inch. ·10	inch. ·01 *·03	inch. ·03
J. Worth	...	·25 to ·35	...	·03	·03 to ·10
J. Squire	·12	·31 to ·50	·12	·20	...
C. O'Donnell	·06	·40	·11	*·01 †·10	·11
J. Linthwaite	·07 to ·15	·10 to ·40	·07 to ·15	·10 to ·20	·10 to ·20
W. Rawson, second observation	·10	·35	...	...	...

It was normal in—

Redmill	·10	·30	·10	·10	·10
Simpson	·10	·25	·10	·10	·06

And was lessened in—

W. Galloway, first observation	·08	·20	·12	·03	·08
Second observation	·06	·20	·05	·015	·015
J. Hart	·08	·18	·09	·04 to ·06	·04
John Shaw	·02 to ·03	*·05 †·23	·02 to ·03	·08 to ·10	·08 to ·10
W. Rawson, first observation—worst	...	·12 to ·18	...	·10	·12
Health	·09	·25 to ·30	·09	·10	·10

The ordinary figures, as also those with † prefixed, denote a forward movement to that extent; those with * prefixed, a backward movement, during inspiration.

In all these cases the muscular action was much exaggerated, but especially in those where the abdominal motion was diminished.

Rawson, an interesting boy of 13, (whose daguerreotypes, were taken first in the tranquil state and then during a deep inspiration,) illustrates this point well. When he was first observed, he had, in addition to habitual enlargement of the lungs, a severe attack of bronchitis; the

to two inches.) The muscular efforts are more powerful in proportion to their inefficiency and to the severity of the disease.

In all the cases the diaphragmatic action was exaggerated, but especially in those where the abdominal motion was diminished. This is well illustrated by the case of Rawson, detailed below. When first examined, he suffered from a severe attack of bronchitis, with emphysema; the diaphragmatic efforts were very laborious, but the abdominal movement was only half the healthy amount, being ·12 to ·18 in.; when observed a second time, after the disappearance of bronchitis, the abdominal movement was ·35 in., while the diaphragmatic effort was inconsiderable. This diminution of abdominal protrusion with manifestly increased diaphragmatic effort, allies in this respect emphysema and bronchitis, with cases of extreme laryngeal obstruction, in which the same phenomena present themselves.

The falling back of the lower end of the sternum and the

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dyspnœa was extreme : at this stage, when the respiratory muscles were strained to the utmost, the abdominal protrusion was only ·12 to ·18 in., while during the second observation, made a month later, when the bronchitis had nearly ceased, the abdominal protrusion was above the average, being ·35 in.

In John Shaw, in whom respiration was very difficult, it will be seen that the abdomen fell back at the beginning of the inspiration, and then moved forward. In this man the entrance of air had a double difficulty in the smaller bronchial tubes and in the obstructed larynx. The falling in of the abdomen at the beginning was due, I conceive, to the lateral expansion caused by the excessive action of the diaphragmatic ribs, the outward movement of which was ·08 to ·1 in., while that of the abdomen at the sides was only ·02 to ·03 in.

It will be observed that in John Shaw, whose muscular efforts were very powerful, and whose abdominal protrusion was the greatest, being ·45 in., the lateral motion of the abdomen was only ·02 to ·03.

This diminution of abdominal protrusion with manifest increase of diaphragmatic effort allies the cases now under review to those in which the outer air-passages were obstructed. By referring to the table of those cases, it will be seen that in most of them the abdominal protrusion was lessened,—in Slater, it was only ·06, while the diaphragmatic action was rapid and exaggerated. In Piner, in whom the obstruction was the greatest, the abdominal protrusion, judging by the eye, was considerable.

adjoining part of the chest is more extensive and greater in amount, in proportion to the amount of obstruction in the smaller bronchi, the energy and inefficiency of the inspiratory musular efforts, and the flexibility of the costal cartilages.*

In the slighter cases the lower end of the sternum recedes only at the beginning of inspiration. The descent of the diaphragm is very rapid at first, a portion of lung is displaced downwards, and, as air cannot enter with sufficient rapidity, the lower parts of the lungs collapse, and the lower end of the sternum is forced back by atmospheric pressure just at the

* The amount of falling back will be seen in the individual cases:—

Cases.	Lower end of sternum.	Sixth costal cartilage.		Fourth costal cartilage.		Eighth rib.	Central abdomen.	Second rib.	
		right.	left.	right.	left.			right.	left.
	inch	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.
Jos. Squire, æt. 30	*·12	*·6 †·24	*·10 †·33	·22 to ·25	·22 to ·25	...	·31 to ·50	·25 to ·26	·22 to ·25
Rawson, æt. 13. See Daguerreotypes.	*·3 to *·06	*·07	*·05	*·02 †·05	*·01 †·03	...	·12 to ·18	·06 to ·11	·12
Second observation	*·08	*·10	*·03 †·02	·03 to ·09	·11	...	·35	·03 to ·12	·15
G. Simpson, æt. 50, bronchitis.	*·05	*·02 †·03	*·04	*·03	*·03	...	·25	·09 to ·12	·08 to ·09
W. Galloway, æt. 40, emphysema, diseased heart, bronchitis.	*·03	*·03	*·03	*·03	*·01 †·04	...	·20	·12	·14
Last observation.	*·04 to *·15	*·02 †·04	*·04 †·04	*·02 †·02	*·03 †·02	...	·20	·08	·12
J. Hart, æt. 32.	*·01 to *·04	·05	·05	·01 to ·03	·03 to ·09	...	·18	·02 to ·09	·03 to ·12
J. Linthwaite, æt. 50.	*·02 †·08	*·01 †·10	*·02 †·08	·08 to ·12	·06 to ·10	...	·10 to ·50	·10 to ·25	·10 to ·25
W. Redmid, æt. 46.	*·02	·02	·03	·03	0	...	·30	·07	·04
J. Worth, æt. 30.	*·01 †·03 *·005 †·03	·03	·04 to ·12	·01	·0 to ·05	...	·25	·02 to ·05	·02 to ·10
J. Shaw, æt. 45.	·10 to ·12	·15	·12	·12	*·03 †·07	...	*·05 †·23	·10 to ·15	·10 to ·15
W. Shaw, æt. 30.	...	...	...	...	...	...	...	·10 to ·15	·08 to ·15
	·04	*·01	*·01 †·01	*·03	*·01 †.02	r. l. *·08 *·07	r. c. l. ·12 ·45 ·10	Tenth rib. ·01 *·03	·03
C. O'Donnell, æt. 44.	·06	*·03 †·03	*·01 †·06	*·01 †·03	*·01 †·04	...	·06 ·40 ·11		

The ordinary figures, and those with † prefixed, denote a forward movement to that extent; those with * prefixed, a backward movement, during inspiration.

We see from the actual observations, that, excepting the two Shaws and O'Donnell, the lower end of the sternum fell back either during the whole inspiration or at the beginning of it, and that the sixth cartilages fell in, especially on the left side in the neighbourhood of the heart, in nearly all

beginning of the inspiration. As the inspiration proceeds, the portion of lung which at first collapses, gradually expands, and towards the end of inspiration the lower end of the sternum moves forward in common with the rest of the anterior thoracic walls.

1st stage.—If the case be slight, the lower end of the sternum falls back only at the beginning of inspiration and then advances.

2nd.—If the case be somewhat more severe, the lower end of the sternum alone falls back through the whole of the inspiration.

3rd.—If the case be still more severe, the sixth costal cartilages fall back in addition to the lower end of the sternum.

4th.—And in the most severe cases, in addition the fourth costal cartilages fall back.

If the case under observation grows worse, the amount and extent of the falling back increases, according to the stages just given; while, if the case improves, the extent of the collapse of the chest diminishes, as in the boy Rawson, in whom, at the first observation, the lower end of the sternum and the sixth and fourth costal cartilages receded; and at the second

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those cases; the amount of retraction of the sixth cartilages bearing a proportion to that of the lower end of the sternum.

During inspiration—

In Worth and Linthwaite	The lower end of the sternum fell back at the beginning and advanced towards the end of the act.
In Worth, Redmill and Hart	The lower end of the sternum alone fell back.
In Galloway (1st observation), Squire, Rawson (2nd observation), and Linthwaite	In addition, the sixth costal cartilage fell back.
In Rawson (1st observation), Galloway (2nd observation), (they were then worse,) and Simpson	In addition, the fourth costal cartilage fell back.

These observations show that a greater number of cartilages fall back in the same case when the patient gets worse, as in Galloway, and a less number when he improves, as in Rawson; thus we are afforded a test of the progress of the case.

observation, when he was improving, the fourth costal cartilage no longer fell in, while the sixth did so. We are thus afforded a test of the favourable or unfavourable progress of the case.

In some cases, the lower end of the sternum, instead of falling backwards, *protrudes during inspiration*; and in these cases *the lower part of the chest,* instead of being flattened, *is narrowed during inspiration.**

* Cases in which the lower end of the sternum protrudes during inspiration :—

In William Shaw and O'Donnell the lower end of the sternum did not fall in, but moved forwards, during inspiration. In Shaw the whole of the lower part of the chest, from the sixth rib down to the eighth, became narrowed during inspiration, the sixth ribs falling in ·01 in., but the eighth ribs as much as ·08 and ·07 in. In Shaw the dorsal curvature, which always exists, to a greater or less extent, in the emphysematous, was unusually great, the lower end of the sternum unusually prominent: the sixth and seventh costal cartilages and ribs advanced somewhat after a boat-shape, and as the rib and cartilage yielded inwards during inspiration, when they were raised they pushed forward the lower end of the sternum, as we have already observed to be the case in rachitic children. (pp. 375-376.)

The great dorsal curvature would also tend to throw forward the lower end of the sternum, as has been already remarked. (pp. 378-379.)

O'Donnell, aged 46, is a less marked illustration of the same thing; in him the fourth and sixth cartilages fell in slightly while the lower end of the sternum protruded. In this case the cause resided in the firmness of the costal cartilages.

In John Shaw, aged 46,—the other man in whom the lower end of the sternum advanced, but who differed from O'Donnell and William Shaw in that, except the left fourth costal cartilage, none of the cartilages or ribs receded,—the firmness of the ribs and costal cartilages was the manifest cause of the want of falling in. In John Shaw alone did the abdomen fall back at the beginning of inspiration; and in him the centre of the diaphragm evidently yielded in the struggle: in the other cases, the abdomen advanced and the sternum or ribs fell in; in him the ribs advanced and the abdomen fell in.

Linthwaite, aged 50, connects the cases in which, during inspiration, the lower end of the sternum receded with those in which it protruded; in him the lower end of the sternum and the sixth cartilage only receded ·02 in., and then advanced ·08 in. With the exception of this trifling retraction at first, Linthwaite's case exactly tallied with John Shaw's; and this difference disappeared in John Shaw after a prolonged examination, when the dyspnœa

In these persons the sixth, seventh and eighth ribs (the intermediate set), from acquired deformity, are hollow at the side, at the place of junction of those ribs with their cartilages; the sternum is prominent, and the lower part of the chest is deep and narrow. The sixth, seventh and eighth ribs fall in at the sides during inspiration close to their costal cartilages, and the lower end of the sternum, in consequence, projects considerably.

In certain cases, no part of the thoracic walls falls in during inspiration.—In some persons, rather advanced in life, the costal cartilages are stiff and unyielding; and in them the chest, instead of receding anywhere, may advance throughout, as in health. In one such case, the abdomen, instead of the lower end of the sternum, was retracted at the beginning of inspiration. The abdominal retraction was evidently caused by the thoracic expansion, in the same way that the usual thoracic retraction is caused by the abdominal protrusion.

In some cases of this class the lower end of the sternum and the adjoining cartilages fall back slightly, just at the beginning of inspiration, and then advance; and in other cases although the thoracic walls may not fall back, yet they stand still just at the beginning of the inspiration. This standing still of the thoracic walls is, if I may so speak, the first stage of their falling back.

In those cases of emphysema and bronchitis in which the thoracic walls recede over the lower end of the sternum and the adjoining costal cartilages, the costal walls at the upper part of the chest usually stand still just at the beginning of inspiration, and then advance. This pause at the beginning of the inspiratory movement of the upper part of the chest is due to the same cause as the collapse of the lower part of the

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increased; for then the lower end of the sternum fell back ·03 in., before advancing. In Linthwaite, the movements, like those of John Shaw, were modified by the stiffness of the costal cartilages. This point will be further illustrated in considering the influence of old age in modifying the respiratory movements in those affected with emphysema.

chest, namely, the obstruction to inspiration, which is indeed greatest at the beginning of the act.

The intercostal spaces fall in during inspiration.—In applying the chest-measurer in the examination of persons affected with emphysema, care must be taken to place the instrument, not over the intercostal spaces, but over the rib. In emphysema the intercostal spaces fall in very notably during inspiration, as Dr. Stokes, Dr. C. J. B. Williams and others have noticed; so much so, that in Galloway, while the sixth rib moved outwards ·04 to ·09 in., the fifth intercostal space retracted ·08 in. This retraction of the intercostal spaces is present where they are over lung, but not where they are over liver. Thus the exact inspiratory descent of the lung can be observed by the eye; the intercostal retraction stops short at the liver and, in a less marked manner, at the stomach; as the lungs, during inspiration, replace those organs, the intercostal retraction extends *pari passu*.

The intercostal retraction over the lung is seen in health during a deep inspiration in all persons not overloaded with fat.

The head is lowered during an ordinary inspiration in emphysema and bronchitis, as well as in all other cases of dyspnœa, whether the person be standing, recumbent, or lying on the side, in which last attitude the motion is usually greatest; in each of the Shaws and in Linthwaite the head was lowered from ·02 in. to ·03 in., and in one case ·05 in.

The expiratory movements in bronchitis and emphysema.—The expiration, except that it is so prolonged, is usually the exact reverse of inspiration. While, during inspiration the lower part of the chest first recedes and then advances, during expiration that part first advances and then recedes: but sometimes the advance of expiration is much greater than the falling back of inspiration. Thus in one case, J. Shaw, towards the end of the examination, when the lower end of the sternum, during inspiration, fell back ·03 in. and advanced ·04 in., it advanced ·1 in. and fell back ·08 in. during expiration.

The advance of the lower end of the sternum during expiration is due to the quick ascent of the diaphragm, which pushes the lungs suddenly upwards.

As the air in the lungs can only escape with difficulty, their lateral diameter is increased and the lower end of the sternum is driven forwards during expiration as much as, or even more than, it falls back during inspiration. As a pause over the upper part of the chest often takes place at the beginning of inspiration, so a like pause, as in Hart's case, often occurs at the beginning of expiration.

Effect of obstruction in the smaller bronchial tubes on the RHYTHM *of respiration.*—The duration of expiration is invariably longer, and in many cases much longer, than that of inspiration. The greater the obstruction, the more prolonged is the expiration. The prolongation of expiration is a long recognized and important sign in bronchitis and emphysema. To estimate the exact relative duration of inspiration and expiration, I beat time very rapidly with the finger and count the beats, first during inspiration, and then during expiration; this plan, or simply counting, tells with accuracy the relative duration of the acts.

The duration of inspiration to that of expiration was, in

J. Shaw		4 to 13
W. Galloway,	1st examination	4 to 8
Do.	2nd examination, when the obstruction was greater	4 to 12
W. Rawson,	1st examination	3 to 8
Do.	2nd examination, when the obstruction was less	6 to 9
W. Shaw		4 to 9
J. Linthwaite		4 to 9
J. Hart		4 to 8
J. Worth		5 to 9
J. Squire		4 to 6
G. Simpson		4 to 4 or 5

The prolongation of expiration is invariable, and it is a measure of the amount of obstruction to respiration—in Rawson, as the obstruction diminished, the expiration shortened;

and in Galloway, as the obstruction increased, the expiration lengthened. The act of expiration is always prolonged, and, which is the important feature in obstruction in the bronchial tubes, it becomes gradually slower towards the end. After abdominal expiration has ceased, thoracic expiration continues for a short time. The cause of the prolonged expiration is apparent.

During inspiration the beginning of the act is spent in enlarging the larger tubes, which expand readily; and in dilating the lesser ones, which, being then smaller, offer greater obstruction to respiration at the beginning than the end of inspiration. This is one reason for thoracic respiration being slower at the beginning of inspiration. Afterwards, as inspiration progresses, the tubes become wider and admit air more freely. The mucous or sonorous rhonchus, if slight, is often present only at the beginning of inspiration, when the entrance through the smaller air-tubes is most obstructed. If the rhonchi be continuous, they are less grave at the beginning than the end of the inspiration.

During expiration the physical conditions are reversed, the air-tubes being all at their largest at the beginning of the act. At first the air rushes out easily from the larger bronchi; as the expiration advances, the smaller tubes diminish, and the mucus they contain fills them more completely. The difficulty to the exit of air from the air-cells is necessarily increased. If sonorous rhonchi be present, they are often, at first, grave: but they gradually rise in pitch towards the end of the act. In such cases the expiration is prolonged, and becomes slower in exact proportion to the increased obstruction in the finer air-tubes. In some cases interrupted rhonchi are accompanied by interrupted expiratory movements.

Whenever, and from whatever cause, the air-tubes, large or small, are clogged with fluid, they obstruct both inspiration and expiration; but the obstruction tells most on the expiration, which is, under these circumstances, at first rapid and then slow, becoming always progressively slower towards

the end. The rapid movement at the beginning is chiefly manifested on the abdomen, the slow movement towards the end, on the walls of the chest.

The rapidity of the expiration at first, and its increasing slowness towards the end, characterizes obstruction in the bronchi from obstruction in the larynx, as in the latter case: the prolonged expiration is equally slow throughout.

While examining a case of bronchitis, I have observed the expiration, previously of increasing slowness, to become suddenly equally slow throughout. This was traceable to the rapid accumulation of sputa between the vocal chords obstructing the larynx. As soon as the larynx was cleared by coughing, the increasing slowness of the expiration towards the end returned.

In simple bronchitis and simple emphysema, the expiration is not so much prolonged as it is when they are combined. In Rawson's case this was well illustrated—as the bronchitis lessened, the emphysema alone acted, and the expiration was not so much prolonged.

The duration of the expiration varies, in these compound cases, with the varying obstruction in the smaller bronchial tubes.

The expiration is, I conceive, not so much prolonged when the obstruction is seated in the larger bronchial tubes, as it is when in the smaller. The cases of Simpson and Eaton, in whom the expiration was not materially lengthened, are examples of this.

In emphysema and bronchitis, owing to the protrusion, during inspiration, of the abdomen and of the upper part of the chest, and the collapse of the lower end of the sternum and the adjoining cartilages, the rhythm of the movements of respiration is different over the abdomen, the upper part of the thorax, and the lower end of the sternum.

Over the *abdomen*, the *inspiratory* protrusion is quick, and equal throughout. During *expiration*, the abdomen retracts very rapidly and extensively just at first, and then falls back very slowly. Sometimes there is a short pause after the first

expiratory movement. After this pause, the abdomen again recedes, though very slowly, and often with two or three interruptions. Abdominal expiration often ceases before thoracic expiration.

Over the *upper part of the thorax,* during *inspiration,* there is, at first, often a pause, or the ribs and sternum move forward slowly at first, and then advance more rapidly and at an equal rate. During *expiration* the upper part of the chest generally pauses just at first; it then moves rather quickly, and afterwards very slowly, becoming gradually slower towards the end. Sometimes there is interrupted thoracic expiration. The thoracic expiration is often prolonged after the abdominal expiration ceases.

The *lower end of the sternum* and the contiguous cartilages, during *inspiration,* either recede throughout, as has been already stated, or fall in at the beginning and then move forward, or only pause at the beginning and then advance. During expiration the movements of the lower end of the sternum are the reverse of those during inspiration. Sometimes when the sternum stands still during inspiration, its motion is reversed at the beginning of expiration.

The characteristic feature of the rhythm of respiration in emphysema is this, that the expiration is quick at first, then slow, becoming gradually slower towards the end.

Effects of obstruction of the smaller bronchial tubes on the movements of respiration during a DEEP *inspiration.*—I have only observed the extreme inspiratory movements in a few of the cases, and at a few points, the condition of many of the cases precluding the inquiry.

As a general rule, the extreme inspiratory movements were much restrained, and sometimes in part reversed where they were reversed in ordinary breathing.

	Extreme breathing capacity.	Inspiration.	Upper portion of sternum.	Second rib.		Abdomen.	Lower end of sternum.	Sixth cartilage.		Eighth rib.	
				right.	left.			right.	left.	right.	left.
	inches.		inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.
W. Shaw	90	ordinary deep	·08 ...	·10 to ·15 ·25	·08 to ·15 ·25	... ...	·04 ·23				
W. Rawson	...	ordinary deep	·04 to ·10 ·30								
Second observation (better)	...	ordinary deep	·03 to ·10 ·50	... ...	... ...	·35 ·50	*·08 *·08 †·20				
Redmill	...	ordinary deep	·05 ·25	·07 ·35	·04 ·30	·30 ·50	*·02 *·03 †·30				
Simpson	...	ordinary deep	·04 ·50	·09 to ·12 ·30	·09 to ·08 ·30	·25 ·35					
Linthwaite	155 140	ordinary deep	·09 to ·24 ·40	·10 to ·25 ·50	·10 to ·25 ·40	·10 to ·40 ·70	*·02 †·08 *·02 †·20 *·02 †·35	*·01 †·10 *·01 †·20	*·02 †·08 *·02 †·17		
John Shaw.	120 190	ordinary deep	·12 to ·20 ·55	·10 to ·15 ·90	·10 to ·15 ·80	*·005†·23 ·80	·10 to ·12 ·50	... ...	... ...	·10 ·45	·10 ·40
J. Worth	230	ordinary deep	·03 to ·05 ·70	·02 to ·05 1·10	·02 to ·10 1·10	·25 ·70	*·005†·03 *·02 †·60				
Health	...	ordinary deep	·03 to ·06 1·0	·03 to ·07 1·10	·03 to ·07 1·10	·25 to ·30 1·0	·02 to ·06 ·90	·02 to ·06 ·80	·02 to 05 ·70	·08 ·65	·08 ·65

The ordinary figures, and those with † prefixed, denote a forward motion; those with * prefixed, a backward motion of the costal walls during inspiration.

From these scanty materials we may conclude that the extreme motion is, in many cases, very materially diminished: thus in Shaw it was only ·25 and ·35 in. at the second rib, instead of being from ·80 to 1·00 inch.

That as the obstruction diminishes, the extreme motion increases. Thus in Rawson, during the first examination, the extreme motion of the upper end of the sternum was ·3 in.; during the second, when there was less obstruction, ·5 in.

That the extreme motion is a test of the extreme breathing-capacity. Thus in William Shaw, whose capacity was only ·90 cub. in., the extreme movement of the second ribs was only ·25 cub. in.; while in Worth, whose capacity was ·230 cub. in., the extreme movement was 1·00 cub. in.

That where the breathing-capacity of the lung is considerable, but the obstruction great, the deep inspiration and expiration are slow. In Shaw, although the capacity and motion were considerable, the deep inspiration and expiration were very slow. Shaw's case was complicated by obstruction in the larynx.

That when the lower end of the sternum or a costal cartilage falls back and then rises during an ordinary inspiration, it also does so during a deep inspiration; as—

	The lower end of the sternum			
		inch.		inch.
In Linthwaite, during an ordinary inspiration . .	receded	·02	and advanced	·08
In Linthwaite, during a deep inspiration . . .	,,	·02 to ·05	,,	·20 to ·35
In Worth, during an ordinary inspiration . . .	,,	·005	,,	·03
In Worth, during a deep inspiration . . .	,,	·02	,,	·60

That when the lower end of the sternum recedes throughout during an ordinary inspiration, it recedes at the beginning of a deep inspiration, and then advances, in proportion to the breathing-capacity: thus—

				inch.		inch.
In Rawson, the sternum in ordinary inspiration			receded	·08	and advanced	0
,,	,,	full	,,	·08	,,	·20
In Redmill,	,,	ordinary	,,	·02	,,	0
,,	,,	full	,,	·03	,,	·30

That when the lower end of the sternum advances, while the ribs fall in to the side, during an ordinary inspiration, it also advances, and to an increased degree, during a deep inspiration: thus—

In William Shaw, the lower end of the sternum during	ordinary inspiration, advanced	.	·04 in.
,, ,,	deep ,, ,,		·23

That when the lower end of the sternum advances, from stiffening of the cartilages, during an ordinary inspiration, it also advances during a deep inspiration, and to a greater degree; and that in such a case the increased lateral expansion of the lower ribs is not proportioned to that of the lower end of the sternum: thus—

		inch		inch.
In John Shaw, while the second rib advanced	from ·1 to ·15	in ordinary	and	·9 on a deep insp.
the eighth rib moved outwards	,, ·1	,,		·45 ,,

That when the deep inspiration is involuntary and almost convulsive, as it is when preceding a cough, it is very rapid;

and from the rapid descent of the diaphragm, those parts of the chest may recede much that only recede a little during an ordinary inspiration: thus—

In Galloway, the lower end of the sternum fell back during an ordinary inspiration . . . . } ·04 in. to ·15 in.

And it fell back during the rapid deep inspiration preceding a cough . . . . . } ·2 in.

Effects of obstruction in the smaller bronchial tubes on the respiratory movements in OLD AGE.—In old age, the cartilages, being ossified, form with the rib one unyielding piece: and in consequence, the lower end of the sternum, instead of falling in, moves forward during inspiration, as we see in—

	Upper end of sternum.	Second rib.		Lower end of sternum.	Sixth cartilage.		Eighth rib.		Abdominal protrusion.	Rhythm. Insp. to Exp.
		right.	left.		right.	left.	right.	left.		
	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	insp. to exp.
T. Eyre, æt. 75.	*·02 †·03	*·05 †·05	* 01 †·02	·06	·07	·06	·04	·04	·35	4 : 8
W. Flinders, æt. 69.	·08	·04	·07 to ·10	·09	·07	·06	·06	·12	·60	6 : 9
T. Thompson, æt. 60.	·06	·07 to ·08	·10	*·01 to †·06	*·04 † 02	*·02 † 06	*·02 †·06	*·03 †·06	·10	4 : 8
Deep inspiration.	...	...	...	·13	...	...	*·10	*·12		
Health in old age, about the average.	·02 to ·06	·02 to ·06	·02 to ·06	·03 to ·07	·03 to ·07	·03 to ·07	·05 to ·10	·05 to ·10	·25 to ·35	4 : 5 or 6

The ordinary figures, and those with † prefixed, denote a forward motion; those with * prefixed, a backward motion of the costal walls during inspiration.

In Eyre, (Table III., Case 109,) and Flinders, (Table III., Case 110,) the deviation from the normal state was not material (I do not know the cause of the slight falling back of the upper portion of the sternum at the beginning of the inspiration in Eyre). The lower end of the sternum moved forwards somewhat more than the average, and the sixth rib moved outwards somewhat less. In both of these, but especially in Flinders, the abdominal movement was excessive.

In Thompson (Table III., Case 111) alone, of the three, was there the slightest recession of the lower end of the sternum and its adjoining cartilages, and in him they only receded at the beginning of the inspiration, while on a deep inspiration they did not recede at all. It will also be observed that the eighth rib fell inwards at the beginning only of an ordinary, but during the whole time of a deep, inspiration. In this respect his case may be compared with that of W. Shaw, (p. 410,) in whom, while the lower end of the sternum advanced, the eighth ribs fell inwards during each inspiration.

The rhythm of respiration is changed in old age as it is in the adult.

Effects of obstruction in the smaller bronchial tubes on the movements of respiration in THE FEMALE.—The great development of the superior thoracic, and the restraint on the intermediate and diaphragmatic, ribs, due to the wearing of stays, causes in the female a considerable variety in the effects of emphysema on the position of the viscera, the form of the chest and abdomen, and the movements of respiration.

	Sternum, upper end.	Second rib.		Sternum, lower end.	Sixth costal cartilage.		Eighth rib.		Abdomen.	Rhythm. Insp. to Exp.
		right.	left.		right.	left	right.	left.		
	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.
Mary Cross, 14, recovering from bronchitis, fever	·05	·03 to ·05	·03 to 05	*·02	*·01	*·02	·03	·02	·15	4 : 6
deep inspiration	·06	·14	·12	*·02 †·05	...	...	...	...	·50	
S. Chamberlain, 20, acute bronchitis, fever	·25	·12	·12	*·02 †·08	·07	·08	...	...	·50	
M. Elliott, 50, emphysema, bronchitis	·15	·12	·15	*·06	*·02 †·06	*·02 †·06	...	...	02 to ·06	4 : 7
Mrs. Cooper, 30, bronchitis	·12	·20	·20	·20	*·08	*·10 †·08	*·06 †·08	*·12	·40	3 : 9
S. Henson, 70	·15	·25	·20	·09	·06	·08	·15	·18	·15	4 : 6
Health, stays off	·06 to ·10	·05 to ·10	·05 to ·10	·03 to ·06	·02 to ·05	·02 to ·05	...	...	·10 to ·20	4 : 5

The ordinary figures, and those with † prefixed, denote a forward movement; those with * prefixed, a backward movement of the costal walls during inspiration.

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The point in which the respiratory movements of the male and female when affected with obstruction in the smaller air-tubes principally differ is the greatly exaggerated motion of the thoracic ribs.

M. Cross, (Table III., Case 113,) a young person recovering from a severe attack of fever and bronchitis, is the only exception; and in her, if the examination had been made a few days earlier, if my eye and recollection do not deceive me, the movements would have been exaggerated also. The above cases illustrate all the principal varieties met with in man.

In Cross, Chamberlain, (Table III., Case 114,) and Elliott, (Table III., Case 115,) the lower end of the sternum receded, as in the majority of adult males.

In Cooper, (Table III., Case 116,) the lower end of the sternum advanced considerably, and the sixth and eighth ribs fell in on each side, as in the case of Wm. Shaw. (p. 410.)

In Mrs. Henson, (Table III., Case 119,) aged 70, the ribs did not yield anywhere, as in John Shaw, p. 410, and the males arrived at old age. (p. 419.)

The rhythm of respiration is changed in females exactly as it is in males.

Effects of obstructed bronchial tubes on the respiratory movements in CHILDREN.—In children affected with bronchitis or hooping-cough, the chest is usually very full and rounded above and in front, the sternum arched, and the dorsum much curved; the lungs are usually elongated, the diaphragm being low; the lower end of the sternum and the lower costal cartilages are depressed. The abdomen is usually full.

In healthy children, unless the abdomen be small and the respiratory movements slight, as has been already stated, the lower part of the thorax retracts during inspiration; the retraction taking place in *healthy* children at the lower end of the sternum and the lower costal cartilages in front; but in *ricketty* children the whole sternum advances, while the lower ribs at the side fall in. (p. 375.)

This is indeed the counterpart of the effects of obstruction in the bronchial tubes on the respiratory movements of the adult.

In children affected with bronchitis and hooping-cough the same phenomena of both classes are present, only the respiratory movements of the upper part of the thorax and of the abdomen are exaggerated; and the receding of the sternum in well-formed children, and the lateral falling in of the lower ribs, with advance of the sternum, in ricketty children, are increased.

It is very difficult to observe the respiratory movements in children; but I have succeeded in examining, in more or fewer points, the respiratory movements in seven children affected with bronchitis, and in five with hooping-cough. I beg to refer to the Table containing them for the particular movements.

It will be observed that the lower end of the sternum protruded, and the lower ribs fell in at the sides, in Lowe, (Table III., Case 125,) Garner, (Table III., Case 127,) and a child with hooping-cough, (Table III., Case 129,) that the ribs did not fall in anywhere in Garton, (Table III., Case 126,) and that the lower end of the sternum and the adjoining cartilages fell back in the remaining eight children. In hooping-cough the form of the chest, position of viscera, and movements of respiration, are the same as in bronchitis. During the hooping inspiration previous to the cough, the vocal chords come in contact and separate repeatedly, giving rise to the inspiratory vocal noise. During the hooping inspiration the whole chest falls in much more than it does in the ordinary inspiration; in fact, obstructed larynx is joined to obstructed smaller bronchi to modify the inspiratory movements.

None of the cases referred to in this section died; but I believe the diagnosis is correct in all the cases. To one point, the enlargement of the lungs, I can speak with absolute certainty.*

Summary.—In emphysema, and, to a less extent, in bron-

* Since writing the above passage, W. Galloway (Table III., Case 98*a*, 98*b*,) died. The autopsy evidenced emphysema (with bronchitis) and great enlargement of the heart.—August 1848.

chitis, the form of the chest and abdomen and the position of the viscera are the same that they are during the deepest possible healthy inspiration.

The chest is full and prominent, the shoulders raised, the spine curved, the sternum forward, the costal cartilages at each side of it full, but not so prominent as usual. The diameter of the chest is everywhere increased, the opposite seventh costal cartilages below the sternum are stretched far apart.

The abdomen just below the prominent xyphoid cartilage is unusually hollow; the diaphragm is low and flat; the lower boundaries of the lungs and heart are a full inch lower than in the normal state. The heart is nearly covered with lung, the exposed portion of it, and consequently its impulse, being below the sternum, behind and to the left of the xyphoid cartilage.

During inspiration the diaphragm descends only from one-third to two-thirds of an inch, and the lower boundaries of the lungs and heart, and the upper boundaries of the abdominal organs, necessarily descend to the same extent. The cardiac region is lowered and lessened, the impulse becoming stronger and lower. The respiratory muscular actions are much exaggerated, while the movements are not proportionally, often not at all, increased. (p. 404.)

The diaphragm descends, the abdomen protrudes, and the superior thoracic (first, second, third and fourth) ribs ascend and advance with energy; at the same time, the lower end of the sternum and the sixth cartilages fall backwards in the greater number of cases, from childhood to the age of 50. (p. 404.)

The lower end of the sternum falls back because the exaggerated action of the diaphragm and of the upper thoracic ribs expands the lungs above, and elongates them below, more rapidly than air can rush in to fill them up; consequently they collapse intermediately, and the lower end of the sternum and the intermediate ribs (sixth, seventh and eighth) are forced backwards by atmospheric pressure. (p. 404, 394.)

In some the lower end of the sternum is prominent, and the lower part of the chest narrow and deep; in these, whatever their age and sex, the lower end of the sternum advances and the sixth and eighth ribs and cartilages fall in at the side.

In general, the lower part of the chest is flattened, but in these it is narrowed and deepened during a deep inspiration. (p. 410.)

In old age and in adults with stiff and ossified cartilages, the lower end of the sternum advances, and the ribs move outwards; the outward movement of the eighth ribs being somewhat restrained during a deep inspiration. In some the lower end of the sternum falls back slightly, and then advances during an inspiration. (pp. 411, 419.)

As both the superior thoracic and the diaphragmatic muscular efforts are always, and the movements usually, exaggerated, the head is lowered at each inspiration, indicating excess of costal motion, while the larynx descends considerably, indicating excess of diaphragmatic action. (p. 412.)

The movement of the ribs and diaphragm during a deep inspiration is restrained. The smaller the breathing-capacity of the lungs, the less the increase of motion on a deep inspiration. (p. 417.)

Those parts of the chest that fall back during *ordinary* inspiration, only fall back at the beginning of a *deep* inspiration, after which, as the inspiration proceeds, they advance in proportion to its depth. (p. 418.)

The expiratory movements are the reverse of the inspiratory: in some, when the ribs fall back slightly during inspiration, they advance considerably during expiration; and in others, where the ribs do not advance during inspiration, but only stand still at the beginning of it, they move forward at the beginning of expiration and then fall backwards. (p. 412.)

The extent of the reversed inspiratory movement over the lower end of the sternum and the intermediate set of ribs is in proportion to the extent of the obstruction and the mobility of the chest. (p. 408.)

The rhythm of respiration is materially and characteristically affected in emphysema and bronchitis. The inspiration is short, the expiration is prolonged. During inspiration the air enters rapidly during the whole act, but the facility for inspiration increases towards the end. During expiration the air rushes out easily and quickly at first, but with increasing slowness and difficulty towards the end. During inspiration the air-tubes become larger towards the end, therefore inspiration is then easier; during expiration the air-tubes become smaller towards the end and more clogged with fluid, and therefore expiration is then more prolonged and difficult. (p. 418.)

The expiration is more prolonged in proportion to the obstruction in the smaller air-tubes; it is longer in emphysema when combined with bronchitis, than in either emphysema or bronchitis simply. It is more prolonged when the obstruction is in the smaller, than when it is in the larger, bronchial tubes. (pp. 414, 415.)

During inspiration the abdomen advances very rapidly; the upper part of the sternum and thoracic ribs stand still just at first, and then advance rapidly; the lower end of the sternum and the adjoining cartilages fall back usually during the whole act, sometimes only at the beginning of it, unless there be malformation of the chest or stiffness of the cartilages. (p. 415.)

During expiration the abdomen recedes very rapidly at first, then stands still, and again falls back interruptedly, and with increasing slowness; the upper part of the chest stands still just at first, then falls back rapidly, and becomes progressively slower towards the end of the act; the lower end of the sternum advances during the whole time, or it advances at first and then falls back. (p. 416.)

The increasing slowness towards the end of expiration distinguishes obstruction of the smaller bronchi from obstruction in the larynx, in which latter case it is also prolonged, but is equally slow throughout. (p. 414, 401.)

Sect. III.—*Effect of Diseases confined to one Lung or one side of the Chest, on the Movements of Respiration.*

A.—*Effect of pleuritis on the respiratory movements.*—I have not observed with the chest-measurer any case of pleuritis affecting the whole lung. In the two following cases the pleuritis was partial.

	Sternum.		Second rib.		Sixth cartilage.		Sixth rib.		Eighth rib.		Tenth rib.		Abdomen.		
	up.	lower.	right.	left.	right.	left.	right	left.	right	left	right	left.	right	cent.	left.
	in.	in.	in.	in.	in.	in.	in.	in.	in	in.	in.	in.	in.	in.	in.
Simpkin, (Table III.,) Case 133.	·10	·11	·11	·08	·07	*·07	·03	*·005	·08	·10	·13	·10	·17	·10	·13
Shepherd, (Table III.,) Case 134.															
First observation.	·05	*·03	·10	·10	*·03 to *·04	*·03	·03	·03	·08	·08	·08	·08	·06	·15	·08
Second observation.	·03	*·02 †·02	·10 to ·20	·10 to ·20	*·01 †·03	*·02	·01	*·01	·05	·03	·05	·04	·05	08	·07

The ordinary figures, and those with † prefixed, denote a forward movement; those with * prefixed, a backward movement of the costal walls during inspiration.

Sarah Simpkin, a woman of 40, had a rustling friction-sound over the anterior and lateral portion of the lower lobe of the left lung and the adjoining portion of the diaphragm. When she attempted to breathe deeply, her breath was caught by a severe pain over the cardiac region. In her the respiratory movements were everywhere normal, excepting just over the seat of the friction-sound, the left sixth costal cartilages moving ·07 in. and the right ·07 in.; the left eighth rib moving outwards ·1 in. and the right ·08 in.; but the left sixth rib fell in ·005 in., while the right sixth moved outwards ·03. In Simpkin's case the pleuritis locally restrained the breathing movement, at the seat of the pleuritis,—the sixth rib, and not at the seat of the catching pain,—the sixth costal cartilage.

Shepherd, a little girl of 7, suffering much from dyspnœa, presented comparative dulness on percussion over the lower lobe of the right lung, and over the upper lobe of the left. The inspiratory breath-sound was diminished, and the expiratory increased, over the lower lobe of the right lung; in the

opposite lobe the inspiration was coarse, the expiration unchanged; next day there was a loud smooth to and fro friction-sound. The expiratory-sound, whispering, as it were, under the ear, was audible when she whispered; and, when she spoke, œgophony was caused by the whispering expiratory friction-sound, accompanying and following the vocal resonance. In this girl, unequivocally suffering from pleuritis, the respiratory costal movements on the first day were perfectly normal. The sixth, eighth and tenth ribs of each side respectively ·03 in., ·08 in., ·08 in.; the right side of the abdomen presented a slight diminution.

Next day, when the dyspnœa was much lessened, the friction-sound being audible over the right lower lobe, the expansion of that lobe was somewhat greater than that of the left.

During the first examination, when the rapidity of breathing was excessive, and the costal and diaphragmatic breathing were both exaggerated, the lower end of the sternum and the sixth cartilage fell back ·03 in., owing to the rapid expansion of lung above and elongation of it below, causing intermediate collapse from atmospheric pressure, as was observed in emphysema and obstructed larynx. (pp. 404, 394.)

These two cases show that pleuritis without effusion may either cause diminished motion or not.

As a general principle, pleuritis undoubtedly does lessen the movements. Andral (Clinique Medicale, ii. 598) says, "Dans la pleurésie costo-pulmonaire la respiration est surtout diaphragmatique; au contraire, dans l'inflammation de la plèvre qui tapisse le diaphragme, ce muscle devient immobile, et la dilatation du thorax est surtout le résultat du mouvement d'ascension des côtes." Dr. C. J. B. Williams (Library of Medicine, iii. 110) considers the sign equivocal, and due to pain. Dr. Walshe (Diseases of the Chest, p. 219) states, that after pain has abated, the motions have acquired greater freedom until they were again obstructed by the accumulating fluid. M. Collin (Dr. Forbes' translation, in his "Original Cases," p. 294) says, that in the earliest stage the motions of the affected side are enfeebled or almost extinguished, the ribs

over the diseased part being fixed and the remainder moveable.

M. Collin's view is certainly too decided: indeed, non-motion in pleuritis would have a very injurious result; the fibrous adhesions, so usually met with, would be short, and confine the lung if there were no motion; as it is, they are long, and admit great freedom of movement; and this elongation of them is due to the to and fro movement of the lungs and ribs during respiration, drawing upon and lengthening the new and plastic adhesions.

The existence of friction-sound is itself a proof of respiratory motion in simple pleuritis, and Dr. Stokes justly attributes the frequent silence of pneumonic pleuritis to the want of pulmonic motion.

Summary.—Pleuritis, it may be justly said, usually restrains the respiratory movements sometimes because of pain, but sometimes although there be no pain. In some cases the movements are not at all lessened, and I believe, in simple or dry pleuritis, they are seldom, if ever, entirely destroyed. The respiratory movements of the opposite lung and of the unaffected portions of the same lung, are, from compensation, exaggerated.

B.—*Effect of effusions into the cavity of the pleura on the respiratory movements.*—This is one of the two cases allowed by Laennec to influence the breathing movements:—"Je n'ai jamais pu constater d'inégalité manifeste et constante dans les movemens des deux côtés du thorax, que dans des cas d'empyème très abondant ou de déformation de la poitrine." (De l'Auscultation Mediate, i. 24.)

Avenbrugger noticed deficient respiratory movement from pleuritic effusion nearly a century ago; M. Collin, Dr. Hodgkin, Dr. Williams, Dr. Walshe, Dr. Hughes, and others, have given to the sign its value; Dr. Stokes and Dr. Townshend, in their admirable descriptions of the disease in question, do not dwell on the symptom.

No disease has been more thoroughly illustrated than this,

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as to the effect of the collection, in increasing the size of the affected side, on the position of the ribs and the intercostal spaces, and the displacement of the heart, the opposite lung, and the abdominal organs.

I have examined with the chest-measurer two cases of effusion into the right cavity of the pleura and three into the left.

	Sternum.		Second rib.		Fourth rib.		Sixth costal cartilage.		Tenth rib.		Abdomen.		
	upper.	lower.	right.	left.	right.	left.	right.	left.	right	left.	right	cent.	left.
LEFT CAVITY.	inch.	inch.	inch.	inch	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.
Walter Webb, æt. 16.	·08	*·01 †·04	·12	·05	·08	0	·06	*·02 †·02	·10	·02	·10	·12	·06
J. Roach.	·12	*·02 †·04	·05	0	·12	0	·08	*·03 †·02	·12	·02 to ·03			
Deep inspiration.	...	...	·20	·12									
T. Cook, æt. 6.	·02	·03	·08 to ·12	0	·05 to ·08	*·01	*·01 †·04	0	·05	·01	·06	·15	·03
Second observation.	*·02	* 04	·08 to ·12	0	·08	0	·08	* 02	·08	0	·12	·22	·03
RIGHT CAVITY.													
Lydia Davis, æt. 18.	·10	*·04	·18	·17	*·01 †·02	*·01 †·01	*·01	*·02 †·02	·06	·12	·12	*·03	·06
James Brown, æt. 21.	·03	·04	·05	·10	·02	·03	·03	·04	·05	·10	·10	·30	·16
Deep inspiration.	...	...	...	...	·40	·70							
Health.	·03 to ·06	02 to ·06	·03 to ·07	·03 to ·07			·02 to ·06	·02 to ·05	·10	·10	·09	·25 to ·30	·09

The ordinary figures, and those with † prefixed, denote a forward movement; those with * prefixed, a backward movement of the costal walls.

In the cases of Webb (Table III., Case 137), Roach (Table III., Case 138), (for whose case I am indebted to Dr. Walshe,) and Davis (Table III., Case 136), the effusion was considerable. In Webb, the left, in Davis, the right, side was much distended. The heart was, in Webb, displaced, and its impulse felt to the right of the sternum, while the impulse of the apex in Davis was felt considerably to the left of the nipple. In Webb, the diameter over the nipples was, on the left side, 7·4 in.; on the right, 6·5 in.—nearly an inch of difference.

The effusion was not considerable in Cook. The left side was, however, an inch larger than the right. The heart beat to the right of the xyphoid cartilage. The effusion was dis-

appearing from Brown (Table III., Case 135), (Dr. Bence Jones favoured me with the examination of Brown and Webb,) the heart having returned to its normal position, and the tape measurements of the two sides being about equal. The diameter over the nipples was, on the right side, 7·8 in.; and, on the left side, 7·4 in.—not quite half an inch of difference.

In all the cases, the motion of the affected side was diminished, while that of the healthy side was exaggerated; the diminution extending, in W. Webb and T. Cook, to all the respiratory movements. In all the cases excepting Cook and Davis, the movements of the superior thoracic ribs—the second—were less affected than those of the intermediate and diaphragmatic ribs. This corresponds exactly to the principal seat of the effusion and consequent obstruction to respiration,—namely, the lower part of the chest.

The abdominal movements in Webb were restrained on the affected side and at the centre, but not on the other side. In Brown and Cook, the recovering cases, the abdominal movement was slightly exaggerated on the unaffected side, and normal at the centre and on the affected side. In Davis, the abdominal movements were, it is stated, reversed. My notes state that the motion was greater on the most affected side. Davis's case, which was obligingly shown to me by Dr. Ormerod, was complicated. The effusion into the right pleural cavity followed pneumonia, which still existed, of the lower lobe of the right lung, and there were indications of disease in the lower lobe of the left lung. As the abdominal movements are stated to be the reverse of what they are in the other cases—namely, greatly increased on the side of effusion—one is inclined to suspect an error in the note; otherwise, the complication must have modified the movements. The movements, both of the diaphragm and of the affected side, being diminished, the respiration by the thoracic ribs is exaggerated.

As the lung, when free from adhesions, is floated forwards at the upper part of the chest, and comes there, if anywhere, in contact with the ribs, so it is there that the respiratory

movements are modified to the least extent. Thus, in Davis Brown, Webb, and Roach—

	Davis.	Brown.	Webb.	Roach.		Roach.
The second rib on the affected side moved during an ordinary inspiration . .	inch. ·18	inch. ·05	inch. ·05	inch. 0	and, on a deep inspiration,	inch. ·12
Second rib on unaffected side . . .	·17	·10	·12	·05	,, ,,	·20

In Davis, the unusual exaggeration of the motion over the upper lobes, both sound and affected, was evidently due to the existing pneumonia, more than to the effusion. In Webb and Roach, the lower end of the sternum, and the sixth costal cartilages of the affected side, receded at the beginning of inspiration, and, towards the end of it, advanced. This partially-reversed motion is evidently due to the displacement, downwards, by the diaphragm, of a portion of the fluid, the chamber holding it being elongated below by the diaphragm, and widened above by the thoracic ribs. The lower part of the chest during inspiration at first collapses over the fluid, from atmospheric pressure. After a time, the increasing amount of air in the lung more than replaces the displaced quantity of fluid, and the walls of the chest again move forward. In Davis, the lower end of the sternum fell back throughout the inspiration, and the fourth and sixth cartilages of both sides receded either partially or entirely. In her, the expansion of both lungs, but especially the right, was impeded by the accompanying pneumonia, and hence I conceive the non-motion of the lower end of the sternum, and of the right sixth costal cartilage, towards the end of the act. (For an explanation of the falling back of certain parts of the chest in disease, see pp. 394, 404.)

In James Brown, the case in which the effusion had diminished, the lower end of the sternum and the sixth costal cartilage advanced during the whole inspiration. In him, the respiratory movement was throughout more nearly normal. The diminution, however, of the movements on the affected side were marked and universal.

	Second rib.	Fourth rib.	Sixth cartilage.	Tenth rib.	Abdomen.
The ordinary inspiratory movements of the right,	inch.	inch.	inch.	inch.	inch.
the affected, side being	·05	·02	·03	·05	·10
Deep inspiration . .	—	·40	—	—	—
Of the left side . .	·10	·03	·04	·10	·16
Deep inspiration . .	—	·70	—	—	—

In a case of extensive effusion, in which paracentesis was performed, I observed that the lower ribs fell in partially on the affected side, while they moved outwards on the healthy side.

I have had no opportunity of observing the diaphragmatic action in those cases where, from the extent of the effusion, the diaphragm is so displaced as to become concave instead of convex.

Deep inspiration.—In the worst cases, the extreme voluntary inspirations were not—indeed, could not be—observed. In Roach, they were very much restrained, the increase being from 0 in. and ·05 in. to ·12 in. and ·2 in. In Brown, the restraint was slight on the healthy side, and considerable on the affected side, the increase being from ·02 in. and ·03 in. to ·4 in. and ·7 in.

Summary.—When fluid is extensively effused into either cavity of the pleura, the affected side is throughout enlarged; the lungs are compressed, and float forwards and upwards, so as to be in contact with the superior ribs; the surrounding organs—namely, the heart, the opposite lung, and the abdominal organs—are all encroached upon and displaced. The motion of the whole affected side, both costal and diaphragmatic, is restrained, while the motion of the whole opposite side, excepting perhaps the diaphragm, is exaggerated. The exaggeration is more marked over the superior thoracic ribs, and the motion of those ribs is less diminished on the affected side, than over the lower ribs.

Owing to the displacement, downwards, of a portion of the fluid, the lower end of the sternum and the adjoining cartilages on the affected side fall back during inspiration, from atmospheric pressure. In extreme cases, the lower ribs fall in at the side during inspiration.

Pneumothorax excites nearly the same displacement in the walls of the affected side, and in the adjoining viscera, that effusion of fluid does, the difference being that, while in the latter the lungs are floated forward, in the former they lie upon the dorsum.

I have not observed any case of pneumothorax with the chest-measurer, but I have minute notes of the motion of the chest in the interesting case of Murden—an old man of 70, over whose chest the wheel of a waggon had passed. No rib was broken, but the left lung was ruptured at the lower anterior angle of the superior lobe: the lungs were affected with Laennec's emphysema. The left side was an inch wider than the right, "the respirations irregular, forty-two in the minute, chiefly abdominal; though all the thoracic muscles are employed, the right side of the chest expands considerably, whereas the left side, an inch wider than the right, does not expand." On the next day it is noticed that "the abdominal muscles contract suddenly and with rigidity at the commencement of expiration, the expiration sometimes commencing with a vocal noise."

I was summoned one day suddenly to a poor woman, dying, the nurse said, in one of the wards. She had phthisis, with cavities chiefly affecting the right side, the left side, as Mr. Martyn observed, having the greatest range of motion.—"On the right side the upper lobe is consolidated, and contains a large vomica, with gurgling heard over the whole lobe and cavernous respiration." When I saw her the respiratory movement of the left side, which was very prominent, was absent, while that of the right side was considerable. She was moribund, and I made no further examination. On post-mortem inspection, pneumothorax in the left cavity was discovered, the air coming from a ruptured abscess seated in the lower margin of the upper lobe. This case, though only partially observed, is interesting, in that first one side, then the opposite, had the greatest amount of motion, just as one or the other had the greatest amount of disease to restrain the motion.

C.—*Effect of condensation of the lung on the movements of respiration.*—Condensation of the lung follows the absorption of pleuritic effusion, when the lung does not recover its expansion, and is owing usually to firm semi-cartilaginous adhesions. The contracted side is in all its dimensions smaller than the sound side; the anterior inner margin of the sound lung encroaches on the contracted side, passing over to that side of the edge of the sternum; the sternum is drawn and the spine curved to the affected side. The diaphragm is high, and the abdominal organs consequently encroach on the chest. The heart, if the left side be contracted, is unusually to the left; if the right side, often greatly to the right, of the sternum; the whole lung, on the affected side, is contracted, the surrounding organs encroaching on that side,—in fact, there is the exact reverse of what the same case presented at the stage of extensive effusion, when the affected side was enlarged, and the fluid, which had condensed the lung, encroached on the surrounding organs, displacing the opposite lung, the heart, and the contiguous abdominal viscera.

In these cases the sound lung is enlarged and its respiration exaggerated.

The case of the boy Cook, already mentioned among those affected with effusion into the pleura, became, after some months, an interesting example of the effect of condensation of the lung on the respiratory movements. (p. 429.)

CASES OF CONDENSATION OF ONE LUNG FROM EFFUSION INTO THE PLEURA.

	Sternum.		Second rib.		Fourth rib.		Sixth costal cartilage.		Sixth rib.		Tenth rib.		Abdomen.			Tape measurements. above nipple.		Tape measurements. lower end of sternum	
	upper.	lower.	right.	left.	right.	left.	right.	left.	right.	left.	right.	left.	right	cent.	left.	right.	left.	right.	left.
	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.
T. Cook, first observation, effusion into the pleura	·02	·03	·08 to ·12	·0	·05 to ·08	·01	*·01 †·04	·0	...	...	·05	·01	·06	·15	·03			10·7	11·2
Ditto, second observation	*·02	*·04	·08 to ·12	·0	·08 to ·12	·0	·08	*·02	...	...	·08	·0	·12	·22	·03				
Expiration	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11·5	11·1
Third observation, condensation of lung	·02	*·03	·10	·0	·05	*·01	*·02 †·02	*·03	·02 to ·05	*·01 to *·03	·06	·01	·15	·20	·07	...	...	12·3	11·2
Deep inspiration	·45	·20	·60	·20	·30	·12	·40	·30	·40	·13	·20	·05	...	·30	...	...	...	12·7	11·3
Antero-posterior diameter at the level of the junction, the fourth rib with its cartilage	...	...	...	...	7·3	6·2													
Barbara Beasley, æt 7, fluid almost gone from left pleural cavity	·0	·12 ?	·10	*·02 †·02	·05	·0	·07	·0	...	...	·05	·0	·08	·15	·0	10·7	9·5		

The ordinary figures, and those with † prefixed, denote a forward movement; those with * prefixed, a backward movement of the costal walls during ordinary inspiration.

When the first observations were made upon Cook, (Table, p. 435, and Table III., Case 139,) the left side, on which was the effusion, was by half an inch larger than the right; the amount of effusion not being great; and the heart was displaced so as to beat to the right of the xyphoid cartilage.

At the time of the second observation, the dimensions of the sides were reversed, the right side being nearly an inch larger than the left, and the diameter of it above an inch greater. The right lung had expanded considerably, that side being an inch and a half larger than on the former occasion, while the left side was less. There was indeed some little respiration returning in the left lung, manifested by some resonance on percussion below the left clavicle. The heart's impulse was now unusually to the left of the nipple. It will be observed that the difference of motion was throughout very nearly the same during the first observation, when fluid was effused and doubtless being absorbed, and in the second, when the fluid had been absorbed and the lung was condensed.

During tranquil inspiration the whole condensed side was motionless, the abdominal movement was less by one half on the condensed than on the sound side, and the lower end of the sternum and the sixth left costal cartilage receded, owing to collapse of the elongated lung. (See p. 429.)

During a deep inspiration every part of the chest expanded, but the forward movement of the left side was only a third of that of the right side. The sixth, eighth and tenth ribs of the affected side moved outwards less in proportion than the superior ribs moved forwards; indeed, the dilatation from the thoracic ribs was markedly greater than that from the diaphragmatic, owing to the lung being more condensed below, and also to its being more elongated by the descent of the diaphragm. The expansion of the left thoracic ribs acts also to expand the left margin of the right lung, which moves during a deep inspiration about half an inch further to the left of the sternum.

The case of Beasley (Table III., Case 140,) resembles that of Cook in the recent, scarcely complete disappearance of

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pleuritic effusion, and in the diminution of measurement; that of the condensed or left lung being 1·2 in. less than that of the right. In Beasley the whole movements of the left side, both costal and diaphragmatic, were annihilated, the left second rib alone moving, and the motion of that rib was exactly balanced, as it first retracted and then advanced ·02 in. The lower end of the sternum advanced in Beasley, whose case differs from that of Shaw in this circumstance, and in the annihilation of the diaphragmatic movement.

The influence of the diaphragmatic descent in Smith caused, as has been seen, elongation and collapse of the lung and consequent falling in of the lower ribs; in Beasley, as the diaphragm did not act, the lung was not elongated, did not collapse, and did not fall in excepting at the second ribs. During a deep inspiration, the sixth rib fell in ·05 in., the diaphragm then most probably descended, elongating the lung, and causing it to collapse. In cases such as this of Smith, when the expansion of one side of the chest is exaggerated, of the other diminished, the sternum moves a little towards the exaggerated or healthy side. This was pointed out to me by my pupil, Mr. Martyn; it is a circumstance that readily catches the eye, and is therefore of value in leading the attention to the cause of it.

Summary.—When the whole of one lung is simply condensed, the movements of that side are either much diminished, annihilated or reversed, while those of the opposite side are increased. The motion of the diaphragm on the affected side, though restrained, is not annihilated, the unexpandable lung being lengthened by the diaphragmatic descent, and the diaphragmatic and intermediate ribs consequently often fall in during inspiration, while the superior ribs are motionless, or move outwards but a little. During a deep inspiration the retraction and rest of tranquil breathing give place on the affected side to inspiratory expansion, greater from the motion of the thoracic ribs, and of the diaphragm, than from that of either the diaphragmatic or intermediate ribs.

The cases of consolidation complicated with phthisis will be considered under that subject.

D.—*Effect of phthisis on the movements of respiration.*—The lungs in phthisis present so infinite a variety of conditions, that we must look for a considerable variety in the phenomena presented by the movements of respiration. It so happens that though I have observed a fair number of cases with the chest-measurer in the advanced stages of phthisis, I have not examined any with it in the early stages.

The whole of one lung affected.—Among the advanced cases, there are thirteen in which the whole of the most diseased lung presented unequivocal marks of disease. The wood-cuts at pages 440 and 441, taken from J. Boot, having tuberculous disease of the whole right lung, represent the position of the ribs and lungs and other viscera, before and after the inflation of the lungs. They show the great diminution in the expansibility of the diseased side. In this case very firm tendinous adhesions enveloped the lower lobes, and combined with tuberculous deposit to prevent their free expansion.

In Neale, (Table, p. 439, and Table III., Case 141,) a communication existed between an abscess in the axilla and a dilated bronchial tube and small tuberculous cavities in the upper lobe of the left lung, through a carious opening in the second rib. The lower lobe contained many tubercles, but was chiefly solidified by the pressure of strong tendinous pleuritic adhesions. In Boot, (Table, p. 439, and Table III., Case 150,) there were cavities in the upper lobes of both lungs, but that of the right lung was chiefly affected, and the tendinous thickened costal pleura restrained the expansion of, and solidified, the lower lobe.

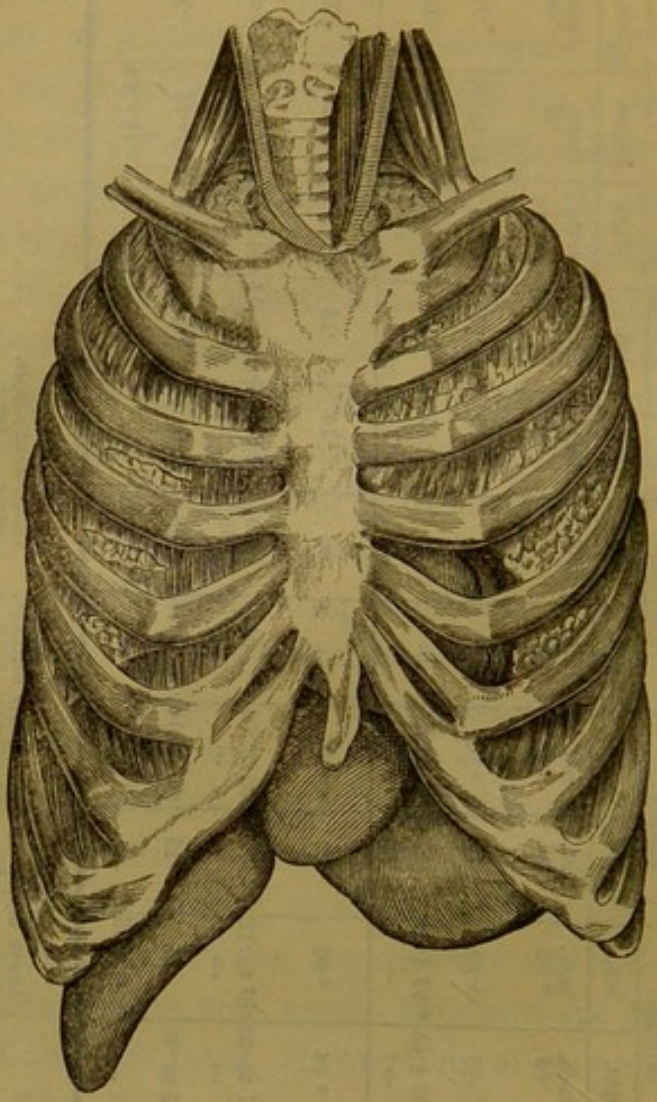
Those cases of phthisis affecting the whole of one lung are so nearly allied in the physical condition of the diseased part, and in the phenomena of respiratory motion, to the cases of condensed lung from pleural adhesions just considered, that it will be well to examine such cases before those where only the upper portion of the lung is diseased.

CASES OF PHTHISIS IN WHICH THE WHOLE LUNG IS AFFECTED.

LEFT LUNG.	Sternum.		Second rib.		Fourth costal cartilage.		Sixth costal cartilage.		Sixth rib.		Tenth rib.		Abdomen.		
	upper.	lower.	right.	left.	right.	left.	right.	left.	right.	left.	right.	left.	right.	centre.	left.
	inch.	inch.	inch.	inch	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.
W. Neale, age 51, tubercles in both lobes, especially the upper: consolidation of lower lobe	*·03	*·04	·11	*·02	·06	*·02	·08	*·04	...	...	·16	·10	·22	·25	·06
Second observation ...	*·02 †·02	*·04	·15	*·01 †·03	·20	*·03	·11	*·03	...	...	·16	·08	·25	·15 to ·20	·14
Daniel Hardy, age 41	*·01 †·01	·11	·08	...	* 02 †·05	*·03 †·04	·12	*·01 †·02	...	...	·15	·09	·18	·15	·01
Deep inspiration	...	...	·15	·05	...	...	·40	·10	...	...	...	...	...	·60	
RIGHT LUNG.															
Joel Boot, age 39, in articulo mortis, p. 440, 441	*·01 †·06	*·10	·06	·10	* 04	*·03	*·05	*·05	...	...	·14	·15	·5	·25	·20
Mary Robinson, age 15 ...	·03 to ·06	05 to ·06	·02 to ·04	·10 to ·12	·01 to ·03	·07 to ·12	·02 to ·03	·05 to ·06	·01	·10	·02 to ·04	·10 to ·15	·04 to ·07	·10 to ·15	·10 to ·15
Deep inspiration	·17	·10	·10	·50	...	...	...	...	·08	·30	·13	·40	...	·50	
Pearson, age 7, in articulo mortis, not quite exact	·13	·10	·15 to ·20	·08 to ·10	·15 to ·20	·06	·15	·08 to ·10	·12 to ·16	·08	·20 to ·15	·15	·10	*·06	·10
Expiration	...	...	·0	·02 †·12	...	·02 *·08	...	...	...	·02 †·10	...	...	...	·10 *·04	

	Above nipple.		Xyphoid cartilage.		Diameter at nipple.	
	right.	left.	right.	left.	right.	left.
Tape measurement in Mary Robinson ...	11·4	11·8	11·1	12·1	5	6·1
Ditto during deep inspiration ...	11·6	12·5	11·2	12·4		

The ordinary figures, and those with † prefixed, denote a forward movement; those with * prefixed, a backward movement of the costal walls during ordinary inspiration.



JOEL BOOT, AGE 39.

In this figure the lungs are not inflated; it represents *tranquil respiration.*

Tubercles and a cavity in the upper lobe of the right lung; tubercles through the right lower lobe; and universally thickened tendinous pleura, prevent the expansion of the whole right lung.

A small cavity on the summit of the left lung: this does not prevent the expansion of that lung, which is free and universal. See pp. 438-443, and Table III., Case 150.

There is, in such cases, general lessening of the most affected and general enlargement of the least affected side; the least affected lung descends considerably, and, in most cases, finds its way beyond the margin of the sternum over to the affected side.

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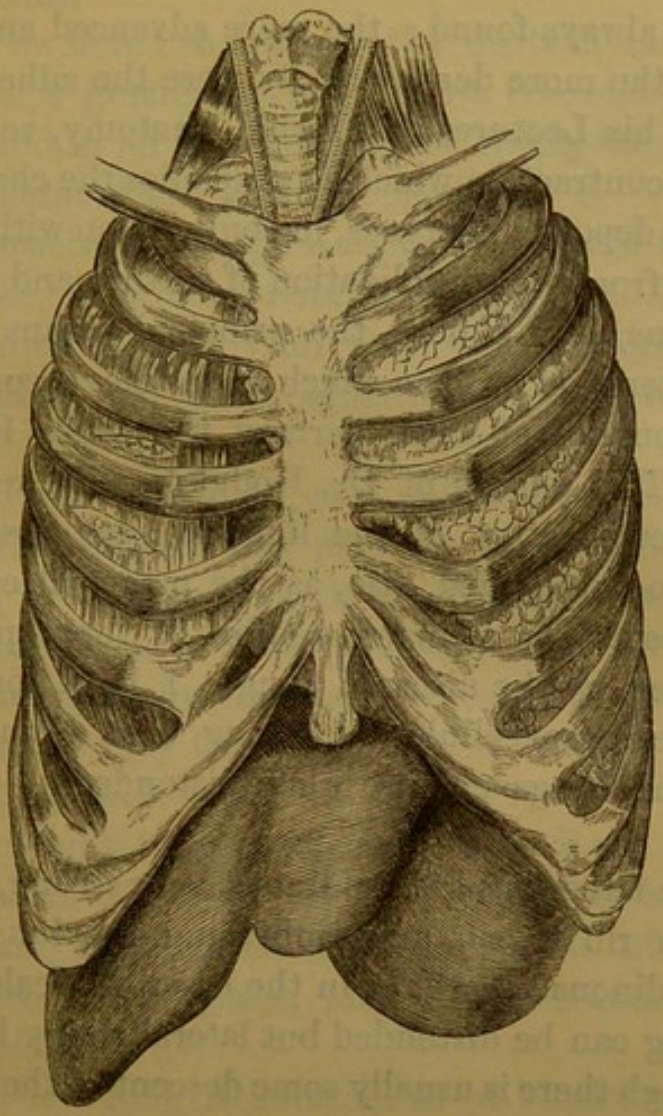

JOEL BOOT, AGE 39.

In this figure the lungs are fully inflated: it represents a *deep inspiration.*

In the cases of Neale, (Table III., Case 141,) and Boot, (Table III., Case 150,), the expansion of the lower lobe was restrained, not by the tuberculous deposit so much as by the firm, strong adhesions. Those adhesions formed continuous bands of strong, thick tendons, passing from rib to rib, and enveloping the whole surface of the lung in contact with the costal pleura: they were truly intercostal adhesions. M. Louis (Dr. Walshe's translation, p. 35) found that out of 112 subjects who died of phthisis, one only was entirely free from adhesions; in twenty-five the adhesions were cellular, easily torn, limited; in the rest, they were either extensive or general, composed,

more or less, of cellular tissue; in these cases, large cavities were almost always found; the more advanced and extensive the disease, the more dense usually were the adhesions. Dr. Hodgkin, in his Lectures on Morbid Anatomy, vol. ii. p. 177, says: "The contraction which accompanies the changes which this pleuritic deposit undergoes, in conjunction with alterations in the lung, from the consolidation of texture and contraction of excavations, is, I believe, the principal means which produces the alteration of form which sometimes accompanies the want of resonance at some parts of the chest, in phthisical patients." This remark of Dr. Hodgkin, with regard to the permanent contraction of the lung in such cases, is, I am convinced, to be applied, also, as the principal cause of the deficient, absent, or reversed motion of those parts of the chest occupied by the diseased lung. I have found, that if adhesions be loose, cellular, and long, even though they be universal, the lungs enlarge when distended to the normal extent.

When the adhesions are tendinous, very strong, intercostal, passing from rib to rib, and embracing the lung in an unyielding tendinous sheath, as in the cases of Neale and Boot, then the lung can be distended but laterally very little, or not at all, although there is usually some descent of the diaphragm, and consequent elongation of the diseased lung, as is shown in the wood-cut, p. 441. In these cases, when the adhesions are cut across, the exposed tissue of the lung is usually in part expansible; but the adhesions prevent, or impede, the expansion.

In Pearson's case, the observations from whom were taken *in articulo*, the distention of the left lung, especially the upper lobe, was much restrained by intercostal adhesions, but not to the almost absolute extent found in Neale.

The impediment to expansion during life was, in these cases, proportioned to the strength and inexpansibility of the adhesions lining and restraining the ribs, and investing the lungs. It will be observed, that although all the movements were restrained, those of the thoracic and intermediate ribs

were so much more than those of the diaphragm and diaphragmatic ribs.

This will be found to apply to the thirteen cases in which there was, to a greater or less extent, consolidation of the lower lobe, and in all of which, except Neale, there were cavities of considerable size in the upper lobe.

The dimensions and respiratory movements of the opposite, or less diseased lung, were notably exaggerated. This exaggeration extended, in nearly all the cases, through the whole lung, the costal and diaphragmatic motion being alike increased.

The inspiratory elevation, and outward movement of the ribs, draws the sternum very palpably over to the unaffected side, a point to which my pupil, Mr. Martyn, drew my attention. In Neale's case, it was well seen that the sternum is drawn to the right by the right costal expansion; and in Boot's, to the left, by the expansion of the left side. (See wood-cuts at pp. 440, 441.)

When the right lung is affected, as in Boot, the exaggerated expansion of the left lung covers the heart during inspiration, and often causes the disappearance of its impulse, from the intercostal spaces, and its appearance below the xyphoid cartilage.

When the left lung is affected, as in Neale, owing to its deficient expansion, the heart is not further covered by it during inspiration, and its impulse, instead of being lessened in the intercostal spaces, is increased, as the heart is drawn downwards.

In Neale, the liver is pushed down extensively by the descent of the right side of the diaphragm, the stomach descending but little; while in Boot, the stomach is pushed extensively downwards, the liver descending but little. Out of thirteen cases, in which the lower lobe was more or less diseased, and in nine of which the left, and four the right, lung was affected, the sixth costal cartilages retracted during inspiration in ten, and the lower end of the sternum in six; in eight of the cases there was retraction of the sixth cartilage through the

whole inspiration; in the other two, only at the beginning. In one of the excepted cases—Elliott (Table III., Case 143,)—the lower end of the sternum fell back at the beginning of inspiration; and in the other—Pearson (Table III., Case 148,)—who was observed *in articulo mortis*, the abdomen retracted during inspiration at the centre, the costal action was consequently throughout exaggerated: in her, the ribs over the affected side protruded slightly, and the abdomen considerably, at the beginning of inspiration.

The retraction was, in these instances, as in those where it occurred from condensation, due to the rapid elongation and collapse of the lower portion of the lung, by the descent of the diaphragm. (p. 436).

In two of the cases, the upper end of the sternum fell back throughout, and in four, just at the beginning of, inspiration. This partial retraction of the upper end of the sternum might be due, in some of the cases, to obstruction to inspiration, from laryngitis. But we shall have to consider another cause, residing in the non-expansibility of the thickened walls of the cavity.

Cavities in one upper lobe.—I have observations of twenty-four cases in which there were cavities in one upper lobe; the upper lobe of the opposite lung was in all the cases notably less diseased, and the lower lobes of both lungs were not appreciably affected. All those cases in which the whole of one lung was diseased have been already taken out and placed in the previous subsection.

Of the 13 cases in which the whole of one lung was more or less solidified with cavities in the upper lobes . . .	in	9, the left was affected. 4, the right ,,
Of the 24 cases in which there were cavities in the upper lobe only of one lung	in	14, the left was affected. 10, the right ,,

The accompanying lithographs from daguerreotypes of Samuel Redgate, (Table III., Case 163,) the once celebrated fast bowler, illustrate the change in the visible form of the chest, and the position of the viscera during a deep inspiration. In the daguerreotype taken during tranquil respiration,

the right side is manifestly larger than the left, but not very materially so; the right lung encroaches on the left side, its inner margin coming beyond the left edge of the sternum. Owing to the falling away of the diminished left lung, the heart is in extensive contact with the costal walls, and its impulse is felt from the third to the sixth costal cartilage.

In the daguerreotype taken during a deep inspiration the left shoulder is scarcely elevated, while the right is raised to a very great extent, and the whole right side is strikingly larger than the left side; the right lung encroaches still further on the left side: the lower margin of that lung descends more than the heart, the impulse of which is not lessened above by the expansion of the left lung, but becomes more extensive below owing to its own descent.

When the right upper lobe is consolidated, the exaggerated expansion of the left lung lowers and lessens the extent of the impulse in the intercostal spaces during an ordinary healthy inspiration; and causes its disappearance from the intercostal spaces, and appearance below the xyphoid cartilage, during a deep inspiration: on the contrary, if the left upper lobe be affected, as in Redgate, the left lung falls back from before the heart, exposing it extensively, so that the impulse is felt often from the second to the fifth or sixth costal cartilage; and during a deep inspiration the impulse increases in extent downwards, without being lessened above.

The following selected cases illustrate the movements of respiration when cavities are seated in the right or left upper lobe.

CASES OF PHTHISIS IN WHICH ONE UPPER LOBE IS AFFECTED.

	Sternum.		Second rib.		Fourth costal cartilage.		Sixth costal cartilage.		Sixth rib.		Tenth rib.		Abdomen.			Tape measurements. above nipple.		Tape measurements. at xyphoid cartilage	
	upper.	lower.	right.	left.	right.	left.	right.	left.	right.	left.	right.	left.	right.	centre.	left.	right	left.	right	left.
LEFT SIDE.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.
S. Redgate, 37, breathing capacity 150, large vomica, improving. (See Lithographs.)	*·01 †·02	*·02 †·05	·06 to ·10	·03 to ·07	·13	*·02 †·02	·08	*02 †·04	·07 to ·09	·03 to ·05	·09 to ·11	·07	·14	·40 to ·50	·08	18·2	16·9	18·2	17 6
Deep inspiration	*·02 †·20	*·02 †·25	·50	·30	·55	·30	·34	·24	·50	*·05 †·30	·30	·30	·24	·90	·18	18·9	17·3		
R. Stanyon, 36, breathing capacity 246, large vomica, getting worse	·08 to ·10	·07	·08 to ·11	·06 to ·08	·06	*·01 †·01	·09	*·01 †·02	·07	·03	·15	·14	·13 to ·15	·35	·18	13·8	16·4	15·5	15·2
M. Castle, large cavity	·13	·06	·12 to ·16	·08 to ·13	·01 to ·05	*·02 †·03	·05 to ·06	·03 to ·05	·06	·03	·15 to ·20	·10 to ·12	·08 to ·09	·15	·07 to ·08	13·8	12·2		
RIGHT SIDE.																			
S. Fowles, 27	·08	*·12	·05 to ·08	·12 to ·14	*·03	·07	*·05	·0	...	...	·16	·15	·15	·20	·16				
S. Daft, 65	·09	*·02 †·08	*·01 †·03	·09	* 03 †·01	·05	*·02 †·04	·08	...	...	*·03	·10	...	·30					
Deep inspiration	...	·60	...	...	...	...	·40	·60	...	...	·30	·50							
J. C. Searle, 25	·06	·05	·06	·12	*·02 †·02	·06	·05	·06	...	...	·07	·08	...	·17	...	15·2	15	14·5	14
Saywell ...	·20	*·02	·20	·20	·03	·02	·04	·03	...	...	·06	·09	·05	·09	·03				
Deep inspiration	...	...	·80	·60		...													

The ordinary figures, and those with † prefixed, denote a forward motion; those with * prefixed, a backward motion of the costal walls during ordinary inspiration.

In only one of the twenty-four cases—Green (Table III., Case 154,)—was the most affected side largest. In Astell, (Table III., Case 155,) the two sides were equal; and in Stanyon, (Table III., Case 162,) nearly so. The increased size of the least diseased lung was not confined to the subclavicular space, but also extended over the whole front of the chest, down to the lower boundary of the heart and lungs, or to the sixth costal cartilages.

I need not say that although the cases are classed as being diseased in the right or left upper lobe, yet the opposite lung is likewise in almost all cases affected with tuberculous disease, though in a less advanced stage. Consequently, although I have observed no cases of incipient phthisis with the chest-measurer, yet in most of the cases the lung having cavities is compared with a lung in the earlier stages.

In twenty-three of the twenty-four cases, the respiratory movements were decidedly and considerably less on the most affected side. In the exception, Saywell, there was undoubtedly a cavity on the right side; yet the motion of that side was a shade greater than that of the opposite. In S. Hoffen my notes state that some of the movements were greater, some less, over the affected side; here I suspect an error.

In only two of the cases was there absolute non-motion over the cavity; these were the cases of Green and Astell, in the first of whom the affected side was the largest, while in the other the two sides were equal; in neither of them was costal respiration exaggerated. The cavity was superficial in Green, but it was not so in Astell; probably in the last case a block of solid tubercle was situated over the cavity: both of these cases had considerable mobility over the opposite second ribs, their extreme inspiratory movements being respectively ·85 in. and 1 in.

In none of the cases was the motion reversed over the cavity through the whole inspiration; though in three of them the rib receded ·01 in. to ·02 in. at the beginning of the inspiration, and then advanced.

If the eye run down the parallel columns of the movements of the second rib, just over the cavity, it will be seen that in nearly all, the motion of the most affected side was about one half of that of the less affected side. The motion of the opposite lung was considerably exaggerated in fifteen cases; moderately so in four; and not so in five. In the ten cases in which the costal breathing was not notably exaggerated, the abdominal was slightly so. Although the cavity has, over its centre, almost always an inspiratory movement, yet at its margins I have often found the motion abolished, and even reversed. The fourth costal cartilage is often over a consolidated portion of lung, which forms the walls of the cavity. The fourth costal cartilages receded either at the beginning or during the whole of an inspiration in fourteen out of twenty-two cases. The fourth cartilages receded in six out of ten cases on the right side, and in eight out of twelve on the left.

Of the whole thirty-nine cases observed in which there were cavities in one lung, there were eleven in which the upper end of the sternum fell in at the beginning of inspiration. This might be in some cases from laryngitis; but as the laryngitis of phthisis does not usually obstruct respiration materially, as is manifested in the case of Andrews, (Table III., Case 179,) I conceive this can seldom have an influence. The falling back of the upper end of the sternum is, I conceive, due to its being so often in front of the consolidated border of the cavity. The lung outside the consolidated portion expands, and the cavity itself expands also, when acted upon by the costal movement. I conceive that the expansion of the lung to each side of the consolidated wall of the cavity stretches that wall and causes it to collapse, hence it so often recedes just at the beginning of inspiration. In a few cases, especially over the fourth rib, the wall recedes during the whole inspiration. For an explanation of the cause of the falling back of the costal walls in disease, see pp. 394-399.

In many cases, both around and over the cavity, the thoracic wall stands still just at the beginning of an inspiration.

This is, as it were, the first stage of an absolute falling back. The same phenomenon is observed in emphysema.

The lower end of the sternum, and the adjoining sixth cartilage on the affected side, recede, either at the beginning of inspiration, or throughout, in about one half of the cases. Here the falling in is due to the elongation of the affected lung through the action of the diaphragm, and its consequent collapse.—See pp. 443, 444.

The elevation of the clavicle and sternum, in the few cases in which I observed it, corresponded with the forward movement of the sternum and second rib. In one half of the cases, the action of the diaphragm is somewhat restrained on the affected side. The movement of the diaphragmatic ribs was diminished

In 6 cases out of 10 on the right side when that side was affected.
And in only 4 „ 13 on the left side „

This preponderance of restraint on the right side is probably due to the presence of the liver, which is often enlarged in phthisis.

While examining the movements over a cavity, I have found, at short intervals, a great change in their amount. This could occasionally be traced to the accumulation of the contents of the cavity at intervals, and to the consequent additional obstruction to its expansion and contraction. The gurgling rhonchus is most usually heard at the beginning of an inspiration, and the end of an expiration; the cavity and its tubes are then smallest, and the fluid it contains most nearly fills it; at the end of inspiration and beginning of expiration, when the cavity is expanded to its full extent, the fluid gravitates to the bottom of the cavity, away from the bronchial inlet; but by and by, when the cavity is again lessened by expiration, the fluid again plugs its outlet, and re-produces the cavernous rhonchus.

The prolongation of the expiration, and its increasing slowness towards the end, is often due to the same cause.

During a deep inspiration the difference between the expansion of the two sides is usually very apparent to the eye. The cavernous lung usually expands from one half to two-

thirds of the amount that the opposite lung does; the proportional difference between the expansion of the cavernous and that of the opposite lung is somewhat lessened, but the actual difference, from the whole motion being increased, is much greater, and, therefore, much more palpable.

If there be disease in one lung, the restrained motion on that side will, as has just been said, be more palpable during a deep than during an ordinary inspiration; but if there be diminished motion during tranquil breathing, without any morbid cause, the difference in the motion will usually disappear during a deep inspiration; the movement, for instance, may be ·03 in. on the right side, and ·06 in. on the left, in tranquil breathing; and on taking a deep breath they may be 1·1 in. on the right, and 1 in. or 1·1 in. on the left. Here we possess an unequivocal sign of the absence of difference in the amount of disease on the two sides.

In many cases, the movements are very much restrained over the cavity during a deep inspiration; if they be so, the movements over the opposite lung are usually also restrained, and in a like proportion.

	Over the Cavity inch.	Over the corresponding part of the opposite Lung. inch.	Abdomen. inch.
In Durow, the movement, on a deep inspiration	·15	·35	·30
Harly	·05	·15	
Rutland	·16	·30	
Porter	·00	·30	
Castle	·20	·35	·40
Smith	·26	·35	·40
Emmet	·35	·60	
Redgate	·30	·50	·90
Searle	·40	·60	
Kirk	·40	·70	1·00
Alvey	40	·85	
Do., second observation	·55	·90	·70
Green	·45	·85	·70
Astell	·70	1·00	
Parson	·70	1·00	1·50
Searle, second observation	·80	1·20	

When the cavity is lessening, and the health improving, the restraint on the cavernous side may increase, while the movement on the opposite side may increase. Thus—

In Robinson (a case of this class long watched)	·10	·50	·50

The extreme advance of the abdomen is, also, usually restrained in proportion (within certain limits) to the restraint on the extreme movement over the cavity during a deep inspiration, as is evident in the above Table.

If the disease be improving, as in Redgate and Robinson, the abdominal motion is proportionally greater.

Cavities, or softening tubercles, in the upper lobes of both lungs in nearly equal degree.—In these cases, the movements of the two sides more nearly balance each other.

The two sides do not usually differ in contour; the whole chest is flat, the sternum being as prominent as, or more so than, the 3rd, 4th, or 5th costal cartilages; the lungs, falling away from the heart, leave it extensively exposed; the mass of the lungs, unless there be universal tuberculous deposit, is diminished; the size of the abdominal, in proportion to that of the thoracic, organs is, therefore, considerably increased, and the hepatic and gastric bulges are high and prominent.

I have examined, with the chest-measurer, four cases of this class.

CASES OF PHTHISIS IN WHICH THE UPPER LOBES OF BOTH LUNGS WERE AFFECTED.

	Sternum.		Second rib.		Fourth rib.		Sixth costal cartilage.		Eighth rib.		Tenth rib.		Abdomen.			Tape measurements. above nipple.		Tape measurements. at xyphoid cartilage.	
	upper.	lower.	right.	left.	right.	left.	right.	left.	right.	left.	right.	left.	right.	centre.	left.	right.	left.	right.	left.
	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.
T. Andrews, sides equal, numerous cavities in both lungs behind	·10	·05	·15 to ·18	·09 to ·15	·06	·05	·05	·05	·12	·12	·10	·10	·14	·20	·20				
J. German, cavities on both sides, more on right	·03 to ·10	·04	·06 to ·15	·10 to ·20	·05	*·01 †·05	·03	·04	...	...	·11	·11	·12	*·05 †·15	·05				
Second observation	·06	*·05	·08 to ·10	·13	·06	·06	·03	·03	...	...	·10	·10	·13	·20	·04				
D. Flanagan, aged 39, cavity in right lobe, deposit in left, sides equal. Diameter—right, 5·7; left, 5·9 inch.	·02 to ·10	*·01 †·02	·04 to ·08	·04	·03	·05	·02	·05	...	...	·05	·05	·05	·18	·08	17·2	17·2	17·2	17
Deep inspiration	...	...	·15	·20															
S. Vallance, aged 15, cavities in both lobes, largest in the left; left side largest	*·02	*·09	* 01 †·03	*·01 †·03	*·02 †·02	*·03	·03	*·03	...	...	·11	·10	·16	·23	·16	13	13	12·5	11·6
Deep inspirat'on	*·04 †·04	...	·25	·35	·30	*·04 †·04	·20	·12	...	...	·30	·20							

The ordinary figures, and those with † prefixed, denote a forward movement; those with * prefixed, a backward movement of the costal walls during ordinary inspiration.

These cases present slight differences here and there, in perfect keeping with the minor difference in disease on the two sides.

In Flanagan, a patient of Dr. Roupell, at St. Bartholomew's Hospital, (Table III., Case 180,) the difference is trifling on a deep inspiration, and does not exist during ordinary breathing; the solidified, or softened left lung, obstructs the movements nearly as much as the cavernous right lung.

A cavity in the middle lobe of the right lung.—I have examined one case of this kind.

In this case, a cavity existed in the middle lobe, and occasioned a very marked restraint in the motion of the 4th and 6th cartilages on that side; in fact, their motion was annihilated, as is shown in the annexed Table.

	Sternum.		Second rib.		Fourth rib.		Sixth rib.		Tenth rib.		Abdomen.		
	upper.	lower.	right.	left.	right.	left.	right.	left.	right.	left.	right.	cent.	left.
J. Tenuini, 40	inch. ·05 to ·10	inch. *·05	inch. ·08 to ·10	inch. ·10 to ·14	inch. ·01 to ·02	inch. ·02	inch. ·0	inch. ·12	inch. ·10	inch. ·12	inch. ·12	inch. ·20	inch. ·10
Deep inspiration	·30	...	...	...	...	...	...	...	·10	·30			

From these observations we may conclude, that wherever and whenever an extensive cavity exists in the lung, the respiratory movements are restrained over that cavity, but not obliterated; that the respiratory movement is greater over the centre than over the circumference of the cavity, and that, immediately over the circumference, the ribs or sternum often recede, either during the whole inspiration, or, which is more usual, only at the beginning of it. The firm, tendinous, pleuritic adhesions that surround the lungs in the advanced state of tuberculous disease have more restraining influence over the movements than the disease itself has.

"Incipient" phthisis.—I have no observations to offer made by the chest-measurer, in persons affected with phthisis at this stage. The united testimony of Andral, Sir James

Clarke, Dr. Forbes, Dr. C. J. B. Williams, M. Collin, M. Fournet, Dr. Hughes, and other accurate observers, affirms, that even in the early stages the movement of inspiration, especially on a deep inspiration, is restrained over the seat of the disease.

The observations of Andral speak directly to the point of the immobility, or partial mobility, of the chest, over that part where the lung is indurated from agglomeration of tubercles.* It follows from the physical nature of the progressive changes in phthisis, that the inspiratory motion over a cavity which has a respiration of its own, must be greater than that over the more solid but softening tuberculous mass that immediately precedes the formation of a cavity. On this point I hope to make further special inquiries.† Andral has, however, decided it as a matter of direct observation.

Summary of the effects of phthisis on the movements of respiration.—In the earlier stages, the movements over the diseased portion of lung are restrained. When a mass of

* "Dans la phthisie pulmonaire, l'on observe un phénomène encore plus remarquable; c'est l'immobilité, ou du moins la dilatation moindre d'une partie plus ou moins étendue d'un des côtés du thorax, là où les tubercules sont agglomérés en grand nombre. Cette immobilité plus ou moins complète d'une partie des parois thoraciques, est surtout évidente chez certains phthisiques, au-dessous de l'une des clavicules, entre cet os et le sein. Ce n'est pas avec l'existence de vastes excavations tuberculeuses que coincide le plus souvent ce défaut partiel des mouvemens des côtes, mais bien avec l'existence d'une pneumonie chronique formée, soit autour de tubercules crus et plus ou moins nombreuses, sois autour de petites cavernes. C'est à dire que l'immobilité partielle des côtes coincide le plus ordinairement avec un son mat."—*Andral, Clinique Medicale*, ii. 97.

† *Postscript, August* 1848.—Dr. Barlow recently favoured me with the observation of a patient of his, at Guy's Hospital, that illustrates this passage. There was a large cavity at the summit of the right lung, and a consolidated mass of tubercles and a smaller cavity at the summit of the left lung. The second, third and fourth ribs were more prominent on the left side than the right; and the respiratory motion, as indicated by the chest-measurer, was greater, both during an ordinary and a deep inspiration, over the extensive cavity on the right side than over the half-consolidated, half-cavernous, lung on the left side.

lung is solidified by tuberculous disease, the mobility is still further restrained. (p. 453-454.)

Where cavities are formed, their inspiratory expansion is much diminished, chiefly by the firm, tendinous, and pleuritic adhesions that embrace the diseased portion of lung. (p. 441-453.)

There is almost invariably some movement of inspiration over the cavity. But although the part in question always advances during inspiration, especially a deep inspiration, yet, at the beginning of the inspiration it sometimes recedes slightly, and frequently stands still just before its inspiratory advance. (p. 447-453.)

The respiratory expansion and movements over a cavity are greatest just towards the end of inspiration and the beginning of expiration, when the cavity and the tubes leading to it are the largest, and when the fluid in the cavity lies in its hollow, and does not plug the bronchial tubes. The obstruction to the movement over many cavities, especially those containing liquid, is greatest just at the beginning of inspiration, and towards the end of expiration, when the cavity and tubes are at the smallest, and the fluid, its amount being the same, plugs the bronchial tubes. The obstruction to cavernous respiration varies with the amount of fluid in the cavity and its tubes. (p. 449.)

The firm walls surrounding a cavity have no inspiratory expansion: the respiratory movements over the region of dulness surrounding a cavity are much smaller than those over the cavity itself; they are often immobile; their motion is often reversed at the beginning or through the whole course of inspiration and expiration. (p. 448.)

The reversed motion is most frequent over the third and fourth cartilages.

The motion of the lower end of the sternum, and the sixth cartilages, on the affected side, is often reversed by the diaphragmatic lengthening and collapse of the lung. (p. 449.)

The descent of the diaphragm is somewhat restrained on the affected side, in about one-half of the cases; the motion of the right diaphragmatic ribs is more frequently diminished than that of the left, when the respective superior lobes are diseased, owing, I believe, to the presence of the enlarged liver. (p. 449.)

When the whole lung is more or less consolidated, and its expansion obstructed by tendinous adhesions, the lateral expansion of the whole affected side of the chest is lessened. (p. 438-444.)

If the diaphragm act freely, the movements of the sixth costal cartilage on the affected side may be reversed. Those of the superior thoracic ribs, over the cavity, are never reversed throughout, seldom even at the beginning of inspiration and expiration, but those of the third, fourth and fifth cartilages are often prevented and reversed.

The respiratory movement of the opposite lung is, in the great majority of cases, exaggerated.

E.—*Effect of pneumonia on the movements of respiration.*—Laennec repeatedly assured himself that the dilatation of the chest was equable in cases of peripneumony, confined to one side.* Grisolle invariably found the dilatation equal, unless pleuritic pain of severe character existed. Dr. Walshe, remarking on these statements, is satisfied that the motions of the chest are diminished in simple pneumonia, with extensive consolidation, independently of the influence of pain. Dr. Stokes incidentally remarks, that the absence of frottement in pneumonia is owing to the diminished motion of the inflamed lung. Dr. C. J. B. Williams states that manual examination may often detect a deficiency in the motion of the ribs of the affected side. M. Fournet observes that, in chronic pneumonia of the upper lobe, diminution of motion is seen. From these statements, one is led, *à priori*, to expect that, in some cases of pneumonia, the movements on the affected side are diminished, and that in others they are

* Dr. Forbes' Translation, p. 13.

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not. This is corroborated by the few observations I have yet made with the chest-measurer in pneumonia.

	Sternum.		Second rib.		Fourth rib.		Sixth rib.		Tenth rib.		Abdomen.			Tape measurements.	
	upper	lower	right	left	right	left	right	left	right	left	right	centre	left	right	left
	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch
H. Kitchen, age 35, pneumonia, rapid recovery	·03	*·01 † 03	·05	·05	·03	·02	·04	·03	·08	·09	·08	·20	·18	17·7	16·4
Deep inspiration	·06	*·02 †·04	·10	·08	·05	·06	·07	·05	·10	·07	·06	·18	·15		
T. Carrington, recovery not very rapid	-05	·03	·03	·03	·0	·03	*·01 †·03	·04	·04	*·01	...	·28 to ·40			
Second observation	*05to*·08	*·07	·03 to ·05	·15	*·02	*·02	*·05	*·02 †·01	·09	·09	·12	·16	·08		
E. Streeton, 18, pneumonia of right lower robe, bronchitis	*·02 †·05	*·10	* 03 †·06	·12	*·06	·04	*·02	·08	·12	·19	·12	·25	·17		

The ordinary figures, and those with † prefixed, denote a forward movement; those with * prefixed, a backward movement of the costal walls during ordinary inspiration.

In Kitchen, the respiration always went on freely. Crepitation in the right lower lobe soon gave place to a mucous rhonchus, and resonance on percussion returned. Viscid brown sputa were readily parted with. The pneumonic lung was, by an inch, the largest. The respiratory costal movements of the affected side were never less than those of the left side, and during a deep inspiration they were somewhat greater. The deep inspiration was remarkably restrained, on both sides, and over all parts of the lung. The movement, on a deep inspiration, was, over the right and left second rib, only ·10 in. and ·08 in. respectively, and a like proportion was kept throughout, so that the costal motion was not a tenth of its natural amount. This small range of respiration on both sides accounts, in part, for the equal expansion, but this is chiefly, I conceive, due to the expansibility of the diseased lung, the air-tubes being at all

times permeable. In fact, consolidation was never established.

Although the *costal* respiration was equal on the two sides, yet the action of the *diaphragm* was considerably less on the affected side, the abdominal movement being ·08 in. on the affected, and ·18 in. on the left side.

The cases of Carrington and Streeton were not purely pneumonia. In Streeton, who died, it was complicated with bronchitis; in Carrington, with the prevailing influenza. In both, pneumonia existed in the right lung, and the movements were restrained over that lung.

Summary.—I am not entitled to infer with confidence, from these scanty materials, what are the characteristic modifications of pneumonia on the respiratory movements.

From what many accurate observers have stated, from the cases here given, and other cases observed without the chest-measurer, and from the nature of the disease and its analogy to condensation of the lower lobe of one lung, one is, I conceive, entitled to say, that when the lower lobe, affected with pneumonia, is consolidated, the costal and diaphragmatic motion over the consolidated portion of lung is restrained.

Pneumonia of the lower lobe may sometimes cause restraint in the movement of the ribs over the corresponding upper lobe. In a case observed by me some years since, my attention was directed to pneumonia in the base of one lung, by the movement over its apex being deficient in comparison with that of the opposite lung.

I believe it will be found that, in all cases of pneumonia of the lower lobe of either lung, the descent of the diaphragm on the affected side is restrained, while that of the opposite side is exaggerated.*

* Dr. Barlow favoured me lately with the examination of a female affected with pneumonia of the lower lobe of the right lung. The movement of the diaphragmatic ribs (the ninth) over the affected side was ·1 in.; over the left side, ·3 in. The abdominal parietes, which had but little motion below the left tenth rib, actually fell in from ·06 in. to ·1 in. over the corresponding point of the right side. This case is an additional proof that non-

That, in those cases where the costal motion is restrained, the restraint will be greatest in the lower ribs—the diaphragmatic and intermediate sets (illustrated by Dr. Barlow's case).

That the expansion of the chest over the unaffected side is exaggerated in all cases, and, in some cases, that also of the thoracic walls over the unaffected lobe of the diseased lung.

In acute pneumonia, the restraint to the increased inspiratory movements, during an attempt at a deep inspiration, is great and universal.

F.—*The rhythm of respiration in those cases where the disease is confined to one lung, or one side of the chest.*—In all the diseases of this class, the rhythm of respiration may be affected. In none of these diseases is the rhythm always deranged. In all of them, when the rhythm is altered, the expiration is prolonged.

The prolongation of the expiration is always, I believe, due to obstruction in the bronchial tubes; and in all these cases the expiration is quick at the commencement of the act, and becomes gradually slower towards the end. In fact, the same class of causes that alters the rhythm in bronchitis and emphysema alters it in the diseases now under review.

In pleuritis and pleuritic effusion, and pneumothorax, the expiration is often retained at first by the involuntary contact of the vocal chords. These suddenly separate with a vocal cry or moan, and the expiration then rushes out very quickly at first, owing to the forcible expulsive action of the expiratory muscles. The same disturbance is met with in pleurodynia, pneumonia, peritonitis, and some other ailments, in which an inspiration excites pain, and the involuntary expiratory vocal efforts just described.

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motion, or even reversed motion, of the diaphragm on the affected side is often an indication of pneumonia affecting the base of the lung.—August, 1848.

In phthisis, the accumulation of fluid in a cavity, or in the bronchial tubes, excites, as in bronchitis, prolonged expiration —quick at first, then slow, and of increasing slowness towards the end, when the narrowing of the air-tubes increases the obstruction from the presence of fluid. The mechanism of the prolonged expiration, slower towards the end, which often exists in phthisis, where there are cavities containing fluid, has been already inquired into. (p. 449-455.)

In phthisis, if there be no obstruction to inspiration and expiration from fluid in the bronchial tubes or cavities, the rhythm of respiration is not usually disturbed.

In pneumonia, I conceive that the rhythm will be disturbed in like manner under the like circumstances, although M. Collin states that, in pneumonia, the inspiration is prolonged.

I beg to refer to the remarks on the Rhythm of Respiration in Emphysema and Bronchitis for a more full inquiry into that subject. (p. 413.)

PART IV.—EFFECT OF DISEASES OF THE HEART AND PERICARDIUM ON THE MOVEMENTS OF RESPIRATION.

SECT. I.—*Effects of Pericarditis on the Movements of Respiration.*

In severe cases, when there is pericardial effusion and the free and attached pericardium are both involved, the central tendon of the diaphragm being inflamed, the motion of the abdomen at the centre may be diminished, absent or reversed during inspiration, and the movements of the left fourth, fifth and sixth cartilages may be reversed, (either wholly, or only at first,) abolished or diminished.*

The movements of the ribs of the right side, and of the

* *Postscript, August* 1848.—Dr. Barlow gave me the opportunity of seeing a patient of his with pericarditis, in whom the abdominal movement was only about ·1 in. below, and to the left of the xyphoid cartilage. In a case of pericarditis, attended by Dr. Barlow, the lad finding relief from it, had of himself put a band round his abdomen, so as to restrain the abdominal and diaphragmatic movement.

left superior thoracic ribs, are at the same time exaggerated.

The retraction of the sternum and of the left costal cartilages is due to the elongation and consequent collapse of the distended pericardial sac by the action of the diaphragm. The exaggerated costal expansion also tends to draw a portion of the fluid away from behind the sternum and the left costal cartilages, and they hence fall back, owing to atmospheric pressure.

If pericarditis be less extensive and acute, the action of the diaphragm and the movements of the left costal cartilages are still restrained, but to a less extent in proportion as the disease is slight or partial.*

Sect. II.—*Effects of enlarged Heart on the Movements of Respiration.*

When the heart is materially enlarged, the expansion of the lower end of the sternum and of the cartilages and ribs

* The effect of diseases of the heart and pericardium on the movements of respiration :—

That the inspiratory descent of the heart may exist in *pericarditis*, even with extensive effusion, was proved by the cases of Redgate and Cummins; diagrams from whom, in life, are given at pp. 532, 534 of my paper in the Provincial Medical Transactions.

In both of these, the seat of the impulse was lowered during a deep inspiration,—in Redgate, from the first, second, and third intercostal spaces in the tranquil state, to the third and fourth spaces; and in Cummins, from the third and fourth spaces, to the fourth and fifth. We have here an absolute proof that the heart may descend during inspiration, in a case of pericarditis with effusion. The case of Cummins proves, however, that though the descent of the diaphragm is not prevented, yet the expansion of the chest on the affected side is restrained, as in him the axillary and sub-mammillary measurements of the right side increased during a deep inspiration, from 12·4 in. to 12·6 in., and from 13 in. to 13·4 in., while the left side was stationary at 12·6 and 13 in. The diaphragm, Redgate's case showed, may be also restrained; the descent of it on the right side being greater than on the left.

In only one of the cases of pericarditis that I have examined with the chest-measurer, Weldon (Table IV., Case 181), was the pericarditis uncomplicated with endocardial noises. His case was, in other respects, more

in front and to the side of the cardiac region is restrained. The size of the heart does not permit the usual extensive forward expansion of the left lung.

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complicated than the rest, as he suffered habitually from Laennec's emphysema, to which rheumatic pericarditis was superadded. I have grouped all the cases of pericarditis, endocarditis, valvular disease, and pericardial adhesions, into one table, to which I refer. By thus grouping them, cases of the same kind are kept together, and the influence of various modifications can be readily compared.

In Weldon, the exposed portion of the heart (the cardiac region) was small, and low down, being behind and to the left of the xyphoid cartilage. This was owing to the emphysematous lungs occupying the space normally occupied by the heart. The chief modifications in the movements of respiration were those of emphysema. The lower end of the sternum at first retracted and then advanced during an inspiration. The peculiarity in the movements, manifestly introduced by the pericarditis, was an additional falling back of the left sixth cartilages compared with the right. While the right retracted ·03 in., the left fell back ·05 in.; and while the right fourth cartilage advanced ·05 in., the left receded ·02 in. at first and then advanced ·02 in. The retraction was here in part due to the emphysema; and, over the left side, in part to the pericarditis. In Hibbert and William Shaw, aged 15, (Table IV., Cases 182-3,) there was rheumatic pericarditis, without effusion, with faint endocardial murmur—aortic in Hibbert, mitral in Shaw. In both of these, the sternum, and the left fourth and sixth cartilages, receded during inspiration, either at the beginning only, or during the whole time, while the motion on the right side was nearly normal. In Lee, Thorley, and Benson, (Table IV., Cases 185, 186, 188,) the heart was enlarged, with some little pericardial effusion; and there were pericardial friction sounds, with exocardial murmurs. In these, as in the others, the motion of the left sixth and fourth costal cartilages was either less than that of the right, or was absent or reversed during inspiration. In all the cases, there was more or less restraint in movement of the abdomen at the centre, while, at the sides, it was scarcely affected.

In Thorley, the abdomen advanced at the centre, on the first examination, ·07 in. At a later examination, when he suffered much from pain and dyspnœa, the abdomen, at the centre, fell back ·1 in. during inspiration; at the side, it scarcely moved. Here the motion of the diaphragm was paralysed at the centre, and almost at the sides. The action of the diaphragmatic ribs was very slight, while the advance of the whole right ribs, and of the upper thoracic left ribs, was much exaggerated.

In the interesting case of a girl, with the examination of which I was favoured by Dr. Gill, suffering from pericarditis, with extensive effusion, the abdomen fell back at the centre during inspiration.

According to Dr. Stokes, muscles, when inflamed, are paralysed. This

If the heart be very large, the lower end of the sternum and the adjoining left cartilages may sometimes recede slightly during inspiration. The descent of the diaphragm is freely permitted both in front and to the sides.*

Sect. III.—*Effects of enlarged Heart with Pericardial Adhesions on the Movements of Respiration.*

If there be pericardial adhesions with valvular disease and enlargement of the heart, the costal expansion in front of the

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is borne out in these cases, where the central tendon of the diaphragm was inflamed, and the action of the diaphragm arrested. The diaphragm fell back, in Thorley's case, on the same principle that the sternum fell back when the diaphragm was active, in hiccough, narrowed larynx, and emphysema. In the latter cases, atmospheric pressure forced back the ribs over the lengthened and collapsed lung; in the former case, the abdomen over the widened and shortened lung. In Thorley's case, the heart's impulse was scarcely lessened above during inspiration, on the second examination, when the diaphragm was inactive; and friction sounds were heard just over the heart. Partial adhesions were probably being formed.

The case of Clark is almost an exception. In reality, the active pericarditis had ceased before its existence was discovered. All the general signs of illness had disappeared. Health was returning, but there was a loud to and fro friction sound, like the rubbing of fine emery paper over the cardiac region. It was evident that active disease had disappeared, and that there was left merely the roughness of the membranes no longer inflamed; in a fortnight, the friction sound disappeared.

* Effect of enlargement of the heart with valvular disease on the movements of respiration :—

In the cases of John Illston and Mary Tomlinson, of whom diagrams are given in my paper on the Position of the Viscera, pp. 652-4, the heart and the left lung descended, as well as the right, to the normal extent during a deep inspiration; the heart's impulse descending in Tomlinson from the third, fourth and fifth intercostal spaces, to the sixth intercostal space, and behind, below and to the left of the xyphoid cartilage.

In the cases of Simmonds, Roe, Soar, and Leavers, (Table IV., Cases 194, 192, 195, 193,) affected with valvular disease and enlargement of the heart, the movements of the left costal cartilages over the cardiac region and of the lower end of the sternum were restrained, while, excepting in Simmonds, the expansion of the superior thoracic ribs and of the whole right side was exaggerated.

In Simmonds, there was mitral regurgitation, but the heart was scarcely enlarged, and the respiratory movements were but little restrained.

heart is restrained, the lung cannot pass in front of the heart, the descent of the diaphragm is restrained, and the heart's impulse is little or not at all lowered at its upper part.

While the movements of the centre of the chest and abdomen are restrained, the lateral superior movements of the former and the lateral movements of the latter are not restrained.

In cases where the pericardial adhesions are firm and the heart enlarged, the advance of the sternum during inspiration is restrained by the adhesions. The action of the diaphragm from below, and of the costal expansion from the sides, withdraws a portion of the heart from behind the sternum; the heart collapses, and as the expanding lungs cannot interpose themselves between the heart and the ribs and sternum, the sternum, especially at its lower end, and the adjoining costal cartilages, especially the left, fall backwards during inspiration.

Owing to the adhesions and the consequent non-intervention of the lungs during inspiration, the extent of the impulse is not lessened above during inspiration. The intercostal spaces which may sometimes be seen to fall in over the lungs during inspiration do not fall in over the heart.

These signs will sometimes enable us to distinguish whether, when the heart is enlarged, there be adhesions or not.*

* Effect of pericardial adhesions on the movements of respiration :—

When the adhesions are loose, the heart free from valvular disease and normal in size, I do not suppose that pericardial adhesions will materially influence the breathing movements.

It is otherwise when they follow a severe attack of rheumatic pericarditis, are firm, and are accompanied by valvular disease and enlargement of the heart.

W. Shaw, (Table IV., Case 197,) aged 14, was just such a case. In him the lower end of the sternum and the adjoining cartilages protruded. The heart's impulse, which was visible in the epigastrium, threw the whole cardiac region violently forwards, with a rapid fall after the systole. The whole sternum fell back during inspiration. The abdominal movement at the centre was restrained, while at the sides it was exagge-

PART V.—THE VARIOUS CAUSES THAT MAY EFFECT ANY PARTICULAR ABNORMAL MODIFICATION OF THE RESPIRATORY MOVEMENTS.

In the progress of this inquiry into the movements of respiration in disease, I have taken the various diseases in their classes, and singly, and endeavoured to ascertain what effect each has in modifying the breathing movements.

I purpose here, in concluding the inquiry, to view rapidly, in their aggregate, the various morbid causes that may effect each particular deviation from the healthy movements of respiration.

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rated. He died. The pericardium was universally adherent. The mitral valves were diseased.

In other cases of adherent pericardium with enlarged heart, I have observed that the impulse was not lowered or lessened above during a deep inspiration.

In Bower, (Table IV., Case 199,) I infer that the pericardium was adherent—the heart being enlarged, the aorta regurgitant—because the impulse, which was very extensive, did not lessen in extent during inspiration. The intercostal spaces fell in over the lungs at each inspiration; their retraction stopped short suddenly at the margin of the cardiac region, just as it did at the upper boundary of the liver. In Bower, as in Shaw, the impulse was strong and heaving—returning suddenly. The region of the cardiac dulness extended considerably to the right of the sternum. In him the sternum at its lower end and the adjoining cartilages, especially the left, retracted during each inspiration; at the same time the sixth and eighth ribs fell in to the side, the left more than the right; while the diaphragmatic ribs and the abdomen to each side moved very freely outwards. The motion of the abdomen at the centre was very much restrained, being only ·15 in., one half its usual amount; while that of the sides was ·18 and ·2 in., right and left, being double the normal amount of motion.

The restraint of the diaphragm at the centre and in front is evidently due to the physical obstacle to its descent in the large and adherent heart, while the posterior portion of lung is, for compensation, called more freely into play, and is not interfered with in its descent.

In Bower, and also in Ellis, (Table IV., Case 198,) an old man who died with pericardial adhesions following pericarditis, the head was markedly lowered (in Bower ·02, in Ellis ·03 to ·05 in.) during each inspiration.

In pericardial adhesions with enlargement, the advance of the sternum is restrained by the adhesions. The action of the diaphragm from below, and of the costal expansion from the sides, withdraws a portion of the heart from behind the sternum, the heart collapses, and the sternum falls back.

Causes that arrest or restrain the Diaphragmatic Movements, and exaggerate the Costal Expansion, during Inspiration. Arranged as the effect is greater or less.

Peritonitis, especially of the diaphragm.
Pericarditis, especially of the central tendon of the diaphragm.
Pleuritis affecting the diaphragm.
Pericardial adhesions, with enlarged heart.
Aneurism of the abdominal aorta, close to the diaphragm.
Tumours attached to the diaphragm.

Ascites, Flatus, Ovarian tumours, } When they distend the abdomen so as materially to push up the diaphragm.

Paraplegia (?) if the phrenic nerves be involved in disease.

Causes that restrain the Costal Movements symmetrically, and exaggerate the Diaphragmatic.

1. Injuries to the spinal marrow, just below the fourth cervical vertebra.
2. Obstructions in the breathing-passages, either the nostrils, fauces, larynx, or trachea.

In hanging, or suffocation, hiccough at the beginning of the act; and in the fits of hysteria, during the violent struggles, when the vocal chords come together, during an attempt at inspiration,—the diaphragm acts with its whole force, draws down and elongates the yielding lungs, which collapse because air cannot enter them, and the chest retracting, is flattened and narrowed by the pressure of the atmosphere.

In croup, the hoop of hooping-cough, the crowing inspiration in children, in hysteria, and in the return noise made during inspiration by exhausted public speakers, described by Mr. Bishop,—the diaphragm acts forcibly, but with less power; the air is not absolutely excluded, but so little is admitted, that the sternum, especially the lower end of it, and the adjoining cartilages, fall back during inspiration.

In œdema glottidis, laryngitis, swollen palate, and obstructed nostrils,—according to the degree of the obstruction is the like result obtained.

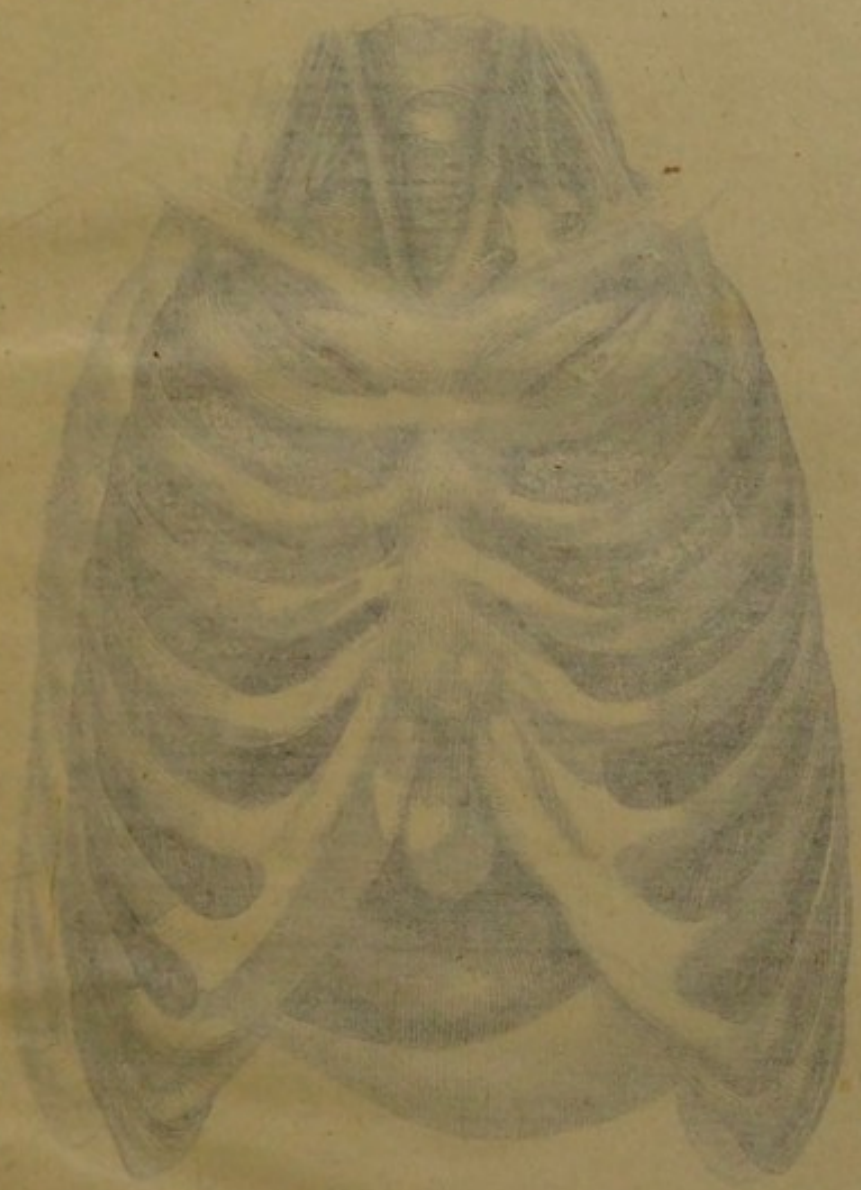
In these cases expiration is usually prolonged, and is in general equally slow through the whole act.

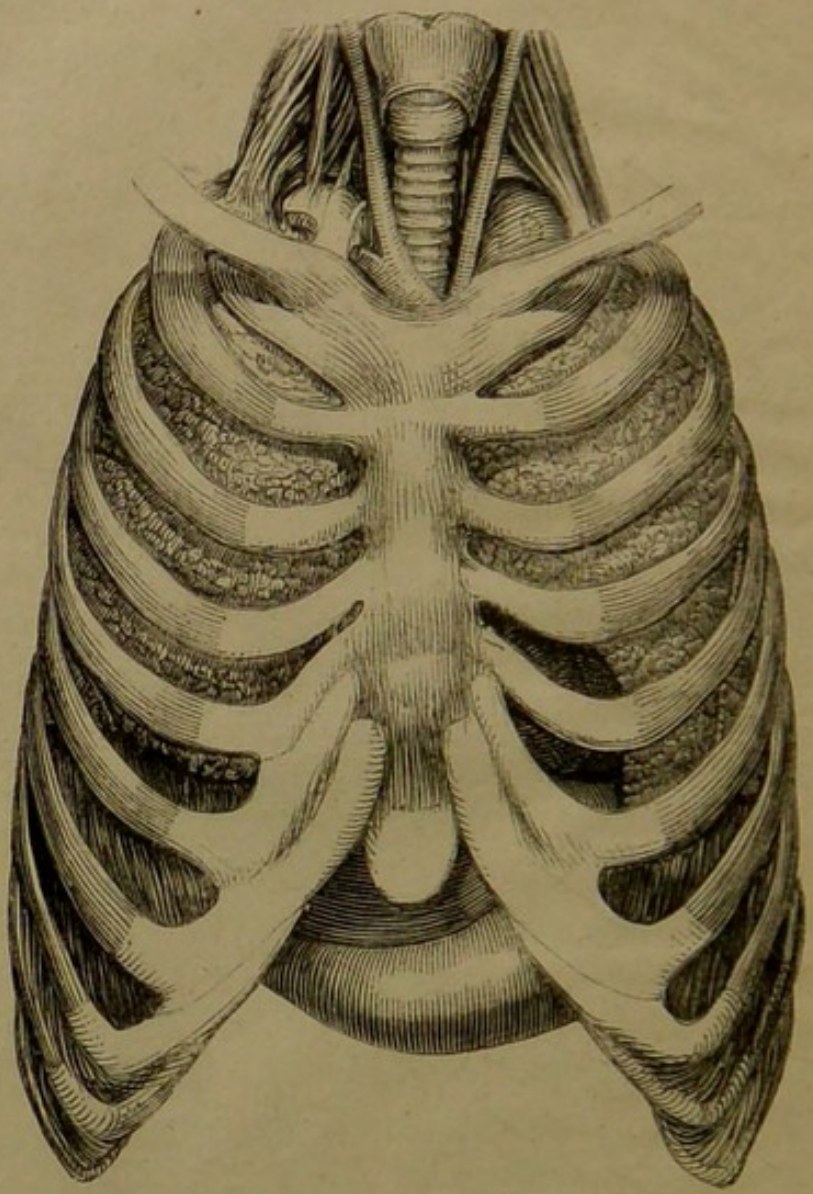
Causes that restrain the Movements of the lower end of the Sternum, and the Intermediate sets of Ribs, and exaggerate those of the Diaphragm, and the superior Thoracic Ribs.

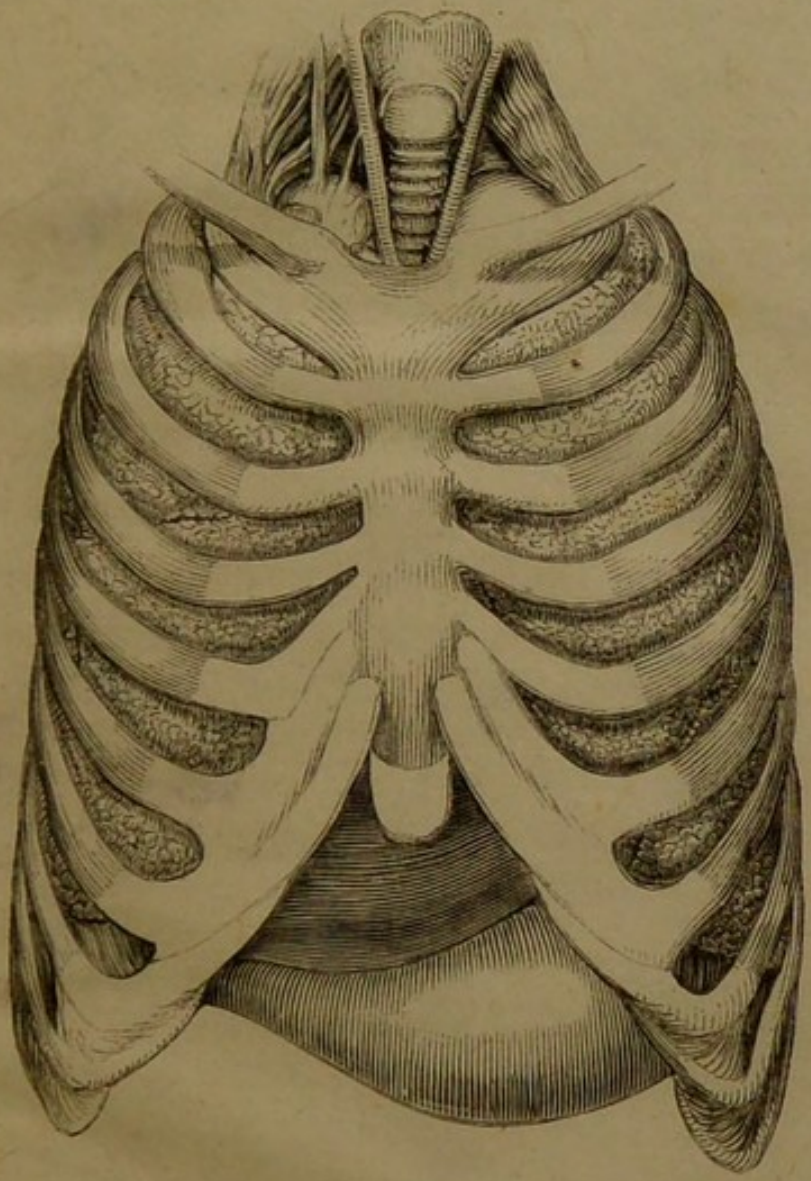
Obstructions in the smaller air-tubes.

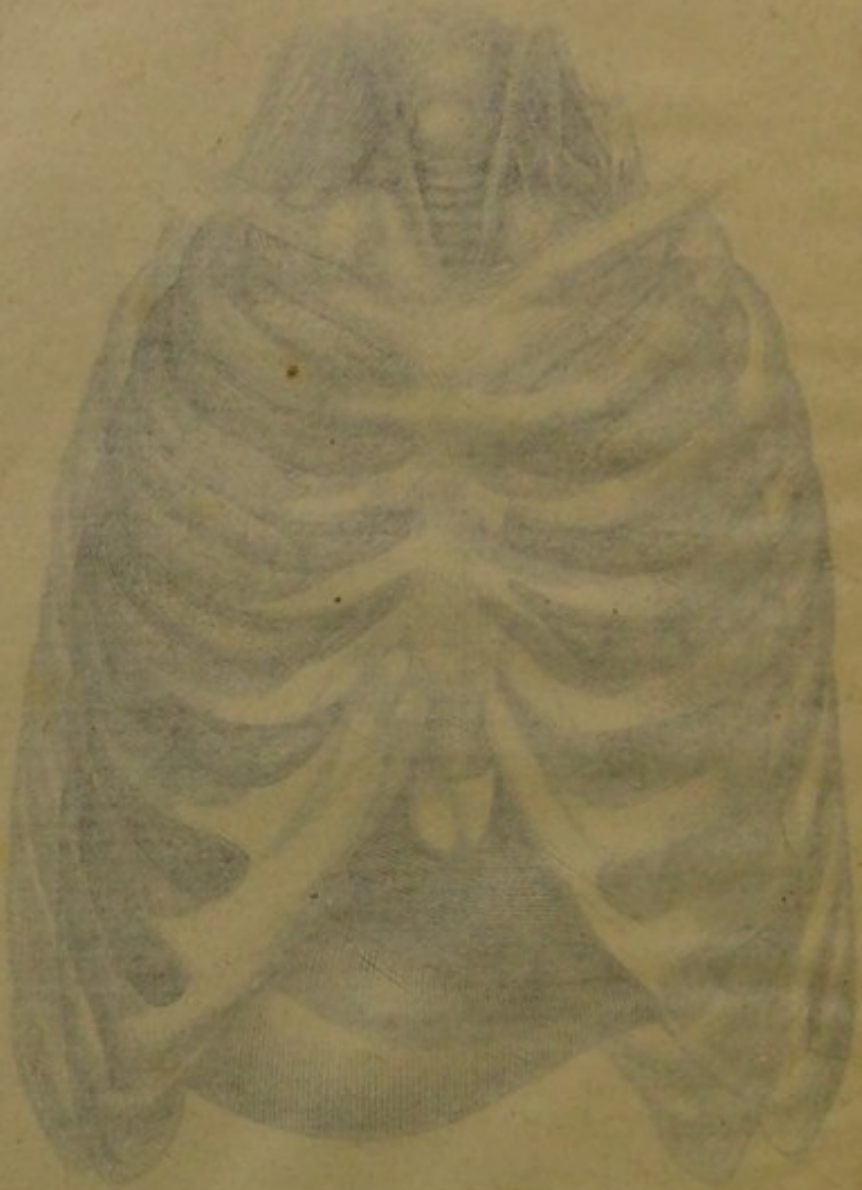
In emphysema and bronchitis, respiration is impeded,—inspiration most at the beginning, expiration at the end, when the small tubes are the narrowest, and the obstruction they offer is greatest.

In these cases, the diaphragm draws down and elongates the lungs, at the same time that the superior thoracic ribs amplify them upwards.









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These actions are performed more rapidly than air can enter; consequently, the lungs collapse, and the chest falls in at the lower end of the sternum and the sixth, fifth and fourth costal cartilages—that is to say, between the two expanded portions.

In healthy infants, the lower end of the sternum falls in during inspiration, especially if the abdomen be large, and the inspiration quick.

In ricketty children, the ribs and cartilages, and the sixth, seventh, eighth and ninth ribs, bend in at their articulation during inspiration, and the sternum protrudes.

In emphysema and bronchitis, if the lower end of the sternum be prominent, and the adjoining sides of the chest sloping, the sixth, seventh and eighth ribs fall in at the side, and the lower end of the sternum protrudes during inspiration.

Cause that restrains the Thoracic Ribs of both sides.

Posterior spinal curvature.

Causes that may arrest or restrain the Costal and Diaphragmatic Respiratory Movements of the whole of one side, those of the opposite side being exaggerated.

Obstruction in the right or left bronchus.

Emphysema and bronchitis of the whole of only one lung.

Pleuritic effusion and pneumothorax distending the whole of one side.

Condensation of the whole of one lung, usually from strong pleuritic adhesions, following empyema.

Consolidation from phthisis, combined with cavities and tendinous adhe sions of the whole of one lung.

Pneumonia, especially if both lobes be involved.

Extensive external injury to the whole of one side (fractured ribs).

Extensive pleurodynia.

Lateral curvature of the spine.

Hemiplegia (?).

Causes that may restrain the Respiratory Movements of the five superior or Thoracic Set of Ribs, in whole or part, of either side, all the other Movements being exaggerated.

Phthisis in all its stages, affecting one upper lobe.

Pneumonia of one upper lobe.

Pleuritis of one upper lobe.

Obstruction in the bronchial tube leading to either upper lobe.

Injuries or diseases of the ribs, or of the parts contiguous, if the movements of the ribs in question cause pain or mischief.

Causes that may restrain the Respiratory Movements of the Sixth, Seventh and Eighth Ribs, or Intermediate Set.

Pneumonia of the lower lobe.

Pleuritis of the lower lobe.

Partial pleuritic effusion.

Condensation of the lower lobe; dense pleuritic adhesions.
Peritonitis.
Local injuries.

The motion of the sixth rib may be restrained by disease of the upper part of the lower lobe, and lower part of the upper lobe.

Causes that may restrain the Diaphragmatic Ribs of one side during Inspiration.

Inflammation of one side of the diaphragm (pleuritic or peritoneal).
Pneumonia of the lower lobe—its lower part.
Any cause that may restrain the movement of one side of the diaphragm.

Causes that may produce retraction of the whole Sternum, and, more or less, the adjoining Cartilages, during Inspiration.

Obstruction to respiration in the outer air-passages.
Pericardial effusion—extensive.
Pericardial adhesions—universal, with enlarged heart.
Pleuritic effusions—universal.
Phthisis affecting the whole of one lobe.
Extensive injuries to the ribs.

Causes that may produce retraction of the lower end of the Sternum.

The same causes that may produce retraction of the whole sternum, when less severe.

Emphysema and bronchitis.
Condensation of the whole of one lung.

Causes that may restrain the motion of the left superior Thoracic Ribs.

Pericardial effusion; pericardial adhesions.
Excessive distention of the stomach.

Causes that may restrain the Motion of the Intermediate Set of Ribs (sixth and seventh) on the left side.

Pericarditis—pericardial effusion.
Enlarged heart—pericardial adhesions.
Distention of the stomach—enlargement of the spleen.

Causes that may restrain the Motion of the left Diaphragmatic Ribs (ninth, tenth, eleventh, and twelfth,) and the left side of the Diaphragm.

Distention of the stomach.
Enlargement of the spleen.

Causes that may restrain the Movements of the Right Thoracic Ribs.

Enlarged liver from adventitious deposits; adherent liver.

These causes may also restrain the movements of the right intermediate and diaphragmatic ribs and the right side of the diaphragm.

Causes arresting the right fourth, fifth and sixth Cartilages and Ribs.

Pneumonia of the middle lobe.
Cavities in the middle lobe.

The motion of any rib, or set of ribs, may be restrained or arrested by various modifying causes, while all the rest of the respiratory movements are exaggerated.

The following admirable remarks, made by M. Andral, in his Clinique Medicale, (tom. ii. p. 98,) comprise everything that has been said, or need be said, on this subject:— "Cette immobilité partielle de quelques côtes n'est pas sans interêt sous le simple rapport physiologique. Ce fait ne prouve-t-il pas que dans l'inspiration les côtes peuvent se mouvoir indépendamment les unes des autres, et qu'elles n'ont pas seulement un mouvement commun? Si, comme nous l'avons vu souvent sur les phthisiques, les côtes inferieures peuvent se mouvoir encore lorsque les supérieures restent immobiles, cela prouve qu'indépendamment de l'action des scalènes, que nous ne nions point dans l'état ordinaire, les muscles intercostaux sont susceptibles à prendre une part active dans l'acte de l'inspiration."

The independence of each intercostal muscle of the action of the scalenus, and the muscles above it, is here affirmed and proved.

PART VI.—ON THE DIAGNOSTIC VALUE OF THE OBSERVATION OF THE MOVEMENTS OF RESPIRATION.

From the many diseases that derange the movements of respiration, from the multifarious varieties of those disturbed movements, and from the same disturbance being produced by different diseases, it is manifest that we cannot form a diagnosis by observing the arrest, restraint, or exaggeration of any particular respiratory movement. While we cannot, however, be thus directed to a final diagnosis, we have made a first good step towards it. We have shut out a number of diseases, of which the existence is disproved by a modification in the respiratory movements, opposite to that which they produce. We have narrowed our inquiry, and isolated it to a certain small class, one or other of which must

be the cause of the deranged movement. The seat of the disease is made out by the inquiry. If we see the movements arrested or restrained over the left upper lobe, we examine that lobe; if that be healthy, we inquire successively whether the heart be diseased, the lower lobe of the lung inflamed, the stomach distended, the intercostal muscles, the ribs, or the neighbouring parts, be injured or diseased, or in pain. If we find that the part of the organ of which the function is arrested be not diseased, we look, in a widening inquiry, for those diseases, or injuries, or malformations, to which the movements of the parts in question would be adverse. Each of these disturbing causes must of course be distinguished by its individual diagnostic signs.

In the *ordinary involuntary respiratory movements*, there are two points to be inquired into—what movements are restrained, and what exaggerated? If respiration be arrested, or restrained, in one part, the exaggeration elsewhere usually more than compensates for the local diminution. The degree of the local exaggeration is usually in proportion to the activity of the disease. If the descent of the diaphragm is restrained by a chronic cause, as in ovarian dropsy, the movements of the thoracic ribs are somewhat exaggerated, but if it is arrested, or restrained, by peritonitis, the exaggeration is much greater, both in effort, frequency, and movement.

The arrest, or restraint, of the involuntary respiratory motion in one part of the chest produces exaggerated motion in all the other parts.

If the motion of any part of the chest be reversed,—as it is in Laennec's emphysema, and laryngeal obstruction over the lower part of the sternum,—we have an almost certain indication that there is some thoracic disease.

Deep voluntary inspiratory movements.—While the derangement of the involuntary breathing-movements gives us certain information, including the possibility of several diseases, and excluding that of all others, the knowledge of the extreme movements during a deep inspiration gives us reasons for setting aside other diseases previously considered possible.

If the movements of any part be restrained during an ordinary inspiration, and yet normal during a deep inspiration, the restraining cause can only be slight.

If the movements, during a deep inspiration, be restrained at one part, and free everywhere else, we may exclude certain acute diseases, as peritonitis and pericarditis, which, while they exaggerate ordinary breathing, are incompatible with a greatly increased deep inspiration.

The extreme movement during a deep inspiration corresponds to the extreme breathing-capacity as ascertained by the spirometer. In fact, in ascertaining this circumstance, the chest-measurer is an imperfect pocket-spirometer which, while it cannot tell the exact capacity, has the additional faculty of localising the diminished movement, if it be local, or of showing it to be diffused over the whole breathing apparatus.

In inquiring into the extreme respiratory movements, we must not overlook the want of control which some persons have over their respiratory movements, who sometimes breathe solely by the ribs, at other times solely by the diaphragm. The best plan with such persons is to direct them by example.

The rhythm of respiration.—If the rhythm of respiration be disturbed, we gain positive information that the disease belongs to a certain small class.

If the inspiration be laborious, the expiration slow, and equally slow throughout, we know that there is obstruction in the breathing-passages, as the larynx or fauces.

If the inspiration be laborious and rather quick, and the expiration prolonged, quick at first and then slow, and gradually slower towards the end, we know that there is obstruction to respiration in the smaller bronchi, as in emphysema, bronchitis and phthisis. In emphysema the obstruction is constant; in bronchitis it is sometimes absent during a short interval, after getting rid of the sputa; and in phthisis it is only present when there is fluid in the bronchi or the cavity.

In many painful diseases, the expiration is at first inter-

rupted, the glottis being closed by the vocal chords; these part with a moan, and the expiration gushes out quickly at first, becoming gradually slow.

In peritonitis, the expiration may be quicker than the inspiration.

The information given by the rhythm of respiration is a valuable assistant to that given by its motion. If the motion be anywhere restrained and the rhythm invariably normal, there is good reason for anticipating that the lungs are free from disease; on the other hand, if the expiration be materially prolonged, we know that the respiratory organs are in fault.

The knowledge furnished by the deranged movements and rhythm of respiration defines the seat of the disease, but not its nature. To ascertain this, the other aids to diagnosis must be employed. This knowledge is the first step in the inquiry, which it does not prolong, but, on the contrary, shortens, as it directs the attention to the affected part.

In this inquiry I have found the chest-measurer essential. For ordinary observation, the educated eye-sight and touch will usually furnish all the needful information. It is in the cases of doubt and difficulty, and especially in persons really healthy, though supposed by themselves to be diseased, that the chest-measurer is most serviceable.

In conclusion, I beg to thank the various medical men here and in London who have very kindly permitted me to avail myself of their cases; and my pupil, Mr. Martyn, who has with patient intelligence assisted me throughout in this inquiry.

The figures in the Tables in the body of the paper indicate the respiratory movements during an ordinary inspiration, unless otherwise specified.

EXPLANATION OF THE TABLES.

The figures on a line with each name, denote the respiratory movement during an ordinary (involuntary) inspiration.

The figures below those of ordinary inspiration, denote the extent of movement during an extreme inspiration.

The movements are given in hundredths of inches.

The tape measurements in inches and tenths of inches.

Figures separated by a line thus 2/5, denote an extent of motion varying from the one to the other.

The sign * prefixed, denotes a falling in of the costal walls.

The sign † prefixed, denotes a rising of the costal walls.

*1 †5 denotes a backward inspiratory movement of ·01 inch, followed by a forward movement of ·05 inch.

The figures under the head of Rhythm, show the relative duration of inspiration and expiration (ascertained by counting, see p. 418).

The figures above the ordinary tape measurements are those during expiration; those below, during inspiration.

N.B. The heading "Sixth costal cartilage" in the tables in the body of the paper correspond with the heading "Sixth rib, anterior" in these tables.

For the method in which the measurements were taken, see pp. 364-366.

The Author's notes of the cases are accessible to any one interested in them.

TABLE I.—*The Movements of Inspiration in Health,*

Males, pp. 367-370, 376-378.

	Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.		Sixth rib, lateral.	
			upper	lower	right	left	right	left	right	left	right	left
1. J. Whitehead	17	had ophthalmia, well, robust health, chest healthy	2 80	2 60	4 100	3 100	3 80	3 80	3	3	3	3
2. G. Withers	29	had lumbago, well, robust labourer, chest healthy	3 80	5 50	6 100	6 100	2½	3	3	3	½	½
3. C. Webster	22	ophthalmia, nearly well, robust labourer, chest healthy	3 100	6 90	3 100	3 100	4 105	4 100	6/7	6	5	4
4. J. Rushworth	23	healthy, chest healthy	*1†2 2/4 120	4 75	2/4 130	2/4 125	3/4 120	3/4 120	4 120	4 120	1	1
5. Charles Cook	30	dyspepsia, chest healthy	4/6 35	3 50	5/7 70	5/7 70	3 40	2 45	*2/ *1 †4 28	*1 †4 28	*1 *5 †35	0/1 *2 †20
6. J. Nettleship	40	dis. of urethra, robust labourer, chest healthy	5 40	5 40	2/7 50	2/7 50	3/5 22	2/4 30	5/8	3/5 17/20	2/3 20/22	1/2 20/22
7. J. Proshaw	30	ulcer of leg, nearly well, chest healthy, remarkably well-made man	5 95	*1†6/6 *3 †35	8 100	7 100	*1 †2/4	*1 †5	5	5	6	4
8. W. Wainman	28	lumbago, nearly well, chest healthy	2 100	5 120	3 115	3 115	3 120	*1 †1 120	6 130	5 130	5 70	*1 †3 70
9. W. Hutchinson	37	dyspepsia, chest healthy, general health good	4 130	5 110	7 110	7 100	5 95	3 90	5 80	4 80	2 80	2 80
10. G. Berridge	33	affection of knee, well, chest healthy	4 42	8 100	2/4 70	2/4 70	2/5 60	2/6 60	4/7 50	3/5 50	2 35	1 30
11. James Ward	39	lumbago, well, chest healthy	½/2 50	5/4 50	2/5 60	7/10 60	2 50	1/2 50	2/5 70	2/4 60	2/3 40	1/2 40
12. Westall	25 or 26	splendid condition, runner, third best in England	2½ 180	4 190	5 225	4½	3½	*1 †1	4	1	...	...
13. Seward	25 or 26	splendid condition, American runner, best in the world	3 100	4 100	3 150	4	2	3	4	2	...	...
14. James Pacey	17	recovered from fever, chest healthy	3	5	6	6	3	*2 †3	7	...	...	...
15. Geo. Wardell	18	recovered from fever, chest healthy	1½	3	6	4	2	2	5	5	...	...
16. W. Attenburrow	22	healthy, robust, chest healthy	5 90	2/3 60	8/10 100	8/10 100	5 100	3 100	3/5 50	2/3 40	4 65	3 60
17. J. O'Connell	45	ulcer of leg, out of health, chest healthy	4/7	3/4	3/7	3/7	1/3 20	3 20	3 20	3½ 20	1/3 20	3 20

observed by the use of the Chest-measurer, pp. 364-378.

Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple		xyphoid cartilage		Abdomen.		No. of respirations per minute.	Breathing capacity.	height.
right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left			
5 70	6 70	5	5	8	25 100	9										c. in.	ft. in.
4 40	4 40	3	3	10	25 100	6	4	4	18·2	18·2	17·4	17 4					
7	6 60	8 50	7	13	40 90	11	4	4	17·4	17·4	16·4	16·4					
6	5	7	8	10	20/28 100	10	5	5	16·5	16·2	16·8	16·9	...	...	24		
4 20	4 26	8 28	6 45	6/8	25 70	8/14	6	6	16·3	16·3	16 16·7	15·5 15·8	...	...	20		
8 35	5 35	7 8/12	5 8/12	5/8 12	25 100	3/6 12	5	5	16·2	16·2	16 17·1	16 17·1	...	...	20	190	5 4½
2	2	5	4	8	35	7	4	4	25	22	24	19·7	...	...	17	340	6 0½
10 130	10 130	8 80	8 80	7	25 100	7	...	...	14·2 ... 15	14·2 ... 15·3	13·5	13·5	12·2	11·8	20	185	5 6½
6 95	6 90	8 95	6 80	8 70	25 140	8 70	5	5	15·8 ... 17·3	15·5 ... 17·3	15·5	15·8	13·5	14·5	20	200	5 9
10 50	7 50	9 60	7 65	12/14 54	35 100	12/14 50	7	8	16·6 17 17·8	16·3 16·9 17·6	16·5	16·2	15	15	10	225	5 8½
4/5 32	4/5 18	4/5 22	3/9 25	5 26	20/30 100	11 20	5	5	18·1 17·3 16·7	17·9 19·1 16·4	17·3	16·9	13·8	13·8	22		
...	...	5	5	12	30	12	5	5	...	...	...	...	...	...	...	290	5 9 or 5 8½
...	...	6	6	9	30	8	...	...	...	...	...	...	...	...	25		5 9
...	...	10	10	15	20 120	15											
...	...	6	7	17	24	15											
9/13	8	9	5	12 10	30 10	10/12 15	...	...	17·3	17·5	16·3	16·2					
3 16	8 16	5 30	8 30	3	25 100	9	4	4	17·3	17·3	18	18					

TABLE I.—*Health*—

		Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.		Sixth rib, lateral.	
				upper	lower	right	left	right	left	right	left	right	left
Males.	18. E. Houghton	16	disease of knee, robust, chest healthy	12 50	5 110	3 90	2 70	3 60	1 90	5	4	3 95	1½ 70
	19. J. Curran	44	stricture of rectum, chest healthy, general health good	4 80	3/4 50	3/5 60	3/5 60	4/7	4/6	4 50	3 50	3 60	3 50
	20. C. Coupe	15	healthy, florid, chest healthy	7	6 40	9 100	9 95	7 80	5 70	6	5	5 50	2/3 40
	21. T. Plackett	14	healthy, chest healthy	2/3	*1 †2	0/4 50	0/2 60	0/2	0/ *1	2	*2 †1	*1/4 55	*1/4 60
	22. S. Bingham	15	broken os humeri, robust	3/8 60	5/10 70	0/3/8 100	0/2/6 80	5/10	3/8	10 100	10 95	8/14	8/14
	23. J. Eddishawe	15	burn, well, perfect health, chest healthy, collier, robust	4 100	*1 †4 70	4 100	2 90	2/5 50	2/4 50	2/4 50	2/4 50	2 40	1 30
	24. George Smith	35	perfect health, chest healthy, robust labourer	5	4 100	5 130	3 120	5 120	2 80	6 70	4 70	4 80	3 70
	25. John Coupe	11	broken arm, nearly well, perfect health, chest healthy	5 110	4 50	7/6 130	6/5 130	3 90	3 85	3 40	3 35	1 75	1 70
	26. J. Clarke	10	healthy, not strong, chest healthy	3 70	5 50	5 100	5 100	3 100	*1 †2½ 100	3	2	1½	1
	27. W. Greenfield	10	disease of knee, pale, chest healthy	0/3 30	1/2 33	0/3 30	0/3 30	...	...	2	2	1	1
Males.—Cases in which breathing was exaggerated, pp. 369, 370.	28. W. Green	19	dyspnœa, chest healthy	10 50	5 50	16 80	16 70	10 80	12 60	5	5	5 70	3 60
	29. W. Stennett	40	compound fracture of leg, pale, chest healthy	3 70	8 50	6 150	6 130	9 105	8 105	10	9	6	6
	30. J. Clay	43	sciatica, chest healthy	7/10 80	...	10/20 95	10/20 100	15/20 80	12/20 75	15 80	15 80	10/15 50	8/13 50
	31. T. Glossop	14	delicate, pale, chest healthy	12/25	10/25	15/40	10/30	5/30 50	5/ 0 50	15/26	18/29	16/25	12/20 20
	32. W. Stevenson	adult	lumbar pain, pale, chest healthy	4/15 50	4/4 60	8/20 70	5/16 70	5/12 80	3/8 75	4 60	4 60	8 80	8 70
	33. J. Beaumont	40	ulcer of leg, health good, chest healthy	8 75	11 50	6 100	10/2 95	8 60	6 50	25	60	2	6
	34. W. Herod	19	diseased ankle, chest healthy, delicate	9 100	7 95	12 100	14 100	3 90	2 65	5 100	4 70	...	...
	35. S. Varney	37	chest healthy	10	8	10 90	12	6	3	6	5	...	...
	36. John Wilson	50	ulcer of leg, fair health, fat, chest healthy	6	8/15 70	4/8 70	5/10 80	*1 †5/15 40	*1†5/*10 45	10 56	8 50	*1 †3 40	*2 †3 50

continued.

Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements.						No. of respirations per minute.	Breathing capacity.	height.
									above nipple		xyphoid cartilage		Abdomen.				
right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left			
12	8	12	6	14	25	8	...	...	16·2	16·2	16·6	16·3				c. in.	ft. in.
100	75	60	45		*30†40												
3	3	3	2	7	16/25	3/6	...	...	17	17	16	15·3					
55	50	55	54		40												
6/9	5/8	8	6/7	12	28	10	5	5	13·5	13·2	13·4	13·3					
				30	100	20											
0/15	4/8	4/8	4/8	8/12	50/60	8/12	6	6	14	14	13·8	13·6	...	...	13	136	4 10
60	60	60			20												
									13·1	12·8							
10	9	12	10	7	45	5	4	4	...	...	13·5	13·5	12	11·5	20		
90	75	80	70	30	70	30			14·8	14·2	1						
7	7	4	4	9	25	9	4	6	14	13·3	14·2	14	12·5	12·5	22	130	4 11½
40	40	40	40	45	120	45			15	14·5							
6	6	16	6	12	35	8	4	4									
10		60	20	70	80	40											
5	5	6	6	10	26	8	5	6	14·4	14	12·9	12·7	12·1	12·1	20	110	4 7½
60	60	35	25	25	50	30			13·2	13							
5½	5	7	6	9	40	7	4	4	12·6	12·6	13	13·2					
50	50																
7	6	6	6	10/16	20/40	8/16	4	4	12	12	11	11½					
					30												
10	8	10	8	9	18	8	...	...	16	17	16	16	...	...	...	185	5 6½
70	70	40	40		20												
11/9	15	9	8	9	20	6	4	4	17·2	17·2	17	16·4	...	...	13		
70	70																
					90	30/40	9	9	16·5	16·5	16·5	16·5	...	...	9		
20/30	20/30	30	30	40	100												
60	60/55				to												
					150												
10/20	10/20	3/7	3/7	10/15	60/90	6/12	...	...	12 3	12·3	12	12	...	...	23		
20		27	27	32	80	28											
10	10	10	9	4	15	4	8	8	15·2	15	16	15·4	...	...	...	208	5 7½
	70	65			90												
...	...	7	7	25	60	25	6	6									
					160												
...	...	7	4	8	30												
		20	20	30	70												
...	...	7	6	14	25	13											
					100												
10	11	9	7	11	45	8	...	...	17	17	18	17·8					
		42	35	11/15	100	8/12											

TABLE I.—*Health*—

		Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.		Sixth rib, lateral.	
				upper	lower	right	left	right	left	right	left	right	left
Male.	37. T. Goodrich	33	healthy, fat, chest healthy	7/20	*5/*15	...	...	10	10	*10/ *20	*8/*20	...	8
Old Men, pp. 370, 371.	38. Wm. Spick	53	healthy, chest healthy	5 50	3	5/8	5/7	4	3	7	7	...	...
	39. W. Beduall	61	cataract, health perfect, chest healthy	8 90	10 90	7/10 75	7/10 70	8/15 80	8/15 80	9 60	7 60	7 60	6 55
	40. J. Wiles	68	sciatica, slight cough, chest healthy	10/12 100	6/14 80	10 50	10 50	10 75	5 75	10 50	5 50	10 25	5 25
	41. J. Shawcroft	65	ulcer of leg, well, health good, heart large, lungs healthy	10/12 80	12/15 90	6/9 50	6/9 40	9/10 80	7/8 45	10 73	7 35	8 75	4 25 *7
	42. S. Mart	71	ulcer of leg, nearly well, fat, health tolerable, chest healthy	7/10 50	6/9 50	12/13 55	12/13 55	4/6 35	4/7 20	4 20	4 20	3/5 20	*1 †2 15
	43. L. Lane	64	had erysipelas in axilla, nearly well, excellent health, robust, chest healthy	2/4 25	1/2 10	1½ 21	3 30	0/1½	0/1½	1 15	1 14	3/0	*1 †1
	44. J. Marshall	65	hernia, healthy, robust, chest healthy	10	14	10	10	10	6	13	12	...	...
Females, pp. 372-374.	45. J. Goodall	35	cataract, hysterical, healthy chest, stays on	15/20 70	7 15	10/18 70	12/20 70	...	...	...	...	4 10	6 13
			stays off	*2 †7 35	3/4 30	6/8 50	6/8 50	...	...	...	...	2/3 10	2 10
	46. J. Green	20	had fistula, nearly well, perfect health, chest healthy, stays on	6/10 50	3/4 20	6/8/10	6/8/10	...	...	...	...	3 10	1/2 10
			stays off	3/10	3/10 35	3/10 50	3/10 50	...	...	2/6	2/6	3 10	2/3 10
	47. E. Ball	25	hysterical affection of knee-joint, health good, chest healthy, stays on	6/10 60	3/5 20	6/12	5/11	...	...	...	...	2 12	1½ 9/10
			stays off	7 70	5 70	8/15	8/15	...	...	...	...	3/4	5/6
	48 M. Daft	17	purpura, improving, chest healthy, stays off	5 35	4 30	6 45	6 45	...	...	...	...	0/1 26	0/1 28
	49*a*. E. Elsom	11	healthy, chest healthy, stays on	8 50	4 30/40	...	...	...	...	...	...	...	...
	49*b*. E. Elsom		stays off	6/7 50	2/5 30	10 60	10 60	...	3 30	*1 †3 25	3/5	*1 †2 *1 †3	...

continued.

Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple		xyphoid cartilage		Abdomen.		No. of respirations per minute.	Breathing capacity.	height.
right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left			
...	...	3 *6	3* 6	...	20 30	...	...	...	...	...	10·2	10·2	10 8	10·8		c. in.	ft. in.
...	...	6	6	20	40 95												
12 60	11 60	10 22	8 22	8	30 50	6	6/7	10/11	15·2 16 16·7	15·5 16 16·7	15·4	15 6	13·7	14	12		
10 30	5 25	4	3	12	50 90	5	6 6 3	6 9	14 4 15 1 15·7	14·5 15·2 15·8	14·8	14·5	13·8	14	16	150	5 7½
20/22 30 *10	*1 †5 30 *10	8 *10 †20	4 *20†15	8 *10†20	35 100	5 *10†15	6	7	15·3 15·6 16·5	15·4 15·7 16	15·5	15·4	14·5	14·5	22		
5/7 5/10	3/4 *8	7 2/4	4 2/2 *2	5/6 20	35 110	5/6 5 *5	6	7	19 19·3	18·7 19	19·2	18·8	16	16·2	18		
4/5 *2 †3	2 *10	4/5	1/2	8	25/40 70	3	8	8	16·9	16·9	17·2	17·2	14·9	15·2	20		
...	...	10	8/9	20	30	20											
...	...	...	...	...	7/8 70	...	7	8	30 30·6	30 30·6	25 25·5	25 25 5	...	...	14		
...	...	...	...	...	15/20 50	...	...	...	30 30·5 31 5	30 30 5 31 5	25 26	25 26					
...	...	...	...	...	8/11 30	...	8	8	33 33·5	33 33·5	26 26 5	26 26 5	...	...	20		
...	...	...	...	...	15/20 50	...	...	...	...	...	14 14·3	13·7 14	14·5 15	14·5 15			
...	...	...	...	...	10 60	...	...	...	34 35·5	34 35·5	29 29·3	29 29·3	...	...	24		
...	...	...	...	...	12/25	...	6	8	33·3 34 35·5	33·3 34 35·5	30 39·5 39·5	30 39·5 39·5					
...	...	...	...	...	15/20 70	...	8	8	13·5 27·8	13·3 27·8	12·5	12	25	25	18		
...	...	...	...	...	10 50	...	5	8									
...	...	...	...	...	20 66	...	...	...	12 12·3 12·6	11·8 12·1 12·3	12	11·8	10·8	10·8			

TABLE I.—*Health*—

		Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.		Sixth rib, lateral.	
				upper	lower	right	left	right	left	right	left	right	left
Females.	50. H. Barton	19	dysmenorrhœa, chest healthy	20 50	10	28	28	10	7	8	...	...	...
	51. Sarah Bluson	19	diarrhœa, chest healthy	18 70	16	25	20	25	16	15	15	...	...
	52. F. A. Winfield	6	healthy, chest healthy	5 25	4/5 20	...	...	...	...	...	...	...	...
Children, pp. 374-376.	53. J. Drake	2 mo.	healthy child, observed asleep, chest healthy	2/4	*1/ *2	...	2/4	...	...	...	*1/*2 *3	...	*½/ *1
	54. F. Williams	1 mo.	healthy child, chest healthy	2/4	*3	3/6	4/6/10	*1	*1	*4	*3	*3	*4
	55. Child	2¼ y.	healthy child, chest healthy	2/4/5	*2/ *5	3/5	3/5	*1	*1	*3/*6 *10	*3/*6 *10	...	*2 *6
	56. M. A. Scott	2y. 8m.	in epileptic fit, chest healthy	2/5 5/10	1/2/0?	... 10/12	2/6 9	...	...	...	2/6	...	*1/*2
	57. Mary Wain	2	abdomen large, chest healthy	4/5	12/20 cr. 20	5/7	...	10/12	...	10/15 cr. 20	...	*2/2 *4/1 cr. 20/30	...

continued.

Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple		xyphoid cartilage		Abdomen		No of respirations per minute.	Breathing capacity.	height.
right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left			
...	...	4	...	...	8 20												
...	...	15	10	10	8/12 60	7/10											
...	...	...	...	...	25 50/60												
...	*1	...	*3/*4	...	8/10												
*2	*6	*2	*3	...	4/6												
*10 *15	*10 *25	1/2	1/2	...	8/15												
...	5	...	4	...	8/12												
cr*20/30 cr†50	...	cr. 5/15	...	...	15/20 cr. 20/40												

TABLE II.—*Cases in which the Respiratory Movements were themselves being healthy,*

		Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.	
				upper	lower	right	left	right	left	right	left
Motion of the ribs of both sides restrained, p. 378.	58. W. Bulwer	9	posterior spinal curvature at sixth dorsal vertebra	5	15	5	5/8	3	2	6	5
	59. A Youth		ditto ditto ...	2	0	30	2 20	2	8	6	2
	60. Clemens		itto at the last dorsal vertebra	4/6 60	9 75	9 70	7 70	3 12	4 40	2 9	5/6 30
Motion of the ribs of one side restrained, p. 379.	61. A Girl		lateral spinal curvature, convexity to right	12/20	12	20/25 70	10 60	15/23 *9*20	3	15 30	8
	62. Wm. Beaton	15	ditto, lower dorsal vertebra	6 60	5 40	10 70	9 70	5 30	3/4 30	6 25	6 25
	63. Rt. Severn	16	injury to left shoulder and cervical vertebræ	*2 †3	*6	3/6	*6	*1 †5	*6	5	*6
	63*a*. Ditto		second observation	2 *2	*2 †3	4/9	*4/5	2	0	9	4
	63*b*. Ditto		third, well	10	11	3/12	3/12	4/8	12	10	4
	64. Wm. Frost	ab. 45	erysipelas of arm ...	8	...	15 40/70	10 25/50				
	65. John Bingham	15	fracture of arm	3/8 60	5/10 70	0/3/8 100	0/2/6 80	5/10	3/8	10 100	10 95
	66. John Lane	64	erysipelatous abscess in axilla	2/4 25	1/2 10	1½ 10	3 10	0/1½	0/1½	1 15	1 14
	67 Mrs. Barker	42	schirrhous ulcer of left mamma	6	6	8 35	6 25	...	...	10 38	5 28
	68. James Ward	39	old injury to second rib	½/2 50	4/5 50	3/5 60	7/10 60	2 50	1/2 50	2/5 70	2/4 60
	69. Wm. Parker	15	abscess between left second and third costal cartilages	3	*4	8	4 8	4	0	*1	*3
	70. John Sketchley		fracture of left rib, rupture of lung	*9 †4	*7	2/9	*5 †7 *5 †3	1	*5	*2 †3	*7/*9
	71. Moore		pleurodynia, near the sixth costal cartilage	2/5/10	2/6	3/5	2/5	4	½/3	6	5
p. 379.	72. C. Williams	40 or 50	heart disease, left hemiplegia	9	0	6	8	1	0	0	0
	73. E. Brooks	4	left hemiplegia	3	2	*1 †1	*1	0	0	*1 †1	0
	74.										
p. 383.	75. W. Glossop	14	exaggerated motion of thoracic ribs from loss of arm	12/25	10/25	15/40	10/30	5/30	5/30	15/26	18/29
Diaphragm restrained, p. 384.	76. W. Barratt	35	acute peritonitis, more severe on left side, following operation for hernia	10	5	16/22	16/22	8	6	8	6
	77. Wm. Kew	22	acute peritonitis ...	15	4	20	30	8	12	6	6
	78. Eliz. Hussey	55	acute peritonitis ...	20	5	33	40	10	10	7	8

disturbed, rendered abnormal, or abnormally changed, the Lungs pp. 378-393.

Sixth rib, lateral.		Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple		xyphoid cartilage		Abdomen.		No. of respirations per minute.
right	left	right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left	
3	4	10	12	15	7	18	20	18									
...	...	...	...	2	1	10	50	7									
...	...	...	...	2	5	4	5	2	...	...	17 5	17·5	15·4	15·2			
...	...	...	...	15	3	15	35	3	...	...	...	...	13·1	13			
6 20	2 20	8 50	8 50	6 35	8 15	7	20 90	4									
...	...	...	...	11	10	16	...	12	...	...	14	14					
...	...	...	...	6	4	...	16 60										
...	...	...	...	15/20	8	20	50	12	...	...	14	14	13·4	13·2			
8/14	8/14	10 90	9 75	12 80	10 70	7 30	45 70	5 30	3	4	16 15·7	16 16·7	15·4	15 6	13 7	14	
3/6 15	*1 †1 15	4/5 *1 †3	2 *10	4/5	1/2	8	25/40 70	3	8	8	16·9 17·2	16·9 17·2	17·2	17·2	14·9	15·2	20
7	1	10	5	11	9	8	18	10	4	4							
2/3 40	1/2 40	4/5 32	4/5 18	4/5 22	3/9 25	5 0/22	23/30 100	11 20/22	5	5	16·7 17·3 18·1	16·4 17·1 17 9	17·3	16 9	13·8	13 8	22
...	...	...	...	9	6	18	25 40	18									
*1†3/5	*8	20	*5	8/11	3/7	22/30	37	10/15	5	10	...	...	...	...	...	...	22
...	...	...	...	8	10	10	35	8	6	6	17	17	15·6	15·3			
...	...	...	...	5	3	5	25	3	6	7							
...	...	...	...	5	2	5	14										
16/25	12/20	10/20	10/20	3/7	3/7	10/15	60/90	6/12	6	6	12·3	12·3	12	12	...	...	23
...	...	...	...	6	6	2	1/5	0	5	3							
...	...	...	...	5	3	7	6	8									
...	...	...	...	2	2	7	3	6									

TABLE II.—

		Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.	
				upper	lower	right	left	right	left	right	left
Diaphragm restrained, p. 384.	79. Wm. Severn	30	chronic peritonitis ...	13 40	5	10	10	5	3	...	5
	80. Ch. Osborne	40	local peritonitis over caput cæcum coli ...	10/15	rises very irreg.	12/25	15/25	10	5/10	8	12
	81. Geo. Simpson	43	tumour in abdomen ...	10 50	5	8	7	6	3	7	5
	82. Wm. St.		enlarged liver, hydatids?	10	2/4	10 40	25 70	1	4	0	*2 †4
	83. John Barton	32	adherent liver	10 45	4 80	19 25	30 60	4 15	30 40	6 13	10 30
	84. N. Stones	69	adherent liver?	7/9 30	4 12	5/6 40	5/6 40/50	0/2 *3 †3	0/2 28	0/3 5	1/4 25
	85. J. Clarke	15	intestinal and gastric distention	6 80	5 50	8/9 110	8/9 100	8 90	4/5 70	10 60	5 45
p. 392.	86. Mrs. Kee	35	pregnant	5 50	3	5	6	...	...	2/4	2
	87. Mrs. Sands	30	pregnant	4 30	3½	5	5	...	...	3	5

continued.

Sixth rib, lateral.		Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple		xyphoid cartilage		Abdomen.		No. of respirations per minute
right	left	right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left	
...	...	...	...	5	5	10	13 35	10									
...	...	...	...	12	10	6/8	10/15	15									
...	...	...	...	5	5	10	15 70	10									
...	...	...	...	*2½	5	10	25	10									
6	12	8	20	7	16	18	*2 †10	25	4	5	15	15	16·6	15·5	14·2	14·2	
10	20	8	20	20	20	40	50	40			15·2	16·3	16 6	16	14·8	15·2	
0	5	2 6	5 10	4/5 †1 *3	6/7 14	4/7 20	30 70	2/4 10	6	9	14 9 15 8	14 9 15·2	15·6	15·6	15·9	15·1	18
9	5	13	10	12	10	15	20	10	4	6	12·5	12·4	12·6	1 2	12 3	12·5	18
60	40	55	45	50	40	30	50	30			13 5	13·4					
5	4	...	...	6/7/8	6	4	8	6/8									
2	½/1	7 30	2 6	4	1	10	10 50	6	4	4	15	15	13	13	...	...	20

TABLE III.—*Cases in which the Respiratory Movements were disturbed, Respiratory Organs,*

		Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.	
				upper	lower	right	left	right	left	right	left
Obstruction to respiration in outer air-passages, p. 393–402.	88. Josiah Chester	13	enlarged tonsils, scarlatina	20/*6†10	*14/*20	30	25	15	15	*10	15
	89. T. Maltby	21	bronchocele	*3 †½ *20 †60	*4 *10 †30	*3 †1	*2 *10†70	*3	*3	*3	*3
	90. Jeh. Mann	23	bronchocele	*2 †5	*1 †5	5	*1 †6	*3	*2 †3	*3	*3
	91. Alf. Scattergood	16	enlarged tonsils, laryngitis	8/15	*4 †7 50	10 100	8 70	10	5/8 60	10/15 60	*1 †6 60
	92. — Robinson	25	obstructed nostrils and fauces	*2 †4 30	*6 †10 *4	10	*1 †6	*1 †2	*3	*1 †5	*2
	93. Ann Slater	27	lacerated larynx or trachea	*6/40	*2/*30	6/60	2/40	2/4	4	2/30	2
	94. Mrs. Meads	27	chronic laryngitis ...	*1 †4	*4	5	5	...	...	*2 †2	*2 †2
Obstruction to respiration in the smaller bronchi, p. 402. Cases of males, in which the lower end of the sternum receded, p. 403.	95. Jos. Squire	30	emphysema and bronchitis	20/30 110	*12 16 *30	25/26	22/25	22/25	22/25	*6 †24	*10†33
	96*a*. W. Rawson	13	emphysema and bronchitis	4/10 30	*3/*6	6/11	12	*2 †5	*1 †3	*7	*5
	96*b*. Do. 1 month afterwards		emphysema and bronchitis, improving	3/10 50	*8 *8 †20	3/12	15	3/9	11	*10	*3 †2
	97. Geo. Simpson	50	bronchitis	4 50	*5	9/12 30	9/8 30	*3	*3	*2 †3	*4
	98*a*. W. Galloway	40	emphysema, heart disease &c.	6	*3	12	14	3	*1 †4	*3 †1	*3 †6 *3
	98*b*. Ditto, second observation		worse	4/10	*4/*15 cough *20	8	12	*2 †2	*3 †2 †2 *2	*2 †4	*4 †4
	99. J. Hart	32	emphysema and bronchitis	2/6	*1/*4 sometimes *1 †5	2/9 70	3/12 60	1/3 20	3/9 30	5	5 70
	100. J. Linthwaite	50	emphysema and bronchitis	9/24 40	*2 †8 *2 †20	10/25 50	10/25 40	8/12	6/10	*1 †10 *1 †20	*2 †8 *2 †17
	101. W. Redmill	46	emphysema	5 25	*2 *3 †20	7 35	4 30	3	0	2	3
	102. J. Worth	30	emphysema and bronchitis	3/5 70	*½ †3 *2 †60	2/5 110	2/10 110	1 80	0/5 80	3 60	4/12 80
	103. G. Rogers	41	emphysema and bronchitis	4/8	*2 †4	*2 †4	6	*2 †2 30	*1 †4 30	*3 †4	*2 †3
	104. J. Shaw	45	bronchitis and emphysema	12/20 55	10/12 †3 *12 30	10/15 90	10/15 80	12	*3 †7	15	12
	105. Hugh James	25	bronchitis, not severe ...	8	6	6	9	5	12	6	7
	106. J. Clews	30	bronchitis, not severe ...	4	5	4	4	0	5	3	6
	107. J. Eaton	40	bronchitis, not severe ...	5	5	5/6	4/7	3/5	1/8	6	3

rendered abnormal, or abnormally changed, by Diseases in the pp. 393-460.

Sixth rib, lateral.		Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple.		xyphoid cartilage		Abdomen.		No. of respirations per minute.
right	left	right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left	
...	...	...	...	12	15	18	0	25									
...	...	...	...	7	6	18	30 100	10	5	8	16	15	14·5	14	...	...	28
...	...	...	...	10	9	...	30 60	3	...	...	11·2	11·2	...	...	...	...	24
...	...	...	...	10/15	10	12	12 100	6									
...	...	...	...	10	9	5	15 20	10	6	10	...	...	...	...	...	...	25
...	...	...	...	...	...	2/20	6/40	2/20									
4	3	7	7	11	12	10	20	10	3	3	14	14	13·6	13·4			
...	...	...	...	20	...	12	30/50	12	4	6							
4/12	5	...	...	...	...	10	12/18	...	3	8							
...	...	...	...	10	12	10	35 50	...	6	9							
...	...	...	...	10	6	10	25	10									
*1 †1	*1 †4	*3	10 *7	3	8	8	20	12	4	8	...	...	15·5	15·5	...	...	28
3/8	4/9	0/*2/5	*5 †3	1/2	½	6	20	5	4	12	16·5	16·5	16·8	16·8	16·6	16·8	28
3/5	2	10	6	4/6	4	8	18	9	4	8	...	...	...	...	...	...	20
8/16 30	6/14 15	12	10	0/20	10/20	7/15	10/50 70	7/15	4/8	9/16	16·2	16	17	16·4	14·8	14·8	19
...	...	...	...	10	10	18	30 50	15									
...	...	...	...	3 40	3/10 50	...	25/35 70	...	5	9	16	16	14·6 15·6	14·8 15·9	...	...	36
...	...	...	...	6	5	8	40	12	5 abdo	9 minal	18·3	18·6	17·5	17·3			
5 35	4 40	10 45	10 40	8/10 25	8/10 20	2/3	*5 †23 80	2/3	...	...	...	13	15·5 16·5	15 15·5	14·2	14·2	22
...	...	6	6	7	10	10	30	15	5	8	17·6	16·7	17	16·3			
8	...	...	...	8	10/12	3	40/50	35	4	6	17·3	17·5	17·8	16·5	...	...	21
4/6	2/5	4	2/5	9	6	8	20/35	15/30	4	4	15·8	15·8	15·8	15·8			

TABLE III.—

Obstruction to respiration in the smaller bronchial tubes.

		Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.	
				upper	lower	right	left	right	left	right	left
Cases in old men, p. 410.	108. W. Shaw	30	emphysema and bronchitis	8	4 23	10/15 25	8/15 25	4	6	*3	*1 †2
	109. J. Eyre	75	emphysema	*2 †6	6	*1 †5	*1 †2	*1 †3	*2 †2	7	6
	110. W. Flinders	69	emphysema	8	9	4	7/10	6/7	5/10	7	6
	111. T. Thompson	60	emphysema	6	*2/6 13	7/8	10	3	...	*4/2	*2 †0
	112. J. Newman	58	emphysema	5 *5 †30	1/2 *2 †60	4 40	5 *4 †30	*3 *5 †40	2	*11 *12†20	*3 *4 †40
Cases in females, p. 420.	113. M. Cross	14	bronchitis	5 6	*2 *2 †6	3/5 14	3/5 12	*1/*½	*1/*½	*½/*1 *3/8*2	*1/*2 8/15*4
	114. Sarah Chamberlain	20	bronchitis left lung ...	25	*2 †8	10/12	10/12	10	10	7	8
	115. J. Elliott	52	bronchitis and emphysema	15	*6	12	15	...	...	*2 †6	*2 †6
	116. Mrs. Cooper	30	bronchitis and emphysema	12	20	2)	12/20	*3 †9	*3 †4 *2	*8	*10 †8 *2
	117. Mrs. Barker	32	bronchitis and emphysema	3/15	*2/*4	4	4	0	0	1	0
	118. Lilly Waud	20	bronchitis, left side ...	6/10	*3	10/15	10/15	...	*2 †2	3	*3
	119. S. Henson	70	bronchitis and emphysema	15	9	25	20	...	...	6	8
	120. Mary Smith		... ...	5	*6	6	6	...	...	*2	*3
Cases in children, p. 421.	121. W. Langsdale	4	bronchitis	3/10	*5/*10	5/12	5/12	0/3	0/3	*4/ *6	*3/ *5
	122. E. Brown	2	bronchitis	5	*2	7	7	3	1	*3	*3
	123. M. Miller	2	bronchitis	4/12	...	6/13	6/14	0	0	*2 /4	*2 /4
	124. T. Smith	6 mo.	bronchitis	1/5	*1/*8	*10/ *15	*10/ *15	...	...	*1/ *3	0
	125. John Lowe	4	bronchitis	8/18	6	3/6	5/12	...	...	*1/ *2	*2/ *8
	126. S. Garton	7 mo.	bronchitis	14/20	10	(?)	6	(?)	0	10	6
	127. Geo. Garner	10 w.	bronchitis	3/20	0/5	...	...	...	...	...	...
	128. Eliz. Walker	3	hooping-cough	9	*1 †4	8/12	8/12	*2	*1	*3	*4

continued.

Sixth rib, lateral.		Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple		xyphoid cartilage		Abdomen.		No. of respirations per minute.
right	left	right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left	
*1	*1 †1	*8 *5 †5	*7 *5 †5	1 *3	3	12	45	10	4	9	16	16	15·6	15.5			
0	0	4	4	4	4/6	10	35	12	4	8	17·2	18	18	18·4			
2	4	6	12	16 15	13	20	60	15	6	9	17·4	17·2	16	15·6			
6	*2 †3	*2 †6 *10	*3 †6 *12	*2	*4	...	10	...	4	8	18·5	18·5	18·5	18			
...	...	...	...	4	6	20	60	20									
½/1	1/2	3	2	3/5	2/5	4	15 50	4	4	6	13·2 13·6	12·6 12·8	12·6	12·5	11·5	11·7	42
...	...	...	...	6	15	20	50	10									
4	4	6	...	10	2	5	2/6	4	4	7	15·5	15·5	13·5	13·5	...	...	32
*4 †2/6	*10	*6 †8	*12	15	8/*2	30	40	20	...	...	14	13·8	12·8 12·7	12·8 12·6			
...	...	...	...	5	6	4	15	7									
...	...	...	...	8	8	...	6/12										
4	4	15	15	15	18	15	15	12	4	6	14·5	14	12·7	12·5			
10	12	...	...	10	12	4	12	10									
*6	*3	*5/*11	*4/ *6	10	3/6	5	16/20	17	3	2	9·5	9·5	9·1 9·3	9·1 9·3			
...	...	...	...	...	4	...	12										
irreg.	...	...	...	...	...	10	10/15	†5/15									
*3	*1	...	...	...	...	...	10										
*1/*1†3	*3	10	*2 †3	7	2/5	7	10	6	...	...	9	9	9·8	9·8			
...	...	...	...	...	6												
...	...	...	*1/*10	...	...	...	...	2									
...	...	...	...	6	6	...	10/20	...	...	...	...	...	...	...	...	...	60

TABLE III.—

		Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.	
				upper	lower	right	left	right	left	right	left
Diseases of one lung, or one side of the chest, p. 426.	Obstruction in smaller bronchi—children.	129. Child	2 bronchitis	10	*3/ *4	7	10	*2	*2	*2	*4
		130. E. Smith	18 mo. hooping-cough	3/10	*2 †4	4/14	3/8	*2	*4	*10	*12
		131. Child	hooping-cough	15	*5/ *6	...	...	...	...	*15	*15
		132. Child	hooping-cough	10	4	12	12	*2	7	*6	*2
	Pleuritis, p. 426.	133. Sarah Simpkin	pleuritis, lower lobe of left lung	10	11	11	8	...	...	7	7
		134*a*. Jane Shepherd, 7, second observation, p. 426	pleuritis, lower lobe of right lung	5	*3	10	10	4	3	*3/ *4	*3
		135. James Brown	effusion into right pleural cavity	3	4	5	10	2 40	3 70	3	4
		136. L. Davis	effusion into right cavity	10	*4	18	17	*1 †2	*1 †1	*1	*2 †2
	Effusion into pleura, p. 428.	137. W. Webb	15 effusion into left cavity	8	*1 †4	12	5	8	0	6	*2 †2
		138. M. Roach, patient of Dr. Walshe	effusion into left cavity	12	*2 †4	5 20	0 12	12	0	8	*3 †2
		139*a*. Ts. Cooke	8 effusion into left cavity	2	3	8/12	0	5/8	*1	*1 †4	0
		139*b*. Ditto, second servation	condensation of left lung	*2	*4	8/12	0	8/10	0	8	*2
	Condensation of one lung, p. 434.	139*c*. Ditto, third observation	condensation of left lung	2 45	*2/ *6 20	8/12 60	0 20	5 30	*1 12	*2 †2 40	*3 30
		140. Barb. Beasley	7 condensation of left lung following effusion	0	...	1	*2 †2	5	0	7	0
	Phthisis affecting the whole of one lung, p. 438.	141*a*. Th. Neale	51 tuberculous disease of the whole of the left lung, cavity in upper lobe	*3	*4	11	*2	6	*2	8	*4
		141*b*. Ditto, second observation	ditto	*12	*12	12	*3	8	*2	12	*12
		141*c*. Ditto, third observation, in articulo	ditto	*2 †2	*4	15	*1 †3	20	*3	118	*3
		142. Mrs. Kirk	42 ditto	10/20	14	20 70	10/14 40	8	*1 *2 †1	14/1 60	*1 †6 30
		143. M. A. Elliott	18 ditto	4	*2 †2	5/10 38	4 30	...	...	4	3
		144. Wm Osborn	46 ditto	*1 †5	*4	10/12 35	*1 †8 35	6	*1 †3	8	*3 †1
		145. D. Harley	41 ditto	*1 †1	11	8 15	0 5	*2 †5	*3 †4	12 40	*1 †2 10
		146. J. Wood	37 ditto	*1 †5	7/6	8/14 90	4 40	5	0	12	*1/0
		147. J. W. Porter	60 ditto	14	10	8 30	5 0	3	*1 †2	8 30	*4 †4

continued.

Sixth rib, lateral.		Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple		xyphoid cartilage		Abdomen.		No. of respirations per minute.
right	left	right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left	
...	...	...	...	...	4												
...	...	...	...	*2	*3	...	25										
...	...	...	...	...	...	...	15										
...	...	...	...	4	3	...	6										
3	*½	8	10	13	10	17	10	13	...	...	...	...	...	...	...	...	24
3	3	8	8	8	8	6	15	8	4	6	...	...	...	...	...	...	52
...	...	...	...	5	10	10	36	16	6	7							
...	...	...	...	3	6	12	*3	6									
...	...	...	...	10	2	10	12	6	5	8							
...	...	...	...	12	2/3												
...	...	...	...	5	1	6	15	3	...	...	10·4	10·1	10·7	11·2	...	...	60
...	...	...	...	8	0	12	22	3									
2/5 40	*1 *3 16	5 35	0/½/1 20	3/6 20	0/½/1 5	10/20	15/20 30	5/10	6	7	11·5 12 12·3	11·1 11·2 11·3	11·5 12·3 12·7	11·1 11·2 11·3	11·3	11·3	20
...	...	...	...	5	0	8	15	0	...	...	10·7	9·5					
...	...	...	...	16	10	22	25	6									
...	...	...	...	25	7	20	12/20	12									
...	...	...	...	16	8	25	15/20	14									
...	...	...	...	7/10 70	6 30	10	25 100	12 10									
6	4	8	10	7	8	7	12	8	4	7	13	12·5					
...	...	...	...	15	10	10	20	4	5	8	17⅗	16⅘	17⅜	16½			
...	...	...	...	15	9	18	15 60	1	...	...	15·5	14·5	15	13·4			
...	...	...	...	15	5	15	30 70	5	...	...	17·4	16·4	16·9	15			
...	...	...	...	9	4	9	25	4	...	...	...	...	16	16			

TABLE III.—

Diseases confined to one lung.

Phthisis of the whole of one lung.

Phthisical cavity in the upper lobe of one lung, p. 444.

	Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.	
			upper	lower	right	left	right	left	right	left
148. Pearson	17	tuberculous disease of the whole left lung, cavity in upper lobe	13	10	17/20	8/10 †4 *12	15/20	6 †2 *8	15	8/10
149. R. Shitlin		ditto	*6	*4	*1 †5	*4 †1 *3 †2	4/*1†4	*1	*5	*2
150. Joel Boot	39	tuberculous disease of the whole right lung, cavity in the upper lobe	*1 †6	*10	6	10	*4	*3	*5	*5
151. M. A.		ditto	5/10	5	2	10/30	3	5/15	2	5
152. Mary Robinson		ditto	3/6	5/6	2/4 10	10/12 50	1/3	7/12	2/3	5/6
153. Wm. Warren	19	ditto	3	4/6	2	3	0/4	0	1 2	*1 10
154. John Green	27	phthisical cavity in the left upper lobe, lower lobe not notably affected	*1 †2	4 *2 †45	3/7 85	0 45	3 80	*2 50	3 85	3 60
155. T. Astell	29	ditto	2	*2	0/1 100	0 70	3 90	*2 75	6 100	3 90
156. James Meads	55	ditto	5	6 *8 †8	8 30	4 8	8 20	4 6	8 26	6 9
157. Rd. Alvey	30	ditto	10	9	12/16 85	5/8 40	12 85	5 40	8	8
158. Henry Trout	20	ditto	5	3	7 80	2/5 40	5 70	2/3 50	4	1
159. John Smith	48	ditto	*3 †3	*4	12 35	5 20	4	0	5	*2
160*a*. Ann Durow	15	ditto	4	*1	6/12	6	*1 †2	*2 †2	3	3/4
160*b*. Ditto, second observation		ditto	4/6	1	8/14 35	4/7 15	6	*3	1	*1½
161. Jas. Parsons	22	ditto	25	*1	27/30 100	12/20 70	10	4/8	10	5/7
162. Rt. Stanyard	36	ditto	8/10	7	8/11	6/8	6	*1 †1	9	*1 †2
163. Sam. Redgate	37	ditto	*1 †2/ *2 †3 *2 †20	*2 †5 *2 †25	6/10 50	3/7 30	13 55	*2†2/7 30	8 34	*2 †6 24
164. Walt. Cavers	18	ditto	*1 †3/15	*3 †4/*1 †13	4/5	*2†2/3	1/4	*2 †3	*1†5/6	*3 †4
165. M. Castle	12	ditto	13	6	12/16 35	8/13 20	4/5	*2 †3	5/6	3/5
166. Ts. Rudland	13	ditto	10	*1 †4	10 30	5 16	0	*1/3	*2 †2	*7
167. Ts. Coates		ditto	*1 †4	*3	†8 70	*1 †5 55	0	*8/11	*9	*4

continued.

Sixth rib. lateral,		Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple		xyphoid cartilage		Abdomen.		No. of respirations per minute.	Breathing capacity.
right	left	right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left		
12/16	8	25	22	15/20	15 †*10 †10	10	*6 cr. 0 †10 *4 cr. †8 *8	10										
...	...	...	...	18	12	25	25	18	5	5	15·5	15·6	15·6	15·2				
...	...	...	...	14	15	5	15	20	...	...	...	...	...	4/5				
1	10/18	2	15	4	15	13	10/30	20	3	3								
1/1½	10	2/3	9/10	2/4	10/15	4/7	10/15 50	10/15	...	...	11·6	12·5	11·2	12·4	10·5	11·5		
...	...	...	...	2	4	3/5	30	3	14·6	15·5	15	15						
...	...	...	...	6/7	6	10	30 70	6	...	...	17·5 18·2	17·3 17·7	16·7 17·7	16·9 17·5	...	...	24	
...	...	...	...	9 70	10 50	30	35 150											
3/6 12	3	14 30	9	1	7	15/23	35 40	15	...	...	15	14·2	14·2	14·5	...	...	32	
9	5/6 30	8	10	13	7	10	30	10										
4	2	12	7	13	8	17	34	10	7	9	16·6	15·5	16	15·3				
...	...	...	...	9	8	22	28 40	20										
...	...	...	...	8/14	10	20/25	25/35	10/20	...	...	12·5	12·5						
...	...	...	...	5	9	9	18 30	5	...	...	eq.	eq.						
...	...	...	...	20	15	20	40	12										
7	3	18	8	15	14	13/15	35	8	...	...	16·8 18·2	16·4 16·9	15·5	15·2	...	...	...	246
7/9 50	3/5 *5 †30	9/12 30	3/4 34	9/11 30	6/7 30	14 24	40/50 90	8 18	7	9	18·5 18·9	17·2 17·3	18·2	17·6	17	17	17	150
3/4	*2 †2	6	*1 †3	2/8	1/2	12	25	3/7	3	6	13·7	13·2	13·3	13·3	11·7	11·8	40	
6	3	15/20	10/12	7	6	8/9	15 40	7/8	...	...	13·8 14·1	12·2 12·8	11·6	10·6	11·3	10·6		
...	...	...	...	10	18	7	25	7	5	9	16·6	16	16	17				
...	...	...	...	6?	6?	...	40											

TABLE III.—

		Age		Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.	
				upper	lower	right	left	right	left	right	left
Diseases confined to one lung. — Phthisical cavity in the upper lobe of one lung.	168. L. Fowkes	27	phthisical cavity in the right upper lobe, lower lobe not notably affected	8	*12	5/8	12/14	*3	7	*5	0
	169. T. Bailley	33	ditto	5/7	4	2/3 35	8 80	0 30	5 60	*1 †1 50	5 50
	170. M. Summer	49	ditto	7	3	8	12	...	...	5	5
	171. Ann Smith	59	ditto	6	*8	5/6 †1 *6	15 *1 †?	*3 6 *3	*2 6 *4	6	7
	172. Sh. Hoffen	50	ditto	12	3	18	12	*4	10	5	*6
	173. J. Daft	65	ditto	9	*2 †8 60	*1 †3 65	9 40	*3 †1	5	*2 †4 40	8 60
	174. Sar. Saywell	20	ditto	20	*2	20 80	20 60	3	2	4	3
	175. J. C. Searles, patient of Dr. Roe		ditto	6	5	4/6 80	12 120	*2 †2	6	5	6
	176. E. Weaver		ditto	7	3	5 40	12 60	*1 †2 35	4 50	4	5
	177. Wm. Rossington	35	ditto	10	...	11	15	4	8	*4	4
Cavities in both lungs, p. 451.	178*a*. J. German	13	both lungs nearly equally diseased	3/10	4	6/15	10/20	5	*1 †5	3	4
	178*b*. Ditto, second observation		ditto	6	*5	8/10	*13	6	6	3	3
	179. Ts. Andrews	22	ditto	10	5	15/18	9/15	6	5	5	5
	180. Ds. Flanagan	39	ditto	2/10	*1 †2	4/8 15	4/8 20	*2†1/3	5	2	5

continued.

Sixth rib, lateral.		Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple		xyphoid cartilage		Abdomen.		No. of respirations per minute.
right	left	right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left	
16	15	6	4	16	15	15	20	16									
...	...	1	4	...	10	12	30	12									
...	...	...	...	4	6	6	5	8	...	...	11·4	12·4					
...	...	...	...	8	18	24	25	10	...	...	12	11·5					
...	...	...	...	9	*2	...	8	*2									
...	...	...	...	*3 30	10 50	...	30										
...	...	...	...	6	9	5	9	3									
...	...	...	...	7	8	8	17	...	5	5	15·2	15	14·5	14			
...	...	...	...	11	7	8	28	10	9	6	15·3	15·6	14·8	14·8			
...	...	...	...	8	9	20	35	35									
...	...	...	...	11	11	12	*5†15/25	5									
...	...	...	...	10	10	15	20	4	4	4							
5	5	12	12	10	10	14	20	20	4	4	14·3	14·3	13·3	13·5			
...	...	...	...	5	5	5	18	8	7	5	17·2	17·2	17·2	17			

TABLE IV.—*Cases in which the Movements of Respiration were disturbed, or*

Pericardial adhesions, p. 463. Enlarged heart, p. 461. Pericarditis, p. 460.

			Sternum.		Second rib.		Fourth and fifth ribs.		Sixth rib, anterior.	
			upper	lower	right	left	right	left	right	left
181. John Weldon	Age 23	pericarditis, slight effusion, acute rheumatism	9	*2 †2	10	9	5	*2 †2	*3	*5
182. Mary Hibbert	25	ditto	*2 †10	*4 †2	18	7	5	*2 †4	4	*2
183. Wm. Shaw	15	pericarditis, endocarditis	*1 †3	...	7/10	*1 †6	*2 †5	*3 †2	4	*4
184. Mary Bale	20	endocarditis, pericarditis	6	*4	12	6	4	*2	4	3
185. Fanny Lee, patient of Dr. Walshe		ditto	2	2	6	8	4	0	3	0
186. Wm. Thorley	20	ditto	12	2 †2 *4	15/20	15	6/10	3 *4	10	2/4
187. George Charlesworth	16	ditto	4	*2 †2	8/12	10	2	*1	*1 †2	*1
188. Emma Benson	17	ditto	5	*4	5/12	8/12	4	1	*3 †3	*3
189. James Hogg	42	pulmonic valves obstructed, regurgitant, heart large	7/9	2/3	6/8	4/8	5/6	2	5	2
190. Thirza Leaf	20	aortic regurgitation, heart large, acute rheumatism	5	5	7	7	...	...	2½	1
191. C. Walls	52	ditto	4	4	2 20	2 20	2 14	0 25	0 14	6 25
192. John Roe	62	mitral regurgitation, heart large	11	9	9/12	9	4	3	1½	5
193. Ann Leavers		ditto	*1†5/8	*2	15/20	6	5	*2	*2 †5	*3
194. Mary Simmonds	25	ditto	5	3	4	6	3	2	3	2
195. John Soar	20	mitral and aortic regurgitation	6	5	10/12	8/12	2	1	4	3
196. W. Thorley second observation	20	endocarditis, pericarditis? and acute rheumatism, partial adhesions?	6/12	*3	15	22	10	5	5/7	3/5
197*a*. Wm. Shaw	11	pericardial adhesion, heart large, acute rheumatism	*4	fell in	8	8	8	rises on expiration	6	about 2
197*b*. Ditto, second observation		ditto, shortly before death	10	*2	16	11	7	0	3	*3
198. Wm. Ellis	70	pericarditis, pericardial adhesion, heart large	26/30	26/30	27	25	20/27	*1†20/20	20	20
199. Herbert Bower	35	pericardial adhesion	*1 †10	*7	18/25	10/15	*3 †7	*4 †4	*8 †7	*8
200. John Perry	25	aortic and mitral regurgitation, heart large, adhesion?	*3/7	*3/*5	10	10	5/7	6	5	3

rendered abnormal, by Diseases of the Heart and Pericardium, pp. 460-466.

Sixth rib, lateral.		Eighth rib.		Tenth rib.		Abdominal.			Rhythm.		Tape measurements. above nipple		xyphoid cartilage		Abdomen		No. of respirations per minute.
right	left	right	left	right	left	right	centre	left	insp.	exp.	right	left	right	left	right	left	
...	...	...	...	12		14/12	20/22	20									
...	...	...	...	10	10	10	10	10									
...	...	...	...	10	8	14	18	12	4	4	12·4	11·8	12	11·4			
...	...	...	...	8	10	8	12	10									
...	...	...	...	4	2	6	8	5									
8/10	3	18/20	10	3	3	2/3	*8 *10 *16	...	4	5	...	...	...	...	...	...	36
...	...	...	...	5	5	15	12	12									
...	...	...	...	5	9	8	15	...	...	...	...	...	...	...	...	...	42
...	...	...	...	5	6	9	16/20	8	4	4	16	15·6	15·8	14·8			
1	1½	6	3	5	5/7	3/10	7/18	6	...	...	15	15·6	13·5	13 5			
...	...	...	...	6/5	3	5	20 100	6									
1½	1	3½	3	6	7	9	15	10	...	...	16·8	16·8	16·5	16 5			
...	...	...	...	8	5	12	25/30	10/12									
3	2	...	...	10	10	13	16	10	5	5	13	14½					
2	2	6	6	12	7	20	30	13	...	...	16 4	16·3	16	16·2			
10	5	14/15	10	15	7	6	7	6	...	...	15·5	15·2	14· 14·5	14.7 14.8			
...	...	...	...	12	about 12	15	about 15	about 15									
...	...	...	...	9	9	...	...	...	...	...	...	...	...	...	...	...	48
5	*3 †7	*1 †3	*5 †2	5	*8	10	35/40	10	4	10	..	...	...	...	...	...	32
*3 †6	*5 †3	*6	*9	12	8	18	15 50	20	4	4							
4	3/5	10	5	9	6	18	25	15	...	...	...	...	...	...	...	...	28

DESCRIPTION OF PLATE VI.

The figures in this plate are copies of daguerreotype views of the chest of William Rawson, the subject of emphysema and bronchitis, during ordinary respiration, and during deep inspiration.—See p. 404.

Fig. 1.—Ordinary respiration. Fig. 2.—Deep inspiration.

DESCRIPTION OF PLATE VII.

The figures in this plate are copies of daguerreotype views of the chest of Samuel Redgate, the subject of phthisis, with a large tuberculous cavity in the upper lobe of the left lung.—See p. 444.

Fig. 1.—Ordinary respiration. Fig. 2.—Deep inspiration.

The lines indicate in both plates the outlines of the internal organs; the concentric lines, the situation of the heart's impulse.

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Fig. 1.

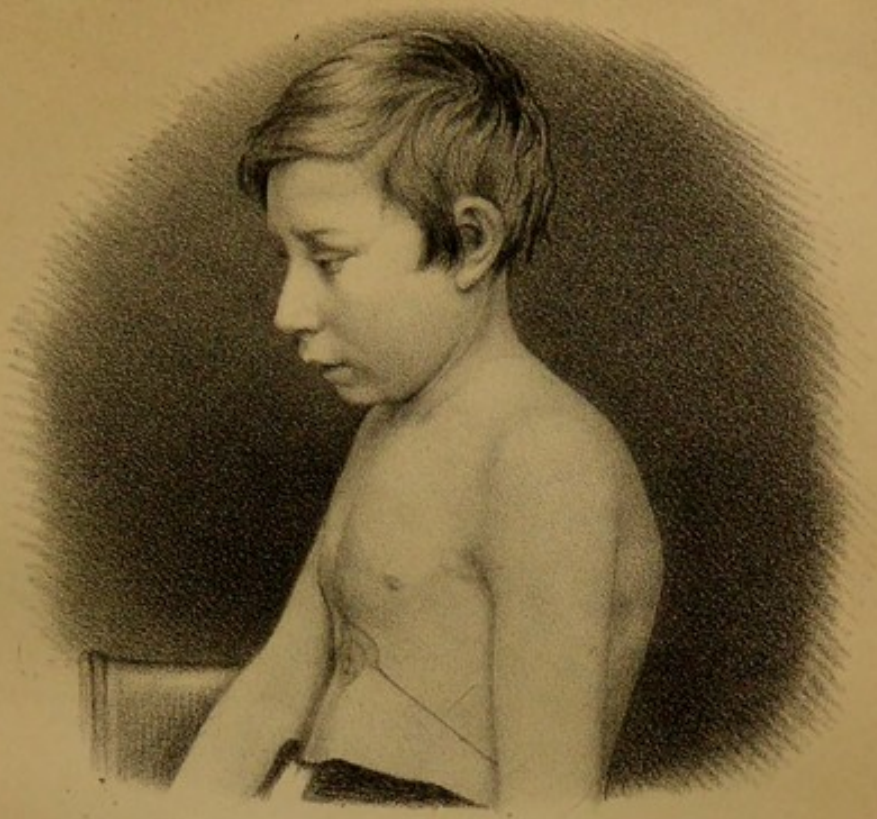


Fig: 2.

WILL.M RAWSON. EMPHYSEMA.

Lithog.d from Daguerreotype by B. George, 54, Hatton Garden

PLATE VII

Fig. 2.

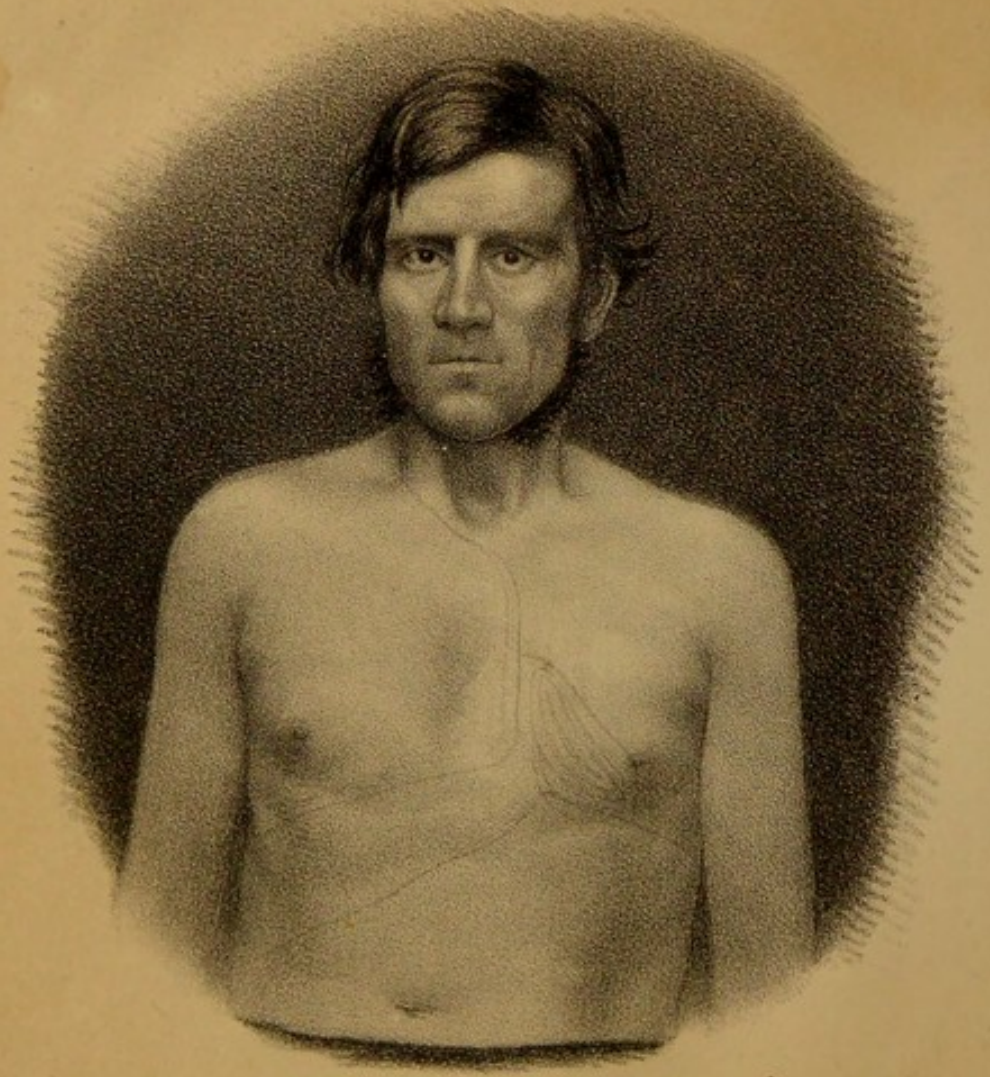
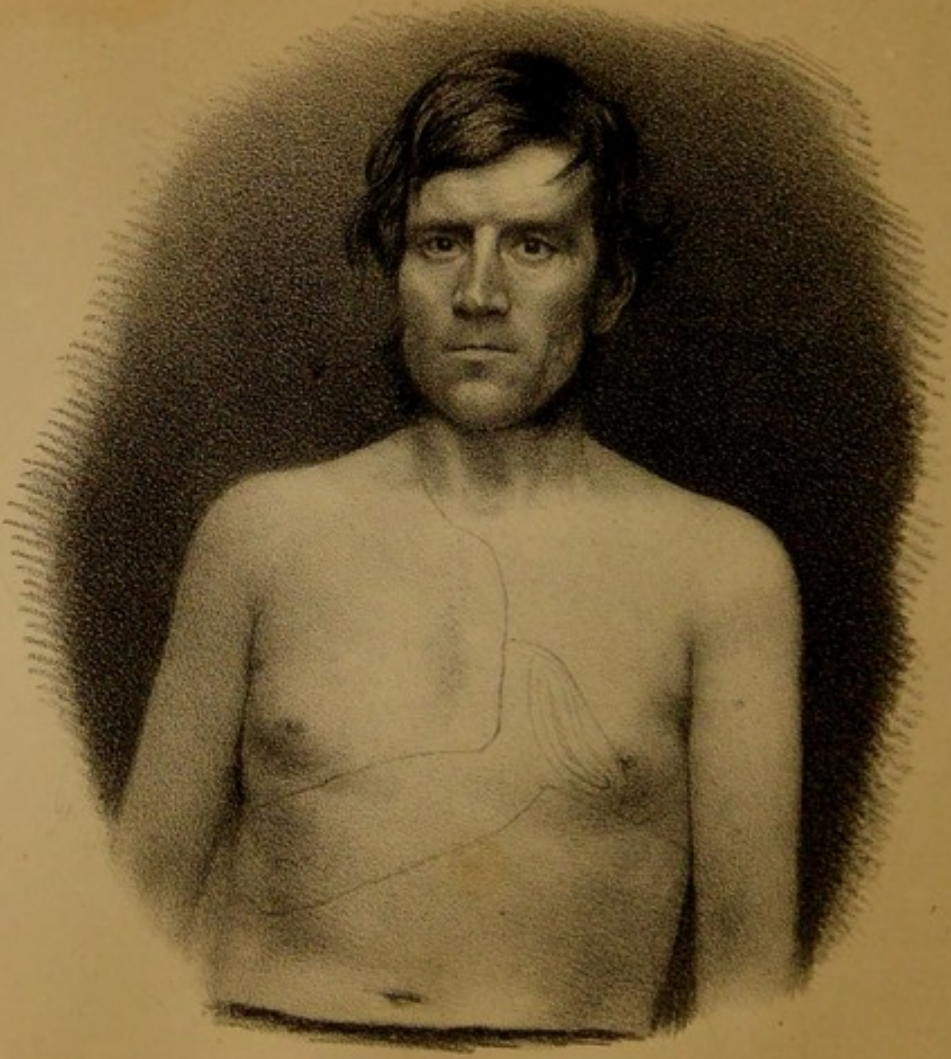


Fig. 1.



VOL. XIII

Lithog.d from Daguerreotype by

SAMUEL REDGATE. PHTHISIS.

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