The discovery of the physiological method of inducing respiration in cases of apparent death from drowning, chloroform, still-birth, noxious gases, etc., etc. / by Henry R. Silvester.

THE DISCOVERY OF

THE PHYSIOLOGICAL METHOD

OF INDUCING RESPIRATION IN CASES OF APPARENT DEATH FROM

DROWNING, CHLOROFORM,

STILL-BIRTH, NOXIOUS GASES,

ETC., ETC.

BY

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AUTHOR OF "THE PHYSIOLOGICAL METHOD OF TREATING INCIPIENT CONSUMPTION WITH DIRECTIONS FOR ITS PREVENTION."

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M.DCCC.LXIII.

"Death may usurp on Nature many hours,
And yet the fire of life kindle again
The overpressed spirits. I have heard
Of an Egyptian had nine hours lien dead,
By good appliance was recovered."

SHAKESPERE, *Pericles*, act iii.

PREFACE.

THE demand for a third edition of this work affords me an early opportunity of remarking that the principles advocated in the following pages have been introduced into the Army and the Navy under the sanction of His Royal Highness the Duke of Cambridge, and His Grace the Duke of Somerset,* respectively. They have likewise been adopted by the Government Emigration Board; and, at the recommendation of the Royal Medical and Chirurgical Society, they have been made the foundation of the New Regulations of the Royal Humane Society. The Committee of the Royal Medical Chirurgical Society, consisting of the following gentlemen,

CHARLES J. B. WILLIAMS, M.D., F.R.S.
C. E. BROWN-SEQUARD, M.D., F.R.S.
GEORGE HARLEY, M.D.

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* *A large portion of the second edition was ordered by the Admiralty with a view to a copy being furnished to each of Her Majesty's ships in commission.*

W. S. Kirkes, M.D.

H. Hyde Salter, M.D., F.R.S.

J. B. Sanderson, M.D.

W. S. Savory, F.R.S.

E. H. Sieveking, M.D.

after laborous experimental investigation, published their report entirely favourable to the method advocated by me, as will be seen further on. Two letters have been inserted and will be read with interest as the recorded opinion of the late eminent Surgeon, Sir Benjamin C. Brodie, Bart., F.R.S.

"Lateat scintillula forsan."

A NEW METHOD OF RESTORING RESPIRATION TO PERSONS APPARENTLY DEAD FROM SUSPENDED BREATHING.

The subject of this work is one of deep practical and physiological importance, and is of direct personal interest to every individual, since no one can claim for himself or his family security from the dangers against which this method proposes a remedy.

In the following pages, I purpose to describe a new method of treating apnœa, or suspended respiration, by inducing such movements of the thoracic parietes through the muscles of respiration, as shall cause the atmospheric air we breathe to be drawn into and again expelled from the lungs of the asphyxiated person—and without having recourse to the employment of any mechanical apparatus. The process is of universal application; it is easy of performance, entirely in harmony with that of Nature, and does not prevent nor interfere with the use of those means in which much confidence has hitherto been placed; such, for instance, as the use of the warm bath and other plans of restoring warmth and circulation.

Apnœa, or suspended respiration, may be the result of drowning, of still-birth, of suffocation, of strangling, of hanging, of garotting, of epilepsy, of apoplexy, of the undue or excessive employment of opium, of chloroform, of certain gases, etc.

The methods usually resorted to for restoring persons affected by suspended respiration may be grouped under three divisions. The first division includes various plans for exciting the reflex function of the nervous system. The second provides for the maintenance of warmth and circulation. The third proposes means for supplying air to the lungs, either by mechanically forcing air into the chest, or by inducing such movements in the thoracic parietes, as shall induce fresh air to enter into the pectoral cavity alternately with the expulsion of the products of respiration.

It is with the third divison that we are especially concerned.

With regard, however, to the second division—the treatment by *warmth and friction* only—I may be allowed to make a few passing observations. There is much difference of opinion, but it must be said that experience is greatly in its favour; greater numbers having been restored by it than by any other means. It is to be kept in mind that persons are usually submerged in cold water, and the chief point aimed at is the restoration and maintenance of the natural temperature of the body, so that pulsation may be increased, and thus respiration encouraged with more hope of success. Hence the Royal Humane Society, in its printed rules, particularly recommended it as a restorative in cases of the apparently drowned, and of the apparently dead, from intense cold, or from hanging. "In one of the most remarkable cases of resuscitation on record, the individual had been fourteen minutes under water, and no signs of returning animation were evinced until the treatment, which consisted simply in the application of warmth and constant friction, had been persisted in for eight hours and a half from the time of the accident." (Taylor, *Med. Jurisp.*)

Edwards, Brown-Séquard, Dr. Marshall Hall, and others, have experimented on animals. But the results of experiments on animals are unsatisfactory, and would not, probably, be applicable to man. "The practical conclusion at which Dr. Hall arrived was, that, in the treatment of apnœa, the continuous warm bath must be excluded. This inference is, we think, scarcely warranted by the facts. In the experiments he made, animals were completely submerged in warm water, so that there was no escape for the products of respiration; whereas, in the use of the warm bath, there would not be this obstacle." (*British and Foreign Med.-Chir. Review*, 1858.) "The duration of life in asphyxia seems to be in proportion, not to the warmth, but to the maintenance of a medium temperature of the patient or of the animal made the subject of experiment. The restoration of warmth can only be safely effected when the respiratory movements are maintained, and the circulation is promoted. The warm bath, used *alone*, appears to have been often fatal." *La ncet*, December 1856.)

Dr. Edward Smith states that the hot water bath might act injuriously by the increased pressure on the chest, and also by the position not being a favourable one for respiration. Dr. Markham has suggested that possibly the warm water bath might do harm by preventing the access of air to the skin, and thus assist the state of asphyxia.

I think we may, notwithstanding, conclude that the warm bath may be considered as an *auxiliary* means, and that much dependence is to be placed on both friction and warmth, and that nothing should be allowed to interfere with the application of those means by which warmth is restored to the skin. "It ought certainly to be borne in mind, that the practice of the Royal Humane Society, whose rules, Dr. M. Hall states, 'may be summed up in one word—warmth!' has been eminently successful." (Vide *British and Foreign Medical-Chirurgical Review*, April 1858.) The impossibility of using the warm water bath during the adoption of the postural method of Dr. Marshall Hall is universally admitted.

In the apnœa of still-born infants, momentary immersion in baths of from 50° to 60°, and 98° to 100°, alternately and quickly, might be tried, as recommended by Dr. Hall.

It is well known that hot air increases respiration, a person respires more frequently in hot air than in cold. It also increases pulsation.

Cold also increases respiration, but acting only as shock it does not increase pulsation.

Accordingly I would suggest the employment of a *hot air bath* where practicable in case of suspended animation as a general stimulant to both the respiration and circulation, with the occasional application of cold to act on the principle of shock, and so accelerate any respiratory efforts.

The air would have free access to the skin, and the position of the body might be such as should be thought desirable.

We now come to the third division of our subject. The introduction of air into the chest.

1st. By the use of instruments.

The mechanical introduction of air into the chest by means of the bellows, by Dr. Sibson's or some other apparatus, appears, theoretically speaking, to be strongly

indicated; but the obvious objection is, that the instruments are not commonly at hand, and whatever is done on these occasions must be done quickly. A similar remark may be applied to the employment of electricity and electro-magnetism, and the introduction of certain gases, oxygen, ammonia, etc. Moreover, Mr. Mare states, that "more good is done by drawing air out of the lungs than by artificially inflating these organs."

2nd. By taking advantage of certain movements of the walls of the chest.

Under this division we come to the examination of some of the various ways of introducing air by imitating inspiration and expiration, employing with that view certain *movements of the thoracic parietes.* We will group them under three heads:—

I. Alternate compression and relaxation of the walls of the chest.

II. The postural method of Dr. Marshall Hall.

III. The method which I beg to introduce to your notice.

I.

Alternate compression and relaxation of the chest.

This is the essential part of the various plans formerly employed. On compression, the walls of the chest descend below their accustomed level, the capacity of the lungs is diminished, and air is expelled. Upon the removal of the pressure or relaxation of the chest, the ribs rise again to their usual and ordinary height, and air is again introduced. There is no elevation of the ribs, such as takes place in natural deep inspiration, in which they are made to rise above their ordinary or quiescent level, and the cavity of the chest greatly increased in size.

These methods have been made the subject of experiment. The apparatus employed was very simple, and consisted of three tubes, one of glass, to be passed into the trachea; another, a bent barometer tube, graduated; and these two connected by a piece of India rubber tubing. The glass tube was passed through an aperture made in the trachea, and firmly secured in its place by a ligature. A small quantity of coloured spirit was poured into the barometer tube, which was in the form of an inverted syphon, and was retained in an

upright position, on a level surface, by an assistant who carefully noted the height of the column of fluid.

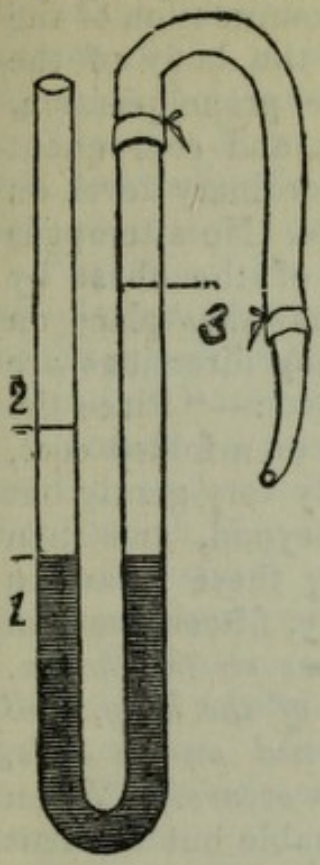


Fig. 1.—1. Natural level of fluid. 2. Height to which fluid rose by pressure on the chest. 3. Point to which the fluid receded in the first leg of the instrument by the drawing of air into the lungs when the chest was expanded by my method.

Trials were made on persons of both sexes and of different ages, and at a length of time after death which varied from one hour and a half to two days, in those with lungs sound or otherwise. BUT PRACTICAL DEDUCTIONS HAVE BEEN DRAWN FROM THOSE CASES ONLY IN WHICH THE RESULTS WERE OBTAINED WHEN THE BODY WAS WARM, AND WHEN TWO HOURS HAD NOT ELAPSED AFTER DEATH. This is very important, RIGOR MORTIS* preventing trustworthy conclusions. THE CHEST SHOULD BE FREE FROM DISEASE.

The subject of experiment was placed in various positions; and on compression of the chest being made, the fluid contained in the inverted syphon, connected with the lungs by the flexible tube, immediately rose; and, when the compression ceased, the fluid fell slowly to its previous level, demonstrating—

1st. That air had been expelled from the lungs—in consequence of the pressure exerted on the parietes of the thorax.

2ndly. That the air returned into the chest, though slowly, upon relaxation of the pressure—in consequence of the feeble elasticity of the chest.

3rdly. That the actual capacity of the chest was not increased by this mode of practice.

II.

Postural Method of Dr. Marshall Hall.

The principle involved in this method of treatment is precisely the same as in the foregoing plan, in which simple compression and relaxation of the chest are em-

* The commencement of rigidity usually takes place within seven hours after death. Its general duration is from twenty-four to thirty-six hours.

ployed to induce expiration and inspiration; the difference being that, in the postural method, the compression of the thorax is occasioned by the weight of the body of the patient resting on the chest during the prone position, followed by the removal of the pressure, and consequent return of the thoracic parietes to their ordinary level on the patient's assuming the supine posture. No attempt is made to enlarge the actual capacity of the chest by inducing an elevation of the ribs, such as takes place on making a deep inspiration. The following directions are given for performing the postural method:—"Place the patient on his face, supporting the chest on a folded coat, or other article of dress. Turn the body very gently but completely on the side, and a little beyond, and then briskly on the face, alternately repeating these measures deliberately, efficiently, and perseveringly, fifteen times in a minute only. (*When the patient reposes on the thorax, that cavity is compressed by the weight of the body, and expiration takes place; when he is turned on his side, this pressure is removed, and inspiration occurs.*) When the prone position is resumed, make equable but efficient pressure with friction along the back, removing it immediately before rotation on the side. (*The first measure augments the expiration; the second commences inspiration.*)"

Numerous experiments have been made on the dead body in order to test the influence the postural method has upon respiration. The following results were obtained by the aid of the apparatus mentioned above, namely, a glass barometer tube bent in the form of an inverted syphon graduated, and containing a little coloured spirit, made to communicate with the trachea by means of a long flexible tube, the joints well secured by ligature.

First: The subject of experiment being placed in the prone position, equable but efficient pressure with friction was made along the back, as recommended by Dr. Marshall Hall, in his rules for restoring persons apparently dead from apnœa. The fluid rose in the bent tube, proving that the compression exercised on the thorax by the weight of the body, etc., did displace some air from the lungs.

Secondly: On turning the body on the side and a little beyond, the column of fluid fell slowly to its former level,

proving that the air returned into the chest, though slowly, upon the removal of the pressure—in consequence of the return of the parietes of the chest, by their feeble elastic force, to their natural level.

Thirdly: It was proved, by the fluid in the bent tube not descending below its level, that the actual capacity of the chest is not enlarged.

Fourthly: From the results of the experiments on simple compression exactly corresponding with the results of the experiments on the postural method, we may infer that these two methods of treatment are identical in principle.

It must be remembered that it is only the "residual air," or that which remains in the chest after an expiration, which is operated upon in the postural method.

The Postural or Ready method of Dr. Marshall Hall has been found open to some objections; for instance:—

1. Expiration is made to precede inspiration, whereas originally expiration is second in order, and not the primary act. In still-born infants, whose lungs have never been inflated, forced expiration, at first, is of course impossible.

2. The expansion of the thorax, or inspiration, being dependent on little more than the elasticity of the tissues, takes place feebly, inefficiently, and slowly, and therefore calls for more active mechanical aid.

3. It is scarcely possible to use the warm bath during the adoption of the postural method.

4. The patient is liable to have the mouth and nose compressed, the face bruised, or the neck twisted by the almost lifeless body being turned alternately on the chest and back fifteen times a minute for some hours. Moreover, to the operator this process is very arduous.

5. When the patient is turned on the face and pressure made on the back (pronated) the contents of the stomach are liable to pass into the œsophagus and windpipe.

6. When the patient is turned "completely on the side and a little beyond" (supinated), the tongue is apt to obstruct inspiration by falling back into the throat, with the epiglottis resting against the back of the pharynx.

7. Both sides of the chest are not equally inflated, one side only being called into action at the same time to any important extent.

8. This process is not entirely in harmony with that of nature. It is not the way in which we generally breathe.

9. The amount of air respired is exceedingly small; this is, doubtless, in consequence of the actual capacity of the chest not being increased.

As to the state of the tongue, I observe that, in cases of asphyxia the tongue is usually swollen, and falls back into the throat, acting as a plug to the pharynx, and a sort of valvular covering to the otherwise patulous orifice of the larynx. In the postural method, when the body is turned on the face, no doubt the tongue falls forwards and draws with it the epiglottis, and leaves the glottis open. This, however, is of little consequence so far as respiration is concerned, for the very compression of the chest by the weight of the body itself forces out the air from the lungs, and so lifts up the valvular covering of the larynx, so that in fact the tongue does not offer any serious obstacle to *expiration* when it is induced by compression of the thorax.

Moreover, in the postural method, the moment the patient is rolled "on the side and a little beyond," in order that *inspiration* may take place, the tongue is liable to fall back into the throat, and its semi-lifeless relaxed tissue to cover securely the orifice of the glottis, and its accurate closure is probably further insured by the suction generated by the return of the thoracic parietes to their natural level, so that the greater the previous compression of the chest, the more firmly is the tongue drawn down as a plug into the throat, when the pressure is relaxed, and the more effectually does it prevent the entrance of air into the lungs.

With reference to the amount of air respired in the Marshall Hall method, Mr. Wildbore states in a letter to the *Medical Times and Gazette*, Nov. 28th, 1858: "I believe that I am correct in saying that the experiments performed by Mr. Hunter and other gentlemen at St. George's Hospital on the dead subject, proved that nearly as much air entered the lungs as would be inhaled in an ordinary inspiration in a state of health;" that is, from six to thirty cubit inches.

I think there must be some fallacy here. The method of performing the experiments just mentioned is by no means satisfactory, and is, I believe, open to obvious objections.

The tube of the pnæometer was passed into one of the nostrils of the patient, the other nostril and lips being closed with adhesive plaster. The want of rigidity of

cheeks and the amount of air in the respiratory tract and even in the stomach, etc., of the patient could scarcely fail to render the indications of the instrument, however perfect in itself, liable to suspicion, if not entirely valueless, in point of scientific accuracy.

In the Marshall Hall method, the amount of air displaced from the chest and *returning* there is exceedingly small,* being according to my experiments a fraction of one cubic inch. Compression of the thorax does at first expel some air, as may be seen above, but the repetition of *simple* rotation has little effect in restoring it.

III.

Dr. Henry Silvester's, or the Physiological Method of Inducing Respiration.

The *new method* which I venture to bring before the profession is an imitation of natural deep respiration, and is effected by means of the same muscles as are employed by nature in that process. In ordinary deep inspiration we lift the ribs and sternum by the pectoral and other muscles which pass between the chest and the shoulders, and thus produce the threatened vacuum which inflates the lungs. In my method we lift the ribs and sternum by the pectoral and other muscles, which pass from the shoulders to the parietes of the thorax, by steadily extending the arms of the patient up by the side of his head: by elevating the ribs the cavity of the chest is enlarged, a tendency to a vacuum is produced, and a rush of air immediately takes place into the lungs. Expiration is brought about by simple compression of the sides of the chest by the patient's arms.

The Principle. Forced enlargement of the capacity of the chest, producing a tendency to a vacuum, and consequently an *inspiration* of air into the lungs, induced by the constrained action of the muscles of ordinary and extraordinary inspiration upon the moveable walls of the thorax.

Diminution of the capacity of the chest and expulsion of the air from the lungs, and consequently an *expiration* induced by compression of the moveable walls of the thorax.

The arms of the patient are to be used by the operator as handles to open and close the chest.

* *Vide* the Report of the Committee of the Medical Chirurgical Society, page 43, below.

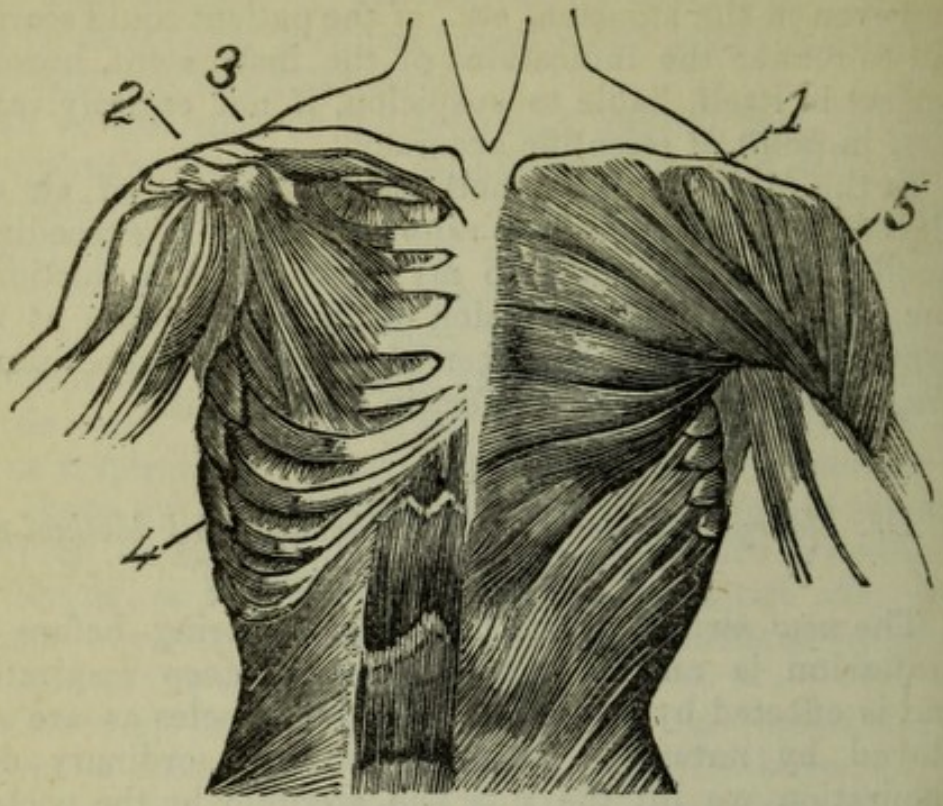


Fig. 4. Diagram of the Muscles in Front of the Chest.

1. The *pectoralis major* arising from the clavicle and from the cartilages of the true ribs, and converging towards the tendon of insertion into the bicipital groove of the humerus.
2. The *pectoralis minor*, arising from the third, fourth, and fifth ribs, near their cartilages, and converging to a tendon, which is inserted into the coracoid process of the scapula.
3. The *subclavis muscle*, which arises from the first rib, and is inserted into the costal aspect of the clavicle for nearly half its length.
4. The *serratus magnus*, placed upon the upper and lateral parts of the thorax, arising from the eight upper ribs, and inserted into the scapula.
5. The *deltoid*, which arises from the external third of the clavicle and from the spine of the scapula, and is inserted into a prominence on the middle of the outer side of the humerus.

All these muscles are put on the stretch, and tend to raise the ribs, when the arms are extended upwards by the side of the head, as described in my method.

This new method has been tested by experiment on the dead body by the same apparatus, the elastic tube being securely fastened into the trachea, in order to avoid the sources of fallacy mentioned above.

The body was placed on its back, supported and a little raised by a small pillow placed under the shoulders. The height of the column of fluid having been first carefully noted, the arms of the subject were raised, and then steadily extended upwards by the sides of the head, so

as to draw up the shoulders and put the pectorals on the stretch, elevate the ribs, and consequently enlarge the cavity of the chest. The result was that the fluid in the bent tube rapidly fell, and so considerably as to recede high up in the leg of the instrument nearest to the body, that is to say, the tendency to a vacuum produced in the chest drew the air into the lungs.

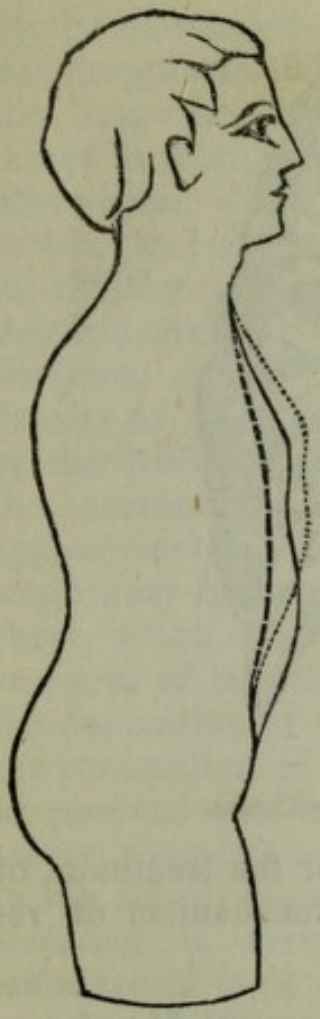


Fig. 2.—Continuous line represents the ordinary state of the chest. Broken line represents the depression of the chest under pressure. Dotted line represents the enlargement of the chest, produced by the *forced action* of the muscles of inspiration. The space between the continuous line and the broken line indicates the extent of respiratory movements in the postural method. The space between the dotted line and the broken line indicates the extent of respiratory movements in my method.

The shoulders and arms were next pressed down upon the sides of the chest, and immediately the fluid rose as much above its usual level in the further leg of the apparatus as it did in the foregoing experiments; demonstrating:

1stly. That the actual capacity of the chest was increased, and air drawn into the lungs by the constrained action of the muscles of respiration upon the moveable walls of the thorax.

2ndly. That expiration was produced by pressing the arms and shoulders down upon the sides of the chest.

3rdly. That the distinguishing feature of my method is the actual enlargement of the cavity of the chest —the elevation of the ribs above their ordinary or natural level.

It is, of course, of consequence to get as much air into the lungs as possible, because there can be but little doubt that fresh air is the proper stimulant to the respiratory efforts, just in the same way that light is to the eye and sound to the ear. The quantity of air respired, according to my experiments on the dead body, appears to be about ten times greater in the method advocated than in the postural method of Dr. M. Hall, and would be amply suffi-

cient to supply fresh air to the lungs of an asphyxiated person.*

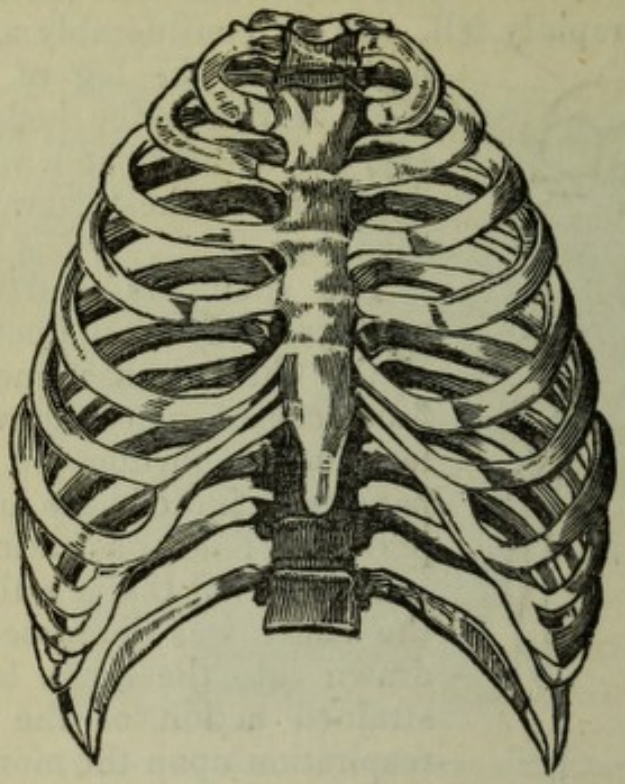


Fig. 3. Front view of the Bones of the Thorax.

Before laying down practical rules for the treatment of apnœa, we may consider shortly the mechanism of respiration in man.

The Mechanism of Respiration in Man.

The general principle of the operation is this:—The lungs are divided into cavities of extreme minuteness; and these cavities or air-cells are all connected with the trachea by means of the bronchial tubes. The lungs themselves are suspended in a cavity that is completely closed, being bounded above and around by the bony framework of the thorax, the interspaces of which are filled up by muscles and

* With regard to the amount of air respired by my method. In a body which had been dead three days, and *rigor mortis* was at first strongly marked; the Committee of the Royal Medical and Chirurgical Society, appointed to investigate the subject of suspended animation, found when performing my method, that a volume of air was inspired amounting to 44 cubic inches, and on sternal pressure 52 cubic inches were expired. In ordinary tranquil breathing adults usually inspire and expire on an average about 20 cubic inches.

membranes, and being entirely cut off from the abdomen below by the diaphragm. Under ordinary circumstances, the lungs completely fill the cavity. But the capacity of the thoracic cavity is susceptible of being greatly altered by the movements of the ribs, and by the action of the diaphragm and abdominal muscles. When it is diminished, the lungs are compressed, and a portion of the air contained in them is expelled through the trachea. On the other hand, when it is increased, the elasticity of the air within the lungs causes them immediately to dilate so as to fill the vacuum that would otherwise exist in the thoracic cavity, and a rush of air takes place down the air-tubes and into the remotest air cells, to equalise the density of the air they include (which has been rarified by the dilatation of the containing cavities) with that of the surrounding atmosphere. The lungs themselves appear to be almost entirely passive instruments of the respiratory function. The dilatation of the cavity of the chest, which constitutes inspiration, is accomplished by two sets of movements—the elevation of the ribs, and the depression of the diaphragm. In tranquil breathing the contraction of the diaphragm is alone nearly sufficient to produce the necessary enlargement of the thoracic cavity, the position of the ribs being very little altered. In the act of deep inspiration, the ribs (whose ordinary direction is forwards, sloping downwards), under the influence of their elevator muscles, namely, the pectoralis muscles, major and minor, the serratus magnus, the scaleni muscles, and the intercostals, pass from the sloping to the horizontal position. By this change, the dimensions of the chest are enlarged in the transverse as well as in the antero-posterior direction, for the middle curved portions of the ribs are carried outwards, and therefore brought further apart from each other, and their sternal extremities are moved forwards, accompanied by the sternum, the distance of which from the dorsal vertebræ is thereby increased. When the respiratory movement is very forcibly performed, the scapula is itself drawn upwards, thus producing an increased elevation of the ribs and an unusual enlargement of the upper part of the thoracic cavity. When deep expiratory action is to be performed, the ribs descend by the action of the muscles of the spine and the abdomen, the diaphragm being

altogether passive. In this manner, by the regularly alternating dilatation and contraction of the thoracic cavity, the air within the lungs is alternately increased and diminished in amount, and thus a regular exchange is secured. The number of the respiratory movements (that is, of the acts of inspiration and expiration taken together) may be estimated at from fourteen to eighteen per minute. (Carpenter's *Physiology*.)

I may also remark that, from the peculiar mode in which the ribs are articulated with the spinal column at one extremity, and from the angle which they make with the cartilages that connect them to the sternum at the other, the act of elevation tends to bring the ribs and their cartilages more into a straight line, and to carry the former to a greater distance from the median plane of the body, whilst the sternum is also thrown forwards. Consequently the elevation of the ribs increases the capacity of the thorax, upwards, forwards, and laterally. Although the range of motion between each vertebra and the ribs attached to it is very limited, yet the whole framework of the chest enjoys such mobility, that by a deep inspiration its cavity is sometimes more than doubled.

I may also mention, that in difficult respiration the muscles of the limbs are made to assist in respiration—the patient seizing hold of any fixed object for the sake of a firm point for the muscles to act from; and that in deep respiration the greatest enlargement of the thoracic cavity in both sexes is made by the ribs, and not by the diaphragm. It appears very questionable whether the diaphragm is affected any further than being flattened, and that without descending.

It is unnecessary to enter upon the chemical phenomena of respiration.

I will now proceed to lay down a few practical rules for inducing respiration in cases of asphyxia.

With regard to the *Apnœa of Still-Born Children*, respiration may generally be excited by dashing cold water on the face and body, by blowing in the face, or by a slap with the flat of the hand on the nates.

Should these measures fail, the following rules for inducing respiration should be put in practice.

In cases of *Narcotic Poisoning*, artificial respiration may by these rules be kept up for any length of time, or until the poisonous matter is eliminated.

Fig. 5.—Diagram to illustrate the manner of performing my method. The asphyxiated patient is supposed to be in the act of drawing an inspiration. The ribs being elevated by the operator, who is stretching upwards the patient's arms.

The following Rules for the treatment of apnœa are deduced from actual experiment, and are in accordance with established physiological principles.

DR. HENRY SILVESTER'S RULES FOR RESTORING SUSPENDED ANIMATION.

Rule I.

To adjust the Patient's Position.

Place the patient on his back, with the shoulders raised and supported on a folded article of dress, and secure the feet.

Rule II.

To Maintain a Free Entrance of Air into the Windpipe.

Wipe the mouth and nostrils. Draw forward the patient's tongue, and keep it projecting beyond the lips. *(If the lower jaw be gently raised, the teeth may be made to hold the tongue in the required position. Should it be found necessary, the tongue may be retained in that position by passing a handkerchief under the chin and fastening it over the head.)*

Rule III.

To Imitate the Movements of deep Respiration.

Raise the patient's arms upwards by the sides of his head, and then keep them stretched steadily but gently upwards and forwards for two seconds. (This action enlarges the capacity of the chest by drawing up the ribs, and induces an *inspiration.*)

Next, turn down the patient's arms and press them gently and firmly for two seconds against the sides of the chest. (This action diminishes the cavity of the thorax, by pressing down the ribs, and produces a forcible *expiration.*)

Repeat these measures alternately, deliberately, and perseveringly fifteen times in a minute.

Rule IV.

To Induce Circulation and Warmth, and to Excite Inspiration.

Rub the limbs from the extremities towards the heart.

Replace wet clothing by warm and dry covering. Occasionally dash cold water in the patient's face. These measures are perfectly compatible with the systematic performance of the imitation of the movements of respiration. A similar remark applies to the use of the warm water bath, or hot air bath, if required.

Explanatory Remarks.

Rule I. The posture recommended is not essential; but in this position the vital capacity of the chest is larger than in any other recumbent attitude. The bony framework of the chest is more free to move, and both sides can be expanded at the same time. This, in fact, is precisely the posture chosen by persons suffering from dyspnœa.

Rule II. In this way the patulous orifice of the windpipe is raised and drawn forward, so that nothing intervenes between it and the natural channel of air through the nose. The tongue is entirely prevented from falling back into the throat, whilst the extent to which the windpipe is put on the stretch is clearly indicated. The pharynx also is sufficiently opened to allow of the removal of liquids, etc., from the mouth, nose, pharynx, etc., if those have not been completely displaced by previous suitable treatment.

Rule III. This process in short accomplishes artificially for the patient exactly what he would himself effect, and by the same muscles, if he had but the will and the power to draw a deep inspiration.

When the ribs are raised the capacity of the chest is enlarged, and a tendency to a vacuum is induced.

The ribs are raised by the pectoral muscles, and the pectoral muscles are put on the stretch by the arms of the patient, and the arms of the patient are drawn up by the operator; the result is that the ribs are raised and the fresh air passes into the chest to occupy the enlargement thus produced; and alternately with this the vitiated air is expelled from the lungs by compression of the sides of the chest.

Should there be any spontaneous efforts to respire—and these efforts at first may not be repeated perhaps more often than twice in a minute—they should on no account be checked by officious interference. Great care

must be taken not to disturb the natural rhythm. The expirations might be made a little more forcible or the inspirations deeper, but that is all.

Possibly the elevated position of the arms, together with the muscular compression exerted on the veins of the upper extremities, might favour the descent of blood from them into the chest at the same time that the tendency to a vacuum produced in the thorax by the elevation of the ribs would induce a rush of fresh air into the lungs.

At the same time that the arms are extended steadily upwards, the lungs might be filled with air by a mouth to mouth inflation.

The following are some of the advantages of my Method:—

1. Inspiration may be made to precede expiration, or it may be second in order at the will of the operator.
2. The expansion of the thorax is artificially insured, and is wholly under the control of the operator.
3. This method may be carried out when the patient is in the warm bath.
4. The patient is not liable to be injured by the manipulation.
5. The contents of the stomach are not liable to pass into the windpipe.
6. The tongue is prevented from obstructing inspiration.
7. Both sides of the chest may be equally inflated.
8. This process is entirely in harmony with that of nature.
9. A larger amount of air is inspired than by any other method.
10. This method is most easy of adoption.
11. Pure atmospheric air is inspired.
12. No apparatus is required.

Several successful cases of resuscitation have been recorded in the medical journals.

The following Directions I drew up as a foundation for the Regulations of the Royal Humane Society at the request of Dr. Christian, they are calculated to be generally useful.

DIRECTIONS FOR RESTORING THE APPARENTLY DEAD

From Drowning, Suffocation, Hanging Strangling, Garotting, Epilepsy, Chloroform inhalation, Noxious vapours, Opium, or Narcotic poisoning.

Send immediately for medical assistance, blankets, and dry clothing, *but proceed to treat the patient* INSTANTLY *on the spot, in the open air.*

The points to be aimed at are—*first*, and *immediately*, the RESTORATION OF BREATHING; and *secondly*, after *breathing* is *restored*, the PROMOTION OF WARMTH AND CIRCULATION.

The efforts to restore life must be persevered in for three or four hours.

TREATMENT TO RESTORE NATURAL BREATHING.

RULE I.

To Maintain a Free Entrance of Air into the Windpipe.

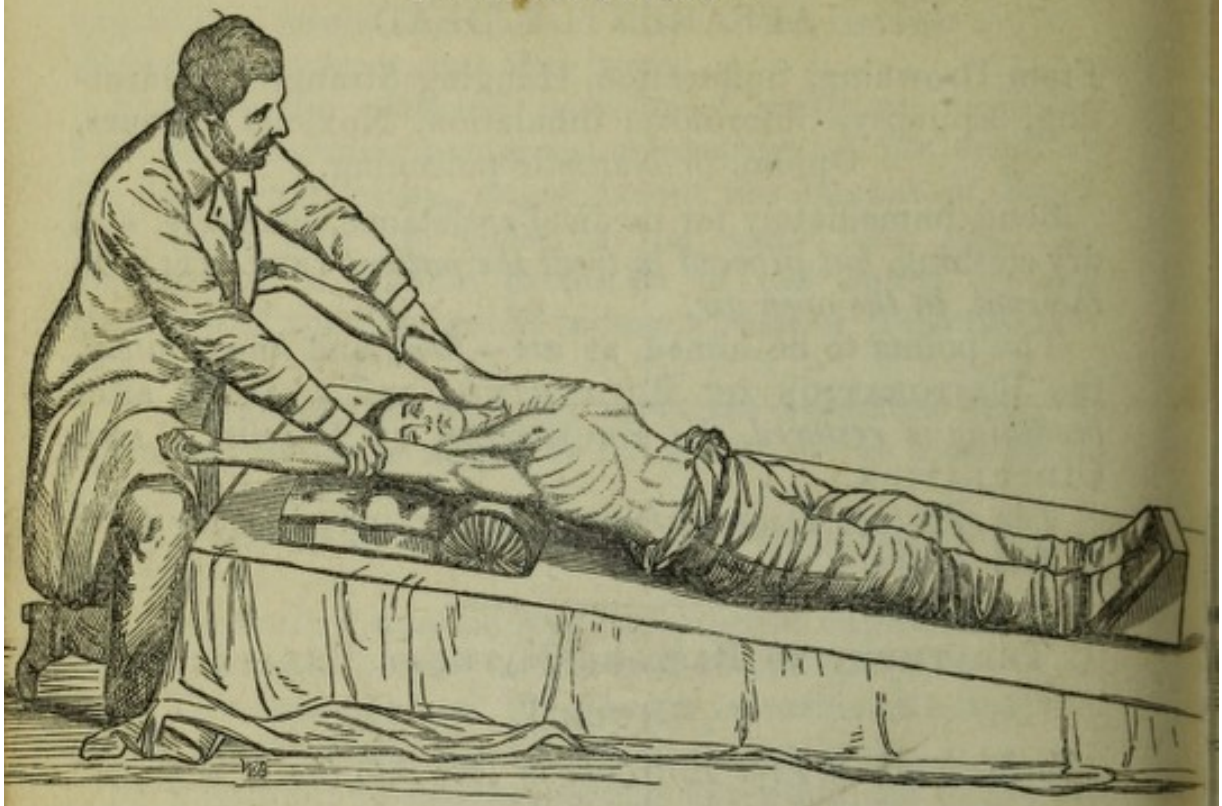
Cleanse the mouth and nostrils; open the mouth; draw forward the patient's tongue, and keep it projecting beyond the lips. Remove all tight clothing from about the neck and chest. In the case of Drowning, in order to insure the escape of fluids from the mouth and chest, in the first instance place the body with the face downwards, and hanging a little over the edge of a table, shutter, or board, raised to an angle of about 30°, so that the head may be lower than the feet. Open the mouth and draw the tongue forward; keep the body in this position for a few seconds or a little longer if the fluid continues to escape. The escape of fluid may be assisted by pressing once or twice upon the back.

RULE II.

To Adjust the Patient's Position.

Place the patient on his back on a flat surface, inclined a little from the feet upwards; raise the shoulders, and support them on a firm cushion or folded article of dress placed under the shoulder blades. Keep the head in a line with the body. In the apparently drowned the head may be a little lower than the feet, to facilitate the escape of fluids from the chest.

I.—Inspiration *



Rule III.

To Imitate the Movements of Breathing.

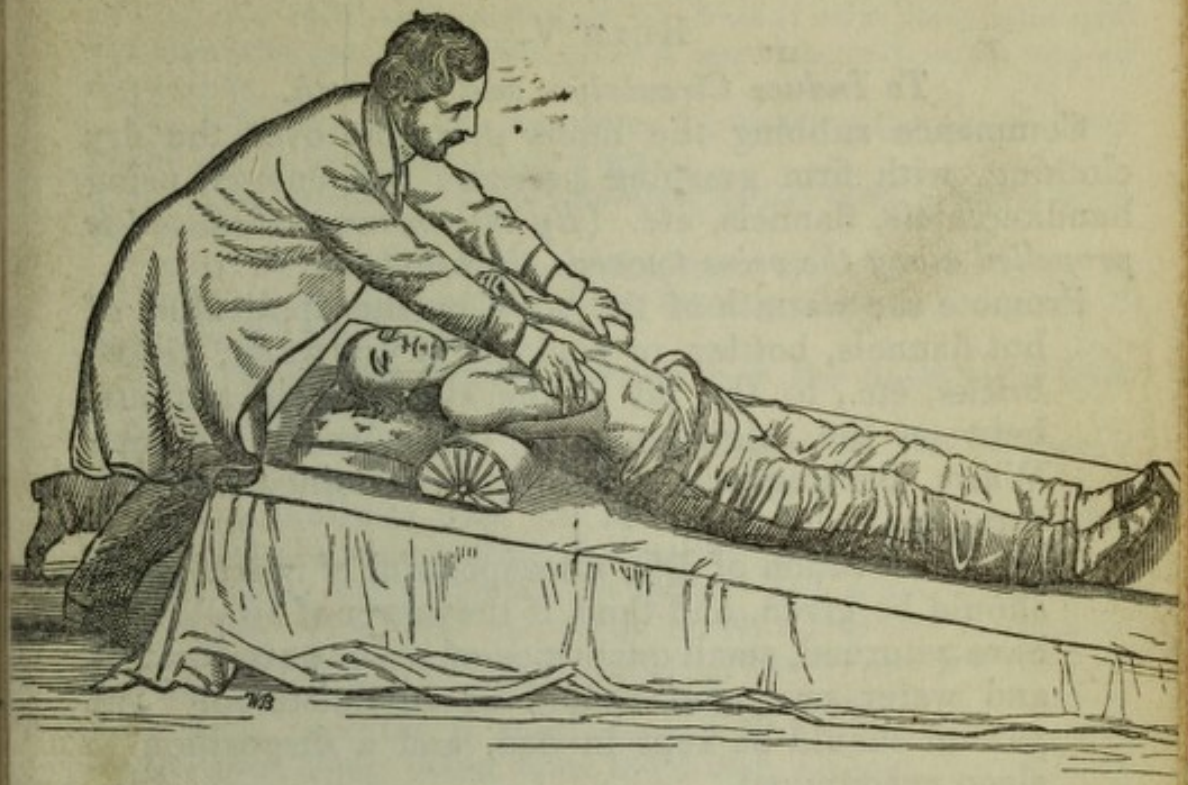
Draw upwards the patient's arms until they nearly meet above his head, the operator grasping them just above the elbows, and keep them stretched steadily, but gently, in an upward and forward direction, for two seconds (*see* Engraving I, Inspiration). (*This action enlarges the capacity of the chest, by drawing up the ribs, and induces inspiration.*)

Immediately turn down the patient's arms and press them gently and firmly for two seconds against the sides of the chest (*see* Engraving II, Expiration); or upon the arms being lowered and replaced by the side, moderate pressure may be made by both hands of the operator upon the lower part of the front of the chest. (*This action diminishes the capacity of the chest, by pressing down the ribs, and produces a forcible expiration.*)

Repeat these measures alternately, deliberately, and perseveringly, fifteen times in a minute, until a spontaneous effort to respire is perceived, immediately

* The Royal Humane Society has kindly allowed me the use of these wood cuts, illustrating the position of the body during the

II.—EXPIRATION.*



upon which cease "to imitate the movements of breathing" and proceed to INDUCE CIRCULATION AND WARMTH (*as below*).

In the apparently dead from chloroform or noxious vapours, *expiration* should be made to precede *inspiration.*

Should a warm bath be procurable, the body may be placed in it up to the neck, continuing "to imitate the movements of breathing." Raise the body in twenty seconds from the bath, and dash cold water against the chest and face, and occasionally pass ammonia under the nose.

RULE IV.

To Excite Inspiration.

During the employment of the above method excite the nostrils with snuff, smelling salts, or tickle the throat with a feather. Rub the chest and face warm, and dash cold and hot (temperature 120° Fahr.) water alternately on them.

employment of my method. They are from photographs taken under my own superintendence.

Treatment After Natural Breathing has been Restored.

Rule V.

To Induce Circulation and Warmth.

Commence rubbing the limbs upwards, over the dry clothing, with firm grasping pressure and energy, using handkerchiefs, flannels, etc. (*By this measure the blood is propelled along the veins towards the heart.*)

Promote the warmth of the body by the application of hot flannels, bottles, or bladders of hot water, heated bricks, etc., to the pit of the stomach, the armpits, between the thighs, and to the soles of the feet. Warm clothing may generally be obtained from by-standers.

On the restoration of life, a teaspoonful of warm water should be given, and then, if the power of swallowing have returned, small quantities of wine, warm brandy and water, or coffee, should be administered. The patient should be kept in bed, and a disposition to sleep encouraged.

I subjoin a report from the *Lancet*, of Dr. Christian's paper on "Restoration from suspended Animation," read before the Royal Medical and Chirurgical Society, with some comments by Dr. Sharpey, F.R.S.

ROYAL MEDICAL AND CHIRURGICAL SOCIETY,

Tuesday, January 22nd, 1861. Mr. Skey, F.R.S., *President, in the Chair. On the Restoration of Suspended Animation in Persons apparently Drowned.* By Dr. Christian.

As to the mode of performing artificial respiration, the method recommended by the Life-boat Institution is what Dr. Marshall Hall called his "Ready Method," while that now used by the Royal Humane Society is the method of Dr. Silvester. On Dr. Marshall Hall bringing his method under the notice of the Royal Humane Society, the Committee adopted means immediately to give it a fair trial. Copies of his instructions were sent to all their medical officers, numbering 120, and the boats of the society on the Serpentine had a platform made on each, on which to manipulate directly the body was taken from the water, and the boatmen were instructed and practised in the performance of the operation as he directs. *After giving the method a full trial in about fifteen cases, the very intelligent superintendent, the boatmen, and the author became so satisfied of its inefficiency to restore animation, and of the difficulty of properly carrying out the manipulations, that he felt himself justified*

in representing those facts to the Committee, and in adopting the plan recommended by Dr. Silvester, which he believed in every way to be superior, more manageable, less likely to injure the patient, will fill the chest with and expel air from it more fully, and will not force the contents of the stomach upwards, and in the way of respiration.

The following are the directions for treating the asphyxiated at the receiving house, Hyde Park :—

Wipe the mouth and nostrils directly the body is taken from the water.

Use Dr. Silvester's method; at the same time let the body be taken as quickly as possible to the receiving-house, and place it in the bath up to the neck.

Raise the body in twenty seconds from the water, and dash cold water against the chest.

Pass ammonia under the nose. *Use again Dr. Silvester's method,* and the inflating apparatus if it fail.

Remove the body from the bath and rub the surface with dry hot towels, perseveringly continuing the other treatment.

After many experiments, the author had come to the conclusion that inflation of the lungs by Dr. Silvester's method, or by the Society's apparatus, is the first remedy, and the shock of the warm bath the second; that after eight minutes' complete submersion, recovery is hopeless; and that when ten minutes elapse, after being taken from the water, without any effort at respiration, it is equally so.

On the subject of the warm bath, which has excited so much discussion as a remedy, he remarked that it must be understood that it is used as an immediate and powerful excitant; and it had so frequently happened, (twice while he was actually present) that a person brought in as asphyxiated, who, to the bystanders, was apparently quite dead, immediately on being placed in the bath, gave the sob or gasp, which is the precursor of respiration, that it might be boldly stated to be a most valuable adjunct to treatment, and properly managed in no way pernicious.

Dr. Sharpey having had the honour of presenting the paper to the Society, could not let it pass without remark . . . . . He would observe, with reference to the method of Dr. Marshall Hall, that he had on one occasion spoken favourably of it, but had seen reason to alter his opinion after more mature consideration of the subject, and after hearing the practical experience of the Royal Humane Society. Dr. Sharpey considered that Dr. Marshall Hall's method could only claim one advantage, and it was not clear that it had even that. This supposed advantage is that the tongue falls forward, and thus does not embarrass respiration. *He thought that Dr. Silvester's method attained this object without any of the disadvantages of the Ready Method.*

The disadvantages of the Ready Method were several.

It must be remembered that a body submerged for some time is practically a dead body, and serious mischief has not unfrequently arisen from rough handling. Again, the constant

turning of the body renders it very difficult to apply warmth, or carry out the other auxiliary means systematically; but, above all, it does not even fulfil its first object of changing the air in the chest.

Dr. Marshall Hall cited experiments in support of his view; but the want of precision in making them is very striking. He (Dr. Sharpey) could not attach any importance to the results of experiments so conducted. Dr. Silvester had repeated them in a more precise way, and could not get a displacement of more than one cubic inch of air.

It would be asked, however, what answer should be made to the many statements of the success of the Ready Method. He would reply, that many of them were in cases of still-born infants, a part of whom, he believed, would recover without any assistance if left alone to themselves, or, at least, by very simple means. Then again, as Dr. Silvester states, there is no air in the lungs of infants. In reference to adults, he (Dr. Sharpey) believed himself right in saying that in many of the cases of recovery after submersion, respiration commenced spontaneously as soon as the patient reached the air. If in such cases Dr. Marshall Hall's method is began at once, it would be unfair to give the credit solely to it. May it not even be, as suggested by Sir B. Brodie, that recovery often follows, not from the means used, but in spite of them?

SIR B. BRODIE, BART., F.R.S.,

On the Marshall Hall and Silvester Methods.

The restoration of persons apparently drowned has been attracting so much attention since Dr. Christian's able paper was read before the Medico-Chirurgical Society, that the two following letters from Sir Benjamin Brodie will be read with interest:—

14, Saville Row, February 13, 1860.

Dear Sir,—I cannot say that I have ever entertained any favourable opinion of what the late Dr. Marshall Hall called his "Ready Method of restoring animation." It seems more than probable that the repeated compression of the chest, for the purpose of expelling all the air from the lungs, would have an injurious effect on the action of the heart. The air drawn into the lungs by the elasticity of the parietes, or walls of the chest, would fall very short of that inhaled in an ordinary inspiration, and this opinion is confirmed by the experiment of Dr. Silvester.

Then the mechanical disturbance, occasioned by the continual rolling and tumbling about of the body, cannot, I apprehend, be otherwise than mischevious where the chances of life and death are equally balanced, and must, in all cases, interfere with the natural process of recovery.

By the method proposed by Dr. Silvester, certainly more air would be drawn into the lungs than by that of Dr. Marshall Hall, and with much less disturbance to the body generally. In some animals, as the rabbit, a very sufficient quantity of air can be drawn into the lungs by a similar method, that is, by the mere

elevation of the ribs. How far in the human subject Dr. Silvester's process would be a sufficient substitute for natural respiration, I do not venture to say; it is a question to be decided only by experiment.

Where the apparatus of the Royal Humane Society for the artificial inflation of the lungs is at hand, I have no doubt that this affords the surest and safest means for imitating natural respiration if the necessary precautions are observed in using it. At the same time, I have no doubt that the late intelligent medical assistant of the Royal Humane Society at Brompton, Dr. Woolley, was correct when he informed me that practically the cases of drowned persons, in which artificial respiration can be employed with advantage, are very few indeed. The first thing to be done is to take the body out of the water as soon as possible, it being always borne in mind that the case is one which admits of no delay, as except under some very rare and peculiar circumstances, there is little chance of life being restored where the period of complete submersion exceeds three minutes and a half. The next thing is to do nothing that can interfere with the natural process of recovery. It is only in those cases in which there is no sign of any effort to breath spontaneously that artificial respiration should be had recourse to, and it is only in a small proportion of these that it proves successful. If you or any one else should be desirous of knowing what more I have to say on the subject of the treatment of those who suffer from strangulation or drowning, I would refer you to what I have published in my volume of "Lectures illustrative of certain points in Pathology and Surgery."

I am, dear Sir, yours very truly,

B. C. Brodie.

Lambton J. H. Young, Esq.,
Secretary to the Royal Humane Society.

Victoria Hotel, St. Leonard's-on-Sea, October 11, 1860.

Dear Sir,—I observe that the first instruction of the Royal Humane Society with regard to the treatment of drowned persons is "that no time should be lost." I conclude, therefore, that these instructions agree with those of the Life Boat Institution; that there should be no delay in carrying out whatever measures are necessary for the purpose of resuscitation. I also conclude, that it never could have been intended that the drowned person should be taken to a house if the house were not close at hand. The only real difference of opinion then seems to be as to the use of the warm bath and the method to be adopted, with a view to restore respiration. Now, with regard to the first of these points, what is really wanted is that the body should not lose its natural heat, and whether this be accomplished by dry application, or by moist application, as the moisture cannot penetrate beyond the cuticle, would appear to be of small importance; and I own that the practical observations on the use of the warm bath, made by the officers of the Royal Humane Society, seem to me to be more likely to lead us to the truth, than the theore-

tical objections to it made by Dr. Marshall Hall. At the same time, I certainly think it important that the temperature of the bath should be rather below—certainly not above the natural temperature of the living body.

With regard to the second point, I do not know that I need do more than refer to what I have said on the subject of Dr. Marshall Hall's proposal. In a letter which I wrote you on the subject formerly, and which is printed in one of the Royal Humane Society's reports,* I may, however, take the oportunity of briefly stating:—

1st. That the interval, during which artificial respiration can be employed is very limited.

2ndly. That if the Royal Humane Society's apparatus be at hand, and the medical man present knows how to use it, this affords by far the safest and surest method of imitating natural respiration.

3rdly. That there is great danger, that the rolling and tumbling about of the body, as proposed by Dr. Marshall Hall, would interfere with the natural process of recovery; at the same time, that it is very doubtful, whether by this method a sufficient quantity of air could be drawn into the lungs to answer any useful purpose.

4thly. *That, at any rate, of the two methods that of Dr. Silvester would be much more effectual, and much less calculated to do injury.*

In the treatment of drowned persons, as in the treatment of disease, the first rule of the medical art is to do nothing that may interfere with the natural process of recovery. When a drowned person is first taken out of the water, if the heart have not actually ceased acting, there is generally a spontaneous effort to respire; that effort may not be repeated perhaps more than twice in a minute, or even not so often in the first instance. But if the attempt to respire has once began, it will, in the majority of instances, continue, the intervals becoming gradually shorter; and I cannot doubt that rough usage, as that which Dr. Marshall Hall recommended, would interfere with it, although it is not very improbable that every now and then some one may recover in spite of it. With regard to the authorities referred to in favour of the practice of rolling about the body, I may observe:—

1st. That I do not know who are the medical bodies referred to as having approved of Dr. Marshall Hall's method. I certainly never heard of the question having been submitted to any of the medical colleges or universities.

2ndly. That I attach little importance to the names of three hundred medical men, who are said to have signed a memorial on the subject, knowing, as I do, how easy it is to procure a great number of signatures to any document, when you have two or three names to begin with; and knowing also that the question as to the mode of death from drowning, is altogether a physiological one, to which the attention of very few medical men

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* Letter printed above.

has been directed, with the exception of those who are actually engaged in teaching physiology.

I send you these observations in compliance with your request; my conclusions have not been hastily formed. The mode of death from drowning, and the treatment afterwards required, formerly occupied a great deal of my attention, and was the subject of a great number of experiments on animals; but I have not trusted to these alone, having had frequent conversations on the subject with a very experienced and intelligent officer of the Royal Humane Society, the late Dr. Woolley, and since then with Dr. Christian.

Yours truly,

L. J. W. Young, Esq., Secretary.

B. C. Brodie.

ROYAL MEDICAL AND CHIRURGICAL SOCIETY,

Tuesday, July 1st, 1862. Dr. Babington, *President, in the Chair. Report of the Committee appointed to investigate the subject of Suspended Animation.**

The inquiry was conducted—

By means of experiments upon living animals;

By means of experiments upon the dead human body.

In investigating anew the subject of apnœa by means of experiments on the lower animals, it seemed expedient to observe, in the first place, the principal phenomena of apnœa in its least complicated form—namely, when produced by simply depriving the animal of air.

The principal facts to which attention was directed during the progress of the apnœa thus induced were—

The duration of the respiratory movements;

The duration of the heart's action.

The duration of the heart's action was observed—

(*a*) In relation to the duration of the respiratory movements.

(*b*) In relation to the time after the stoppage of the breathing.

From the experiments performed it appeared that in the dog the average duration of the respiratory movements after the animal has been deprived of air is 4 min. 5 sec., the extremes being 3 min. 30 sec. and 4 min. 40 sec. The average duration of the heart's action is 7 min. 11 sec., the extremes being 6 min. 40 sec. and 7 min. 45 sec.

From these experiments it appears that on an average the heart's action continues for 3 min. 15 sec. after the animal has ceased to make respiratory efforts, the extremes being 2 min. and 4 min. respectively.

Rabbits on an average ceased to make respiratory efforts in 3 min. 25 sec. Their hearts' action stopped in 7 min. 10 sec.; consequently the interval between the last respiratory effort and the cessation of the heart's action was 3 min. 45 sec.

The next question investigated was—the period after the

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* A portion of this Report is extracted from the "Lancet," the rest from the "Transactions of the Royal Medical and Chirurgical Society."

simple deprivation of air at which recovery is possible, under natural circumstances, without the aid of any artificial means of resuscitation.

The experiments performed led to the conclusion that a dog may be deprived of air during 3 min. 50 sec., and afterwards recover without the application of artificial means; that a dog is not likely to recover, if left to itself, after having been deprived of air during 4 min. 10 sec.

The force of the inspiratory efforts during apnœa was observed in the experiments to be so great that it was determined to measure them. They were found to be capable, in the dog, of raising a column of mercury four inches. It appeared, moreover, that their force increases up to a certain period.

In other experiments, plaster of Paris, and even mercury, were thus drawn upwards into the minute bronchial tubes.

It is easy to understand, therefore, how foreign bodies may be drawn into the lungs in cases of drowning, and the importance of this fact in the consideration of the pathology and treatment of apnœa.

The Committee next passed on to the subject of drowning.

The first question investigated was—For what period can an animal be submerged, and yet recover without the aid of artificial means?

It was found as the result of numerous experiments on dogs that, in striking contrast to the previous ones, 1½ minute's immersion in water suffices to destroy life.

Other experiments satisfactorily showed that the difference of time between simple apnœa and that by drowning is not due to submersion, or to depression of temperature, or to struggling, but that it is connected with the fact, that in the one case a free passage of air out of the lungs, and of water into them, is permitted; in the other, the exit of air and the entrance of water are prevented.

There can be no doubt, from other considerations put forward, that although both these circumstances are concerned in producing the difference observed, yet that it is mainly due to the entrance of water and the effects thereby produced.

The treatment of apnœa was next considered.

For conclusions respecting artificial respiration, the Committee refer to the second portion of the report.

Many other methods of resuscitation which have been recommended were employed, including actual cautery, venesection, cold splash, alternate application of hot and cold water, galvanism, puncture of the diaphragm.

Although some of the above means were occasionally of manifest advantage, no one was of such unequivocal efficacy in a sufficient number of cases as to warrant the Committee in specially recommending its adoption.

The experiments upon the dead subject were made with a view to determine the value of the various methods which have been employed for alternately compressing and expanding the cavity of the chest in such a manner as to imitate the natural movements of the thoracic walls in breathing. The following methods have been investigated:—

1. Pressure exerted by the hands on the anterior wall of the thorax, the body being in the prone posture. Such pressure has for its object, to expel a portion of the air contained in the chest: on relaxing the pressure, the chest expands and air enters.

2. The postural or so-called "ready" method, described by Dr. Marshall Hall, which consists essentially in "turning the body gently on the side and a little beyond, and then briskly on the face alternately;" and in making pressure along the back of the chest each time the body is brought into the prone position.

3. The method of Dr. Silvester, in which the action of the pectoral and other muscles passing from the shoulders to the parietes of the chest in deep inspiration is imitated. An inspiratory effort is produced by extending the arms upwards by the sides of the head; on restoring them to their original position by the side of the body, the expanded walls are allowed to resume their previous state, and expiration takes place,* the quantity of air expelled being in proportion to that which had been previously inspired.

It being necessary to measure the flow of air in and out of the respiratory cavity under conditions of pressure closely resembling those which exist in natural respiration, no means of measurement could be used, which, in its working, would offer any appreciable resistance to the passage of air. With this consideration in view, an instrument designed by Dr. Sanderson was employed.

A cylinder of glass, three inches in diameter, is suspended by its closed upper end in a suitable cylindrical receiver of larger dimensions, half filled with water, in the same manner as the cylinder of an ordinary spirometer. Instead, however, of being supported as in the spirometer by an arrangement of pulleys, the cylinder is connected by a chain with one end of a scale-beam which bears at its opposite end a counterpoise. The weight of the counterpoise is equal to the weight of the cylinder when its open mouth is plunged to a given depth in the water of the receiver, care being taken that the air included in the cylinder shall communicate freely with the atmosphere. The scale-beam is supported at its centre of gravity by a knife edge, resting on a steel surface, so as to secure perfect freedom of movement. With the same view, the end of the beam on which the cylinder rests is furnished with a knife edge, on which the bearing of the latter is supported; the other end is prolonged into a needle or pointer, the movements of which are indicated on a graduated brass scale or circle, and the whole is so adjusted as regards the quantity of water in the receiver, that the beam shall be horizontal, in which position its index points to 0 of the graduation. Air enters or escapes from the measuring cylinder by a U-shaped tube, one leg of which is in the axis of the re-

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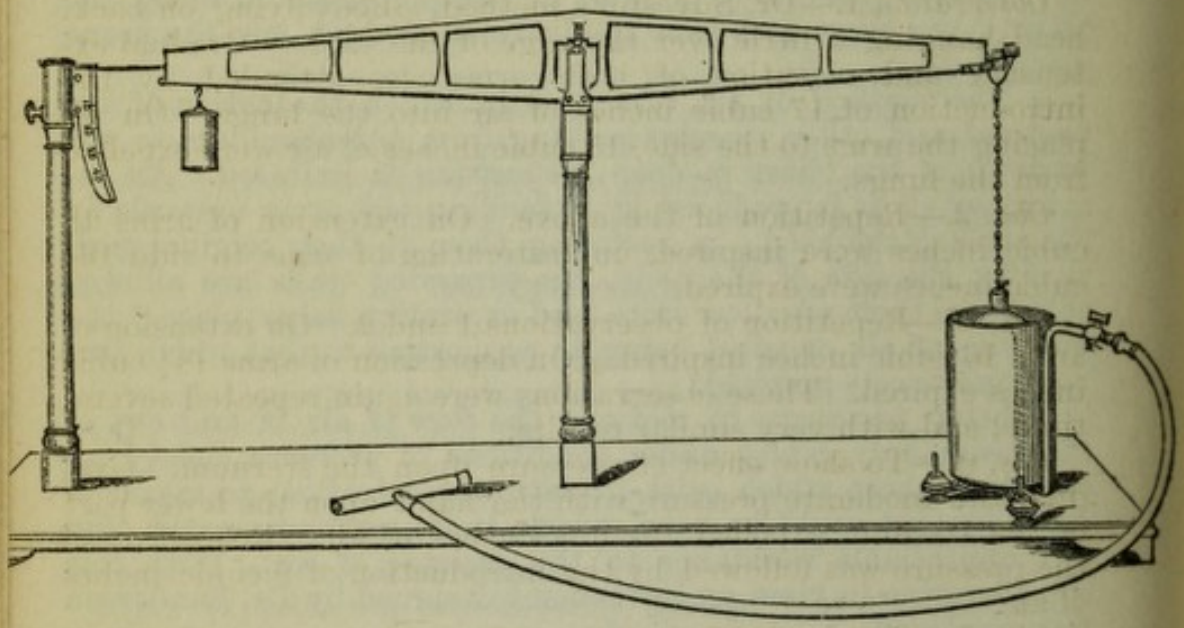
* *Vide* page 13.—Expiration is brought about by *compression* of the sides of the chest by the patient's arms.

ceiver, its open end rising above the level of the water; the other outside of the receiver is furnished with a stop-cock, and connected with the respiratory cavity when the apparatus is in action. To effect this connection, a T-shaped tube of gutta-percha is employed. The cross-bar, about seven-tenths of an inch in width, is adapted to the trachea by one of its ends; the stem of the T is connected with the stop-cock by a length of flexible tube.*



In such an instrument it is obvious that the quantity of air contained in the cylinder is indicated by the position of the beam, and consequently of the pointer. The graduation of the scale was effected by introducing measured quantities of air through the stop-cock, and marking off the successive positions of the needle, the apparatus having been first so adjusted as to stand at zero at the commencement of the operation. The numbers on the scale express in cubic inches the quantity of air in excess of the quantity at first contained. The measurement is subject to an error, arising from the fact that the weight of the cylinder varies inversely as the proportion of it which is immersed in water, but the amount of this error is so inconsiderable that it may be entirely disregarded. The receiver was furnished with a water manometer, or pressure gauge, by which the effects of these differences of weight were at all times shown; in no position of the apparatus did the depression of the column exceed four-tenths of an inch, so that the error could in no instance amount to more than 1000th part of the whole volume of air contained in the apparatus and in the thorax together.

In all the experiments, the measuring apparatus was directly connected with the trachea, the object in view being to determine the changes of capacity of the respiratory cavity under the most simple conditions possible.

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* *The Royal Medical and Chirurgical Society has kindly allowed me to make use of this illustration.*

Experiments on the dead body, to determine the best method of introducing air into the lungs.

February 24th, 1862.—At St. Bartholomew's Hospital.

Subject I.—A middle-aged, well-formed man, dead several days; commencing decomposition; chest natural in form, and normally resonant on percussion, except in the right lower lateral region, where it was dull.

Observation 1.—Dr. Silvester's method. Body lying on back, head hanging a little over the edge of the table. Gradual extension and elevation of both arms was attended by the introduction of 17 cubic inches of air into the lungs. On replacing the arms to the side, 15 cubic inches of air were expelled from the lungs.

Obs. 2.—Repetition of the above. On extension of arms 18 cubic inches were inspired, on restoration of arms to side 16½ cubic inches were expired.

Obs. 3.—Repetition of observations 1 and 2. On extension of arms 16 cubic inches inspired. On depression of arms 14½ cubic inches expired. These observations were again repeated several times, and with very similar results.

Obs. 4.—To show effect of pressure upon the sternum. Gradual and moderate pressure with the hand upon the lower part of the sternum expelled 15 cubic inches of air. Relaxation of the pressure was followed by the introduction of 9 cubic inches of air.

Obs. 5.—To show effect of Dr. Silvester's method combined with pressure on the sternum. On extension of the arms 17½ cubic inches of air were inspired. On depression of the arms 15 cubic inches of air were expired. On making pressure upon the middle of the sternum, 8 additional cubic inches were expelled, *i. e.*, 23 cubic inches altogether.

Obs. 6.—Repetition of Silvester's method and pressure. On extension of arms 17 cubic inches were inspired. On depression of arms 13 cubic inches were expired. On making pressure upon the lower part of the sternum 11 additional cubic inches were expelled, *i. e.*, 24 cubic inches altogether.

Obs. 7.—To show effect of pressure on lower part of sternum alone. This caused an expulsion of 10 cubic inches of air.

Obs. 8.—To show effect of pressure with the hands applied simultaneously to both sides of the chest. This caused an expulsion of 8 cubic inches of air.

In each of the above experiments to show the influence of pressure, a block was placed under the shoulders of the subject. The degree of pressure exerted was moderate, and not more than might be applied to the living body without injury.

Obs. 9.—Dr. Marshall Hall's method. At the commencement of the observation, the body was lying on the back. On turning it to the left side, 2½ cubic inches of air were inspired. On placing it on the abdomen, 7 cubic inches of air were expired. On restoring the body to the supine posture, very little interchange of air took place.

On repeating the other methods with this body, no uniform or definite results were now obtained; it was thought that some obstruction to the air-passages, from fluid or otherwise, had been caused by the postural change in the Marshall Hall method. No further observations, therefore, were made with this subject.

Subject II.—Same day and place. The body of an apparently healthy young man, who had been killed by concussion of the brain, caused by falling from a cab; dead about three days; no signs of commencing decomposition. No evidence of fractured ribs, or of any external injury. Good resonance on percussion over the front and sides of the thorax.

Obs. 10.—Marshall Hall method. Body lying supine at the commencement of the observation. When turned on to the side, there was no indication of an interchange of air, the index remaining motionless. When the body was turned to the prone posture, 7½ cubic inches of air were expelled. When the body was restored to the supine posture, 2 cubic inches were found to have been inspired during the movement from the face to the back. The observation was repeated, the body being rendered prone, and then restored to the supine posture, but no interchange of air at all was now indicated. The small amount of air moved in the first of these two observations, and the negative result of the last, led to a careful inspection of the apparatus, to see if it was in fault; but it was found to be in perfect working order, as the results of the succeeding observations will show.

Obs. 11.—To show effect of pressure on the lower part of the sternum. Moderate pressure expelled 10 cubic inches of air. Relaxation of the pressure was followed by the introduction of the same amount of air, namely, 10 cubic inches.

Obs. 12.—Pressure on the middle of the sternum expelled 8 cubic inches of air, and a like amount of 8 cubic inches was inspired on relaxing the pressure. The last two observations were repeated several times, and were uniformly attended with the same result, showing that 2 more cubic inches of air were interchanged during lower than during middle sternal pressure and relaxation.

Obs. 13.—To show effect of middle and lower sternal pressure combined. The result was the same as when lower sternal pressure alone was practised, namely, an expulsion of 10 cubic inches of air, followed by the inspiration of a like amount of 10 cubic inches on relaxing the pressure.

Obs. 14.—To show effect of lateral pressure with both hands. Pressure on both sides simultaneously applied, expelled 11 cubic inches of air; a corresponding amount of 11 cubic inches were inspired on removing the pressure. This pressure was made rather firmly.

Obs. 15.—Dr. Silvester's method. On elevating the arms 18 cubic inches of air were inspired. On replacing the arms to the side, 16 cubic inches were expired. On repeating this observation, 14 cubic inches were inspired; 11 expired.

Obs. 16.—To show effect again of sternal pressure and relaxa-

tion. This process was repeated several times in succession, and with the constant result of from 8 to 10 cubic inches of air being interchanged each time. In this observation, ordinary respiratory murmur was distinctly heard on applying the stethoscope to the chest during the interchange of the air.

Obs. 17.—Dr. Silvester's method. This was again repeated, and an average result obtained, that about 17 cubic inches of air entered and left the lungs each time.

Obs. 18.—To show effect of pressure by means of a broad bandage encircling the chest. This was practised several times, and showed, as an average result, that from 8 to 10 cubic inches of air were expelled by the pressure, and re-entered on relaxing the pressure.

March 19th, 1862.—At St. Mary's Hospital.

Subject III.—A middle-aged thin man, dead about three days, no decided signs of decomposition; rigor mortis strongly marked; chest tolerably resonant on percussion, except over lower half of right side, where it was dull.

Obs. 1.—Dr. Silvester's method. On gradually raising the arms, 24 cubic inches of air were inspired. On replacing the arms to the side, 23 cubic inches were expelled.

Obs. 2.—Repetition of the above. On raising the arms 26·6 cubic inches were inspired. On replacing the arms 27·8 cubic inches were expired.

Obs. 3.—Repetition of the above. On raising the arms 25·4 cubic inches were inspired. On replacing the arms 25·4 cubic inches were expired.

Obs. 4.—On laying a 5½ lb. weight upon the lower part of the sternum 0·35 of a cubic inch of air was expelled.

Obs. 5.—The last observation was repeated several times, with the view of determining how much air could be expelled by that amount of sternal pressure; the average result was 0·25 of a cubic inch.

Obs. 6.—On making moderate pressure with the hands over the lower part of the sternum 12·1 cubic inches were expelled. On relaxing the pressure, 8·4 cubic inches were inspired.

Obs. 7.—On repeating the last observation 11 cubic inches were expelled by the pressure, 9·7 cubic inches inspired on withdrawing it.

Obs. 8.—Another repetition of the same. 11 cubic inches were expelled by the pressure; 11 cubic inches were inspired on relaxing it.

These observations, showing the influence of moderate hand pressure upon the lower part of the sternum, were repeated several times, and gave the same general result, namely, that from 10 to 12 cubic inches of air were interchanged by the alternate pressure and relaxation.

Obs. 9.—Dr. Silvester's method repeated. On extension of the arms 29 cubic inches of air were inspired. On replacement of the arms to the sides, 26·6 cubic inches were expelled.

Obs. 10.—Repetition of last observation; results the same.

Obs. 11.—Another repetition. Extension of arms caused 29 cubic inches to be inspired. Replacement of arms caused a corresponding amount of 29 cubic inches to be expired.

Obs. 12.—Results not reliable.

Obs. 13.—To show the effect of Dr. Silvester's method when combined with pressure on the sternum. On raising the arms, 29 cubic inches of air were inspired. On replacing them, 29 cubic inches were expired. On adding sternal pressure, 12 more cubic inches were expelled, giving a total of 41 cubic inches interchanged.

Obs. 14.—To determine the quantity of air which could be introduced into the lungs by elevation of the lower ribs, so as to imitate the action of the diaphragm. On raising the lower ribs on the two sides simultaneously, by means of the hands, and then allowing them to subside, it was found that about 5 cubic inches of air were thus interchanged.

Obs. 15.—Repetition of the last observation: results the same.

Obs. 16.—To determine the quantity of air interchanged by alternate compression and relaxation of the sides of the chest. On pressing both sides simultaneously, with the hands, and then relaxing the pressure, it was found that about 5·3 cubic inches of air were interchanged. On applying stronger pressure, 7·3 cubic inches were interchanged.

Obs. 17.—Dr. Silvester's method was again tried, and with results similar to those last recorded.

Obs. 18.—A failure. *Obs.* 19.—A failure.

Obs. 20.—Dr. Marshall Hall's method. When the body was turned from the supine posture to one side, 7·2 cubic inches of air were inspired. On turning the body on the face, 7·2 cubic inches were expelled. On making pressure over the back, 8·5 additional cubic inches were expelled, giving a total of 15·7 cubic inches of air expelled by this method.

Obs. 21.—The last observation was repeated, but the amount of air now interchanged was very much less, being scarcely 2 cubic inches during simple rotation. Pressure on the back, however, when the body was prone, expelled between 7 and 8 cubic inches more.

Obs. 22.—Another repetition of the same method: results the same as in Obs. 21.

Obs. 23.—Dr. Silvester's method again tried. On raising the arms, 44 cubic inches of air were inspired. On replacing the arms, 38·6 cubic inches were expired.

Obs. 24.—Repetition of the last observation. Results about the same, proving an interchange of nearly 40 cubic inches of air by this method.

Obs. 25.—Another repetition of this method. Extension of arms caused 38·6 cubic inches to be inspired. Replacement of arms was attended by the expulsion of a like amount of 38·6 cubic inches.

During the last few experiments the rigor mortis had been greatly overcome, and the upward movement of the arms could be practised much more readily than at first, and much as it would be during life or suspended animation.

March 20th, 1862.—At St. Mary's Hospital.

Subject IIIa.—The same body as in the last observation.

Obs. 1 and 2.—Dr. Silvester's method. Extension of arms introduced 41 cubic inches of air into the lungs. Replacement of

arms to side caused 41 cubic inches to be expelled. Pressure on the sternum expelled 10 additional cubic inches of air, giving a total expulsion of 51 cubic inches. On relaxing the sternal pressure, 7 cubic inches were inspired.

Obs. 3 and 4.—Repetition of last. On elevation of arms, 42 cubic inches of air introduced. On replacement, 42 cubic inches of air expired. On sternal pressure, 10 additional cubic inches expelled, giving a total of 52 cubic inches expelled. On relaxing the sternal pressure, 7 cubic inches were again inspired.

Obs. 5.—To show the influence of weight laid upon the sternum. A 7 lb. weight on the sternum expelled 1 cubic inch of air; a like amount re-entered the chest on removing the weight.

Obs. 6.—Weights to the amount of 14 lb. expelled 3 cubic inches. A like amount of air re-entered on removing the weights.

Obs. 7.—Weights to the amount of 20 lb. expelled 4 cubic inches. The amount which re-entered on removing the weights was not noted. In the last three observations the weights were placed upon a board lying in the axis of the body, so as to diffuse the pressure.

Obs. 8.—Twenty pounds in weights lying across the lower part of the sternum, expelled 6 cubic inches of air; 5 cubic inches re-entered the chest on removing the weights.

Obs. 9.—Repetition of Observation 8: results the same.

Obs. 10.—Weights to the amount of 20 lb. laid across the upper part of the sternum expelled 5 cubic inches of air; 4 cubic inches re-entered on removing the weights. No increase in the amount of air expelled took place on moving the weights lower down the sternum.

Obs. 11.—Pressure with the hands on the lower part of the sternum expelled 6 inches; 4 cubic inches re-entered on withdrawing the pressure.

Obs. 12.—On applying the stethoscope to the thorax, while Silvester's method of imitating respiration was being employed, a distinct and continued subcrepitant râle was heard during inspiration, and also, though less in duration and strength, in expiration. The surface of the thorax was not œdematous, as proved by division of the skin. The results were the same when the stethoscope was applied over the denuded muscles of the thorax as over the skin.

March 24th, 1862.—At St. Bartholomew's Hospital.

Subject IV.—A middle-aged, emaciated man, died of phthisis and destitution; dead about three days. Rigor mortis moderate. Apex of right lung rather dull on percussion.

Obs. 1.—To determine amount of air introduced into lungs without opening the trachea. The nose and mouth were covered with the mouth-piece of an inhaling apparatus and made quite air-tight, except where communicating with the tube of the instrument employed for the purpose of the observation. The body was placed supine; the head hanging back over the edge of the table. On applying the Silvester method of inspiration no air was drawn into the chest.

Obs. 2.—Repetition of the above, with the exception that the

head was placed level on the table: the same negative result was observed.

Obs. 3.—Another repetition: the head now turned to one side; result the same.

Obs. 4.—Another repetition: body placed on abdomen, forehead resting on arm: the same negative result.

Obs. 5.—Position the same as in Observation 4; pressure now made on the back expelled one cubic inch of air, which re-entered the chest on relaxing the pressure.

These observations showed that there was some obstruction interfering with the entrance of air into the chest. The mouth was rather firmly clenched, and was with difficulty forced a little open, yet the nostrils were probably free; it was thought, therefore, that most likely the obstruction was situated about the glottis, and occasioned by the tongue.

Obs. 6.—The trachea was now opened and a tube introduced and secured, as in all the previous observations. Silvester method. Only about 1½ cubic inches of air could be interchanged. Probably some obstruction in the lungs or air-passages.

Obs. 7.—Marshall Hall method. Only about 1½ cubic inches of air could be interchanged by this, as by the last method.

Further experiments with the body were, accordingly, not tried.

March 24th, 1862.—At St. Bartholomew's Hospital.

Subject V.—A middle-aged woman; died of epilepsy.

Obs. 8.*—Marshall Hall method. On turning the body to the side from the supine posture, 5 cubic inches of air were inspired; on placing the body prone, with forehead resting on hand, only 2 cubic inches were expelled.

(There is a note to this observation that it is not a satisfactory one.)

Obs. 9.—The plan of rotation, according to Dr. Marshall Hall's directions, was now practised several times, with the same general result, namely, that about 5 cubic inches of air were interchanged by the rotating process; and that 5 additional cubic inches were expelled by pressure on the back while the body lay on the abdomen.

Obs. 10.—Dr. Silvester's method. On elevation of arms, 9 cubic inches of air inspired; on depression of arms, 6 cubic inches of air expired.

Obs. 11.—The last observation was repeated several times, and with the average result, that 5 or 6 cubic inches of air were interchanged.

No pressure on the sternum was practised in these observations; they were limited to the effects of simple elevation and depression of the arms.

Obs. 12.—Pressure on the sternum with the hands, expelled 8 cubic inches of air.

Obs. 13.—Marshall Hall method repeated. Only 2 cubic inches could now be interchanged.

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* Numbered in continuation of last series, the experiments being conducted on the same day.

Obs. 14.—The same repeated with both arms folded under the chest; this arrangement caused an additional expulsion of 4 or 5 cubic inches.

Obs. 15.—Attempts at inflation of the lungs by a pair of bellows succeeded in forcing in only 2 cubic inches of air.

The experiments with this body were discontinued.

May 31st, 1862.—At the Marylebone Workhouse.

Subject VI.—An old man; dead about twenty-four hours; emaciated; died from old age and bronchitis. (The lungs were examined after the experiments, and found largely infiltrated with bloody serum, and the smaller bronchi plugged with ropy mucus.)

Obs. 1.—To determine influence of tongue in impeding entrance of air into the lungs.

A.—When the tongue was drawn forward out of the mouth, and held there by a ligature, air could be readily blown down the trachea and œsophagus, visibly distending the thoracic and abdominal cavities.

A a.—Pressure on the larynx interrupted the passage of air along the œsophagus.

B.—When the tongue was pressed tightly back into the pharynx entrance of air was prevented, both into the larynx and œsophagus.

C.—The tongue left loose in the mouth and allowed to fall back by its own weight, permitted the entrance of air into both canals, though less freely than in *A*.

D.—When the head hung back over the table, air seemed to pass more freely than when it was simply resting on the table.

Obs. 2.—The trachea was now opened and a tube introduced; air was blown into the lungs and allowed to escape again, and the process was repeated several times in imitation of ordinary respiratory movements. The pressure required to introduce about the amount of air usually respired was equal to that of a column of mercury about one-tenth of an inch in height.

Obs. 3.—Dr. Silvester's method. Head of subject hanging back over the edge of the table. Only from 4 to 6 cubic inches of air were interchanged by this method.

Obs. 4.—The method repeated. The head was resting on the table; results the same.

Obs. 5.—The method repeated. The head in the same position as in the last observation, a block placed under the shoulders; about one cubic inch more was interchanged.

Obs. 6.—The addition of sternal pressure at the end of the last observation expelled scarcely any more air.

Obs. 7.—Silvester's method again repeated; 6 cubic inches of air were now interchanged. The addition of sternal pressure at the end of the observation expelled about 5 cubic inches more. The small amount of air interchanged in these observations led to the supposition of there being some obstruction either in the air passages or lung structure, or both. Abundant mixed crepitations were detected in the lungs during the forced respiratory movements, and gave support to this view; and examination after the experiments were ended confirmed it. Nevertheless the observations were continued a little longer.

Obs. 8.—Marshall Hall method. On turning the body from the supine to the lateral posture, 1½ cubic inches of air were inspired; replaced on the back no air was expelled. When the body was turned on to the stomach, about 4 cubic inches of air were expelled. Pressure on the back expelled 1 cubic inch more.

Obs. 9.—The last observation repeated; amount of air now interchanged was much less.

Obs. 10.—The Silvester method repeated; scarcely any result, only 1 or 2 cubic inches of air interchanged.

Obs. 11.—The bronchial tubes were now cleared of much tenacious, ropy mucus, by repeatedly sponging them out with a probang. The Silvester method was then again repeated, but with the same negative result as in Observation 10. The experiments with this body were accordingly discontinued.

April 17th, 1862.—At St. Bartholomew's Hospital.

Subject VII,—A youth, æt. 17, dead five days from typhus fever. There was hypostatic discoloration of the lower parts of the body; the thighs were thickly scattered with petechial spots, the body was deformed from lateral curvature of the spine.

Obs. 1.—On raising the arms according to Dr. Silvester's method, 18·5, 19·5, and 19·5 cubic inches of air were inspired in three successive movements.

Obs. 2.—On making compression on the sternum, 14·5 cubic inches of air were expelled, but on relaxing pressure only 11 cubic inches entered the trachea.

Obs. 3.—On repeating the last observation, 12 cubic inches of air were expelled by compression of the sternum, and 11 cubic inches re-entered the chest on relaxing the pressure.

Obs. 4.—Repetition of the last observation; 13 cubic inches of air were expelled by compression of the sternum; 12 cubic inches re-entered on relaxing the pressure. The experiment was repeated several times, with exactly the same results.

Obs. 5.—On raising the arms, according to Dr. Silvester's method, 15 cubic inches of air were inspired. On replacing the arms to the sides 10 cubic inches were expired. This observation was repeated several times, with the same result.

Obs. 5 *a.*—Pressure applied to the sternum after the last Silvester observation expelled 17 cubic inches of air. On withdrawing the pressure, however, only 11·5 cubic inches of air were inspired.

Obs. 6.—The arms were again raised, according to the Silvester method, and compression applied immediately after they had been brought to the side, with precisely the same results; and this process was repeated several times.

Obs. 7.—The body was placed in the prone posture, with the right arm under the forehead, and the position of the needle noted. The body was then turned over so as to rest on the back; the position of the needle was unaltered. On placing the body on the side, 2·5 cubic inches of air entered the chest. On placing the body in the supine posture, the same quantity of air escaped.

Obs. 8.—On placing the body on the left side and a little over, 8 cubic inches of air were inspired. On repeating the prone posture, 5 cubic inches were expelled.

Obs. 9.—The method of Dr. Silvester was then repeated; 11·5 cubic inches of air were inspired on raising the arms; 11·5 cubic inches expelled on replacing the arms; 16 additional cubic inches were expelled on compressing the sternum, yielding a total of 27·5 cubic inches of air expelled from the chest.

General results.

1. As regards the volume of air which can be expelled from the thorax by compression of its walls, and inspired by the elastic expansion consequent on relaxation of the pressure, it was found—

(*a*) That pressure by both hands on the lower third of the sternum in the adult male subject usually displaced from 8 to 10 inches of air.

The pressure actually exerted amounted to about 30 lbs. It was, therefore, not greater than might be safely applied to the living subject. The volume of air expelled varied from 8 cubic inches to 15 cubic inches.

(*b*) That pressure made in the same manner on the upper part of the sternum usually displaced 2 or 3 cubic inches less than pressure on the lower part.

(*c*) That pressure exerted by one hand on the upper part, by the other on the lower part of the sternum, produced about the same results as were observed in *a*.

In this case the whole amount of pressure did not exceed that exerted in *a*.

(*d*) That the pressure of a weight laid on the lower third of the sternum produced similar results according to its amount.

(*e*) The lateral pressure exerted on the ribs or costal cartilages of both sides simultaneously was in no instance more effectual.

(*f*) That compression by a broad bandage encircling the chest, the ends of which were crossed over the sternum, and drawn in opposite directions by two persons, produced no greater effect than pressure with the hands on the sternum or sides.

II.—The method recommended by the late Dr. Marshall Hall for imitating respiration was applied to each of the subjects experimented upon, in accordance with his published instructions. Sometimes this plan was tried first, before any other method was employed, sometimes afterwards. It was usually repeated several times on the same subject, and during the same series of experiments.

As regards that part of the method which consists in turning the body alternately "very gently on the side and a little beyond, and then briskly on the face," it was found that the volume of air exchanged was variable in the same subject, but always inconsiderable. It usually happened that a quantity of air, varying from 1 to 8 cubic inches, never more, generally much less than 8, was inspired when the body was turned from the supine posture to one side. When the body was placed on the abdomen with the head resting on the forearm, a somewhat larger quantity was expelled, never exceeding 10 cubic inches. On restoring the body to the lateral posture, the amount of air

inspired was usually less than that which had been expelled by pronation. But the quantity expelled and inspired in each movement was scarcely ever precisely equal.

The volume of air expelled when the body was placed on the face was much increased if pressure was at the same time made on the spine, the amount of this increase varying according to the degree of the pressure, and in those experiments in which such pressure was made, it was found that the quantity of air which was inspired on rotation of the body to the side, was much less than that which had been expelled by pressure.

As regards the whole amount of exchange of air produced by the method of Dr. Marshall Hall, "to imitate respiration" it varied much according as the subject was favourable, or the contrary, sometimes not exceeding a few cubic inches, but never exceeding 15 cubic inches.

III.—As regards the method above described as that of Dr. Silvester, it was found that, on extending the arms upwards, a volume of air was inspired into the chest which varied, in different subjects, from 9 to 44 cubic inches; and it was observed that the results obtained in successive experiments on the same body were remarkably uniform, in which respect, as well as in their quantity or amount, they contrasted with those obtained by the method of Dr. Marshall Hall. On restoring the arms to the side, as directed by Dr. Silvester, the quantity of air expelled was generally nearly equal to that previously inspired, occasionally less.

Dr. Silvester recommends that on bringing down the patient's arms they should be gently and firmly pressed against the sides of the chest, so as to diminish the cavity of the thorax.* It was found that this pressure could be exercised with greater facility, and equal effect, by placing the hands on the lower third of the sternum, as already above described. By alternating the movements of the arms with pressure of this kind, a regular exchange of air was produced, the quantity of which, in several instances, exceeded 30 cubic inches, and in one instance amounted to 50 cubic inches. In those cases in which a less respiratory effect was produced, the deficiency was always distinctly attributable to unfavourable conditions, particularly the existence of obstructions in the respiratory passages.

Without expressing an opinion as to the efficacy of the method of Dr. Silvester as a means of restoring suspended animation in cases of drowning, its claims to be considered as an effectual means of producing an exchange of air similar to that effected by the respiratory movements, appear to us to be satisfactorily established. As has already been pointed out by Dr. Silvester, the condition of the thorax after the cessation of breathing being that of expiration, it is desirable that the first step in the restoration of breathing should be a movement of expansion; in this respect the method he has proposed enjoys a marked superiority over that of Dr. Marshall Hall, which has for its object to force air from a chest which has already discharged its

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* *Vide "The Physiological Method of Treating Incipient Consumption," by the author, for further investigations on this subject.*

natural quantity. It also appears to be an important advantage in this method, that, in each movement of expansion, both sides of the chest are left free from compression, and therefore free to move, while the postural method of Dr. Marshall Hall leaves only one side free to expand. As regards facility, and readiness of application, there is also no donbt that the method recommended by Dr. Silvester is at least equally if not more effective than the Marshall Hall plan.

In the course of the experiments on the dead body certain facts and observations were recorded not immediately bearing on the main subjects of inquiry. The principal of these are stated in the following paragraphs:

Inflation.—A few experiments were performed relating to the efficiency of the inflation of the lungs through the mouth of the subject, which led to the conclusion that with proper precautions, such inflation is perfectly practicable. The following were among the results noticed:

1. As regards the position of the tongue and its influence in impeding the entrance of air, it was found that in the dead body this organ is apt to offer great obstruction to inspiration by falling back into the pharnyx, and closing the laryngeal aperture. No air could be forced through the mouth in a body lying on the back so long as the tongue remained undisturbed, but when it was drawn forward and held out of the mouth by a ligature, or by the pressure of the teeth upon it, air could be injected by the œsophagus and larynx, so as to distend both the abdominal and thoracic cavities. On leaving the tongue loose in the mouth, and allowing it to fall back by its own weight, air could also be introduced, but much less freely than when it was drawn forwards. Complete obstruction to the passage of air was produced by pressing the tongue back into the pharynx, no air entering either the larynx or œsophagus.

When the head of the subject was allowed to hang back over the edge of the table, air seemed to pass into the chest more readily than when the back of the head rested upon the table.

2. It was found that the whole quantity of air introduced by inflation could be compelled to enter the respiratory cavity by pressing back the larynx against the spinal column. By this expedient the passage of air down the œsophagus was at once intercepted, while its transit down the trachea continued to take place as freely as before, so that it affords a ready means of preventing the passage of air into the stomach during artificial respiration.

3. During inflation of the lungs a sound, closely resembling that of the ordinary vesicular murmur, is plainly heard, proving that air enters not merely the larger air passages but the vesicular structure of the lungs. Marked expiratory murmur was also heard during the recoil of the lungs and thoracic parietes after inflation. In cases where the bronchial tubes were obstructed by secretion, the various kinds of crepitation could be distinguished.

In the treatment of apnœa generally, the Committee venture to offer the following suggestions:

That all obstruction to the passage of air to and from the lungs be at once, so far as practicable, removed; that the mouth and nostrils, for example, be cleansed from all foreign matter or adhering mucus.

That, in the absence of natural respiration, artificial respiration, by Dr. Silvester's plan, be forthwith employed in the following manner:—The body being laid on its back (either on a flat surface, or better, on a plane inclined a little from the feet upwards), a firm cushion, or some similar support, should be placed under the shoulders, the head being kept on a line with the trunk. The tongue should be drawn forward so as to project a little from the side of the mouth; then the arms should be drawn upwards until they nearly meet above the head, the operator grasping them just above the elbows, and then at once lowered, and replaced at the side. This should be immediately followed by moderate pressure, with both hands, upon the lower part of the sternum. This process is to be repeated about twelve or fourteen times in the minute.

That if no natural respiratory efforts supervene, a dash of hot water (120° Fahrenheit) or cold water be employed, for the purpose of exciting respiratory efforts.

That the temperature of the body be maintained by friction, warm blankets, the warm bath, etc.

In the case of drowning, in addition to the foregoing suggestions, the following plan may be, in the first instance, practised:—Place the body with the face downwards, and hanging a little over the edge of a table, shutter, or board, raised to an angle of about 30°, so that the head may be lower than the feet. Open the mouth and draw the tongue forward; keep the body in this position for a few seconds, or a little longer if fluid continues to escape. The escape of fluid may be assisted by pressing once or twice upon the back.

It will be seen that these investigations relate only to two forms of apnœa—that produced by the simplest means, apnœa in its least complicated form, and that produced by drowning. It was found to be utterly impracticable, in the time allotted, to extend our inquiries to other forms of apnœa. Indeed, even within these limits, the Committee have found it necessary to disregard many collateral questions of great interest, and to confine their attention to the chief features of the subject.

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