HARE. (H. A.) & MARTIN. (E. d.)

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THE VALUE OF THE ELECTRICAL METHODS EMPLOYED FOR THE RESUSCITATION OF PERSONS WHO HAVE CEASED BREATHING.

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THE VALUE OF THE ELECTRICAL METHODS EMPLOYED FOR THE RESUSCITATION OF PERSONS WHO HAVE CEASED BREATHING.[1]

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In patients under ether, the movement of the diaphragm is an exceedingly interesting study, for before the condition known as surgical anæsthesia is developed, while there is still some rigidity, and the throat reflex is not completely

[1] Part of an essay to which was awarded the Warren Triennial Prize of the Massachusetts General Hospital, June, 1889.

abolished, the contractions of the diaphragm are frequently so violent that unless the laryngeal opening be absolutely free, the intercostal spaces are depressed and the abdominal contents thrust violently downward and outward. Just so soon, however, as the chin is pulled forward and a free access of air is allowed, the abdominal displacement is not so great, though it still remains present, and the chest movement is no longer reversed. As the ether is pushed, the respirations become purely thoracic, the diaphragm no longer taking part in the respiratory cycle, or becoming so relaxed that it allows the chest on expansion to aspirate the abdominal viscera upwards, as is shown by the retraction of the belly walls at a time when they should normally expand with the thorax in inspiration. This observation would seem to point to the fact that the primary stimulant action of ether upon the respiratory apparatus is particularly felt by those centres which govern the movements of the diaphragm, and that, as this is the case, these centres later on are the first to feel the paralyzing effect of still larger amounts of the drug.

This gives us, therefore, yet another danger signal during the administration of the ether, and we hold that the integrity of the diaphragmatic function, as represented by the movements of the belly walls, should be as carefully observed as are the thoracic excursions, the character of the pulse, or the condition of the pupil. The rule may therefore be laid down that when the diaphragm ceases to act, anæsthesia has been carried to its extreme legitimate limit, and that the use of an anæsthetic after this time must be carried on with the greatest care and watchfulness.

We have made other observations which tend to confirm the belief that the diaphragm is the first to yield to respiratory paralysis. In death from any cause, the progress of failure of respiration will, in the vast majority of cases, be denoted by a failure on the part of the diaphragm primarily with compensatory excursions of the chest; and it is also to be noted that as the chest movements fail, the accessory muscles of the neck come into play. These muscles in time cease to act, the hyoidean group lose their *point d'appui*, the chest remains motionless, the lower jaw is dropped, and the scene is closed by a few gasps.

In our experiments made upon animals with coal gas[1] it was found that this order of muscular involvement was adhered to, and that as the animal returned from death's door, a reversal in the order of return functional activity was apparent, the neck muscles acting first, the chest muscles next, and the diaphragm last. Whenever this sequence is disturbed the changes are probably produced by some reflexes which escape attention, and which exert a stimulating effect, particularly upon the diaphragmatic apparatus. Thus, it has been shown that when the communicating fibres from the higher centres to the respiratory centre are cut, so as to set aside any cerebral influence, inspirations may be excited by peripheral stimulations, such as pinching the skin, douching with cold water, or the application of electricity, and that under these circumstances the diaphragm responds more readily than do the other respiratory muscles.

Not only have we found this to be true, but Marckwald has also made a

1 University Medical Magazine, September, 1889.

FIG. 1.

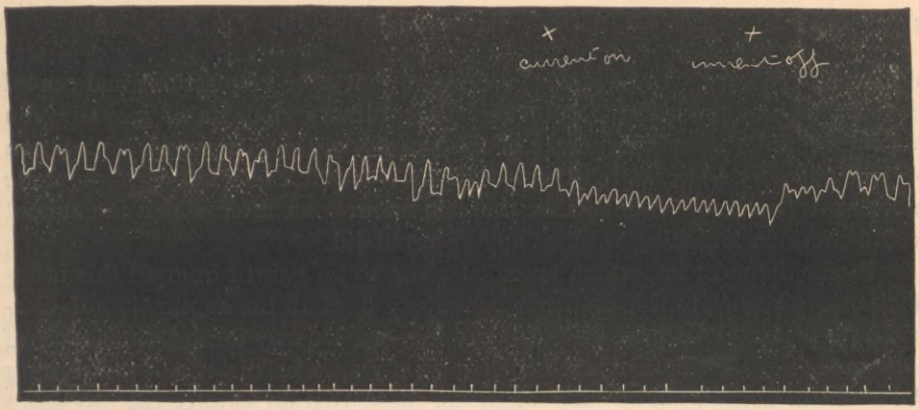


FIG. 2.

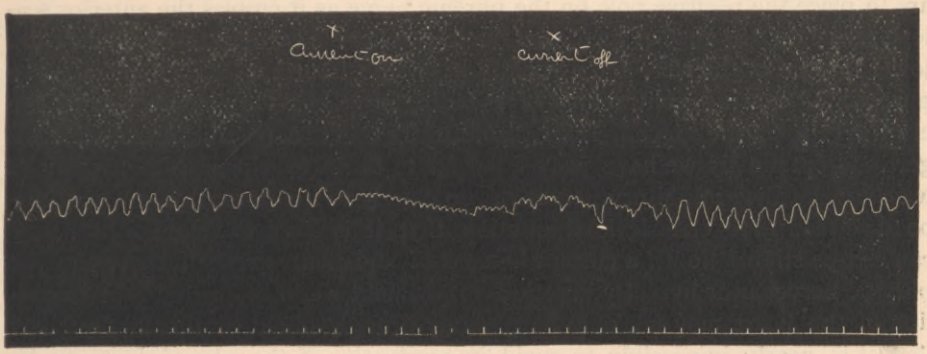


FIG. 3.

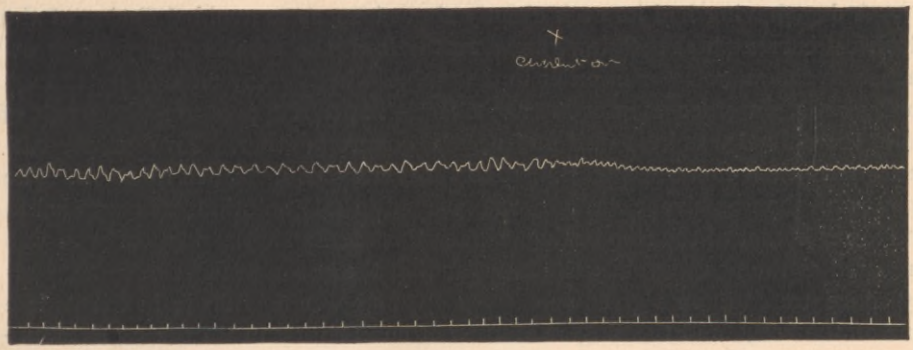
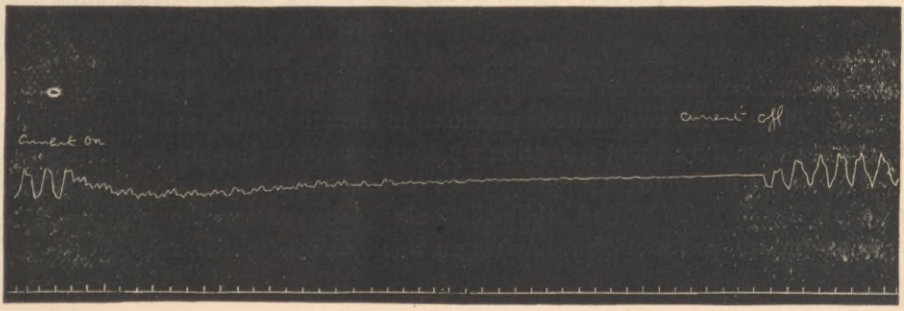


FIG. 4.



similar observation. In dogs we have found that after respirations had ceased from profound etherization, and where the ordinary methods of resuscitation were unavailing, a rapid exposure of the anterior crural nerve and stimulation of the same by a strong interrupted current would cause full diaphragmatic movements, soon supplemented by thoracic excursions, after which the animal would continue breathing without any external aid.

By far the most important practical point to be gained from all this information is in regard to the methods commonly used in the application of electricity to persons who have ceased breathing, particularly during the action of an anæsthetic. While few text books give any specific directions concerning the practical application of such methods, those that do so force the physician to a method at once dangerous and impractical, for the directions usually given are to place the positive pole on the phrenic nerve as it crosses the anterior scalene muscle at the root of the neck, the negative pole being pressed against the lower margin of the ribs, and a rapidly interrupted current being used with the purpose of causing contraction of the diaphragm by the direct action of the electricity upon the nerve. Even theoretically this is a possible source of danger, and practically we have proved danger to be an ever-present fact under its use. The cardiac inhibitory nerves run so closely to the phrenic fibres, and respond so readily to electrical stimulation, that it is hard to imagine how they can escape stimulation if a current be used of sufficient strength to excite the phrenic nerves near by. By practical experiment we have proved that inhibition of the heart may not only be possibly brought about by this method, but that it is nearly impossible to avoid its production if the phrenics are to be reached at all. (See tracings).

A dog, having had its neck cleanly shaved so as to avoid diffusion of the electrical current, was tied down and anæsthetized, the carotid artery being attached to the manometer in order to determine whether any circulatory change took place. In order to prevent any change in arterial pressure, the result of pain, the animal was kept well under the influence of ether. Two gravity batteries were then connected with a Dubois-Reymond coil, pushed up to 10. The sponge of the negative electrode, well soaked in salt solution, was applied to the lower border of the ribs in the axillary line, and a single point of wire was prepared as the positive electrode in order that the current might be more readily concentrated upon a given spot. An opening was now made in the middle line of the belly, and the fingers of the left hand thrust in till the vault of the diaphragm could be distinctly felt and its movement noted. On pressing the positive pole into the phrenic region at the root of the neck, forcible unilateral diaphragmatic contractions were excited, together with violent movements of the foreleg on that side, and it was found that to affect the diaphragm the electrode must be placed on exactly the right spot and pressed in the right direction. The violent contractions produced in the other muscles made it impossible to tell except by direct palpation whether or not the diaphragm was acting.

The action under these circumstances on the heart was most striking (see tracings), for it was found that the only place where the positive pole could be put to contract the diaphragm also *inhibited the heart.*

If a current, by no means as strong as that frequently used in cases of suspended animation, produces such a profound effect upon the heart of a moderately anæsthetized dog, its effect upon a heart already overburdened by congestion or depression would be most disastrous.

Against the reflex excitation of respiration there cannot be the same objection. The electric brush produces a more powerful effect upon the terminal extremities of the sensory nerves than any known method of stimulation. Far more powerful than the douche and than abdominal applications of ether, as recommended by Hare,[1] it should be used under all circumstances when death threatens from respiratory failure. It should not, however, be applied to the neck, but a sponge electrode being placed at the base of the ribs the brush should be applied at intervals to the epigastrium, to be removed when inspirations result, and reapplied when breathing movements cease. If artificial respiration is being carried on by Sylvester's or other of the recognized mechanical methods, the wire brush should be applied during the inspiratory movements.

It would seem probable that in those cases where the use of electricity has been resorted to, the return to life has been the result of reflex stimulation rather than a direct effect on the phrenic nerves. On the contrary, the striking effect upon the heart, shown by tracing No. 4, suggests the thought that the improper application of electricity may, in the past, have been an important factor in determining a fatal issue.