

EXPERIMENTS  
ON  
THE LARYNGEAL NERVES AND MUSCLES OF  
RESPIRATION, ETC., IN A CRIMINAL  
EXECUTED BY HANGING.

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IN January, 1875, Dr. S. Weir Mitchell called my attention to a paper by Dr. George Johnson, read before the Royal Medical and Chirurgical Society, Dec. 8, 1874 (*Med. Times and Gaz.*, Dec. 19, 1874, p. 700), "On the Laryngeal Symptoms which result from pressure of Aneurismal and other Tumors on the Vagus and Recurrent Nerves." In this paper Dr. Johnson quotes two cases of bilateral palsy of the larynx observed during life by the laryngoscope, in which the post-mortem showed that the vagus and recurrent nerves of one side only, and not on both sides, were compressed, and he expressed the belief that "pressure on one recurrent nerve, which is an efferent motor nerve, will cause direct unilateral palsy of the larynx, but cannot cause either bilateral spasm or bilateral palsy; pressure on the trunk of the vagus, involving its afferent fibres, may cause both bilateral spasm and bilateral palsy of the

larynx." The reason for this bilateral action he considered to be the intimate connection between the nerve nuclei of the two sides, so that, according to Broadbent's hypothesis, each nucleus possesses bilateral activity. Dr. D. Powell stated that he had obtained similar results in the dog, but called attention to the difference that existed in different animals, and that faradization of the recurrent in the cat produced abduction of the cords, and that Dr. J. Reid had produced bilateral spasm in the dog on galvanizing one recurrent only.

Some years ago Dr. Mitchell had discovered the remarkable chiasm in the recurrent laryngeal nerves in the *Chelonia*. He had sought it in the cat and rabbit, but had not found it. He had not, however, examined the dog, and these statements of Dr. Johnson, coupled with Dr. Mitchell's former discoveries, prompted the proposal that I should assist him in a few experiments to determine the facts in the dog, and the probabilities in man, of a chiasm of the minuter fibres of the recurrences, which, though not demonstrated anatomically, might yet be proved physiologically.

A few days later, by the courtesy of Dr. F. F. Maury, I was invited to be present at the execution of Frederick Heidenblut, and it occurred to me that here was an opportunity to test the question on man himself, instead of the dog. Accordingly it was arranged that Dr. Carl Seiler should make the laryngeal examinations, while I dissected the nerves and faradized them, according to directions drawn up by Dr. Mitchell. I was also assisted by Drs. Maury, Butcher (the prison physician), T. H. Andrews,

T. G. Morton, and Kirkbride, and Messrs. Garrett and Biddle, medical students.

Heidenblut was hanged at 10.45 A. M., January 20, 1875. After hanging half an hour, his body was cut down and carried into a small room near by, when I dissected the left vagus and recurrent laryngeal nerves as low down as possible in the neck (being very careful not to cut any branches, or injure them by the forceps, etc.), and slipped a small piece of pure india-rubber cloth under each, as an insulator. The body was then placed in a chair, and the attempt made to observe the vocal chords in the ordinary way, but the mechanical disturbance caused by the rope, and the tenacious mucus which had gathered in the larynx, made this impossible, so that I was compelled to open the larynx between the thyroid cartilage and the hyoid bone by a very small opening, just large enough for the mirror, when an excellent view of the chords was had by Dr. Seiler. Repeated faradization, both with weak and with strong currents, and galvanization with from four cells up to forty, of the recurrent and also of the vagus, produced decided movements of the left chord only, and none of the right. I applied the two wires directly to each nerve, so that no other part should be involved, as might be the case if sponges were used. By these means I simulated the irritating action of a tumor as nearly as possible, and I found on later careful dissection that none of the fibres of the vagus were probably injured, and the cerebral circuit broken. The knot in the rope had been tied under the left ear, the head was thrown to the right, and thus the main injury to the soft parts was on the

right side. The right sterno-mastoid muscle was cut completely in two, its two ends being held together only by the connective tissue of its sheath. The left was only bruised. The vagus was not, so far as I could perceive, mechanically injured on either side. The superior laryngeal nerve was not mechanically injured, nor cut by opening the larynx. The hyoid bone was broken on both sides at the junction of the body and greater cornua. The vertebræ were neither broken nor dislocated, a condition I have verified in two other cases of judicial hanging.

The definite conclusion to be drawn from the experiment is that no chiasm of the inferior laryngeal nerves exists. No reflex motion was observed in the larynx, but the mechanical violence in such a mode of death is so great, and yet its effects may so easily escape observation, that, I think, as yet, no rigorous conclusion can be stated until other similar experiments are made, in which this source of error is absent.

At 12.10 P. M., having finished with the larynx, I proceeded to experiment on the muscles of respiration, a subject I had long desired to investigate. I first dissected the left phrenic, and insulated it with rubber, as before. I tried both wires to the nerve, but neither with the eye nor with a tape measure encircling the chest at the ensiform cartilage (marking  $29\frac{1}{2}$  inches), was the slightest movement observed. I tried then a wire to the nerve, and with a sponge followed the border of the diaphragm, and then with both sponges to the diaphragm; but in no instance did I obtain the least response, either with the constant or the interrupted current. No reason could

be assigned for this failure to respond. Further dissection of the nerve showed everything normal and apparently uninjured.

I then proceeded to the intercostals. Probably no other muscles have been so variously interpreted as to their action, whether the inferences were drawn from theory as to how they must act mechanically, from direct dissection on the human body, from vivisections on the lower animals, from experiments on the dead body, or from faradization on the living. The most noteworthy modern observations are by Hutchinson (*Todd's Cyc. Anat. and Phys.* "Thorax"); Bean and Maissiat (*Archiv. Gén.*, 1842); Sibson (*Philos. Trans.*, 1846); Tranbe (*Beitrag. zur Exp. Path. u. Phys.*, 1846); Donders (*Handb. tot der Natuurk. van der Gezond. Mensch.*, Utrecht, 1853); Ludwig (*Lehrb. der Physiol.*, ii. 308); Budge (*Die Wirkung der Intercost. Muskeln*), and Duchenne (*Physiol. des Mouvements*, 1867, p. 641). The variety of opinion is seen in quoting these and other authors, as follows:—

1st. Both the intercostals are inspirators. Borelli, Sénac, Boerhaave, Winslow, Haller, Cuvier, Budge, Duchenne.

2d. Both are expirators. Vesalius, Diemerbroeck, Sabatier, Bean and Maissiat, Longet (though he is in doubt).

3d. The externals are expirators and the internals inspirators. Bartholin.

4th. The externals are inspirators and the internals are expirators. Spigelius, Vesling, Hamberger, Marcacci, Hutchinson, Donders, Ludwig, Flint,

Huxley, Marshall, Sibson (the last four especially, however, with modifications).

5th. The internals and externals are both expirators and inspirators. Mayer, Magendie, Bouvier, Burdach, Cruveilhier.

6th. They act together, but in one part of the chest are both inspirators, and in another both expirators. Behrens.

7th. They are neither expirators nor inspirators, but simply mechanically form a part of the chest-wall. Van Helmont, Arantius, Neneranzius.

No one, however, that I can discover, has before faradized the dissected muscles directly on the recently dead body, as in this instance.

At 12.26 P. M. I dissected off all the other muscles, and exposed the intercostals from the median line to the line of the axilla, and applied the interrupted current by two very small wet sponges, from the first intercostal space to the eighth. I first applied them to the intercartilaginous portion of the internal intercostals, and found that they all raised the cartilage below them. The external intercostals were then faradized, when the upper rib was pulled down very markedly, while the lower was just perceptibly raised. The depression of the first rib was very slight, but, as each external intercostal was examined in turn, the movement increased from the first to the seventh (the last four were not examined), while the elevation of the rib below varied but little. By means of hooks the fifth rib was fixed, and afterward the sixth rib, and the fifth external muscle faradized, with the same result as before. In order not to confuse the action of the external with that of the

underlying internal intercostal, nor the action of the intercartilaginous portion of the internal with the remainder of the internal, the external intercostals in the fourth, fifth, and sixth spaces were now carefully dissected away, and the internal muscles faradized from the cartilages to the axillary line, and in each case with very slight depression of the upper rib and marked elevation of the lower rib. Hence the conclusion was irresistible that the internal intercostals are inspirators, and the external expirators. I am aware of the imperfections of the observations. Nearly two hours had elapsed since death had occurred; the posterior half of the muscles was not examined, only three of the internals were examined where covered by the externals, no rigorous measurements were taken of the range of movement, etc.; but so far as they go they seem to warrant the conclusion already stated, and to point out the road to the proper method of determining decisively the action of these muscles.

Having but little time for further observation, I examined carefully but one muscle of the face. All had as yet perfectly retained their electro-muscular contractility. I placed one pole on the seventh nerve, and passed the other small sponge in the median line of the face, from the hair to the tip of the nose. I then placed one sponge on the middle of the nose, and passed the other up and down the middle line. At no point did I get any upward movement of the frontal muscle in its middle portion, but from just between the eyebrows down to the middle of the nose, the pyramidalis nasi always pulled the skin down. Subsequent dissection showed a well-developed

pyramidalis and no interruption in the fibres of the occipito-frontal on the forehead, in the median line. I am disposed, therefore, with Mr. Darwin (*Expression in Man and Animals*, p. 190), to regard the pyramidalis nasi as the direct antagonist of the central portion of the occipito-frontal, and *vice versâ*.

I would also take occasion to point out what important results this new method of investigation—the *faradization of the muscles on the recently dead*—promises to yield. In the living it is almost impossible to obtain the action of one muscle alone, especially in the face, where the emotions, pain, amusement, etc., involuntarily arouse the action of other muscles. In the recently dead the results will be far more accurate, and therefore for the anatomist, the artist, and the physiologist, they are of the greatest interest and importance.