THE SURGICAL TREATMENT OF PARALYSIS OF THE VOCAL CORD AND OF PARALYSIS OF THE DIAPHRAGM.*

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(With Special Plate.)

I.—THE VOCAL CORDS.

EXPERIMENTS performed on the monkey and the dog show that end-to-end, or end-to-side, anastomosis of the recurrent laryngeal nerve to the phrenic nerve is successful in restoring, after a certain lapse of time, movements of abduction and adduction of the vocal cord comparable to those of the opposite or normally moving cord. After section of the recurrent laryngeal nerve the vocal cord assumes a typical cadaveric position and the inner border is concave and flaccid. After six or eight weeks from the date of the operation the inner border of the immobile cord becomes straight and tense. There is, in fact, a tension about the previously paralysed cord which had not been present before. Four months after the first experiment of recurrent laryngeal-phrenic end-to-end anastomosis was carried out both vocal cords were moving equally in tranquil respiration. Six months after the experiment was done the previously paralysed cord moved more strongly than the other, and seven months after the experiment there was excessive, almost violent, movement as compared with the vocal cord on the normal side. This result was hardly a surprise, because the nerve current required to cause contraction of one half of the muscle of the diaphragm must be considerably stronger than that required to energize the small intrinsic muscles of the larynx.

The best method of anastomosis of the recurrent laryngeal nerve to the phrenic nerve so as to obtain recovery of movement of the paralysed vocal cord in rhythm with the movement of the normal cord remains to be determined.

In certain experiments in the monkey the root of the phrenic nerve from the third cervical nerve, or the root of the phrenic nerve from the fourth cervical nerve, was united side-to-end to the recurrent laryngeal nerve; and in others the root was divided and united end-to-end to the divided recurrent laryngeal nerve. In other experiments the divided recurrent laryngeal nerve was united end-to-end to the proximal segment of the divided main trunk of the phrenic nerve; and in yet others the end of the divided recurrent laryngeal nerve was anastomosed end-to-side to a small lateral incision made in the side of the main trunk of the phrenic nerve.

In some cases the end-to-side anastomosis of the recurrent laryngeal nerve to a root of the phrenic nerve or to the main trunk of the phrenic nerve was effected by making a small longitudinal median incision into the part of the phrenic nerve selected for the site of anastomosis and attaching the cut end of the recurrent laryngeal nerve to it. The end-to-side operation is the operation of choice—that is, if there is sufficient length of the recurrent laryngeal nerve to bring across the carotid sheath to the side of the phrenic nerve without tension on the anastomosis. If, however, the available length of the recurrent laryngeal nerve is insufficient to reach the phrenic nerve, then the phrenic nerve must be divided and the proximal end brought across to meet the divided distal end of the recurrent laryngeal nerve. The actual method of anastomosis, whether by lateral incision or longitudinal median incision, did not seem to affect the final result. We believe, however, that the plan of lateral

incision is the plan to adopt when end-to-side anastomosis is performed, as there is a definite and immediate approximation of divided nerve fibres. In such cases a partial or complete paralysis of one half of the diaphragm follows, but in a few weeks the paralysis passes away.

In man, therefore, the operation of choice is recurrent laryngeal-phrenic anastomosis, end-to-side, the lateral incision of the main trunk of the phrenic being carried out in order to obtain a raw surface of cut nerve fibres to which the distal end of the cut recurrent laryngeal nerve is attached.

This decision is based not only on the recurrent laryngeal-phrenic nerve anastomosis experiments, but on the results of a large number of experiments in which the two ends of a divided nerve were implanted at varying distances apart into the side of, or into median incisions in, a neighbouring nerve. These experiments have been reported,² and they seem to prove that the lateral incision method leads to more rapid and satisfactory recovery of the muscles supplied by the divided nerve than when its two ends are implanted into median longitudinal incisions made in the neighbouring nerve.

There is also no advantage in attaching the recurrent laryngeal nerve to one of the roots of the phrenic. When the root is divided and its proximal end sutured end-to-end to the recurrent laryngeal nerve the distal end of the root has sometimes been left without being joined to another nerve, and sometimes it has been joined end-to-end to the divided proximal end of the descendens noni nerve. In either case, even when the vocal cord muscles function again, there seems to be some delay in the recovery of normal contractions of the whole muscle of the diaphragm. It is curious to note that the quickest return of function of the vocal cord follows end-to-end anastomosis of the recurrent laryngeal to the proximal cut end of the main trunk of the phrenic nerve, and the most rapid recovery of the whole diaphragmatic muscle has followed end-to-end anastomosis of the distal cut end of the phrenic nerve to the proximal cut end of the descendens noni nerve. This latter result is in itself surprising, as we have not been able to obtain return of movement in the vocal cords during tranquil respiration by means of descendens noni-recurrent laryngeal end-to-end anastomosis. We do not suggest any explanation of this experimental finding.

There is another point about end-to-side recurrent laryngeal-phrenic anastomosis. In some cases there seems to be delay or arrest in the complete recovery of the movements of the vocal cord, or there may be delay in the complete recovery of the diaphragm, or there may be delay in the complete recovery of both vocal cord and diaphragm. The cause of these variations would seem to be that the nervous energy travelling through the phrenic nerve is overtaxed. While before the operation the nerve current of the phrenic nerve had to cause only contraction of one half of the diaphragm, after the operation it has now also to excite contraction in the intrinsic muscles of the larynx. In all departments of life the pursuit of two objectives may delay or hamper complete success in either or both of them. Napoleon wrote to his vacillating Admiral Villeneuve, "It seems to me your purpose is not exclusive enough for a great operation. You must correct this fault, for that is the art of great successes and of great operations." This famous maxim is true not only of the great operations of war but also of those of surgery.

Nevertheless the success which has followed the end-to-side anastomosis experiments makes it clear that this is the best operation to perform. (Fig. 19.) The experiments in which more than one anastomosis was carried out are less likely (except in special circumstances, as when there is only a short piece of the recurrent laryngeal nerve available) to find a permanent place in surgical practice. The best recommendation of recurrent laryngeal-phrenic end-to-side anastomosis is that it is a simple procedure and is frequently followed by the best functional results.

The number of experimental anastomoses of the recurrent laryngeal nerve to other nerves done is 33: 6 anastomoses to the vagus nerve end-to-side, 7 anastomoses to the descendens noni nerve end-to-end, and 20 anastomoses to a root or the main trunk of the phrenic nerve. The end-to-end anastomosis with the main trunk of the phrenic nerve

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The microscopical sections have been cut and stained by Mr. Steward at the Royal College of Surgeons by the kind permission of Sir Arthur Keith.

produced an unnaturally wide abduction movement of the cord, while the end-to-side anastomosis to the phrenic nerve was followed by an abduction movement comparable to that of the opposite or normal cord in tranquil respiration.

The attachment of the divided end of the recurrent laryngeal nerve to a root of the phrenic nerve instead of to the main trunk does not appear to present any advantage. When one root of the phrenic nerve was divided a portion of the corresponding half of the diaphragm was paralysed, but in one experiment there was complete recovery from this after some months, following the attachment of the proximal end of the divided descendens noni nerve to the distal end of the root of the phrenic nerve. It will be seen in the second part of this paper that paralysis of one half of the diaphragm is under the control of the surgeon and that this paralysis need no longer be of serious concern to the operator.

In the hussar monkey the microscope shows that the root of the phrenic from the third cervical nerve is composed of many fine presumably motor fibres and some large fibres, while the root from the fourth nerve contains many large as well as small fibres. A large number of microscopic sections of the nerves of the neck of man and the monkey have been examined, and large and small nerve fibres in varying proportion have been seen in all the nerves. (Figs. 1 to 4.) In the microscopic sections of the superior laryngeal nerve and of its internal and external branches there appears to be a marked difference in size between the nerve fibres (sensory) of the internal branch and the nerve fibres (motor) of the external branch. It has not been possible, however, to follow this distinction with any certainty in the case of the other nerves. All so-called motor nerves contain large nerve fibres, but whether these are motor or sensory it is not possible to tell.

The operation of recurrent laryngeal-phrenic anastomosis end-to-side (by lateral incision of the main trunk of the phrenic nerve) has been performed by one of us in the case of a woman, aged 54, who eight months before the anastomosis operations suffered from paralysis of both vocal cords following an operation for removal of a thyroid tumour. Five months after the anastomosis operation on the right side and four months after the anastomosis operation on the left side were carried out both cords of the patient were showing slight abduction excursions in tranquil respiration, and the paralysis of both halves of the diaphragm had completely disappeared.

Experiments had been performed before the recurrent laryngeal-phrenic anastomosis was attempted. In these the vagus nerve and the descendens noni nerve were united to the divided recurrent laryngeal nerve. In the end-to-side recurrent laryngeal-vagus anastomoses and the end-to-end recurrent laryngeal-descendens noni experiments, the vocal cord in each case recovered its tension, and its inner border became straight, but no movement of abduction was observed in tranquil respiration some eighteen months after the operation. This movement, however, was obtained by partially asphyxiating the animal while it was under ether by pressure on the trachea. The inspiratory effort on releasing the pressure on the trachea became so powerful that the muscles of the immobile vocal cord recovered sufficient nervous energy to contract. In one case, four and a half months after descendens noni-recurrent laryngeal

anastomosis, the monkey was placed under ether and pressure was made on the trachea. This induced strong adduction of both vocal cords. As soon as the pressure which had induced partial asphyxia was relaxed, wide outward excursions of both vocal cords, equal on the two sides, were observed and continued for two or three minutes. The excursions of the previously immobile cord gradually diminished in extent as the asphyxia passed off, and then ceased.

This experiment (originally suggested by Professor Starling) possibly gives the key to the problem of re-education in man of the paralysed vocal cord after anastomosing the recurrent laryngeal nerve to the phrenic nerve. "Holding the breath" is necessarily followed in man by a strong inspiratory effort, which would probably cause in man, as in the monkey experiment, abduction of the previously immobile vocal cord, so that a patient's immobile or slightly moving cord might at last be re-educated to act in an harmonious subconscious normal respiratory movement with the vocal cord of the opposite or healthy side.

This method of re-education—"holding the breath"—is being employed in the case of the woman mentioned above, and in addition a galvanic current has been passed across the larynx for ten minutes once or twice a day since the operation, in the hope that it would influence the recovery of the intrinsic muscles of the larynx and perhaps prevent the scar tissue of the operations from causing undue pressure on the nerves and the anastomoses.

That a nervous impulse could pass through the anastomoses made between the recurrent laryngeal nerve and the vagus and descendens noni nerves was clear from the following experiments.

1. Fifty days after a descendens noni-recurrent laryngeal anastomosis was done in a monkey the wound was opened and the anastomosis exposed. On

stimulating (1) the hypoglossal nerve proximal to the origin of the descendens noni nerve, (2) the descendens noni, (3) the site of the anastomosis, the vocal cord was seen to abduct.

2. Seven months after a recurrent laryngeal-vagus anastomosis was done in a monkey the wound was opened. The vagus was stimulated (1) proximal to the anastomosis, and (2) at the site of anastomosis. The vocal cord was seen to abduct.

These stimulations caused abduction of the previously immobile cord; the excursions of the cord were not so wide as on the opposite or healthy side. Later (when perhaps the abductor was tired) strong adduction was observed.

The recognition of the certainty of recovery of the movements of the vocal cord which follows recurrent laryngeal-phrenic anastomosis made us abandon the operation of uniting the recurrent laryngeal nerve with either the descendens noni nerve or the vagus nerves. The object in view is not merely to obtain a return of tone in the cord, however desirable this may be, but to win by means of operation a recovery of the movements of adduction and abduction equal and synchronous with the movements of the opposite or normal cord.

From the experience gained from the monkey experiments it is not possible to state at what period after the experimental operations movement of the recovering cord first occurs. The animals have to be kept for nerve anastomosis experiments to mature for long periods of time. They are valuable and scarce, and an anaesthetic is dangerous.

DESCRIPTION OF SPECIAL PLATE.

(FIGS. 1 TO 4.)

FIG. 1.—Transverse section of the phrenic nerve of the hussar monkey. ($\times 50$.) The large nerve bundle comes from the fourth cervical nerve. The next largest bundle comes from the third cervical nerve. The smallest nerve is presumably the root from the fifth cervical nerve, but this root was not seen during the dissection. The nerve bundle arising from the fourth cervical nerve contains much larger fibres than the nerve bundle from the third cervical nerve. This difference in the size of the nerve fibres may indicate some difference in function.

In man the roots of the third and fourth cervical nerves can be seen to join a little below the point where the root from the fourth cervical nerve is given off. They are enclosed in one sheath beneath the fascia of the scalenus anticus muscle, but can be seen to continue as separate nerves on the way down the neck. So clearly separate are the two roots of the phrenic that a lateralized tenotomy knife can be passed between them and either nerve can be divided without injury to the other. This anatomical fact was taken advantage of in the experiment on a hussar monkey in which the separation of the two roots was observed. In this monkey the root from the fourth cervical nerve was divided with a tenotomy knife as described and united end-to-end with the divided recurrent laryngeal nerve. The difference in size of the nerve fibres of the different roots as observed in the hussar monkey is not seen in the phrenic of man.

FIG. 2.—Transverse section of the superior laryngeal nerve in a man aged 40. ($\times 30$.) The main trunk is divided into one large bundle of fibres and four smaller ones. The fibres of the large bundle are much larger than those of the small bundles.

FIG. 3.—Transverse section of the internal branch of the superior laryngeal nerve. ($\times 30$.) The drawing shows three bundles of fibres. The fibres in the large bundle are all of comparatively large size. It would appear that in the superior laryngeal nerve the large fibres are sensory and the smaller ones motor in function.

FIG. 4.—Transverse section of the external branch of the superior laryngeal nerve. ($\times 50$.) The drawing shows four bundles of fibres. The fibres are small except a few large ones scattered among the masses of small fibres.

COLLEDGE AND BALLANCE: SURGICAL TREATMENT OF PARALYSIS OF THE VOCAL CORD AND OF THE DIAPHRAGM.

FIG 1.

FIG. 2.

FIG. 3.

FIG. 4.

COLLEDGE AND BALLANCE: SURGICAL TREATMENT OF PARALYSIS OF THE VOCAL CORD AND OF THE DIAPHRAGM.

FIG. 5.

FIG. 6.

FIG. 8.—Adduction.

FIG. 9.—Abduction.

FIG. 10.—Adduction.

FIG. 11.—Abduction.

FIG. 12.—Adduction.

FIG. 13.—Abduction.

FIG. 7.

In man, however, when these operations become performed generally it will be possible to note week by week, by the aid of the laryngoscope, the slow but certain stages of recovery of movement of the vocal cord. It appears from the experiments, however, that the movement of adduction reappears earlier than that of abduction, and this corresponds with the familiar clinical experience that the abductors of the cords are more vulnerable than the adductors. The adductors, too, correspond to the flexor muscles of the limbs, and it is a common experience that after a nerve lesion of a limb the flexor muscles recover before the extensors. Negus points out that in evolution "adduction is an older function than abduction; therefore the power of the former survives that of the latter."

In disease, and possibly in injury, one intrinsic muscle of the larynx may atrophy though its nervous supply is intact, while the other intrinsic muscles are acting normally. Hughlings Jackson and Morell Mackenzie published a case in 1866.² The abductor muscles were found greatly atrophied after death, while the nerve structures were intact. It would appear also that bilateral paralysis of the abductor muscles may arise from disease of the nerve fibres distributed to these muscles without paralysis of the other intrinsic muscles of the larynx.³ In our experiments when perfect functional recovery is not present these facts should be remembered. It may be that some intrinsic muscle or some nerve filaments have not regenerated so well as others. This demonstrates the necessity, at a later stage of the experiments, for the careful study of microscopical sections of each intrinsic muscle and of its motor nerve fibres.

In the experiments the recurrent laryngeal nerve has always been completely divided, and as a result the vocal cord occupies the cadaveric position; but in cases of abductor paralysis in man the paralysed cord lies nearer to the mid-line than the cadaveric position because of tonic contraction of the adductor muscles.

Another question also requires an answer: When the vocal cord is moving normally through nervous impulses conveyed to it through the phrenic nerve, will the patient be able to phonate? This is the question asked by the late Sir Frederick Mott. The answer can hardly be decided by experiments on the monkey; operation on man will give the reply. This is the decisive experiment. Sir Frederick Mott pointed out that the lemur monkey of the forests of Sumatra possessed a highly developed larynx, and that these animals were said to sing in chorus in their native wilds. He suggested that one of these monkeys should be obtained, as it would be very important to know whether, after a recurrent laryngeal-phrenic anastomosis had been performed, the singing voice would return or be modified; but it has not been possible to obtain a lemur monkey.

The recovery of the movement of the vocal cords after recurrent laryngeal-phrenic anastomosis has been filmed, and the appearances are described in another part of the paper.

It is not possible to say how long after paralysis of the vocal cord has taken place it would be justifiable to attempt to restore the movement of the cord by surgical operation.

The surgical treatment of paralysis of the face may be attempted as long as contraction of the muscles of the face, however feeble—if necessary under an anaesthetic—can be obtained by stimulation through the skin with the galvanic current. It does not appear whether this method has been employed in the case of the intrinsic muscles of the larynx, but an electrode might be introduced into the larynx through the laryngoscope and a galvanic current used in order to find out whether any movement of the paralysed vocal cord can be induced. Frazier and Chevalier Jackson have advised that mobility of the crico-arytenoid joint should be tested with a long probe, lest the cartilages have become fixed either from arthritis or from secondary changes in the joint following prolonged paralysis and interference with its nerve supply.

There is another point of contrast also: in paralysis of the face some treatment, perhaps intermittent, such as massage and galvanism, has almost always been adopted to

maintain the nutrition of the muscular fibres; so that, years after a complete palsy of the face has occurred, nerve anastomosis may be followed by a wonderful recovery of the facial muscles. The fact that, in the case of the patient previously quoted, eight months elapsed between the injury to the recurrent laryngeal nerves and the anastomosing nerve operations, and that already there is promise of a successful result, is a hopeful augury for the performance of the operation when the paralysis has continued for a much longer period than eight months.

Two experiments have been performed in which the recurrent laryngeal nerve was divided three months and six months before it was united to the phrenic nerve, but the specimens from these cases are not yet ready for publication. (Figs. 5 and 6.)

Altogether twenty experiments have been performed in which the

recurrent laryngeal nerve has been anastomosed in various ways to a root of the phrenic nerve or to the main trunk of the phrenic nerve, and the results leave no question in the mind as to the success of the operation. When both recurrent laryngeal nerves have been anastomosed to the corresponding phrenic nerves the result is not always at first satisfactory. In a large rhesus monkey in which the operations on the two sides of the neck were separated by a long interval of time no stridor and no difficulty of breathing occurred; but in two baboons and two dogs it was noticed that while in tranquil respiration there was no stridor, yet when these animals became excited noisy respiration occurred. In these baboons and dogs it must be noted that the central nervous connexion of both recurrent laryngeal nerves and both phrenic nerves had been disturbed—the recurrent laryngeal nerves being united to the proximal part of the divided phrenic nerves and the distal part of the phrenic nerves to the divided proximal parts of the descendens noni nerves. Further, the depressor muscles of the larynx in the baboons were paralysed for a time, the distal segment of the descendens noni nerve on each side of the neck being united end-to-side to the lower border of the hypoglossal nerve, and in some other cases to the side of the phrenic nerve proximal to the recurrent

DESCRIPTION OF SPECIAL PLATE.

(FIGS. 5 TO 13.)

FIG. 5.—Microscopic appearance of phrenic nerve of a baboon distal to a descendens noni-phrenic anastomosis eighteen months after the performance of the anastomosis. ($\times 150$.) Cajal stain.

FIG. 6.—Microscopical appearance of recurrent laryngeal nerve of a baboon distal to a recurrent laryngeal-phrenic anastomosis eighteen months after the performance of the anastomosis. ($\times 150$.) Cajal stain. The recurrent laryngeal nerve had been divided in the lower part of the neck six months before the anastomosis operation was done.

FIG. 7.—Dog. Photographs by Mr. Melville of the position of the diaphragm at the end of expiration and at the end of inspiration (Experiment I). A, End of expiration. B, End of inspiration. Twenty seconds elapsed between the two exposures. Each exposure lasted an eighth of a second. Both halves of the diaphragm are contracting through nerve currents passing through the descendens noni-phrenic anastomosis.

FIGS. 8 AND 9.—Dog under ether anaesthesia (Experiment I). Rapid respiration described by Richet by the name "polypnoea." Stated by Semon and Horsley as occurring when the lower third of the cortex of the precrucial gyrus is stimulated. The rapid respiration is frequently observed during ether anaesthesia in this animal and is relieved by the administration of a little chloroform. Note the wider space between the arytenoid cartilages in abduction. The film was taken fifteen months after a recurrent laryngeal-phrenic end-to-end anastomosis was performed on the right side, and ten months after the recurrent laryngeal-phrenic end-to-end anastomosis was done on the left side. In this case the main trunk of the phrenic was used for the end-to-end anastomosis on the left side, while on the right side the end-to-end anastomosis was made to the proximal segment of the root of the phrenic arising from the sixth cervical nerve. (See also Figs. 14 and 15.)

FIGS. 10 AND 11.—Large rhesus monkey; tranquil respiration (Experiment II). Note the wide angle formed by the two sides of the arytenoids in abduction and the lesser angle in adduction. These photographs do not give the same effect as seen in the film. For example, in the film much more adduction is visible; the channel between the vocal cord approximates to a slit-like opening. The film was taken two years and six months after the operation of recurrent laryngeal-phrenic end-to-side anastomosis was performed on the right side, and thirteen months after the operation of recurrent laryngeal-phrenic anastomosis end-to-end was done on the left side. Note the wider abduction movement of the vocal cord on the left side. (See also Figs. 16 and 17.)

FIG. 12.—Same monkey. Strong adduction during partial asphyxiation. The cords have nearly passed off the field.

FIG. 13.—Same monkey. Wide abduction following immediately after pressure on trachea was relaxed.

laryngeal-phrenic end-to-end anastomosis. It is true that operations on the two sides of the neck were separated by a considerable length of time, but now, when both cords were moving, when both halves of the diaphragm had recovered from paralysis, and when the muscles on both sides of the neck were again working normally, why is it that noisy respiration on excitement occurs? It must be remembered that the muscles innervated by the recurrent laryngeal, phrenic, and descendens noni nerves are intimately associated in the respiratory movements. The noisy respiration caused by the inco-ordination of muscular movement does not appear surprising, since complicated nerve arrangements must be made in the central nervous system before the nerve cells of the central connexions of the phrenic and descendens noni nerves are brought into nervous union with those nerve cells which control under normal circumstances the rhythmical respiratory movements of the vocal cords and each half of the diaphragm. Time alone offers the probability or possibility of complete recovery.

The end-to-side and end-to-end anastomoses of the distal end of the divided recurrent laryngeal nerve to the main trunk of the phrenic nerve on one side of the neck have been invariably successful, in that they are followed by apparently normal movements of the corresponding vocal cord; but when such an operation has been carried out on both sides of the neck, the movements of the vocal cords, thus energized through union with the corresponding phrenic nerves, have shown in a few instances an inco-ordination or false timing of the movements of the vocal cords, indicating that though the respiratory centre is working yet it has not regained normal control. This paradoxical result affects the vocal cord on the side which was first operated on, though previous to the second operation this vocal cord was moving equally and synchronously with the opposite or normally moving vocal cord.

There are other points to consider. The end-to-end suture of the extremely fine nerves in the monkey is not in all cases carried out so perfectly as is desirable; and again, the presence of scar tissue at the site of anastomosis may possibly delay or weaken the passage of a nervous impulse. These, no doubt, are theoretical considerations, but the fact remains that when both recurrent laryngeal nerves have been anastomosed end-to-end to the corresponding phrenic nerves a paradoxical movement of the vocal cords has been seen, adduction occurring in inspiration and abduction in expiration.

Inco-ordination is also seen in emotional movement, such as laughing, after a nerve anastomosis has been performed for facial palsy. The distortion of the face may be so great that, superficially observed, it appears that no recovery has taken place; but if and when by re-education both sides of the face work together the distortion on emotional movement does not occur. It may be that in the practical application of the operation for double abductor paralysis the difficulty of inco-ordination may be avoided or minimized by performing the operation on one side only, leaving the opposite cord without movement, since it is a commonplace observation that unilateral paralysis frequently causes neither dyspnoea nor lasting alteration in the voice.

In Blalock and Crowe's paper⁴ admirable figures are given of regeneration of the recurrent laryngeal nerve distal to anastomosis with the descendens noni nerve and the vagus nerve. This regeneration we have found whatever cervical nerve has been anastomosed to the recurrent laryngeal nerve. In our experiments in no instance could the recovery of the movements of the vocal cord be compared to that obtained by anastomosis of the recurrent laryngeal nerve to the phrenic nerve. In our experiments, too, monkeys were chiefly used, and in Blalock and Crowe's dogs only. We think the experiments with the monkey give results which are of more service for comparison when the time arrives for their application to the surgery of man. Blalock and Crowe recommend the selection of the descendens noni nerve or the upper root of the phrenic. They say that the best results are obtained by making the anastomosis close to the larynx, as the axis cylinders have a shorter distance to traverse before reaching the end-organs in the intrinsic laryngeal muscles; but this is a theoretical statement, and represents a theory of nerve

regeneration which is not universally accepted (see *Healing of Nerves*, Ballance and Stewart).

Blalock and Crowe state that the entire severance of the phrenic or vagus involves a needless risk. No one has suggested the entire severance of the vagus, and in man we only recommend the division of the trunk of the phrenic when there is not a sufficient length of recurrent laryngeal nerve to bring across the carotid sheath in order to carry out an end-to-side anastomosis. We do not believe in risk associated with division of the phrenic on one side (it is often destroyed at the present time in the treatment of some forms of phthisis and bronchiectasis), and we know that the anastomosis of the proximal end of the divided descendens noni nerve to the distal cut end of the phrenic will eventually result in complete recovery from paralysis of the diaphragm. We have employed end-to-end and end-to-side anastomosis of the recurrent laryngeal nerve to the upper and middle phrenic roots, but we are convinced that end-to-side anastomosis of the recurrent laryngeal to the trunk of the phrenic is the operation of choice. Further, our experiments teach us that operation on one of the phrenic roots does cause a partial paralysis of the diaphragm. We agree, however, with these authors that light ether anaesthesia is of great importance in observing the movements of the vocal cords; deep anaesthesia or morphine may abolish the movements and lead to wrong conclusions. This point was insisted on also by Semon and Horsley.

DESCRIPTIONS OF EXPERIMENTS.

In each experiment before the sutures were passed to bring the cut ends of the several nerves together the recurrent laryngeal and phrenic nerves were stimulated with the faradic current. The contraction of one half of the diaphragm was easily observed, and so was the movement of the corresponding vocal cord, by means of the laryngoscope. It was noted, too, that the contraction of the muscle of one half of the diaphragm was sometimes associated with contraction of the lower intercostal muscles. These latter muscles being associated in normal respiratory action with the muscle of the diaphragm seem to have received a reflex hint to carry on as normal.

It has been already said that twenty experiments in which the recurrent laryngeal nerve was united to the phrenic nerve have been performed. When both recurrent laryngeal nerves were anastomosed to the corresponding phrenic nerves the two operations were counted in the above list as two experiments. In the following description of certain of these experiments when two operations have been done on the same animal it has been found more convenient to reckon such a procedure not as two experiments but as one.

EXPERIMENT I.—Dog.

This animal was constantly barking, which was a fact of value in relation to the nature of the experiment proposed to be performed. The dog was deeply anaesthetized with ether, but unfortunately just before the film was about to be taken the respiration became very rapid, shallow, and panting. The film therefore shows much smaller excursions of the cords than have been observed to take place when the respiration is quiet and natural. The right cord, however, will be seen to have a wider abduction movement than the left, and this is probably due to the fact that the operation on the right side of the neck was performed five months before that on the left side. The film was taken fifteen months after the operation was done on the right side of the neck and ten months after the operation was done on the left side of the neck. (See Figs. 8 and 9.)

First Operation (Right Side).—Recurrent laryngeal nerve to the proximal segment of the root of the phrenic derived from the sixth cervical nerve—anastomosis end-to-end. Descendens noni nerve to the distal segment of the root of the phrenic derived from the sixth cervical nerve—anastomosis end-to-end. (Fig. 14.)

In this case it will be seen that the root of the phrenic from the sixth cervical nerve was used for the anastomoses and not the main trunk of the nerve.

The animal began barking again vigorously three months after the operation, and five months after the operation the right cord was moving synchronously and equally with the normal cord on the left side.

It was decided to do a similar operation on the left side.

Second Operation (Left Side).—Recurrent laryngeal-phrenic (main trunk) anastomosis, end-to-end. Descendens noni-phrenic (main trunk) anastomosis, end-to-end. (Fig. 15.)

Thus on the left side of the neck a different operation was done from that carried out on the right side of the neck. The recurrent laryngeal nerve and the main trunk of the phrenic nerve were divided and the proximal end of the divided phrenic was united end-to-end with the distal cut end of the divided recurrent laryngeal nerve. The descendens noni nerve was divided in the operation on the right and left sides of the neck, below the

origin of the branches to the omo-hyoid, sterno-hyoid, and sterno-thyroid muscles, and its proximal end united to the distal end of the divided root or main trunk of the phrenic nerve.

Six months after the operation on the left side of the neck the dog was barking again loudly, but perhaps the bark was not exactly the same as before the operations; the movements of both cords were equal and synchronous.

*Examination of the State of the Diaphragm (at University College).—*A film of the contractions of the diaphragm cannot at

to be that the prolonged anaesthesia required for the filming of the vocal cords had interfered with their normal rhythm of movement.

The appropriate area of the cortex cerebri was stimulated, but no movement of the vocal cords was seen; when the cortical stimulation was done the animal had been under deep anaesthesia for some time.

EXPERIMENT II.—Large Rhesus Monkey.

*First Operation (Right Side).—*Recurrent laryngeal-phrenic anastomosis, end-to-side. The recurrent laryngeal nerve was divided and the distal cut end united, end-to-side, to a small median incision made in the main trunk of the phrenic nerve. (Fig. 16.)

Six months later the right cord was moving synchronously with the left.

*Second Operation (Left Side).—*Seventeen months after the operation on the right side the following operation was per-

FIG. 14.—Dog (Experiment I). Recurrent laryngeal-phrenic (root from sixth cervical nerve) end-to-end anastomosis. Descendens noni-phrenic (distal end of divided root from sixth cervical nerve) end-to-end anastomosis.

FIG. 15.—Dog (Experiment I). Recurrent laryngeal-phrenic (main trunk) end-to-end anastomosis. Descendens noni-phrenic end-to-end anastomosis.

present be taken, but Mr. Melville hopes that before long this may be possible. Professor Elliot Smith's report is as follows:

The first examination was made with the radiographic screen ten months after the operation was done on the right side of the neck and five months after the operation was done on the left side of the neck.

Report on the Right Side.—The major part of the right half of the diaphragm is contracting normally, especially the posterior portion; but an area of the muscle is still paralysed.

Report on the Left Side.—Active contraction of all parts of the muscle.

Five months later another examination was made. The report stated that both halves of the diaphragm were actively contracting, and there was no sign of paralysis on the right side. (Fig. 7.)

Ten months after the second operation was done the vocal cords were moving equally and synchronously as seen through the laryngoscope. At this time the movements of the vocal cords were filmed. The film shows that the excursions of the right vocal cord were slightly more pronounced than those of the left vocal cord.

Some little time after the filming of the vocal cords it was noted that the dog was suffering from stridor and that the bark was very hoarse. The animal was not under constant observation as it was kept at the farm laboratories. It seemed that the stridor and hoarseness might be accounted for either by the prolonged anaesthesia necessary for the filming upsetting the respiratory rhythm, especially as multiple anastomoses had been done, or possibly that the extension of the neck during the filming had stretched or in some way damaged the anastomoses. The larynx of the dog was examined again, when, though the vocal cords were actively moving, adduction was seen to take place in inspiration and abduction in expiration. All observers note that the movements of the vocal cords are very sensitive to deep anaesthesia.

Three months after the filming of the vocal cords the dog was anaesthetized again, and killed with ether at the close of the examination.

There was still the paradoxical movement of the vocal cords as described above, but adduction was accompanied by movement of the larynx as a whole, caused by the subhyoid muscles, so that possibly the adduction may have been due to extrinsic influence and not caused simply by contraction of the intrinsic muscles.

The following experiments seem, however, to point to a different conclusion.

1. Stimulation of the undivided recurrent laryngeal nerve on the left side was followed by adduction of both vocal cords.
2. Stimulation of the distal end of the divided recurrent laryngeal nerve was followed by adduction of both vocal cords.
3. Stimulation of the proximal end of the divided nerve was followed by adduction of the opposite vocal cord.

The two last observations are paradoxical and contrary to what occurs in normal circumstances, so that the truth seems

FIG. 16.—Rhesus monkey (Experiment II). Recurrent laryngeal-phrenic anastomosis, end-to-side. (Small median incision made in middle of phrenic trunk.)

FIG. 17.—Rhesus monkey (Experiment II). Recurrent laryngeal-phrenic end-to-end anastomosis. No anastomosis of distal part of phrenic to any other nerve.

formed on the left side: Recurrent laryngeal-phrenic (main trunk) anastomosis, end-to-end. No anastomosis of distal end of phrenic to any other nerve. (Fig. 17.)

Six months later both cords were moving well, but the left cord (the recurrent laryngeal had been attached to the whole phrenic) showed a wider abduction excursion than the left.

The Diaphragm.—Examination at University College with the radiographic screen by Prof. Elliot Smith, Dr. Beattie, and Mr. Melville, two years and five months after the operation on the right side and twelve months after the operation on the left side. The report on the right side stated that all parts of the diaphragm were contracting equally and well. That on the left side was as follows: "No contraction of any part of left half of diaphragm; cupola moves passively upwards and downwards with respiration."

This monkey is still alive and well. It is three years since the recurrent laryngeal-phrenic anastomosis was done on the right side and one and a half years since the recurrent laryngeal-phrenic anastomosis was performed on the left side. This animal has never had any stridor. Both vocal cords are apparently moving naturally. It is to be noted that, though the left half of the diaphragm is paralysed, the right half is contracting through nervous influences passing in the normal manner through the right phrenic nerve—a recurrent laryngeal-phrenic end-to-side anastomosis having been done. (Figs. 10 to 13.)

EXPERIMENT III.—Baboon.

Operation (Right Side).

—Recurrent laryngeal-phrenic end-to-end anastomosis. Descendens noni (proximal end) - phrenic (distal end) end-to-end anastomosis. Descendens noni (distal end) - hypoglossal end-to-side anastomosis. (Fig. 18.)

A. The Vocal Cords.

Four months afterwards: Right vocal cord moves equally with left in tranquil respiration. Six months after operation: Right vocal cord moves more strongly than left. Seven months after operation: Right vocal cord moves excessively as compared with the movements of the left vocal cord; the movements of the cords are, however, synchronous. (Observed by Sir David Ferrier and the late Sir Frederick Mott.)

B. The Diaphragm.—Examination by Dr. Eidinow with the radiographic screen at the Hampstead Institute seven months after

FIG. 18.—Baboon (Experiment III). Recurrent laryngeal-phrenic end-to-end anastomosis. Descendens noni-phrenic end-to-end anastomosis. Descendens noni-hypoglossal end-to-side anastomosis.

the operation. The report stated that both halves of the diaphragm contracted equally and normally. (Professor Leonard Hill agreed with this report.)

C. The Depressor Muscles of the Hyoid Bone and Larynx.—Seven months after operation: The muscles on the right side of the neck react to the faradic current in a normal way and like those on the left side of the neck.

The baboon became ill two weeks later and was destroyed by ether inhalation.

EXPERIMENT IV.—Dog.

First Operation (Right Side).—Recurrent laryngeal-phrenic (main trunk) end-to-end anastomosis. Descendens noni-phrenic (main trunk) end-to-end anastomosis.

Three months later the animal was running about in good health; there was no sign of difficulty in breathing.

Six months after the operation: Both cords move equally and synchronously. Perhaps there is not quite so much abduction of the right cord as there is of the left cord. The adduction movement of both cords is strong.

The wound was opened and the hypoglossal nerve proximal to the origin of the descendens noni nerve and the descendens noni nerve proximal to its anastomosis with the phrenic nerve were exposed and stimulated with the faradic current. Contraction of the right half of the diaphragm occurred and continued rather violently for a short time after the faradic stimulation ceased. Previous to this experiment no difference could be detected on inspection and palpation between the movements of the upper half of the right abdominal wall and ribs and the movement of the corresponding parts on the left side.

Second Operation (Left Side).—six months after operation on the right side.—Recurrent laryngeal (main trunk) -phrenic end-to-end anastomosis. Descendens noni-phrenic (main trunk) end-to-end anastomosis.

Nine months after the second operation: Some stridor had been noted for two or three months when the animal was excited.

Vocal Cords.—Both cords abduct, but the right moves more actively than the left. Adduction, which is a strong movement on both sides, takes place in inspiration and abduction in expiration.

Diaphragm.—Examination by Professor Elliot Smith at University College. The right side showed normal diaphragmatic contraction; all the muscle was acting. On the left side the movement appeared to be less in amplitude than that on the right. It seemed that some of the muscle fibres on the ventral surface were not yet active.

Two months after the examination at University College the animal was killed by the inhalation of chloroform. Before death took place both recurrent laryngeal nerves were exposed near the larynx and stimulated with the faradic current. Stimulation of the right recurrent laryngeal nerve with a moderate faradic current caused strong adduction of both cords. When the stimulation ceased the cords moved outwards, leaving a wide air space. Stimulation of the left recurrent laryngeal nerve gave the same result, but the movement on the right side was stronger than that on the left.

The paradoxical movement of the vocal cords is discussed in another part of the paper. In normal circumstances the stimulation of the intact recurrent laryngeal nerve is followed by an equal movement of both vocal cords. It is interesting that the same result obtained in this case, though each recurrent laryngeal nerve had been anastomosed to the corresponding phrenic nerve. Both halves of the diaphragm were contracting through nerve currents passing through the descendens noni-phrenic anastomoses, but the left muscle of the diaphragm had not completely recovered.

EXPERIMENT V.—Dog.

First Operation (Right Side).—Recurrent laryngeal-phrenic (main trunk) end-to-end anastomosis. Descendens noni-phrenic (main trunk) end-to-end anastomosis. Only one root (that from the sixth cervical nerve) was observed at the operation.

Seven months later the right vocal cord moved synchronously with the left vocal cord, but the abduction excursion on the right side was slightly more marked than the same movement on the left side. The abdominal wall and ribs moved on the right side in the same manner as those on the left side, showing there was no paralysis of the diaphragm.

Second Operation (Left Side).—eight months after first operation.—Recurrent laryngeal-phrenic (main trunk) end-to-end anastomosis. Descendens noni-phrenic (main trunk) end-to-end anastomosis.

Three months later there was no stridor or other evidence of difficulty of breathing.

Four months after the second operation the animal died of acute lobar pneumonia.

The microscopic sections of the nerves and intrinsic muscle of the larynx have not yet been studied. They will form the basis of another paper.

EXPERIMENT VI.—Dog.

Operation (Right Side).—Recurrent laryngeal-phrenic end-to-side anastomosis. The end of the recurrent laryngeal nerve was sutured to a small transverse incision made in the side of the trunk of the phrenic nerve formed by the union of the roots from the fifth and sixth cervical nerves.

Two months after operation the animal was barking again.

Three months after operation the right vocal cord was straight, tension good. Slight abduction was observed during tranquil respiration. The barking of this dog had become a nuisance.

Seven months after operation the right vocal cord moved actively, equally, and synchronously with the left vocal cord.

Diaphragm.—Examination at University College with the radio-

graphic screen by Professor Elliot Smith and Mr. Melville, who reported: "Both halves of the diaphragm contracting equally and normally." A few weeks previously, at another examination, the report was as follows: "Both halves of diaphragm contracting well. Right half is contracting well and as a whole, but a small area near the vena cava seems to be lagging behind the rest."

EXPERIMENT VII.—Hussar Monkey.

Operation (Left Side).—Recurrent laryngeal-phrenic end-to-side anastomosis. The anastomosis was made by the method of lateral incision. (Fig. 19.) The phrenic nerve was seen to be formed of two bundles of nerves. A fine tenotomy knife was passed between them and made to divide one of the bundles. Into the gap thus made the cut end of the recurrent laryngeal was fixed by one suture of the finest catgut. The two nerve bundles of the phrenic nerve came respectively from the third and fourth cervical nerve. That from the fourth cervical nerve was the larger, and it was this bundle which was divided; so the anastomosis was between the fourth cervical root of the phrenic and the recurrent laryngeal nerve. Whether the healing process spread the anastomosis to the root from the third cervical nerve or whether the anastomosis remained a pure recurrent laryngeal-phrenic (fourth root) junction is not known.

Three months after the operation Dr. Eidinow examined the diaphragm with the radiographic screen. Report: Left Half of diaphragm contracting normally. (Professor Leonard Hill concurred in the report.)

Six months after the operation the vocal cords were examined. Report: Deep anaesthesia: shallow breathing. The glottis in this animal is normally widely open. It never moves in its large cage, and therefore the respiratory centre has the minimum amount of work to do. The left vocal cord is tense and straight, but immobile. There is scarcely any movement of the right vocal cord.

Nine months after the operation the normal position of both vocal cords seemed to be wide abduction. There was slight abduction of the left vocal cord. Strong adduction of both cords was caused by partial asphyxiation, which was followed by strong abduction, which was not so marked on the left side as on the right. Deep anaesthesia abolished the movement of both cords. Two weeks after this examination the animal died.

EXPERIMENT VIII.—Large Barking Baboon.

First Operation (Right Side).—Recurrent laryngeal-phrenic end-to-end anastomosis. Descendens noni-phrenic end-to-end anastomosis.

The recurrent laryngeal nerve had been divided three months before this operation. The distal end of the descendens noni nerve was not united end-to-side to the hypoglossal. During the operation the root from the third cervical nerve was not seen; the root from the fourth cervical nerve was comparatively large. It is not certain whether the trunk of the phrenic nerve formed by the junction of the third and fourth nerve roots was divided and employed in the anastomosis or whether only the root of the phrenic from the fourth cervical nerve was used. The laryngoscope showed the right vocal cord without tone, with a concave border and immobile. Before doing the anastomosis the recurrent laryngeal nerve was stimulated, when a slight adduction movement of the right cord was seen. Dr. Charles Mayo, Dr. Franklin Martin, Dr. Cabot, and Dr. Willis of America, and Dr. Tapia of Madrid, were present at the operation.

Four months after the operation the baboon was barking loudly again, and on using the laryngoscope the right vocal cord was seen to have regained its tone its inner border was straight, but it was still immobile. During this examination the anaesthesia was deep and the respiration very shallow.

Second Operation (Left Side). performed nine months after the first.—Recurrent laryngeal-phrenic end-to-side anastomosis.

The right vocal cord now shows a slight abduction excursion in tranquil respiration. For three months this monkey has been barking so loudly that the neighbours have complained of the barking of the "dog." After the operation which paralysed the left vocal cord the movements of adduction and abduction of the right vocal cord became quite obvious.

Six months after the second operation an examination of the movements of the diaphragm was made by Professor Elliot Smith, Dr. Beattie, and Mr. Melville, who reported as follows:

The right half of the diaphragm is contracting in the normal manner and the muscular portion appears to be completely functioning.

In the left half of the diaphragm the movement is not normal; amplitude less than that on the right side. Query: the muscular fibres are not all yet acting.

Two months before Professor Elliot Smith made this examination it was noted that this baboon suffered from stridor when excited or angry, and that the barking was less noisy, less frequent, and changed in character.

After the examination of the movements of the diaphragm an attempt was made to examine the vocal cords, but the examination was unsatisfactory and the animal died from an overdose of anaesthetic shortly afterwards. It was suspected that the stridor was due to a paradoxical movement of the vocal cords.

FIG. 19.—Hussar monkey (Experiment VII). Recurrent laryngeal-phrenic end-to-side anastomosis. The anastomosis was done by the method of lateral incision of the phrenic nerve.

It may be added that the microscopical examination shows regeneration of axis cylinders in both recurrent laryngeal nerves and in both phrenic nerves below the anastomoses. All the

FIG. 20.—Baboon. Recurrent laryngeal nerve anastomosis, end-to-side, to the root of the phrenic nerve coming from the fourth cervical nerve (Experiment X). Death three months and twenty days after operation. B. The nerves removed after death. A. Microscopical sections. ($\times 10$.)

after this laryngoscopic examination the monkey became ill and was destroyed by ether inhalation. Before death ensued the right recurrent laryngeal nerve was exposed and stimulated with the faradic current. The results were as follows:

Undivided recurrent laryngeal nerve:—(a) Weak current: both cords move equally. (b) Somewhat stronger current: strong adduction of opposite cord.

Divided recurrent laryngeal nerve:—(a) Proximal end: strong adduction of opposite cord. (b) Distal end—weak current: adduction of both cords. Somewhat stronger current: powerful adduction of opposite cord.

intrinsic muscles of the larynx appear to the naked eye to be in a healthy state, though the microscopical examination of each intrinsic muscle is not yet complete. It is to be noted that the distal part of the descendens noni nerve was not united to the lower border of the hypoglossal; this was a mistake in the operation; the animal had a long neck, but it was believed, however, that the descendens noni was divided below the origin of the nerves to the sterno-hyoid and sterno-thyroid muscles. The nerve to the omo-hyoid muscle was divided.

The following three experiments illustrate the difficulty, even when every care is taken, of keeping monkeys alive for the long periods of time required for final results to be obtained in nerve anastomosis experiments.

EXPERIMENT IX.—Baboon.

*Operation (Left Side).—*Recurrent laryngeal-phrenic end-to-side anastomosis.

Three months later the left vocal cord showed no movement during tranquil respiration, but its border was straight and it had recovered its tone. A week

It is difficult to explain these movements of the vocal cords, but the same results were obtained in a similar case in which the recurrent laryngeal nerve on the side opposite to the one stimulated had been anastomosed to the phrenic nerve. It is worthy of note that though the left vocal cord was devoid of movement in tranquil respiration, yet when the opposite recurrent laryngeal nerve was stimulated by the faradic current its excursions were much more marked than those of the vocal cord on the normal side. It is therefore clear that a nerve current was already capable of passing through the recurrent laryngeal-phrenic anastomosis.

EXPERIMENT X.—Baboon.

Operation (Right Side).

—Recurrent laryngeal-phrenic end-to-side anastomosis. The end-to-side anastomosis was to the root of the phrenic nerve from the fourth cervical nerve by the method of median incision. (Figs. 20 and 21.)

Three and a half months later the right cord had regained its tone—border straight. Dr. Eidinow examined the movements of the diaphragm by means of the radiographic screen; and reported that the right half of the diaphragm was contracting normally.

The animal was taken suddenly ill and died a few days later.

EXPERIMENT XI.—Baboon.

Operation.—Recurrent laryngeal-phrenic end-to-end anastomosis. The end-to-end anastomosis was to the proximal part of the divided root of the phrenic nerve from the fourth cervical nerve.

One month later the animal died of tuberculosis.

[A full description of the method of taking the cinematograph pictures will be contained in the second part of the paper to be published next week.]

REFERENCES.

¹ *British Journal of Surgery*, vol. xiii, 1926. ² *Medical Times and Gazette*. ³ See Riegel's case quoted by Morell Mackenzie, *Diseases of the Nose and Throat*, p. 451. ⁴ *Archives of Surgery*, 1926, vol. 12, p. 85.

TRAUMA AS A CAUSE OF AURICULAR FIBRILLATION:

ITS MEDICO-LEGAL SIGNIFICANCE.

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Is trauma or physical strain to be accepted as an exciting factor in the production of auricular fibrillation?

This is a matter of considerable practical importance because of its medico-legal bearing, apart altogether from the obvious clinical interest. In the valuable and helpful book by Dr. E. M. Brockbank on *Incapacity and Disablement in its Medical Aspects* the author states quite definitely that he has "never met with a case in which auricular fibrillation could be attributed to sudden strain," and expresses the view that he would be "very unwilling to believe that strain could cause it." Since there is nothing to suggest that he has in mind the effect of strain on a healthy heart we can only conclude that he holds the view that strain will not induce fibrillation, even in a heart damaged by disease.

Our experience is contrary to that of Dr. Brockbank, and we feel that it is desirable to put on record a few cases in which the advent of fibrillation might reasonably be ascribed to trauma or physical strain.

The view is generally held that fibrillation, as met in clinical practice, is always superimposed upon a pre-existing pathological change in the heart. This probably holds good in the large majority of cases. It is open to doubt, however, whether there are not exceptions to this rule. Even granting that some myocardial change must precede fibrillation, the medico-legal question is simply whether physical effort does not prove in some instances the determining factor in its onset. And it must be remembered that once fibrillation has begun it tends to persist.

Auricular fibrillation is an added disability and is sudden in onset, though the ensuing cardiac failure resulting from the fibrillation may take time to develop and manifest itself.

That auricular fibrillation is a disability *per se* is beyond question. This is clearly shown in those patients in whom the fibrillation is paroxysmal, who know when an attack begins, and who are conscious both of the onset and the offset of the fibrillation. Such patients are clearly aware of an increased liability to shortness of breath on effort. They have no delusions in regard to the matter; previous to the onset of the disorderly rhythm they can undertake physical effort without distress, but while fibrillation is present such physical effort cannot be undertaken with comfort. When an attack is over (after a short period of subsequent exhaustion) the reserve is again unimpaired. Whatever the pathological changes in such a heart they are in existence before an attack, during an attack, and after an attack. The factor responsible for the disability is the onset and the presence of fibrillation. When that disappears the heart is back again to its old standard.

It is the ventricles which do the work of the heart. They are the pump. Their health or disease has nothing to do with the inception of fibrillation of the auricles. Their