ANASTOMOSES BETWEEN THE RECURRENT LARYNGEAL AND PHRENIC NERVES.

The Condition of the Intrinsic Muscles and Nerves of the Larynx of a Rhesus Monkey more than Three Years, and Two Years, after Operation.

BY

LIONEL COLLEDGE, M.B., B.Ch.Camb., F.R.C.S.,

SURGEON, EAR AND THROAT DEPARTMENT, ST. GEORGE'S

HOSPITAL;

AND

SIR CHARLES BALLANCE, K.C.M.G., M.S., F.R.C.S.,

CONSULTING SURGEON, ST. THOMAS'S HOSPITAL.

(With Special Plate.)

The Operations.

Right Side.—Recurrent laryngeal-phrenic end-to-side anastomosis performed three years and four months before death. A longitudinal incision was made in the middle of the phrenic nerve; the divided distal end of the recurrent laryngeal nerve was inveigled into the slit in the phrenic nerve and fixed by one stitch of the finest catgut. On direct examination of the larynx the right vocal cord was seen to be paralysed.

FIG. 1.—Rhesus monkey. Recurrent laryngeal-phrenic anastomosis—end-to-side. (Small median incision made in middle of phrenic trunk.)

FIG. 11.—Rhesus monkey. Recurrent laryngeal-phrenic end-to-end anastomosis. No anastomosis of distal part of phrenic to any other nerve.

Left Side.—Recurrent laryngeal-phrenic end-to-end anastomosis performed two years before death. The cut ends of the two nerves were brought together by one stitch of the finest silk (Van Horn, arterial). On direct examination of the larynx the left cord was seen to be paralysed, while the right cord was moving normally. The distal end of the divided phrenic nerve was not anastomosed to any other nerve.

Result of the Experimental Operations.

(A) **The Vocal Cords.**—Six months after the operation on the right side the right vocal cord was moving synchronously with the left. Six months after the operation on the left side the left vocal cord showed a wider abduction movement than the right. It must be remembered that on the left side the recurrent laryngeal nerve had been attached to the whole phrenic nerve. Thus while the excursion of the right cord, following end-to-side anastomosis, was approximately normal, the excursion of the left cord following end-to-end anastomosis was greater than normal. One week before the death of the monkey Sir David Ferrier, Professor Cushing, and Dr. Dale saw the movements of these vocal cords through the direct laryngoscope, and the greater movement of the left vocal cord was still evident. The movement of the vocal cords was filmed,¹ and the wider abduction excursion of the left cord was demonstrated in the film.

(B) **The Diaphragm.**—It was obvious on inspection of the abdominal wall that the right half of the diaphragm was contracting while the left half was paralysed. Professor Elliot Smith, Dr. Beattie, and Mr. Melville examined the movements of the diaphragm by means of the radiographic screen.² Their report states that all parts of the right half of the diaphragm were contracting equally and

well, and that there is no contraction of any part of the left half of the diaphragm, the cupola moving upwards and downwards with respiration. After the left half of the diaphragm was paralysed it was noticed that the monkey never regained the power of moving and jumping rapidly about the large cage in which he was confined. At no time did this monkey suffer either from stridor and difficulty in breathing, or from paradoxical movement of the vocal cords.

Necropsy.

(A) **The Diaphragm.**—The right half of the muscle of the diaphragm was thick, firm in texture, red in colour, and of normal appearance. The left half of the muscle of the diaphragm was thin, light pink in colour, and flabby in texture. Joining the left phrenic nerve in the thorax (below the site of section) was a small nerve which arose from the brachial plexus. This root of the left phrenic nerve was not seen at the operation. The left phrenic nerve below the site of division was smaller than the right phrenic nerve.

DESCRIPTION OF PHOTOMICROGRAPHS ON PLATE.

Note.—The right recurrent laryngeal nerve was divided and the distal end anastomosed with the phrenic nerve three years and four months before the death of the monkey. The left recurrent laryngeal nerve was divided and the distal end anastomosed with the phrenic nerve two years before the death of the monkey.

FIG. 1.—Left crico-arytenoideus posticus muscle ($\times 850$). Note the transverse striation of the muscle. Cajal stain.

FIG. 2.—Right crico-arytenoideus posticus muscle ($\times 850$). Note the transverse striation of the muscle. Cajal stain.

FIG. 3.—Left crico-arytenoideus posticus muscle ($\times 400$). Note the end organs and nerve fibres. Cajal stain.

FIG. 4.—Right crico-arytenoideus posticus muscle ($\times 350$). Note the perfection of the end organ on the side of the striated muscle fibre, also the nerve fibres. Cajal stain.

FIG. 5.—Left crico-arytenoideus posticus muscle ($\times 400$). Note regenerated bundles of nerve fibres in muscle. Cajal stain.

FIG. 6.—Right crico-arytenoideus posticus muscle ($\times 400$). Note regenerated bundles of nerve fibres in muscle. Cajal stain.

FIG. 7.—Left crico-arytenoideus lateralis muscle ($\times 850$). Note the transverse striation. Cajal stain.

FIG. 8.—Right crico-arytenoideus lateralis muscle ($\times 850$). Note the transverse striation. Cajal stain.

FIG. 9.—Left thyro-arytenoideus muscle ($\times 850$). Note the transverse striation. Cajal stain.

FIG. 10.—Right thyro-arytenoideus muscle ($\times 850$). Note the transverse striation. Cajal stain.

FIG. 11.—Arytenoideus muscle ($\times 850$). Note the transverse striation. Cajal stain.

FIG. 12.—Left recurrent laryngeal nerve ($\times 850$). Note regeneration of axis cylinders. Cajal stain.

FIG. 13.—Right recurrent laryngeal nerve ($\times 1,000$). Hardened in Müller's fluid and stained by the Weigert and Strobo methods. Reticular appearances (neuro-keratin) in the medullary sheaths. The axis cylinders are coloured as well as the neuro-keratin network. "There is reason to believe that the apparent reticular structure is due to the way the myeline constituents have undergone coagulation and separation under the influence of the hardening reagent." The nerve has regenerated.

(B) **The Larynx.**—The intrinsic muscles on both sides were dissected and separately placed in hardening fluid. The small nerve going to each muscle was demonstrated, and as each muscle was defined a portion of the nerve passing to it was divided. Thus each small muscle was placed in the hardening fluid with a portion of its nerve attached. Each of the muscles appeared to be plump, normal in appearance, and red in colour.

(C) **The recurrent laryngeal and phrenic nerves** were also preserved.

Remarks on Striated Muscle.

On examining the microscopic sections of the intrinsic muscles of the larynx the pattern of the striation is seen to vary. It is hardly to be supposed that the striation of the different muscles is essentially different. The authorities agree that the microscopical appearances of muscle in contraction are not the same as when relaxation is present; indeed, Starling states that in contraction there is an apparent reversal of the situation of the light and dark stripes. According to Engelmann the isotropic (singly refracting) part diminishes in volume in contraction, while the anisotropic (doubly refracting) part increases. The real meaning of striation is unknown. This is not essential to contraction, for unstriated muscle contracts. The main difference between the two classes of muscle is that the

LIONEL COLLEDGE AND SIR C. BALLANCE: ANASTOMOSES BETWEEN THE RECURRENT
LARYNGEAL AND PHRENIC NERVES.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7.

FIG. 8.

FIG. 9.

FIG. 10.

FIG. 11.

FIG. 12.

FIG. 13.

LIONEL COLLEDGE AND SIR C. BALLANCE: ANASTOMOSES BETWEEN THE RECURRENT
LARYNGEAL AND PHRENIC NERVES.

FIG. 14.

FIG. 15.

FIG. 16.

A. WATT, R. C. J. MEYER, AND A. CAMPBELL: OPERATION FOR PITUITARY TUMOUR. (See p. 748.)

FIG. A.—Showing position of the tumour.

SYDNEY SMITH: IDENTIFICATION FROM A FINGER-TIP REMOVED BY A BITE. (See p. 757.)

FIG. 1.—Tip of finger removed by bite.

FIG. 2.—Finger-print of right index finger of accused.

typical cross striated muscle fibre is dependent on the impulses from the central nervous system to set it into activity.

The Stimulation of the Cortex Cerebri.

Before the monkey was killed the right cerebral cortex was stimulated with the faradic current, a Sherrington single electrode being employed for the purpose (see Fig. 16).

DESCRIPTION OF PHOTOMICROGRAPHS ON PLATE.

FIG. 14.—Photomicrograph of muscle bundles in right half of diaphragm ($\times 700$). Three years and four months after recurrent laryngeal-phrenic end-to-side nerve anastomosis: showing that this method of operation has left no permanent effect on this half of the diaphragm.

FIG. 15.—Photomicrograph of muscle bundles in left half of diaphragm ($\times 350$). Two years after recurrent laryngeal-phrenic end-to-end nerve anastomosis. The distal end of the phrenic nerve was not anastomosed to any other nerve. No transverse striation is shown in the photograph. On examining many other sections faint striation of a muscle bundle was occasionally seen, and this perhaps was due to the fact revealed at the autopsy that below the point of section of the phrenic nerve a small nerve from the brachial plexus joined the phrenic nerve in the thorax.

FIG. 16.—Drawing of right half of brain of the monkey (natural size). A, Faradic stimulation of the cortex at this point caused elevation of the upper lip on the left side. B, Stimulation of the cortex at B caused abduction of the vocal cords. Unfortunately the point of the cortex at which the maximal adduction movement of the vocal cords occurred was not marked. It was in front of the area which on stimulation caused abduction of the vocal cords. The adduction movement was much stronger than the abduction movement, which was distinct from the abduction movement associated with the respiratory rhythm.

The cortical areas stimulated correspond to those originally defined by Semon and Horsley. The interest of the cerebral stimulations carried out by us is that the nerve impulses passed along the phrenic nerve, then through the phrenic-recurrent laryngeal end-to-end anastomosis to the recurrent laryngeal nerve and intrinsic laryngeal muscles.

Semon and Horsley³ showed that unilateral stimulation invariably produces bilateral effect. They at first thought that there was no abduction centre in the brain cortex, but they demonstrated that direct excitation of the accessory nucleus in the medulla always evoked abduction of the vocal cords. They found no difficulty in evoking complete bilateral adduction movement of the vocal cords by stimulating an appropriate area of the cerebral cortex. If the stimulation is prolonged the "besoin de respirer" overcomes the influence of the artificial stimulus and evokes a powerful abduction movement of the vocal cords. They explained these diverse effects in this way: Phonation (that is, adduction) is a purposive or volitional act, while abduction is essentially related to the so-called automatic processes of organic life—that is, abduction serves inspiration.

In the later paper these authors show that there is a definite area on the cortex of the brain, stimulation of which causes abduction of the vocal cords. They point out that Krause (1878) was the first to localize the phonatory area in the cortex of the dog's brain. Ferrier, however, had previously reported that excitation of a certain cortical area in the dog elicited barking. Risien Russell⁴ described separate areas of the cortex of the brain in which excitation evoked the movements of abduction and adduction of the vocal cords. Risien Russell also separated the abductor from the adductor nerve bundles in the recurrent laryngeal nerve—the abductor fibres being situated on the inner side of the nerve, while the adduction fibres are on the outer side. Stimulation of the abductor fibres produced unilateral abduction movement only, while division of the abductor fibres caused atrophy of the corresponding abductor muscle. We have been unable to separate the abductor nerve bundle in the way described by Risien Russell.

Operation in Man.

It would appear that the proper operation to perform in man in cases of paralysis of a vocal cord is recurrent laryngeal-phrenic nerve end-to-side anastomosis. This has been successful in the one case in which this operation has been carried out.⁵ Independent of the cases in man in which by stab or gunshot wound, or during an operation, the recurrent laryngeal nerve has been divided, and in which an immediate anastomosis should be effected, we are of opinion that if a vocal cord (or cords) has been para-

lysed for three months with no sign of improvement in the condition, a recurrent laryngeal-phrenic nerve anastomosis should be forthwith carried out.

Note.—Figures showing regeneration of the phrenic and recurrent laryngeal nerves after similar anastomoses had been effected were published in the *British Medical Journal*, March 26th, 1927 (see Figs. 5 and 6 in plate facing p. 555).

The experimental nerve anastomoses were carried out at the National Institute for Research, Mount Vernon, Hampstead. The microscopic specimens and photomicrographs were prepared by Miss Glascock and Mr. Stewart at the Royal College of Surgeons.

REFERENCES.

- ¹ See *British Medical Journal*, March 26th and April 2nd, 1927. ² *Ibid.*, April 2nd, 1927. ³ *British Medical Journal*, 1889, and *Trans. Roy. Soc.*, 1890, B. ⁴ *British Medical Journal*, 1892, and *Proc. Roy. Soc.*, 1895. ⁵ *British Medical Journal*, July 30th, 1927, p. 158.

OPERATION FOR PITUITARY TUMOUR.

REPORT OF A CASE.

BY

ANDREW WATT, M.B., F.R.C.S., R. C. J. MEYER, M.D., F.R.C.S.,

AND

ANDREW CAMPBELL, M.B., F.R.C.S.,

GENERAL HOSPITAL, JOHANNESBURG.

(With Special Plate.)

A EUROPEAN, aged 23 years, complained that during the last five or six years his left eye had been noticeably weaker than the right. In November, 1926, he suffered from severe headaches when reading for an examination. In February, 1927, when marking the register, he found that when he thought the pen was touching the book it was actually about an inch away from it; he was unable to see with the left eye alone. There was no complaint of headache, no vertigo, and no vomiting. At the beginning of April Dr. Meyer was consulted, and the patient was sent into hospital for investigation under Dr. Andrew Watt.

The previous history showed that the patient had fallen off a horse in 1918, but though unconscious for some time he suffered no other ill effects. In 1919 he had influenza. In 1920 he was hit over the left eye by a cricket ball. There is no family history of nervous or eye trouble, and the father, mother, brothers, and sisters are all well. He smokes ten to fifteen cigarettes daily and is a total abstainer. His condition on admission to hospital was recorded as follows.

The patient is a well-built, healthy looking individual, about 5 ft. 8 in. tall. There is no abnormality in his gait and the grips of both hands are normal. There is no tremor; the motor functions and the various reflexes are normal, as is sensation. The bowels are regular and the appetite is good; there is no frequency of micturition, and urine analysis reveals nothing abnormal. The heart and lungs are sound, and the Wassermann reaction is negative.

Examination of the cranial nerves shows the sense of smell to be normal; vision is impaired, pupils react to light and accommodation, there is no ocular paresis, no nystagmus, and no strabismus. There is no anaesthesia of the face or scalp. The functions of the seventh nerve are normal, and there is no impairment of taste. The movements of the tongue and swallowing are normal. The basal metabolic rate is normal.

Blood sugar before glucose meal (200 grams)	0.11 per cent.
" " 30 minutes after glucose meal ...	0.16 "
" " 60 " " " " " " " "	0.14 "
" " 90 " " " " " " " "	0.13 "
" " 120 " " " " " " " "	0.14 "

Sugar was not found in the urine before the glucose meal, but a trace was present two hours after. The cerebro-spinal fluid was under a pressure of 250 mm. water. The globulin was not in excess of the normal, and the sugar percentage was 0.09. The sodium chloride figure was 720 mg. per 100 c.cm. No characteristic curve was obtained with gold solution. A cell count yielded a total of two lymphocytes per c.mm.

A blood count taken on June 18th was as follows: haemoglobin 95 per cent.; colour index 0.98; red cells 5,810,000; leucocytes 8,000; polymorphonuclears 52 per cent.; large mononuclears 2 per cent.; lymphocytes 46 per cent. The red cells showed slight anisocytosis with a very moderate degree of polychromasia.

The patient was referred to Dr. Campbell for examination of the ear, nose, and throat, and for the vestibular tests. Both drumheads were retracted, and he could hear a whisper at over 16 feet on both sides. Tuning-fork tests were normal. There was no spontaneous nystagmus, no spontaneous past-pointing, and