Observations

ON THE

ALTERATION OF THE CIRCULATION OF
THE BRAIN BY SURGICAL MEANS
IN DISEASES OF THE CENTRAL
NERVOUS SYSTEM

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(With Special Plate)

It is a well-known principle underlying the physiology of the central nervous system that hyperactivity accompanies slight degrees of asphyxia or anoxaemia. The operation of this principle suggested itself to me when I had observed the results following a sympathetic thoracic trunk section on a patient suffering with extensor spasm. I was demonstrating the ipsilateral effects showing how the ipsilateral forearm fell when released from the perpendicular position, when to my surprise the contralateral forearm fell much more rapidly. The operation of sympathetic thoracic trunk section profoundly alters the cerebral circulation, and the result I had observed was explained by the change in circulation in the opposite side of the brain. It then occurred to me that in paralysis agitans, spastic hemiplegia, and other conditions, I had been operating upon the side of the manifestation of the lesion instead of on the side of the lesion in the brain. This reflection opened up a new aspect of the surgery of the sympathetic nervous system—that of changing the reflex activity of the central nervous system by altering the blood supply of the brain rather than attempting to change its peripheral manifestations by cutting peripherally directed rami of the sympathetic nervous system. The following paper is an account of the technique and results of sympathetic thoracic trunk section in various surgical operations and laboratory experiments.

EXPERIMENTAL EVIDENCE

The control of the cerebral blood vessels by the sympathetic nervous system has long been disputed. Forbes and Wolff,¹ as a result of carefully planned experiments, conclude that: "It seems justifiable to state that evidence of a quantitative nature has been obtained that the circulation of the mammalian brain is controlled in part by cerebral vasomotor nerves." I repeated this experiment, and found on stimulating the cervical sympathetic trunk in the region of the stellate ganglion that there was a constriction of the vessels of the brain, and that the brain visibly shrank away from its parietes. Taking these observations into consideration, I divided the thoraco-cervical sympathetic trunk on the left side at its exit from the thorax in a goat. This led to a rise in temperature on the left side of the face and ear, partial collapse of the left nostril, and movement of the whole lower jaw to the right side; the left eyelid drooped. These were ipsilateral effects, but there were also contralateral effects. Under the influence of ether anaesthesia changes in the behaviour of the limbs and head were noticed. At a certain stage of anaesthesia the limbs of the goat become rigid, as in decerebrate rigidity; as a result of cutting the cervical sympathetic trunk a change in this behaviour occurs.

The trunk was cut on the left side, and when the animal was placed on its back, with its head held in the middle line, the contralateral limbs exhibited a loss of tone. Extension did not appear in them, and there was a com-

plete loss of resistance to passive movements. In other words, the "elastic contraction" and "plastic contraction" of Sherrington were absent on the right side, but present on the left. When the hind limbs were stretched in a horizontal direction and were suddenly released the flexor muscles of the left hind limb underwent a myotatic contraction, but the position of extension was more or less maintained. The right hind limb on being released went straight back into the flexed position, exhibiting the phasic, but not the postural, part of the myotatic reflex. When both limbs were flexed the right hind limb was more abducted than the left. The fore limbs also showed a contrast in behaviour in respect to passive movements and posture. Extension at the shoulder in a perpendicular direction appeared on the left side, while the right limb fell flaccid under the influence of gravity. The muscles of the neck controlling the position of the head behaved peculiarly. Instead of being flaccid on the right or contralateral side when the animal was lying on its ventral aspect, the muscles of the right side of the neck and head pulled the head into rotation and lateral flexion to the right. If this action were controlled from the cortex or midbrain, or as low down as the medulla, the head should have turned to the left, as this was the side on which the limbs exhibited excessive tone. This would have been consistent also with de Kleijn's observation, in which tone was increased on the side to which the head turned.

The centres for reflex lateral flexion and rotation of the neck are in the first, second, and third cervical segments. Therefore, in the case of this animal, these centres were hyperactive on the right side, and this was the side with the blood supply unaltered—that is, a certain degree of vaso-constriction was present. When the skull was carefully opened, and the dura cut away from the exposed brain, a difference in the condition of the cerebral hemispheres was at once apparent. On the ipsilateral side the blood vessels were smaller and anastomoses less frequently seen than on the contralateral side (Fig. 1 on Plate). The whole of the contralateral side appeared congested and bluer than the ipsilateral. This was not what I expected to find, since the previously quoted experiments showed a vaso-constriction on stimulating the sympathetic nerves, but it must have been due to dilatation of the venules ensuring greater drainage. The pulsations were greater on the ipsilateral side, and after an interval of about fifteen minutes the ipsilateral cortex gradually shrank away from the skull. The shrinkage could not have been due to pressure of the atmosphere alone, since it did not affect the contralateral side, which was also exposed. Similar consistent phenomena have been observed in eight animals.

The Decerebrate Animal

A left thoracic sympathetic trunk section was performed in a second goat ten days before decerebration; a left lumbar sympathectomy had been performed about six months before, which led to a loss of resistance to passive movements in the left hind limb. When the skull was opened to carry out the operation of decerebration, similar changes to those described in the first animal were noticed, although the common carotid arteries had been ligated low down in the neck. The whole of the right-side vessels were larger, and there were more numerous visible anastomoses on the right side of the brain than on the left. This indicates again that there was better drainage in the left side, as it is principally veins which appear on the surface of the brain. After decerebration the animal was placed on its back; extension appeared in the left limbs, but the right limbs remained flexed. This was a contrast to the difficulty in flexing the limbs of the left side. The right-sided limbs took up the position determined by

gravity, while the limbs on the left side remained extended. If both were simultaneously stretched in a perpendicular direction, the left would remain extended, while the right fell under the influence of gravity. It will be noticed that extension appeared in the left hind limb in spite of the ramisection which had been previously performed. Similar differences in behaviour were exhibited by the fore limbs.

When the animal was placed in the ventral attitude the movement of the head was again peculiar, and similar to that described in the previous experiment. Instead of turning to the left, as might be expected from the behaviour of the limbs, the head flexed laterally and rotated to the right—the side on which the limbs were flaccid. Since the nerves controlling the limbs, head, and neck decussate in the pyramids, this showed that the centre for this movement was below the decussation of the pyramids. In the decerebrate animal the centre for extension is somewhere caudal to the superior colliculi. In the movement of the head extension was not a dominant feature, but the head was held in a semi-extended position while the movements of rotation and

FIG. 3.—Showing relation of phrenic nerve to brachial plexus.

lateral flexion with a moderate degree of extension were performed. When "elastic contraction" was not present the left hind limb took up a position similar to that of the right hind limb, while the fore limbs exhibited the differences that were previously noted. This is in keeping with previous experiments.²

OPERATIVE PROCEDURE IN MAN

The actual and possible applications of the surgical alteration of the circulation of the brain by operations on the sympathetic nervous system in treatment of diseases of the central nervous system are many and varied. A clear conception of the results and rationale can be grasped only by understanding the operative procedure.

The sympathetic nerve supply of the upper limb and brain comes from the upper thoracic region of the spinal cord. This supply reaches the upper limb through the post-ganglionic fibres coming from the first and second thoracic ganglia and from the inferior and middle cervical ganglia. The sympathetic nerve supply reaches the brain by the cervical sympathetic trunk, and also by the sympathetic fibres supplied to the carotid and vertebral arteries from the superior thoracic ganglion and inferior cervical ganglion. All of these are post-ganglionic in their distribution—that is, they go to some peripheral structure, but have no connexion with the central nervous system

directly. There is an occasional branch from the second thoracic ganglion to the first thoracic nerve.

Operation of Thoracic Sympathetic Trunk Section

The incision is made across the insertion of the sterno-mastoid in a slightly upward and lateral direction for about five centimetres; the platysma is split longitudinally. The external jugular vein may usually be avoided, but if it crosses the wound it should be divided and ligated. A dissection through the cervical fascia displays the sterno-mastoid muscle, and on a slightly deeper plane is seen the omohyoid muscle. Both these muscles are retracted medially, though occasionally it is necessary to retract the omohyoid laterally. The deep layer of the cervical fascia must then be opened to display the nerve roots of the brachial plexus and the scalenus anterior muscle (Fig. 3). This muscle is then evulsed piecemeal with the strabismus hook. The phrenic nerve should be avoided as it passes from above downwards and inwards on the anterior surface of the scalenus anterior. After the scalenus anterior has been evulsed Sibson's fascia comes into view. This must be broken

FIG. 4.—Showing diagrammatically relation of first thoracic ganglion.

through with the point of the finger or with a dissector to display the parietal layer of the pleura covering the apex of the lung. The thoracic sympathetic trunk must be sought on the medial and posterior wall of the space thus exposed. The subclavian artery is drawn downwards and the sympathetic trunk may be found by displaying the vertebral artery. The sympathetic trunk lies immediately posterior, though sometimes it is placed laterally, to this vessel. Dissection, with a small swab of gauze on a pair of forceps along the postero-medial side of the space, will reveal the trunk as it crosses the space between the first and second ribs (Fig. 4).

The trunk is then lifted with a blunt strabismus hook, and may be torn through with a sharp hook just above the second thoracic ganglion. If it is desirable to take out the whole of the supply to the brain, the branches of the first thoracic ganglion are divided and the ganglion removed. This is easily done if the trunk on the strabismus hook is followed upwards. This confers upon the patient a Horner's syndrome. The occasional ramus from the second thoracic ganglion to the first thoracic nerve may be seen crossing the first intercostal space, and may be divided if it is desired to divide the whole sympathetic supply to the ipsilateral upper limb. If an alteration in the cerebral circulation only is desired, this ramus may be left intact.

IMMEDIATE CHANGES FOLLOWING THORACIC SYMPATHETIC TRUNK SECTION

These are:

1. Diminution of tone on the same side of the face and muscles of the upper limb. This is shown by the diminution in the size of the naso-labial fold, and by a collapse of the angle of the mouth and of the nostril of the same side. It is also seen in the sacro-spinalis and trapezius muscles at their attachments to the occiput. On the side of the trunk section the muscles will be found to be slacker than on the opposite side.

2. Sluggishness in the fall of the eyelid on the side of the division of the sympathetic trunk as compared with the rate of fall on the other side. This is best seen in light anaesthesia.

3. Contraction of the pupil. This is not a constant sign if the sympathetic trunk alone is divided below the first thoracic ganglion. It certainly follows removal of the first thoracic ganglion. The whole eye is retracted following trunk section.

4. Cessation of sweating on the same side of the face and forehead and upper limb. This is a most valuable immediate sign of division of the thoracic trunk, and a difference in sweating in the two sides of the face appears even when the patient has had a preliminary dose of atropine.

5. Circulatory changes. Immediately after the operation of thoracic sympathetic trunk section the colour of the same side of the face is paler than that of the other side. This is particularly noticeable if the patient is cyanosed. The ear on the same side appears pink and on the opposite side a bluish colour. The colour of the ipsilateral limb will be pinker than the contralateral limb, but in a few days becomes paler. This indicates an increase in the circulation through dilatation of the arterioles and venules. Changes in cerebral circulation remain constant after a few days. The capillaries regain their tone, but the arterioles remain dilated, thus leading to a lowering of blood pressure with an increase in circulation. As already described this is distinctly shown in the goat, in which a venous congestion is present on the contralateral side after trunk section while the animal is under anaesthesia. This appeared even at the end of fourteen days after sympathetic thoracic trunk section. The whole brain is bluer compared with the paler colour on the ipsilateral side, and the venous vessels appear to be more numerous on the contralateral side.

6. The temperature of the ipsilateral limb and of the side of the face is higher than that of the contralateral limb and face.

7. When the patient has recovered from anaesthesia the lid of the eye on the same side will be found to be drooped. This is not always permanent, but the lid takes up a less drooped position in about fourteen days.

From the above ipsilateral results of trunk section it will be seen that the description of Horner's syndrome should be altered, as it consists not only of retraction of the eye, a contracted pupil, and ptosis of the upper lid, but there are changes in the facial musculature as well (Fig. 2 on Plate). The changes in the ipsilateral facial musculature and in the ipsilateral muscles of the neck are due to increased blood supply of the reflex arc of the cervical cord and of the facial nucleus.

CHANGES IN THE CONTRALATERAL SIDE

The chief contralateral effect following thoracic sympathetic trunk section is a change in tone in the whole side, but this is not so noticeable in the face. While the patient is under anaesthesia this change in tone is greater in the contralateral limbs. This is shown by the rate of fall of the forearm from the perpendicular to the horizontal

position. If both forearms be flexed at the elbow and allowed to fall simultaneously the contralateral forearm will reach the horizontal before the ipsilateral. Although tone is decreased in the ipsilateral limb the degree is not so great as in the contralateral limb, due to the complete abolition of tone in this limb while the patient is under anaesthesia. A similar effect is shown in the behaviour of the lower limbs. When both are lifted off the bed while the patient is under light anaesthesia and in a condition similar to a decerebrate animal, the contralateral limb falls first. The clonus exhibited by spastic limbs also disappears or is modified after thoracic trunk section. The same effect was noted in the conscious state in one patient suffering from post-encephalitic rigidity. He found that the contralateral great toe could be flexed more easily, and at rest occupied a less dorsiflexed position, than the ipsilateral great toe, although both occupied similar positions before operation, and that if both legs were dropped simultaneously when he was in the sitting position, the contralateral reached the ground first. In another case greater range of passive movement appeared in the ankle-joint. There was so great a diminution of rigidity that the patient was able to perform active movements of dorsiflexion with ease, whereas these had been difficult previously. There is also evidence of diminution of tone.

The effect of increased tone is seen in the slow movements of those affected with Parkinsonian rigidity; this is due to a failure of reciprocal innervation. The intrinsic muscles of the hand are usually so affected that the movements are impeded or rendered impossible by an abnormal increase in tone. The loss of balance is sometimes a manifestation of the same cause and effect. The patient is unable to effect rapid changes in contraction of his muscles, and so is unable to compensate for changes in the centre of gravity. The actual practical result following bilateral trunk section in one patient suffering from the effects of encephalitis was resumption of walking and the ability to feed himself after three years of incapacity.

A loss of rigidity on the contralateral side is the result of division of the thoracic sympathetic trunk, and this effect becomes pronounced as time goes on. This is less noticeable in Parkinsonian rigidity than in congenital spastic hemiplegia and congenital spastic paraplegia, in which the initial changes are in the cerebral circulation.

LOSS OF TREMOR

This effect is seen in Parkinsonism with tremor. There is an immediate diminution of tremor, which ceases altogether in a few days' time. With the recovery of capillary circulation (which takes about four days) the tremor reappears temporarily in a modified form, and the patient has greater control over it than before operation. When tremor is exaggerated diminution only may be expected from treatment.

The tremor of Parkinsonism ceases with the onset of hemiplegia of vascular origin and returns as the latter condition clears up. It is also abolished by the lightest anaesthesia—only a few breaths of ether being necessary to obliterate it. Its association with excitement, together with the facts mentioned above, lead me to suggest that the tremor of Parkinsonian rigidity is cortical in origin.

DISCUSSION OF TONE

As a result of my observations I believe that tone is bound up in some way with the function of the sympathetic nervous system, since there is a loss of resistance to passive movement and an alteration in posture after division of the rami communicantes or the thoracic sympathetic trunk. Tone is reduced by cutting the peripheral sympathetic nerve fibres subserving the blood supply of the spinal cord or by cutting the nerves subserving the blood supply of the brain. Spasm, such as

seen in extensor spasm, is an aspect of the function of the midbrain. It is not abolished by cutting the sympathetic nerves, which alters the blood supply of the spinal cord, and this is a point where inaccuracy of description and observation has led to a diversity of opinion. The loss of resistance to passive movement which I have already described^{2,3} and also described by Gilbert Phillips,⁴ is an expression of loss of tone, and this tone is distinct from extensor spasm or "elastic contraction." Tone is thus a reflex function of the spinal centres. The presence of shortening reactions indicates that a certain degree of "elastic contraction" is present. In the absence of "elastic contraction," as in the spinal animal, there is a resistance to passive movement in both flexors and extensors which is lost after section of the sympathetic nerves, and this activity should, in my opinion, be called "tone," leaving the term "postural tone" to be applied to that activity of the midbrain which subserves posture.

The frightened child will go into spasm under inspection, and this spasm, if continued, will mask any alteration in tone. The decerebrate animal shows both spasm and increased tone. The extension imposed upon the animal by the reflex activity of the midbrain may be increased by depriving it of oxygen and decreased by insuring a good supply of fresh air. This extension is often so forceful that it is impossible to flex the limb. This is the "elastic contraction" of Sherrington, as opposed to his "plastic contraction," which appears when the extending element is not so strong and when lengthening and shortening reactions may be obtained with ease. The alteration in the state of the muscles of the limb influenced by changes and position of the head, as described by Magnus and de Kleijn, are not changes in tone, but are of the nature of elastic contractions or postural activity.

EXPLANATION OF EFFECTS

There are ipsilateral and contralateral effects. The sympathetic fibres of the cervical sympathetic trunk and those going to the brain by the vertebral and carotid arteries are distributed to the arteries and veins of the brain. Therefore the effect of cutting them must be sought in the blood vessels of the brain and of the head and neck. The effect as seen on the skin of the face, head, and upper limbs is to produce a pale, dry skin. This indicates that the change is in the arterioles and venules, but that the capillaries may remain contracted and respond to hormonal or chemical stimuli. According to Lovatt Evans the blood vessels of the brain are usually in a state of dilatation.⁵

I have already described the changes in cerebral circulation following thoracic sympathetic trunk section in the goat. Dr. Brearley has found in human patients who have undergone the operation of sympathetic thoracic trunk section that there is an ipsilateral dilatation in the blood vessels of the retina. The changes seen here are in the arterioles and venules, since the capillaries could not be seen with an ordinary ophthalmoscope.

The presence of a Horner's syndrome is not necessarily associated with dilatation of the vessels of the retina. In one patient with a definite drooping of the lid and a contracted pupil, Dr. Cedric Cohen found no evidence of dilatation of the blood vessels of the retina on the side operated upon. In this patient the ramus of the first thoracic nerve alone had been divided. When there is a defective blood supply to the brain cells their nutrition suffers and the cells may undergo atrophy. A definite train of symptoms seems to be associated with diminished blood supply before cell atrophy supervenes. For example, the lethargy of encephalitis lethargica may be due to defective blood supply of the brain.

I have been able to show that the tremor and rigidity of paralysis agitans may be alleviated by a thoracic

sympathetic trunk section on the contralateral side. The tremor of paralysis agitans is diminished immediately after operation, and becomes progressively ameliorated. In one instance it disappeared in six weeks and in others immediately after operation as long as the patient rested. Exercise, such as walking, was associated with a temporary return of slight tremor. This would look as if the centres concerned in the production of rigidity and tremor are progressively improved, and that the rigidity and tremor are sometimes the result of a defective circulation and not always of sclerosis in these centres. Tremor may arise from increased activity of the cortical cells and rigidity from hyperactivity of the corpus striatum, in each instance due to relative anoxaemia. It must be clearly understood that if the disease has been present for a long period, although the original changes may have been only circulatory, organic cellular changes have been established, the sequence of events being, first, diminished blood supply, and, secondly, cell atrophy. When cell atrophy is present the possibility of a restoration in function by altering the blood supply is remote, as is shown by the results in retinitis pigmentosa.

APPLICATION OF SURGERY OF THE SYMPATHETIC NERVOUS SYSTEM TO MENTAL ABERRATION

My attention was first drawn to the psychic effect of cutting the sympathetic cervical trunk in a patient suffering from spastic hemiplegia. There was an abnormal mental condition in this patient; he was cranky and bad tempered, and not amenable to discipline before operation, and the sister in charge of him noticed that after operation on the opposite side to the lesion in the brain he was quite good tempered and obedient, and became the most willing patient in the ward. This result has been obtained consistently in a large number of instances; it may be attributed to a change in the circulation of the brain. These results, taken in conjunction with experimental evidence of change in circulation, led me to try the effects of cutting the sympathetic nerves in other conditions, including congenital mental deficiency and in lethargy associated with encephalitis lethargica.

APPLICATION TO NEUROLOGICAL CONDITIONS

Congenital Spastic Hemiplegia

The signs of disease exhibited on one side of the body are due to hyperactivity of the opposite side of the brain. The hyperactivity may be in the corpus striatum or in the midbrain or in the cortex of the cerebrum. The accepted theory is that the signs of disease are release phenomena, and that the hyperactivity of the lower centres is due to loss of control from the higher centres; my results show that the hypertonicity of the muscles is probably bound up with hyperactivity associated with alteration in the circulation of the brain. After sympathetic thoracic trunk section the spasm and rigidity of the contralateral limb are very much reduced. In several instances, hands which had exhibited spasm lost this condition, and in many others both elastic and plastic rigidity disappeared in the contralateral limbs.

Congenital Spastic Paraplegia

Formerly I operated on the lumbar sympathetic trunk for spastic paraplegia affecting the lower limbs and of cerebral origin. In this operation the peripherally directed sympathetic fibres were divided in the lumbar region. This led to a definite result, and in a questionnaire to my patients, a good result was returned from 75.6 per cent. (thirty-five patients), but even so the "elastic contraction" was only modified and a certain degree of rigidity remained. Now I divide the thoracic sympathetic trunk to alter the blood supply of whole of the half of the brain,

with the result that there is a greater diminution of tone in the contralateral limbs.

One instance may be quoted. A girl, aged 10, suffered from congenital spastic quadriplegia. She had never walked or stood or been able to sit up properly. Ten days after the second operation she was standing alone, and is now learning to walk. The important point is that her reflex activity returned to normal and the Babinski reaction was decreased in amplitude when the patient was last seen. This result has been seen in every instance of spastic paraplegia in which the contralateral side has been comparable with the ipsilateral lower limb after a unilateral thoracic trunk section. Before operation the patient's legs hung in an extended posture, and shortening reactions were present when she was placed on a couch with the lower limbs extended beyond the supporting surface. After operation the legs hung down with knees flexed in a perpendicular position, and the shortening reactions were absent, though a knee-jerk was obtainable. In this patient both the "elastic" and "plastic" contractions of Sherrington were modified, although the patient still retained the active control of the limbs and normal phasic response to the knee-jerk.

There is no possibility in this procedure of ascribing the changes in reflex activity to injury of the medullated nerves, since the site of operation is in the region of the brachial plexus and the changes I have described are in the activity of nerves of the lumbo-sacral plexus supplying the opposite lower limb. Nor can alteration in blood supply of muscles be held responsible, since the vasomotor nerves of the limb are not cut and there is no interference with the peripheral circulation. In my opinion the changes are due to an alteration of the blood supply of the brain, leading to a depression of the hyperactivity associated with poor blood supply of that organ.

The effect of altering the cerebral circulation in this condition is illustrated by the effects of treatment in the following patient.

A boy, aged 12, had previously walked, but very badly, on account of the extensor spasm of his right lower limb. His right upper limb had a continuous extensor spasm also with flexion of the hand. The severity of the spasm of his right lower limb may be judged from the fact that he had had the tendo Achillis lengthened twice, but unsuccessfully—in Liverpool in 1926 and in Gabowen in 1928. After this, the extensor spasm gradually developed, and when I saw him he was suffering spasms every five minutes, which were present throughout the day. They were so painful that they made him scream, and were so violent that they would throw him out of bed; he could not stand or walk, and had to be fed. The extensor spasm involved his head, back, and all limbs; the condition resembled rigidity of a decerebrate animal. Between the spasms shortening reactions of the knee-jerk were not present, but the spasm did not leave the right lower limb or right hand. It was therefore not a continuous spasm, but when present the patient exhibited opisthotony. The cause of his condition is open to question, but I have seen a similar condition in a child of 3 with spastic chorea.

Extensor rigidity is not uncommon in children, and is characterized by opisthotony and extension of all limbs. It is usually a severe grade of so-called spastic chorea. It may be a congenital condition or it may be developed in early infancy. I have observed it to commence at the age of 2 as irregular twitching movements which gradually developed into extensor spasm.

In this instance the patient was born at full time and seemed well until about 10 months old, when he had a fit. Between the spasms he could control the left hand, but all his life he had been unable to open the right hand. The condition may be due to a tumour or haemorrhage or simply venous congestion in the region of the midbrain. Whatever the cause, the condition was relieved and the relief gave grounds for reflection. The child underwent operation in September, 1930; a sympathetic thoracic trunk section was performed on each side at intervals of fourteen days. This

was followed by immediate relief, and the child was able to walk about a fortnight after the second operation. On December 15th the father wrote to me reporting that the child slept well, that they were never disturbed by him at night, and that he was able to walk about alone in the house. On April 27th, 1931, nearly eight months after operation, his father reported that he could notice a great improvement: "he goes round about the house unaided, and often trots off with other children to play . . . he continues to be very jolly and good tempered, giving us little trouble compared with the past; it is a pleasure to be in his company." There was thus a mental change in the patient also.

Trigeminal Neuralgia

Trigeminal neuralgia is probably an expression of hyperactivity of the trigeminal ganglion as a result of vasoconstriction following toxæmia of some kind. The results following thoracic sympathetic trunk section justify the procedure. I have operated upon four patients, one a child, having all the signs of trigeminal neuralgia for two years, with complete relief fourteen days after operation, and the others, adults, with typical trigeminal neuralgia.

Retinitis Pigmentosa

In this disease relief is obtained if the patient retains central vision. Contracted fields of vision are enlarged and acuity of vision is increased. But there is no relief obtained if sight has been absent for years, as the atrophy in these patients is too far advanced to be recoverable.

Raynaud's Disease

Some apology may be necessary for introducing the subject of Raynaud's disease into a neurological discussion, but it is really relevant, since it concerns the hyperactivity of the sympathetic nervous system. As I have said before, the changes in blood supply produce a warm, pale skin, indicating a dilatation of the arterioles, and not a pink, warm skin, which would indicate that the principal change was in the capillaries. There is an immediate dilatation of capillaries, as indicated by the pinkness and warmth of the skin, but as the capillaries regain their tone independent of the nervous system, the colour of the skin becomes paler, while still retaining its warmth. The hand takes on the temperature of the surroundings, even after sympathetic trunk section.

Lethargy of Encephalitis

Lethargy associated with encephalitis is a most distressing symptom. The patient feels as if all his energy has been drained away; in addition, he is mentally fogged, and feels as if there were a haze clouding his mental processes. This condition is often accompanied by rigidity or tremor, or both. The following history illustrates the result of treatment by thoracic sympathetic trunk section.

The patient complained of loss of energy of three years' duration, and his friends said that he had lost all power of initiative; he would take three or four minutes to reply to a simple question. He had become very shy, and was always tired. He had typical Parkinsonian facies, with staring eyes and mask-like expression, more pronounced on one side. He walked with more or less rigid limbs on the right side; he had a limp, and the right upper limb did not swing. There was a slightly exaggerated phasic response in the knee-jerk, but relaxation time was slow, and the leg did not oscillate on the right side. This indicates an increase in tone. The left side gave a normal response, with oscillations. The patient was tested in a reclining attitude, with the legs hanging freely over the end of the couch.* The Babinski reaction was negative, and the cerebro-spinal fluid did not react to the Wassermann test. On account of the great rigidity and increased tone of his right side, I decided to divide the left thoracic sympathetic trunk. This was done

on February 4th, 1931. Immediately after recovery from the anaesthetic the patient's own words were: "I feel more alive." He answered questions immediately, and his stammering, which had worried him before operation, had disappeared. His face had improved in appearance in that the mask-like expression had more or less disappeared. When he was able to walk, two days after operation, it was found that his right arm swung normally, and there was no limp or rigidity apparent; his reflexes had returned to normal. On March 10th he was eating well—he had not cared for food before operation. He had no hesitation about speech; he laughed spontaneously, and could carry on an intelligent conversation. He felt less depressed, and had daily periods when he felt quite well. He has not completely recovered, but he is very much improved.

Congenital Mental Deficiency

Congenital mental deficiency is usually gauged by physical accomplishment. For example, holding the head up, sitting up, walking, and talking, are usually considered expressions of intellectual development in children. If that is accepted and taken into consideration with signs of lack of mental development, the alteration of the circulation of the brain in a mentally defective infant patient, as shown in the following history, is important.

The patient, aged 2 years and 4 months, was unable to sit up, hold her head up, or make any attempt to stand or walk. She took no notice of her surroundings, was inattentive, and did not talk. At the age of 2 years she had exhibited irregular jerky movements; these were followed by fits, mainly affecting the left side. In the fits she bit her tongue, breathed heavily, and lost consciousness. When seen on February 12th, 1931, the patient had had ten fits within a few weeks. She was chronically constipated; perspired freely; reflex activity was normal. She underwent operation on March 24th, when a right thoracic sympathetic trunk section was performed. She sat up three days after operation, and stood up after four weeks. Excessive perspiration ceased seven days after operation. For the first five weeks after operation the bowel motions were never solid, and the patient did not need aperients; now she has an occasional dose of aperient, but never more than once a week, and her bowel movements are normal. I have had similar results following an operation on the right side, and a like result following an operation on the left side.

Deafness

Deafness was relieved in a patient suffering from retinitis pigmentosa. He had been deaf since birth, but had been partly relieved after the removal of adenoids. The effect of sympathetic trunk section on the right side was a relief of deafness on the left side, and vice versa. After the first operation he could hear band music, and now he can hear human speech. A peculiarity of his hearing is that there are gaps in the scale; he can hear a few notes, then misses a few, hears higher notes, and so on.

Headache

In another patient suffering from retinitis pigmentosa headaches were relieved. Previous to operation they had been as frequent as three or four times a week; now they have become rarer, and occur about once in a fortnight. Vertigo disappeared in another patient after operation.

Epilepsy

In the treatment of epilepsy in adults thoracic sympathetic trunk section has not been successful. I have operated upon five patients suffering from epilepsy and imbecility of varying degrees, but in no instance was the operative treatment effective in diminishing the number of fits. On the other hand, in children treatment by thoracic sympathetic trunk section is sometimes successful. I have had three instances in which fits of true epileptiform type have completely disappeared. When fits are asso-

ciated with spastic hemiplegia relief is almost invariable, following thoracic trunk section.

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REFERENCES

- ¹ *Arch. of Neurol. and Psychiatry*, 1928, xix, 751 and 1057.
- ² *Med. Journ. Australia*, 1924, i, 77.
- ³ *Surg., Gynecol. and Obstet.*, 1924, 101.
- ⁴ *Brain*, 1931, liv, 320.
- ⁵ *Recent Advances in Physiology*, 1930, fourth edition.
- ⁶ *British Medical Journal*, 1931, i, 11.

Croonian Lectures

ON

LIVER AND SPLEEN: THEIR CLINICAL AND PATHOLOGICAL ASSOCIATIONS

BY

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LECTURE II

In my first lecture I dealt with the intricate vascular arrangements of the liver. I shall now begin by discussing the circulation through the spleen.

VASCULAR CIRCULATION THROUGH THE SPLEEN

I have already dealt very fully with this matter in my Lettsomian Lectures, and can therefore be brief. I must, however, draw attention to the most important points. The splenic artery, remarkable for its large size in proportion to the bulk of the organ, subdivides until, finally, each branch bifurcates to form two slender arterioles, named "penicilli" by Ruysch (1696). These small arterioles, as was emphasized by Cohnheim (1867), are end-arteries, and do not anastomose. On these penicillar branches lie the peculiar structures known as ellipsoids, a full account of which I have already published elsewhere. An important practical point having, I believe, a definite bearing on the mechanism of production of some of the splenomegalies was shown by Tait and Cashin (1925)—namely, that the ellipsoids act as potential valves, preventing all flow of blood backwards from the venous to the arterial side of the spleen. Quite recently, Nisimaru and Steggerda (1932), working in Barcroft's laboratory in Cambridge, have thrown doubt on this valve-like action of the ellipsoids; but in their experiments pressures of 40 to 50 mm. Hg or more were reached before the perfusion fluid passed back from the venous to the arterial side. The splenic vein is even more remarkable than the artery for its large calibre. Tait and Cashin (1925) were much impressed by its great contractility when stimulated electrically, and suggested the possibility that contraction in disease might well be of importance for the development of some human splenomegalies.

My views on the essential mechanism of the circulation through the spleen have already been published. Following the important observations of Barcroft and some simple experiments of my own with Cashin, I have concluded that, on the evidence at present available, the best working hypothesis (agreeing with many observed facts) is to regard the circulation through the spleen as twofold. The mechanism is suggested in the accompanying diagram. The first or ordinary circulation going on continually is a direct one, the blood being pumped through the splenic artery into venous sinuses, and from thence passing directly into the veins. The second circulation is intermittent, brought about by contraction and enlargement of the whole spleen. It consists of an emptying of

N. D. ROYLE: ALTERATION OF CIRCULATION OF BRAIN BY SURGICAL MEANS

FIG. 1.—Side from which sympathetic control was removed. Showing changes in circulation.

FIG. 2.—Showing changes in facial musculature on left side after sympathetic thoracic trunk section. Note the difference in amplitude of smile.

L. A. H. SNOWBALL: DISRUPTION OF PELVIS

FIG. 1.—X-ray showing separation of symphysis, fracture dislocation of left sacro-iliac joint with upward displacement of left innominate bone, and fracture of right pubic ramus.