Observations

ON

THE PRINCIPLES GOVERNING THE EARLY TREATMENT OF INFANTILE PARALYSIS.

BY

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THE treatment of infantile paralysis, being mainly a question of restoration of function, is dominated from the outset by anatomical considerations, or, to speak more correctly, by considerations which are confirmed by a study of comparative anatomy. In this paper I propose to deal with the question of treatment from the point of view of—I, Rest; II, Muscular function.

It is generally conceded that this disease is an inflammatory one, and that for the treatment of inflammation rest is essential. But rest must be immediate, since, in addition to inflammation, with the possible destruction of central nerve cells, muscle adjustments are altered as soon as the disease has begun. As I wrote five years ago:

Since rest is the basic treatment of inflammation, only by placing the parts concerned in an anatomical position of rest—the “zero” position—can the door be closed on all sources of irritation, and the spinal cord, nerve cells, receptive centres, and muscle be placed at physiological rest; that is, only through the zero position can you offer the greatest physiological opposition to the destructive effects of inflammation.

At the outset it may be mentioned that for a proper appreciation of the principles governing rest of joint or muscle a knowledge of the writings of Owen Thomas and Robert Jones is essential. Just as John Hunter in his Croonian Lectures may be said to have laid down the basis of our true conception of the physiology of muscular action, so Owen Thomas may be regarded as the founder of the true principles by which surgical rest is effected. The great advance that has taken place in recent years in our knowledge of the biology and surgery of nerve and muscle has received its impetus from the Liverpool School of Orthopaedics.

I. ANATOMICAL REST OF THE UPPER AND LOWER LIMBS.

When we speak of anatomical rest of a joint we mean that the muscles which act on that joint have been passively controlled; a muscle is not rested unless the joint or joints with which it is in relation are rendered immobile. Resting a knee by means of plaster from the mid-thigh to the mid-leg may be “surgical” but is not anatomical. A tuberculous ankle is not at rest if the knee be mobile, nor is the knee unless the hip and ankle are fixed. In the upper extremity so fine and correlated are the muscular adjustments that adequate fixation of one joint is best secured by fixation of all three. The biceps is related to both the elbow and shoulder, and muscles acting on the wrist and fingers arise above the elbow-joint.

(a) Upper Limb.

Recumbency in bed at the outset should be insisted on. The ideal position is as follows: The thumb is adducted, owing to the importance of finger opposition, fingers slightly flexed, wrist slightly extended, hand placed midway between pronation and supination, elbow slightly flexed to relieve biceps and brachialis, and the arm abducted to a right angle or even higher to help the flexors, deltoid, and trapezius. The biceps is not rested by mere flexion, for the long head crosses the shoulder, and

not only should we have flexion of the forearm but the arm raised as in deltoid cases. In other words, to speak of relaxing a biceps by means of a sling, that is, by merely flexing the forearm, is anatomically unsound. The upper limb can be immediately rested as follows:

With the child lying in bed one pillow can be placed in the axilla and, with the limb resting on another pillow, safety pins attach the sleeve of the dress to it at the arm and wrist so that the limb is abducted, elbow flexed, and the brachial plexus, being thus relieved from strain, rested.

As soon as possible a splint should be applied to give effect to the above considerations, of which the following, introduced nine years ago, is a useful model (Fig. 1). The basis is a stem of malleable iron $\frac{1}{2}$ in. wide and $\frac{1}{8}$ in. thick. This runs up the mid-axillary line from 1 in. above the costal edge to the axilla and follows the above contour of the under surface of the arm and forearm to the wrist, being bent to the requisite angle at the axilla and elbow. A piece of aluminium or tin, shaped to the hand, is atached at the wrist termination, so as to allow the mid prone and supine position, and the fingers rest on a pad of wool. Wings $\frac{1}{2}$ in. by $\frac{1}{4}$ in. are attached at the wrist, elbow, and upper arm and two wings pass round the chest, being attached to the stem, one at the costal extremity and the other below the apex of the axilla. The ends of these chest wings are connected anteriorly by strap and buckle. The limb is lightly bandaged on and a piece of bandage or webbing over each shoulder from the front to the back is sufficient to hold the splint well into the armpit.

FIG. 1.—A simple upper limb splint.

(b) Lower Limb.

It is essential at the outset—even if only one limb be affected—to rest the two, as pelvic tilting the result of overaction of one side easily occurs, and once having occurred is never overcome. It is also difficult at the outset to make sure whether the abdominal muscles are affected, and furthermore, only in this way can we prevent undue rotation of the hip, abduction, or adduction, to which there is so great a tendency. Hence the importance of noting the relationship of the two anterior superior spines to the umbilicus, or, more correctly, to the mesial plane. The spines should be on the same plane.

This can be immediately effected temporarily by means of two padded boards placed behind the knee from the upper third of thigh to lower third of leg with a connecting piece across the middle—or two long back splints with foot-pieces, joined together—and permanently by a double Thomas splint. By this means also we protect the quadriceps extensor (so important for the erect position), placing a small cushion of wool under the knee so as not to overstretch the flexors. With the feet elevated on a pillow the ilio-psoas is rested.

As regards the feet, trouble is likely to arise from deformity even after the first day, and especially foot-drop, inversion, or eversion. Whatever form of foot splint is used to prevent deformity, it is essential that the foot be kept well against the foot-piece by means of a webbing or other form of strap gripping the ankle firmly. The ordinary foot-piece is usually insufficient for continuous use, and a splint modelled to the foot is best. The basis of rest is recumbency in bed, and preferably on a firm mattress.

Anatomically, then, the upper and lower limbs can be easily and should be immediately rested. If these details are attended to we have gone a long way on the road to secure a recovery. By failure to effect anatomical rest at the outset can largely be ascribed the bad results met with in this disease.

II. MUSCULAR FUNCTION.

In this section I propose to deal with the deltoid and the quadriceps extensor of the knee. The former is

generally considered the most difficult for recovery, while loss of function in the latter is responsible for the swinging limbs and crutchdom to be met with in any large city.

At the outset I wish to refer to the case of a woman who thirteen months before being seen had fallen on her right shoulder. Pain, swelling, and stiffness followed, for which massage and forced movements "to break down adhesions" were used. On examination, in spite of the fact that the head of the humerus could be rotated freely there was inability to abduct the arm, when sitting, more than 2 in. from the side. When lying down, however, with a small pad under the head, she was able to her astonishment to abduct the arm to a right angle and, though with difficulty owing to some contraction of the pectorals, to raise it above her head. The limb was placed on a splint of the type illustrated in Fig. 1 to stretch the contracted adductors. When the splint was taken off she was still unable to abduct the arm when sitting up, but on lying down she raised it above the head with ease and in two days was able to raise it not only when lying flat, but also when the head was elevated on a pillow. Within a fortnight she was able to raise the hand above the head when sitting up, having during that time been gradually raised by pillows to the erect position, the movements each day being commenced in the lying down or zero position. A week later she was able to raise the arm immediately on sitting up.

Furthermore, cases of quadriceps "paralysis" were met with in which the patient was unable to stand, or, when lying in bed, raise the heel with the knee extended; yet when he lay on the side opposite to that which was affected and the knee was acutely flexed the leg could be extended with the greatest ease. Because the patient is unable to raise the heel off the ground with the knee straight when sitting on a chair—is unable, that is, to do 100 units of work—we are not justified in calling the quadriceps "paralysed." On the same reasoning the quadriceps tested with the patient in bed and the knee acutely flexed might be regarded as normal since it can perform the functions of the quadriceps as given in the textbooks, that is to say, extension of the knee.

These phenomena admitted, of course, of only one explanation—namely, that the disease was revealing functional stages in the evolution of these muscles. They showed clearly that their action was a complex function, one made up of several separate activities, and hence the term "paralysis" of muscles is really referable to the loss of some, not necessarily all, of their functions; the recovery, like the loss, follows in a biological or evolutionary sequence.¹

The dominant factor in man is the erect position, and the study of muscular action throughout the mammalia shows that orthograde functions have been superimposed on muscles adapted originally for plantigrade motion; new muscles have not been called into being. Although Charles Bell taught us that the anterior cord presides over muscular action, and Marshall Hall that movement can occur reflexly from irritation independently of volition, a study of cases of infantile paralysis in man—regarded as the most advanced mammalian type—demonstrates the fact also that the anterior cord not merely presides over "muscular action" but recognizes the components of which the function is made up, and that these cell-controlled components always bear a definite sequence one to another. Though similarly placed in an anatomical sense, the action of the quadriceps is vastly different in platypus and in man. The quadriceps in platypus responds to the anatomical test of extension of a flexed knee, but that is a different function from that of a quadriceps which will allow of the orthograde posture. The quadriceps of the ape has a

more complex function than that of the platypus, and so similarly has man's compared with the anthropoid. A patient who can raise the heel off the ground when sitting with the knee extended will be able to extend the acutely flexed knee in bed; but the patient who can do the latter need not necessarily be able to do the former. When, therefore, we are told that the quadriceps is paralysed merely because the patient is unable to raise the heel off the ground we are told something which is biologically unsound. This is a question apart altogether from volition, since in infantile paralysis we are dealing with a disease in which, generally, cerebration is unaffected.

In the koala we see a typical exhibition of deltoid function amongst the marsupials. Compared with the wombat the deltoid in the koala has become differentiated from the outer pectoral, trapezius, and brachio radialis (Fig. 2). Although the koala in the fork of a tree, supporting himself with one hand, can reach for his eucalyptus leaf, that is a different matter from the ability to raise the arm when in the orthograde posture.

Again, a study of the anthropoids at any menagerie shows the reluctance with which the forelimb is dispensed with as a means of support. The ape prefers the knee slightly bent, with the balance afforded by one or both

fore limbs. To assume the orthograde posture is an effort, and a still greater one while so supported to raise the fore limb above the head. The stiffening of the knees by the quadriceps, which has enabled man to stand and walk; and the ability not only to dispense with the fore limb for support, but to elevate it when erect above the head, are late acquisitions in man's evolution, and are hence unstable.

Compared with embryology, which gives us an imperfect picture of man's evolution from the point of view of structure, comparative anatomy not only gives a correlated history of the past, but often points the directions in which man's future physical evolution may progress. As an example, it will be conceded that inversion or eversion of the human foot are diminishing since the foot is not, as in koala, provided with an opposable hallux, that the tibia is the dominant bone, and that the fibula is disappearing. The fibula in the kangaroo, from the point of view of function, is non-existent,

having become approximated to the tibia, reminding one of the manner in which the appendix has become fused with the ileum in the wombat. In the kangaroo a struggle exists round the ankle as elsewhere, between individual muscles, not only for position but for existence. The kangaroo's foot can be regarded, then, as of especial value in enabling us to recognize that certain muscles are "survival results" (Fig. 3). Even if the "paralysed" patient be treated at a stage of the disorder where some surgical interference is necessary, the comparative method of treatment still dominates the surgeon's action—whether the method be the "strengthening of the weak" by muscle or nerve transplantation, or the "weakening of the strong," as by tendon lengthening or division. If we are utilizing a tibial or peroneal muscle for grafting, it is important to know which tibial or which peroneus is the more useful in the body economy; and similarly, if we are diminishing the power of eversion because the tibials are weak, or inversion because the peronei are damaged.² The results obtained from nerve and muscle grafting in paralysis have so far been disappointing, and for the reason that muscle function—the important factor—receives such scant consideration. It seems ridiculous to graft a biceps femoris or other hamstring to the quadriceps and expect it to restore extension—that is, to repeat the biological history of the function of that muscle—unless we have a clear idea

FIG. 2.—Deltoid evolution in the marsupials. The shoulder region of the Australian koala (*Phascogalea cinereus*). P, Pectoralis major. D, Deltoid. T, Trapezius. R, Triceps. B, Brachio-radialis. H, Biceps.

of the entities of which that function is composed. Again, presuming we have reinforced the circumflex nerve of a paralysed deltoid, it is surely too much to expect that nerve impulses will stimulate the muscle to repeat in sequence the events of its evolutionary history. When we speak of successful restoration of function of the deltoid, do we refer to 10 units of work or 100 units—that is, orthograde abduction?

To give a complete biological history of the action in orthograde man of the deltoid and quadriceps is not possible. Links in the chain are missing, and even the gap between two members of one order—namely, the wombat and koala—cannot be filled. From researches on muscular action amongst the mammalia, and especially monotremes and marsupials, extending over the past eight years, together with studies on numerous cases of human paralysis, I have adopted the following principles in seeking to restore function in a case of paralysis affecting the quadriceps or deltoid muscles.

A paralysed limb should be handled with the greatest gentleness, and, when taken off the splint, should occupy at first the position it had when supported by the splint. The arm with a paralysed deltoid should not be allowed to drop when taken off the splint, nor a knee be bent up, nor allowed to hang over the edge of the bed. We should avoid movement just as much as in the case of a fracture of the humerus or of the femur. Hence also the importance of a firm bed, so that movements can be carried out without disturbing the patient. It is best to place a sheet of cardboard under the limb to obviate all resistances to movement.

(a) Quadriceps.

The maximum work—namely, 100 units—is represented by the ability to stand erect with the knees straight, or to raise the heel off the bed when lying with the knee extended, and similarly when sitting on a chair. The minimum is represented by the ability to straighten the knee without abduction with the patient on the back and the knee slightly bent, actively or passively. On flexing the leg, for example, 1 in., it may be noticed that the limb falls straight, or, if bent say 3 in., the patient may be unable to straighten the knee, but can prevent the limb abducting; that can be regarded as evidence of recovery. The flexion is gradually increased, the fall being gradually replaced by a definite push, till finally the patient, holding the knee in the position of acute flexion without abduction

FIG. 3. Dissection of the extensor aspect of the leg in the kangaroo (*Macropus gig.*), showing the tibialis anticus as the "selected" inverter. A, Tibialis anticus. E, Common extensor. F, Common flexor. P, Peroneus. N, Semi-tendinosus. B, Semi-membranosus.

or adduction of the thigh, is able to straighten the limb. It may be necessary to initiate action with the patient lying on the opposite side, and not on the back, beginning with a 2 in. flexion, and in this early movement hip action is unhindered. An early sign of recovery is the power of adduction or abduction of the whole limb when on the back with the knee straight, especially the latter. Progress can be stimulated by bandaging a splint to the back of the knee.

Our next endeavour is to secure extension from full flexion when lying on the opposite side, with the thigh fixed. This is accomplished by beginning with, say, a 2 in. flexion and gradually increasing, always commencing each day, however, at the 2 in. stage. It is wrong practice to flex the knee beyond a point at which extension effort becomes manifest. The action is aided by allowing the patient to flex and extend the knee when on the side, but with the thigh free.

The time now comes when our attention is directed to the power of raising the heel off the bed from the hip with the knee extended. To our surprise the patient, when lying on the sound side, may lift the limb in one piece and swing it forwards and backwards with ease. This is an action of the ilio-psoas muscle, but is only rendered possible by the action of the quadriceps extensor in keeping the knee stiff. If unable to do this we can initiate and practise the movement with the knee stiffened by a cardboard or wooden splint behind the joint—that is to say, we produce an artificial quadriceps. Objection may be raised that the elevation of the limb in one piece when on the side is dependent on the stiffening action of the lateral ligaments. It is, however, a distinctly muscular action, and ligaments do not cause movement. This can be proved in the case of a severe quadriceps paralysis when the patient with a sound ilio-psoas will make unsuccessful efforts to raise the heel when on the side, the knee remaining bent; but when a splint is applied behind the knee will lift the limb with ease. Although able to raise the limb in one piece when on the side, yet when turned on the back this, which is the maximum effort, is impossible. The graduated method is again applied. We gradually alter the tilt of the body, which can be done by means of a pillow, from the lateral to the supine position, till finally our maximum of 100 units of work is reached. If, when seen, the knee has flexed from over-strong hamstrings, it should be straightened and bent gradually, before true function is commenced. The two actions should go *pari passu*, and as already stated there should be no flexion beyond the point at which extension-effort has become manifest.

(b) Deltoid.

With the patient on his back in bed and a low pillow supporting the head we may find that he lifts the abducted arm readily off the cardboard, or if passively raised is able to maintain it so. Our object is to recover the power of abduction from the side to the right angle. If we lower the arm from the right angle abducted position to the side, the patient is unable to abduct to the right angle; but if we lower it, say, two inches, supporting the patient's elbow on the palm of our hand, it may be raised to the right angle readily. We gradually lower the supported elbow, beginning each day at our original minimum, till finally there is abduction with the arm at the side. There will be recovery in this posture when the patient can abduct to the right angle *ab initio* with the arm at the side. This procedure is then repeated with the patient slightly raised by means of an ordinary pillow under the head, and in this manner he is gradually elevated to the orthograde or erect posture. The 100 units of work or maximum have been achieved when the patient is able, when sitting up, to straightway abduct the arm from the side to a right angle. Similar principles would apply in cases of nerve injury, or injury of the muscle with loss of function. The results presented at the Berlin Congress in 1911 by Mayer of Cologne, and based on an early paper of the writer's on upper limb paralysis published in Australia, are worthy of notice.

The dissections shown in the figures, together with numerous others, illustrating the evolution of muscular action in the mammalia, are now in the possession of the

Hunterian Museum, London. For valuable help in the preparation of these I am indebted to Major C. V. MacKay, R.A.M.C.

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THE MODERN TREATMENT OF DIABETES MELLITUS.

AN ABSTRACT OF THREE LECTURES DELIVERED AT
THE LONDON HOSPITAL.*

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A FEW weeks ago the following dialogue might have been heard in the staff room of the London Hospital:

Surgical Colleague: I see that you are lecturing on the modern treatment of diabetes; now, tell me, are you going to tell us anything which I was not taught as a student?

Leyton: I believe so.

S. C.: Is there some new drug which possesses a specific action?

L.: Not that I know of.

S. C.: Then tell me in a nutshell the difference between the modern treatment and that which I was taught.

L.: You were taught that so long as a diabetic was placed on a diet which was free from carbohydrate all was being done that could be done. The main idea in the modern treatment is that a period of alimentary rest leads to an alteration in the metabolism of the diabetic which makes it approach that of the normal individual. A patient suffering from severe diabetes is unable to metabolize the carbohydrate part of the protein molecule; after alimentary rest, he is able not only to utilize all the protein but also to oxidize carbohydrate given in the food as such. This tolerance for carbohydrate is developed. Limits for protein and fat are found, and these forms of food are not given in unlimited quantities. Too much protein causes a return of sugar in the urine.

S. C.: Does the new treatment really allow you to prolong the lives of young individuals who have developed severe diabetes?

L.: Undoubtedly.

It is this treatment which I wish to describe in sufficient detail to permit all to test the accuracy of my replies in the conversation.

Diabetes mellitus is the name given to a series of diseases which may be recognized by a departure from the normal metabolism. The change which makes itself most evident is the excretion of dextrose in the urine in quantities which may be detected by the ordinary tests whilst a normal diet is being taken. It is true that sugar appears in the urine in meningitis, exophthalmic goitre, and in gross diseases of the pancreas; these do not come under the heading of diabetes mellitus.

The definition given above includes so-called "dietetic glycosuria." Without wasting time in an academic discussion as to whether such a disease exists, let us assume that it is safer to consider all cases of glycosuria to be diabetes mellitus and treat them as such. No harm will be done and many lives will be prolonged.

The causes of diabetes mellitus are not known. Perhaps it will assist us to understand the modern treatment if we adopt a speculative explanation of its cause, even if this subsequently be proved incorrect. Diabetes mellitus includes at least three conditions:

1. Sugar in the urine with an increase in the sugar in the blood.
2. No sugar in the urine (at times) with a considerable increase of sugar in the blood.
3. Sugar in the urine without any increase of sugar in the blood.

The two conditions first named are in my opinion due to an altered nerve control of the pancreas, whilst the third is due to the production of a phloretin-like body in some of the tissues.

The similarity between diabetes mellitus and exophthalmic goitre leads me to think that an altered nerve

control plays an important part. Cannon has shown that if the central end of the phrenic nerve be sutured to the peripheral part of the cervical sympathetic, the nerve grows down, and then the impulses which would have been transmitted to the diaphragm at every respiration are conducted to the thyroid gland, with the result that the animal develops all the signs and symptoms of exophthalmic goitre.

Partial excision of the pancreas produces an effect in an animal simulating in many ways diabetes mellitus. Nevertheless, from *post-mortem* examinations, we know that in the majority of diabetics no recognizable lesions are found in the pancreas.

There are many other possibilities. In normal health there is a balance between all the tissues in the body; any departure from this balance is compensated rapidly. Emotions cause a temporary alteration in the balance. Anger and fright stimulate the suprarenal glands, causing the sugar in the blood to be increased, the blood to coagulate more rapidly, the bronchioles to dilate, the muscles to become fatigued less easily, digestion to be inhibited, and the blood to be redistributed in the body. Cannon explains these changes as those which would assist an animal to fight successfully, and that these emotions were originally associated with struggle. Indirectly the same emotions increase the rate of metabolism through the increase in activity of the thyroid. Emotions have a direct effect upon glycosuria too.

Allen found that small highly bred dogs, if a part of the pancreas were removed, and the animals put upon a diet which under ordinary conditions allowed them to be free from glycosuria, passed sugar in the urine when frightened.

This observation upon animals, and many similar upon man, suggested the possibility that hypnotism might prove of assistance in the treatment of severe diabetes. Our observations on this matter are insufficient to allow me to make any announcement to-day.

SELECTION OF CASES FOR TREATMENT BY "ALIMENTARY REST."

If it be thought advisable to give a treatment a descriptive name rather than that of its inventor I suggest that the Allen treatment be called the "Treatment by Alimentary Rest," for three reasons: (1) It seems to me probable that the alteration in metabolism which occurs when food is withheld is due to rest of the various glands which are stimulated during digestion, and not to the simple absence of food. (2) To prevent confusion between the Allen treatment and the Guelpha treatment, which has been called "the starvation treatment" for quite a long time. (3) Starvation treatment is a name which does not commend itself to patients.

Since the treatment entails alimentary rest for several days it is obvious that not every case should be submitted to it.

Method of Determining Suitability of Case.

(a) Physical.

If the patient be suffering from any other disease which is likely to lead to dissolution during the next few months he should not be asked to undergo the discomfort of alimentary rest because the recompense for the self-denial is too small.

My experience[†] has taught me that, in spite of the fact that not infrequently a patient suffering from rapidly progressive pulmonary tuberculosis may lose the sugar in the urine as the disease progresses, nevertheless cases of diabetes complicated by pulmonary tuberculosis are not suitable for treatment by the Allen method.

Every effort must be made to be certain that the patient is not suffering from active tuberculosis. We all know that often it is extremely difficult to make up our minds on the diagnosis even when uncomplicated; when diabetes is present the difficulty is increased ten times. Many of the more delicate tests prove fallacious.

The rise of temperature with exercise will not necessarily take place in a diabetic. Tuberculin may not be used because any man who awakens quiescent tuberculosis in a diabetic is guilty of manslaughter.

The examination is limited to inspection, palpation, percussion, auscultation, and radiography. Even the most careful and experienced may err when limited to these

* The lectures will appear in detail in the *Clinical Journal*, March, April and May.

† Joslin's experience is not similar.