A Clinical Lecture

ON

THE ORTHOPAEDIC TREATMENT OF POLIOMYELITIS.*

BY

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THE surgical treatment of poliomyelitis includes a great deal which can be carried out by any practitioner, whether physician, surgeon, or both.

It is customary for purposes of treatment to divide the course of a case into three stages: the early, acute stage, which lasts while there is pain and tenderness in the muscles; the second or convalescent stage, during which the recovery of power is taking place—it lasts to the end of the first and sometimes the end of the second year; and the third stage, which begins after the lapse of two years: until this stage all reconstructive surgery is delayed.

FIRST STAGE.

During the first stage the spinal cord is the seat of a haemorrhagic inflammation, which is gradually subsiding. Those anterior horn cells which have been only temporarily thrown out of action gradually return to health and perform their normal functions, while others which have been damaged too severely to recover degenerate. The flaccid paralysis affects a more or less wide range of muscles—very often a much wider range than would be suspected from an examination of the patient a few months later.

Unfortunately we cannot tell at first which muscles will recover rapidly, which will recover more or less completely though slowly, and which will remain completely paralysed. Therefore we must treat all the muscles alike until such time as recovery indicates which require special care.

The first essential of treatment is rest, both for the spinal cord and the affected muscles. All patients are best kept in bed for a time; Batten¹ insisted on three weeks, even in mild cases. Steps should be taken to provide absolute rest for all the affected muscles, and this involves rest for all their opponents as well should these not be paralysed. There seems to be a great tendency to delay doing anything, particularly in a bad case, until the acute stage has passed off. This is, I think, a mistake. Splints or other fixation apparatus should be applied at the earliest possible moment, the limbs being fixed in the neutral position. Without fixation deformities are certain to occur. The apophthegm, "Prevention is better than cure," applies with as much force in this instance as in any other. The neutral position is one in which, as far as possible, no one muscle or group of muscles around a joint is favoured to the detriment of others. Thus the foot is put at a right angle, the knees are straight, the hips are straight and the spine flat. The position of the hip and knee joints can be assured by rest on a flat bed, with a towel and a couple of sandbags to keep the knee from flexing, but the feet require some simple splint of tin, wood or plaster-of-Paris to hold them at the right angle. As regards the arm, the best position is one of abduction of the shoulder, flexion of the elbow to a right angle, supination of the forearm and dorsiflexion of the wrist. This position is not entirely governed by a desire to find the neutral position, but partly with an eye to favouring those muscles which we know recover with difficulty, and of which the recovery is more important than that of their opponents; for instance, the deltoid, biceps, etc. This position can be retained by sandbags while the patient is lying flat, but a splint is necessary as soon as he sits or stands. The simplest splint is one made of tin. Such splints serve a double purpose—to give rest and to prevent deformity.

As regards the correction of deformity at this stage, it will be found easy to stretch contracted muscles. When the muscles are still tender, except in cases where this tenderness is unduly prolonged, very gentle persuasive

manipulations with fixation on a splint which is slightly altered in shape each day will achieve correction of the deformity. The stretching is painful, and must be done with the greatest gentleness; if the foot is fixed in the position which is the best possible one day, it will usually be found possible to improve this slightly the next.

Lovett and Richardson,² in 604 cases, found that in 49 per cent. the pain and tenderness had disappeared by the end of the second week, and in a further 13 per cent. by the end of the fourth week, and that it was quite exceptional to find any tenderness after the second month.

Massage should be carried out with the greatest gentleness, and one must be guided by its effect in each case. If the patient cannot stand even gentle massage, it must be discontinued. Lovett² considers it harmful, as since it is painful it irritates an already inflamed cord, and he forbids it absolutely while there is tenderness. In the majority of cases, if done properly, it should not be painful and can do no harm, and it unquestionably prevents some of the wasting of the muscles. Electricity is useless at this stage.

A word of caution seems to be called for with regard to the spinal muscles. There are undoubtedly cases which develop a spinal curve while still lying flat on the back, the position they have been in since the onset of the disease; there are others in which the onset of lateral curvature has been less rapid, but in which a distinct cause is present in the unequal affection or recovery of the muscles of the two sides of the body, or of the two legs, etc.; but there are some cases of scoliosis seen at a later stage which make one wonder whether they ought not to have been prevented. In such cases a special cause for the deformity is absent, all portions of the erector spinae acting well. One cannot exclude unequal power in the two erectors spinae as the cause, but this could equally well have resulted from the stretching of the muscles on the convex side of the curve and relaxation of those on the concave side—that is, it is the result and not the cause of the curvature. A case in which the spinal muscles, though slightly affected at first, have recovered, but still remain weak when the child first begins to sit up, is just the subject for scoliosis. I would urge the advisability of raising the child to a sitting position slowly and gradually by means of a bed rest and pillows. The spinal muscles should be massaged, and any paresis and tendency to curvature looked for.

The possible causes of scoliosis in poliomyelitis cases are:

1. Paralysis or weakness of (a) the spinal muscles on one side; (b) the abdominal muscles in one loin, and of the intercostals on one side; (c) of one psoas (as first suggested by Elmslie).
2. General weakness of all the spinal and accessory muscles.
3. Contracture of one hip.
4. Shortness of one leg.
5. Paralysis of one shoulder.

SECOND STAGE.

There is no question that signs of recovery may appear in muscles previously paralysed up to the end of the first year. In a case treated well throughout, a muscle which is absolutely paralysed after twelve months must be regarded as hopeless (Jones).⁴ During the second year further recovery may take place in all those which have to some extent recovered, but a muscle which remains paralysed for many months before showing any return of power will never be of much use to the patient.

The treatment during the second stage comprises the following: Keeping the part warm, relaxation of the paralysed or weak muscles, massage and re-education of muscles, to which must be added "correction of deformity," if such has been allowed to occur. Additional covering for a paralysed limb is essential even in the summer months. The difference in power of a cold and a warm muscle is surprising.

The next point is, in my opinion, the most important. Without adequate support recovery is bound to be far from complete, and will be coupled with deformity. Unfortunately the efficient use of splints is a factor in treatment most often neglected. It is not at all uncommon to find a patient in whom deformities have occurred provided with beautiful walking apparatus, but the use of night splints has been omitted. Splints are more efficient correctors of a tendency to deformity than any walking

* Delivered at the Hospital for Sick Children, Great Ormond Street, on October 28th, 1920.

apparatus. Thanks largely to Sir Robert Jones's repeated utterances on this subject, it is now generally agreed that avoidance of over-stretching of a paralysed muscle, particularly in the early stages of its recovery, is essential for good recovery. The wisdom or necessity of carrying this to the extent of never for an instant allowing any paralysed or weak muscle to be stretched even to a moderate degree, has been questioned by Langley.⁵ Whether this prevention of over-stretching should be carried to the extent of absolute relaxation—or, in other words, whether the neutral position is sufficient—or whether the limb should be put in a position to relax the paralysed muscles at the expense of their unparalysed opponents, is still an open question. If all the muscles of a limb are paralysed, the neutral position is, of course, the correct one; but supposing the anterior tibial group paralysed, and the tendo Achillis muscles acting, there is a strong tendency to equinus, and I think the best position is one of slight calcaneus, for a certain amount of slipping of bandages can then occur without the foot dropping beyond a right angle. Moreover, we not only want to see power returning in the anterior muscles, but we want to see equilibrium established between the anterior and posterior muscles at the earliest possible moment, so that apparatus may be gradually discarded. Some weakening by over-stretching of the opponents, therefore, is not altogether a bad thing in such a case.

One word of warning must be given as to the bandages or straps used to hold a limb in a splint. In the case of the leg these should encircle the foot and ankle and, at most, the lower third of the leg; the muscles themselves should be free of all pressure.

The splints must be left on day and night, and removed only for washing, massage, etc., when the position of the limb should be maintained by the hand of the attendant so long as any marked degree of weakness persists. The different methods of fixation for different parts of the body will be referred to later. As soon as recovery has progressed sufficiently walking should be encouraged, suitable apparatus being employed. So important do I consider the fixation of the part and the relaxation of the paralysed muscles that in certain difficult cases where the supervision of splints, etc., has been most inadequate I have applied an irremovable plaster-of-Paris case, with gratifying results; on removal of the plaster a month or two later, a muscle which had previously shown no flicker of voluntary power has been found acting strongly. This method may be used with advantage in cases other than poliomyelitis, where one muscle or group of muscles has been weakened or paralysed by persistent over stretching.

Re-education of Muscles.

This is a term of which we have heard much in recent years, but it means nothing more than exercises carried out with a minute regard for the development of individual muscles. Enormous improvements have taken place in this branch of treatment recently as the result of medical men giving careful attention to the subject instead of leaving the cases to masseuses. W. Colin Mackenzie's⁶ name will always be associated with this work. Mackay⁷ recently published an excellent paper on infantile paralysis, from the point of view particularly of splinting and re-education. There is no doubt that active exercises are the best means of increasing the power of a weak muscle, provided that muscle has recovered sufficiently to contract voluntarily. Massage may improve nutrition, and more particularly check malnutrition, but it cannot cause a muscle to hypertrophy; alternate contraction and relaxation repeated over and over again can alone accomplish this. Normal voluntary contraction is always to be preferred, though electrical stimulation, when applicable, comes next in usefulness because it produces contraction.

A very important point always to keep in mind in the re-education of muscle is to make the load proportionate to the power of the muscle. It is worse than useless to try and make a partially recovered but very weak muscle produce a movement against the force of gravity. To put gravity out of court the limb is placed so that the muscles to be exercised move the part in a horizontal plane. To make it easier for this movement to be performed with the limb resting, the latter is often placed on a board sprinkled with powder to make it slippery. By this and other means the patient is induced to contract even the weakest muscles

over which he has any control. Fatigue is to be avoided at all costs, therefore constant skilled attention during the performance of exercises is essential.

Recovery can take place, particularly when the damage is slight; without any special treatment in the way of re-education, and this without deformity, provided splints have been employed, but without splints anything approaching perfection is impossible.

Massage should be continued with slightly greater vigour, but it is always well to keep in mind, as Sir Robert Jones⁸ has pointed out, that a paralysed muscle may be damaged by heavy manipulation. If a tendency to deformity in any one direction is present, the foot should be manipulated in the opposite direction so as to prevent the occurrence of contractures. This is a most important detail, and should be carried out morning and evening by the nurse or attendant. It is often asked after one, two, or more years have passed since the onset of the disease, "Is it any good going on with massage?" My reply is, "The more that limb is massaged, the more it is exercised, and the greater the care taken in keeping it warm, the less will it lag behind its fellow in growth; and the smaller will be the increase in the 'shortening' as the child grows up."

As regards electrical treatment, we must remember that there is a great deal of difference between a child with poliomyelitis and an adult with, say, a musculo-spiral paresis. In the latter it is easy to pick out individual muscles, and, moreover, the patient will readily stand the discomfort of the treatment, whereas in a child a stronger current is necessary to penetrate the relatively thicker layer of skin and fat overlying the shrunken muscles, so that a stimulus sufficient to cause contraction is too painful to be borne by the child; as Batten⁹ insisted, such a current usually causes contraction of the healthy opponents, and results in stretching rather than in active shortening of the muscles we are attempting to treat. In older children—and children vary considerably in how much they feel the faradic current—this method should be employed when practicable. In the majority of cases it will be found more worry than it is worth. This holds good for both the galvanic and the faradic currents. As regards other forms of electrical treatment, I must confess myself sceptical. Whether an electric bath with a uniform current passing through it does more than stimulate the skin I am very doubtful. As a means of diagnosis the faradic current is useful; it confirms our clinical diagnosis as to which muscles are really paralysed.

DEFORMITIES.

The causes of deformity are gravity and the inability of a weak or paralysed group of muscles to elongate their opponents after the latter have contracted. These two causes may work together or separately. A deformity becomes fixed, that is, intractable by ordinary manipulation, as the result of contracture of unparalysed or stronger muscles; after a time there will be in addition accommodative changes in the ligaments, bones, etc. Contracture of the muscle is due to the shrinking of the areolar fibrous tissue which binds the fasciculi together into an anatomical muscle. If this is not stretched in the normal way by contraction of opponents or by daily manipulations, it becomes permanently short and elongation is impossible.

It is, perhaps, not generally recognized that a totally paralysed muscle in poliomyelitis cannot become contracted, and that contracture of a muscle is proof of some, though perhaps not very obvious, recovery of tone in that muscle. As an example, equinus does not result when all the muscles below the knee are paralysed, even though the foot has been unsupported by a splint; in such a case flail ankle results. If any shortening of the tendo Achillis muscles is present there must be some return of power in the calf which should be capable of further development, though possibly not to the extent of being useful to the patient.

It sometimes happens that one muscle around a joint will recover sufficiently to be a strong factor towards the development of deformity, but being alone, or at the most having one adjacent muscle acting, it is impossible to make use of that power for the good of the patient. In other words, that muscle is a good deal more worry than it is worth. In such a case we may be driven to throwing the muscle out of action altogether by excision of a large piece of its tendon. The only other alternative is to transplant the tendon to a position where its power will be

harmless even if not particularly useful. As an example we may take the case of the biceps femoris surrounded by paralysed muscles and causing the triple deformity of flexion, valgum, and external rotation at the knee-joint. The tendon may be transferred to the front of the joint to take the place of the quadriceps, but I have yet to see the case where it has become an efficient extensor of the knee.

As already stated, operative treatment during the second stage should be confined to the correction of deformities; they are bound to get worse if untreated, and so long as they are present, muscles which may have a potential power of recovery are being ruined by overstretching.

The operative procedures are practically limited to tenotomies, fasciotomies, wrenching and tendon lengthenings. The latter is preferable in the bigger tendons; in the tendo Achillis, for instance, the Z method should be employed, and it matters little whether this is done by the open or the subcutaneous procedure. Sufficient lengthening of the tendon will be obtained, without undue elongation and resulting loss of power, if the tendon is allowed to unite with the foot at a right angle. I prefer the open method, particularly when the recovery is fairly evenly distributed in the muscles below the knee; it is more accurate, and the ends of the tendon can be sutured so as just to allow the foot to be brought to the right angle before the calf muscles are pulled on. The foot should then be dropped a little and held in this position for a few days, then gradually brought to a right angle and kept there. Walking should not be permitted for six weeks.

Having corrected deformities, the parts should be retained in the over-corrected position so as to relax as much as possible the weak muscles and stretch the strong, while re-education, massage, etc., are carried on vigorously.

Genu Valgum.

A not uncommon deformity at the knee, already referred to, due to the pull of the biceps muscle which has alone recovered, or has recovered to a greater extent than the rest of the muscles about the joint, is a triple one—a combination of genu valgum, flexion of the knee, and external rotation of the tibia. The biceps may or may not require lengthening, but in all cases correction must be gradual. I have found a jointed apparatus in which by means of a key the relative position of the two halves of the splint can be altered, of great service. Plaster is applied to the thigh and leg, the apparatus is adjusted to the same angle as the deformity, applied to the plaster, and more plaster bandages added to fix the thigh and leg pieces respectively. By means of the key daily improvement in the position of the joint can be brought about. Osteotomy is not required.

Splints.

For the foot I like a "tin shoe" which is made specially to meet the requirements of the particular deformity present. If the tendency is towards equino-varus, for instance, the sole plate should be above the right angle, should be everted, and should be curved, concave outwards, so that the foot when fixed to it will be in a position of calcaneovalgus, with the fore part of the foot abducted. A quadrant and screw with a hinge at the ankle may be added when full correction is impossible at first, so that alterations in the splint may be made as the patient improves.

For the knee either a tin shoe with the calf-piece carried up to the buttock or a celluloid splint may be used.

In the hip we usually have to contend against flexion deformity; it is best dealt with by making the child sleep on a double inclined plane bed. This is easily made by putting a firm bolster crosswise beneath the centre of the mattress. Towels and sandbags to keep the knees down will ensure a hyperextended position of the hip-joints, provided these joints are kept at the highest point of the bed. Jones points out that some internal rotation is necessary to ensure stretching of all tissues. If full extension of the joint is impossible, a sandbag may be placed across the lower end of the femur for an hour or two twice a day, while ordinary weight extension is applied to the leg.

For the arm the particular splint used must depend on the distribution of the paralysis, but in many cases the birth palsy splint shown or some modification of it will be found suitable.

For difficult cases, or where economy is necessary, although adequate supervision is available, removable

plaster-of-Paris shoes or other splints are useful. Celluloid, which was introduced in the treatment of these cases by the late Dr. Batten,¹⁰ is excellent for some cases, but I think there has been a tendency to use it in unsuitable cases. As usually made for the legs, celluloid splints are most inefficient as holders of the foot and preventers of deformity, though they answer admirably in cases of paralysis about the knee-joint. Personally I use them only in severe cases—that is, where the whole limb is paralysed more or less completely, and where the tendency to deformity of the foot must of necessity be comparatively weak. Experience teaches me that one or two points should be mentioned. Complete correction of deformity is essential before the use of these splints. It is not uncommon to see a celluloid splint made to fit a knee with a definite genu valgum. Secondly, in taking the model, plaster bandages must be carried right up to the top of the thigh or even further, and right to the tip of the toes; it is not uncommon to see the splint reaching only two-thirds of the way up the thigh and ending behind the ball of the foot. Thirdly, the foot must be at a right angle, and kept in this position during the whole of the period of the taking of the cast.

It is impossible to describe in detail walking apparatus for use by day, but a few points may be mentioned. One question that arises in every case with a tendency to drop-foot is whether a toe-elevating spring should be used or only a right angle "back-stop," which means that the joint opposite the ankle is so constructed that dorsiflexion is free, but plantar flexion cannot proceed beyond a right angle. I am inclined to favour the latter, for a spring is either so strong that the calf muscles cannot overcome it at all, and the patient walks on the heel, or the calf muscles are made unduly strong by having to overcome the pull of the spring. This is an undesirable result, as it is equilibrium between the opposing groups of muscles that we are so anxious to obtain.

In paralysis of the glutei muscles it is necessary to have an accumulator acting behind the hip-joint of the iron, to replace the paralysed muscles and retain the patient in an erect position. To get a firm attachment for the accumulator it is necessary to have a celluloid spinal jacket made; and it is also an advantage to have celluloid sheathing pieces for the thighs riveted to the "irons." The jacket can be cut away freely in front and be little more than a back plate, provided that there is no scoliosis.

THIRD STAGE.

We now have to consider the various problems which confront us when further recovery of muscle power is impossible.

Tendon Transplantation.

Orthopaedic surgeons are fairly well agreed upon the general principles which should govern the surgeon in carrying out tendon transplantation. An operation of this description should never be done until at least two years have elapsed since the onset of the disease, and never till any deformity present has been fully over-corrected. To shift a tendon and expect its muscle to correct deformity is bound to lead to disappointment. What we hope to achieve by tendon transplantation is to restore or increase the power of movement in a certain direction, to give stability to the part, and to check a tendency to deformity, and thus to make possible a reduction in the amount of apparatus worn by the patient. Sir Robert Jones,¹¹ to whom one naturally turns for help in this as in every branch of orthopaedic work, has insisted on the importance of selecting for transplantation tendons of which the muscles have shown definite evidence of very considerable recovery. Transplantation of a muscle which is only just acting is worse than useless.

The transplanted tendon should always be attached subperiosteally or even in a tunnel in the bone whenever this is possible, rather than simply sewn to another tendon. It is not advisable as a rule to shift the attachment of a tendon half-way round the circumference of a limb; particularly is this so when the muscle has a pure action. For instance, good results are not usually obtained by trying to make a pure flexor into an extensor. An operation commonly practised is that of shifting the biceps femoris tendon and inserting it into the patella. I am open to conviction, but I have still to see such a shifted biceps contract alone at will, and produce extension of the

knee-joint. I have seen it contract with the flexors and interfere with the action of its fellows, but this is a very different thing from this muscle producing extension of the knee-joint at the will of the patient. On the other hand, the tibialis anticus is a dorsiflexor of the foot as well as an inverter, and when shifted to the outer side of the foot still acts as a dorsiflexor, and comes into action as such at the will of the patient, but its new attachment makes it combine dorsiflexion with eversion instead of inversion. In such a transplantation we do not rely on re-education of higher centres; hence the success which follows such an operation.

One of the most satisfactory transplantations is insertion of the extensor longus hallucis tendon into the head of the first metatarsal for those cases with a tendency for the ball of the big toe to drop, and for the big and other toes to cock up in the hammer position; more or less valgus is a common accompaniment; the tibialis anticus is usually paralysed, though not always. The line of action of the transplanted tendon is not appreciably altered, and being meant for an elevator of the fore part of the foot, it achieves this object with ease. There is one small addition to the operation as usually performed that I have found useful. The operation is followed by flexion of the terminal phalanx of the big toe, a condition which may be distinctly annoying to the patient, particularly when putting the foot into a boot. To avoid this, I sew the distal cut end of the extensor proprius tendon to the slip from the extensor brevis to the big toe, the terminal joint of the big toe being fully extended. The distal portion of this tendon now acts as a ligament, and prevents the dropping of the terminal phalanx.

Transplantations for paralysis of the upper limb are much less commonly performed. The war provided us with a useful experience in transplantations about the wrist-joint. In the forearm we have a very different problem from that encountered in the foot. In the hand and wrist deliberate, exact, and even fine movements are necessary, whereas in the foot mere stability is necessary, together with the gross movements of dorsiflexion and plantar flexion of the foot. Fortunately the synergic action of muscles about the wrist enables us to select tendons for transplantation which are normally called into action by forced contraction of the muscles which have become paralysed and which we wish to replace; as a result, anything in the way of re-education of higher centres, if this be possible at all, is not required. If the dressings are removed three weeks after operation, the desired movements of the fingers and the thumb can be performed readily, and with suitable treatment these movements rapidly become brisk and strong. Such a result unfortunately is not invariable, and for two reasons: either the muscles selected for operation are not the best, owing to an error of judgement on the part of the surgeon, or because the paralysis has limited the choice, or the technique of the operation is imperfect, the error usually being on the side of laxity of the transplanted and paralysed tendons.

This brings us to the important point of the strain that should be put on a transplanted tendon before it is attached to a bone or other tendon. There are two schools of thought on this subject: one says that the tension of the transplanted muscle should be no more than the normal tension of that muscle when the joint upon which it normally actuates is in the neutral position; whereas the other school says that the graft should be carried out with the tendons as tight as possible. When operating for the relief of peripheral nerve injuries, in which cases the muscles selected for transplantation are healthy, and have as a rule never been paralysed, there is no question that tightness of the tendons at the moment when the sutures are being inserted can alone give satisfactory results. In poliomyelitis, however, the problem is not quite the same; the muscle selected for grafting has almost certainly been paralysed at some time previously, and cannot therefore be expected to stand stretching in the way that a healthy adult muscle can. However, I am now transplanting tendons in cases of poliomyelitis with a much greater strain upon them than I did before the war, and I am convinced that the results are thereby improved.

One more point must be referred to, and that is the necessity for protecting the grafted muscle from undue strain for several months after the operation. This is

particularly necessary in the foot, where body weight and gravity play such important parts in the production of deformity. Exercises to develop power in the transplanted muscles should, of course, be carried out after sufficient time has elapsed for firm union of the transplanted tendon to occur at its new insertion.

ARTHRODESIS.

Arthrodesis should never be performed before about nine years of age, and gives better results if even further delayed.

In the shoulder there are two necessary conditions—fair power in the muscles fixing and moving the scapula, and sufficient recovery in the forearm and hand to warrant the operation. The elbow may be kept at a right angle by removal of skin from the front of it.

Arthrodesis of the hip-joint for poliomyelitis seems to me to be very rarely justifiable. The same may be said of the knee-joint. The chance of breaking the leg with the bones imperfectly developed, as they must be in a grossly paralysed limb, must be great; moreover, I think it only fair that the patient should be left to judge for himself whether he would sooner wear apparatus for the rest of his life and be able to bend his knee to sit down, or whether he would prefer a rigid straight leg.

In the ankle arthrodesis gives an excellent result in some cases, but not in all; the result apparently depends on the stability of the subastragaloid and other joints of the foot. If the mid-tarsal joint (Jones)¹² or the subastragaloid joints are fixed in addition, the results are much improved. Whitman's¹³ operation, which involves removal of the astragalus and shifting backwards of the foot so that the tibio-fibular mortice embraces the anterior end of the os calcis, gives excellent results in those almost completely paralysed legs. This is a particularly useful operation when calcaneus or calcaneo-valgus is present and tendon transplantation is impracticable or is considered insufficient by itself. The peronei, if acting, should be attached to the os calcis or tendo Achillis, as practised by Whitman.

The results of the insertion of silk to act as ligaments are, I think it may be fairly stated, very uncertain, and the improvement cannot be relied upon to last. As in every branch of surgery, particularly orthopaedic surgery, those who are keenest on, and employ to the greatest extent, a particular method of treatment are those who will get the best results therefrom; but my own experience of this method is that it cannot be relied upon to prevent a relapse of the deformity. The same may be said of tendon fixation, though I am not prepared to deny that both these methods may be of use when combined with tendon transplantation in selected cases. If a hole is bored through an atrophic bone—the tibia, for instance—and through it is passed a strand of silk, the opposite end of which is attached to a bone in the foot and the thread tightened, the weight of the foot, with or without the assistance of the calf muscles, will cause gradual absorption of the hole in the bone under the constant pressure of the silk, so that sooner or later the tightness of the thread eases off and the foot is no longer held in the desired position.

As regards the spine, poliomyelitis provides us with some of the most difficult cases to treat. As Lovett¹⁴ has pointed out, the deformity can begin while the patient is still in bed. In such cases I have found it advisable to use corrective slings pulling horizontally in opposite directions, made of towels or broad strips of flannel and tied to the sides of the bed. In the usual child's cot it is possible to apply these slings without compressing the chest and the abdomen by attaching the two ends of a sling to the upper and lower bars of the side rails respectively.

Tilting of the pelvis may be corrected by a perineal band pulling obliquely upwards on one side, while a weight extension on one leg pulls downwards on the other. Later a plaster bed, moulded to the patient in the slightly over-corrected position, if this position is possible, may be used for sleeping or resting in; while if walking is possible a celluloid jacket, holding the spine in the over-corrected position, may be used. Correction can also gradually be achieved by the use of a plaster bed with pieces of broad webbing stretched across so as to bring pressure to bear on certain spots—for example, the prominent ribs on the convex side of a curve, as first suggested, I believe, by Mr. Openshaw.¹⁵ I prefer to use felt pads in the floor of the bed to serve the same purpose.

In recent years, with the increase of bone grafting, particularly as the result of the pioneer work of Albee, grafts and other methods of bony fixation have been employed for the fixation and prevention of deformity of the spine in these cases. Unquestionably this is a justifiable procedure in selected cases, but many cases are not severe enough, while others are so severe and intractable, or are so hopelessly crippled generally, that the operation is unjustifiable. A case with obliquity of the pelvis and lumbar curve due to paralysis of the psoas or abdominal and lumbar muscles on one side, seems to me one in which operative fixation of the spine is worthy of serious consideration in the absence of any contraindications. Again, some severe "C" curves which are seen before fixation of the deformity to any great extent has occurred should also be treated by gradual correction as far as possible, with a view to eventual fixation by a bone graft. More is being done along these lines in America than in this country, by Albee¹⁶ and Mackenzie Forbes¹⁷ among others.

REFERENCES.

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MITRAL STENOSIS, AURICULAR FIBRILLATION, AND THE ACTION OF DIGITALIS.*

BY

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A WRITER in this JOURNAL† recently made the statement: "A clear conception of auricular fibrillation is essential to the management of heart disease." The commonest antecedents of this disorder are mitral stenosis and myocardial degeneration; it also occurs in connexion with arteriosclerosis, aortic and mitral incompetence, and certain acute diseases, as rheumatic fever, pneumonia, diphtheria, and infective endocarditis.

Whatever the cause of the fibrillation it can be most profitably studied in relation with mitral stenosis. If we wish to understand mitral stenosis, as we commonly see it in young adults, we must go back to the rheumatic heart affections of childhood. Our conceptions of rheumatism are apt to be dominated by the occurrence of arthritis. In adults arthritis is the prominent symptom; the heart affection is incidental. In children, on the other hand, the joint signs are often transient, insignificant, or absent, while carditis is very common. I use the word "carditis" advisedly, because pericarditis and endocarditis never occur without myocarditis. It is in children especially that this liability to pan-carditis exists. Murmurs and friction are well known and common signs, but the most striking sign of all, to my mind, indicating involvement of the myocardium, is the accelerated cardiac action which may continue for weeks or months following an attack of rheumatic fever or chorea. These cases need prolonged rest if the cardiac condition is to have time to quiet down. Valvular and muscular lesions are incurable, and the only chance of averting or mitigating their effects is to encourage resolution of the infective process by means of rest.

The structure of the rheumatic nodules on the valves and in the wall of the heart is similar to that of the subcutaneous fibrous nodules occasionally met with. The effect of the nodules on the valves may be rapidly destructive, causing, in the case of the mitral, more or less regurgitation; these cases may end in mitral stenosis from subsequent contraction of the fibrous ring to which the valve segments are attached. But a more common origin of stenosis is the presence in the valve of islets of infection, which lead to a chronic process of sclerosis extending over

years. Rheumatism is proverbially relapsing, and knowing its nature we can have no doubt that from time to time extensions of the infection in the heart take place, not necessarily accompanied by arthritis, but gradually leading to a tighter and tighter narrowing of the mitral orifice. Mitral stenosis is commoner in women than in men; chorea is commoner in girls than in boys. Acute observers like Barlow have suggested that the partiality of chorea for the female sex may to some extent explain the frequency of mitral stenosis in women. Chorea, like rheumatism, is notoriously apt to relapse; sometimes a murmur can be heard during an attack, sometimes not. I believe that most, if not all, cases of mitral stenosis are due to sclerosing valvulitis, whether choreic, rheumatic, or merely latent; its destructive effects are slow and insidious; the mitral curtains become thickened, indurated, and adherent at their margins, and it is not realized till years have elapsed that an irremediable narrowing has occurred. This sclerosing process may cause no alteration of the heart sounds till it has been at work a considerable time.

The symptoms and signs of mitral stenosis may be divided into (1) the incipient stage; (2) the stage of full development; (3) the stage of auricular fibrillation. In the first two stages the pulse is regular; in the last it is grossly irregular.

Mitral Stenosis: Early Signs.

The first stage causes no symptoms, hence it will not be recognized unless looked for. Children of known rheumatic history ought to have their hearts examined from time to time, especially at the time of choosing a career. Every patient ought to be examined both in the standing and the recumbent position; a presystolic murmur, not heard in the standing position, will sometimes be brought out if the patient does a little exercise and then lies down. An important early sign is an apparent reduplication of the second sound at the apex. It is not a true reduplication, as the second part of the sound is produced at the mitral and not at the semilunar valves. A real reduplication, heard at the base, is due to asynchronous closure of the sigmoid valves, but is of no importance as an early sign. An apparent doubling of the first sound at the apex may be due to a short and ill-developed presystolic murmur. An instructive case of this kind lately came before our special neurological board for army pensioners:

He was a man, aged 25, who complained of muscular pains and occasional swelling of the ankle-joints. I noticed slight, irregular, jerky movements of the right arm and leg, but as tremors and spasms are very common in this class of case, the significance of the symptom did not at first occur to me. In both standing and lying positions the heart's impulse was slightly forcible, though there was no obvious enlargement; the first sound was rather loud and accompanied by a systolic murmur; the second sound at the apex was reduplicated. At this moment one of my colleagues happened to come into the room and I asked him to confirm the signs. While he was listening he exclaimed: "Why, the man's got chorea!" and so he had plainly enough.

Here we had the three parts of the rheumatic picture pieced together—namely, the muscular and arthritic pains, the heart lesion, and the chorea. These early signs indicate heart disease of at least three years' standing, and the fully developed signs of mitral stenosis indicate disease of five or more years' standing. This man was working as a coal-miner, and illustrates the point of unsuitability of occupation. He was advised first to have treatment from his insurance doctor, and then to change his occupation if possible.

Intermediate and Later Signs.

The fully developed signs of mitral stenosis are so well known that I need only refer briefly to them. A presystolic thrill felt at the apex and terminating with the impulse is almost pathognomonic. The rough presystolic murmur of crescendo character, terminating in a short snapping first sound, and the accentuated pulmonary sound are well known and typical signs. It must be remembered that the murmur is heard over a very limited area—that is, the immediate neighbourhood of the apex; neglect of this fact has sometimes led to failure in diagnosis. The short first sound resembles the second sound in quality, and as the second sound often cannot be heard at the apex care must be taken not to mistake the presystolic murmur for a systolic one, and the first sound for the second. This mistake can be avoided by timing the

* A paper read before the Nottingham Medico-Chirurgical Society, February 16th, 1921.

† Review of *The Mechanism and Graphic Registration of the Heart-beat*. By Dr. T. Lewis. Vol. ii, 1920, p. 166.