A Lecture ON THE TREATMENT OF INFANTILE PARALYSIS:

A STUDY IN BIOLOGY.

DELIVERED TO THE MELBOURNE MEDICAL STUDENTS' SOCIETY,

BY

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I HOPE to recount the results of my work on infantile paralysis carried on during the last eight years. The disease is widespread in its incidence, and essentially of the first few years of life. It attacks apparently the most healthy types, and, unless the correct treatment is recognized, it ruins physically those it is unable to slay, converting perhaps in a night the healthy child into a cripple.

PATHOLOGY.

The essential feature of this disease is an inflammatory affection of the cells of the anterior cornua of the spinal cord resulting in a paralysis of corresponding muscle groups. The inflammation may not be limited to the anterior cornual cells, but may affect other portions of the cord and the meninges, but in infantile paralysis *per se* these other effects are transient. The onset may be sudden, or preceded by a period of general malaise lasting several days, or as long as two or more weeks.

During the stage of inflammation, as evidenced by rise of temperature or pain, the treatment advocated was that of an ordinary feverish attack, antipyretics and purgatives being advised. On the subsidence of the feverish symptoms the accepted treatment was directed to maintain the tone of the muscles found to be paralysed by means of massage and electricity; but if in spite of these measures the muscles did not recover, the explanation given was not a recognition of improper treatment, but that the case was hopeless because the anterior cornual cell itself had not recovered and never would. Such a line of treatment largely left everything to chance, and apparently the cell did not often recover, since cripples from this disease are to be found in practically every city and town in the world.

The question of the muscle itself as even a factor in the treatment was never considered, and yet we know that biologically it preceded nerve tissue. No tests were ever applied to the muscle except the ones of extreme muscle function—namely, asking the child to raise its arm above the head when standing or sitting up, or standing the child on the affected leg to test the action of the quadriceps; and if the patient could not perform these extreme movements the anterior cornua cells were generally regarded as hopeless.

With the pathology I agree; with the deductions drawn from it I wholly disagree. Round the question of the action of muscles lies the whole principle of treatment. Though anatomically we speak of a muscle as being a flexor or extensor, we really refer to the maximum function of the muscle, and the question arises of the recognition of the minimum of muscular function for any particular muscle; for it is only by the recognition in treatment of its minimum function that the muscle may ultimately be coaxed up to its maximum—the ideal.

Hence when we speak, as have the authorities of the Rockefeller Institute, of an anterior cornual cell having been "irreparably damaged," we can only recognize this through the degree of paralysis present in the corresponding muscle group, a factor which altogether depends on the nature of the test applied.

For example, this statement as to "irreparable damage" might be applied to the cell condition, when the quadriceps failed to contract sufficiently to enable the patient to elevate the limb in one piece when lying on the back; yet such a quadriceps tested from zero might show every other function to be present, and the cell, if these further tests only were applied, would necessarily be regarded as

recovered. "Irreparable damage" and "paralysis" are really referable not to the muscle itself, but only to loss of part of its function, the restoration of which follows a simple biological law. So-called irreparable damage of the cell must be judged by loss of all the functions of a muscle—all must be tested, not some or any. This simple biological point is the basis of scientific treatment.

Acting on this principle in an old case of so-called cell destruction, as evidenced by paralysis and deformity of many years' standing, I found that such apparently paralysed muscles would often recover. One of my first cases was a boy from a neighbouring State with an acutely contracted knee owing to paralysed quadriceps and over-action of the hamstrings of nine years' standing. The boy was absolutely dependent on crutches. This knee was straightened by gradual continuous pressure, and the muscles were re-educated so that the boy was able finally to stand on the leg without support—an example of a muscle recovering its function whose controlling anterior cornual cells were supposed to be irreparably damaged, and which itself had been overstretched for nine years by powerful hamstrings. Such a result is explained by Jones¹ as due to the fact that relaxation of the quadriceps has allowed of the "taking in of the slack." Relaxation is but part of the treatment, and I may mention that I have relaxed many such quadriceps for twelve months and longer, and this particular case for three months, without result till I recognized biological re-education of muscle.

Relaxation means muscle stagnation—nowhere more than in relation to the quadriceps—and is a fallacious doctrine, since it is really leaving the muscle in the zero position, the starting point and not the end of treatment. Mere relaxation does not train a muscle to functionate; the mechanical interference with function from contracted antagonistic muscles is not the only factor to contend against. Such results were difficult to understand, viewed in the light of the deductions we were taught from the old pathology, and I began to wonder whether the chief affection might not perhaps lie in the muscle itself and the anterior cornual cell be secondarily affected, and therefore not such an important factor. With the assistance of Dr. Stapley of the Melbourne University, I carried out various experiments at the Melbourne Zoological Gardens and also numerous comparative studies on muscles at the Veterinary School.

My conclusions were:

1. That as a primary pathological factor the muscle by itself could scarcely be considered.
2. That biologically, however, it was all-important for the purposes of treatment.

I ascertained that through the muscle treatment could be directed towards the restoration of function of what I regarded as the partially damaged anterior horn cell or towards the bringing of new nerve control factors into play, remembering always cell adaptability and the precedence in biology of function over structure.

THE IMMEDIATE TREATMENT OF A CASE OF INFANTILE PARALYSIS.

The treatment for any paralysed muscle is immediate rest; but that alone is not sufficient—it must not only be immediate, but also anatomical.

It must be immediate, because the disease at once destroys muscle adjustments; and so fine are these that immediately the nerve cell governing the action of a flexor, for example, is affected, its extensor opponent begins to overact, and this overaction must be prevented for three reasons:

1. It does not allow complete rest of the affected anterior horn cell, being a constant source of irritation.
2. By overstretching the affected muscle it interferes with its recovery.
3. Even though the nerve cell and affected muscle may recover their power, deformity is inevitably produced, interfering with future utility—for example, recovered extensors of leg unable to act owing to a talipes equinus due to a contracted tendo Achillis.

The rest must also be anatomical because, as I stated in the *Australasian Medical Journal* (June, 1911): "Since rest is the basic treatment of inflammation, only by the

zero or anatomical position can the door be closed on all sources of irritation, and cord, nerve, receptive substance, and muscle be placed at physiological rest; that is, only through the zero position can you offer the greatest physiological opposition to the sources of inflammation."

A muscle is rested only when it is placed in a position in which its work is zero and its origin and insertion are as nearly as possible on the same horizontal plane, for the resumption of function, which should be gradual, is always easiest along a straight line. The zero position is the position of anatomical rest in which the individual muscle itself is relaxed, and both its own action and that of its opponent prevented.

My practice when re-educating a muscle is to begin each day at zero, and gradually to work up to and beyond the highest point achieved the day before. If, for example, the knee be contracted owing to a paralysed quadriceps and overacting flexors, it is obvious that the former being at a disadvantage for functioning, equilibrium has been destroyed. Hence we place the quadriceps in a position of relaxation (knee extension), prevent the overaction of its opponent when resting by means of a splint, or when exercising by means of position, then daily work at it to restore the lost equilibrium, by recognizing that it is incorrect to flex the knee beyond the point from which extension is possible—that is, at which effort becomes manifest—thus recognizing the cessation of its opposition to its opponent flexor.

There is relatively a much higher organization and specialization of the upper limb with an enormously greater correlation with intellectuality and natural and acquired skill. The upper limb of man, with its fine intrinsic and extrinsic adjustments, is in marked contrast to that of *Macropus*, in which, in spite of a dependent forelimb, we have defective muscle development and absence of a pollex. In man, so even is the adjustment that the loss of function of the adductor pollicis or pronator teres or supinator brevis may be sufficient to ruin the utility of the upper limb. Furthermore, the more tendinous the muscle the less its power of recovery, and the less the utility of a muscle or its importance in the animal economy the greater the liability to affection.

For the upper limb the anatomical position is as follows: The thumb is adducted because opposition to the fingers is essential, fingers slightly flexed, wrist slightly dorsiflexed on account of the grip, hand placed midway between pronation and supination, elbow slightly flexed to relieve the biceps and brachialis anticus, 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-joint; 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.

Rest I effect by means of a special arm splint introduced some six years ago, and simple both in its construction and application. The basis of the splint is a stem of malleable iron $\frac{1}{2}$ in. wide by $\frac{3}{8}$ in. thick. This runs up the mid-axillary line from costal edge to the axilla, and follows the contour of the under surface of arm and forearm to wrist, being bent to the requisite angle at the axilla and elbow. A piece of aluminium or tin shaped to the hand is attached at wrist to allow of the median position above stated, and the fingers rest on a pad of wool. Wings $\frac{1}{2}$ in. by $\frac{1}{4}$ in. are attached at wrist, elbow, and upper arm, and two wings two-thirds round the chest; the ends, being connected by a strap and buckle, are attached to the stem, one at costal edge and other below axilla. The limb is lightly bandaged on, and a piece of bandage over each shoulder from the front to back is sufficient to hold the splint well up against axilla. If no splint be at hand, nevertheless the limb must be placed at rest by some simple appliance—as, for example, 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 dress to it at arm and wrist so that the limb is abducted, elbow flexed, and brachial plexus rested.

As regards the lower limb, it is important to remember that not only is it a question of muscular movement but also of the support of the superincumbent body weight. The great point in beginning treatment is the relation of the two anterior superior spines to the umbilicus; the spines

should be on the level; the feet should be at a right angle to the leg, and possible inversion or eversion guarded against. If the flexors are affected with overacting extensors (an extremely rare condition), it is best to flex the foot in the equinus position. The knee should be extended, as the quadriceps is the great muscle for the erect posture, but one must be careful not to overstretch the flexors, so it is best also to apply a slight cushion of wool under the knee. The hip should be slightly flexed to rest the ilio-psoas muscle. It is a good rule at the outset, if only one limb is affected, to rest the two until the paralysed one has recovered, as pelvic tilting, the result of overaction of one side, may easily occur, and, once having occurred, is never overcome. It is also difficult to make quite sure at the beginning whether the abdominal muscles are affected, but if the two spines are on a level tilting will never occur. Furthermore, only in this way can we prevent undue rotation of the hip, either external or internal, and especially the former, to which there is so great a tendency.

This may be effected in various ways. A double Thomas splint, with slight flexion at hip, or the lower part of a Thomas, namely, from the thigh wings to the leg wings, and a cross bar, or simplest of all, a piece of padded board behind each knee from the middle of thigh to middle of leg and a connecting piece across the middle, a pillow under the feet allowing flexion at the thigh. As regards the feet, trouble is likely to arise from deformity even after the first day, and this is largely due to the fact that lateral movements are not prevented. The ordinary foot-piece on a back splint is insufficient. A tin splint lined with chamois and extending to upper third of leg is best. The leg-piece extends half round the circumference of the leg and the foot-piece has its edges turned up for 1 in. on the inside and $\frac{3}{4}$ in. on the outside, thus forming lateral shields to keep the foot in position. By means of pieces of webbing and buckle suitably applied the foot can be held in perfect position. Immediate attention to this detail will repay you. If you have nothing at hand a pillow can be kept against the foot to maintain the right angled position. If, in addition to the limbs, the muscles of the neck and back are affected a double Thomas splint with head extension is best, but the point to remember is that these muscles, as a rule, recover spontaneously. My firm belief is that if cases of infantile paralysis were only regarded most seriously at the outset—on the level, say, of a gangrenous appendix—and not left until something developed, not only would subsequent treatment be rendered comparatively easy, but the splints might act prophylactically and actually abort an oncoming paralysis.

THE RE-EDUCATION OF THE "PARALYSED" MUSCLE.

No definite time can be stated when re-education should begin, but the two guides would be the temperature and pain; until the cessation of these the limbs are best rested as advised, and rested only. The difficult question then arises, to find some work the muscles can actually do; and although such work may be the minimum for a healthy muscle, it may be the maximum for the affected muscle. Again I would emphasize that it is not a question of paralysis of muscle, but the loss of certain functions of the muscle, and it is to obtaining the resumption of these that our energies are directed. In the upper limb I will indicate the method of re-education to produce elevation and the recovery of elbow flexion; and in the lower, that for the quadriceps, as these give most trouble.

A child with a presumably functionless deltoid, if tested sitting up, may be unable to elevate the limb to the slightest extent; but test the same child when lying down, and the deltoid may then show complete functional power. Hence the idea for treatment would be the re-education of the deltoid with the patient first lying down and then gradually working to the erect position, the child being elevated by means of pillows. Deltoid action can be first encouraged by slightly lowering the arm from the right angle and asking the child to raise it, also by rolling him slightly to the opposite side and elevating the elbow off the pillow and seeing if he can maintain it in this position. In this manner the patient is encouraged at first twice a day and later for half an hour four times a day to abduct the arm from the side with flexed and later extended elbows and also to raise it above the head. In a recent case after anatomical rest the rapidity with which

function returns in the lying down position is surprising. In the same way with regard to elbow flexion the patient commences work in the lying down position, gradually acquiring as in the case of the deltoid the erect position; with the limb worked in this manner it is surprising what an amount of function a biceps may have which we regarded as hopeless. The great underlying principle of the work is to pick up a minimum function and to use it as the commencement. Referring to this question of the upper limb I wrote some five years ago:

The all-essential thing in this treatment is that it must be immediate. To me it admits of no delay. It is a recognition of the principle that the muscle will work, but to work it must be coaxed. It is antagonistic to the principle that whips the tired horse. The muscles are immobilized as soon as seen, and not left to hang till the splints are ready in perhaps a week's time. We would rest a fractured bone immediately or surgically clean a compound fracture, and why differentiate in the case of a nerve or muscle? . . . My belief is that with immediate anatomical rest the necessity for mechanical or operative treatment later will be minimized and, in the majority of cases, rendered unnecessary in the upper limb.

If the knee be bent when lying down the function of the quadriceps is to straighten it. It also permits of abduction or adduction of the limb in one piece. Further, with the normal quadriceps we are enabled to lift the heel off the ground with the knee extended. Unless this latter function can be performed there is inability to maintain the erect attitude, since the quadriceps, when we stand, maintains that stiffening of the knee which is essential for the erect posture. This further power of the quadriceps has been a late acquirement in man's physical evolution. With one quadriceps intact the erect position may still be maintained. Thus, quite apart from the action of the back and buttock muscles, the maintenance of the erect position really depends on this later acquired function of the quadriceps, for if this be lost, though every other muscle of the body be intact, we fall. Loss of this function is responsible for the large amount of crutchdom following this disease seen in any large city, and would be obviated by the conversion of the limb into one rigid piece, as by a piece of board behind the knee or by an extended knee splint.

Though similarly placed anatomically, the action of the quadriceps is vastly different in the *platypus* and in man. If we take a lower limb with a quadriceps that has been paralysed for some time, on flexing the knee with the patient reclining and taking away any support the limb still flexed falls usually in the abducted position, for if there be no quadriceps power not even the weight of the limb will be sufficient to straighten the knee. On flexing the knee for, say, 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 it falling out; that to me is evidence of commencing recovery, and week after week the flexion is increased, the fall being gradually replaced by a definite push till finally the patient, holding the knee in the position of acute flexion without adduction or abduction of the thigh, is able to straighten the limb. In this early movement hip action is unhindered, and it may be necessary to commence with the patient on his side and not on his back. The patient is then encouraged to abduct and adduct the limb in one piece, the latter being usually more difficult; then, with the patient lying on the sound side, the thigh steadied, and the hip action prevented, extension is practised from the various degrees of flexion till full flexion is reached. This constitutes a pure knee action. But such a limb is not yet able to bear half the body weight. In ideal recovery the patient is able to raise the heel off the ground with the knee extended. Here again the principle of gradual acquisition of muscular power comes into play. Thus, if we alter the leverage by turning the patient to the opposite side, usually we find the limb can be lifted in one piece. That the quadriceps is the factor here, and not gravity and the knee ligaments as has been averred, is easily proved in a patient unable when on the side to lift the limb which remains flexed at the knee, but able when an artificial quadriceps is provided, that is, a piece of board behind the knee to stiffen it, not only to lift the heel off the bed on the side, but even on the back.

From the side gradually week after week the body tilt is altered till finally the supine position is reached. Then, and then only, is our patient ready for walking as far as the quadriceps is concerned, but it is best not to allow it without having the knee supported, otherwise the tendency

is for the patient to acquire balance either by everting the limb or hyper-extending the knee, or both. Hence an ordinary knee splint with a hinge may be used. The knee hinge is locked at first, so that movement is obtained from the hip, and the knee rested in the extended position. Gradually slight flexion is allowed and increased till full flexion is reached, when the splint may be discarded.

BIOLOGICAL PRINCIPLES IN THE TREATMENT OF DEFORMITIES.

It is obvious that if the foregoing principles are carried out there will be comparatively little necessity for surgical interference, as pelvic tilting, buttock wasting, curvature of the spine, contracted knees and deformed feet, which go to make up the usually formidable and apparently hopeless picture, are all preventable. The usual surgical procedures are the overcoming of contractures, division or removal of deep fascia over muscles, muscle or tendon transplantation, nerve grafting, fixing a joint either by arthrodesis or excision.

Joint Fixation.

The scope of the two last named is extremely limited. Arthrodesis is useful, especially in an old case of flail shoulder where we have a good hand and biceps. It is necessary to remember that by arthrodesis a joint is condemned for life and even should muscles ever recover they will never have a chance for action. Hence, all possible means of recovery should be exhausted since opening a joint is a serious procedure. It is worth remembering that many cases of excision of the knee for disease in the young frequently return with contracture and in some cases backward dislocation necessitating a splint which the operation was designed to obviate. By means of a Thomas knee splint we can produce an artificial arthrodesis and with the boots properly built up and stiffened obviate the inconveniences of a flail ankle, and all the time we have the chance of improving the condition of the muscles.

Contractures.

Concentration of force, as Hunter taught us, may be regarded as the first principle in the treatment of contractures, especially in the young. In other words, given a pressure continuous and concentrated, contractures, even of the extreme and apparently hopeless type, will be found to yield without the aid of what should always be the last resort—the knife. If a muscle contracts, it will relax if coaxed, not forced to do so. I refer especially to contractures at the knee and elbow, which will often respond to the pressure of a bandage and straight splint. Operation is indicated in old contractures about the ankle, contracted pronator teres, and fascial contractures of the thigh, especially marked at the anterior superior spine and outer thigh above the knee, where I have known a fascial band to be nearly $\frac{1}{2}$ in. thick.

Operation on the Deep Fascia.

Although it is common enough to see that muscle thought most hopeless of all—the quadriceps extensor of the knee—after being condemned both on electrical and utilitarian grounds as hopeless, brought back into action, it may be stated that no muscle should be condemned till it has been properly tested, and this ensures that there be no mechanical interference with its working. It is usual to speak of the contraction of strong unaffected antagonistic muscles as the great bar to recovery; it is certainly an important factor, yet the deep fascia over muscle as a factor seems not to have been considered. An affected or paralysed muscle is one whose work has been interfered with, and in the animal economy diminution of work means atrophy of tissue. The deep fascia which in the forearm and over the extensors of the leg, for example, forms a little-yielding firm band, accommodates itself obviously to the muscle condition present; when later a call is made on the muscle for increased work it is found to be bound down, and this is as great a hindrance to recovery as a contracted tendon. Splitting the fascia and removing portion of it is an operation easy to perform and harmless, and it is surprising how what appears at first an anaemic mass of muscle will, with the application of warm saline, bulge out and assume a healthy appearance and later on functionate. I have performed this operation frequently, and rarely without result, over the extensors of the leg, and I think it should always

accompany the straightening of an acquired talipes equinovarus.

Muscle Transplantation.

In muscle transplantation there is the risk not only of failure to obtain function to the affected part but actually weakening the non-affected, and, in my opinion, by working on the re-education method, interference will very seldom be found necessary. It seems to me a fallacious argument to expect a flexor of the leg to act as an extensor if grafted on to the patella, when we know the complicated action of the quadriceps. The large percentage of failures seen in the after-results of nerve and tendon grafting is due to the fact that re-education methods have not been practised and persisted in. As in the case of recovery of a paralysed muscle, so with a reinforced one, working from zero must be insisted on. In the last six years I have never performed a muscle or nerve grafting. In foot eversion following "paralysis" of the tibials, the unaffected peronei pulling the foot out, the usual idea would be to strengthen the weaker group by grafting on to the tibials from unaffected or recovered extensors or flexors. But, biologically, one knows that eversion and inversion of the foot are diminishing, that the tibia is the dominant bone in the leg, and that the fibula is disappearing. Just as the appendix approaches the ileum, becoming finally incorporated in its wall as in *Phascolomys*, and the right adrenal the liver as in the true *Phalanger* (*Trichosurus*), so does the fibula the tibia, as evidenced by *Macropus*. A struggle exists round the ankle, as elsewhere, between individual muscles, not only for position, but for existence—a fact Hunter seemed to recognize. Hence the biological idea would be not to strengthen the weak, but to weaken the strong. The suggestion then might be made of division of the peronei since the tibials were "paralysed"; but, recognizing again that paralysis in this disease may denote merely loss of part of function, the abolition of eversion might mean recovery of inversion with deformity. Hence we wish to weaken eversion but not to abolish it. So, which is to go, the longus or brevis? Now, in *Phascolarctos* the peroneus longus adducts the big toe, and in *Phascolomys*, with a diminutive big toe, we have a relative diminution in size of the longus, seen more markedly in *Macropus*. The longus attachment is retreating, and a retreating muscle is a weakening one. Low down in the vertebrate scale the position of the brevis is fixed, and a comparison of these muscles in *Phascolomys*, *Macropus*, and *Phascolarctos** shows the greater belly muscularity of the brevis, which, and not the longus, is the principal everter. So, to weaken eversion without its abolition the brevis must go. Traction made with a forceps on the exposed peronei at the outer malleolus in the living subject in these cases demonstrates the comparative weakness of the longus in everting as against the brevis; further, the latter is usually very muscular there. Similarly with the tibialis posticus and anticus, the anticus is the selected muscle, and low in the vertebrate scale we may see a tibialis anticus even larger than the extensors. In *Macropus* a powerful inversion is noticed not to counteract the peronei, but to overcome the gravitational effect of a large body poised on practically one toe. The anticus, which is relatively enormous, is chosen, while the posticus has diminished to an almost tendinous thread, dependent for its diminutive pull on the flexors.

The Use of Serum.

In cases arising during epidemics it is conceivable that the use of a serum might be serviceable prophylactically. A serum could scarcely be expected to evolve lost muscle power, although occasionally as a prophylactic measure it might be applicable in a hospital where numerous cases were present. It would be impossible, however, even under those conditions, to foresee in every instance that the child was sickening for this particular disease, apart from the known difficulty in an infant with loss of muscular power of differentiating infantile paralysis from, say, rheumatism or epiphysitis; by the time the correct diagnosis has been made, the chances for a preventive or

curative serum are gone. In this disease, then, it is not merely a question of prevention and cure, but prevention, cure, and restoration of function of paralysed muscles, or, to put it more correctly, the resumption of certain functions of muscle which have been lost.

The Use of Thymus Gland.

I have dealt recently with the biology of the thymus gland as evidenced by a study of the marsupials and monotremes; it is present throughout life in the *Ornithorhynchus*, *Echidna*, and *Dasyurus ursinus*. All, but especially the latter, have also well defined parathyroids. I have never found a trace in the "selected" marsupial, *Phascolomys*, nor in *Phascolarctos* (koala). It is absent in the "selected" macropod (*Mac. ualab*), but present in the kangaroo (*Mac. giganteus*). The correlated evidence as regards the muscles of these animals is extremely interesting; no one animal with a retained thymus represents a fixity of muscular development comparable with the supreme physical type—*Phascolomys*. We know practically nothing as regards the function of the thymus. It is a characteristic of early life; it begins markedly to disappear about the sixth or seventh year, and in the adult nothing is to be seen macroscopically; at birth it weighs $\frac{1}{2}$ oz. or more, and is somewhat heavier at the end of the second year. Cases of a defined thymus being retained throughout life are recorded—a fact of no little importance. The gland is at its maximum when muscular action and co-ordination are developing; when these have been well established, it begins to disappear. Although it begins to disappear early in life, the question arises, Should it necessarily disappear then? Is its absence beneficial in all or some? Are conditions superimposed causing its too early disappearance in some to whom thymic secretion perhaps may be a necessity?

I regard its use as being indicated in infantile paralysis, particularly in the early stage; a child can take 15 to 20 grains in twenty-four hours. As I have written previously: "Its use is, of course, accessory to the basic treatment, rest—that is, the anatomical rest of muscle, and a recognition that poliomyelitis represents, not a paralysis, but a loss of part of muscular function; that the zero position of muscle must be found; and that the muscle must be re-educated along the lines of the acquisition of its muscular function; and, above all, that the rest be immediate."

Massage.

Until a muscle has recovered it should only be massaged in the zero position and in the mildest manner possible. It is erroneous to expect massage to initiate function, but it may undoubtedly strengthen function found to be present in the muscle. Thus in the upper limb, where there is an obvious gulf between the performance of muscular function when the patient lies down and sits up, there should be no exhibition of massage till at least the whole of the muscular functions can be performed lying down, and then it should only be used on the limb placed in a similar position to that occupied when in the splint. A paralysed limb should be handled as carefully as a fractured limb. Massage in a recent case is best avoided till the patient can elevate the upper limb when sitting up, and the heel when lying on the back. The muscle enlarges not from the amount of work done for it but from the amount of work it itself does. The importance of the mental factor in securing recovery of the affected muscle is of prime importance. In experiments on animals this factor explains their limitation, for no analogy can be drawn between results where guided mentalization governs volition, and where it is absent. The muscle cell has potentialities which it will not yield by force. It has been a big struggle from the monotremes to the marsupials, and up to man—functions and muscles striving for the supremacy. The erect position ultimately depends on a function of one muscle—the quadriceps—and is lost if that fails, though all else remains. The orang in walking balances by means of the hand. We have advanced further, since we can dispense with the assistance of the upper limb, and, furthermore, are able when standing to elevate the hand above the head. But remember these functions are unstable; they came last, easily go, and are hardest hit in infantile paralysis. It can confidently be stated that the prognosis can be regarded as hopeful provided the zero position of the muscle be recognized. This is opposed to the old view, by

* These three members of their order I have chosen for the following reasons: In *Phascolomys*, without doubt the "selected" member, we have extraordinary muscular development for purposes of strength. In *Phascolarctos cinereus*, with a double pollex and the big toe acting as a pollex, we can study muscular co-ordinations and adjustments. And in *Macropus*, where we have the attempt at the erect position, we see the development of certain muscles and the retrogression of others, especially in the upper limb and leg and foot, thus enabling us to estimate selected tendons by survival results.

which the amount of work a muscle was asked to do was usually in excess of cell recovery; the resumption of work should be gradual—that is, presumably with cell recovery. The treatment of the muscle is all-essential in the disease. Instead of waiting for a chance recovery in the corneal cells and treating in a perfunctory way the muscles with massage and electricity, we recognize that every affected muscle will work, provided that a commencement be made from zero. It is recognized that an affected limb will retain its heat and show little waste provided that it be rested and worked within physiological limitations. Work must not be done for the muscle, it must itself work.

In conclusion, I would like to mention certain references that to me stand as landmarks—namely, Hunter's lectures on muscular motion, perhaps the master's greatest work; Hughlings Jackson, who taught us the application of Darwin's work to the nervous system; and Owen Thomas, who pointed out the significance of surgical rest. It is to the credit of this great man that he placed his back against the tide that unfortunately the antiseptic system loosened, and Australia owes a no small debt to my teacher, Dr. Peter Bennie of this city, for his unswerving support during the last thirty years of Thomas's work.

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A FIELD HOSPITAL IN BELGIUM.

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THE opportunity of a surgeon in war depends more upon the rapidity with which the wounded reach him than upon any other circumstance. The downward progress of a man gravely wounded is so rapid that a few hours' delay may mean the loss of a life or a limb. For the past three months we have worked in a hospital which has always been within a few miles of the firing line, and we hope that our experience of surgery under these conditions may not be without interest.

The British Field Hospital for Belgium began its work in Antwerp with a well-equipped hospital of 150 beds and a staff of 8 doctors, 20 nurses, and 5 dressers. In five weeks 500 Belgians and 70 British were admitted to its wards, in addition to a large number of slighter cases treated and sent on to other hospitals. On October 8th, 1914, in view of the German occupation, the hospital had to leave Antwerp. We retired, however, in good order, bringing with us, on seven motor buses, all our wounded (73 Belgian and 40 British), all our staff of 40, and practically our entire equipment.

After a week in London to refit, a fresh start was made at Furnes on October 19th, and there the hospital is still at work, acting as the official field hospital of the Belgian army. Furnes is at the centre of the curve formed by the river Yser, and at a distance from the trenches varying from five to eight miles at different points (December, 1914). It is an old Flemish town of about 6,000 inhabitants, and the hospital is established in the large Episcopal College of St. Joseph. It has accommodation for about 100 patients, although by the use of straw wards we have housed as many as 150 on more than one occasion. Every day the military authorities visit the wards and transfer to base hospitals at Calais and Dunkirk every patient who can be moved. The turnover is therefore very large, and has reached as many as 100 in one day. These evacuation arrangements enable the hospital to deal with a very large number of patients, though they make it somewhat difficult to follow any but a few special cases throughout their course.

It will thus be seen that the hospital has enjoyed all the advantages, and some of the dangers, of a well-equipped establishment close behind the fighting line. It has also the immense advantage of a fleet of motor ambulances to bring the wounded direct from the trenches. Dr. Munro's

Ambulance Corps works in conjunction with the hospital, and brings the wounded in with the least possible delay. Most of our cases are received within the first twenty-four hours and in some cases they have reached us in less than an hour from the time of injury. There can be few hospitals so fortunately placed.

Before proceeding to discuss the various injuries which we have been called upon to treat, we must consider for a moment certain general features common to all cases admitted to the hospital. All have been living in the trenches for some weeks, their clothes are sodden and caked with dirt, exposure and insecure sleep will have left some traces on the men themselves. In most cases they must have lain in the trenches for at least some hours after being wounded, for as a rule it is impossible to remove wounded during daylight. When fighting is at all severe they may lie for many hours before they can receive any attention at all. On one occasion we took in five Germans who had lain wounded in the trenches for five days with absolutely no attention at all, two of them with compound fractures of the femur. To physical exposure must be added the mental effect of the terrific bombardment at close range which has been such a prominent feature of the fighting in this neighbourhood. The men seem dazed, stupefied, and apathetic to a degree with which we were not familiar in the less strenuous conditions of the fighting around Antwerp.

When we add to these general conditions the loss of blood and the actual shock which must be associated with any severe injury, it will be seen that the first efforts of the surgeon must be directed to the treatment not of the injury itself, but of the general condition of the patient. He must be got warm, his circulation must be restored, he must be saved from pain and protected from further shock. In other words, saline infusion and morphine form the starting point in every serious case. Bleeding rarely requires immediate attention. Unless it had been dealt with effectively on the field, the patient could not have reached hospital. But the means adopted were probably very primitive, and with improvement in the circulation bleeding may recur. This is a very real and serious danger which must on no account be overlooked.

We cannot urge too strongly the necessity for deferring any serious surgical procedure until all that is possible has been done for the general condition of the patient. It need not take long. Hot-water bottles, an enema of coffee and brandy, a quarter of a grain of morphine, and a pair of subcutaneous needles delivering really hot saline, will carry through a serious operation a patient who half an hour before was cold and pulseless. We are dealing with absolutely healthy individuals, and their rate of recovery is amazing.

Two features are common to practically all wounds produced by projectiles in the present war. All are septic and in all there is great destruction of tissue. These two facts are correlated, for the infection is certainly not due to the organisms with which one is familiar in ordinary surgical work in England, but in a large degree, at any rate, to saprophytes. The patients never show the phenomena of acute sepsis as seen in civil practice, but rather a condition of almost pure sapraemia. The wound may be a black and gangrenous crater, such as would under ordinary circumstances be incompatible with life, but its edges show no spread of infection, the patient is comfortable, and has no rise of temperature, and with suitable treatment the wound will become covered by healthy granulations and rapidly heal. In bad cases, it is true, ordinary sepsis may develop, but this occurs very late and is obviously due to a secondary infection bearing no relation to the original bacteriology of the wound. The recognition of this fact is of extreme importance, for all wounds must be treated with full surgical asepsis, whilst a liberal use of hydrogen peroxide will destroy most of the organisms primarily present. We do not here refer to the special infections of gas gangrene and tetanus.

The destruction of tissue is so great that each side has repeatedly accused the other of using dum-dum bullets. This is based on an entirely mistaken reading of the evidence. Our opponents do not use such bullets, for the very good reason that they have discovered something far more deadly at long range. Their pointed bullet is carefully constructed so that its centre of mass is far back. On striking any tissue, soft or hard, it at once turns over and