THE SURGERY OF BRAIN DAMAGE

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Management of the secondary effects of brain damage may be primarily medical, as in the treatment of spasticity and epilepsy, or it may be surgical in which case it may fall within the sphere of the orthopaedic surgeon, the orthopedic surgeon and the neurosurgeon. This communication is concerned particularly with the neurosurgical aspects of treatment of brain damage.

PALLIATIVE SURGERY

At the outset it must be clearly stated that surgery cannot be the be-all and end-all of treatment of any patient with brain damage. Surgery is merely a part of the total management and must be integrated into the individual treatment programme for the patient. Most of these operations are destructive procedures to a greater or lesser extent and to advise surgery in this nature in a patient who already has gross loss of function, is a step not to be taken lightly.

Remarkable results following surgery are often due as much to the personal attributes of the patient, his drive and commitment, as to the surgical procedure. Children with brain damage who have successful operations, usually have parents with the ability to guide their disabled child through his therapy to become a balanced personality despite physical handicaps and their psychological concomitants.

Surgery of Spasticity

Spasticity is a common result of brain and spinal cord damage in adults and children. It is a reflex effect from the normal tonic inhibitory influence on cells which subserve somatic motor functions. If the basic pathology cannot be affected by treatment, therapy is directed at the final common pathway subserving muscle tone. It is well known how spasticity can hamper a patient's progress and how relief of spasticity by physiotherapy, medication or surgical means, can at times restore a patient to activities which before would have been thought impossible. Non-surgical means of alleviating spasticity, should be given an adequate trial before resorting to surgery. There is no point in adopting a die-hard attitude to some method of treatment and stretching the patient on the rack that particular method, waiting for a miracle. If the patient is progressively getting worse, denying him the benefit of adequate surgery is as foolish as surgical overenthusiasm.

The aims in treatment of spasticity are:
1. To relieve spasticity, and
2. To retain, if not improve, motor, sensory or sphincter function.

The final neural pathway for spasticity traverses the afferent fibres, the interneurones and efferent neurones at any particular spinal segment. Chemical or surgical treatment is directed at interruption of afferent, interneuronal or efferent pathways. Treatment by tenotomy or tendon lengthening deals with the mechanical effects of spasticity.

NEURECTOMY

This may be performed either by chemical or surgical means and usually interrupts efferent and afferent pathways to a muscle.

Chemical Neurectomy

Local injection of phenol or alcohol to interrupt...
Function in a nerve has a well-defined place in treating spasticity. The muscle nerve points in question are localized with stimulating electrodes and then injected. The effects are, however, transient (Cain et al, 1966; Lacomis et al, 1966). Phenol injection into spastic muscles has been used particularly in mobilising the spastic arm and hand in hemiplegic patients. The obturator nerves may be painted at open operation with phenol to relieve adductor spasm.

**Surgical Neurectomy**

The most frequent operation of this type is obturator neurectomy for adductor spasm in the leg.

There are a few basic criticisms of neurectomy, the first being that a peripheral nerve is sectioned. If it is a mixed nerve, there is sensory loss with its attendant risks. Irrevocable loss of muscle power occurs and muscle wasting and later contracture of the wasted muscle may follow. Neurectomy is not rejected entirely, but plays a very clearly defined, if limited, part in the management of spasticity.

**RHIZOTOMY**

**Surgical Posterior Rhizotomy**

In 1898, Sherrington demonstrated that decerebrate rigidity in experimental animals could be reduced by posterior nerve-root section. This effect is due to interruption of afferent input from muscle spindles as well as other receptors.

Bischoff in 1951 applied this concept to man by performing posterior root section for spasticity so as to reduce the sensory input which propagates spasticity. This involved section of L. 2, 3, 4, 5 and S.1 posterior roots. The idea was to leave some posterior root sensory areas intact as it rapidly became apparent that the sensory loss was a major deficit to some of these patients who were immobile on account of their paraplegia. The beneficial effects, however, were of short duration so that this operation fell into disrepute fairly quickly.

**Anterior Rhizotomy** was introduced by Munro in 1945. It does provide complete relief of flexor spasms but at the price of faciadic paralysis and can therefore only be done below the level of complete cord lesions. In both these kinds of rhizotomy, permanent loss of neural function follows in a person already neurologically disabled, and there is no hope of any recovery ever. Patient selection has therefore to be extremely careful.

**Selective Anterior Rhizotomy (Munro, 1952)**

Every second or third fascicle of the particular nerve-root concerned is divided so as to reduce motor outflow two- or threefold. If too many fascicles are divided, faciadic paralysis ensues. It was a valuable method but lacked proper physiological control.

**Functional Posterior Rhizotomy**

To overcome the difficulties of sensory loss and paralysis following root section, various types of selective posterior root section have been developed [Gros et al, 1971; Fraioli & Guidetti, 1977]. Fascicles of roots are sectioned according to the effects produced by electrical stimulation or every fascicle is partially sectioned, or, only 2 or 3 fascicles in a posterior root are left intact. This is usually done in the lumbar region because not all fascicles are divided or divided completely. There is no extensive or disabling motor deficit. This method works on the basis of reduction in total input without loss of essential sensation, particularly proprioception.

What is somewhat surprising at first, is that there is relief of spasticity at levels higher than the area sectioned, particularly in children with cerebral palsy. Experimental justification for this has been provided by Kirk and Denny-Brown (1970). There is in these children inadequate suppression of input and by reducing the afferents at a few segments, lessens the total input into the entire nervous system which can then function better even at higher levels.

**Chemical Rhizotomy**

Maher (1957) treated a series of patients with intrathecal phenol for various indications and in this group included a patient with spastic paraplegia. This method was rapidly accepted and developed particularly by Nathan (1959, 1965). It is a method of treatment with considerable risks attached to it if not correctly carried out, but, if the necessary precautions are taken and the injection of the correct strength of phenol solution given under perfect radiological and clinical control, it becomes virtually risk-free. It can allow function to be recovered by removal of disabling spasticity and it can even be given to ambulant patients without producing added neurological deficit. It works on the basis of non-selective destruction of nerve fibres in the posterior nerve roots which consequently reduces the inflow of impulses into the affected segments.

The disadvantages of the method are, in the first place, the risks attached to the operation.

Long-term use of phenol is followed by tissue fibrosis, progressive loss of muscle power and may not be lasting.

To limit the phenol effect to the desired nerve roots, Harris and Simpson (1964) suggested laminectomy for these patients as a prelude to the nerve-root section, followed by electrical stimulation with glycerin and phenol. Even this procedure may be only transiently effective and adds the burden of a laminectomy to patients rather severely disabled already.

**LONGITUDINAL MYELOTOMY**

**Bischoff Type 1 (1951)**

Lateral longitudinal myelotomy is directed at cutting longitudinally the association fibres of Kölliker running between the anterior and posterior horns and in this way interrupting some of the interneurones concerned in maintaining spasticity. Lateral longitudinal incisions are made in the spinal cord, along the line of the dentate ligaments from L.1 to S.1. If the bladder is spastic, one side is cut down to S.5. Bischoff noted that this operation relieved spasticity but tended to interfere with the corticospinal tract and deuscussating sensory fibres and therefore modified the operation.

**Bischoff Type 2 (1967)**

This is a median posterior longitudinal myelotomy. An incision is made in the midline posteriorly to the level of the central canal and lateral extensions are then made at right angles to the initial incision interrupting the connections between anterior and posterior horns, but without any damage to the corticospinal tracts. A considerable number of these operations have been done and the results have been very promising. We have done three with rather satisfactory results and no loss of neurological function. All three patients were restored to activities which they had not had before.

**CEREBELLAR DENTATOTOMY**

The effect of cerebellar lesions on tone have been known for a long time. Clinical application of these
facts to patients with abnormalities of posture and tone, stems from the work of Nashold and Slaughter (1969). The operation is stereotactically performed and involves an incision in the skin. The incision is a small incision along the extensor surface of the arm. The muscle fibers are cut with monopolar coagulation. The axons are cut with a small incision in the skin. The muscle fibers are cut with monopolar coagulation. The treatment of choreo-athetosis is improved with partial denervation. The results are variable and not always lasting, but they are reported that about 50% of the patients have a 78% improvement in children with cerebral palsy and movement disorders. The small lesion may be accurately placed in a predetermined target such as the globus pallidus or ventro-lateral nucleus of the thalamus without damaging the motor or sensory tracts. By 1953, Narabayashi could report that about 50% of the first group of choreo-athetotic patients treated by chemopallidectomy were improved and in 1962, he reported a 78% improvement in children with cerebral palsy and movement disorders.

Only children without evidence of spasticity and of normal neurological reflexes are suitable candidates for thalamotomy, which may affect dystonia. Most authors believe that dystonic and choreiform movements are helped more than athetosis by thalamotomy. In our experience with two patients, dystonia has responded extremely well to venolateral stereotactic thalamotomy.

SURGERY FOR SEIZURES

An area of cerebral tissue may be destroyed by a wide variety of pathological processes such as vascular occlusion, haemorrhage, inflammatory lesions, mechanical trauma or compression by any expanding intracranial mass. When this destroyed area heals, functional neurological disturbances may become an epileptogenic focus. It should be noted that the epileptic discharge does not originate in the lesion but in the border zone between it and normal brain. Usually, such a focus lies in the cortex.

Indications for Surgery

A focal lesion producing partial or generalized epilepsy such as a brain tumour, A-V malformation, cyst or abscess, which can be removed safely and with minimal additional surgical trauma. Usually, these patients are operated upon because of cerebral compression rather than epilepsy, which is regarded as incidental and symptomatic.

Epilepsy which is uncontrollable medically, and which originates from a localized focus that can be removed without producing new neurological deficit. Removal is best done by hemispherectomy or cortical scar excision.

Hemispherectomy

A small group of children with infantile hemiplegia developed intractable epilepsy and later severe behavioural disturbances. The cause of the hemiplegia may vary. The epilepsy may be partial or generalize but, usually the latter. Behavioural disturbances are the most notable feature of this disorder; temper tantrums, violence, cruelty towards weaker individuals, and lack of discipline are the outstanding features. There are gross EEG abnormalities and plain X-rays show asymmetry of the skull while air studies reveal marked unilateral ventricular enlargement.

For this kind of problem, Krynauw (1950) performed hemispherectomy, removing the almost completely destroyed hemisphere. A large number of cases have been reported (McKissock 1953, Wilson 1970). Despite occasional late deaths due to haemorrhagic complications, 2 out of 3 of the survivors are seizure-free and a further 14% much improved. It is probably the most radical and also the most successful operation for epilepsy. It does not add to the patient's neurological deficit, which may indeed be lessened.

The success with this pioneering operation, led to Penfield's work with temporal lobe epilepsy as a result of which patients with this type of epilepsy are one of the ones most likely to benefit from surgery in the form of temporal lobectomy, provided that the correct indications are adhered to.

THE SURGERY OF ABNORMAL MOVEMENTS

Choreo-athetosis is common in children as part of the cerebral palsy syndrome. They do not only have disturbing abnormalities of posture and movement, but also abnormalities of voice, speech and of body language. The operation of the anterior column section has met with little acceptance because of the motor and sensory deficits in these children. The operation was more or less forgotten except for sporadic reports till 1932, when Bucy and Buchanan revived this work by subpial excision of the motor and premotor strips with some success and noted that the dystonic movements were less favourably affected than the choreic (Bucy, 1951).

Any cortical operation left the patient not only with some weakness which could perhaps be regarded as a reasonable exchange but also with a very real risk of added post-traumatic epilepsy. Occasionally, however, patients had better motor function after operation than before.

A more limited attack on the so-called pyramidal tract was directed at the corticospinal motor tracts in the cerebral peduncles (Walker, 1949). This is a difficult operation as the anatomy does not conform to the textbook description; even electrostimulation does not resolve the problem completely. The results are variable and not always lasting, but it has retained a certain popularity in the hands of some surgeons (Maspes & Pagni, 1964).

SPINAL TRACTOTOMY

Surgery directed at the upper cervical spine such as anterior column section, has met with little acceptance because of the motor and sensory deficits incurred when adequate relief of choreo-athetosis was obtained (Putnam, 1942).

BASAL GANGLION SURGERY

Direct surgical attack on the basal ganglia in the treatment of dyskinesias, was pioneered by Meyers (1942). With the development of stereotactic surgery, this method became the accepted way of dealing with movement disorders. The advantages are that a small lesion may be accurately placed in a predetermined target such as the globus pallidus or ventro-lateral nucleus of the thalamus without damaging the motor or sensory tracts. By 1953, Narabayashi could report that about 50% of the first group of choreo-athetotic patients treated by chemopallidectomy were improved and in 1962, he reported a 78% improvement in children with cerebral palsy and movement disorders.

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Excision of cortical scars

Surgery for the cure of this type of epilepsy must include the mapping and removal of the entire epileptic area without producing any new neurological deficit.

There is a very low mortality in this type of surgery and the success rate (total abolition or marked reduction in seizures) is about 50% to 70%, but the failure rate is virtually constant. For success, strict indications must be adhered to. Full and adequate medical therapy must have failed. Careful clinical and laboratory investigations must indicate that there is a focal cortical lesion present and the area of cortex involved must be dispensable without adding to the patient's neurological deficit. (Rasmussen, 1969). There are other forms of surgery for epilepsy but their results are less predictable and their application has not become widespread.

Surgery of abnormal behaviour

Some epileptics develop severe behaviour disorders such as aggressiveness, extreme restlessness, destructiveness and unprovoked violent behaviour. When all medication fails, and the patient can only be institutionalised, certain forms of surgery may give relief; the "sedative surgery" of Sano. Stereotactic amygdaloectomy, cingulotomy and postero-medial hypothalamotomy have all been reported as being beneficial but this is surgery which should not be lightly undertaken on account of the moral and ethical considerations involved.

THE SURGERY OF RAISED INTRACRANIAL PRESSURE

Brain damage may follow on elevated intracranial pressure as indicated earlier on. There are two conditions which deserve special mention. The commonest is the development of hydrocephalus after any form of cerebral injury and the other is porencephaly.

Hydrocephalus

Any lesion which leads to obstruction of the outflow of a lateral ventricle, third ventricle, aqueduct of fourth ventricle, or even which leads to obstruction of the temporal horn of one lateral ventricle may cause a varying degree of hydrocephalus proximal to the level of obstruction. Hydrocephalus produces secondary damage due to stretching of the paraventricular fibres and pressure. The symptoms of raised intracranial pressure such as headache, vomiting and papilloedema are to be watched for. Perhaps more important than these, although a little more subtle, are symptoms such as failure of concentration, intellectual fall-off and loss of recent memory. The latter ones may present themselves earliest of all to the therapist. The medical attendant should take heed of these complaints to prevent irreparable brain damage by early surgery. Investigations often show a so-called occult hydrocephalus where there are no symptoms of raised intracranial pressure but only those of intellectual impairment, unsteadiness of gait and incontinence of urine. There are many methods available for treating hydrocephalus surgically, and these can be very effective in restoring a patient to normal life.

Porencephalic Cysts

These cerebral cavities of varied aetiology occur particularly in children. They occur within the cerebral substance and communicate with the CSF pathways. Such communications may become smaller or blocked off and as fluid is being pumped into them without any outflow, they become secondarily space demanding. They need early management to prevent further damage to the brain which has already suffered considerable injury.

CONCLUSION

A wide range of clinical conditions and a large number of surgical procedures have been mentioned. They may seem confusing, but it does indicate the inadequate state of our knowledge and therapy of the brain damaged individual. Careful patient selection for surgery is essential if success is to be expected. For this personal contact with the patient and a thorough understanding of his problems must be established by the therapeutic team of which the surgeon must function as a part.

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