Papers and Originals

Rehabilitation after Head Injury*

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Brit. med. J., 1968, 1, 465-470

Ruscoe Clarke had the dust of war on him, and, like so many of his era, was concerned primarily with the acute phase after trauma, and the early mortality. His contributions in this field are well known. But, as Sir Alexander Drummond (1961) observed in the inaugural lecture, Ruscoe Clarke's vision was of efficient overall care for the injured until the patient was restored to health and, if possible, to a normal life. I feel, therefore, that were he here today he would be as active in dealing with the problems of rehabilitation.

Service in the R.A.M.C. developed Ruscoe Clarke's interest in the care of the injured, and he paid tribute to the organization of the Army Medical Services. This would therefore seem to be an appropriate moment to record the contribution the Services have made to the subject of this lecture. In the same way that they led the campaign for the prevention of head injuries by the use of crash helmets for motor-cyclists as long ago as 1941 (Cairns, 1941), so the pattern of rehabilitation after head injury, much of which is still true today, was laid down during the war years, especially at the Military Hospital for Head Injuries at Oxford, by such men as Symonds, Riddoch, Cairns, Ritchie Russell, and Reynell. This work continues today. The Army Neurosurgical Unit at Colchester takes a particular interest in the possibilities of rehabilitation after severe head injury, believing, what is surely true, that any rehabilitation programme must include all cases. Even though the path to recovery after such injury is long and at times disappointing, it is what can be achieved in these conditions that underpins the high recovery rate for the majority of the less severely injured.

Similarly, Lewis (1966) has reported from the R.A.F. Unit at Chessington the good results obtained by an active rehabilitation programme. Though this has been known in the Services so well for many years, the lesson has still not been fully exploited in civilian life. This is not to say that isolated and successful efforts in the civilian field have not been made—witness, for example, the programme set up for the care of head injuries by Rowbotham in Newcastle. But the pressures in the early days of the National Health Service to provide for the acutely ill—and rightly so—have not so far allowed in general the development of the facilities that are so sorely needed for the aftercare of head injuries.

This lecture is concerned with an attempt to estimate the present need and the patterns along which a rehabilitation service might develop. The time is opportune. As a result of better treatment for the acute head injury in the years since the war, and the rising numbers of head injuries, attention is now focused on the many survivors who clearly require special facilities if a practical recovery is to be made. London (1968) has drawn attention to the concern that is being increasingly felt over the country. It should be observed that this need is

accentuated by modern economic conditions. There is little place or time for the disabled in families where all the adults are working. Some patients who at a certain stage after their injury would benefit by being in their own environment are thus denied this most effective method of rehabilitation, for which an expensive hospital bed is a poor substitute.

Size of the Problem

What is the size of the problem? An earlier estimate indicated that over 100,000 cases of head injury are admitted to hospitals in this country every year, the usual criterion for admission being a degree of cerebral concussion (Lewin, 1964). Recently the Ministry of Health recorded a figure of 107,000 admissions for 1963, and noted that this represents an increase of over 50% since 1955.

The injuries are of all grades of severity, and some estimate of these can be made from a study of the Head Injury Service at Cambridge. Here all cases of trauma are admitted to the Accident Service and every case of head injury, both mild and severe, comes under the care of the neurosurgical unit. In this way some 750 cases of head injury are admitted a year, with an average mortality of 3.5%. If we consider the severity of the general concussive effect alone, as judged by the duration of the post-traumatic amnesia, then, as would be expected, the vast majority of these patients sustain *mild or moderate concussion* with a post-traumatic amnesia of less than 24 hours. Their subsequent problem is not so much one of return to the former occupation, for this may be expected, but the time taken to achieve this and the incidence of various symptoms which are commonly grouped under the term "post-concussional syndrome." A few patients in this group remain with specific disabilities from focal neurological lesions and epilepsy. When discussing this group it should also be remembered that many other patients are not admitted to hospital at all, but are treated by general practitioners in the patients' homes.

A *major head injury* with a post-traumatic amnesia of more than 24 hours is sustained by 7.0% of direct admissions. Here the degree of disability and its type varies considerably. Analysis of our cases showed that four-fifths of the survivors, representing 78% of the group, finally returned to their former work, though several after many weeks or months. However, one-fifth were left markedly below the pre-injury level and either returned to much simpler work or to a sheltered workshop, or were unemployable. The worst cases in this group are those few patients who survive the immediate injury but thereafter remain unconscious for weeks and months. In addition to a prolonged rehabilitation programme, should they survive, they also require special inpatient hospital facilities. The incidence of patients with prolonged unconsciousness, to which further reference is made below, appears to be about 0.4%.

Earlier experience at Oxford and the report by London (1968) suggest that these figures are a fair sample of head

* The Eighth Ruscoe Clarke Memorial Lecture, delivered to the Institute of Accident Surgery, Birmingham, on 5 May 1967.

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injury cases admitted to hospital, though clearly they will vary with the criteria for admission, the mortality rate, and the definition of post-traumatic amnesia. Translation of these figures into the national setting would suggest that some 7,500 cases of major head injury are admitted to hospitals in this country every year and 400 patients a year require the full nursing facilities for the management of prolonged unconsciousness. Every year about 1,200 new patients are left either working at a simpler level (60%) or requiring special care (40%). When it is remembered that the majority of these patients are relatively young, the mounting tide of such a problem is immediately apparent.

The rehabilitation facilities required for these various groups may now be conveniently discussed separately.

Though we shall be concerned here primarily with the period after the acute phase, rehabilitation includes the prevention of complications after head injury. The situation after a head injury is a dynamic one, and, apart from the well-defined complications such as intracranial haematoma and infection, it is now clear that part of the mortality and subsequent disability after head injury is due not to the immediate brain injury directly but to preventable developments in the acute stage such as hypoxia, chest complications, brain swelling and infarction, and metabolic disorders. In no other field is it more true to say that rehabilitation begins at the roadside, from the moment of injury.

Mild and Moderate Head Injury

A progressive rehabilitation programme for the main group of patients with uncomplicated head injuries and a post-traumatic amnesia of less than 24 hours is of first importance, for these are the patients who with few exceptions should make a complete recovery with return to work in an average of four to six weeks. Yet many still have weeks of unnecessary invalidism with economic loss both to themselves and to the country. The main requirements are an understanding of the natural recovery from cerebral concussion, the institution of a rehabilitation programme from the day of injury, and advice and guidance available until the patient has returned to his work. Prolonged bed rest has given way to early but gradual mobilization as soon as the patient is comfortable. The details of management and the important part the physiotherapist may play at this stage in the resumption of activity and the prevention of such symptoms as vertigo have been set out elsewhere (Lewin, 1966). The pressure on hospital beds is severe, and unhappily some of these patients fall between the necessity for early discharge and insufficient integration between the hospital, general-practitioner services, and ancillary services concerning what is required in the continuing programme.

The incidence of the symptoms of the "post-concussional syndrome" is significantly reduced if, after mild head injury, patients can be retained in hospital until they are up and about and able to walk out of the hospital ward to their homes. A programme of progressive activity is set out for them for the coming weeks and the situation is checked at a subsequent outpatient appointment. With the numbers involved it is not always possible to do this for every patient, but the same result can be achieved if the active support of the general practitioner is enlisted and it is stressed that what happens in the early weeks largely dictates the final pattern of recovery.

Guttmann (1943), working in the head injury unit at Oxford, set out very clearly the results that can be achieved along these lines. Subsequent experience has added little to his findings. He observed that less than half the patients after head injury had headache at any time at all, and that 80% of the patients were discharged from hospital after such a programme free from symptoms. Dealing with headache in particular, he observed that in the early months headache was a commoner complaint among those with mild than with severe head injury

—which is not surprising in the absence of more obvious disability—but that by six months there was no significant difference. At that time after injury, only 23 of the series of 300 patients with head injuries were still complaining of headache. Guttmann found that six of these had had a previous history of lifelong headache and that in nine others there were obvious psychogenic factors.

Another symptom encountered after head injury is dizziness and/or vertigo. Yet Symonds (1942) found that true vertigo occurred in only some 8% of head injuries and that in nearly half of those the symptom was related directly to ear trauma.

What, then, do we mean by the post-concussional syndrome? What is the basis for the common assumption that the various symptoms in this complex are to be expected after head injury, that they may drag on for weeks or months, and that there is little that can be done about them?

Post-concussional Syndrome

This syndrome is defined as a triad of symptoms: headache, vertigo and dizziness, and nervous instability. Symptoms of nervous instability include impairment of intellect, loss of self-confidence, ready fatigue and lassitude, impairment of memory and concentration, intolerance of alcohol, and inability to express oneself readily. A moment's reflection shows that what has been done here is to group together some of the commoner problems arising in the early stages after head injury, and, without further consideration of diagnosis or possible treatment, to lump them together and infer that this is a syndrome which is a complication of head injury. I believe that this has been a disservice to the patient recovering from head injury. It has obscured the fact that several of these symptoms are part of the normal recovery progress in the early weeks when reintegration of mental and physical activity is taking place. Their relationship to concussion is the same as the temporary limp which accompanies the patient's early attempts to walk after a fractured femur. Yet no one would dignify the limp as a complication of a fractured femur. This false identification of a syndrome has not encouraged the diagnosis of focal symptoms and signs which may present in some patients, has denied specific therapy which may be suitable for some, and has obscured the fact that some patients require a rehabilitation programme tailor-made for their needs.

It has already been shown that headache is by no means a constant accompaniment of head injury. Careful analysis of this symptom in those who do complain of it subsequently shows that a proportion have a specific focal cause such as scalp neuritis, myalgia, or the effects of injury to the air sinuses, all of which may respond to appropriate local measures. Again, the common complaint of light-headedness and dizziness on first getting up after a concussion is largely a matter, not of treatment, but of prevention by supervising the way in which early mobilization is begun. These symptoms are likely to be troublesome in the older patient or where there has been sub-arachnoid bleeding, but supervision from the physiotherapist during the early phase of mobilization and advice on daily living during the early weeks afterwards, with reassurance of the future, can often prevent prolonged invalidism. Where there is true vertigo, an accurate diagnosis of its cause, whether brain stem or due to ear trauma, is essential, for specific treatment can relieve some patients.

Perhaps, however, it is in the field of the third component of the triad, "nervous instability," that opinion varies the most—whether the symptoms are directly related to the effects of the cerebral concussion or are predominantly psychoneurotic and determined by the patient's premorbid personality. This has always seemed to me a rather futile debate, for it is as unrealistic to minimize the main physical cause of these symptoms as it is to ignore the obvious truth that the degree to which a patient adjusts after a concussion will at least depend partly on his

personality and on his present anxieties and stresses. In this connexion the work of Caveness (1966), from a study of missile and non-missile head injuries in the Korean campaign, should be noted. The relation between injury and the symptoms was clear, but 5% of controls matched for age and service in Korea and without any injury also showed several symptoms of the post-concussional syndrome. Where, therefore, these symptoms predominate the first requirement is to assess the degree to which the various factors are at play. Solution of personal problems may be the prime requirement for some, or a detailed psychological assessment to identify a specific disturbance of memory or intellectual loss may be required. This undertaking, though time-consuming, can be rewarding and lead to appropriate rehabilitation.

In making these brief comments on the post-concussional syndrome I am not suggesting that the matter is an easy one, nor ignoring the fact that there are some patients who continue to present continuing symptoms for which no obvious cause can be found. What I am trying to emphasize, however, is that the incidence of this syndrome can be considerably reduced if it is prevented in the first instance by an active rehabilitation programme from the day of injury, and that those patients who do suffer continuing symptoms should have a close analysis made of their likely cause and be given appropriate treatment. This assessment should be made in the early weeks, before the patient's confidence has been lost by prolonged invalidism.

Epilepsy

A brief note may be made here of the incidence of epilepsy, since this is a complication worrying to both doctor and patient. Though the overall risk of epilepsy after recovery from acute head injury is about 5%, it is now clear that such a blanket figure is of little value in assessing the risk for individual patients. It is more important to recognize those particular head injuries for which there is an especial risk of epilepsy and the need for prophylactic anticonvulsants, and on the other hand to give confidence to those patients to whom the risk is known to be very slight. Thus it can be said that a head injury with a post-traumatic amnesia of less than an hour, and uncomplicated by early epilepsy or a fracture of the skull or other complication, has an incidence of subsequent epilepsy of no more than 1%. On the other hand, the figure can rise to 30% where there has been an intracranial haematoma, and to 50% where there has been a depressed fracture with dural penetration associated with a post-traumatic amnesia of more than 24 hours. Between a quarter and a third of all patients with epilepsy in the acute period after injury will have further attacks in later years (Jennett and Lewin, 1960; Jennett, 1962). It follows that routine administration of anticonvulsants merely because a patient has had a head injury is not indicated, but there are certain groups where prophylactic treatment is advisable.

Epilepsy by itself is rarely the predominant factor after head injury which determines a rehabilitation programme, though clearly its occurrence may dictate the patient's future work and he may require the help and guidance of a rehabilitation service.

Major Head Injury

An obvious gap in our rehabilitation services at present is the lack of facilities for some of the 7,500 patients a year who sustain a major injury. As a result of the concussive injury alone, return to work is rarely achieved under eight weeks. Where the post-traumatic amnesia exceeds a week, the period of invalidism is usually of the order of three months, extending to much longer periods for the severe injury, and here return to work is often on a part-time basis initially and at a simpler level. Another factor is the presence of associated neurological disabilities which are more frequent with the major injuries.

A hemiparesis, dysphasia, or visual defect, for example, may well alter the whole pattern and tempo of rehabilitation. Yet, as has been shown from our figures, 80% of these patients ultimately return to their former work. Miller and Stern (1965) also drew attention to the good long-term prognosis of major head injury. In their long-term follow-up of a selected series of head injuries seen personally, all with a post-traumatic amnesia exceeding 24 hours and an average of 13 days, only 10 of the 85 adult patients were finally unemployable, and half had escaped any loss of occupational status.

We are dealing, therefore, with an eminently recoverable group. We should set to it that facilities are available for the care of these patients, and look again at their special needs in order to reduce the time of invalidism and minimize the resultant disability. The first essential is an accurate diagnosis of the particular defects that are present, and this may well require the co-operation of a team which would include a neurologist, neurosurgeon, psychiatrist, and psychologist. Particular problems, especially in these days when multiple injuries are so common, may also need the help of the orthopaedic, maxillo-facial, ophthalmic, or otological surgeon. Certain intracranial complications of head injury may require diagnosis and treatment. Other patients will require special physiotherapy, occupational therapy, or speech therapy. Though mental confusion may continue for some weeks, special psychiatric care is indicated for few patients. Nevertheless a section in a psychiatric hospital can be invaluable in treating most effectively this small group of patients.

The main deficiency after the acute period is over is the lack of a centre with inpatient and outpatient facilities where the integration of all the activities that may be required to restore a patient to health can take place and a progressive programme be planned and carried out. At this stage these patients do not qualify for an acute hospital bed and tend to sit at home until sent prematurely to an industrial rehabilitation unit, for which they are not yet ready, or to a convalescent home, which is best reserved for the patient after mild injury for whom return home, which normally provides the best environment for recovery, is for particular reasons impracticable.

In general the present industrial rehabilitation centres are not suited to the patient after major head injury until a much later stage of his convalescence, when mental recovery is far advanced. These patients have a combined mental and physical impairment, and the pace of these units is not precisely suited to their needs. If one were to pick out the one symptom which makes rehabilitation difficult one would select the impairment of memory. The importance of memory in this context has been well summarized by Cameron (1963): "Intelligence may be the pride, the towering distinction of man; emotion gives colour and force to his actions; but memory is the bastion of his being. Without memory there is no personal identity, there is no continuity to the days of his life. Memory provides the raw material for designs both small and great. Thus governed and enriched by memory, all the enterprises of man go forward."

Prolonged Unconsciousness

A special note should be made of the comparatively recently recognized group of patients who, as a result of more active treatment in the acute stage after head injury, survive the initial period but thereafter remain unconscious for weeks and months. Although those who show some recovery merge with the severer cases of the main group just described, yet the time relationships make them stand out, and certainly their requirements demand special consideration. The definition I have used before delineates this group. They are the patients who remain in coma or sufficiently unconscious to be mute and unresponsive to speech and commands, are unable to swallow, and require artificial feeding for at least a month or more. As has already

been mentioned the incidence is small, but 400 such patients every year make heavy and continued demands on medical and nursing staffs. Some of these patients remain in this stage for months. The longest personal record I have is of three and a half years.

In an earlier paper (Lewin, 1965) a study was made of 130 such patients. Of these two-thirds survived, of whom three-quarters ultimately made a practical recovery. By this is meant that they were able to return to work or to run their homes once more, though the majority were left with some degree of mental and/or physical disability. It should be noted, however, that a third of the survivors made a mental and physical recovery comparable to the pre-accident status. This, therefore, is yet another example of the compensatory powers of the brain and of the need to provide adequate facilities for all head-injured patients, both mild and severe.

The first requirement of this group is full hospital care and unremitting medical and nursing supervision. Harnessed to this is daily physiotherapy, and at a later stage the services of a main physiotherapy department, including hydrotherapy, together with occupational therapy and probably speech therapy as well. In a hard-pressed hospital the disproportionate amount of care that has to be lavished on such a patient with an uncertain prognosis inevitably leads to agonizing decisions of priorities. However, I do not think that segregation of these patients into a few main centres is either necessary or desirable. Instead we should promote the idea of a ward for the young chronic sick for each major hospital complex, to which these patients could go once their condition is stabilized after the first two months or so. The facilities they require at that stage are very much the same as the majority of other patients who need a ward of this kind demand. A recent analysis suggests that the majority of the young chronic sick who need inpatient care suffer from a neurological illness, particularly multiple sclerosis and cerebrovascular disease. Thus it would be possible to concentrate the specialized medical, nursing, and ancillary skills that are required. The recovering survivors would return at a later stage to a rehabilitation unit for head injuries, and still later to sheltered workshops or industrial rehabilitation units if necessary.

In this group will also be found a few patients in whom the presenting problem in management is dementia. The new image of our psychiatric hospitals should now include a section for those patients with major psychiatric disturbances following neurological illness, where they could be under the care of a psychiatrist taking a particular interest in this field and could benefit from the special workshops available.

Research and Rehabilitation

Medical and engineering advances of recent years have not been sufficiently harnessed so far to the needs of the head-injured patient. To illustrate this, a few topics may be selected where the time is ripe for further development and research.

Locomotor Difficulties

First, the locomotor difficulties caused by ataxy, spasticity, and paresis may be mentioned. It is now well recognized that the long-term prognosis for motor impairment is good. Expert physiotherapy is invaluable in getting these patients up and about once more. Unfortunately it is not always possible to follow through the early stages of such a programme begun in the ward, and the subsequent need is not always satisfied by intermittent journeys to outpatient physiotherapy departments. A short stay in a unit concentrating on these patients can cut short this period of convalescence significantly. The potentiality of the various mechanical aids for the disabled is

still not sufficiently exploited, owing partly to their scarcity, but also in part to ignorance of what is really available. Thus a rehabilitation unit should include a home unit where the housewife in particular can be retrained with aids to daily living. Comparatively simple alterations at home, the provision of chairs and simple appliances such as hoists, can often allow an otherwise dependent patient to return to his family circle, which all would agree is the best milieu in which to make a practical recovery if this is possible.

Types of Mental Impairment

Secondly, there is a need for a closer study of the types and pattern of mental impairment following head injury. Instead of the general description of impaired memory and concentration, we should attempt to identify the patient's particular defect and then seek ways to compensate for it or plan retraining. The balance of impaired activities varies from patient to patient. In Cambridge we are particularly interested in this project in conjunction with the University Unit for Research on Medical Applications of Psychology under the direction of Dr. J. L. Gedye. Our intention is first to identify the problem in conjunction with the Department of Clinical Psychology, headed by Dr. Moyra Williams, and then to seek specific retraining methods. In the same way that a patient is supplied with an external appliance such as a stick to aid walking during the recovery phase, so it should be possible with automation to supply, for example, the memory that the patient is temporarily lacking and thus allow him to concentrate in progressive stages on what he can do, rather than try to cope with a traditional overall rehabilitation programme. Such a man-machine partnership would not supplant personal supervision but would allow a patient to learn at an early stage at his own speed, when memory is still impaired, the machine supplying the continuum of memory. A skilled task can usually be broken down into a series of less skilled ones. It is hoped in this way to help the patient with memory-retraining.

The use of discrimination and selection of alternatives would seem particularly appropriate for the early rehabilitation of dysphasic patients (Filby and Edwards, 1963). It will also be apparent that the end-result of this could be that for those few patients who remain with permanent memory and intellectual impairment the availability of a special programmed machine might allow them to return to jobs requiring simple repetitive skills, where otherwise they would be unemployable. All who have treated patients after major head injury will know the difference between the patient who gains confidence by having had demonstrated to him the fact that he can do something, and the one who goes through a routine rehabilitation programme without specific reference to his needs. The possibilities of this approach have been elaborated by Gedye (1967).

Neuropharmacology and Neurochemistry

A third line of research has to do mainly with neuropharmacology and neurochemistry. Emotional disturbances after head injury may not only present a problem in the acute stage but be carried on into the convalescent period. The value of tranquillizers such as chlorpromazine for the disturbed and aggressive patient, and the use of thiopropazate for children with hyperkineticism and disturbed behaviour, so frequent after severe head injuries in children, are well known. The control of rigidity and tremor after basal ganglia injuries with benzhexol hydrochloride and the value of muscle relaxants such as mephenesin and diazepam in the treatment of spasticity are other examples. But it is largely a matter of trial and error. Just how valuable they are has not been fully elaborated in this context and would repay study.

Chemistry of Memory

A possible development for the future stems from the evidence that is beginning to accumulate on the chemistry of memory. Dixon (1962, 1967), from the Department of Pathology, Cambridge, has postulated that memory and thought involve permanent patterns impressed on the macromolecular fabric of the neurone. A transient lipid pattern generated by external impulse can become aligned with a specific peptide pattern already present in the cell. These patterns then become established as functional components of the membrane mosaic. Further fabrication of the identical peptide pattern is stimulated and mediated through ribonucleic acid. By such a concept, the coma of concussion is related to transient disalignment of orientated lipids and proteins in the shaken neurone. Retrograde amnesia is consequent on this disalignment before the peptide pattern has been evoked. Memory and thought depend on permanent macromolecular patterns. Parallel with this comes the recent experimental work of Ishii (1966), who has shown that under the experimental conditions of brain compression there is a marked decrease in lecithin content of the white matter and in the gangliosides of the cortex, roughly proportional to the severity of the animal's condition. More important is his further observation that administration of cytidine nucleotides, which play an important part in the biosynthesis of lecithin, produced a beneficial effect on the animal. Less dramatic effect was noted when giving phenazopyridine hydrochloride derivatives to restore ganglioside metabolism.

Work by Cameron (1963) highlights the association between memory and ribonucleic acid, and the observations by Sved and Wainrib (1961) and Montanari *et al.* (1961) that administration of R.N.A. can improve memory has clear implications in the field of rehabilitation.

Cerebral Blood Flow

The recent technical advances in the estimation of cerebral blood flow and circulation time also have their application in head injury. Taylor and Bell (1966) have suggested from a study of 70 patients that post-concussional symptoms are associated with slowing cerebral circulation and that there is a relation between the improvement of symptoms and the return of circulation time to normal.

Research is an integral part of a sound rehabilitation project, and these brief illustrations show that rehabilitation after head injury is ripe for re-examination of its methods and the promotion of new ideas. Such a venture, however, is not appropriate to acute hospital beds, but requires units for the purpose.

Planning for Rehabilitation

In this lecture an attempt has been made to show the size of the head injury problem and the need for the development of rehabilitation services in the country. One can delineate broad groups with their special needs and within these groups again particular mental and physical disabilities which require special care. It is apparent that no one simple solution immediately emerges. What is required in every area is an organization that can identify at an early stage those patients who require help and integrate the various services that may be required by head-injury patients as a whole. These will include the various medical specialists; provision for physiotherapy, occupational therapy, and speech therapy; and the inpatient services for the young chronic sick, for rehabilitation, and, for the few, psychiatric accommodation. It includes liaison with the disablement resettlement officer, and the local arrangements for sheltered workshops, industrial rehabilitation units, and retraining centres. This area co-ordinating function need not be expensive. A head injury bureau could be established with a medical social worker having a particular interest in this problem. She would maintain contact with the patient until

recovered and would be available to patient, general practitioner, and consultant. The bureau is likely to be more effective if it is under the charge of one consultant, but these details would naturally vary from area to area. An advisory centre of this kind would do much to cut down the present invalidism.

In addition to this, however, there is a need for a rehabilitation unit for each region to deal with particular head injuries which would have the full range of diagnostic facilities and rehabilitation requirements. They would be most conveniently sited near to, and in liaison with, regional neurological and neurosurgical units.

Such a unit need not be separate, and indeed could with advantage be part of a larger rehabilitation unit for the particular hospital—for the head-injured patient benefits from being among patients with dissimilar problems; provided always, however, that within such a unit the head injury section with its special needs and different tempo is identified. Some of these units should be encouraged to undertake research projects. There is already sufficient variety to encourage the particular interests of a region without reduplication. As indicated in this lecture, this may vary from purely laboratory research to immediate practical application in the gymnasium. Field research would define the best ways of rehabilitating a patient for a particular job at an early stage in convalescence before the degree of mental and physical recovery is sufficient for progress to be made at an industrial rehabilitation unit or Government retraining centre. In this respect the contribution that Lord Nuffield made during the war years, when he introduced such a scheme for some head-injured patients in the then Morris Workshops at Oxford, should be remembered.

The recent development of a Head Injury Rehabilitation Trust in Birmingham is an exciting one and an excellent example of what those interested in this subject have in mind. A rehabilitation workshop linked to the needs of local industry is properly sited here. Another unit in a more rural district could well consider the development of a farm for the neurologically disabled along the lines of the farms belonging to the mental hospitals of a generation ago, and geared to getting the patient back to work.

The cost of road accidents in Great Britain last year was estimated at £267m. It is clear from all the figures that head injuries contribute significantly to this vast and growing sum, the major proportion of which is due to invalidism and loss of output. After head injury we are dealing with a recoverable lesion for the vast majority, and what is needed to make this so could be set up for a fraction of the present loss of time and money from invalidism due to lack of these facilities.

In conclusion, I refer again to the role that clinical and laboratory research must play in future plans for rehabilitation, not only to ensure that this is not overlooked, but to emphasize what the man whom we commemorate today consistently practised and taught—the need for research over the whole field of trauma.

Summary

It is estimated that at least 7,500 cases of major head injury are admitted to hospitals in this country every year, of which 400 are associated with prolonged unconsciousness lasting more than one month. Every year some 1,200 patients are left working at a simpler level or requiring special care.

For these and for some in the much larger group of mild and moderate head injury improved rehabilitation facilities are required. The favourable prognosis and the ability of the brain to compensate even for severe head injury is stressed.

Research is an essential partner to rehabilitation, and illustrative examples are given in the fields of locomotor disability, mental assessment, and neurochemistry.

Planning for rehabilitation requires integration of all the services in the area, and the identification of those patients who

require help at an early stage. It is recommended that area co-ordinating services for head injuries be set up, and some rehabilitation centres developed to deal especially with particular injuries.

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Pulmonary Function in Bronchial Asthma*

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Brit. med. J., 1968, 1, 470-475

Compared with the large number of pulmonary function studies that have been made in patients with air-flow obstruction from bronchitis or emphysema, there have been relatively few in patients with spasmodic bronchial asthma (Bates and Christie, 1964). Some clinicians hold that asthma, in contrast with bronchitis and emphysema, does not cause serious disturbance of the blood gases, though the reports of Herschfus *et al.* (1953), Williams and Zohman (1959), and several studies in the past 12 months do not support this view.

Clinically, asthma patients may be divided into two types—those ("extrinsic") who show definite sensitivity to external allergens and those ("intrinsic") who do not. The purpose of this report is to help to define the extent of the functional lesion as air-flow obstruction varies in asthma, to try to find out how it differs from the changes in function in bronchitis and emphysema, and to see whether there is any functional difference between the clinical types of extrinsic and intrinsic disease.

The present paper reports the changes which occurred in the total lung capacity, in the carbon monoxide transfer factor, and in the arterial blood gases as the air-flow obstruction varied, in nine patients with severe spasmodic bronchial asthma, five of whom were selected as having the extrinsic and four as having the intrinsic type of asthma. These changes are contrasted with those in a group of 15 patients with chronic bronchitis and radiological evidence of emphysema who had relatively fixed air-flow obstruction.

The results of the work show how various tests of lung function can be helpful clinically as a guide to the treatment of patients and suggest the importance of the frequent measurement or the continuous monitoring of the PCO_2 in severe attacks of asthma.

Selection of Patients

Asthma

We chose for study only patients who fulfilled certain criteria of being asthmatic, but showed no evidence of any complicating

disease, especially infected bronchitis or emphysema. We followed two recent expert committees (Ciba Guest Symposium, 1959; American Thoracic Society, 1962) in defining asthma as variable air-flow obstruction. We used two criteria of variability. Any patient selected for study had to have had at least two attacks of wheezing breathlessness interspersed with symptom-free periods. The F.E.V.₁ must have been shown to vary by at least 30% of the predicted value at different times in the previous six months. In all our patients variation of the F.E.V.₁ was at least 0.97 litre (Table I) and the best values approached normal. We tried to get patients who showed an increase in eosinophils in their blood or sputum, especially when they were thought to be examples of extrinsic asthma.

TABLE I.—Clinical Features of Patients

Case No.	Age	Sex	F.E.V. ₁ (l.)			Age at Onset (Years)	Eosinophils		Cigarettes (/day)	Sputum (ml./day)	History of Allergy	Skin Tests
			Maximum	Minimum	Predicted		Blood (/ml.)	(Sputum %)				
Group 1												
1	31	F	2.15	0.48	3.05	0	1,600	20	—	—	+	House dust
2	30	F	2.65	1.40	2.93	0	400	6	20*	—	+	Cats.
3	34	F	2.65	1.40	2.07	7	N.R.	—	—	—	+	Feathers
4	40	F	1.84	0.75	2.08	3	720	—	—	—	+	House dust
5	41	M	1.97	0.54	3.85	9	N.R.	—	—	—	+	Feathers
												Grass pollen
												House dust
Group 2												
6	41	M	3.44	0.65	3.05	40	810	—	—	—	—	—
7	53	F	1.97	0.65	2.01	49	530	—	—	—	—	—
8	56	F	1.30	0.38	2.01	47	220	1	—	—	—	—
9	56	M	1.95	0.43	2.80	55	525	—	20*	<5	—	—

* = Nil for last year. N.R. = Not recorded.

We excluded any patient with an abnormal electrocardiogram or a diastolic blood pressure greater than 110 mm. Hg. We tried to exclude coexisting chronic bronchitis by rejecting subjects who had smoked more than 20 cigarettes a day and who, in clinical remission, produced more than 5 ml. of sputum a day or had clinically infected sputum (in fact only one of our subjects (Case 9, Table I) had any sputum at all during remission of asthma).

In addition, the chest radiographs of all prospective patients were examined for evidence of emphysema by two radiologists

* This article forms part of an M.D. thesis submitted to the University of Newcastle upon Tyne.

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