Discussion

From the experiments described there can be no doubt that in very large doses certain soluble iron salts, whether ferrous or ferric, whether of organic or inorganic acids, and whether normally ionizable or complexes of the "scale salt" type, are toxic to at least three species of laboratory animals. It is reasonable, and probably a wise precaution, by extrapolation to accept as proved that all similar iron compounds can, in excessively large doses, kill mammals of any species, including man. It must, however, be emphasized that toxic doses really are excessive. The amount of ferrous sulphate necessary to kill on the average one out of two 10-stone (63.5-kg.) men, if man's susceptibility on a body-weight basis is assumed to be the same as that of the rabbit, would represent at least several hundred tablets of 3 gr. (0.2 g.) of exsiccated ferrous sulphate, each containing 1 gr. (65 mg.) of iron. Obviously the number may be considerably smaller for infants and young children, being reckoned in tens rather than hundreds.

The similarity in behaviour of various iron preparations suggests that after solution in the stomach they are all reduced to the ferrous state and that ferrous iron when present in very large amounts, whether wholly ionized or not, is alone responsible for the damage. Ferrous sulphate should be completely ionized at high concentrations, and ferrous gluconate probably hardly ionized at all even at low concentrations, yet they show indistinguishable toxicities in very high doses. It may be remarked, in passing, that none of the ionizable iron compounds exists as such in the stomach after therapeutic doses: apart from un-ionized hydrochloric acid in the gastric contents, there will then be present in solution the chloride, sulphate, and other anions, the hydrogen, iron, and other cations, and the various un-ionized soluble constituents. Forbes's contrasting of ferrous sulphate with ferrous chloride in solution therefore seems to be misleading even when the sulphate has been ingested at much above the therapeutic level.

The post-mortem and histological examinations have furnished no positive information about the *modus operandi* of iron at orally toxic levels. A decision between shock due to tissue damage—which at worst was not very great and appeared rapidly reversible in the milder cases—and systemic effects following passage of excess iron into the blood stream cannot be made on the basis of our experiments. They were, in any event, carried out with an immediately practical object—to find and record at what doses therapeutic iron preparations could exert toxic effects on experimental animals. The results of these experiments are reassuring. They show, at any rate in so far as the experimental animals react similarly to man, that the gap between curative and harmful doses of iron compounds is very large—and obviously still larger between preventive and fatal doses. Indeed, I doubt if there are many medicinal substances with so large a "therapeutic index." The upper dose of ferrous sulphate, according to the *British Pharmacopoeia*, is 0.3 g., which would be contained in five tablets of the product causing fatalities that led to this investigation. In few circumstances is it likely that an adult would be recommended to take more than 12 such tablets a day, and the results suggest the harmlessness of anything less than several hundred tablets taken all at one time and on an empty stomach. It is, however, desirable that physicians and pharmacists should warn parents and adults generally that iron preparations should be kept out of reach of the very young.

In the experiments described above I have received the technical assistance of Mr. G. A. Romer in the preparation of sections and slides, and much useful advice from Dr. J. Ungar, to both of whom I wish to extend my thanks.

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AN EXPERIMENT IN REHABILITATION

BY

J. R. NAPIER, M.R.C.S., L.R.C.P.

Late Chief Assistant, Orthopaedic Unit, Hill End Hospital, St. Albans

J. N. BARRON, F.R.C.S.Ed.

Plastic Unit, Hill End Hospital

T. P. GREGORY

Hospital Resettlement Officer, Hill End Hospital

AND

D. R. THOMPSON, M.R.C.S., L.R.C.P.

Medical Officer, De Havilland Aircraft Co., Ltd., Hatfield

During the recent war, with its urgent demands for manpower, the attention of the medical services was sharply focused on to an aspect of clinical treatment that had under less pressing conditions been of relatively secondary importance. The economic aspect of medical or surgical treatment assumed an importance equal to that previously held by the somewhat ambiguous criterion of a "good clinical result." This is none the less true of to-day. The essence of the problem facing the clinician from the first day of treatment onward can best be expressed in the form of the question: How may this man be returned to his accustomed way of life and employment with a minimum loss of time and skill? The answer to that question embodies the full significance of the term "Rehabilitation," which must include the repair of the injury as well as the restoration of functional efficiency.

In industry to-day there are several examples of the successful handling of the problem of rehabilitation of the injured workman by a close liaison between medical and industrial authorities, the responsibility of treatment being shared equally between the two. Such schemes are at the present time too elaborate and costly to be undertaken by the smaller concerns. In this paper we have briefly described an experimental rehabilitation scheme carried out during wartime. We have attempted to underline the principles of treatment and to show how such a scheme may be applied to the industrial injuries of peacetime, with the minimum of special equipment, under existing factory conditions.

The Scheme

During 1945 and 1946, thanks to the co-operation of a near-by aircraft factory, a number of long-term Service and ex-Service cases drawn from the orthopaedic, plastic, and peripheral nerve injury units of Hill End Hospital were sent to work in the factory in chosen occupations. The choice of Service men, the majority complete strangers to factory life, was governed partly by the preponderance of Service casualties and partly by the special problem that they offered. As already stated, they were mainly "long-term" cases requiring a series of reconstructive operations or a long course of physiotherapy. It was thought that this experiment might have the double advantage of providing selected remedial exercises and, at the same time, a much-needed change of surroundings.

Sixty-nine patients took part in the scheme, spending an average of 63.9 hours at work over a period of seven weeks. Attendance at the factory was on four afternoons a week from 1.30 to 4.30, the mornings being left free for attention in the physiotherapy department. It was considered of the utmost importance that the scheme should be an adjunct to regular physiotherapy rather than, in any way, a substitute for it (see below).

Clinical control of the scheme lay in weekly factory "rounds" by the surgeon in charge of the case, the works medical officer, and the hospital rehabilitation officer, when the methods employed were discussed and criticized. The jobs, all of which came under the heading of unskilled work, were chosen from a large variety of industrial operations in accordance with the requirements of the disability. Some examples of these jobs are: bench assembly work, light assembly work in a warm electroplating "shop," drilling (using bench drill and single-spindle drill), hacksawing, Lister truck driving, preparation of fuselages, press operating, spray painting, and dismantling wrecked aircraft.

Many production operations, including those mentioned, demand movements which in certain conditions are of remedial value: the movements are for the most part both *repetitive* and *controlled*—two factors which count for a great deal in this connexion. Furthermore, by *simple* adaptation many of the jobs can be altered to suit the strength or range of the operator. Thus by varying the effective length of the operating lever the power required to work a drill may be stepped up or down. Again, by simple alteration of the *height* of the operating handle of a machine a gradual increase in range of, for example, the shoulder-joint can be encouraged.

This series of 69 cases included 53 of upper-limb injury, 46 (87%) of these resulting from gunshot wounds. The upper-limb injuries were various, and included a large number of disabilities which, from the point of view of rehabilitation, offered three main problems that could be summarized broadly under the clinical headings of joint stiffness, loss of muscle power, and muscle contractures. There were in this series no cases in which joint stiffness was present alone. In 26 cases (49.1%) it occurred in association with loss of muscle power, and in 10 (18.9%) it was present in association with both muscle contractures and loss of muscle power. Loss of muscle power was present alone in 11 cases (20.7%), was associated with muscle contractures in 6 (11.3%), and was associated with both joint stiffness and muscle contractures in 10 (18.9%). In no case was muscle contracture the only pathology.

(1) Joint Stiffness

Functional inactivity with resulting venous and lymphatic stasis is the most frequent factor in the production of post-traumatic joint stiffness (Watson-Jones, 1943). Prolonged inactivity results in irreversible changes occurring in capsular and ligamentous tissues, with the formation of intra-capsular adhesions. Attempts to increase the range of movement by *passive forcing* of such joints often result in further damage to the soft tissues, with further limitation of movement. Bearing these precepts in mind, the problem of overcoming joint stiffness was approached mainly from the point of view of *active* mobilization.

One man had severe limitation of the elbow-, wrist-, and finger-joints as a result of seven months' immobilization and disuse of the right upper limb on an abduction frame for the treatment of a gunshot wound of the shoulder region which involved the brachial plexus. The patient was first put to work on light assembly in the electroplating shop, where the temperature is maintained at between 80° and 90° F. (26.6° and 32.2° C.). He was later transferred to hacksawing, an occupation requiring great muscular effort and involving all the joints of the

upper limb, including the shoulder-joint. The hacksaw was modified by padding the handle to allow him to grip it firmly within the range of his metacarpo-phalangeal joint movement (Fig. 1). This produced a pronounced improvement of muscle

FIG. 1.—Patient using hacksaw with padded grip.

power associated with a greatly increased range of joint movement throughout the limb. As the metacarpo-phalangeal joint flexion improved, the padding of the handle was reduced.

The beneficial effect of prolonged active and resisted movements in a warm atmosphere was most marked.

A man whose fingers were almost immobile as a result of a gunshot wound of the hand responded notably to an occupation designed to give him active movements in a warm atmosphere. He drove a Lister truck on light haulage jobs within the factory precincts; the frequent stops and starts necessitated almost continual use of the clutch handle, which he operated with his injured hand, and which was situated in the stream of hot air from the motor.

Where the joint stiffness was not so severe less specific and controlled operations were applied. Among those which proved valuable was one in the salvage department where a spanner was the main instrument and a high degree of mobility of the hand was necessary.

(2) Loss of Muscle Power

Restoration of muscle power in cases uncomplicated by joint stiffness, flexion contractures, or nerve lesions offered few problems in treatment if a graduated scale of exercise was provided. When complicated by stiffness of joints the improvement of muscle power is no less important. "A stiff joint with powerful muscles is less disabling than a mobile joint with powerless muscles" (Watson-Jones, 1943). It was found that industrial operations designed primarily to increase joint movement might fail in this, but, as a result of increased muscle power, improve the efficiency of the joint within its limited range. Where loss of muscle power resulted from denervation atrophy more carefully graduated control of work done was required. Muscles showing return of voluntary power after recovery from a lower motor neurone lesion tire extremely rapidly, and it is advantageous to encourage the use of splints where possible. It must, however, be borne in mind that splinting in peripheral nerve injuries is designed to compensate, so far as is possible, for the paralysis and to encourage active

movement rather than to restrict movement. In a recovering radial or post-interosseous nerve lesion a "cock-up" splint not only releases the re-innervated wrist extensors from the effect of gravity but puts the antagonists at a disadvantage. The active contraction of the extensors of the wrist is in no way interfered with by this manoeuvre.

(3) Muscle Contractures

A large proportion of patients treated in this scheme were suffering from peripheral nerve injuries. The frequent occurrence in median and ulnar nerve lesions of fibrous muscle contractures affecting flexor muscles of the forearm presented a special problem. Whether the fibrous contracture resulted from a true ischaemic lesion, a denervation atrophy, or a simple muscle destruction, the clinical picture varied only in degree. The principle adopted in treatment of these contractures was a gradual passive stretching of the muscle, using the wrist as the fulcrum, the fingers being maintained in extension throughout.

A patient who sustained a gunshot wound of the upper arm causing an axonotmesis (Seddon, 1942) of the median and ulnar nerves had a severe flexion contracture of the fingers of eighteen months' duration. When he started work on sandpapering aircraft fuselages his degree of contracture allowed him to work only on the upper surface of the fuselage (Fig. 2). He was encouraged to work down the curved surface of the fuselage, thus gradually and necessarily extending his wrist

while maintaining the fingers in extension until, as shown in Fig. 3, the contracture was sufficiently overcome to permit him to sandpaper the side of the fuselage with his wrist in dorsiflexion. The result was achieved in 131 hours, covering a period of three months.

Another method employed to give a similar effect is shown in Fig. 4, which illustrates a fly-press with a modification plate attached to the handle. Forward pressure with the flat of the hand is required to operate the press, thus forcibly extending the wrist, the fingers being maintained in extension against the plate by a leather cuff. Over-extension at the metacarpo-phalangeal joints is prevented by means of a padded fulcrum placed behind the metacarpal heads.

Another patient gained 45 degrees of wrist extension with no further compensatory clawing in 117 hours during a period of three and a half months. In both cases corrective splinting was used, and daily physiotherapy was given over the whole period. When seen one year later neither case showed a recurrence of the contracture.

Comment

At first sight it would seem that the experiment described above can have little application to an industrial rehabilitation scheme. The patients were not factory workers and the injuries were in the main not those usually associated with industrial accidents. However, as we have already stated, most upper-limb injuries, whatever their origin, may ultimately present one or more of the triad of joint stiffness, loss of muscle power, and muscle contracture. Such differences that occur are mainly in degree. It is certainly true to say that the injuries dealt with in this experiment were more extensive and of longer standing than those commonly met with in industry. In the acute injuries of industry the problem confronting the surgeon is more likely to be prophylactic than remedial. That is to say, he will more often be concerned with the prevention of onset than with the treatment of the established triad.

We have already laid stress on the importance of the continuation of physiotherapy throughout the period of industrial rehabilitation, and provision was made that this side of clinical treatment was not interfered with. There are certain aspects of remedial treatment that can be carried out only in a properly equipped physiotherapy department and for which industrial rehabilitation can offer no substitute. For example, no amount of active movement of a limb will prevent ultimate fibrous-tissue replacement occurring in a denervated muscle which requires daily galvanism if rapid progressive atrophy is to be minimized (Bowden, 1945; Jackson and Seddon, 1945). There is evidence, however, that passive movement of the denervated muscle is beneficial in preventing the onset of muscle contractures.

In regard to mobilization of stiff joints, much can be done in the physiotherapy department, where the skilled application of heat in the form of wax baths or ray treatment, combined with careful active and passive movements, is in the early stages of greater value than any of the industrial methods. On the other hand, a variety of industrial operations offer unrivalled opportunities for encouraging active mobilization of stiff joints through the improvement of muscle power transmitted over them.

The modern occupational therapy department offers ample opportunity for improvement of muscle power, but in relation to an industrial accident service it has the obvious disadvantage of keeping the workman away from his work rather than getting him back to it. However, the occupational therapy department, with its varieties of hand looms, bicycle fretsaws, printing presses, etc., need not be very far removed from the concept of a hospital workshop equipped with a variety of simple industrial machines that might well

FIG. 2

FIG. 3

FIG. 2.—Patient sandpapering fuselage on its upper aspect. The wrist cannot be extended further without compensatory clawing of fingers. FIG. 3.—Showing wrist extension achieved after three months' treatment.

FIG. 4.—The hand in position on the adapted fly-press.

form as it were the "nursery slopes" from which the injured workman graduates to his own factory.

Although the inferences of this paper have been drawn from experience of "long-term" cases, much has been learnt about the possible application of such results to the treatment of acute injuries. Apart from the prophylactic aspect—the prevention of adhesions and loss of muscle tone—recently injured joints and muscles appear to respond rapidly to the controlled industrial methods of rehabilitation of this type. Furthermore, when the injury is of industrial origin the early return of the absentee to full-time or part-time selected work not only prevents a loss of skill and a lowering of morale that so often follows in the wake of prolonged unemployment but also tends to reduce the exaggerated importance attached by the workman to the accident.

Summary

This paper presents an experiment in the rehabilitation of injured Service men using existing conditions in industry.

The principles of treatment are discussed and illustrated.

From the inferences made the application of such a scheme to a peacetime industrial accident service is discussed.

We are indebted to Dr. W. J. T. Kimber, medical superintendent, Hill End E.M.S. Hospital, for help and advice on the organization of the scheme; to all sections of the De Havilland Aircraft Co., Ltd., for their willing co-operation; and to Mr. S. L. Higgs and Mr. Rainsford Mowlem for permission to publish the cases.

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ACQUIRED SYPHILIS IN CHILDREN

BY

MARJORIE MURRELL, M.B., D.P.H., F.R.C.S.Ed.
Clinical Tutor

AND

MARY SCOTT GRAY, M.B., Ch.B.
Clinical Assistant

Venereal Diseases Department, Edinburgh Royal Infirmary

To the great increase in early syphilis during the war years may be attributed the emergence of cases of acquired syphilis in children. Six cases are here recorded in order to focus attention on the possibility that the disease is transmitted through close contact with actively infectious individuals, either adults or children, and by contact with infected articles, and on the possibility of such transmission occurring even in families where there are no known cases of syphilis. For example, several children have been brought for examination because they had picked up and inflated condoms found in the parks, and one of the cases reported may have been infected in this way. Poor environmental conditions, carelessness, and lack of attention to hygienic precautions are not invariably present as contributory factors, as infections through contacts have occurred in professional homes. The early recognition of these cases is of such vital importance, both to the child and to those in close contact, that acquired syphilis as a possible diagnosis should be considered in any case in which there is a rash accompanied by headache, sore throat, and adenitis, and where the rash does not conform to the commoner skin conditions or to one of the other exanthemata. The frequency of the commoner symptoms and signs of secondary syphilis in this group of cases is shown in Table II.

Unfortunately, in no case so far has syphilis been suspected while still in the primary stage, although a primary sore on the tonsil was detected in two of the secondary cases now reported. If a chancre appears on the lip, characteristically as a solitary indurated erosion with accompanying unilateral indolent rubbery enlargement of the neighbouring lymphatic glands, it should not be missed, and yet experience shows that suspicion is often not aroused until the secondary stage is reached. All the cases in the present series had had symptoms for three or four weeks before arriving at the clinic.

In the past five years six cases have been examined and treated. Tables I and II give the chief points noted. In

TABLE I

Case No.	Date Seen	Age (yrs.)	Sex	<i>T. pallidum</i> Demonstrated	Site*	Source of Infection
1	4/1/45	3½	M.	+	Anus	Mother
2	17/6/41	6	M.	—	—	Parents
3	14/8/45	7	F.	+	Labia	Indian servant
4	4/5/46	7	F.	+	Vulva	Found condom in park; always sucks things she picks up
5	26/6/46	8½	F.	—	—	Parents
6	26/7/46	16	F.	+	Anus	Nephew with acute congenital syphilis

* Area from which serum (for demonstration of *T. pallidum*) was obtained.

TABLE II

Case No.	Malaise	Headache	Sore Throat	Pains in Limbs	Rash	Alopecia	Sore in Mouth	Adenitis	Condylomata Lata
1	+	—	—	—	—	—	+	+	+
2	+	+	+	—	+	—	—	+	—
3	+	—	+	—	+	—	—	+	+
4	+	—	+++	—	+	++	+	+	+
5	+	—	++	+	+	—	—	+	—
6	—	—	+++	—	+	—	—	++	+

each case the Wassermann and Kahn tests of blood taken at the patient's first appearance were strongly positive, and the cerebrospinal fluid, taken in all except one case within the first fortnight, gave entirely negative findings in respect of cell count, globulin estimation, Wassermann reaction, and gold-sol test.

Diagnosis

A detailed history of the illness should be obtained, noting particularly the time incidence of the various symptoms. As a rule malaise and anorexia are early symptoms, then follows the rash and sore throat with adenitis, the condylomata in the genital or anal regions being late in appearance. Should, however, the primary sore be on the mouth or tonsils, the first symptoms will be referred to this area, and in that case the associated glandular enlargement is very noticeable and is usually commented upon.

The family history should be obtained in full, with particular reference to whether the parents have ever had treatment for syphilis. An inquiry should be made as to who sleeps with the child and looks after him; whether he keeps his own towels and washing things; whether he uses outside lavatories; and whether he has been staying away from home recently. A thorough examination should then be carried out from head to foot, noting especially the condition of the hair and scalp, mouth, skin, glands, and genitals. Serum should be taken from moist lesions, after ascertaining whether antiseptics or ointments have recently been applied, and blood taken for Wassermann and Kahn tests.

Differential Diagnosis.—All the other infectious diseases associated with rashes must first be eliminated, particularly rubella, which was diagnosed originally in Case 2. The throat infection may also be suspected—diphtheria, Vincent's angina, and streptococcal tonsillitis with a streptococcal rash all being possibilities. In children the rash of