be warned against exertion till his response to exercise becomes satisfactory.

Prevention

Prevention has to be considered from two points of view—the protection of camp sites and of troops compelled to enter mite-infested areas. When a choice of camp sites is possible a dry area should be chosen. The site should be thoroughly cleared of all grass and vegetation by cutting, oiling if possible, and burning. Indigenous labour should be employed when available. For important camps a bulldozer would be invaluable; the ideal to be aimed at is to obtain a surface covered with earth or sand and completely free from vegetation. When this is impracticable an effort should be made to provide such a surface for occupied quarters and paths, and to prohibit all straying from the prepared ground. The work should, if possible, be carried out under the supervision of an expert entomologist. The protection of troops compelled to expose themselves to risk is a troublesome problem, complicated by the difficulty of designing mite-proof clothing which would be tolerable in tropical conditions. The detailed measures now adopted cannot, for security reasons, be completely divulged, but it is known that mite repellents, such as dimethyl phthalate, have been applied to the skin and clothing, and that intensive study of the whole subject has been carried out by competent experts.

The control of rats and other animal reservoirs of infection must be undertaken with great circumspection, and only under expert guidance, for the reasons already given. Rats should certainly be discouraged from infesting the camp by keeping every scrap of food out of their reach and by seeing that no suitable nesting-places are available for them. The camp should be kept free from animals of every kind; to ensure this a high standard of tidiness is needed, especially in cookhouses and food stores. Rat and mouse holes can safely be treated by cyanide gas; trapping and poisoning may be risky.

Prevention by egg-yolk or animal-lung rickettsial vaccines has been the subject of close investigation by experts, but many difficulties are likely to be encountered in work of this kind. The instruction of all who are exposed to risk must form an important part in the campaign against scrub typhus; success can be achieved only by the intelligent co-operation of everyone. There is plenty of evidence that the disease is being taken very seriously by the Allied Forces in the East, and there are good grounds for hoping that the energetic measures of control now being adopted will reduce the scrub-typhus menace to negligible proportions.

SCRUB TYPHUS: A CLINICAL STUDY

BY

M. C. MENON, M.B., B.S. Madras

Lieut.-Col., I.M.S./I.A.M.C.; Officer in Charge, Medical Division of an Indian General Hospital (C)

AND

COLIN IBBOTSON, M.B., Ch.B.

Capt., I.M.S./I.A.M.C.

During the period Nov., 1944, to Jan., 1945, 110 British patients suffering from scrub typhus were treated in a forward Indian general hospital. This paper is a summary of the clinical records of these cases and of impressions gained with regard to diagnosis, prognosis, and treatment. The patients were all drawn from units of a British formation which entered a small "typhus island" in N.E. Burma during the first week of November. The preventive measures now in force had not at that time been adopted, and the onset of symptoms in the first cases occurred on Nov. 17—that is, approximately two weeks after entry into the affected area.

The first group of patients were admitted to the general hospital on Nov. 27, and in the next three days the total number had reached 41 (1 officer and 40 B.O.R.s). In December there were 69 admissions (3 officers and 66 B.O.R.s), most of whom reached us during the first nine days of the month. After this date fresh cases were received only very occasionally, owing to more efficient prophylaxis and to the fact that the main body of the formation had driven beyond the endemic

zone. At first, cases reached the general hospital on the fifth to tenth day of the illness. Later, as forward medical units became more "typhus conscious," the disease was recognized earlier, and patients were evacuated about the third or fourth day.

Clinical Features

The onset was usually sudden, with severe headache and fever, with or without a rigor. The temperature usually reached 103° within the first 48 hours, and was often slightly higher. Thereafter the fever was usually continuous, but a four-hourly chart sometimes showed an intermittent type, a sudden drop to normal or subnormal, accompanied by profuse sweating, taking place in the early hours of the morning. The average duration of fever was 15.7 days (extremes, 5 days and 29 days), the return to normal being by lysis. Twenty-five cases had fever of 10 days' duration or less. Headache was present in 100% of cases from the onset of the illness. It was often frontal or retro-orbital, and of such severity that it was not relieved by the usual analgesics. Sore throat, with injection of the fauces, was present in 54% of cases; it was so severe as to prevent swallowing in 4 cases (3.6%).

Primary Lesion or Eschar.—56% of cases showed typical eschars. The lesion was generally single, but 3 cases each had 2 eschars, and one case had 3. The eschar may be missed if the search is not thorough. In several cases the eschar was found on the scrotum, the perineum, or between the buttocks. The common sites, in order of frequency, were the axilla, the anterior aspect of the trunk, the forearm, the leg, and the back of the chest. The patients were rarely aware of the existence of the lesion, and in only two cases could the men recall having noticed it before the onset of general symptoms. These troops were so inured to jungle sores, however, that it is not surprising that they took little heed of an extra one.

Conjunctival injection and marked flushing of the face were common signs, being observed in 82% and 65% of cases respectively. They were of assistance in the early diagnosis of the disease, since they were present by about the third day.

Adenitis.—Of the cases 98% showed moderate enlargement of the lymph nodes in all areas. The glands were not visibly enlarged except in a small number, but were very readily palpable, discrete, rubbery, and sometimes tender in the first week or so. Enlargement was appreciable by the fourth day of the illness. Except in a few cases, the glands draining the eschar were not noticeably larger than those palpable elsewhere.

Rash.—In 64% of the cases there was a maculo-papular rash—more rarely purely macular—on the fifth or sixth day of the illness. It lasted three to four days and was distributed mainly on the trunk, the face, and the proximal portions of the limbs. One case presented unusual features, in that at the time of the maculo-papular rash, and healing as the latter faded, there were multiple superficial herpes-like erosions of the glans penis, similar lesions of the buccal mucosa, and an oval sloughing ulcer of the lower lip. The Kahn reaction in this case was negative, which answered a suspicion that temporarily occurred to us, and the patient subsequently became the subject of typical typhus necropsy.

Mental State.—There was some definite alteration in 50% of the cases. This varied from a drowsy apathy with mental confusion, in average cases, to restlessness, delirium, and sometimes a "typhoid state" in grave cases. Mild cases showed no mental change other than that caused by the constant intense headache.

Respiratory Signs.—50% of cases had signs of a diffuse bronchitis, and they produced a variable amount of mucoid sputum which was occasionally blood-tinged or rusty. Unless the sputum became purulent or the total white cell count rose above 10,000 per c.mm., we regarded this as a rickettsial bronchitis or pneumonitis—part of the typhus syndrome, and not an indication for chemotherapy. Cyanosis and an increased respiratory rate were observed to be of grave prognostic significance. These signs did not often tally with the physical signs in the chest.

Hiccup was noted in 20% of cases, and was distressing to the medical and nursing staff as well as to the patients affected. It was a symptom of grave prognosis also. Six of our 9 fatal cases were thus affected. In some cases the symptom may be

the result of enlarged mediastinal glands, though we considered it generally an indication of impending uraemia, the average blood urea in these cases being 80 mg. per 100 c.cm.

Chest Radiography.—A portable apparatus was not available; consequently cases were not x-rayed until the onset of convalescence. The first 8 cases at this stage showed completely normal chest films, after which the investigation was abandoned except when specially indicated.

Splenomegaly.—The spleen was palpable, sometimes easily so, in over 50% of cases. Since all patients were taking suppressive mepacrine, however, and 15 (13.6%) had demonstrable malaria parasites in the blood on admission, it was not possible to say to what extent typhus itself might have been the cause of the enlargement. We feel that, in an endemic malarious area, too much importance should not be attached to this sign.

Urinary System.—The urine, chemically and microscopically, was found to be normal. Neurological abnormalities—incontinence or retention—occurred in 15% of cases.

Cardiovascular Signs.—The pulse rate tended to be rather low in relation to the temperature in the first few days of the illness, but in the later stages of the acute phase it went up to 130 or more. Dilatation of the heart was not appreciable clinically. In downhill cases the blood pressure became progressively lower. The only positive sign, apart from tachycardia, occurred in 4 cases (3.6%) which manifested repeated extrasystoles. No bruits were heard. Tachycardia sometimes persisted well into convalescence.

Nerve Deafness.—This is probably a valuable sign, but one which we found difficult to assess owing to the profound apathy common in these patients and their slow cerebration. In general we found measured speech as well understood as a stentorian voice.

Neck rigidity and stiffness were noted in 6 cases (5.4%) in the early stages. The C.S.F. was clear and under normal pressure.

Blood Investigations.—The total red, total white, and differential white counts revealed no abnormality in the majority of cases. We attached significance to a total W.B.C. count exceeding 10,000 per c.mm. (see below).

Weil-Felix Reaction.—We took the agglutination of the Kingbury strain of *B. proteus* (OXK) in dilutions of 1/125 or greater to be diagnostic. The average titre obtained on the 17th day of illness was 1/250, the greatest being 1/12,500 (19th day). We feel that the (OXK) titre is by no means indicative of the severity of the infection, and that a titre lower than 1/125 does not negative a clinical diagnosis. In our series 20 persistently gave positive results in titres lower than 1/125, but we have no doubt that they were cases of scrub typhus. In most instances the titre rose steadily during the first three weeks and then began to fall.

Complications

Lung Complications.—Bronchopneumonia (4 cases) and lobar pneumonia (3 cases) were observed. There were the usual clinical signs and a raised total white cell count, the increase being largely polymorphonuclear. Three of these cases developed empyema, two of them resolving after aspirations and local and parenteral penicillin, and one requiring rib resection. The pus aspirated revealed staphylococci and streptococci in one case and no growth in the second; in the third case, which failed to respond to penicillin, staphylococci were grown at first, but later *B. coli* (penicillin-resistant) was cultured.

Alimentary Complications.—Parotitis, 1 case; haematemeses, 1 case (fatal); diarrhoea, 3 cases.

Cardiovascular Complications.—Femoral thrombosis, 2 cases; unexpected myocardial failure during convalescence, 1 case.

Nervous Complications.—Transverse myelitis syndrome, 1 case; mild peripheral neuritis, 6 cases.

Bed-sores.—3 cases.

Concurrent Disease.—Malaria, M.T. or B.T., 15 cases (2 cerebral malaria); amoebic dysentery, 2 cases; dysentery, bacillary exudate, 2 cases.

Course and Prognosis; Morbid Anatomy

The fever usually lasted a little over two weeks. Recovery was rapid. Signs of ill omen were cyanosis, increased respiratory rate, hiccup, retention of urine, and gross mental changes. In our series 9 out of 110 patients died, giving a mortality rate of 8.2%.

One of our patients died unexpectedly four days after the temperature had reverted to normal. We found a flabby dilated heart with moderate fibrosis, and could point to no cause other than acute myocardial failure. One died after a haematemeses, and post-mortem examination revealed numerous submucous haemorrhages in the stomach and small intestine. The other seven deaths were attributable to toxæmia, and occurred between the 12th and 24th days of the illness. Enlargement of the mediastinal and mesenteric lymph glands was commonly found, with congestion of the liver, a soft enlarged spleen, and congestion of the lungs, sometimes with subpleural haemorrhages.

Diagnosis

Clinical diagnosis was easy owing to the presence of associated cases. A sudden onset with severe headache, followed by the combination of sustained pyrexia, enlarged rubbery lymph nodes, conjunctival injection, a maculo-papular rash, and an altered mental state—a combination which most cases presented by about the fourth or fifth day—will rarely be anything else even in the absence of an eschar. A typical eschar together with any of the above signs was considered diagnostic. The Weil-Felix reaction was of value as later confirmation, but reached significant levels too late to be of assistance in the early stages.

Differential diagnosis resolved itself into two phases—that before the lymph nodes enlarged, and that which pertained afterwards. In the first phase malaria and fevers of the dengue-sandfly group were likely to be confused. The onset in the case of enteric was usually not so abrupt. The cases which showed stiffness of the neck muscles gave rise to the suspicion of meningitis, which was excluded by lumbar puncture. Primary infections of the respiratory tract (streptococcal sore throat, acute bronchitis, bronchopneumonia, and lobar pneumonia) gave little trouble because of the correlation of other symptoms. In the second phase glandular fever, acute leukaemia, and agranulocytosis were excluded by a white cell count. In measles the first symptoms are coryzal, Koplik's spots will be present, and the temperature will fall before the rash appears. Secondary syphilis will very rarely be so severe, and the proportionate predominance of individual symptoms and signs will be different. Serum reactions will be positive.

Treatment

General.—In no disease is the physician less important except as a guiding force, and the nurse more essential. These particular patients were fortunate in having a ward sister who accepted this from the start and gave up practically all her "off-duty" time week after week. Nursing must be intensive and continuous, without which many patients who otherwise would live will inevitably die. An adequate diet was maintained—a minimum of 2,400 calories daily, including 100 g. of first-class proteins—and dehydration and salt depletion were combated. Most patients, with sufficient encouragement, took fluid and semi-solid nutriment by mouth. If not, the transnasal intra-gastric Ryle's tube was employed. Intravenous fluids tended to aggravate the respiratory symptoms, and in any case were of use only in a grave emergency. Vitamin concentrates of A, B, C, and D were available and were given to all patients as a routine. Since these patients came from a highly malarious area, a full course of mepacrine was given from the date of admission, followed by suppressive treatment. Pressure points and oral hygiene required constant attention. Rest in bed was enforced till the pulse rate settled to normal (usually 10 to 12 days after the temperature touched normal), and then patients were allowed to get up and move about gradually.

Symptomatic Treatment.—Insomnia, due usually to intense headache, was treated with potassium bromide, chloral hydrate, each 15 gr., and tr. op. i. m. 15: or paraldehyde 6-8 c.cm. intramuscularly in severe cases. Paraldehyde by mouth was usually not tolerated. Hiccup was difficult to manage, and responded

best, even though only temporarily, to inhalations of CO_2 and oxygen. Cyanosis and respiratory distress responded well to continuous oxygen administration, though this treatment had to be continued as long as three days in some cases. Patients with meningitic symptoms were lumbar-punctured, principally from the diagnostic point of view. Removal of cerebrospinal fluid did not appear to alleviate the symptoms.

Treatment of Complications and Concurrent Diseases

Lobar and lobular pneumonia due to secondary pyogenic infection were treated with sulphathiazole in the usual dosage. Of 7 cases so treated, 3 developed empyema. Treatment adopted for this was repeated aspiration followed by instillation of penicillin into the pleural cavity, combined with intramuscular penicillin in dosage of 100,000 Oxford units daily. This treatment led to resolution in two cases, but the third became contaminated with *B. coli*, and rib resection was necessary to complete the cure.

The case of parotitis cleared up without resort to surgery. The two cases of femoral thrombosis were treated along the usual lines, but recovery was marred by a residual oedema of the leg. Retention of urine called for twice-daily catheterization until bladder control was regained. Bacillary and amoebic dysentery were controlled with sulphaguanidine and emetine respectively.

Summary

A series of 110 cases of scrub typhus in British patients is described.

The disease generally presented a clear-cut symptomatology, and clinical diagnosis was not difficult.

The Weil-Felix reaction becomes positive in significant titre too late in the illness to be of much assistance in the early diagnosis.

The differential diagnosis and prognosis are discussed and the pathological findings in the fatal cases recorded.

We wish to thank Col. P. H. Addison, I.M.S., for permission to present this account

BIBLIOGRAPHY

D.M.S., A.L.F.S.E.A. Technical Memo. (Medical) No. 6, 1944.
Ransome, G. A., Gupta, L. M., and Paterson, J. C. S. (1944). *British Medical Journal*, 2, 594.

THE EFFECTS OF MECHANICAL STRESSES ON MAN*

BY

B. H. C. MATTHEWS, C.B.E., Sc.D., F.R.S.

LECTURE II

In aircraft man moves at very high speeds, but high speed in itself does not produce any physiological effect if the pilot is protected from high wind-pressures in a closed cockpit. However, when motion changes rapidly, either in direction or in magnitude, the pilot is subjected to very great mechanical stresses not ordinarily met with on the ground. The practical effects of these may be separated into two classes of phenomena: (1) those associated with change of speed such as occurs in catapult-launching or in crash-landing, where high acceleration or deceleration acts for a short time; and (2) those associated with change of direction of motion, which may be of long duration but of less magnitude, as when an aircraft executes a tight spiral. The physiological effects produced depend on the value, duration, and line of action of the force acting on the body and also the area over which the force acts on the body. The magnitude of the force acting on a body, owing to its inertia during change of motion, depends on the rate of change of velocity and the mass of the body. The numerical factor to be related to physiological effects is the change of velocity in feet/second/second. The acceleration due to gravity giving a body its normal weight is 32.2 ft./sec./sec., abbreviated in the sign "g," and it is convenient in physiological work to consider the rate of change of motion in terms of multiples of "g." This makes it possible to give the forces acting a numerical value. It must be

emphasized that the acceleration communicated to one part of the body, if it acts only for a very short time, may not produce so great an acceleration on other parts of the body owing to transmission of the forces via parts of the body which yield. For example, if the chair in which a man is seated is given an upward acceleration of 5 g for only one-fiftieth second, the acceleration at the head will have a much lower value and act for a longer time owing to transmission of the force through yielding parts of the body.

If large forces act on a small area the commonest result is a penetrating injury. It is forces acting over a small area in this way which produce all common accident injuries, and to prevent these it is important in aircraft design to avoid projections in the cockpit with which the pilot may come into violent contact if the aircraft is suddenly decelerated, as in crash-landing. Injuries of this type are greatly reduced by the use of properly designed harness to prevent motion of the body relative to the cockpit. Here will be considered only those cases where a large force acts on the body over a considerable area and penetrating injury does not occur.

Physiological Disturbances

Fig. 1 gives in diagrammatic form the tolerance of the seated body to acceleration when it is adequately supported to meet the force. This is drawn as two separate lines, to distinguish between short-acting forces, which may result in mechanical failure of parts of the body, and long-acting forces of lesser

FIG. 1.—Acceleration tolerable to a seated man.

magnitude, which produce physiological disturbances, particularly of the circulation, without permanent structural damage. The upper part of the curve is only a rough indication, and requires further definition of the exact support of the body, which makes a very great difference to the tolerable acceleration. In other postures the tolerable acceleration varies widely. Thus in a standing man fracture of the lower leg is a possibility at 3 g, and is very likely to occur at 7 g. A seated man accelerated forward can tolerate very high acceleration, probably over 25 g. For acceleration in the reverse direction, such as the deceleration in crash-landing, the body must be restrained by a harness, and unless the head is restrained (which is not often practicable) neck injury may occur at less than 25 g. Above this, evisceration may occur. Very high acceleration can be tolerated if it acts on a man supported spread-eagle on his back—probably at least 250 g (de Haven, 1942).

These figures must be regarded as a rough indication only, for unless conditions of support are exactly defined, wide variations may occur in practical cases. They are based on evidence from several sources—viz., (1) From experiment. Squad. Ldr. Stewart has carried out many catapult experiments with various postures, experiencing the accelerations which can be tolerated without injury. (2) From analysis of accidents, where it is often possible to reconstruct probable forces that have been in action. (3) From an analysis of unsuccessful suicide attempts which has been made by de Haven (1942).

The problem of concussion is too extensive to be considered here. The forces necessary to produce concussion, if penetrating injury does not take place, appear from de Haven's figures to be very high indeed, perhaps 300 to 400 g. Experiments by Denny-Brown and Russel (1941) also show that very high acceleration is required to produce unconsciousness in animals, though in practical rather than theoretical cases the work of Holbourn (1943) suggests that injury may result to the brain when the head receives a much lower acceleration if the

* The second of two Oliver-Sharpey Lectures before the Royal College of Physicians of London, March, 1945.